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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

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

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Executive summary

The **Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VIII and IX** [WGACEGG] met for the second time in Lisbon, Portugal, from the 27 November – 1 December 2006. During this year's meeting, the WG centred its attention on: a) comparative results of the anchovy juvenile surveys in the Bay of Biscay; b) a proposal for a future coordination of the anchovy juvenile surveys, and an analysis of the possibilities of further improvements in the spring acoustic and egg production surveys; c) a proposal for a common database and basic tools for data exploration for the acoustic surveys off the Iberian Peninsula and Armorican Shelf; d) first application of DEPM for Gulf of Cádiz anchovy; e) the preparation of a new DEPM survey for horse mackerel off the Atlantic façade of the Iberian Peninsula; and f) new improvements and analysis of precision and bias for egg production and acoustic surveys. Final results for anchovy and sardine estimates of biomass from acoustic (2006) and DEPM (2005 for sardine off Iberia and anchovy in the Gulf of Cádiz; 2006 for anchovy in the Bay of Biscay) were also presented and discussed in the group, although some of these results were previously presented to the Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine and Anchovy (WGMHSA). Discussions on topics a) and b) were included specifically to deal with the EU special request to ICES on the Bay of Biscay anchovy surveys, while topic e) was included in this year's agenda, following a proposal from a group of IPIMAR scientists who will be carrying out a horse mackerel DEPM survey in the Atlantic waters off the Iberian Peninsula for the first time in 2007.

Comparison of the anchovy juvenile surveys provided differences of the absolute biomass estimates which are not fully understood. A workshop to analyse the source of the differences is recommended for early next year. An exercise to describe the features of each of the anchovy surveys, including the juvenile ones, was also carried out and a new combined anchovy juvenile survey in the Bay of Biscay was proposed as an improvement over previous surveys. This new survey will maintain the double objective of providing an estimate of juvenile abundance, comparable with the available time-series of the juvenile abundance index, and information on the recruitment process. The importance of coordinated and combined surveys was also discussed in relation to other acoustic and egg production surveys. A proposal for a common format database, with added tools for easy combination and representation of data was made in the group. This database will extend the capabilities of the Group to analyse broad scale patterns, spatial comparison between acoustic and egg production results and interchange and intercalibration of data. The necessity of a common format database was agreed in the group and further work on the database will be carried out in the anchovy juvenile comparison workshop. In relation to the first application of the egg production method in the Gulf of Cádiz, the methods used are regarded as the appropriate ones, egg production and adult parameters estimates are within the range of parameters found in the bibliography, and final SSB estimates are very similar to ones provided by acoustic surveys in the area.

In relation to the 2007 horse mackerel egg production survey, a detailed list of requirements to implement a DEPM based SSB estimator, as well as a detailed survey plan for the survey was produced. A series of analyses of the sources of bias for egg production and acoustic methods was also carried out, centered on:

a) bias related to the estimation of the parameters of the mortality curve, including the effects of spatial distribution of eggs and adults,

b) estimation of spawning fraction for anchovy and the effects of different post ovulatory follicles ageing methods, and

c) variability of the assumed values for the target strength of sardines and anchovies, both among the institutes involved in this WG and in the existing bibliography.

In relation to WGACEGG ToRs, ToRs a and b (planning and coordination of acoustic and egg surveys) were intensively discussed in the group. As detailed above, a proposal for improving coordination of all existing acoustic and egg production surveys for sardine an anchovy in ICES areas VIII and IX was made. Planning of next year surveys for sardine and anchovy, and exceptionally for horse mackerel was also accomplished, while improvements in the standardization of analysis procedures were achieved.

In relation to ToRs c and d (cross validation and integration of acoustic and egg production based spawning stock biomass estimates), some advances were achieved in the interim period between last year and this year WG meeting, and were included together with advances from EU project FISHBOAT. Initial comparison of spatial distribution of acoustic and DEPM based spawning biomass estimates provide comparative results, although these results are considered incipient and further research is required. Global comparison between the time series of acoustic and DEPM spawning biomass estimates provide different perspectives in the different stocks; good agreement in Gulf of Cádiz anchovy estimates, intermediate agreement in Iberian Peninsula sardine estimates and important differences in Bay of Biscay anchovy estimates. These results suggest that the characteristics of the different stocks and ecosystems may be affecting the different methods in different ways. Further research is also considered necessary in this field.

In relation to ToR e (provide new procedures and software for egg production estimation), some new advances were presented in the group, and most of the applications of the egg production methods in the different species and areas are carried out using the software developed within WGACEGG and previous Study Groups. Main remaining issues in this topic include how to proceed when positive mortality estimates arise from a given DEPM survey, and the re-estimation of all egg production estimates using spatial explicit egg production models.

ToR f (integration of environmental information in the analysis of sardine and anchovy communities and their relation with the ecosystem) was only partially dealt with in the WG. Environmental information was used mainly to explain spatial patterns in the distribution of sardine and anchovy, and as an auxiliary tool to explain differences between acoustic and egg production estimates. Further research in next WG meetings is considered to be necessary in relation to this topic.

1 Introduction

1.1 Terms of Reference

The **Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VIII and IX** [WGACEGG]. (Chair: M. Bernal, Spain) met in Lisbon, Portugal from the 27 November – 1 December 2006 to:

a) plan and coordinate egg surveys in ICES Areas VIII and IX and standardize analysis procedures;

b) plan and coordinate acoustic surveys in ICES Areas VIII and IX and standardize analysis procedures;

c) develop a framework to cross-validate egg production and acoustic methods for the estimation of Spawning-stock biomass and its distribution;

d) explore the possibilities to integrate egg production and acoustic based Spawning-stock biomass estimates;

e) finalize new egg production procedures and associated software developed under SGSBSA;

f) integrate biological/environmental information from surveys and additional sources to study the relationships between sardine and anchovy and the pelagic community in ICES Areas VIII and IX.

1.2 Report structure

Report structure this year was designed to be similar to last year WG report. Section 2 dealt with recent acoustic and egg production surveys of sardine and anchovy in ICES Areas VIII and IX. This section includes results previously presented in the assessment WG (acoustic and DEPM estimates of anchovy in the Bay of Biscay; acoustic estimates of anchovy in the Gulf of Cádiz; sardine acoustic and DEPM estimates — ICES, 2006a), together with revised estimates (anchovy DEPM estimates in the Gulf of Cádiz) and new estimates of juvenile abundance. A general view of the distribution of the different species in ICES Areas VIII and IX is presented in Section 2.1.1. Results for anchovy are separated by stock (Section 2.2.2 — Bay of Biscay and Section 2.2.3 — Gulf of Cádiz), while for sardine a general view of the Iberian stock, together with the adjacent Armorican Shelf area, is initially presented (Section 2.3), and results by area are discussed within different subsections of each method. Section 3 deals with the planning and coordination of next year acoustic autumn juvenile (Section 3.1.1) and spring biomass (Section 3.1.2) surveys, as well as with next year egg production surveys (Section 3.2). This year report includes the planning of next year horse mackerel DEPM survey (Section 3.2.3), and some thoughts on improving coordination of the current surveys in order to extend their objectives or covered areas (Section 3.2.4). Section 4 deals with the recent advances in both egg production (Section 4.1) and acoustic estimation (4.2), while Section 5 describes different approaches in the comparison and integration of acoustic and egg production surveys.

2 Recent fisheries independent surveys of sardine and anchovy stocks in ICES Areas VIII and IX

2.1 Introduction

2.1.1 General distribution of species in ICES Areas VIII and IX

A general distribution of the different pelagic species in ICES Areas VIII and IX from survey trawls performed at the acoustic surveys of each institute (IPIMAR, IEO and IFREMER) during 2006 can be observed in Figure 2.1.1.1 (in Kg) and 2.1.1.2 (in number of individuals).

Compared with other adjacent areas in the European Atlantic waters, the Bay of Biscay and the Iberian Peninsula show high pelagic fish diversity. The target species for this WG show a different distribution, with sardine spreading through all the covered area (and beyond), while anchovy shows two local population at the Bay of Biscay and the Gulf of Cadiz. In the Portuguese area, because the survey is targeted on sardine, most of the fishing stations are located near shore, where the probability of finding sardine is higher. Thus, fishing station reflects the fish pelagic community located close to de coast, which, in general is dominated by sardine. The Spanish and French acoustic surveys, although having as target species sardine and anchovy, performed the hauls with the aim of detect all the pelagic species presented in the areas (to identify echo traces). Sardine and anchovy are accompanied by other pelagic species like mackerel (*Scomber scombrus*), predominantly off the North Iberian coast, horse mackerel (*Trachurus trachurus*), spread through the Iberian Peninsula, the Armorican shelf and beyond, a local population of sprat in the Bay of Biscay, and other species like chub mackerel (*Scomber japonicus*) abundant in the Gulf of Cadiz and south Portugal, bogue (*Boops boops*), *Trachurus mediterraneus*, *Capros aper*, *Micromesistius potassou* and hake (*Merluccius merluccius*). The distribution of these species shows the different dynamics, which can be described within the context proposed by SGRESP (ICES 2005d).

The time-series of fishing stations performed during the Spanish acoustic surveys carried out between 1992 and 2002 in ICES Subareas VIIIc and IXa North has been analysed in order to achieve a general distribution pattern of the main pelagic fish. Although hauls have been done in an opportunistic way, to identify echo traces and/or to sample biological parameters or even with different gears and vessels, they provide qualitative information on presence/absence allowing investigation of the preferential areas or potential habitat for each particular species at the survey time.

For these purposes, the surveyed area was divided in seven geographical strata according to oceanographic, bathymetry and topographic features as follows:

1) South Galicia (between 41.75 to 43 -Cape Finisterre-)
2) Between Cape Finisterre and Cape Estaca de Bares (west of 8°'W)(Artabro Gulf)
3) Between 8°'W and 6°45'W
4) Between 6°45' W and 5°18'W (i.e. the area around Cape Peñas and the adjacent canyon of Avilés)
5) Between 5°18' W and 4°W (the area around the Llanes canyon and the Cachucho –Le Danois- bank)
6) Between 4°W and 2°45'W (the area between the western part of Cape Ajo and Cape Machichaco)
7) Lower than 2°45'W, the inner part or the Bay of Biscay

Also, two depth strata were defined in order to allocate coastal and related communities. For each haul, mean depth, latitude, longitude, timing, year, vessel and gear were retained together with de presence/absence (1/0) of the following fish species: sardine, mackerel, horse mackerel, anchovy, boarfish *Capros aper*, snipefish *Macroramphosus scolopax*, blue whiting, white horse mackerel, chub mackerel, bogue and hake. Preferential area in spring was defined as those strata in which any particular species occurred in almost 4 surveys along the time-series or in at least 45% of the surveys which had data for a given stratum.

In all, 270 hauls were analysed, ranged from 11 performed in 1995 to 47 in 2002 (with no surveys in 1996 and 1996). Mean number of fish species per haul is 3.7 and remained quite constant along time-series (ranged from 3.2 to 4.3). Only sardine, mackerel, horse mackerel, blue whiting, bogue and hake had a consistent presence along time-series (presence above 25% of the hauls for a given year in at least the 50% of the surveys).

Figures 2.1.1.3 to 2.1.1.12 and Table 2.1.1.1 show the preferential areas for each species. For sardine are the coastal waters throughout the surveyed areas and offshore in central waters of the Cantabrian Sea and in the inner part of the Bay of Biscay. Mackerel and horse mackerel have the widest preferential area and can be found everywhere, except the coastal waters of the Artabro Gulf for horse mackerel. Blue whiting has its preferential area around the slope and the coastal waters of the inner part of the Bay of Biscay. Chub mackerel, white horse mackerel and bogue are mainly located in the eastern part of the Bay of Biscay, in coastal waters with an offshore extension of bogue in the central part of the Cantabrian Sea. Anchovy has also its preferential area in the inner part and in the coastal waters of south Galicia. Hake, like blue whiting, is distributed offshore but it can be also found in coastal waters of central and eastern Cantabrian located in the central part of the Cantabrian Sea. Boarfish has its preferential area close to coast around Cape Peñas and offshore in the surrounding areas.

Table 2.1.1.1. Preferential areas (o) for each species.

SPECIES	DEPTH\AREA	1	2	3	4	5	6	7
Sardine	D<125 m	o	o	o	o	o	o	o
	D>125 m	x	x	x	o	o	x	o
Mackerel	D<125 m	o	o	o	o	o	o	o
	D>125 m	o	o	o	o	o	o	o
Horse mackerel	D<125 m	o	x	o	o	o	o	o
	D>125 m	o	o	o	o	o	o	o
Anchovy	D<125 m	o	x	x	x	x	o	o
	D>125 m	x	x	x	x	x	x	x
Boarfish	D<125 m	x	x	x	o	x	x	x
	D>125 m	x	x	o	x	o	x	x
Blue whiting	D<125 m	x	x	x	x	x	x	o
	D>125 m	o	o	o	o	o	o	x
White horse mackerel	D<125 m	x	x	x	x	o	o	o
	D>125 m	x	x	x	x	x	x	x
Chub mackerel	D<125 m	x	x	x	o	o	o	o
	D>125 m	x	x	x	x	x	x	x
Bogue	D<125 m	x	x	x	x	o	o	o
	D>125 m	x	x	x	o	o	o	x
Hake	D<125 m	x	x	x	o	o	o	o
	D>125 m	o	o	o	o	o	x	o

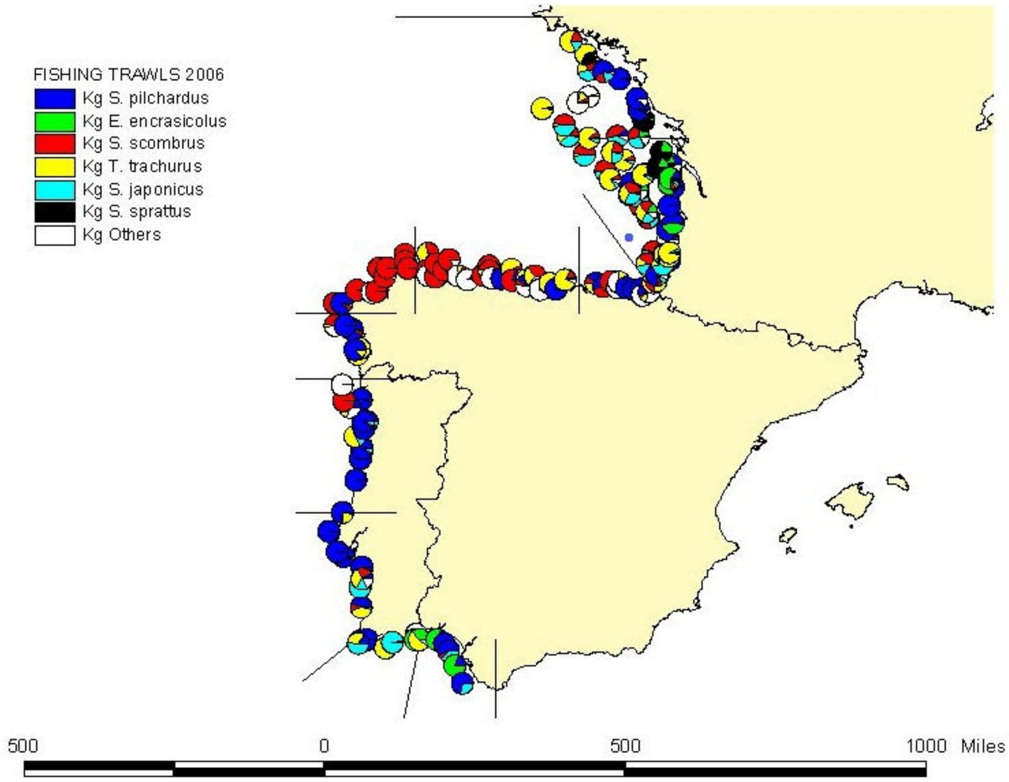


Figure 2.1.1.1. Fish species proportion (in Kg) in the fishing stations performed during the acoustic surveys undertaken in spring 2006 (April and May).

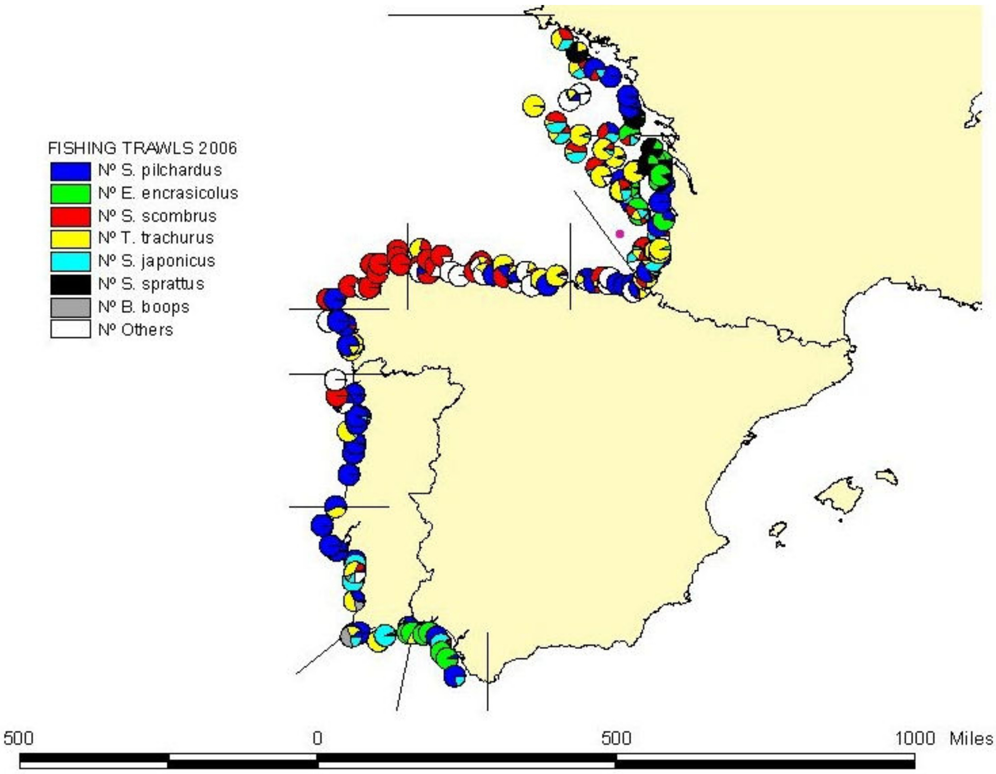


Figure 2.1.1.2. Fish species proportion (in nº individuals) in the fishing stations performed during the acoustic surveys undertaken in spring 2006 (April and May).

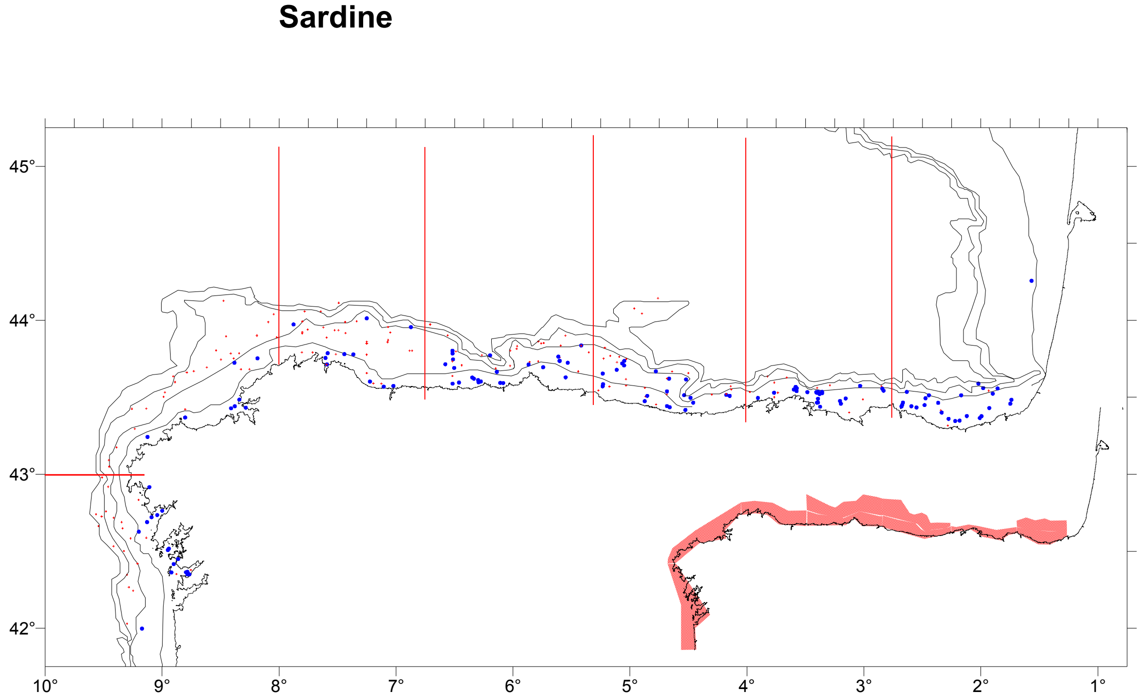


Figure 2.1.1.3. Preferential area in spring for Sardine.

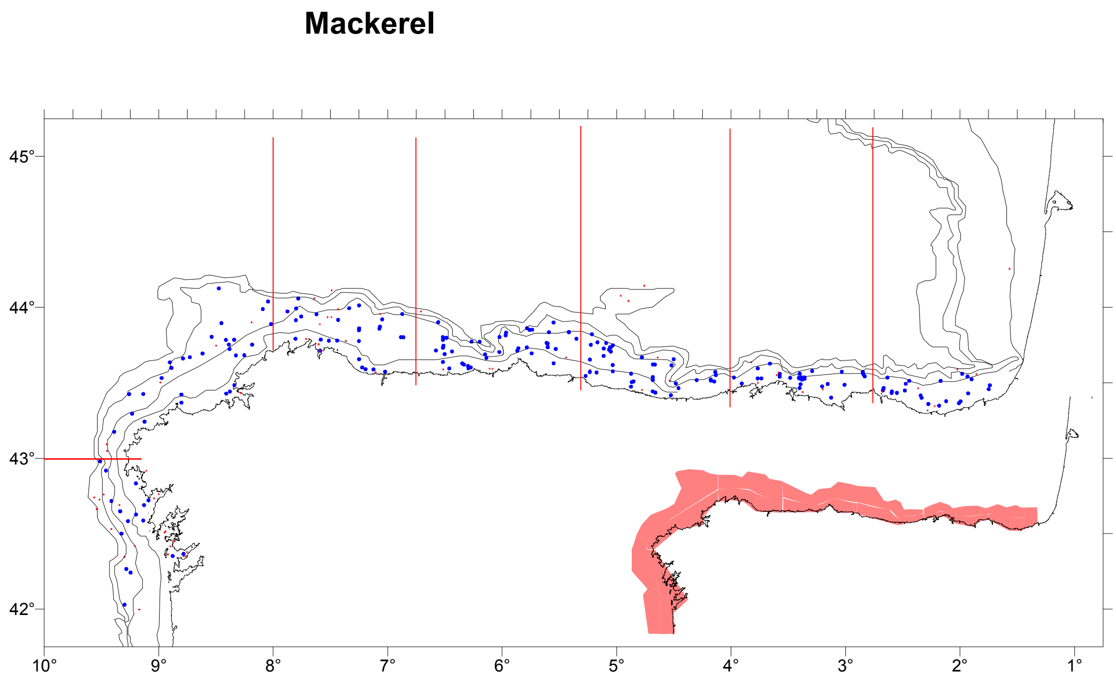


Figure 2.1.1.4. Preferential area in spring for Mackerel.

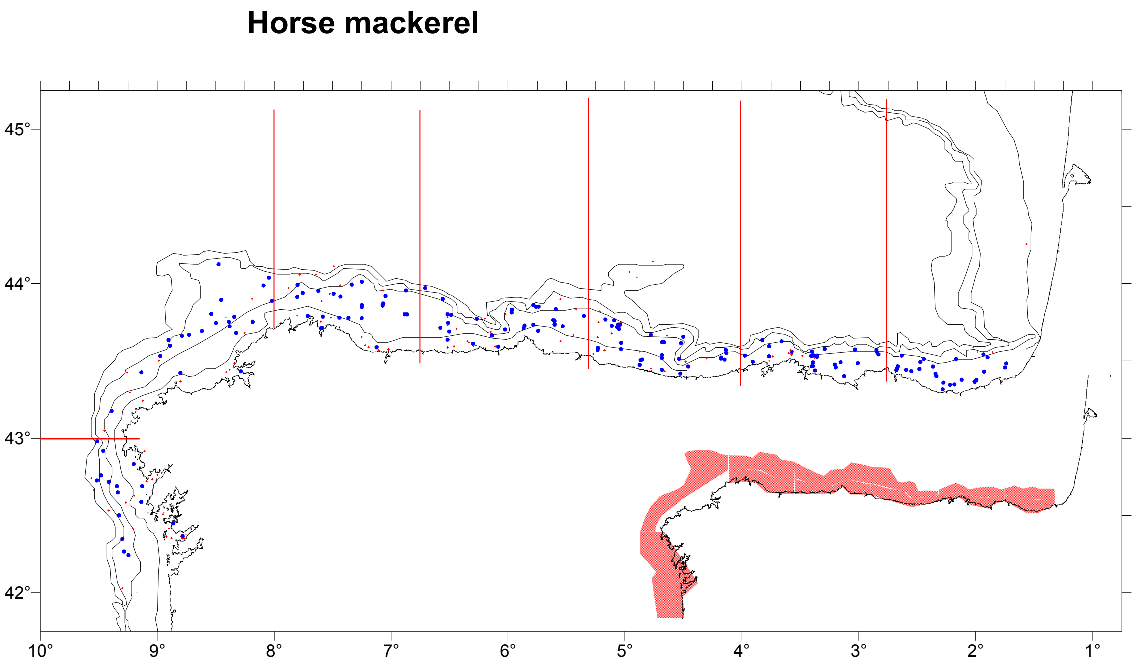


Figure 2.1.1.5. Preferential area in spring for Horse-mackerel.

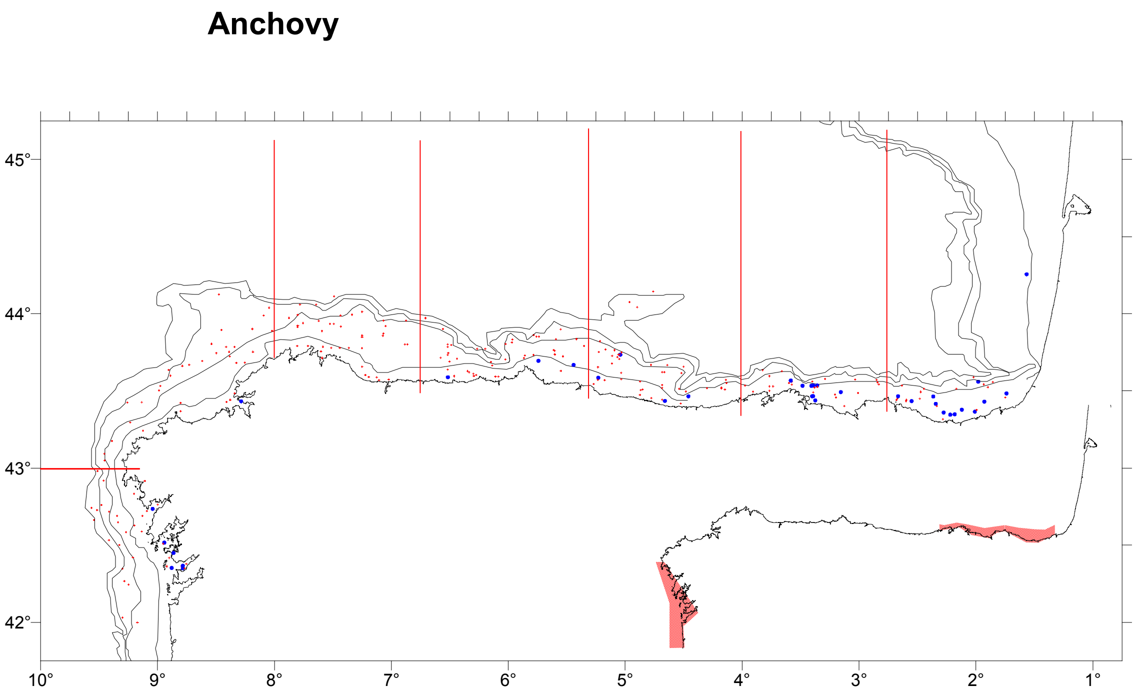


Figure 2.1.1.6. Preferential area in spring for Anchovy.

Capros aper

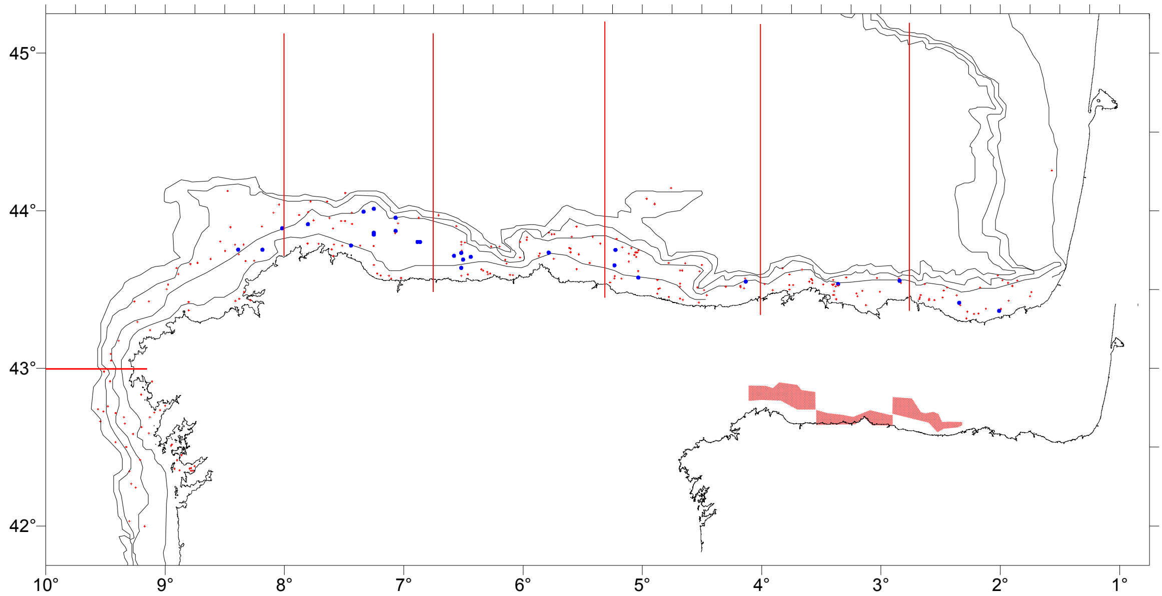


Figure 2.1.1.7. Preferential area in spring for Boarfish.

Blue whiting

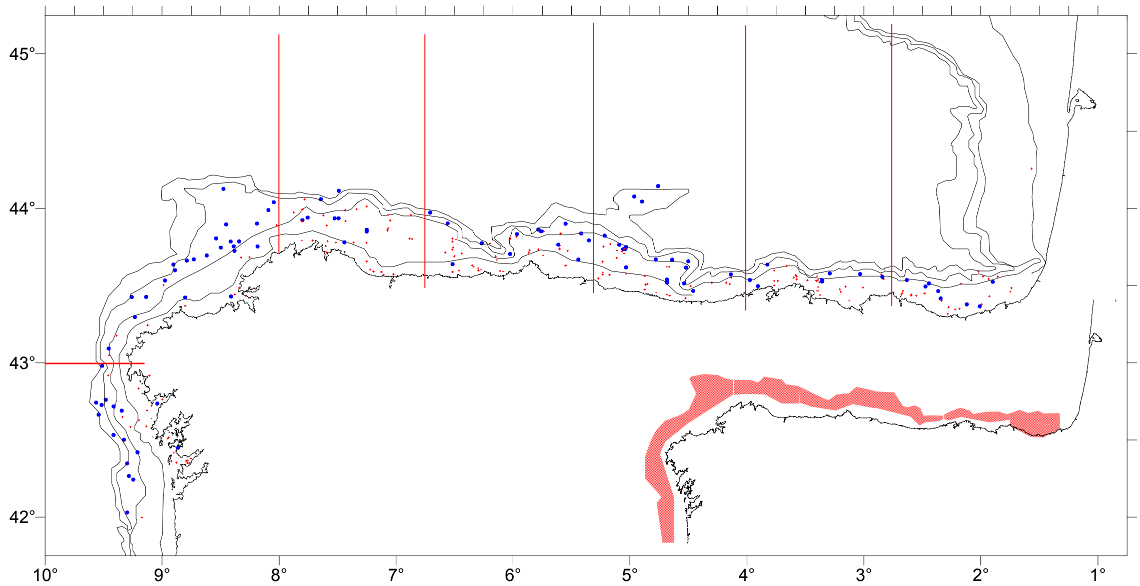


Figure 2.1.1.8. Preferential area in spring for Blue whiting.

Trachurus mediterraneus

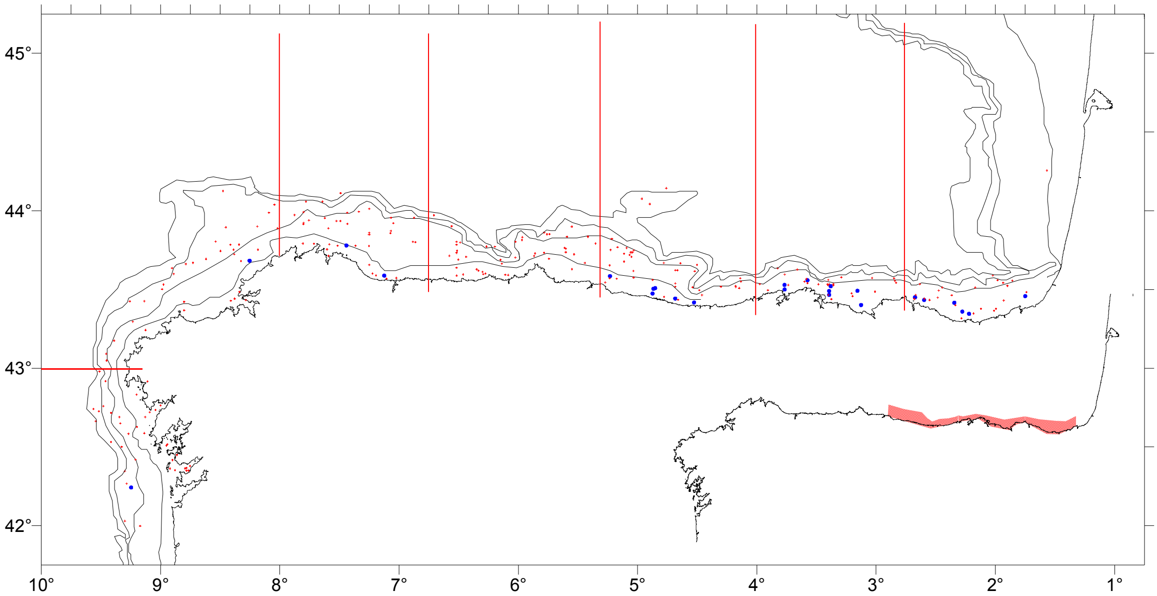


Figure 2.1.1.9. Preferential area in spring for White horse mackerel.

Scomber japonicus

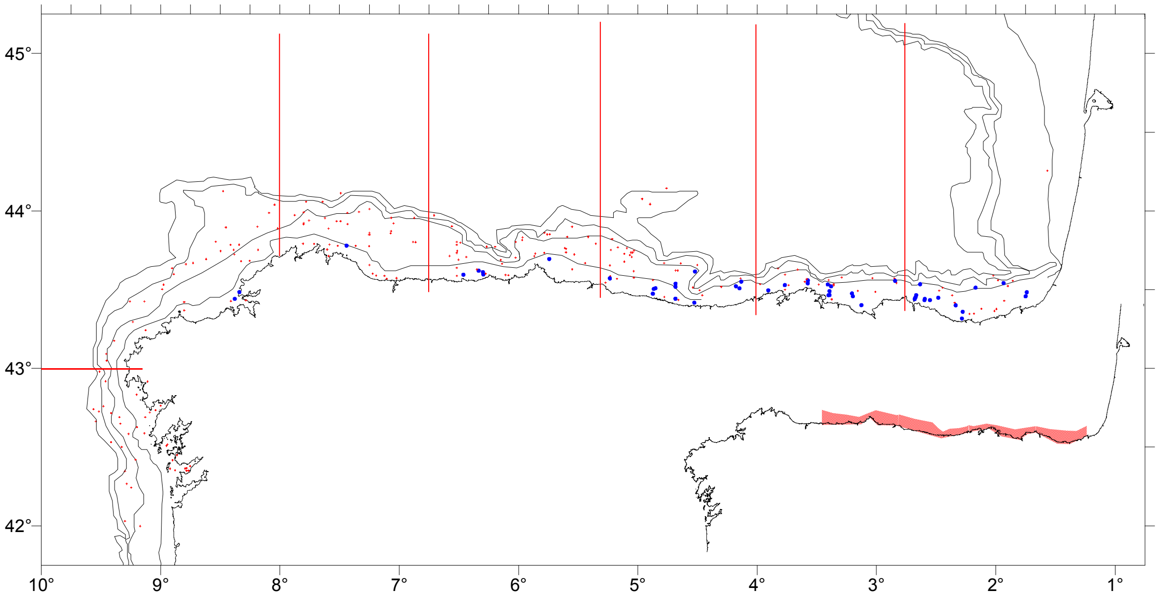


Figure 2.1.1.10. Preferential area in spring for Chub mackerel.

Boops boops

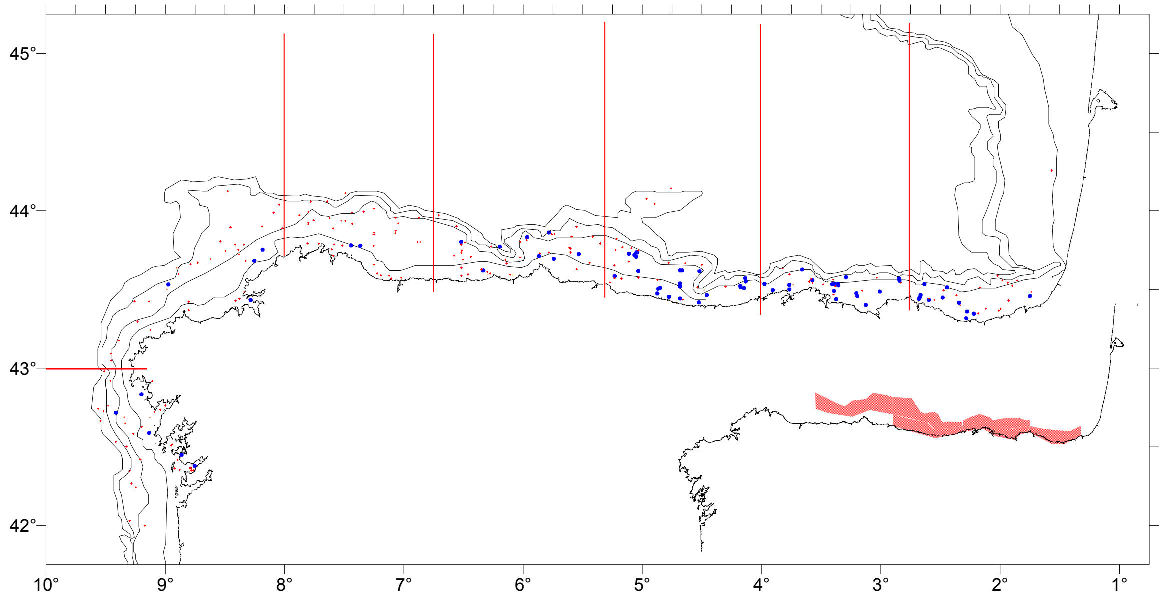


Figure 2.1.1.11. Preferential area in spring for Bogue.

Hake

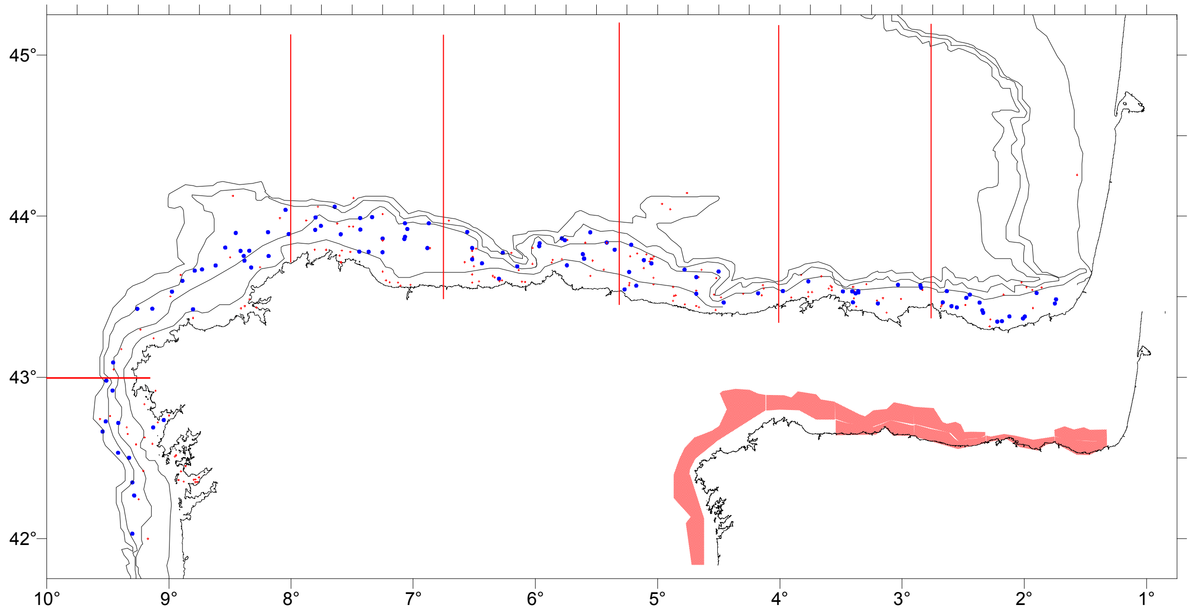


Figure 2.1.1.12. Preferential area in spring for Hake.

2.2 Anchovy surveys in Areas VIII and IX

2.2.1 General anchovy distribution

Energy allocated to anchovy (in spring)

Acoustic energy in s_A (m^2/mn^2; NASC, Nautical Area Scattering Coefficient) allocated to anchovy (*Engraulis encrasicolus*) during the spring acoustic surveys carried out by the IPIMAR (April), IEO (April) and IFREMER (May) in their respective areas has been plotted in Figure 2.2.1.1. The covered area was the continental shelf (till the 200 m isobath) and it could be noted that the higher integration values (red and green dots) for this species are located in the Gulf of Biscay (France) and the Gulf of Cadiz (Spain), being practically nulls in the rest of the prospected area. Null values (black points) describe the tracks performed in every survey. Values higher than 1000 m^2/mn^2 are located only in the Gulf of Cadiz (maximum of 1940) and in the Bay of Biscay (maximum of 1362 m^2/mn^2). In this last area, these values are located principally near the coast, and correspond to small fish (see Section 2.2.2.2.2).

2.2.2 Anchovy surveys in Areas VIII

2.2.2.1 Distribution and abundance of spawning population from egg production surveys

2.2.2.1.1 Egg distribution and estimates of egg production (CUFES + pairovet)

The DEPM survey BIOMAN06 was carried out on-board RV "Vizconde de Eza" from 4 to 24 of May on the Bay of Biscay in the main time and area of spawn of anchovy. The objectives of the survey were to estimate the spawning-stock biomass and the population at age of the Bay of Biscay anchovy. In all, 404 vertical tows were obtained using a PairoVET net (150µm) in those, 2707 anchovy eggs were found. CUFES was used as an auxiliary sampler to determine the outer limit of the spawning area in the oceanic part and to intensify or relax the sampling intensity. In all, 836 CUFES samples were obtained.

Temperature and salinity profiles were obtained in every station using a CTD RBR-XR420. In addition, surface temperature and salinity were recorded in each station with a manual thermosalinometer WTW LF197.

Figure 2.2.2.1.1.1 shows the egg abundance distribution (number of eggs per 0.1 m²) found during the 2006 survey in the Bay of Biscay and the limit of the positive area 24 614 Km^2 (solid line) and the total area 53, 991 Km².

Up to 44º50´N anchovy eggs were spread from the French coast until the 200 m iso-line. There were less abundance of eggs between the coast and the 100 m iso-line and more between the 100 and 200 m iso-lines. There was a gap of anchovy eggs in the area of Arcachon. In the area of influence of the Gironde River the eggs were distributed between the coast and the 100 m iso-line. The eggs were found well near the coast and near the 100 m iso-line. The maximum abundance of eggs encountered in a station was 105 eggs/0.1 m^2.

The eggs staged in 11 stages, were transformed into daily cohort abundances using the ageing Bayesian method. Daily egg production (P_0) and daily mortality rates (z) were estimated by fitting an exponential mortality model to the egg abundance by cohorts and corresponding mean age. The model was fitted in two manners: a) As a weighted Non Linear Regression model and b) As a generalized linear model (GLM) with negative binomial distribution and log link. Table 2.2.2.1.1.1 shows the resulting P_0 (eggs / 0.1 m^2 per day), z and corresponding total egg production (P_{tot}). For consistency with the past series of estimates, the results adopted were those arising from the exponential mortality model fitted using non-linear regression. The GLM estimate is just done for comparison purposes.

2.2.2.2 Distribution and estimates of adult parameters

The adult samples were obtained from three different sources: samples taken directly during DEPM survey on-board RV "Vizconde de Eza" (3), samples from the French acoustic survey conducted by IFREMER on-board RV "Thalassa" (11) and opportunistic samples from the commercial fleet (23) (Figure 2.2.2.1.2.1). A Biological sampling was performed for all samples, including collection of otolith samples to produce the Age Length Key (**ALK**). To produce the ALK in all, 1462 otoliths readings from 30 anchovy samples taken on-board RV "Vizconde de Eza" and purse-seines were available. To estimate the population at age in all, 37 samples were selected and 4 regions were defined: Garonne, Arcachon, Adour and Outer region.

Body weight of anchovies and gonad weight were corrected for the increase in weight due to conservation in formaldehyde solution by multiplying it by 0.98. Formaldehyde **total length** was also corrected by a factor equal to 1.02. Those factors were calculated as the mean factor from 1997 to 2006. Total weight of hydrated females was corrected for the increase of weight due to hydration. Figure 2.2.2.1.2.2 shows the distribution of anchovy female mean weight. There is a gradient from inshore to offshore. For the **batch fecundity** (F) estimates, the hydrated oocyte method was followed (Hunter *et al.,* 1985; Lasker, 1985). 61 hydrated females from 8 samples, ranging from 14 to 59 grams gonad free weight were examined. An analysis was conducted to verify if there were differences in the batch fecundity in the strata defined. No significant differences were found, so a unique stratum was considered for estimating the batch fecundity (see batch fecundity regression in Figure 2.2.2.1.2.3). To estimate **spawning Frequency** (S), i.e. the proportion of females spawning per day, histological slides of 925 ovaries were obtained from 29 samples. It was calculated as the average of day 1 and day 2 spawners. Females showing Day M (nuclear migration) and Day 0 follicles were corrected for over-sampling. The **sex ratio** was estimated as the average ratio between the average female weight and the sum of the average female and male weights of the anchovies in each of the samples. All the adult parameters estimates are showed in Table **2.2.2.1.2.1**

2.2.2.2.1 Spatial distribution and biomass estimates of the target species

Overall, these results lead to an average **daily fecundity** estimate of 50eggs/gram (CV=0.091) and a **spawning biomass** estimate of **21, 436 tonnes** (CV=0.13).

Table **2.2.2.1.3.1** shows the biomass estimates and the numbers-at-age estimates. A historical perspective of the biomass estimates in relation to previous ones can be seen in Figure 2.2.2.1.3.1.

2.2.2.3 Distribution and abundance of spawning population from acoustic surveys

An acoustic survey was carried out in the Bay of Biscay from 1–30 May on-board the French research vessel "Thalassa". The objective of PELGAS06 survey was to study the abundance and distribution of pelagic fish in the Bay of Biscay. The target species were mainly anchovy and sardine and were considered in a multi-specific context. The results have to be used during ICES working groups in charge of the assessment of sardine, anchovy, mackerel and horse mackerel and in the frame of the Ifremer fisheries ecology programme "resources variability".

To assess an optimum horizontal and vertical description of the area, two types of actions were combined:

- Continuous acquisition by storing acoustic data from five different frequencies and pumping seawater under the surface, in order to evaluate the number of fish eggs using CUFES system (Continuous Underwater Fish Eggs Sampler)), and
- discrete sampling at stations (by trawls, plankton nets, CTD).

2.2.2.3.1 Distribution of total acoustic energy

The strategy was the identical to previous surveys (2000 to 2005):

- acoustic data were collected along systematic parallel transects perpendicular to the French coast (Figure 2.2.2.2.1.1**).** 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 20/25 m depth to the shelf break.
- acoustic data were collected only during the day because of anchovy behaviour in this area; this species is usually grouped very close to the surface during night and so "disappear" in the blind layer for the echosounder between the surface and 10 m depth.

In all, 56 pelagic hauls (Figure 2.2.2.2.1.2) were carried out for identification of echo traces and biological data.

Two echosounders were used during the whole survey (SIMRAD EK60 and OSSIAN 500). Energies and samples provided by split-beam transducers (5 frequencies EK60, 18, 38, 70, 120 and 200 kHz) and simple beam (OSSIAN 49 kHz) were simultaneously visualized, 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 at cap Machichaco on the north coast of Spain in good meteorological conditions.

Acoustic data were therefore collected along a total amount of about 3800 nautical miles during the survey from which 1355 are usable for evaluation.

All the acoustic data along the transects were processed and scrutinised. Acoustic energies (Sa) have been cleaned by sorting only fish energies (excluding bottom echoes, parasites, plankton, etc.) and classified into 6 categories of echo traces which could be associated to species according to catches in the area:

- D1 – energies attributed to horse mackerel, mackerel and gadoids corresponding to cloudy schools or layers close to the bottom or of small drops in a 10 m height layer close to the bottom.
- D2 – energies attributed to anchovy, sprat, sardine and mackerel corresponding to the usual echo traces observed in this area since more than 15 years, constituted by schools, mainly situated between the bottom and 50 meters above. These echoes are typical of coastal areas and sometime more offshore.
- D3 – energies attributed to blue whiting and myctophids offshore.
- D4 – energies attributed to sardine, mackerel or anchovy corresponding to small and dense echoes, very close to the surface. These echoes are very predominant around the shelf break. Catches showed a predominance of mackerel, sardine, horse mackerel, and anchovy only around "Fer à cheval" area.
- D5 – energies attributed to small horse mackerel only when they were gathered in very dense schools
- D6 – energies attributed to the same species than D1 and D2 but when this classification was not clear enough

Distribution of main echoes are gathered in Figure 2.2.2.2.1.3**.**

2.2.2.3.2 Species composition and length/age composition

Two methods were used to calculate assessments of anchovy: a first one by attributing only one haul to each Esdu (called ref. Haul) and a second one by gathering hauls according to the species communities.

a) Assessment by Ref. Hauls

To each Esdu is affected a haul to split the energy into species according to catches proportions and weighted by TS. The hauls are chosen in respect of the echo traces types and proximity. Surface hauls are attributed to D4 energies whereas classical hauls are attributed to D1, 2, 3, 5 or 6 energies.

Therefore a biomass is calculated for each Esdu in tons or in numbers. The results from Pelgas06 are represented on Figure 2.2.2.2.2.1. Two distinct areas may be noticed, one inshore along the coast between Bayonne and the Gironde, and the second one offshore in the area called "Fer à cheval" between 100 and 120 m depth.

Biomass are gathered in the table below:

	BIOMASS	NUMBERS	COEF. VAR.
Côte	25 534	1 893 844	14.78
Fer à cheval	5 656	125 423	30.89
Total	31 190	2 019 267	

b) Assessment by strata

As previous years, the global area has been split into several strata where coherent communities were observed (species associations) in order to minimize the variability due to the variable mixing of species. Figure 2.2.2.2.2.2 shows the strata considered to evaluate biomass of each species. For each stratum, energies where converted into biomass by applying catch ratio, length distributions and weighted by abundance of fish in the haul surrounded area.

A total biomass of 30 549 t of anchovy and 228 483 t of sardine have been estimated. Biomass assessments for each species, by strata, are gathered in **Table 2.2.2.2.2.1**:

Main of the anchovy was observed along the coast in shallow waters (from the coast to 50 m depth between Bayonne and the Gironde. It was small fish (from 70 to 180/kg) mixed with sardine and sprat in front of the Gironde and with sardine and horse mackerel in the south. Big fish (20 to 50/kg) was observed at the shelf break in the area of "Fer à cheval", either in the bottom area, or at the surface (between the surface and 30 m below).

2.2.2.3.3 Spatial distribution and biomass estimates of the target species

From pelagic hauls carried out during PELGAS06, 21 042 fish were measured and 1749 otoliths were collected for age determinations (anchovy and sardine).

The length distributions are presented in Figure 2.2.2.2.3.1 and age compositions gathered in Figure 2.2.2.2.3.2.

A biomass estimate in tons and in number has been processed for each area at age group using length distributions at each closest haul. According to the very different length structure between the 2 separate areas of distribution: coastal and offshore fish. Two different age/length keys (Massé *et al.* WD 2006) have been settled and applied separately. The results have already been described in WGHMSA report (ICES 2006a - Section 10.4.2.)

2.2.2.4 Distribution and abundance of juveniles from acoustic surveys

2.2.2.4.1 JUVENA results

The project JUVENA aims at estimating the abundance of the anchovy juvenile population and their growth condition at the end of the summer in the Bay of Biscay. The long term objective of the project is to be able to assess the strength of the recruitment entering the fishery the next year.

This year the survey took place on-board two vessels equipped with scientific acoustic equipments and with two different fishing gears: purse-seine and pelagic trawl (Table 2.2.2.3.1.1). The actual coverage of both vessels is presented in Figure 2.2.2.3.1.1. The distribution of anchovy was found confined practically in the continental shelf, extending from 6º W in the Cantabrian Coast to the 47º30’ N in the French Coast (see Figure 2.2.2.3.1.2), with the bulk of the population concentred in the Northern part of the sampling area (to the North of 45º N). In this northern area, the distribution was extended from the coast to the 100 m isobath, was composed of adults and juveniles and was found mixed with other species; while at the south, anchovy population was predominantly juvenile, located close to the surface in waters less than 50 m depth.

The abundance of juveniles obtained this year constitutes, in relative terms, the third in magnitude of the four points of the JUVENA series (Table 2.2.2.3.1.2 and Figure 2.2.2.3.1.3), being almost 50% less than the obtained in 2005 and a 30% less than the one obtained in 2004. Nevertheless, this year high abundances of anchovy adults were found, in a way that summing up the total contribution of juvenile and adults, the 2006 estimate jumps to the second place in the series, with an estimated population 30% higher than the one obtained in year 2003.

In general terms, we consider the 2006 year survey successful, given the large amount of positive anchovy hauls, the large sampled area and the performance of the equipment and vessels. Especially important it has been the possibility of performing the survey with two vessels with different fishing gears, both capable of survey shallow water areas.

The biomass estimates hereby presented are still pending of an exhaustive checking of the method and a sensitivity analysis to the parameters used in the data processing. In addition, given the experimental nature of this survey, the biomass estimates should not be taken as absolute biomass values yet, but as relative ones, valid only to point out the relative changes in juvenile abundance in the surveyed area between years.

2.2.2.4.2 PELACUS1006 results

The PELACUS-1006 cruise (autumn PELACUS) is framed within the activities of the IEO project ECOPEL, which aim is the study of the fisheries of small pelagic fishes under the ecosystem approach perspective. The general objectives of the autumn PELACUS cruise were the estimation of the abundance and spatial distribution of small pelagic fishes in the southern part of the Bay of Biscay (BB-S: area within east of 5º W, south of 46º N) in September-October, and the study of the physical and biological processes involved in the regulation of these populations. The mission focuses particularly on the estimation of abundance / spatial distribution of anchovy juveniles on the process of recruitment of young-of-the-year anchovy. The estimation of the abundance and spatial distribution of small pelagic fishes has been carried out by the echo-integration method, and the detections were identified by means of opportunistic pelagic trawls. Spawning distribution of sardine and anchovy was also studied by egg sampling with the CUFES system, and physical and biological information was also acquired, both continuously underway and at fixed oceanographic stations, in order to characterize the hydrographic conditions and plankton distribution in the studied area. The sampling strategy focused on the characterisation on oceanographic conditions and components of the pelagic ecosystem (from picoplankton to fish) at regional scale (BB-S) and mesoscales in the zones of Cap Breton (CP: 43.5º N, 2º W) and plume of La Gironde (LA: 45.5 N), where the higher abundance of anchovy was found.

PELACUS-1006 was carried out on-board RV “Thalassa” (Table 2.2.2.3.2.1), between the September 22 and October 17 2006, with the participation of researchers and technicians from the IEO, IFREMER and AZTI. The cruise coverage corresponds with the area which is assumed to be the habitat of the bulk of the anchovy juvenile population (Figure 2.2.2.3.2.1).

Hydrographic and hydrodynamic conditions during the cruise are presented in Figure 2.2.2.3.2.2. Relatively higher surface temperatures where recorded in the area, especially in the inner part of the Bay of Biscay. Sea surface salinity evidence the extension and position of the frontal area related with the plume off La Gironde. The general circulation in the oceanic part was cyclonic, and eastward over the shelf. A retention area (anticyclonic) was clearly recognized in the inner part of the Bay of Biscay, in the Cap Breton area.

The distribution of the hauls (Figure 2.2.2.3.2.3) for the identification of echo traces and posterior allocation of acoustic energy to species (Figure 2.2.2.3.2.4) were evenly distributed. The nautical area scattering coefficient (s_A, m^2/nm^2) allocated to fish was positive in 26% of the total surveyed area used for the purpose of biomass estimation of pelagic fishes (8450 nm^2).

The fishing operations for the identification of echo traces and allocation of energy to species during the first leg of the cruise (the one used for estimation of biomass of the different species) localized in those areas where schools of different fish species were observed. 16 out of 37 hauls in this leg were positive in relation to anchovy (Figure 2.2.2.3.2.5).

Anchovy schools were observed close to the bottom was observed in 3 main areas (Figure 2.2.2.3.2.6): inner shelf off La Gironde, inner shelf of Arcachon and south of Cap Breton, representing respectively 7, 2 and 1% of the total sampled area. For these zones, the total estimated biomass was around 4000, 1500 and 200 T respectively. The Result of the estimation of abundance and biomass of anchovy is given in Table 4.2.2.3.2.2.

During the second leg of the cruise, devoted to get insights in the hydrodynamic / ecological processes that could be relevant for the recruitment process, it has been observed a series of hydrodynamic structures (i.e. retention area in the inner part of the shelf; changes for a downwelling to an upwelling regime in the Cantabric Sea from the first to the second leg of the cruise) that can be related to observed changes in the distribution of anchovy juveniles (details in the working document in the Annexe).

2.2.2.4.3 Comparison of anchovy juvenile survey results

Both surveys (JUVENA and PELACUS10) use acoustic techniques to estimate the abundance of juveniles in the Bay of Biscay in about the same period (with an average difference in time of 5 days) and covered roughly the same area (BoB). Also, both surveys use the same acoustic equipment, the same calibration methodologies, the same layer echo integration methodology for the biomass estimation and the same TS values for the main pelagic species (see the methods of both surveys in Sections 2.2.2.3.1 and 2.2.2.3.2). Nevertheless, the two surveys have several differences in the methodology and strategies: first, the Juvena survey put the effort in assuring the coverage of the potential area of juveniles, while the Pelacus10 survey concentrated the coverage in a smaller area and devoted part of the effective survey time to ecological studies concerning recruitment processes. In addition, different vessels were used by the two surveys (see Table 2.2.2.3.1.1 and Table 2.2.2.3.2.1) of different sizes and equipped with different fishing gears. In total 37 and 70 fishing hauls were achieved by JUVENA and PELACUS 10 surveys respectively, of which 16 and 54 positive for anchovy.

Both surveys were partially coordinated by means of periodical interchange of information during the coverage and the conduction of an intercalibration exercise in a common area (the surroundings of the Garonne river), surveyed in the same period by the vessels of both surveys in order to provide comparable data from both estimates.

The results from both anchovy juvenile surveys presented a difference of an order of magnitude in their absolute anchovy abundance estimates in the surveyed area, being the bigger estimate provided by the Juvena index (see Table 2.2.2.3.1.2 and Table 2.2.2.3.2.2). Part of this difference can be attributed to the different coverage of the region, by which JUVENA survey covered both shallow and offshore areas up to 47º 30'N (maximum Latitude), while PELACUS10 could not operate in the regions shallower than 30 meters and did not cover areas to the north of 46ºN. Nevertheless, even reducing the comparison to common areas, well surveyed by both cruises (South of 46ºN and deeper than 30 m), the main discrepancy in abundance estimates remained by a factor of 7 between the two estimates.

A preliminary analysis was performed on data from the intercallibration area agreed by both surveys. The result of this analysis suggests that the difference in the results can not be attributed to the malfunction of the equipments, or to methodological numerical calculations. The main identified candidate to have provoked these discrepancies is the allocation of energy to the different detected species (possibly caused by different fishing strategies used by both surveys or by the different catching capabilities of the fishing gears). Other possible candidate could be the delay between both surveys coverage, due to the potentially fast changes in the distribution of the population in this period, or different reaction of fishes to the vessel track.

In order to understand the differences found in this preliminary analysis, WGACEGGS recommends further analysis of the methodology and the allocation of energy to species by both survey methodologies. A workshop has been arranged by the different involved institutes to address this issue. The workshop will take place in the Ifremer Institute in Nantes during the last week of February of 2007, involving members of AZTI and IEO teams as well as Ifremer acoustic experts acting as external advisers. The results of this experience will be presented in the 2007 WGACEGGS meeting.

Currently, WGACEGGS recommends taking the acoustic biomass estimates of juveniles not as absolute biomass values, but as relative ones, valid only to point out the relative changes in juvenile abundance in the surveyed area between years. Therefore, the differences in absolute levels between the PELACUS and JUVENA anchovy juvenile cruises do not invalidate the temporal trend observed in the JUVENA time-series. Nevertheless, a careful intercalibration of vessels and fishing strategies, and the understanding of the differences observed in this year juvenile abundance indices should be achieved in the near future if a coordinated survey comparable with the JUVENA series is to be established.

2.2.3 Anchovy surveys in Area IX

2.2.3.1 Distribution and abundance of spawning population from egg production surveys

2.2.3.1.1 Egg distribution and estimates of egg production (CUFES + pairovet)

Since 2004 several surveys in Gulf of Cadiz have been carried out in June on-board RV "Cornide de Saavedra". The aim of these surveys has been to estimate the stock of anchovy by direct methods: acoustic and DEPM. In all cases the survey season were attempted to be coincident with the anchovy peak-spawning season in this area. During 2004 and 2006 two acoustic surveys were carried out (BOCADEVA-0604 and ECOCADIZ-0606) and in 2005 a DEPM survey (BOCADEVA-0605) (Jiménez *et al*., 2004, 2005; ICES, 2006a).

Eggs distribution. Review on CUFES results (2004–2006 period)

In all surveys above CUFES sampler (Continuous Underwater Fish Egg Sampler, Checkley *et al.,* 1997) was used. Surveyed area occupies from Trafalgar Cape to San Vicente Cape (ICES Subdivision IXa South, Gulf of Cadiz). Surveys design based in a systematic grid with the transect perpendicular to the coast (21 transects, 11 in Spanish waters and 10 in Portuguese waters) and evenly spaced at 8 nm. The surveys sampling scheme was semiadaptative, with the adaptative rule of enlarging the radials in case of anchovy eggs presence at the end of each transect, until finding two consecutive CUFES negative stations. The shallowest limit being established at 30 m depth in 2004 survey, as close to the coast as possible in 2005 and at 20 m depth 2006 surveys, while the offshore extension were decided adaptively (see working document presented in the WG).

In acoustic surveys sampling grid coincided with the one established for the acoustic sampling with both sampling carried out simultaneously and always in daylight. However in DEPM survey sampling was carried out during 24 h.

CUFES samples filtered water volume (about 600 l/min) was integrated each 3nm approximately. The CUFES collector was fitted with a 335 µm net. Samples from CUFES station were preserved in a 4% buffered formaldehyde solution and preliminary sorted and classified in 3 stages of development on-board (with the exception of 2004 survey) (ICES, 2005a). On the other hand the CUFES system had coupled a thermosalinometer (Sea-Bird SBE 21) that register temperature, salinity and fluorescence at 5 m depth continuously along the transects in 1-minute intervals, although not fluorescence records in 2004 survey.

In BOCADEVA-0604 survey (2004) in all, 99 CUFES stations were carried out along the whole study area. All the radials, with the exception of radials most eastern and closest to the Strait of Gibraltar, registered presence of anchovy eggs. The obtained results were: a total sampling surface area of 9345 km^2 and a total spawning area surface of 4952 km^2. In all, 14946 anchovy eggs were sampled. Most of the eggs were obtained in the coastal strip between Huelva and Cadiz.

In BOCADEVA-0605 (2005) in all, 101 CUFES stations were carried out. Positive stations for anchovy eggs were 45.9% (50 stations). In all, 2995 anchovy eggs were sampled. Total surveyed area was 12329 km^2. Finally in ECOCADIZ-0606 (2006) total surveyed area was 12329 km^2 and in all, 134 CUFES stations were carried out in this survey. In 91 stations were found anchovy eggs (68%). In all, 5723 anchovy eggs were sampled. A summary of results is shown in Table 2.2.3.1.1.1.

Figure 2.2.3.1.1.1 shows abundances spatial distribution of anchovy eggs by survey. The most anchovy egg abundant survey has been BOCADEVA-0604 (Figure 2.2.3.1.1.2), but Figure 2.2.3.1.1.3 shows that there was not significant differences between egg density median by survey.

Egg Production estimation

BOCADEVA-0605 is the first anchovy DEPM survey in the Gulf of Cadiz. The survey was carried out on-board RV “Cornide de Saavedra” from the 10–22 June 2005 coincident with the anchovy peak-spawning season in this area (ICES, 2006b). The specific Ichthyoplankton objectives were to obtain the spatial distribution of the eggs and to delimit the current extension of the anchovy spawning area, and to estimate the anchovy daily eggs production (P_0) of the Gulf of Cadiz. This estimation has been carried out using the statistical package “R” (see the WD presented in the WG).

PAIROVET samples have been made every 3 nm. The PAIROVET was equipped with nets of 150 µm of mesh size and flowmeters to estimate the volume of filtered water. Vertical hauls were carried out to a maximum of 100 m depth or to 5 m above the bottom in shallower depths. A profile CTD (Sea-Bird SBE 25) to determine temperature, salinity and fluorescence was carried out in each PAIROVET station. CTD profiles were performed to 100 m or 5 m above the bottom in shallower waters.

In all, 119 PAIROVET stations were carried out. Positive stations for anchovy eggs were 38 7% (46 stations). In all, 583 anchovy eggs were captured by PAIROVET, most of eggs (93%) taken in Spanish waters (Table 2.2.3.1.1.2). Figure 2.2.3.1.1.4 shows CALVET egg densities (egg/m^2) by station. A 94% of the total captured eggs were classified into 11 development stages (Moser and Ahlstrom, 1985). All stages were found in PAIROVET samples, except the stage XI. The most abundant stages were: II, III and IV (21.1, 26.2 y 18.9%) (Figure 2.2.3.1.1.5).

The first step to obtain a proper Daily Egg Production estimation makes reference to the areas that are analysed during the process: Sampling area, area corrected with the coast and definitive positive area. To estimate the sampling area limits is necessary to propose a resolution in pixels and to provide the minimum distance (in radius of a circumference) that represents each station. It was determined a resolution of 600 pixels and a distance (area of influence) of 9 miles for each station. Thereafter, to carry out the whole process with the same resolution, it decided to leave the resolution of 600 pixels: sampling area, coast correction and estimation of the positive area. The sampling area was 11712.87 km^2.

Apart from the delimitation of the survey area, was the delimitation and estimation of the positive area (area in which spawning occurs). To calculate the positive area, the part corresponding of the script was executed, with a resolution of 600 pixels, and an area of influence by station of 9 miles. Figure 2.2.3.1.1.6 represents the positive stations (= with eggs). In this map two clear differentiated areas can be observed. The stratum 1 it corresponds to Spanish waters and the stratum 2 it corresponds to Portuguese waters. The extension of these positive areas was: Stratum 2: 1351.15 km^2 and stratum 1: 4470.14 km^2.

Next step was to analyse available incubation models to obtain the pattern of embryonic development that better adjusted to our data. Since it doesn't have an incubation model for anchovy of the Gulf of Cadiz, the data of an incubation experiment carried out by AZTI for the anchovy of the Bay of Biscay were used. The applied models were: Lo, GAM y multinomial. After a preliminary discussion of the results obtained in this first analysis, it was determined that the best embryonic development model is the multinomial, since it is statistically the more correct, and it was assumed this way in the last WGACEGGS (ICES, 2006b).

Egg parameters estimated are shown in Table 2.2.3.1.1.3. The differences in the values obtained by stratum are clear. $P_{tota}l$ from stratum 1 is 108.09·e10 eggs/day, and 2.61·e10 from the stratum 2. In the stratum 2 the z estimated are positive, although de SSB estimated by DEPM is very similar to the acoustic estimation. It is maybe due to the low egg abundance encountered in this stratum.

2.2.3.1.2 Distribution and estimates of adult parameters

Adult anchovy samples for DEPM purpose were obtained from pelagic trawls (concurrently with the plankton survey) during 2005 anchovy DEPM survey in the Gulf of Cadiz on-board the RV "Cornide de Saavedra". Additionally adult samples were collected from the commercial purse-seiner. The description of the characteristics of the fishing stations, the sampling strategy adopted for the collection of adult samples and the protocols used in the histological processing of these samples has been previously described by Millán *et al*. (2005).

Preliminary results of mean female weight (W) and sex-ratio (R) were presented in the last working group but no batch fecundity (*F*) and spawning fraction (*S*) estimates since samples still were under histological processing and analysis. In WGACEEG 2006 has been present either revised or new estimates for the whole set of adult parameters from the 2005 anchovy DEPM survey (Millán *et al*., 2006).

For each of the adult parameters, mean and variance were estimated following the Picquelle and Stauffer's (1985) weighting procedure. Routines for the adult parameters estimation were developed under "*R*" environment by Miguel Bernal during an IEO internal *Workshop on the DEPM-based SSB estimation under "R" environment* held in June this year.

Batch fecundity (F). A spatial structure was clearly evidenced for the mature female mean weight and batch fecundity (Figure 2.2.3.1.2.1). In agreement with the spatial distribution of the daily egg production, a data post-stratification in two geographic strata was considered and tested for all the adult parameters. The limit of separation of these two different strata was established at the meridian 7º30' W, which in some extent split the whole study area in the Spanish (stratum 1) and Portuguese waters (stratum 2). The suitability of this post-stratification for the whole individual data set of this parameter was tested by considering 4 nested GLM models to check the differences between strata in the gonad-free weight and batch fecundity relationships (Table 2.2.3.1.2.1). The analysis confirmed that a post-stratification was necessary since significant differences between the two stratum were found (ANOVA**,** α=0.01) (Table 2.2.3.1.2.2; Figure 2.2.3.1.2.2).

This model was formulated as follows:

$$F = -2234.96 + 881.26 * Wnov_{S1} + 680.44 * Wnov_{S2}$$

The batch fecundity estimates, *F*, in each stratum were:

Stratum 1: F_{S1}=11470 eggs/batch (CV= 0.05)

Stratum 2: F_{S2}=13808 eggs/batch (CV= 0.03)

Spawning fraction (S): The distribution of anchovy gonad stages among the spawning females during the period 14: 00–02: 00 GTM on based to data from 2004 and 2005 surveys (Figure 2.2.3.1.2.3) showed that the daily spawning duration of anchovy in the study area extends from 16: 00 to 21: 00 GMT (6 hours). The percentage of female in spawning (recent POFs and hydrated plus POFs females) increased from 60% to 100% in the range time between 20: 00 and 22: 00 GMT. Therefore, we may assume that the peak spawning time is about 21: 00 GMT.

POFs degeneration rates in the study area are unknown and POFs had to be assigned to stages-ages according to the traditional method (Motos, 1996), although considering as the peak spawning time the species-specific one in the study area.

The stratified estimates of the spawning fraction, *S*, were:

Stratum 1:S_{S1}= 0.210 (CV= 0.08)

Stratum 2: S_{S2}= 0.226 (CV= 0.11)

Mean female weight (W)*:* Total weight of hydrated females was corrected for the increase of weight due to hydration. Data on gonad-free-weight (Wnov) and corresponding total weight (Wt) of non-hydrated females from the surveys were related by a linear regression model:

$$Wt = -0.2136 + 1.0774\ Wnov\quad R^2 = 0.99$$

The mean weight estimates, *W*, were:

Stratum 1: W_{S1} = 16.54 g (CV= 0.04)

Stratum 2: W_{S2} = 25.19 g (CV= 0.03)

Sex ratio (R)*:* was estimated as the percentage (in weight) of females in the mature population. The overall sex ratio by stratum was:

Stratum 1: R_{S1}= 0.537 (CV= 0.01)

Stratum 2: R_{S2}= 0.532 (CV= 0.01)

2.2.3.1.3 Spatial distribution and biomass estimates of the target species

During the analysis processes in order to estimate both anchovy eggs and adults parameters, some differences were detected (*BOCADEVA-0605* DEPM survey). In eggs, spatial distribution of abundance and parameters were very different between Algarve and Spanish South Atlantic Region (Spanish waters of the Gulf of Cadiz). In adults parameters, the mean weight of female and the batch fecundity were different too (Millan *et al*., 2006). For this reason, it decided to estimate the anchovy spawning-stock biomass in the Gulf of Cadiz (2005) for two strata independently. The stratum 1, correspond with Spanish waters, and stratum 2 correspond to Portuguese waters.

Routines for the adults and eggs parameters estimation were developed under "R" by Miguel Bernal during a DEPM workshop organized by IEO and celebrated last June. Routine for the SSB final estimation has been finished during this WG. The obtained results are shows below:

- Anchovy SSB (Stratum 1, Spanish waters) = 13821.85 tons
- Anchovy SSB (Stratum 2, Portuguese waters) = 396.77 tons
- Anchovy total SSB in the Gulf of Cadiz = 14218 62 tons

2.2.3.2 Distribution and abundance of spawning population from acoustic surveys

Results from the most recent surveys carried out both by Portugal in November 2005 and April 2006 (*SAR05NOV*, *SAR06ABR*) and by Spain in June 2006 (*ECOCÁDIZ 0606*) in waters from the ICES Division IXa have been previously reported this year to the WGMHSA (Marques and Morais, 2006; Ramos *et al*., 2006) besides to this WG. It must be reminded that the Portuguese surveys acoustically sample the Atlantic-Iberian continental shelf waters of its EEZ and those ones belonging to the Spanish Gulf of Cadiz with the RV "Noruega", whereas the Spanish survey, carried out on-board RV "Cornide de Saavedra", restricts its sampling area to only the Portuguese Algarve and Spanish Gulf of Cadiz waters (i.e. ICES Subdivision IXa South). Regarding their objectives, the Portuguese surveys are mainly aimed at the mapping of the spatial distribution of sardine and anchovy, and the provision of acoustic estimates of abundance and biomass for both species by length class and age groups (for the time being only for sardine). Although the main objective of the Spanish survey is the mapping and the size-based and age-structured acoustic assessment of the anchovy SSB, and hence the survey 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. In any case, the progressive inclusion of alternative (continuous and discrete) samplers for collecting ancillary information on the physical and biological environment are shaping these surveys as true "pelagic ecosystem surveys".

As for the surveys herein described, the bad weather during the Portuguese November 2005 survey prevented from acoustically surveying the Cadiz area (in all, 60 transects were surveyed). Both in the Portuguese April- and Spanish June 2006 surveys all the planned acoustic tracks were performed (69 in the Portuguese survey, 21 in the Spanish one). The surveys were carried out following the methodologies reported in the last WG.

2.2.3.2.1 Distribution of acoustic energy allocated to anchovy

November 2005 Portuguese survey (SAR05NOV)

The scarcity of anchovy during this survey (the species was only present in 1 trawl haul) and the fact of the Gulf of Cadiz (area where the species used to be concentrated) was not acoustically sampled were the causes that prevented from mapping the acoustic energy allocated to the species as well as to provide any acoustic estimate.

April 2006 Portuguese survey (SAR06ABR)

Anchovy was exclusively concentrated between Faro and Cape Trafalgar being absent in the Portuguese West coast (Figure 2.2.3.2.1.1). As usual, the main concentrations were found in the Spanish waters of the Gulf of Cadiz, in depths ranging between 40 and 100 meters. In the last two transects of this area (near Cape Trafalgar) no anchovies schools were detected.

June 2006 Spanish survey (ECOCÁDIZ 0606)

Anchovy in this survey showed a broader distribution in the Subdivision IXa South than the one described from the Portuguese survey conducted two months before. So, the species was mainly distributed in the Spanish waters off the Gulf, with the highest densities occurring in the central part of the sampled area, mainly between 20 and 50 m depth, although an isolated nucleus of high density at 130 m depth in front of the Huelva coast was also observed. In the Portuguese waters the species was restricted to the westernmost shelf although showing very low densities, and being completely absent between Cape Santa Maria and Tavira, a situation that was not observed in the previous Portuguese survey (Figure 2.2.3.2.1.2).

2.2.3.2.2 Species composition and length/age composition

November 2005 Portuguese survey (SAR05NOV)

In all, 29 trawl hauls (23 pelagic trawls, 6 bottom trawls) and 1 commercial purse-seine haul were performed during the November 2005 Portuguese survey. From this total of fishing stations 27 (21 pelagic, 6 bottom) were considered as valid ones (Figure 2.2.3.2.2.1). Sardine *Sardina pilchardus* was present in 20 trawl hauls, being predominant in the fishing stations performed in the Portuguese Central-North subarea (OCN). In the remaining surveyed area species like horse mackerel (*Trachurus trachurus*), chub mackerel (*Scomber japonicus*) and bogue (*Boops boops*) were dominant in the catches. As noted above, anchovy was only present in 1 trawl haul. By this reason and because the Cadiz area was not covered during this survey it was not performed any abundance estimate for anchovy.

April 2006 Portuguese survey (SAR06ABR)

Thirty six fishing stations (25 pelagic trawls, 11 bottom trawls) were considered as valid ones from in all, 40 trawl hauls during the April 2006 Portuguese survey and sardine was present in 32 of them (Figure 2.2.3.2.2.2). As usual, sardine was the dominant species in the West Coast, between Caminha and Cape Espichel. In the remaining Portuguese coast sardine was usually captured together with other pelagic species such as horse mackerel, chub mackerel and bogue. Anchovy was present in 8 trawl hauls, all located between Faro and Cape Trafalgar.

Anchovy length compositions obtained from Algarve and Cadiz presented some similarities. Both areas presented a unimodal length distribution (modal length: 12.5 cm – Algarve; 11 cm – Cadiz) and a similar range (10.5–16 cm—Algarve; 9.5–16 cm—Cadiz), (Figure 2.2.3.2.2.3). However, Algarve presented a higher number of larger individuals. In this area anchovies with lengths between 12 and 13.5 cm represented 78% of the total number estimated.

June 2006 Spanish survey (ECOCÁDIZ 0606)

Thirty seven valid fishing stations performed with a pelagic trawl from in all, 39 fishing operations were conducted during the June 2006 Spanish survey. From the total of valid fishing stations, three fishing stations were carried out by night as a part of an exercise of *in situ* determination of the anchovy target strength, TS (see Section 6.2.1), and they were excluded from the final set of 34 fishing stations used for the acoustic assessment (Figure 2.2.3.2.2.4). Even so, the total number of valid fishing stations was substantially greater than the one recorded in 2004 (13 hauls). Moreover, an additional improvement with respect to the 2004 acoustic survey was the increase of the acoustic sampling coverage of the coastal waters of the study area by extending the shallowest limit to the 20 m isobath, as it is routinely designed in both Portuguese and Spanish acoustic surveys surveying the Atlantic Iberian waters, instead of the 30 m isobath.

From the total of captured species stood especially out sardine (present in 28 from 34 hauls) and chub mackerel (27 hauls), followed by anchovy and bogue, (23 hauls), the blue jack mackerel, *Trachurus picturatus* (21 hauls), and mackerel, *Scomber scombrus* (18 hauls). Total catch and catch rate (per hour of effective trawling) per haul, both in numbers, showed that: anchovy was dominant in the hauls performed in the Spanish waters, sardine was more evenly distributed through the study area, Chub mackerel was almost exclusively present in the Portuguese waters, and mackerel and horse mackerel were very scarce in the hauls. On the other hand, it was noteworthy the greater relative importance of the "others species" category in the valid hauls conducted in the Portuguese waters. An inspection of the species composition of this category in such hauls revealed that the blue jack mackerel was the most important species within this species mixing.

Size- and age-based estimates confirmed the east-west increasing size (-age) gradient described in previous years, with the largest (and oldest) anchovies being more abundant in the westernmost limit of their distribution, and the main recruitment area located in the shallow waters close to the Guadalquivir river. So, anchovy size in the Portuguese waters ranged between the 10.5 and 18 cm size classes (mode at 13.5 cm, mean length at 14.09 cm). In the Spanish waters the size range oscillated between the 8 and 17.5 cm size classes (mode at 12 cm, mean length at 12.02 cm), with anchovies smaller than 12 cm accounting for 50.7% of the estimated abundance in this region (Figure 2.2.3.2.2.5). As for ages are concerned, 71.5% of the estimated total of older anchovies (2+ age group) occurred in the Spanish waters. Nonetheless, from these older anchovies, the oldest ones (3 year olds) were captured to the west of Cape Santa Maria (Table 2.2.3.2.2.1).

2.2.3.2.3 Spatial distribution and biomass estimates of the target species

November 2005 Portuguese survey (SAR05NOV)

No anchovy acoustic assessment is available from this survey because of the reasons given in previous subsections.

April 2006 Portuguese survey (SAR06ABR)

The total biomass estimated was 24.1 thousand tonnes (2246 million fish), which is near the average value for entire time-series (26.2 thousand tonnes) (Table 2.2.3.2.3.1). Like in previous years the area with the highest anchovy abundance was the Spanish Gulf of Cadiz (1928 million fish), representing 81% (19.6 thousand tonnes) of the total estimated biomass. As previously referred, the Portuguese coast presented some differences concerning to the last surveys. No anchovy schools were found in the coast in front of Lisbon and the abundance estimates for Algarve were the highest of the time-series (319 million fish, 4.5 thousand tonnes).

June 2006 Spanish survey (ECOCÁDIZ 0606)

The total biomass estimated for anchovy in Subdivision IXa South was 27.8 thousand tonnes (2487 million fish), Spanish waters accounting for the 95.8% and 93.4% of the total abundance and biomass, respectively (2384 million fish, 25.9 thousand tonnes), (Table 2.2.3.2.3.2). The historic peak in the abundance and biomass estimates recorded for the Algarve anchovy in the April Portuguese survey (and coming from a relatively small area, between Faro and the Spanish border) was not corresponded with the estimates resulting from the Spanish survey (103 million fish, 1.8 thousand tonnes), despite in this last survey the species showed a broader distribution in this subregion.

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 Subdivision IXa South only (Spanish surveys) are shown in Tables 2.2.3.2.3.1 and 2.2.3.2.3.2.

The estimates from those surveys covering the whole southernmost subdivision show through the series that the bulk (about or higher than 90% of both the total abundance and biomass) or even the whole of the anchovy population is concentrated in the Spanish waters of the Gulf of

Cadiz. A broader species distribution along the subdivision, as may be inferred from the availability of estimates for both Algarve and Gulf of Cadiz areas, are only recorded in some surveys (in boldfaced red in the two tables). The differences found both in the survey season and in the magnitude of the resulting estimates suggest that such increases in the occupied area by the species should be driven by other factors than seasonal and/or density-dependence related ones (Ramos *et al*., 2005).

For comparative purposes, Figure 2.2.3.2.3.1 shows the available series of anchovy acoustic estimates from Subdivision IXa South obtained in Portuguese surveys together with the estimates from the 2004 and 2006 spring Spanish surveys (coloured estimates in the tables above). The depicted data series show several gaps which makes difficult to follow any clear trend, mainly in the last years. Biomass estimates from 1998 to 2003 in this Subdivision have oscillated between 21 and 34 thousand tonnes; however, available estimates in 2004 and 2005 have decreased down to 13–14 thousand tonnes, evidencing a possible decline in the population levels. However, the picture of an alarming decreasing trend just in 2004–2005 was warned in the last year's WGMHSA and WGACEGG that it should be initially considered with caution for several causes. First, the estimates themselves in such years seemed to be affected by problems related either to the sampling coverage of shallow waters (2004 Spanish survey, Ramos *et al*., 2004; ICES, 2006b) or to the echo traces discrimination between fish and plankton (2005 Portuguese survey, Marques *et al.*, 2005; ICES, 2006b). Second, the survey season for the Spanish surveys (mid to late June) 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. Notwithstanding the above, the 2005 and 2006 Portuguese survey seasons were coincident and their estimates, therefore, comparable, and they indicate an evident recovered population in 2006 up to a level close to the average estimate in the (Portuguese) historical series. The close similarity between the 2006 estimates from the Portuguese and Spanish surveys reinforces the above statement on a population recovery this year in the subdivision.

Table 2.2.2.1.1.1. P_0, z and P_{tot} estimates fitting a Non linear regression model and a GLM.

	1-BAYESIAN + N LINEAR		2-BAYESIAN + GLM	
	Value	**CV**	**Value**	**CV**
P_0	4.3265	0.17	4.8927	0.10
Z	0.266	0.40	0.2602	0.20
Ptot	1.065.E+12	0.17	1.204.E+12	0.10

Table 2.2.2.1.2.1. DEPM 2006 estimates of the adult parameters and SSB in the total area with correspondent Standard error (S.e.) and coefficient of variation (CV).

PARAMETER	ESTIMATE	S.E.	CV
DEP	1.06E+12	1.78E+11	0.1674
R'	0.54	0.0073	0.0136
S	0.26	0.0150	0.0572
F	9046.24	1054	0.1165
Wf	25.46	2.0832	0.0818
DF	50.14	-	0.0910
BIOMASA	21 436	4084	0.1905

Table 2.2.2.1.3.1. SSB 2006 estimates and the correspondent standard error (S.e.) and coefficient of variation (CV) of the proportion by age (Pa) and numbers-at-age estimates (N age).

PARAMETER	ESTIMATE	S.E.	CV
BIOMASS	21 436	4084	0.1905
Wt	18.17	2.20	0.1209
POPULATION	1204	303	0.2513
Pa 1	0.82	0.0466	0.0567
Pa 2	0.14	0.0362	0.2677
Pa 3	0.04	0.0116	0.2697
Nage 1	998	290	0.2907
Nage 2	157	38	0.2414
Nage 3	50	12	0.2377

Table 2.2.2.2.2.1. Biomass assessments for sardine and anchovy by strata from PELGAS06 survey.

	STRATA	AREA	SARDINE (T)	*CV*	ANCHOVY (T)	*CV*
Adour	1	599	25 094	*0.28*	7 241	*0.28*
Large sud	2	2194	1 610	*0.23*	401	*0.23*
Gironde côte	3	2233	51 228	*0.14*	13 380	*0.14*
Fer à cheval	4	1244	7 149	*0.47*	865	*0.47*
Loire côte	5	1968	96 841	*0.22*	198	*0.22*
Plateau	6	6497	134	*0.31*		
Accores nord	7	2470	53	*0.32*		
Surface – Adour	8	2169	94		799	
Surface - Fer à cheval	9	3511	15 098	*0.36*	7 664	*0.36*
Surface – Nord	10	6725	31 182			
Total			**228 483**		**30 549**	

Table 2.2.2.3.1.1. Dimensions of the two vessels and installed equipment on-board.

	FV "Itsas Lagunak"	RV "Emma Bardán"
Length (m)	33	29
Width (m)	8	7.5
Draught (m)	4.2	3.5
Echosounder	Simrad EY60, 38 y 120 kHz	Simrad EK60, 38, 120 y 200 kHz
Sonar	Furuno CH37	Simrad SH40
	Purse-seine	pelagic (15 m vertical opening)
Fishing gear	dimensiones: (350 x 80 m)	Otter boards: Polyice Apollo
	mesh: 4 mm side	mesh: 4 mm side
Hydrography	CTD, EDAS	CTD
Plankton	150 um	Pairovet (150 um), MIK (1000 um)

Table 2.2.2.3.1.2: Synthesis of the abundance estimation (acoustic index of biomass) for the four years of surveys.

Year	Region	<Sa>	Area	<size>_juv	<size>_adul	Biom_juv	Biom_adul	Biom_TOTAL
2003	South	368.60	3302.80	8.20		97 498.50	0.00	97 498.50
	North	444.40	172.50	11.10	14.10	1103.00	1383.50	2486.50
	TOTAL		3475.30			98 601.50	1383.50	99 985.00
2004	South	0.90	47.00	6.00		1.90	0.00	1.90
	North	562.20	1859.90	11.00	13.80	2404.10	3451.00	5855.10
	TOTAL		1906.90			2406.00	3451.00	5857.00
2005	South	721.67	5390.05	6.64		125 922.30	0.00	125 922.30
	North	326.00	2399.93	9.83	11.91	8208.80	20 369.80	28 578.60
	TOTAL		7789.98			134 131.10	20 369.80	154 500.90
2006	South	366.05	1200.49	7.21	11.46	19 893.33	175.73	20 069.06
	North	390.65	5862.65	11.25	12.41	52 265.24	56 903.64	109 168.88
	TOTAL		7063.14			72 158.57	57 079.38	129 237.95

Table 2.2.2.3.2.1. Characteristics and equipment of the RV "Thalassa".

CHARACTERISTICS	DIMENSIONS / EQUIPMENTS
Year of construction	1996
Length (m)	73.65
Width (m)	14.90
Draught (m)	6.10
Maximum speed (knots)	14.6
Speed during acoustic exploration (knots)	9–10
Speed during trawl (knots)	3–4
Echosounder	Simrad ER 60 - 18/38/70/120/200 kHz
Omnidireccional sonar	Simrad SR 240–24 kHz
Net sonde	OSSIAN 500 12/49 kHz - Micrel
Pelagic trawl	Pelagic 72/76 (30 m vertical opening, 120 m between otter boards) and 57/52 (20 m vertical opening, 100 m between otter boards). Otter boards Thyboron. Mesh size (extended), 20 mm.
Positioning system	PACHA 2000–16 kHz - Thomson
Minimum depth for pelagic trawl operation	30 m in hard bottom areas; 25 m in soft bottom areas.
Thermosalinograph	SBE 21–Seabird
Fluorometer in continuum	Turner
Meteorological station on-board	MILOS 500 - Väisälä

Table 2.2.2.3.2.2. Estimated abundance (x10^6 inds.) and biomass (T) of the evaluated species.

SPECIES	ABUNDANCE (x10^6 INDS.)	BIOMASS (T)
Sardina pilchardus	139	7736
Engraulis encrasicolus	**1284**	**6140**
Scomber scombrus	40	10749
Scomber japonicus	74	16580
Trachurus trachurus	370	37861
Trachurus mediterraneus	77	19415
Trachurus picturatus	11	0.019
Boops boops	12	0.305
Micromesistus potassou	463	5173

Table 2.2.2.3.2.3. Estimated abundance (x10^6 inds.) and biomass (T) of the evaluated species in the inner shelf off La Gironde estuary (between 30 and 100 m depth; and 45º 20' – 45º 40' N).

SPECIES	ABUNDANCE (X10^6 INDS)	BIOMASS (T)
Sardina pilchardus	45.46	1062
Engraulis encrasicolus	**266.29**	**1543**
Scomber scombrus	0.20	0.040
Scomber japonicus	0.20	0.053
Trachurus trachurus	17.80	0.703
Trachurus mediterraneus	0.48	0.117

Table 2.2.3.1.1.1. Summary table by survey (CUFES sampling).

SURVEY	YEAR	METHOD	SURVEYED AREA (KM^2)	N. TRANSECTS	N. STATIONS	POSITIVE STATIONS
BOCADEVA-0604	2004	Acoustic	9345	21	99	53
BOCADEVA-0605	2005	DEPM	12329	21	101	50
ECOCADIZ-0606	2006	Acoustic	12329	21	128	91

Table 2.2.3.1.1.2. Total anchovy eggs sampled by stratum, radial and development stage (PAIROVET).

Area	Radial	Development stages											No clasificates	Total eggs
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI		
Spanish waters	1	0	0	0	0	0	0	0	0	0	0	0	1	1
	2	1	0	1	0	0	0	1	0	1	0	0	0	4
	3	0	1	1	4	0	2	2	4	0	5	0	12	31
	4	0	13	0	0	0	0	4	0	0	0	0	3	20
	5	0	65	114	46	0	2	4	29	21	7	0	6	294
	6	0	5	9	12	0	2	0	0	1	18	0	3	50
	7	1	19	1	0	8	5	0	0	0	0	0	3	37
	8	0	0	1	32	8	0	0	0	3	8	0	2	54
	9	1	0	2	6	11	0	0	0	2	7	0	1	30
	10	0	2	11	0	1	0	0	0	0	0	0	0	14
	11	0	1	3	0	0	1	0	0	1	0	0	0	6
Portugueses waters	12	0	0	0	0	0	0	0	0	0	0	0	0	0
	13	0	0	0	0	0	0	0	0	0	0	0	1	1
	14	0	0	0	0	0	0	0	0	0	0	0	1	1
	15	0	0	0	0	0	0	0	2	0	0	0	0	2
	16	3	0	0	3	0	0	0	0	0	6	0	2	14
	17	1	0	0	0	0	6	0	0	0	0	0	0	7
	18	0	9	0	0	0	0	1	4	1	0	0	2	17
	19	0	0	0	0	0	0	0	0	0	0	0	0	0
	20	0	0	0	0	0	0	0	0	0	0	0	0	0
	21	0	0	0	0	0	0	0	0	0	0	0	0	0
												Total	37	583

Table 2.2.3.1.1.3. Anchovy of the Gulf of Cadiz. Egg parameters.

PARAMETERS	ESTRATUM 1 (SPANISH WATERS)	ESTRATUM 2 (PORTUGUESE WATERS)
Po (eggs/m^2/day)	241.8	19.3
P_{total} (eggs/day)	108.09 E+10	2.61 E+10
Z (day^{-1})	-0.04	0.006

Table 2.2.3.1.2.1. Nested Analysis of Variance Table for selecting the GLM model expressing the functional dependence between batch fecundity and gonad-free weight.

```
Model 1: Fobs ~ -1 + Stratum + Wnov:Stratum
Model 2: Fobs ~ Wnov:Stratum
Model 3: Fobs ~ -1 + Wnov:Stratum
Model 4: Fobs ~ -1 + Wnov
 Res.Df RSS Df Sum of Sq F Pr(>F)
1 266 644974394
2 267 646442089 -1 -1467695 0.6053 0.437252
3 268 669232854 -1 -22790765 9.3994 0.002394 **
4 269 803650457 -1 -134417603 55.4364 1.346e-12 ***
---
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Table 2.2.3.1.2.2. ANOVA table for GLM 2.

```
Call:
glm(formula = Fobs ~ Wnov:Stratum, data = adults.dat, weights = 1/sqrt(Wnov),
 na.action = "na.omit")
Deviance Residuals:
 Min 1Q Median 3Q Max
-4061.75 -1034.18 -23.32 1041.50 4370.79
Coefficients:
 Estimate Std. Error t value Pr(>|t|)
(Intercept) -2234.96 728.45 -3.068 0.00238 **
Wnov:Stratum1 881.26 42.19 20.886 < 2e-16 ***
Wnov:Stratum2 680.44 30.62 22.222 < 2e-16 ***
---
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
(Dispersion parameter for gaussian family taken to be 2421131)
 Null deviance: 1907760248 on 269 degrees of freedom
Residual deviance: 646442089 on 267 degrees of freedom
AIC: 5134.1
Number of Fisher Scoring iterations: 2
```

Table 2.2.3.2.2.1. Anchovy in Subdivision IXa South: estimated abundance (thousands of individuals) and biomass (tonnes) by age groups in the June 2006 Spanish acoustic survey.

AGE CLASS	ALGARVE	CÁDIZ	TOTAL
	Number	**Number**	**Number**
0	0	0	0
I	93597	2359828	2453424
II	9562	24235	33797
III	91	0	91
TOTAL	**103250**	**2384062**	**2487313**
Age class	**ALGARVE**	**CÁDIZ**	**TOTAL**
	Weight	**Weight**	**Weight**
0	0	0	0
I	1609	25400	27010
II	231	524	755
III	4	0	4
TOTAL	**1844**	**25924**	**27769**

Table 2.2.3.2.3.1. Anchovy estimated abundance (millions) and biomass (tonnes) in Division IXa from Portuguese acoustic surveys by area and total. Regional and total estimates for the Subdivision IXa South on coloured background. Red bolded cells correspond to surveys covering the whole Subdivision with estimates from each of the regions in the Subdivision.

SAR Series		Portugal				Spain	IXa South	TOTAL
Survey	Estimate	Central-North	Central-South	South (Algarve)	Total	South (Cadiz)		
Nov. 1998	Number	30	122	**50**	203	**2346**	**2396**	2549
	Biomass	313	1951	**603**	2867	**30092**	**30695**	32959
March 1999	Number	22	15	*	37	**2079**	**2079**	2116
	Biomass	190	406	*	596	**24763**	**24763**	25359
Nov. 2000	Number	4	20	*	23	**4970**	**4970**	4994
	Biomass	98	241	*	339	**33909**	**33909**	34248
March 2001	Number	25	13	**285**	324	**2415**	**2700**	2738
	Biomass	281	87	**2561**	2929	**22352**	**24913**	25281
Nov. 2001	Number	35	94	-	129	**3322**	**3322**	3451
	Biomass	1028	2276	-	3304	**25578**	**25578**	28882
March 2002	Number	22	156	**92**	270	**3731 ****	**3823 ****	4001 **
	Biomass	472	1070	**1706**	3248	**19629 ****	**21335 ****	22877 **
Feb. 2003	Number	0	14	*	14	**2314**	**2314**	2328
	Biomass	0	112	*	112	**24565**	**24565**	24677
April 2005	Number	0	59	**0**	59	**1306**	**1306**	1364
	Biomass	0	1062	**0**	1062	**14041**	**14041**	15103
April 2006	Number	0	0	**319**	319	**1928**	**2246**	2246
	Biomass	0	0	**4490**	4490	**19592**	**24082**	24082

*** Due to the distribution observed during the survey, the last transect (near the border with Spain) that normally belongs to the Algarve subarea was included in Cadiz.** Corrected estimates after detection of errors in the S_A values attributed to the Cadiz area (Marques and Morais, 2003).**

Table 2.2.3.2.3.2. Anchovy estimated abundance (millions) and biomass (tonnes) in Subdivision IXa South from Spanish acoustic surveys by area and total.

Spanish Surveys	Estimate	Portugal: South (Algarve)	Spain: South (Cadiz)	TOTAL IXa South	Sampling grid	Sampled depth range
June 1993	Number	-	462	-	Zig-zag	20–500 m
	Biomass	-	6569	-		
Feb. 2002*	Number	-	18202	-	Parallel	20–200 m
	Biomass	-	212935	-		
June 2004**	Number	91	804	894	Parallel	30–200 m
	Biomass	1793	11376	13168		
June 2006	Number	103	2384	2487	Parallel	20–200 m
	Biomass	1844	25924	27769		

* Estimates should not be considered because problems found with the performance of the echosounder transductor.

** Possible underestimation due to the shallow waters between 20 and 30 m depth were not acoustically sampled.

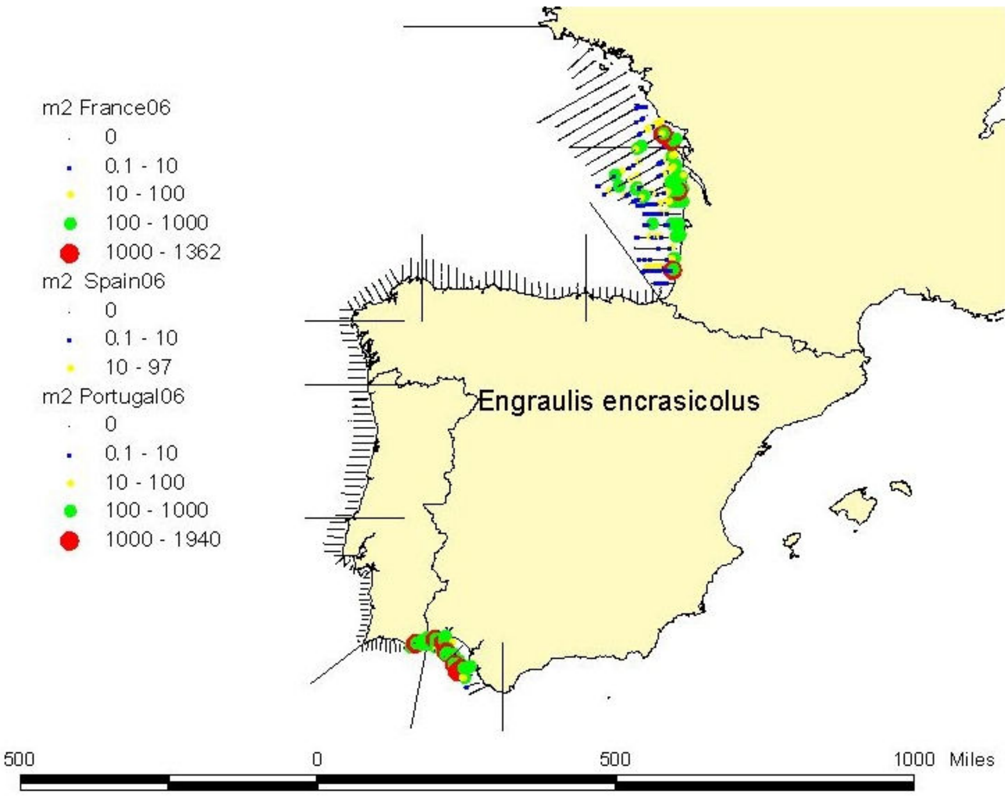


Figure 2.2.1.1. Acoustic energy in s_A (m^2/mn^2, Nautical Area Scattering Coefficient: NASC) attributed to anchovy (*Engraulis encrasicolus*). Data comes from the acoustic surveys carried out in spring in this area (Portugal, Spain and France).

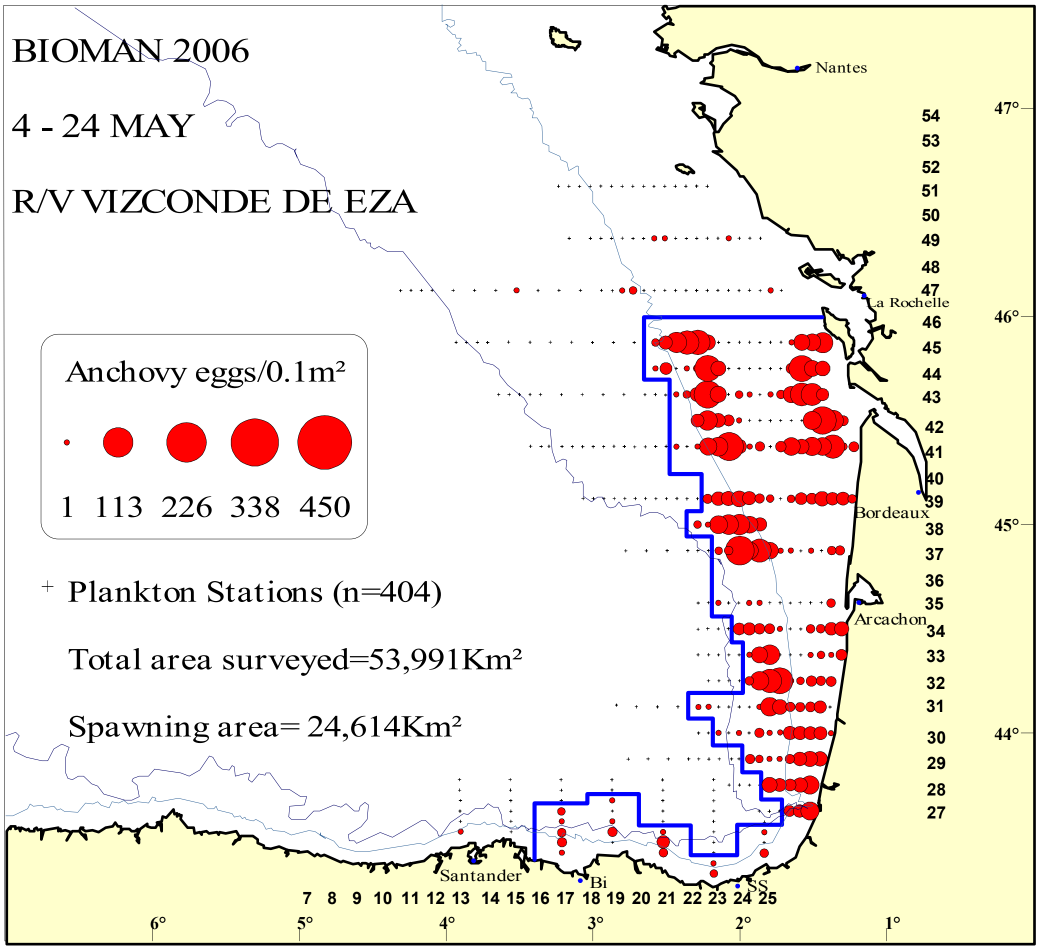


Figure 2.2.2.1.1.1. Anchovy eggs distribution and abundance (egg/0.1 m^2) found during the DEPM survey BIOMAN 2006. Solid line encloses the positive spawning area.

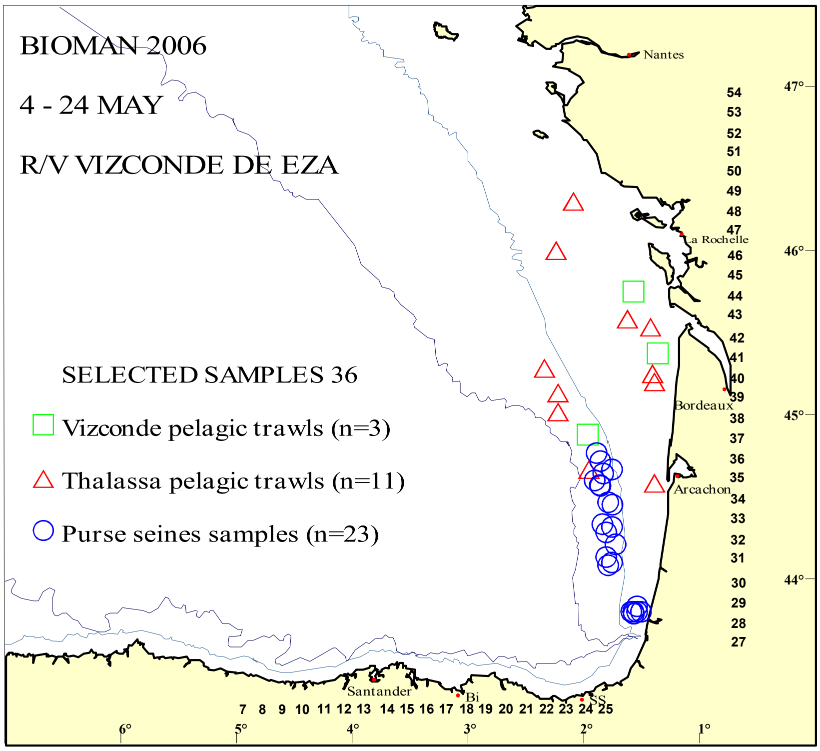


Figure 2.2.2.1.2.1. anchovy adult samples selected for the S estimates.

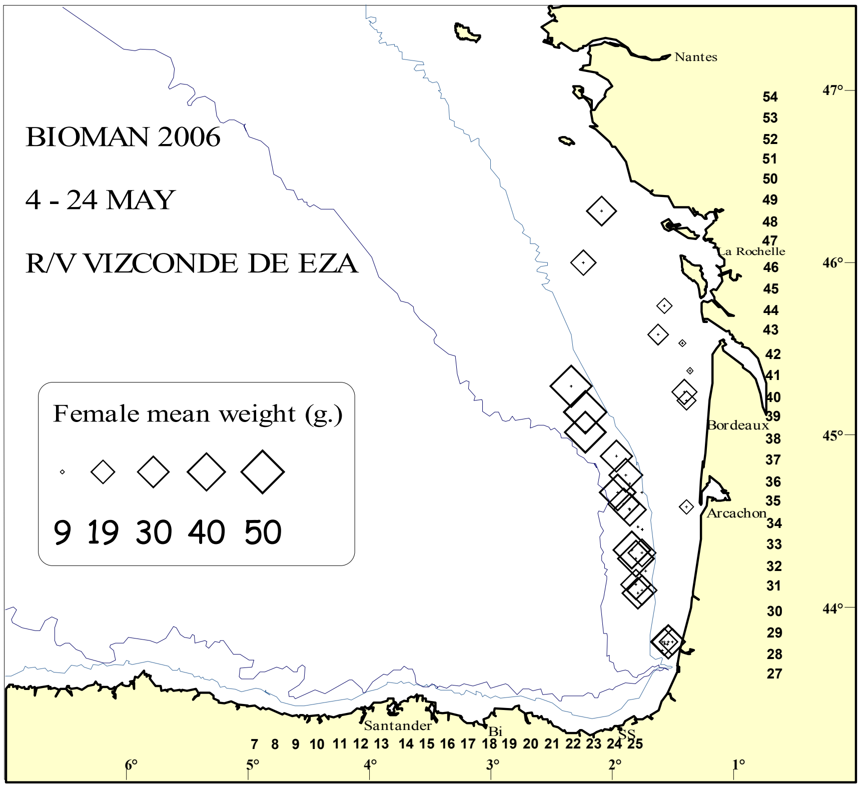


Figure 2.2.2.1.2.2. Spatial distribution of females mean weight (g) per haul from selected samples.

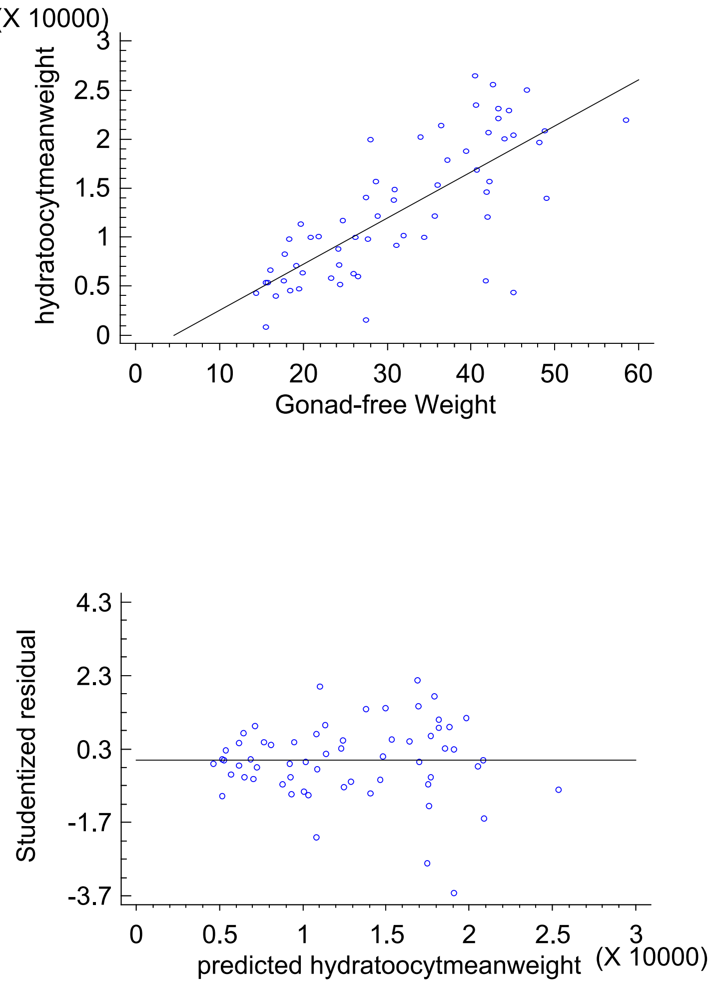


Figure 2.2.2.1.2.3. Plot of linear regression model of hydrated oocytes vs. gonad-free weight, and residuals.

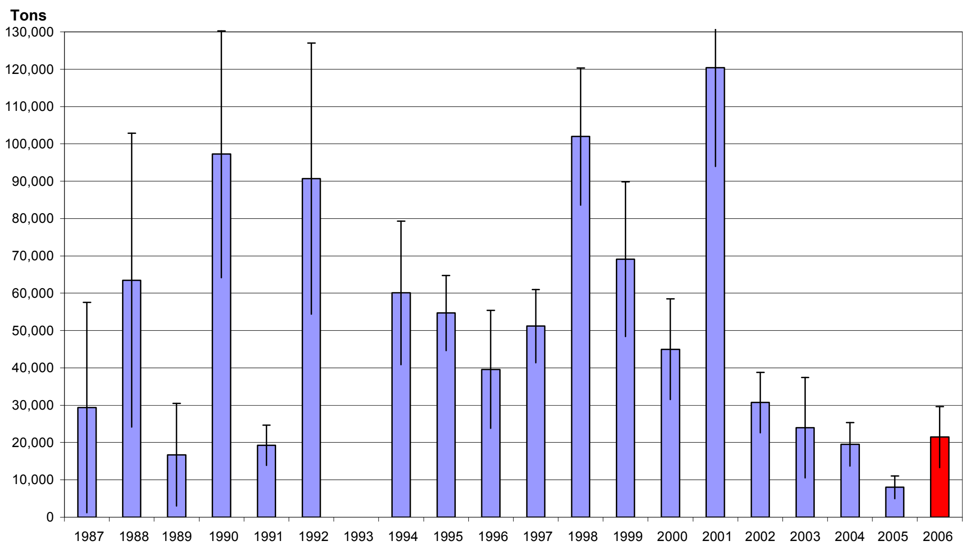


Figure 2.2.2.1.3.1. Series of Spawning-stock biomass estimates (tonnes) obtained from the DEPM surveys since 1987. Most of them are full DEPM estimates, except in 1996, 1999 and 2000, which were deduced indirectly.

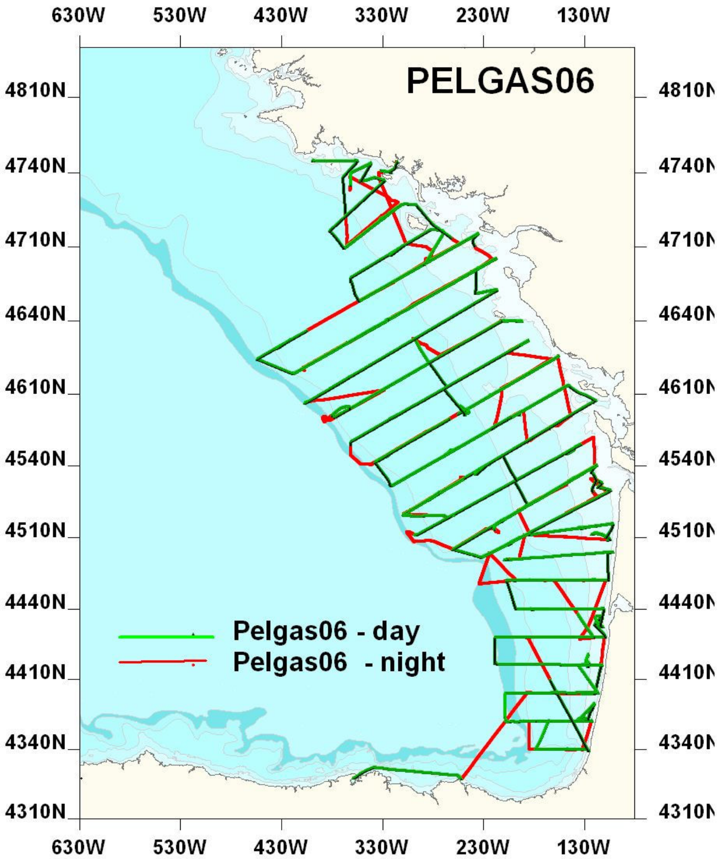


Figure 2.2.2.2.1.1. Transects prospected during PELGAS06 (day in green and night in red).

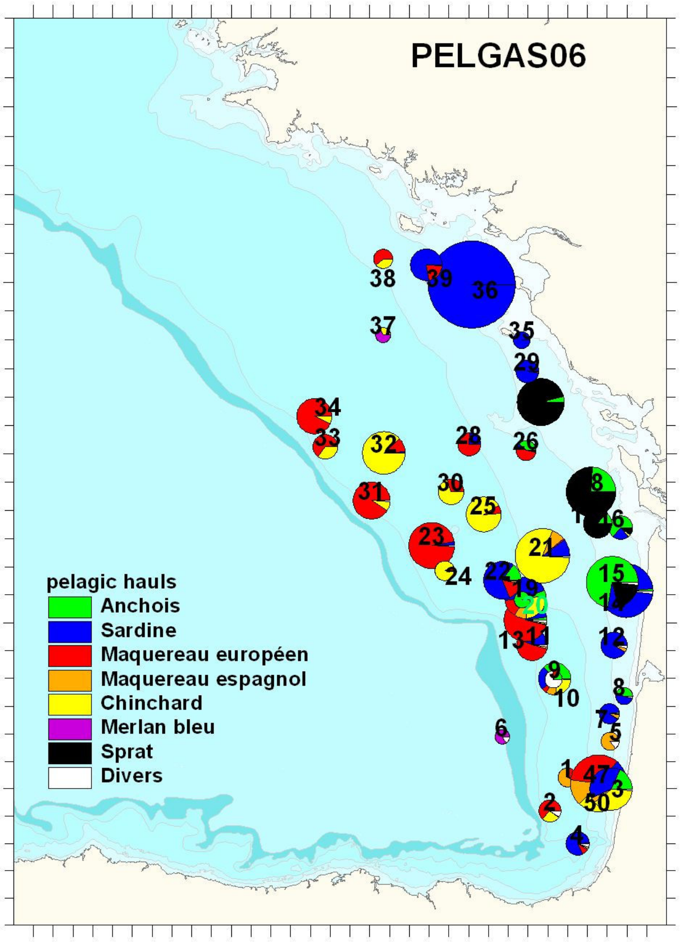


Figure 2.2.2.2.1.2. Species distribution according to identification hauls.

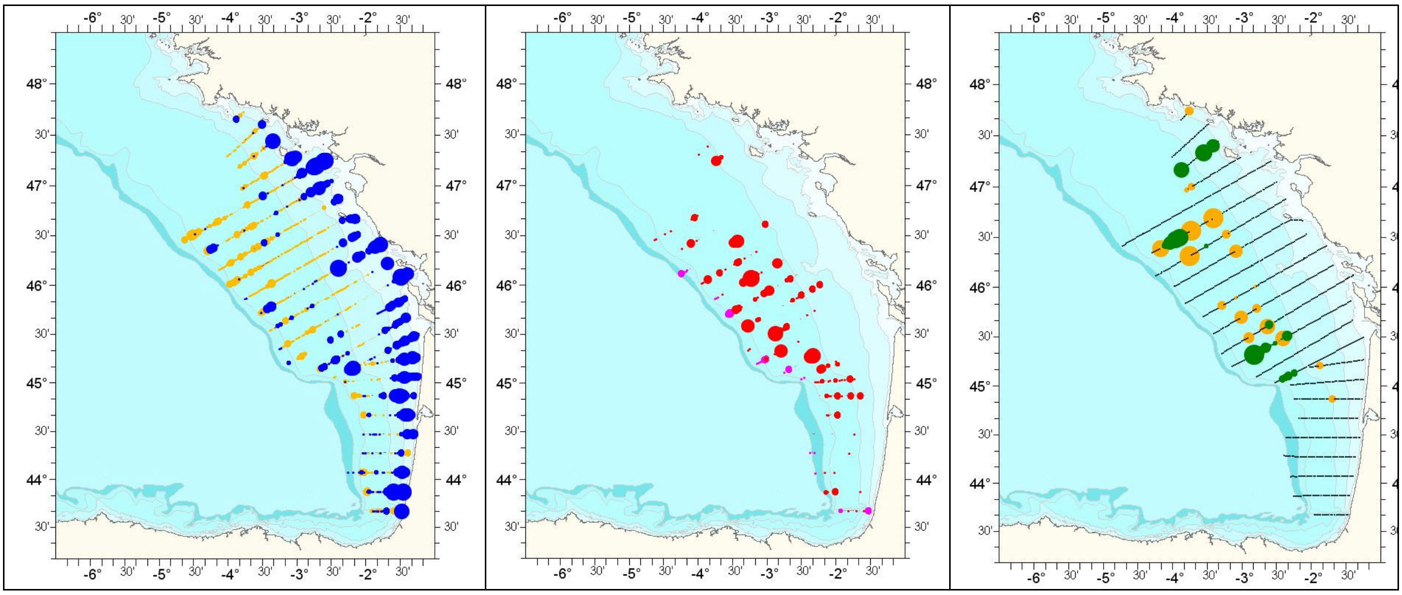


Figure 2.2.2.2.1.3. Distribution of energies according to echo types. From the left to the right: D1 (yellow) and D2 (blue), D3 (pink) and D4 (red), D5 (orange) and D6 (green).

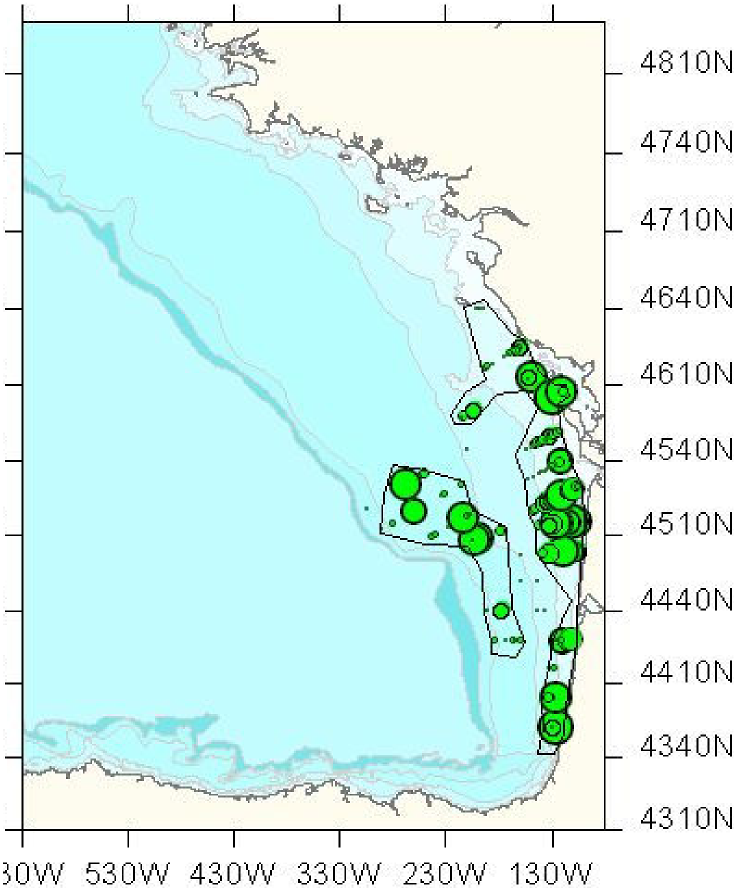


Figure 2.2.2.2.2.1. Anchovy biomass per Esdu as processed after PELGAS06.

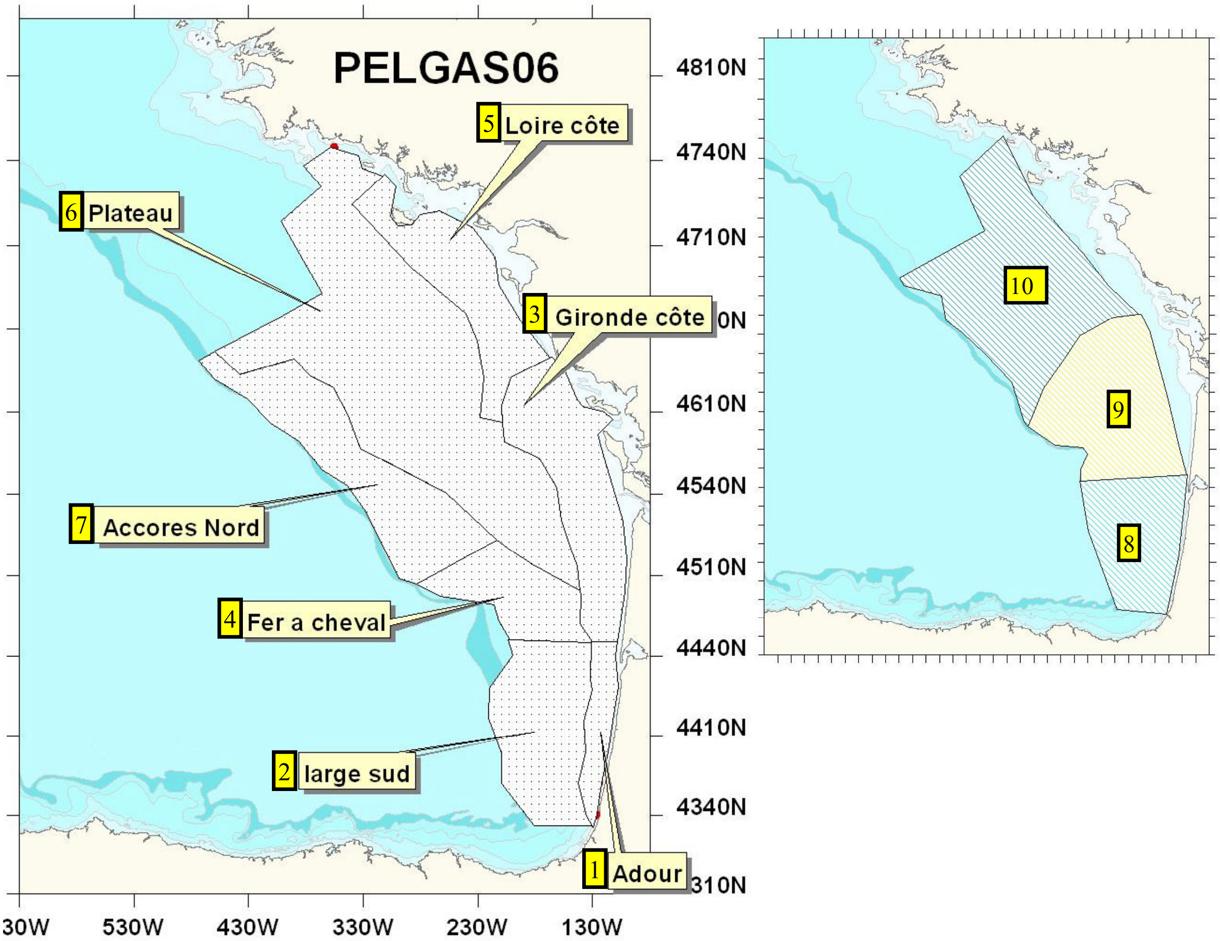


Figure 2.2.2.2.2.2. Strata considered according to echo types D1, D2, D3, D5 and D6 (left) and to surface echoes – D4 (right).

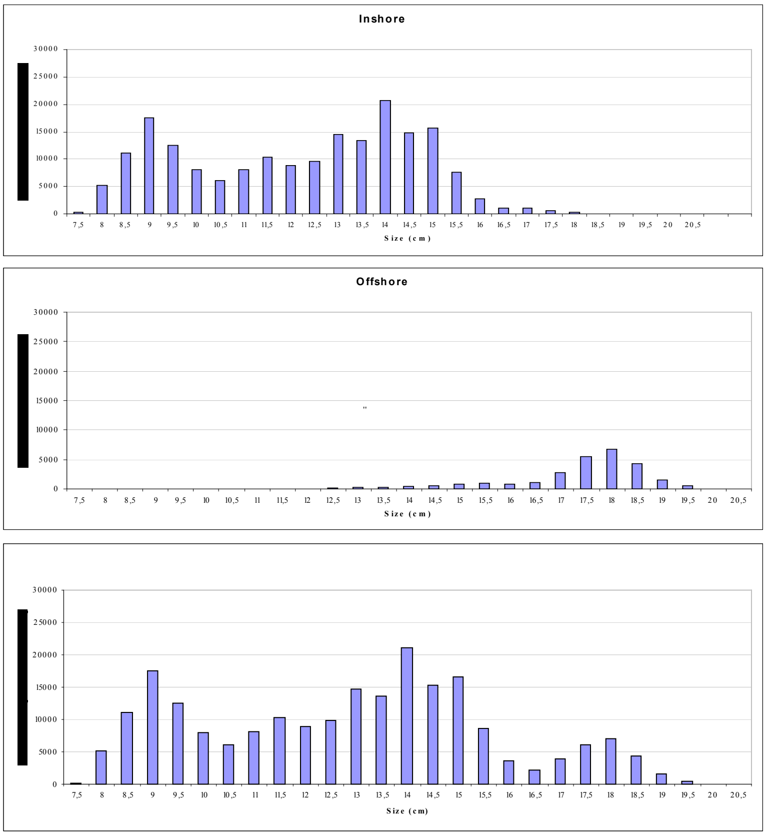


Figure 2.2.2.2.3.1. Anchovy length distributions during PELGAS06.

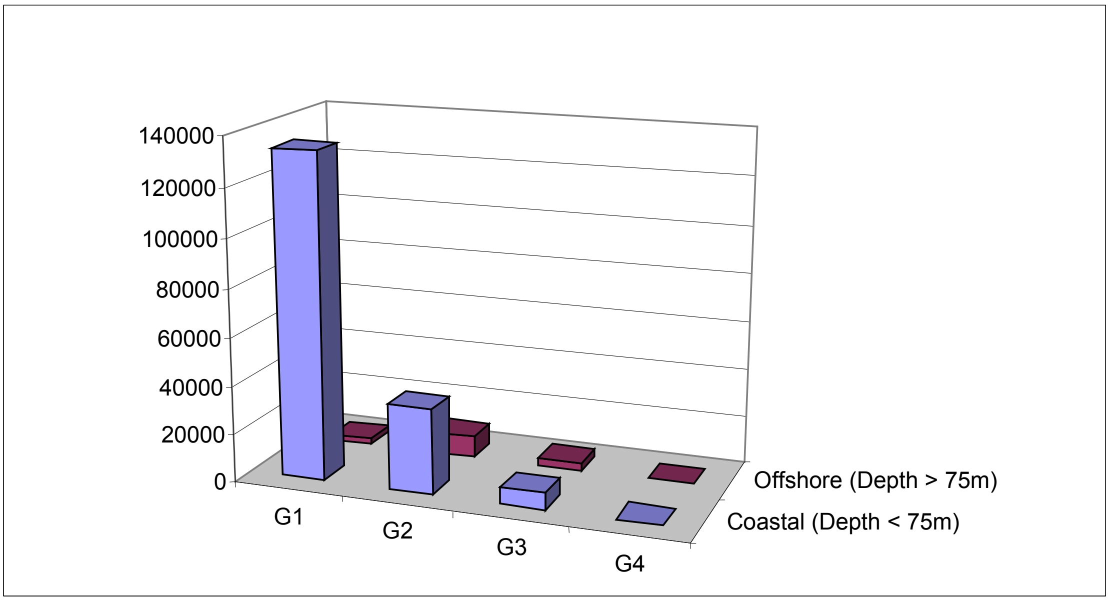


Figure 2.2.2.2.3.2. Anchovy age distributions (in relative numbers of fish – cumulative numbers per nm² along the transects) during PELGAS06 according to the coastal and offshore areas.

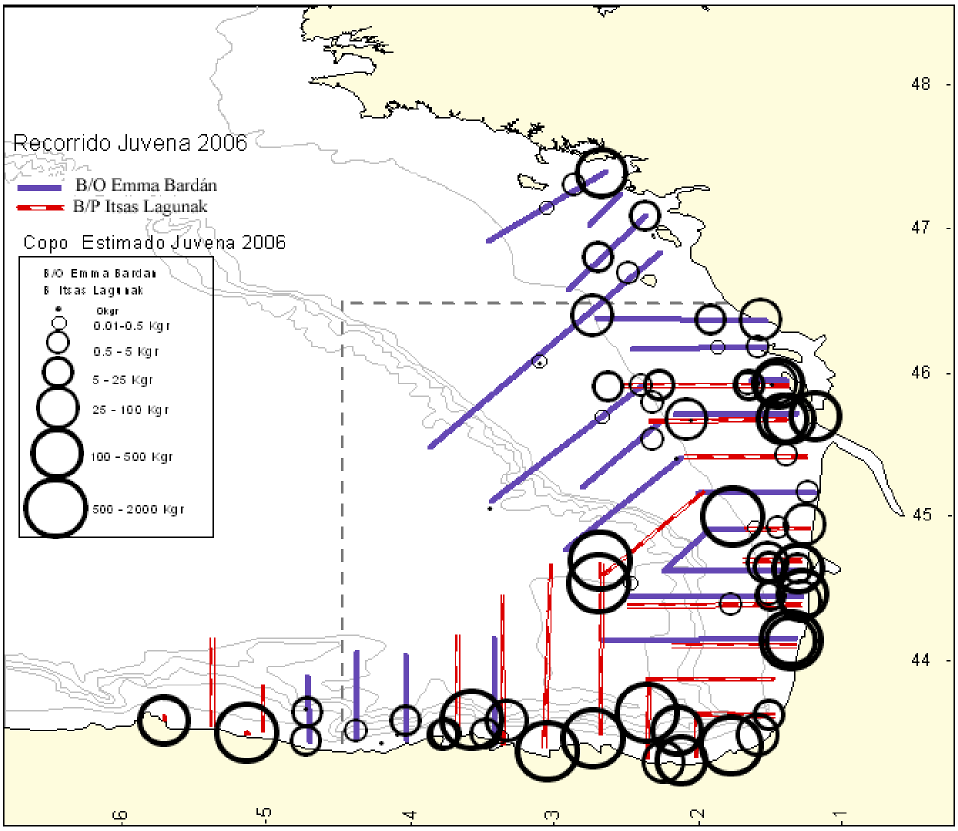


Figure 2.2.2.3.1.1. JUVENA 2006 actual transects, along with the estimated weight of the hauls. The minimum foreseen coverage is delimited by the dashed line.

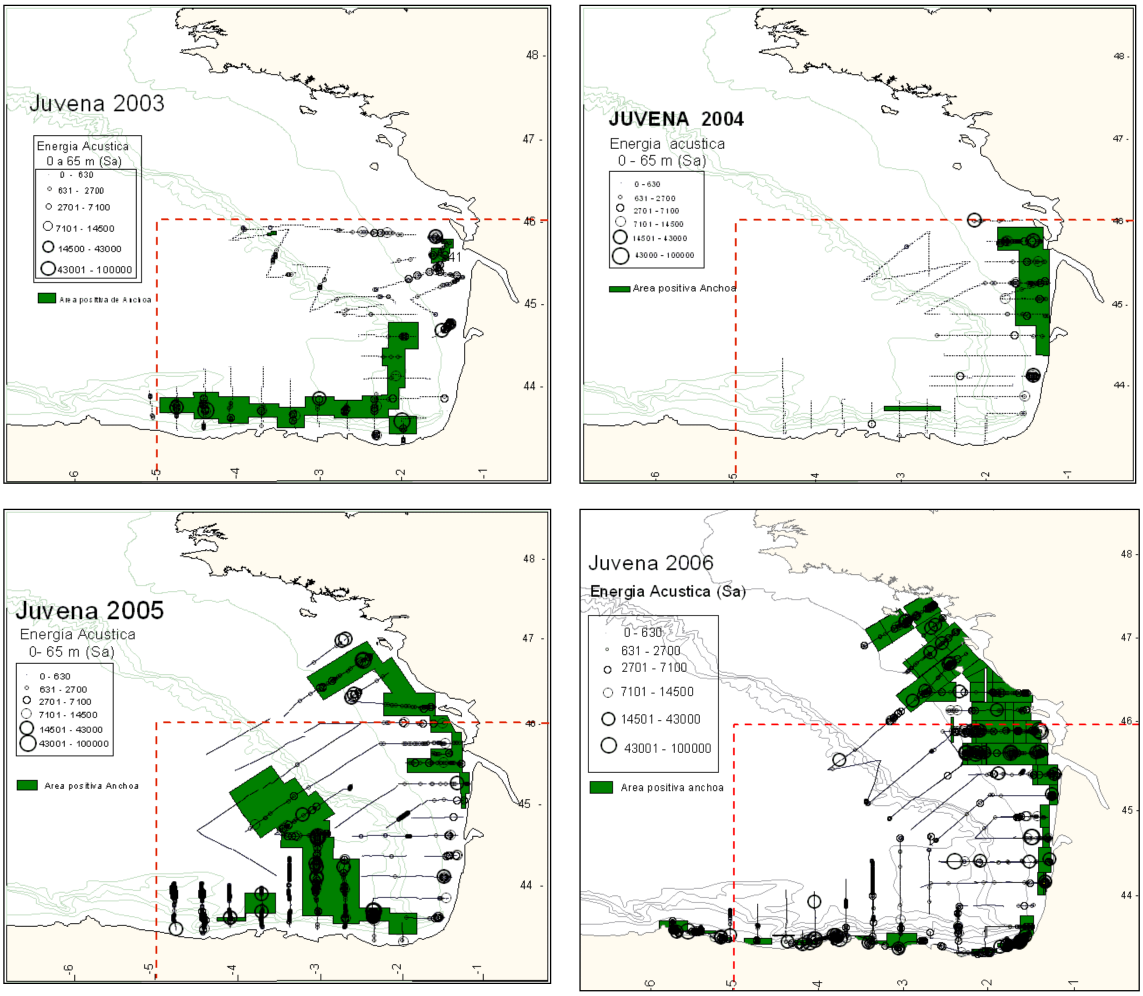


Figure 2.2.2.3.1.2. Positive area of presence of anchovy and total acoustic energy echo-integrated from 5 to 65 m depth (from all the species) in the JUVENA cruises. The area delimited by the dashed line is the standard area for inter annual comparison.

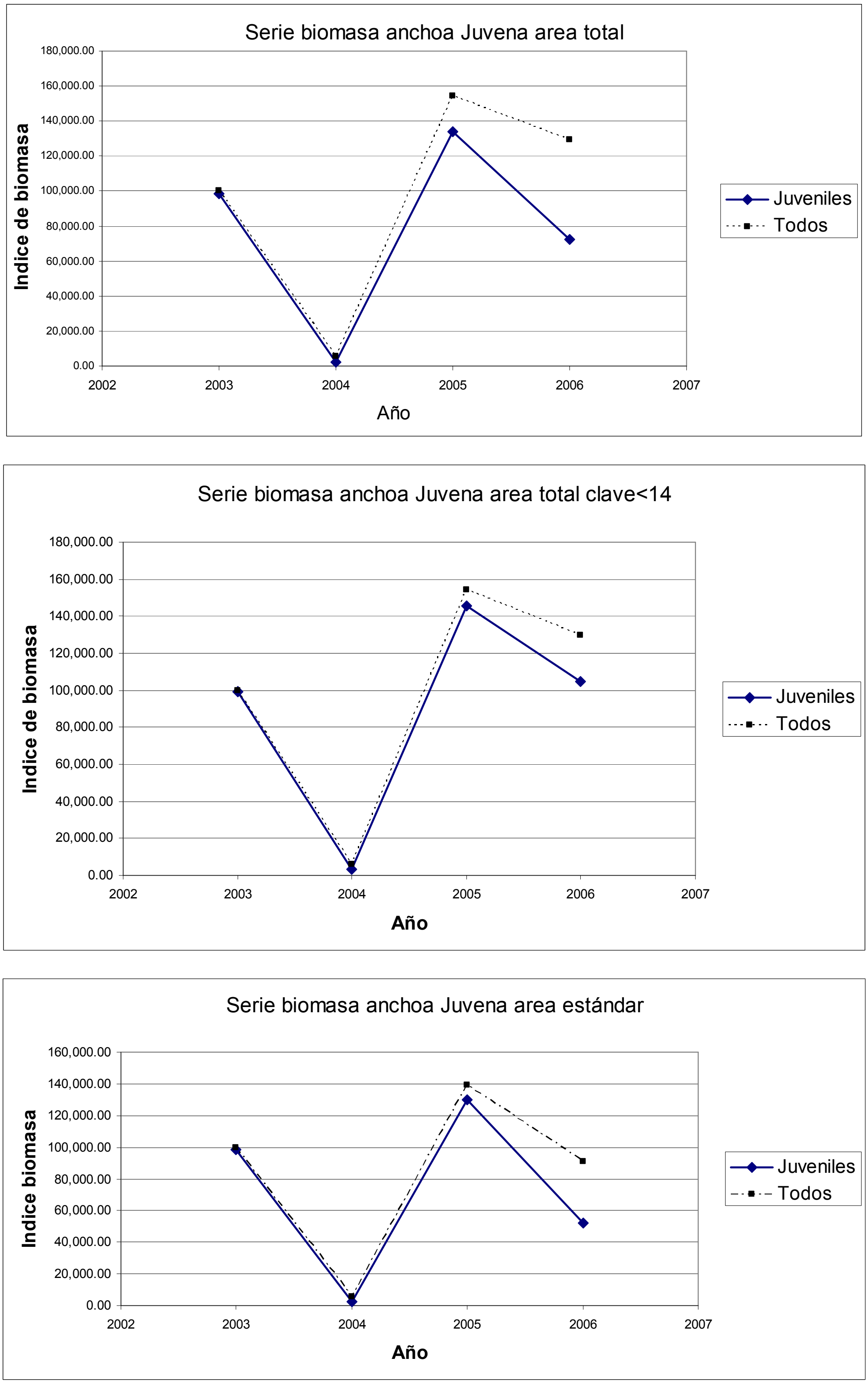


Figure 2.2.2.3.1.3. Temporal series of the estimated abundances for anchovy juveniles (continuous line) and juveniles plus adults (dashed line). Top panel: abundances obtained every year in the total sampling area. Center panel: abundances obtained with the key<14. Bottom panel: abundances obtained inside the Standard area.

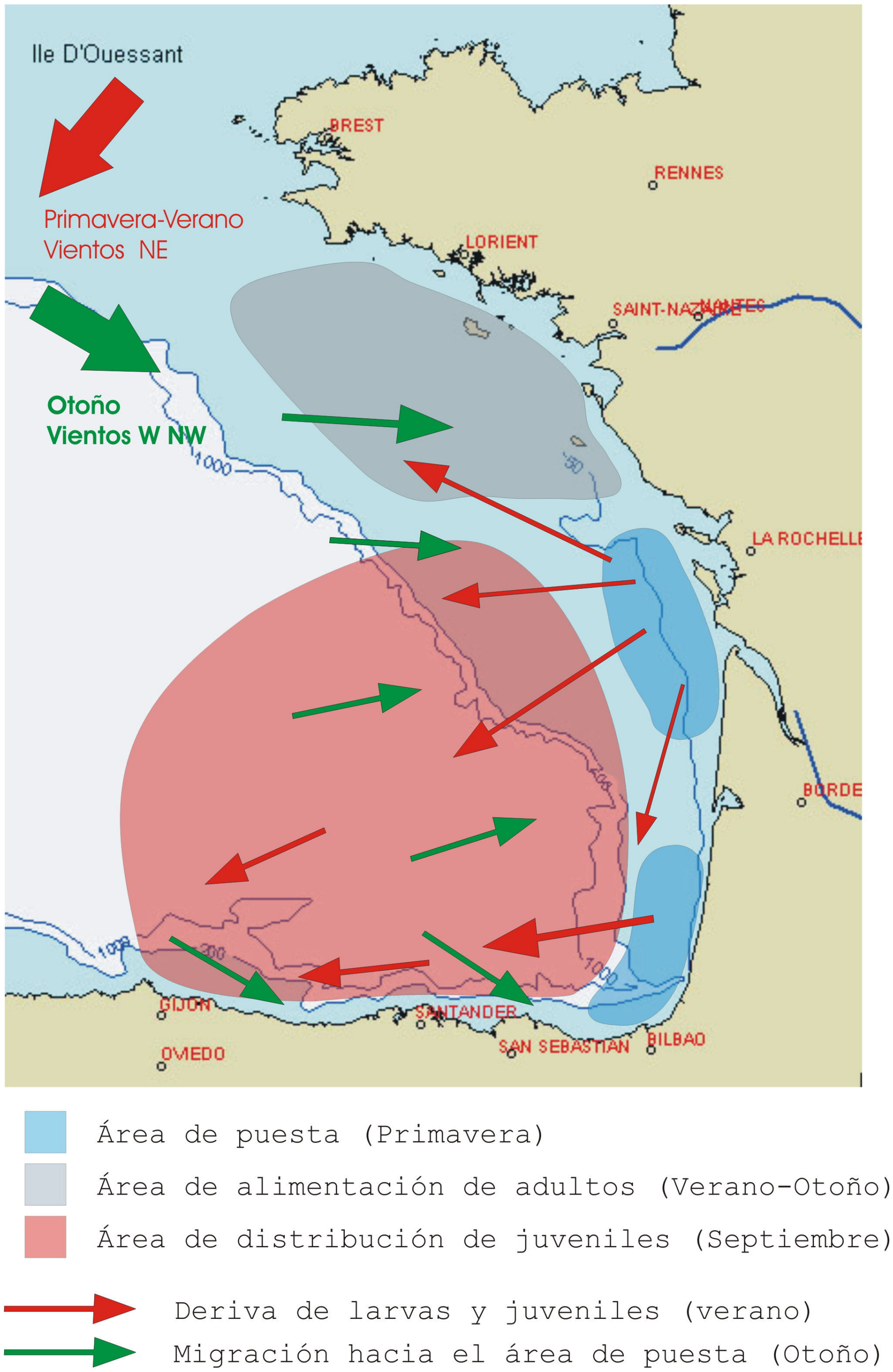


Figure 2.2.2.3.2.1. Scheme of spatial pattern of anchovy recruitment in the Bay of Biscay (re-drawn from Figure 19 of Uriarte *et al.* 2001 and Figure 13 of the ICES Report of SGRSESP 2004).

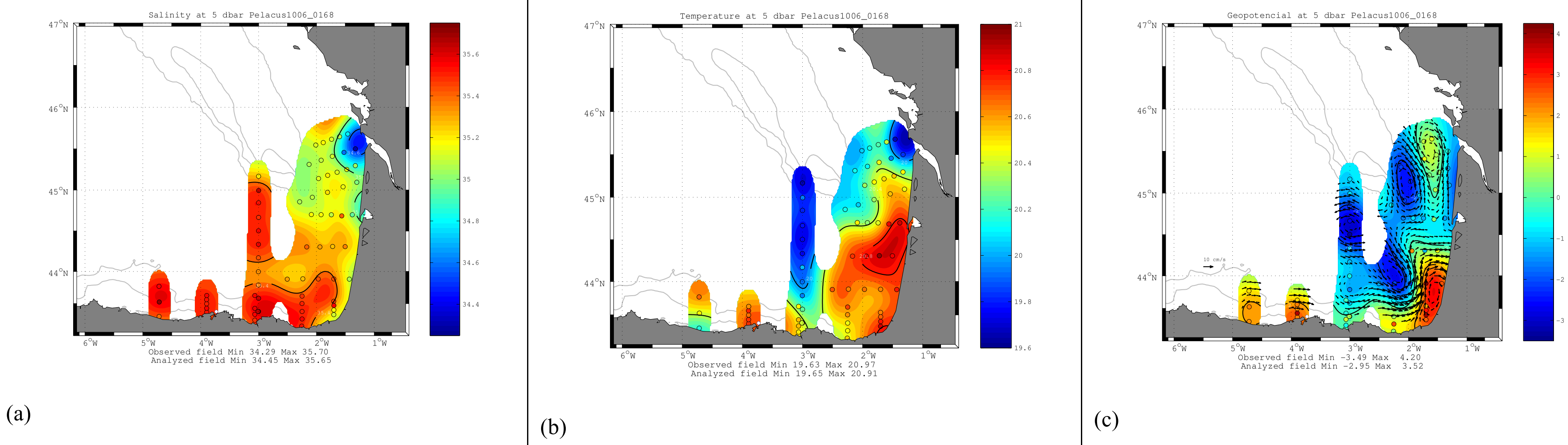


Figure 2.2.2.3.2.2. PELACUS1006; Salinity (a), temperature (ºC) (b) and sea surface height anomaly (cm) and estimated geostrophic currents (cm/s) (c) in the surveyed area.

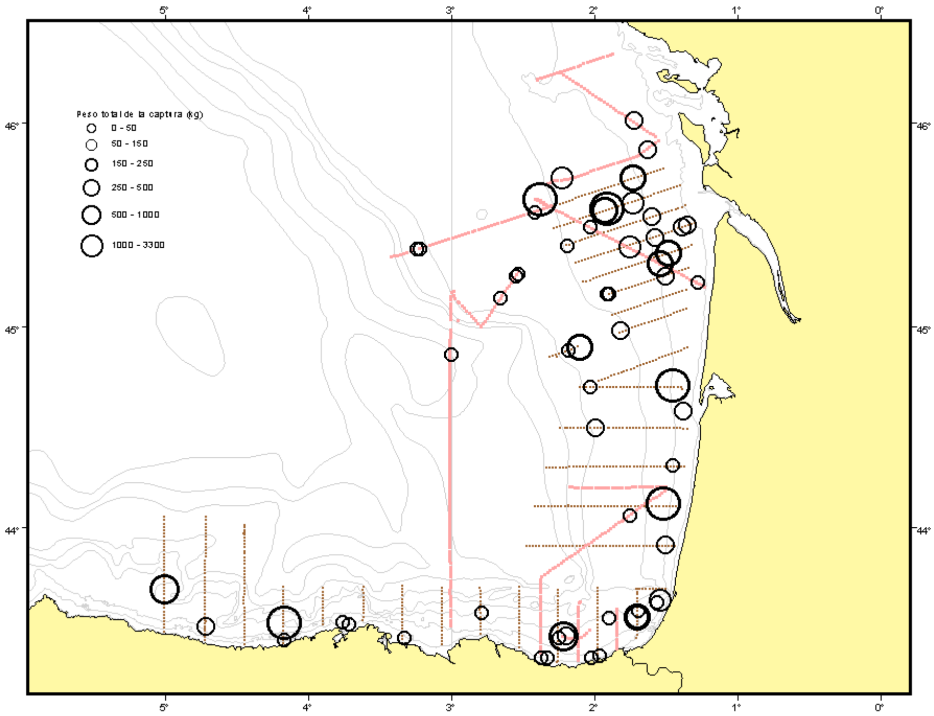


Figure 2.2.2.3.2.3. PELACUS1006; Position and total weight (kg) of the hauls from the pelagic trawls carried out during the survey.

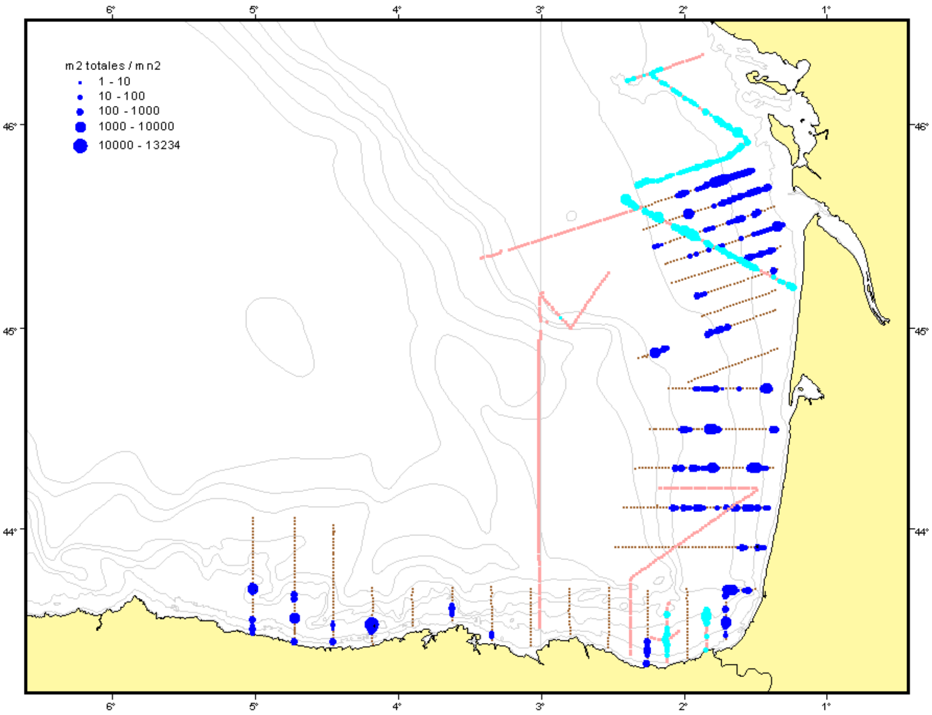


Figure 2.2.2.3.2.4. PELACUS1006; Total acoustic energy –coefficient of dispersion by square nautical mile (m^2 / mn^2) in the first and second legs of the cruise.

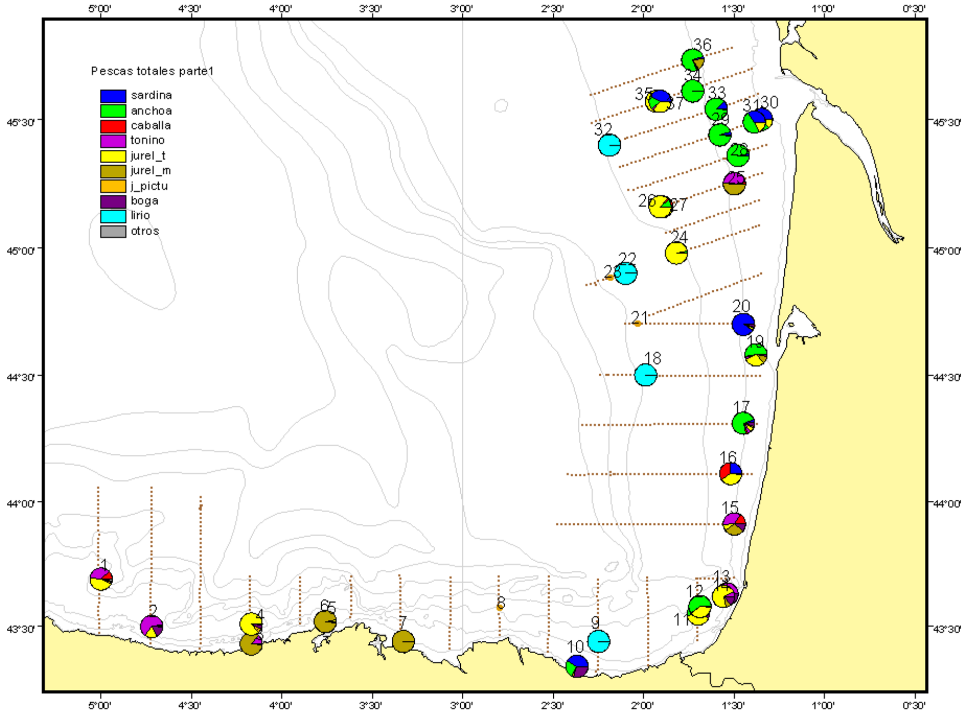


Figure 2.2.2.3.2.5. PELACUS1006; Species composition of the hauls expressed in percentage of abundance (first leg).

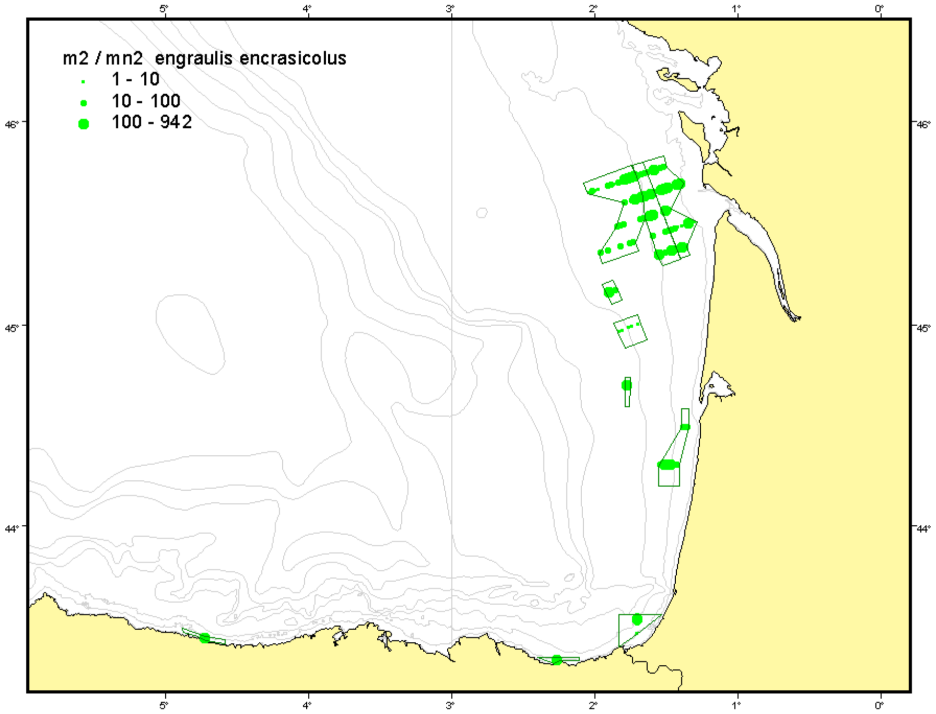


Figure 2.2.2.3.2.6. Spatial distribution of s_A (m^2/mn^2) attributed to anchovy (*Engraulis encrasicolus*).

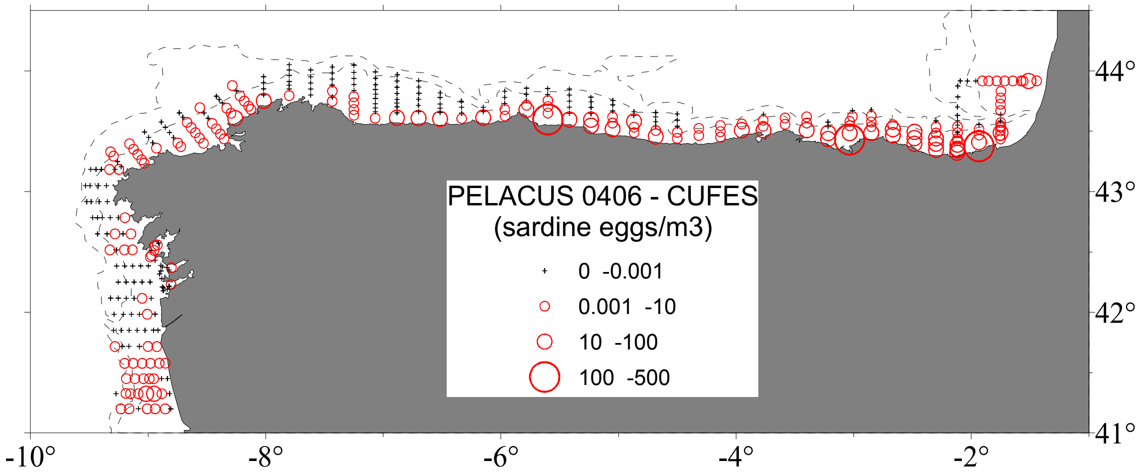


Figure 2.2.3.1.1.1. Sardine egg distribution and abundance (eggs/m3) found during PELACUS 0406 survey by CUFES.

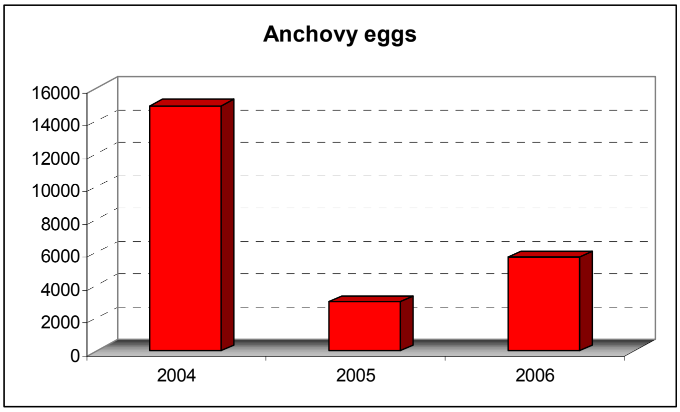


Figure 2.2.3.1.1.2. Anchovy eggs number sampled by survey.

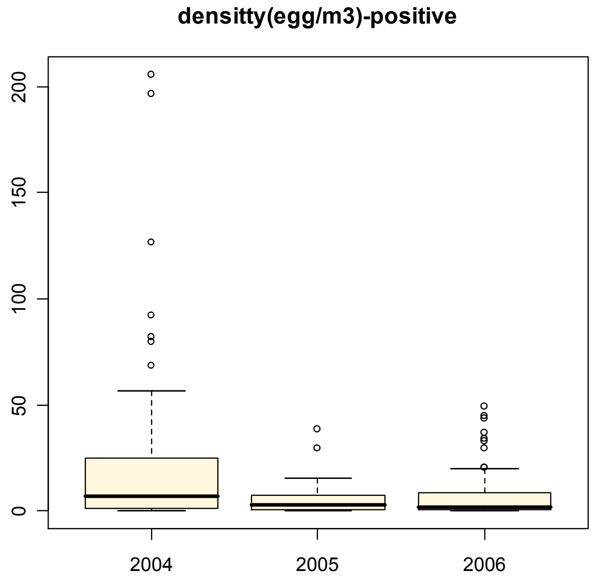


Figure 2.2.3.1.1.3. Boxplot of anchovy eggs abundance (eggs/m^3) by survey.

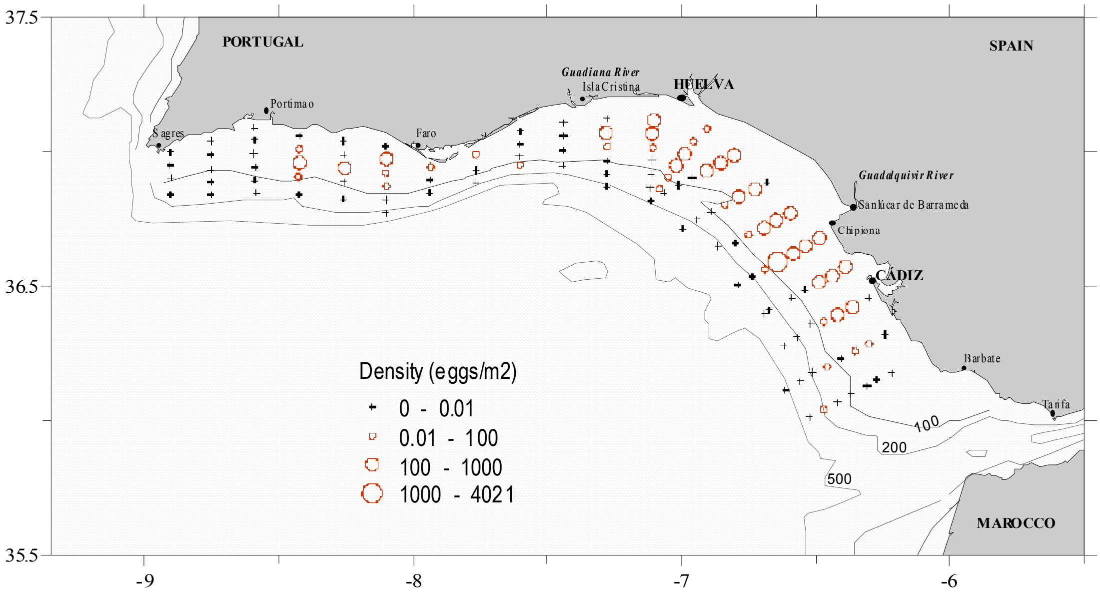


Figure 2.2.3.1.1.4. BOCADEVA-0605. Anchovy egg densities (eggs/m^2) obtained by PAIROVET.

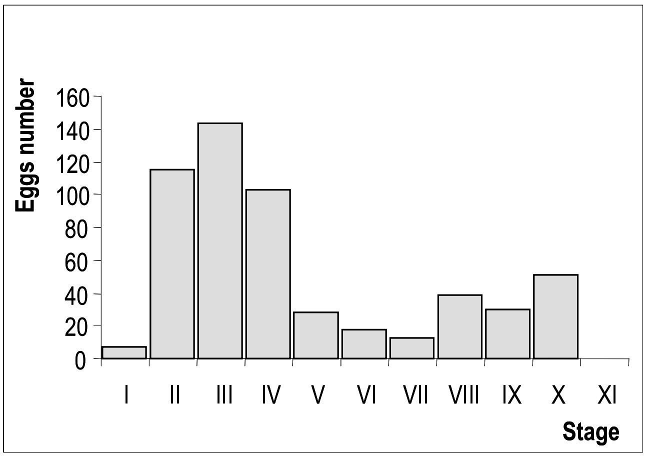


Figure 2.2.3.1.1.5. Relative importance of anchovy egg development stages sampled by PAIROVET.

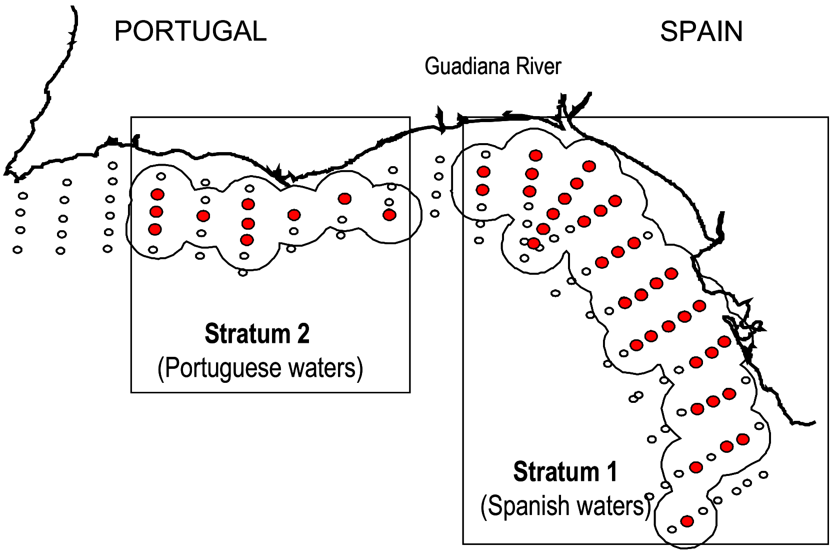


Figure 2.2.3.1.1.6. BOCADEVA-0605. PAIROVET positive stations.

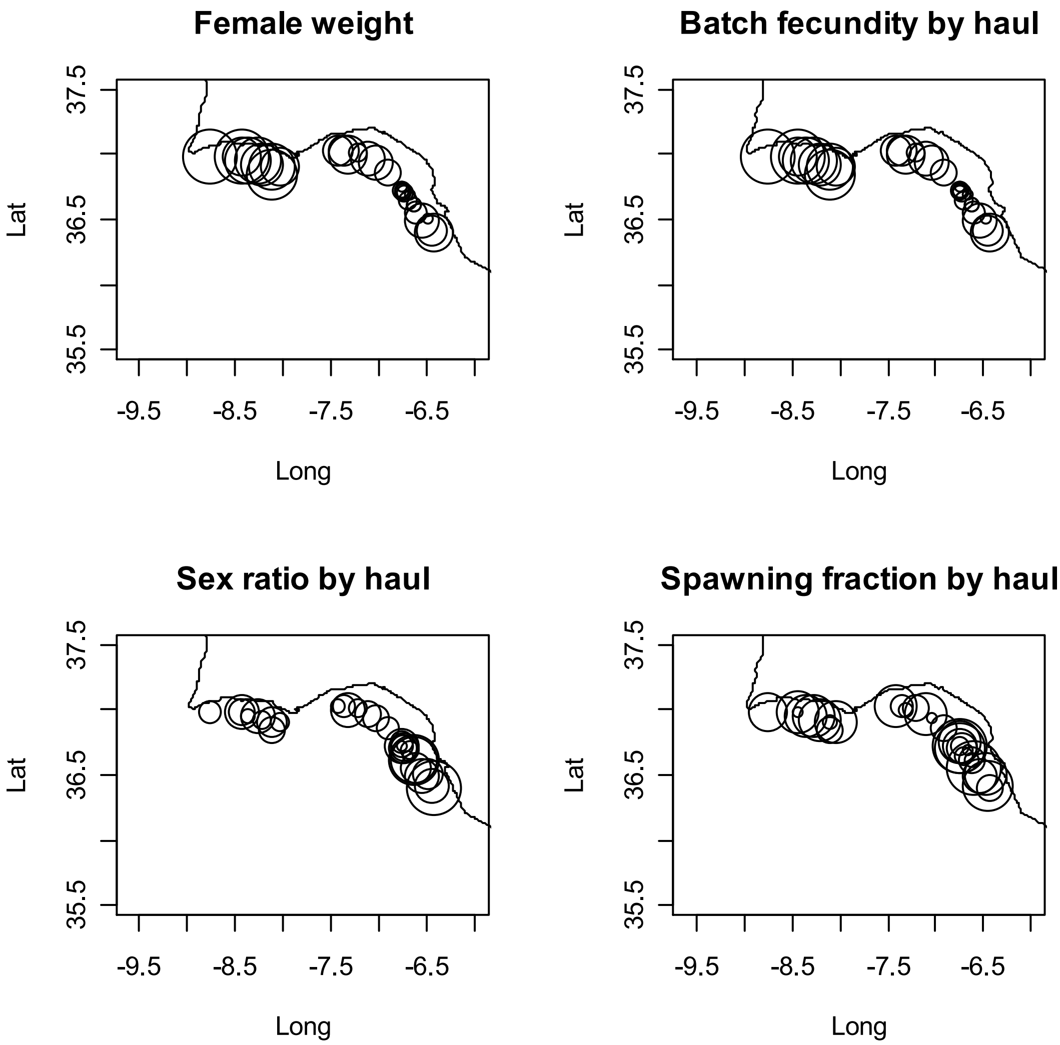


Figure 2.2.3.1.2.1. ***BOCADEVA 0605*** **survey. Spatial distribution of mean estimates of the adult parameters per haul for the Gulf of Cadiz anchovy.**

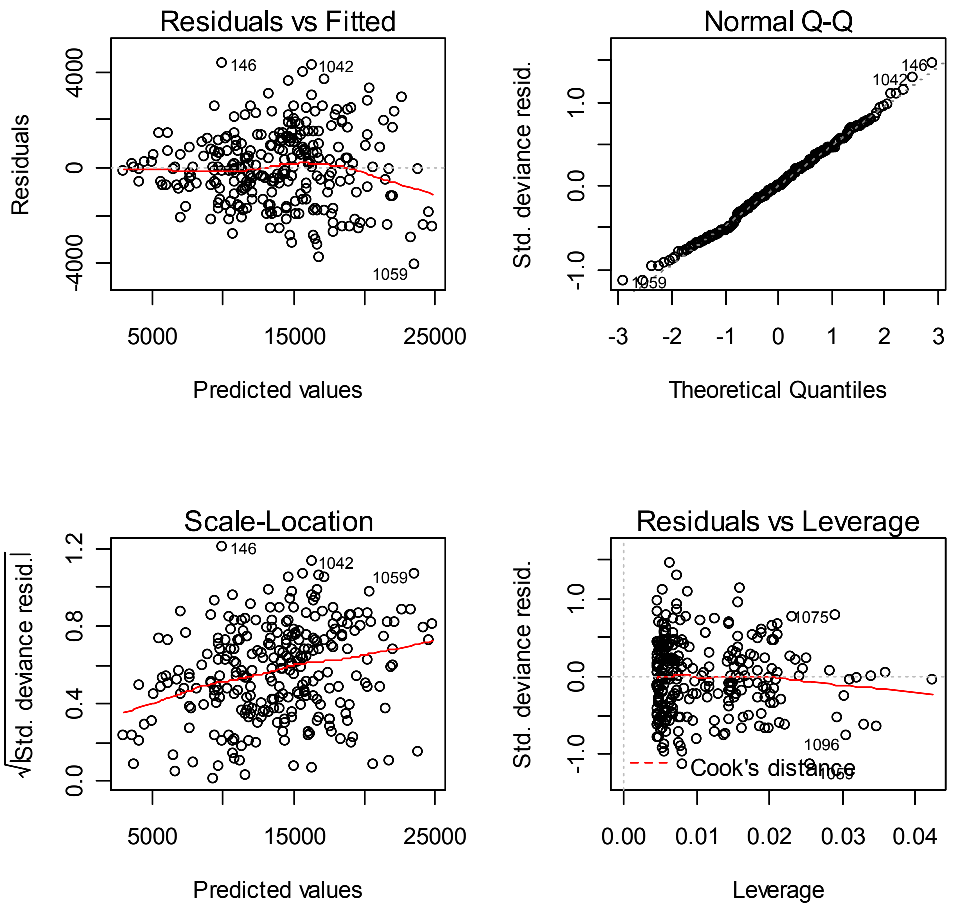


Figure 2.2.3.1.2.2. Residual inspection plots for the Generalized Linear Model 2 (different slopes and equal intercept different from 0) fitted to anchovy batch fecundity data.

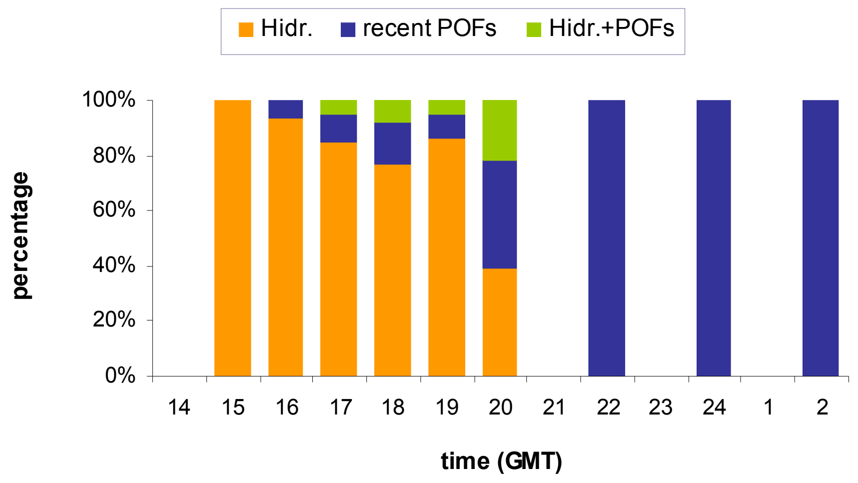


Figure 2.2.3.1.2.3. Distribution of anchovy gonad stages among the spawning females during the period 14: 00–02: 00 GMT (pooled data from 2004 and 2005 surveys).

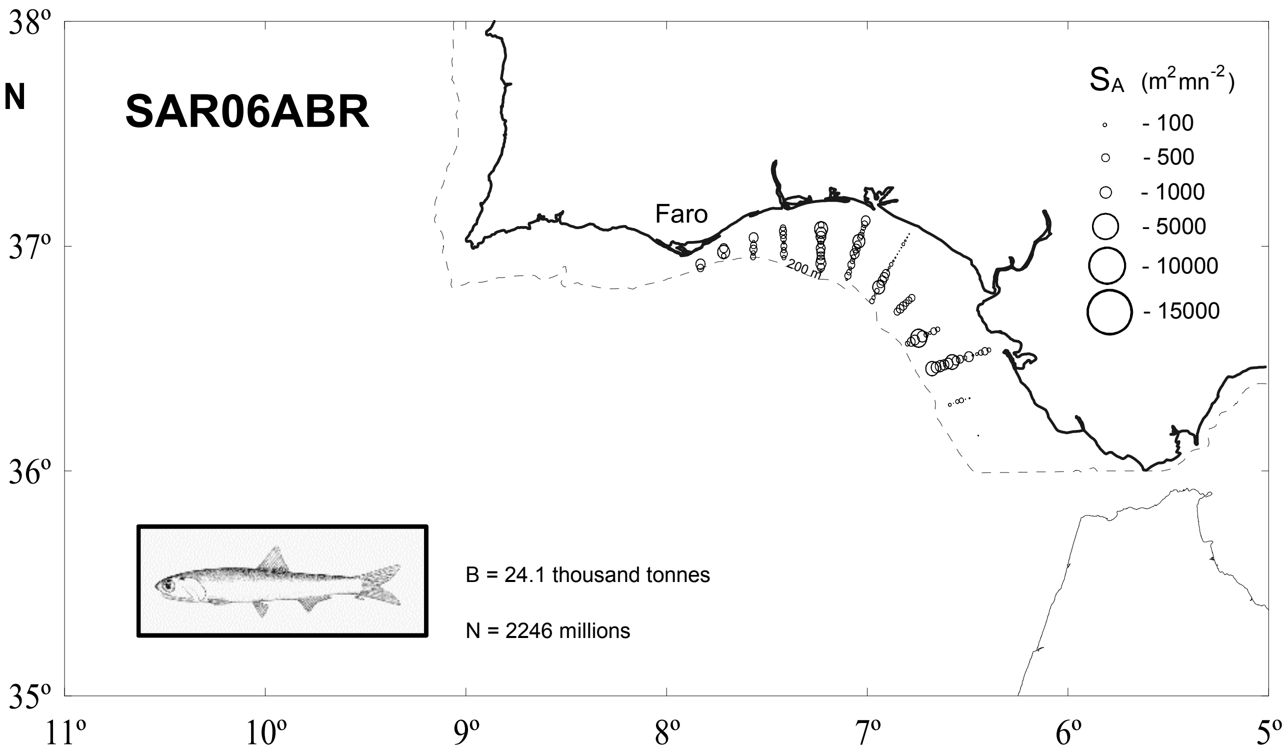


Figure 2.2.3.2.1.1. Anchovy in Division IXa: acoustic energy distribution per nautical mile during the April 2006 Portuguese survey. Circle diameter is proportional to the acoustic energy (S_A).

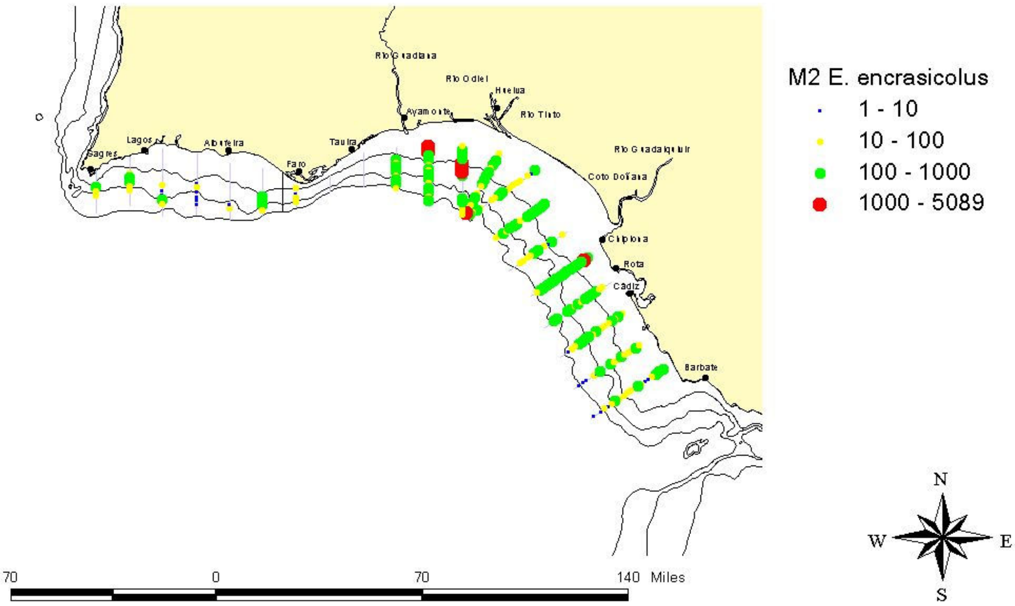


Figure 2.2.3.2.1.2. Anchovy in Subdivision IXa South: acoustic energy distribution per nautical mile during the June 2006 Spanish survey. Circle diameter and colour scale are proportional to the acoustic energy (S_A). Homogeneous size-based post-strata used in the biomass/abundance estimates are also shown.

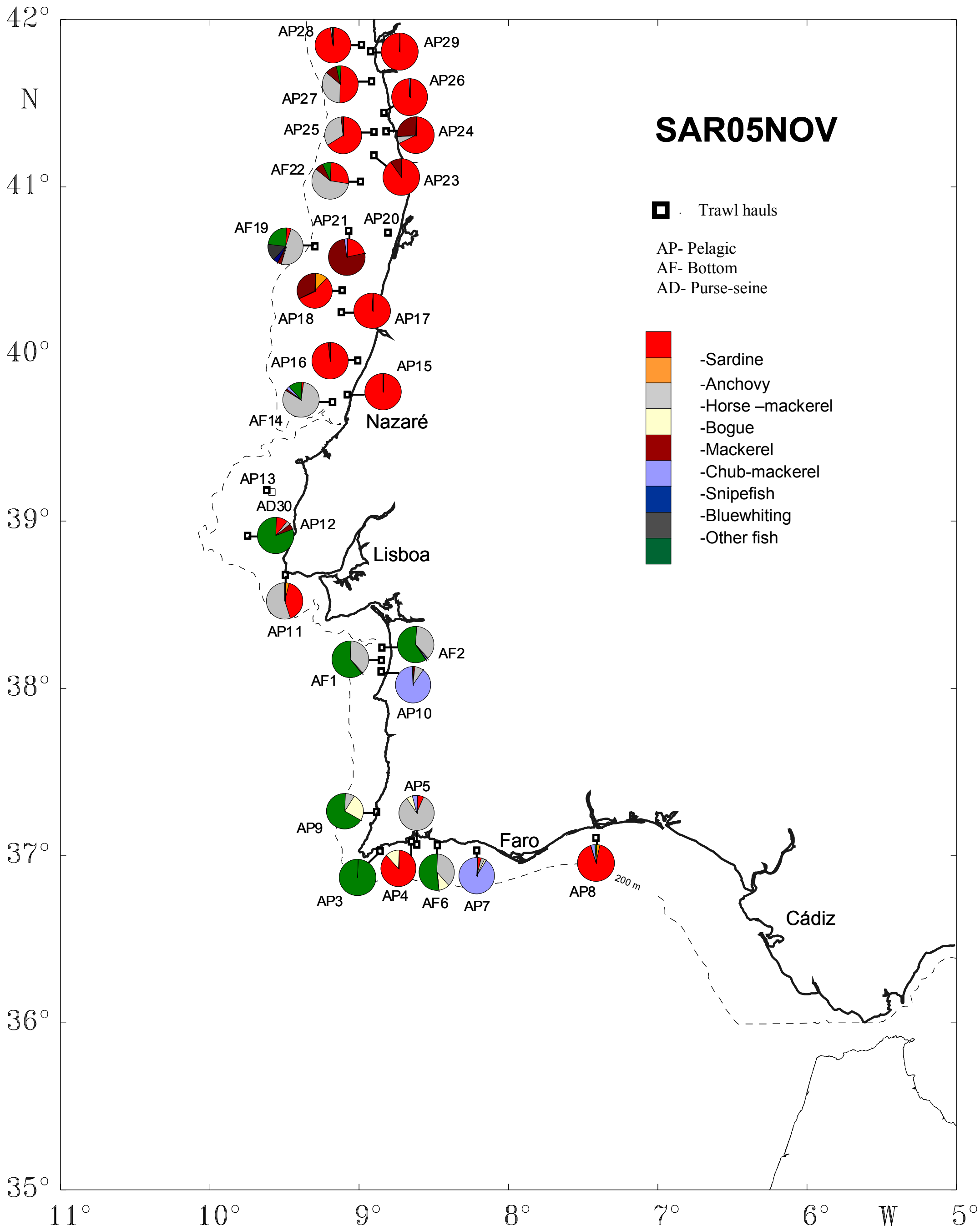


Figure 2.2.3.2.2.1. Anchovy in Division IXa: fishing trawl location and haul species composition during the November 2005 Portuguese survey. (AP- Pelagic trawl; AF- Bottom trawl; AD – Purse-seine).

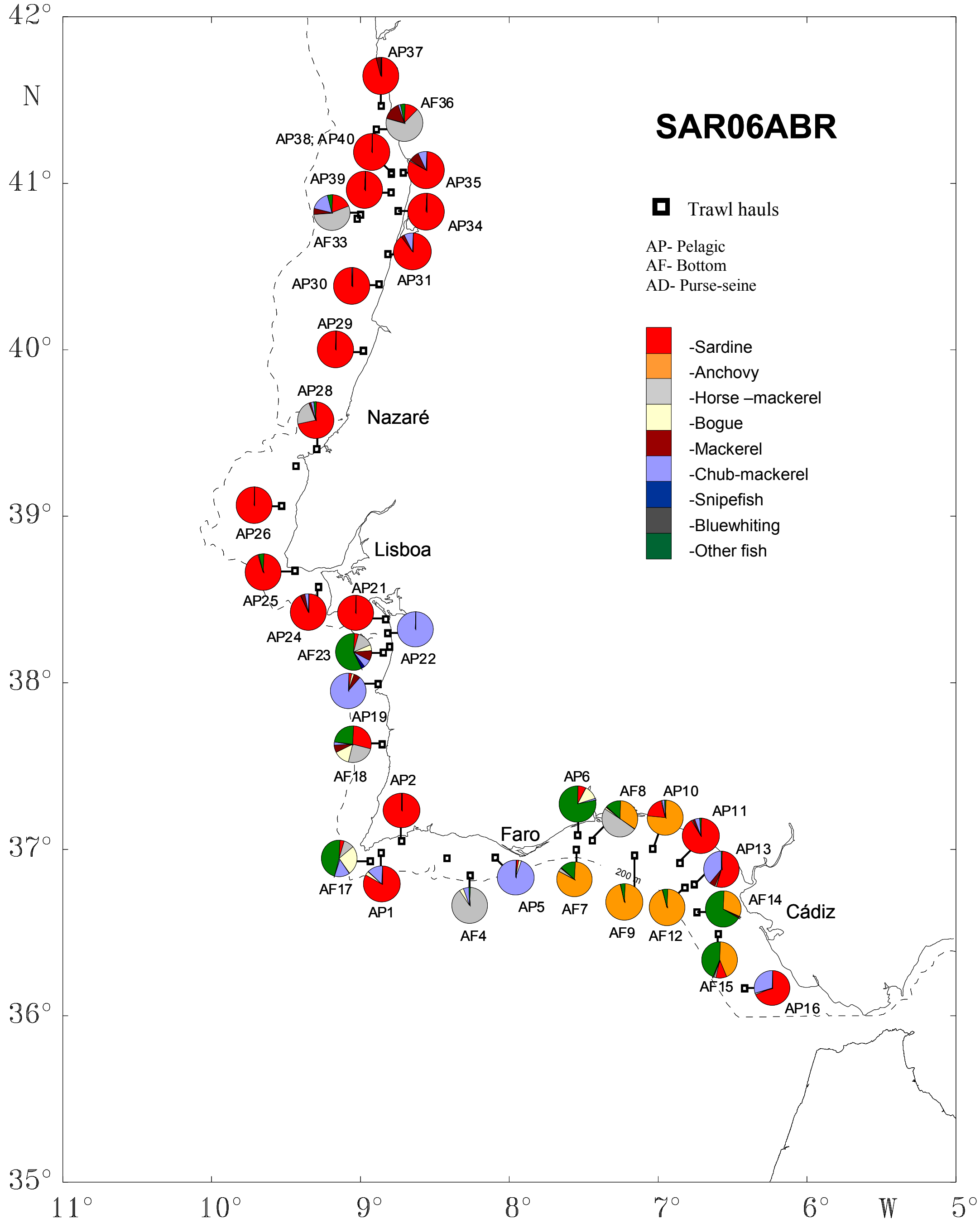


Figure 2.2.3.2.2.2. Anchovy in Division IXa: fishing trawl location and haul species composition during the April 2006 Portuguese survey. (AP- Pelagic trawl; AF- Bottom trawl).

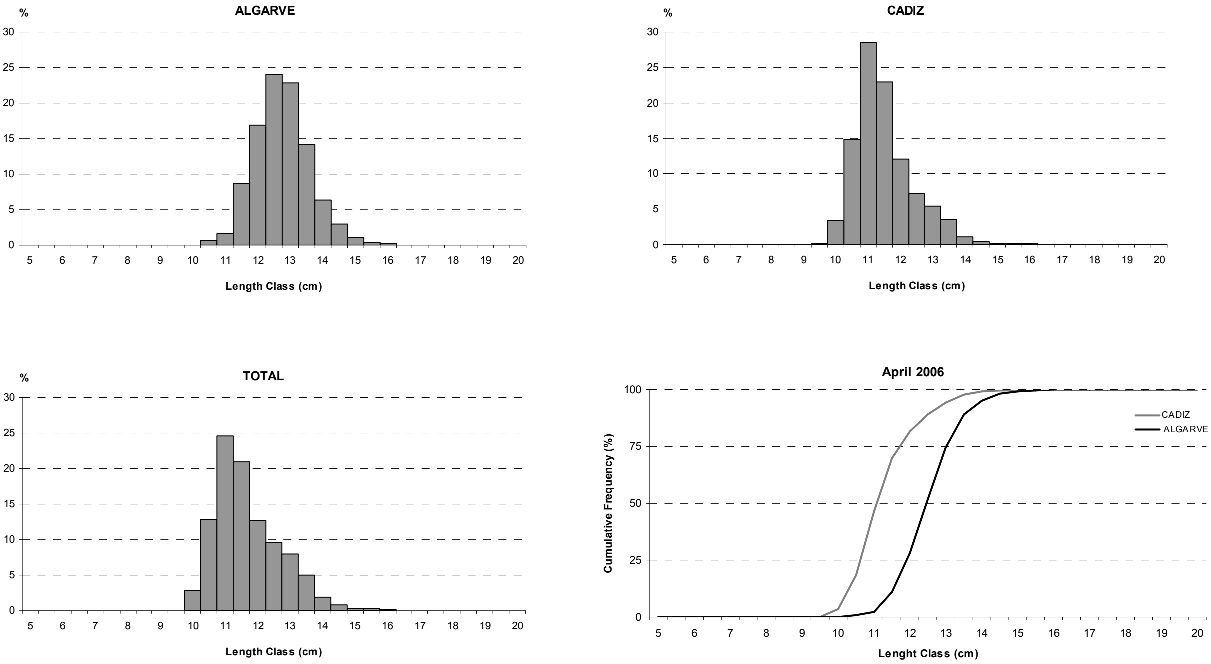


Figure 2.2.3.2.2.3. Anchovy in Division IXa: estimated abundance by length class by region and total area during the April 2006 Portuguese acoustic survey. Bottom right: cumulative frequency (%) by length class and region.

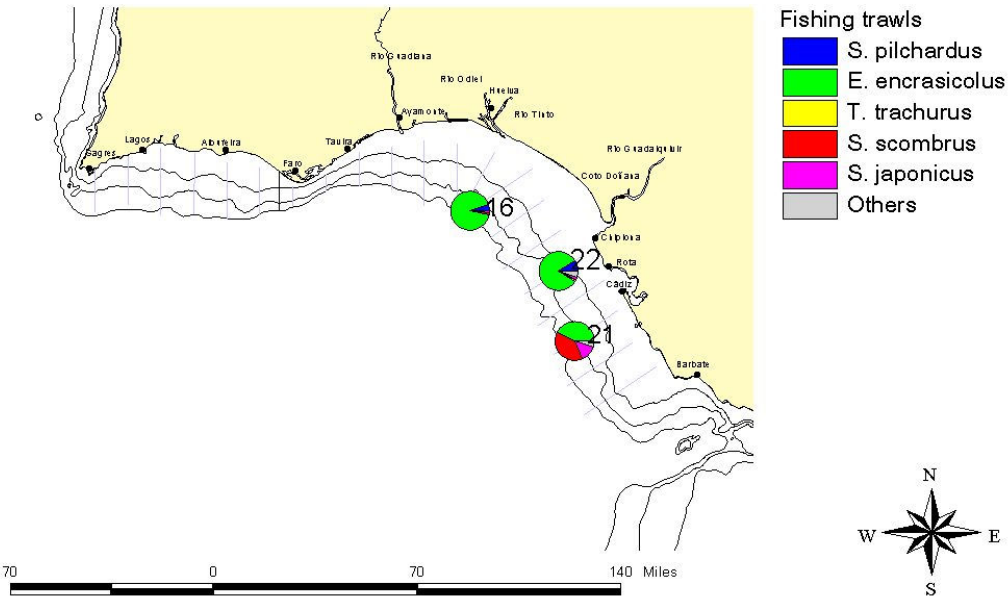


Figure 2.2.3.2.2.4. Anchovy in Subdivision IXa South: fishing trawl location and haul species composition during the June 2006 Spanish survey.

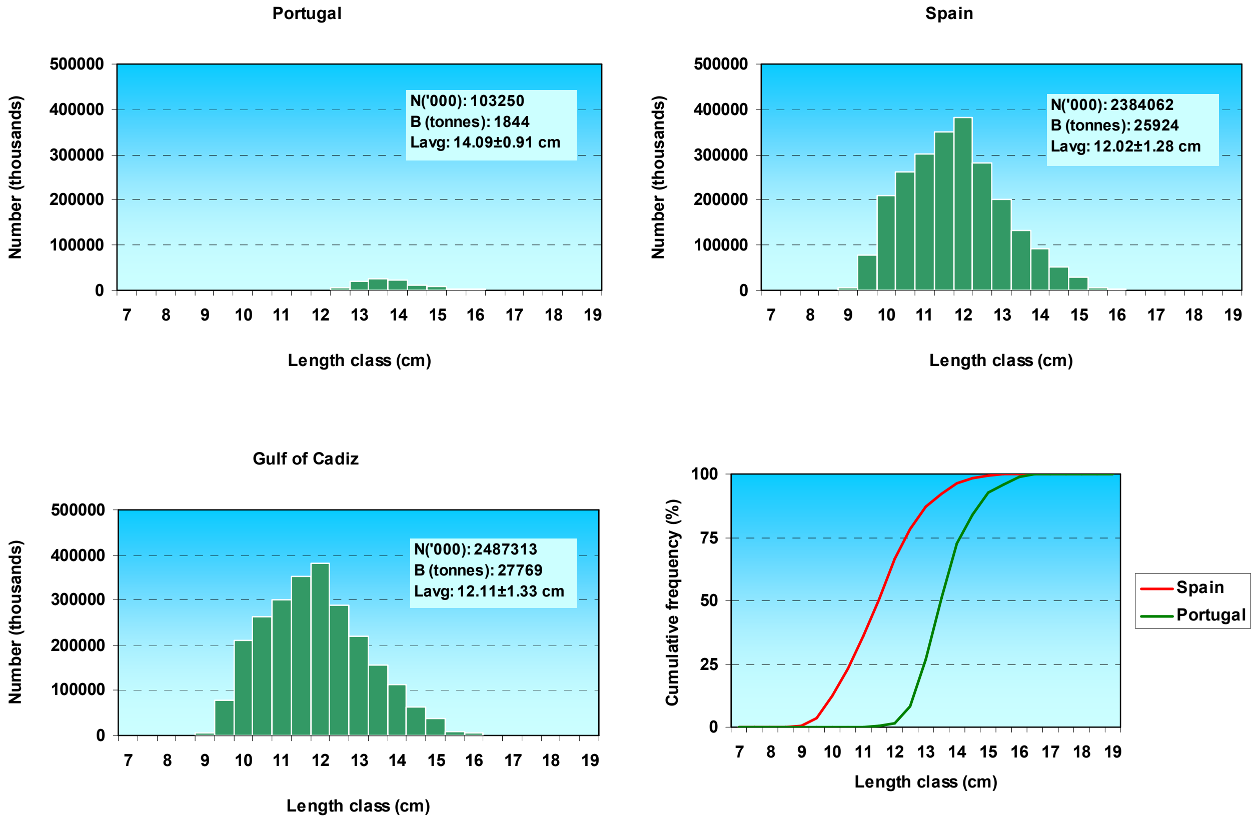
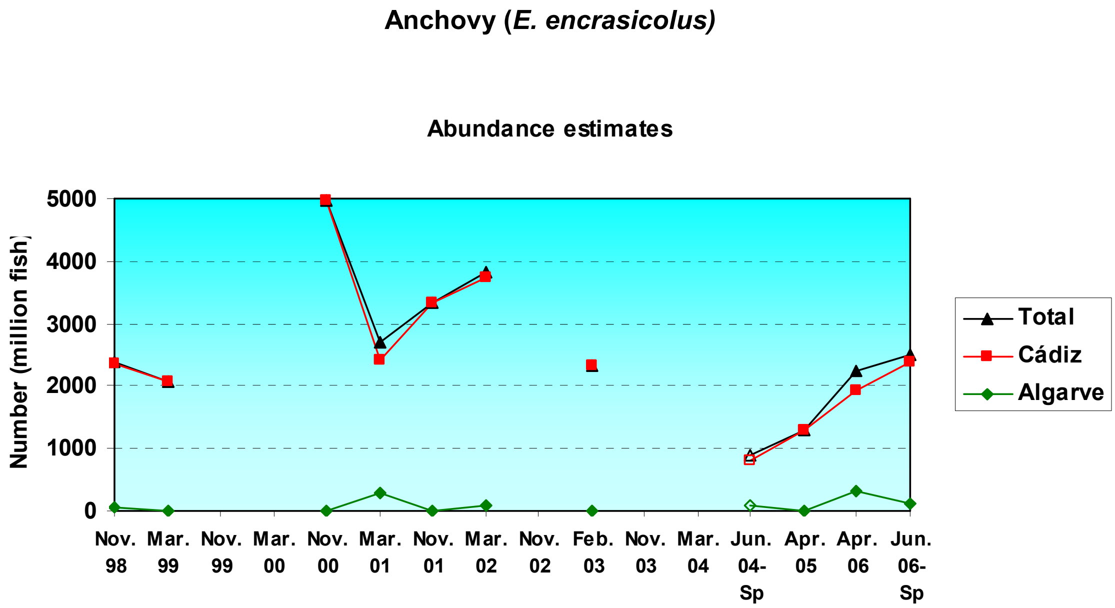


Figure 2.2.3.2.2.5. Anchovy in Subdivision IXa South: estimated abundance by length class by region and total area during the June 2006 Spanish acoustic survey. Bottom right: cumulative frequency (%) by length class and region.



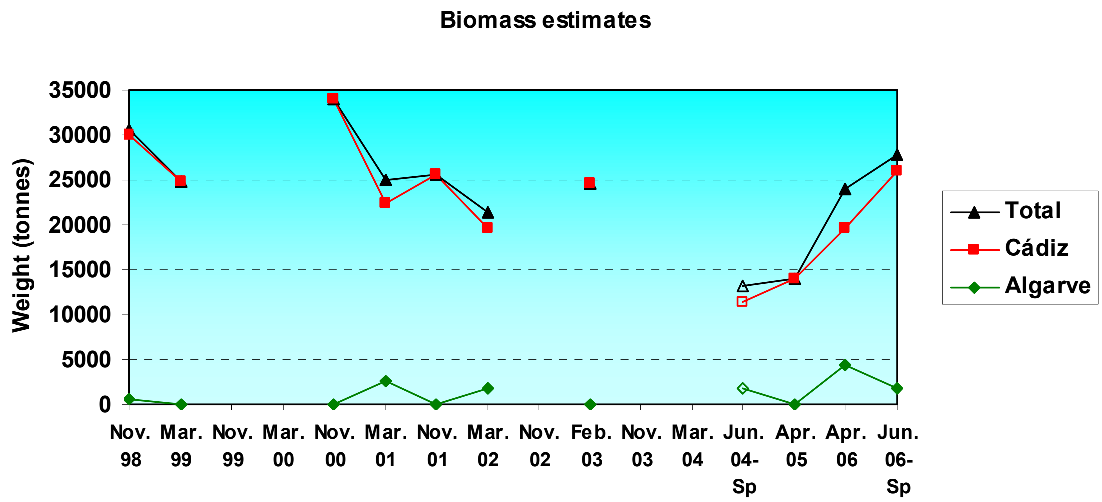


Figure 2.2.3.2.3.1. Anchovy in Subdivision IXa South: historical series of acoustic estimates from Portuguese and Spanish surveys (Sp).

2.3 Sardine surveys in Areas VIII and IX

2.3.1 Distribution and abundance of spawning population from egg production surveys

2.3.1.1 Distribution of eggs in areas VIII and IX from CUFES and PAIROVET samples

Global distribution of eggs off the Iberian Peninsula and adjacent waters from both pairovet and CUFES samplers was presented in last year WG report (ICES 2006b). Global coverage for 2006 is only available from CUFES samplers, as no sardine DEPM survey was carried out in this year. Samplers from Portuguese area are still under process, so only results on the distribution of eggs off the Northern Iberian coast in 2006 are available to this year WG meeting. 2006 global coverage of the Iberian Peninsula using data from the Portuguese coast and from the Armorican shelf will be presented in next year WG.

2.3.1.1.1 Distribution of eggs off Northern Iberia from CUFES sampler

The acoustic survey PELACUS 0406 was conducted by IEO from the 3–26 April 2006 on-board the RV “Thalassa” covering Spanish waters in ICES Divisions VIIIc and IXa North as well as the northern part of Portugal and a rather small area of the southern French shelf. During the survey, in addition to standard acoustic transects, a CUFES system (Continuous Underwater Fish Eggs Sampler) (3 m) was incorporated in order to study the abundance and distribution of sardine eggs. In addition, a continuous acquisition and storing of surface temperature and salinity data from thermosalinometer is also carried out with intention of characterisation of sardine spawning area.

In all, 370 CUFES samples were obtained distributed along 61 transects. 18249 sardine eggs were found in 174 of the 370 CUFES stations, distributed mainly in the inner shelf over the entire survey. From the total of 61 transects, only 6 (located in the western sector) did not register positive CUFES stations (sardine egg presence). Low abundance sardine eggs were found in the off Spanish west coast (ICES Division IXa North).

Figure 2.3.1.1.1.1 shows the sardine egg abundance distribution (sardine eggs per m^3).

Quotient plots were implemented to characterize the spawning habitat of sardine eggs (sardine egg density) in regard to physical parameters. Sea surface temperature during the survey ranged from 12.9 to 16.7°C and temperature preferences were 13.25 to 14ºC (Figure 2.3.1.1.1.2). Salinity preferences were ranges from 35.25 to 35.75 and 33.75 psu (Figure 2.3.1.1.1.3). And Quotient plot using depth (transformed to logarithm scale) show a high quotient value in 33 m and a minor peak between 60 to 110 m (Figure 2.3.1.1.1.4).

2.3.1.2 Estimates of egg production by areas

2.3.1.2.1 Estimates of egg production in North Spanish waters

During 2005, the IEO (Instituto Español de Oceanografía) carried out two combined surveys one for ichthyoplankton (SAREVA 0405) and another for adult surveying (PELACUS 0405), covering waters and the inner part of the Bay of Biscay (from 42°N to 44°N). The aim of these surveys was evaluating the spawning biomass of the sardine (*Sardina pilchardus)* off the North Atlantic Spanish coast by the daily egg production method (DEPM). The methodology used to in these surveys are given in 2005 WGACEGGS report.

Total egg production

In 2005 WGACEGGS meeting was presented a WD with a preliminary egg production of 2.92 10^{12} egg/day (CV = 26%), but could have been overestimated since some problems had been detected in the process of total spawning (positive) area estimate. A revision of the egg production estimates was suggested by the WG.

In this review model was also fitted with a generalized linear model (GLM) with a negative binomial distribution. As result same values of mortality estimation (-0.009 h^{-1}) and daily egg production (209.54 egg/m^2) were estimated. But the total sampling surface area was estimated at 36760 km^2 and the total spawning area surface of 10033 km^2. Then the total egg production was estimated in 2.10x10^{12} eggs/day (CV = 22.8%).

2.3.1.2.2 Estimates of egg production in Portuguese and South Spanish waters

Details on ichthyoplankton sampling and estimates of egg production in Portuguese and South Spanish waters were presented in last year WG (ICES 2006b), where a total (unstratified) estimate of 4.1 * 10^{12} (CV=24%) was provided and the impact of post-stratification into 2 or 4 strata was also considered. The final estimate of egg production for the 2005 survey was based on post-stratification into two strata (western Portugal and southern Iberia) and amounted to 4.25 * 10^{12} but had a higher CV (27%). Production was higher and more precisely estimated off western Portugal (3.04 * 10^{12}; CV = 34%) than off southern Iberia (1.21 * 10^{12}; CV = 39%). It should also be noted that the mortality estimate for the southern stratum was non-significant.

2.3.1.3 Distribution of adult parameters in areas VIII and IX

2.3.1.3.1 Estimates of adult parameters in North Spanish waters

The adult sardine samples were obtained from 59 pelagic trawls (RV "Thalassa") and 17 purse seining hauls (commercial vessel). Overall samples were obtained from the shelf between 30–200 m. isobaths (Figure 2.3.1.3.1.1).

In each haul, a random sample of 50–100 sardines during the biological sampling was utilized for the estimation of the sex ratio (R), the spawning fraction (S) and female mean weight (W) parameters. When hydrated females appeared, an additional sampling was done for the purpose to obtain 100 hydrated females in overall survey in order to estimate batch fecundity (F).

For each of the adult parameters, mean and variance were estimated following the Picquelle and Stauffer's (1985) weighting procedure. Adult parameters were estimated under a library "R" environment designed by M. Bernal.

Mean female weight (W): Total weight of hydrated females was corrected for the increase of weight due to hydration. Data of ovary free weight (Wnov) and correspondent total weight (Wt) of non hydrated females from the survey were related by a linear model. The model was fitted using data from 586 non–hydrated females collected during the PELACUS 0405 survey. Figure 2.3.1.3.1.2):

$$Wt= -3.105 + 1.113\ Wnov\ (R2=0.98)$$

Mean female weight for the whole survey area was 78.55 g (CV=5%).

Sex ratio (R): Sex ratio of mature population was estimated as weight ratio of females in the mature population (stage maturity 2 or higher). In all, 1188 mature sardine from 30 samples were used for the estimation of the overall sex ratio in the surveyed area. The sex ratio was 0.525 (CV =0.4%).

Spawning fraction (S): Spawning fraction was estimated using the composite sample of day-1 and day-2 POF´s. In all, 631 non-hydrated ovaries of sardine adult females were considered for the estimation of the spawning fraction. The estimated spawning fraction for the whole surveyed area was 0.0628 (CV=16%).

Batch fecundity (F): In all, 276 hydrated females from 14 samples were collected from the whole surveyed area. However, only 114 females without POF´s were used to estimate the batch fecundity. Figure 2.3.1.3.1.3) shows Batch fecundity vs. gonad free weight for the hydrated sardine females. To estimate Batch fecundity a linear model and two generalized linear models (GLM) with a negative binomial and Poisson error distribution were considered. This model was formulated as follows:

$$F= 9.39 + 130.1 * Wnov \ (R^2 = 0.45)$$

Following the above model, mean batch fecundity for sardine in 2005 was estimated to be 32322 (CV= 4%).

When represent adults parameters in space (Figure 2.3.1.3.1.4) no clear spatial differences are found.

2.3.1.3.2 Estimates of adult parameters in Portuguese and South Spanish waters

Details on adult sampling from the 2005 DEPM survey of IPIMAR and preliminary estimates of adult parameters based on the samples obtained on-board RV “Capricornio” were provided in the report of last year. Within 2006, the remaining samples (obtained by purse-seiners) were analysed and final estimates were obtained separately for western Portugal and Southern Iberia.

Mean female weight (W): Mean female weight was estimated based on the fresh total weight of all females that were not immature or hydrated (from macroscopic maturity data). For thawed or preserved in formalin fish, the back-transformed fresh weights were obtained from regression coefficients obtained in laboratory experiments. Similar to other years, mean female weight was considerably lower than off northern Spain, being estimated at 45.6 g (CV = 6%) off western Portugal and 46.7 (CV = 7%) off southern Iberia.

Sex ratio (R): Sex ratio of the mature population was estimated as the weight ratio of females in the mature population (stage maturity 2 or higher). Sex ratio was lower than in previous applications, being 56.4% (CV = 6%) of western Portugal and 51.2% (CV = 13%) off southern Iberia.

Spawning fraction (S): Spawning fraction was estimated using the composite sample of day-1 and day-2 POFs. S values were more similar to the 1997 and 1999 estimates, being higher than the extremely low values obtained in 2002. Spawning fraction was estimated at 6.0% (CV =15%) off western Portugal and 12.2% off southern Iberia (CV = 15%).

Batch fecundity (F): Batch fecundity results were presented on the report of the last year, based on 50 hydrated females without the presence of POFs. Mean batch fecundity was estimated at 18900 eggs (CV = 7%) off western Portugal and 18600 (CV = 8%) off southern Iberia.

2.3.1.4 Distribution of sardine Spawning-stock biomass in Areas VIII and IX.

2.3.1.4.1 Distribution of sardine Spawning-stock biomass in northern Spanish waters

Sardine spawning-stock biomass off the northern Spanish waters was computed according to a unique stratum. The estimated spawning biomass for the whole surveyed area (off North Atlantic Spanish coast) was 154.5 10^3 t with a CV of 29%.

From a historical point of view the 2005 sardine spawning biomass estimate (154.5 10^3 t) is the highest of the whole series (Table 2.3.1.4.1.1). This high value of SSB in 2005 was mainly due to the increase of egg production estimates and decrease spawning fraction estimate (Table 2.3.1.4.1.2). Total egg production estimates show a high value in relation previous years; this can be explained by the manifest increase of egg production from 1999. However, in relation the low value of 2005 spawning fraction estimate not suitable cause can be find.

In order to clarify cause of this low value of Spawning fraction during 2005 is recommended a review of adult parameter data will be made.

2.3.1.4.2 Distribution of sardine Spawning-stock biomass in Portuguese and southern Spanish waters

Traditional estimation of sardine spawning biomass for the 2005 DEPM survey of IPIMAR was based on post-stratification into a western and southern stratum. Total biomass was estimated 264.1 thousand tones with a CV of 33%. The estimate is lower than 2002 and similar to those of the late 1990s. However, unlike the estimates in the late 1990s, most spawning biomass in 2005 was found in the western stratum, while large quantities of juveniles were observed in 2005 off northern Portugal.

In addition, the revision of adult data from previous DEPM applications off Portugal and southern Spain were completed during 2006. A summary of the main revisions was provided by Stratoudakis and Bernal (2006) and Table 2.3.1.1 shows the revised estimates for the period 1997–2005 that were used for sardine assessment in 2006. The estimates used for assessment are the sum of the biomasses for western Portugal and southern Iberia using post-stratification, although the Table also provides estimates of DEPM parameters and spawning biomass without stratification for comparison purposes. It should also be noted that the egg production estimates provided in this Table are not all based on the same method of estimation and are taken from the individual reports for each survey. However, given that the latest research on egg production estimation (see other sections of this report) indicates that there will be a need in the near future to re-estimate egg production (to account for the likely under-sampling of very young eggs and following a consistent strategy for mortality estimation) it was decided to use the existing estimates of egg production for this revision.

2.3.2 Distribution and abundance of spawning population from acoustic surveys

2.3.2.1 Iberian spatial distribution of sardine

Acoustic energy in s_A (m^2/mn^2; NASC, Nautical Area Scattering Coefficient) allocated to sardine (*Sardina pilchardus*) during the spring acoustic surveys carried out by the IPIMAR (April), IEO (April) and IFREMER (May) in their respective areas has been plotted in Figure 2.3.2.1.1. Values higher than 10000 m^2/mn^2 are scarce (black points) and situated in the IX ICES area (Spanish and Portuguese areas). Sardine appears, principally, near the coast in areas where the continental shelf is narrow (Portugal and Spain). In French waters, with a continental shelf wider, sardine has a more extended pattern.

An historical perspective of global distribution of sardine biomass by age and by ICES rectangles off the Iberian Peninsula can be observed in Figure 2.3.2.1.2.

2.3.2.2 Estimates of fish abundance, length/age distribution and biomass by area

2.3.2.2.1 Estimates of fish abundance and biomass in French waters

During the spring acoustic survey PELGAS006, sardine was observed and samples collected for biological parameters. The survey was already described in Section 2.2.2.2. A sardine biomass of 228 500 t was estimated (Table 2.2.2.2.1).

The distribution of sardine is represented in Figure 2.3.2.2.1.1, and the length distribution in Figure 2.3.2.2.1.2. Most of it was present along the coast in the southern area and in the south of Brittany.

2.3.2.2.2 Estimates of fish abundance and biomass in North Spanish waters

Spanish acoustic survey PELACUS0406 has been carried out in April 2006 in Northwestern and North Atlantic waters off the Iberian Peninsula (ICES Areas IXa North and VIIIc).

Although mainly aimed at estimation of sardine (*Sardina pilchardus*) in Spanish waters in the spawning period, data of other pelagic species as mackerel (*Scomber scombrus*), horse mackerel (*Trachurus trachurus*) and anchovy (*Engraulis encrasicolus*) were also collected, due to the multispecificity of the area.

The aim of the survey was to provide an abundance and biomass estimate for sardine in this area, to map the distribution of this species and to provide age disaggregated abundance indices for stock assessment. The results of this survey have been presented in the WGMHSA06.

Survey design consisted of a systematic grid, normal to the coastline, with transects evenly distributed each 8 nautical miles, from 20 isobaths to 200 m depth. In all, 60 tracks were performed with in all, 997 nautical miles, starting in Portuguese waters (in front of Matoshinos, and ending in French waters) (Figure 2.3.2.2.2.1). For the purposes of assessment only Spanish waters between the borders with Portugal and France (ICES IXa-N, VIIIc-W, VIIIc-EW and VIIIc-EE) were considered.

Acoustic equipment consisted of a multi-frequency EK-60 scientific echosounder (18, 38, 70, 120 and 200 kHz). Frequencies were calibrated using recommended methods (Foote 1982; Foote *et al*., 1987) and standard targets for the particular frequencies. Acoustic data were only obtained during daytime. Data were stored and post-processed using SonarData Echoview software. The elementary distance sampling unit (EDSU) was fixed at 1 nm. Fish abundance estimation was done for the 38 kHz frequency using the Nakken and Dommasnes method (Nakken and Dommasnes, 1975). The threshold used to scrutinize the echograms was –60 dB. Total sardine NASC (nautical acoustic scattering coefficient, m^2/mni2) detected during the survey has been of 87441, decreasing from last years (Figure 2.3.2.2.2.2).

Fishing stations for biological sampling and fish ID were carried out during daytime. Fishing stations were opportunistic according to echogram information and were sampled using a pelagic trawl. Length frequency distributions (LFD) were obtained for all the fish species in trawl samples (either from the total catch or from a representative random sample). For the purpose of acoustic assessment, only those size distributions based on a minimum of 30 individuals and a normal distribution were considered valid. Otoliths were also extracted from sardine in these biological samplings in order to estimate age and obtain the length-age key from each survey. These keys have been applied to length distributions and age distributions have been obtained. In all, 61 fishing hauls were performed to characterize echo traces (Figure 2.3.2.2.2.3), 54 of them in Spanish waters. An effort has been done to increase the number of identification fishing trawls in Spanish waters, from 30 hauls in 2003 to 54 in the present year (Table 2.3.2.2.2.1). This has allowed characterizing in a more consistent way the schools in this area.

Fishing valid sardine hauls (more than 30 individuals and a normal distribution) has been 22 (42% of the total fishing hauls). Sardine length range was 15 to 25.5 cm (Figure 2.3.2.2.2.4). 93% of fishing individuals were ≥ than 19 cm.

Sardine abundance (nº individuals) estimated in the area has been $1484*10^6$ (Table 2.3.2.2.2.2), being similar to the one estimated in 2005 ($1471*10^6$). In Galician waters (IXa-N area) were found smaller lengths (modes of 17 and 21 cm) than in the rest of Cantabric waters (VIIIc-W, VIIIc-EW and VIIIc-EE). 53% of individuals were between 15 y 19.5 cm and 47% between 20 y 25.5 cm (Figure 2.3.2.2.2.5).

Sardine biomass estimated in area has been 93436 tons (Table 2.3.2.2.2.3), with an increase of sardine biomass from last year (2005= 68146 tons). 37% of biomass for sardine lengths between 15 and 19.5 cm, and 63% of biomass corresponding to lengths between 20 and 25.5 cm (Figure 2.3.2.2.2.6).

2.3.2.2.3 Estimates of fish abundance and biomass in Portuguese and South Spanish waters

November 2005 Portuguese survey (SAR05NOV)

In the OCN (Central-North) region sardine presented a broad distribution area, extended from the coast to the 100 m depth contour line. In the OCS (Central-South) region sardine was scarce, being almost absent between Cape Espichel and Cape S. Vicente. In Algarve a few sardine schools were detected, mainly near shore (Figure 2.3.2.2.3.1).

Table 2.3.2.2.3.1 shows the abundance in number and biomass by age groups for each zone and Portugal. Size composition of the estimated abundance by region is given in Figure 2.3.2.2.3.1. The OCN zone presented a population structure dominated by juveniles from 2005 (age 0) and also confirms the strong 2004 recruitment (age I). The OCS zone had a multimodal age (and size) structure corresponding to juveniles and adults. Juveniles represent 46% of the abundance estimated for this zone and were located mainly in front of Lisbon. Algarve, despite of the low abundance shows an interesting percentage of juveniles (66%).

The estimated biomass for the Portuguese coast was 504 thousand tonnes corresponding to 17800 million individuals (Tables 2.3.2.2.3.2 and 2.3.2.2.3.3). In the OCN zone the estimated abundance was one of the largest ever found for this area (458 thousand tonnes; 16600 million individuals), only surpassed by the November 2000 survey. On the contrary in the OCS zone sardine abundance was one of the lowest of the series (34 thousand tonnes; 863 million individuals). Algarve was also depleted of sardine with an estimation of 12 thousand tonnes (333 million individuals).

April 2006 Portuguese survey (SAR06ABR)

As seen in Figure 2.3.2.2.3.2 sardine was mainly distributed over the Western coast from Caminha to Cape Espichel. In the OCN area sardine presented a wide spatial distribution, extended from near coast to around 80 m depth, being more abundant between Porto and Figueira da Foz. In the OCS area, the sardine was scarce, being almost absent between Cape Espichel and Cape S. Vicente. Off Algarve the main sardine concentrations were found in the Western part, between Sagres and Portimão, being almost absent in the remaining Algarve area. In the Cadiz Bay sardine was regularly distributed from shore to around 60 m depth.

Table 2.3.2.2.3.4 shows the abundance in number and biomass by age groups for each zone, Portugal and Total area. Size frequency histograms for regional and total acoustic estimates of the abundance are shown in Figure 2.3.2.2.3.2. Although this survey is not appropriate to properly observe the recruitment strength, it is clear that the 2004 survey recruitment (age II) was a strong one.

The total estimated sardine biomass was 637 thousand tonnes corresponding to 16.5 billion individuals (Tables 2.3.2.2.3.2 and 2.3.2.2.3.3). Off the Portuguese coast the abundance (548 thousand tonnes; 13 billion) was mainly due to the OCN zone contribution. The OCS abundance estimates (138 thousand tonnes; 2.9 billion individuals) was clearly greater than those obtained in the November 2005 survey. The sardine abundance estimation for Algarve also showed an improvement in relation to the previous survey, but below the average survey series abundance. The sardine abundance in Cadiz Bay doubles in relation to the April 2005 survey.

June 2006 Spanish survey (ECOCÁDIZ 0606)

Sardine showed in the surveyed area an opposite distribution pattern to the one previously described for anchovy in Section 2.2.3.2.1, the former species showing the highest densities in both extremes of the surveyed area, specially in the western sector (Burgau-Albufeira in Portuguese waters, as also was described for the species in the April 2006 Portuguese survey) between 35 and 52 m depth, and avoiding the central part, just where anchovy showed more abundant. Again, the Cape Santa María’s shelf area seemed to play a role of “barrier” in the sardine distribution, although something weaker than that found in the anchovy distribution. The easternmost area of higher densities was the zone comprised between the Bay of Cadiz and Cape Trafalgar (Figure 2.3.2.2.3.3). Size composition of the surveyed population, as inferred from fishing hauls, showed the localization of at least two coastal recruitment areas, one between Ponta de Sagres-Burgau (52–58 m depth) and the other one between Vila Real de Santo Antonio and Punta Umbría (39–49 m depth).

No age-structured estimates of sardine abundance and biomass from this survey were available for the present WG. Sardine overall size composition was bimodal, a fact much more evident in the Portuguese waters, where these two modes (recruits *vs.* adults) were clearly separated. So, in these waters the sardine size ranged between the 9 and 21.5 cm size classes, with an overall mean size estimated at 17.33 cm, but showing two modes at the 11 and 18.5 cm size classes, the smaller sardines composing the first modal component (≤13 cm) accounting for 11.4% of the total estimated abundance in this region. In the Spanish waters sardine was captured with a size range oscillating between the 9 and 20 cm size classes (overall mean size at 17.17 cm), showing a somewhat more mixed size distribution than in Algarve, although it was still possible to identify two modal components featured by the modal classes of 12.5 and 17.5 cm. However, the relative importance of the juvenile modal component (≤13.5 cm) was much lower (1.9%) than the observed in the Algarve (Figure 2.3.2.2.3.4).

The total biomass estimated for sardine in Subdivision IXa South was 123.8 thousand tonnes (2874 million fish), Portuguese waters accounting for the 51.8% and 50.3% of the total biomass and abundance, respectively (64.2 thousand tonnes, 1446 million fish), (Table 2.3.2.2.3.5).

Table 2.3.1.1. DEPM parameter estimates and sardine spawning biomass for the Portuguese surveys (Portugal and Gulf of Cádiz) over 1997–2005, using traditional estimation, with and without post-stratification into western and southern area. Egg production is measured in number of eggs * 10^{12}, female weight in grams, batch fecundity in number of eggs * 1000 per batch, spawning fraction and sex ratio are percentages and spawning biomass is estimated in 1000 tonnes.

YEAR	VARIABLE	W PORT	SOUTH	TOTAL (STRATA SUM)	TOTAL (NO STRATA)
1997	Egg production	1.10 (34)	3.24 (39)		4.72 (32)
	Female weight	48.5 (7)	43.1 (7)		46.6 (5)
	Batch fecundity	18.0 (6)	16.1 (6)		17.4 (5)
	Spawning fraction	0.060 (25)	0.061 (24)		0.060 (17)
	Sex ratio	0.659 (4)	0.576 (6)		0.609 (4)
	Spawning biomass	**75.0 (44)**	**246.9 (47)**	**321.9 (37)**	**345.2 (37)**
1999	Egg production	2.07 (30)	3.15 (34)		5.00 (35)
	Female weight	45.8 (6)	42.1 (6)		44.8 (5)
	Batch fecundity	18.6 (6)	17.6 (6)		18.4 (5)
	Spawning fraction	0.133 (19)	0.070 (32)		0.113 (17)
	Sex ratio	0.681 (5)	0.540 (7)		0.602 (5)
	Spawning biomass	**56.3 (37)**	**199.3 (48)**	**255.6 (38)**	**179.0 (40)**
2002	Egg production	1.32 (24)	0.89 (36)		1.69 (24)
	Female weight	45.1 (5)	40.0 (5)		42.5 (4)
	Batch fecundity	14.5 (7)	12.6 (6)		13.5 (5)
	Spawning fraction	0.024 (27)	0.038 (31)		0.030 (21)
	Sex ratio	0.608 (3)	0.612 (5)		0.610 (3)
	Spawning biomass	**281.4 (37)**	**121.5 (48)**	**402.9 (31)**	**302.8 (33)**
2005	Egg production	3.04 (34)	1.21 (39)		3.76 (27)
	Female weight	45.4 (6)	46.4 (7)		45.7 (5)
	Batch fecundity	18.9 (7)	18.6 (8)		18.8 (5)
	Spawning fraction	0.060 (15)	0.122 (15)		0.079 (11)
	Sex ratio	0.564 (6)	0.512 (13)		0.545 (6)
	Spawning biomass	**215.8 (39)**	**48.3 (45)**	**264.1 (33)**	**212.3 (31)**

Table 2.3.1.4.1.1. Sardine Spawning Biomass off north Spain, estimated by DEPM. Coefficient of Variation in brackets.

YEAR	SSB (1000 t)
1997	20.7 (84)
1999	13.4 (77)
2002	50.7 (33)
2005	154.5 (29)

Table 2.3.1.4.1.2. DEPM parameter estimates for the sardine off the North Atlantic Spanish coast in period of 1997–2005 (Total adults parameters estimates were not available in 1997 and 1999). Coefficient of variation in brackets. Egg production is measured in number of eggs * 10^{12}, female weight in grams, batch fecundity in number of eggs * 1000 per batch, spawning fraction and sex ratio are percentages and spawning biomass is estimated in 1000 tonnes. *Estimated using transect as sampling unit.

YEAR	PARAMETER	GAL	W CANT	E CANT	TOTAL
1997	Egg production				0.72 (82)
1999	Egg production				0.34 (44)
2002	Egg production	0	0.66 (32)	0.20 (31)	0.52 (33)*
2005	Egg production				2.1 (23)
1997	Female weight				70.1 (6)
1999	Female weight				66.3 (41)
2002	Female weight	67.6 (11)	78.6 (8)	77.7 (6)	
2005	Female weight				78.6 (5)
1997	Batch fecundity				26.5 (5)
1999	Batch fecundity				21.8 (12)
2002	Batch fecundity	23.6 (13)	27.7 (8)	26.9 (6)	
2005	Batch fecundity				32.3 (4)
1997	Spawning fraction				0.18 (15)
1999	Spawning fraction				0.14 (26)
2002	Spawning fraction	0.243 (38)	0.075 (14)	0.125 (20)	
2005	Spawning fraction				0.063 (16)
1997	Sex ratio				0.52 (11)
1999	Sex ratio				0.55 (45)
2002	Sex ratio	0.519 (7)	0.604 (14)	0.494 (22)	
2005	Sex ratio				0.525 (6)

Table 2.3.2.2.2.1. Fishing trawls carried out during the PELACUS surveys. Spanish area (in bold) between Portuguese and French borders.

PELACUS	2001	2002	2003	2004	2005	2006
Total nº fishing trawls	**38**	**46**	**38**	**52**	**55**	**61**
Valid fishing trawls	**36**	**44**	**37**	**48**	**55**	**58**
Valid fishing trawls Spanish area	31	33	30	31	45	52

Table 2.3.2.2.2.2. Sardine abundance (nº individuals by length) estimated by ICES areas in the Pelacus0406 acoustic survey.

SARDINE. PELACUS0406. ABUNDANCE (Nº INDIV). ICES AREAS.					
	IXa-N	**VIIIc-W**	**VIIIc-EW**	**VIIIc-EE**	
Length	**S2, S3**	**S4, S5**	**S6, S7**	**S8**	**Total Spain**
15	2468451	0	0	0	**2468451**
15.5	16120885	0	0	0	**16120885**
16	100830269	0	0	0	**100830269**
16.5	142645353	0	0	188919	**142834272**
17	154442072	0	0	377731	**154819803**
17.5	135834739	0	0	566650	**136401389**
18	78851082	0	0	629587	**79480669**
18.5	46167884	11453916	476868	983201	**59081869**
19	33343764	25827032	894655	2500791	**62566242**
19.5	6955149	25815160	1788706	3941903	**38500918**
20	3793318	53151185	11957763	7800559	**76702825**
20.5	6258512	49719500	20567963	6997814	**83543789**
21	8405475	31337673	19263085	8810204	**67816437**
21.5	6084028	28815538	45639949	9208562	**89748077**
22	3887871	28890316	53475862	12587517	**98841566**
22.5	4597048	21399148	49347761	11643983	**86987940**
23	2416000	15437957	48033735	11287618	**77175310**
23.5	0	7451912	35582931	8896730	**51931573**
24	0	5463246	27308533	5785392	**38557171**
24.5	0	1508992	11666041	1922400	**15097433**
25	0	524665	2557089	996212	**4077966**
25.5	0	0	0	73410	**73410**
Total	**753101900**	**306796240**	**328560941**	**95199183**	**1483658264**

Table 2.3.2.2.2.3. Sardine biomass (tons by length) estimated by ICES areas in the Pelacus0406 acoustic survey.

SARDINE. PELACUS0406. BIOMASS (TONS). ICES AREAS.					
	IXa-N	**VIIIc-W**	**VIIIc-EW**	**VIIIc-EE**	
Length	**S2, S3**	**S4, S5**	**S6, S7**	**S8**	**Total Spain**
15	71.944	0	0	0	**72**
15.5	514.89	0	0	0	**515**
16	3519.069	0	0	0	**3519**
16.5	5425.482	0	0	7.185	**5433**
17	6385.45	0	0	15.617	**6401**
17.5	6090.406	0	0	25.407	**6116**
18	3825.379	0	0	30.544	**3856**
18.5	2418.314	599.966	24.979	51.501	**3095**
19	1881.989	1457.729	50.496	141.15	**3531**
19.5	422.189	1567.022	108.577	239.28	**2337**
20	247.188	3463.547	779.217	508.316	**4998**
20.5	437.054	3472.092	1436.335	488.683	**5834**
21	628.011	2341.38	1439.232	658.25	**5067**
21.5	485.573	2299.8	3642.576	734.946	**7163**
22	330.965	2459.363	4552.271	1071.545	**8414**
22.5	416.806	1940.221	4474.27	1055.738	**7887**
23	232.992	1488.791	4632.231	1088.544	**7443**
23.5	0	763.363	3645.059	911.367	**5320**
24	0	593.726	2967.796	628.736	**4190**
24.5	0	173.769	1343.408	221.375	**1739**
25	0	63.946	311.656	121.418	**497**
25.5	0	0	0	9.459	**9**
Total	**33334**	**22685**	**29408**	**8009**	**93436**

Table 2.3.2.2.3.1. Sardine in Division IX: abundance in number (thousand) and biomass (tonnes) by age groups estimated in the Portuguese November 2005 acoustic survey.

SAR05NOV	OCN	OCS	ALGARVE	CADIZ	PORTUGAL	TOTAL AREA
Age class	**number**	**number**	**number**	**number**	**number**	**number**
0	7452078	399349	219647		8071074	
I	9122140	106833	13073		9242046	
II	19148	67737	27508		114393	
III	9272	120819	11748		141839	
IV	8341	106764	22494		137599	
V	11555	53162	12108		76825	
VI+		7911	26747		34658	
Total	**16622534**	**862575**	**333325**		**17818434**	

SAR05Nov	Ocn	Ocs	Algarve	Cadiz	Portugal	Total Area
Age class	**weight**	**weight**	**weight**	**weight**	**weight**	**weight**
0	149774	4390	5264		159428	
I	305070	5159	572		310801	
II	1143	4441	1417		7001	
III	645	8038	662		9345	
IV	615	7550	1331		9496	
V	819	3939	797		5555	
VI+		721	1968		2689	
Total	**458066**	**34238**	**12011**		**504315**	

Table 2.3.2.2.3.2. Sardine in Division IX: abundance (billion) in each zone, Portugal and total area, for the Portuguese acoustic surveys carried out in November 2005 and April 2006.

SURVEY	OC. NORTH	OC. SOUTH	ALGARVE	CADIZ	PORTUGAL	TOTAL
SAR05NOV	16622	863	333	-	17818	-
SAR06ABR	9514	2856	716	3399	23086	16485

Table 2.3.2.2.3.3. Sardine in Division IX: biomass (thousand tonnes) in each zone, Portugal and total area, for the Portuguese acoustic surveys carried out in November 2005 and April 2006.

SURVEY	OC. NORTH	OC. SOUTH	ALGARVE	CADIZ	PORTUGAL	TOTAL
SAR05NOV	458	34	12	-	504	-
SAR06ABR	370	138	40	89	548	637

Table 2.3.2.2.3.4. Sardine in Division IX: abundance in number (thousand) and biomass (tonnes) by age groups estimated in the Portuguese April 2006 acoustic survey.

SAR06ABR	OCN	OCS	ALGARVE	CADIZ	PORTUGAL	TOTAL AREA
Age class	**number**	**number**	**number**	**number**	**number**	**number**
I	3472528	871626	39348	2957108	4383502	7340610
II	5430794	1448580	204905	360025	7084279	7444304
III	53664	173967	178424	37323	406055	443378
IV	142404	98980	64443	12703	305827	318530
V	136243	148560	160147	25815	444950	470765
VI+	278778	114013	68772	5956	461563	467519
Total	**9514410**	**2855727**	**716039**	**3398930**	**13086176**	**16485106**

SAR06ABR	Ocn	Ocs	Algarve	Cadiz	Portugal	Total Area
Age class	**weight**	**weight**	**weight**	**weight**	**weight**	**weight**
I	109413	34944	1605	73142	145962	219104
II	222131	68862	10081	11844	301074	312918
III	3126	9746	9751	1686	22623	24309
IV	8688	6351	3950	608	18989	19597
V	8428	10087	10130	1356	28645	30001
VI+	18020	8451	4677	308	31148	31456
Total	**369806**	**138441**	**40194**	**88945**	**548441**	**637385**

Table 2.3.2.2.3.5. Sardine estimated abundance (millions) and biomass (tonnes) in Subdivision IXa South from Spanish acoustic surveys by area and total.

SPANISH SURVEYS	ESTIMATE	PORTUGAL: SOUTH (ALGARVE)	SPAIN: SOUTH (CADIZ)	TOTAL IXA SOUTH	SAMPLING GRID	SAMPLED DEPTH RANGE
June 1993	**Number**	-	2485	-	Zig-zag	20–500 m
	Biomass	-	90974	-		
Feb. 2002 *	**Number**	-	3479	-	Parallel	20–200 m
	Biomass	-	73930	-		
June 2004 **	**Number**	**56**	**881**	**937**	Parallel	30–200 m
	Biomass	**2310**	**24258**	**26568**		
June 2006	**Number**	**1446**	**1428**	**2874**	Parallel	20–200 m
	Biomass	**64187**	**59662**	**123849**		

*** Estimates should not be considered because problems found with the performance of the echosounder transductor.**

**** Possible underestimation due to the shallow waters between 20 and 30 m depth were not acoustically sampled.**

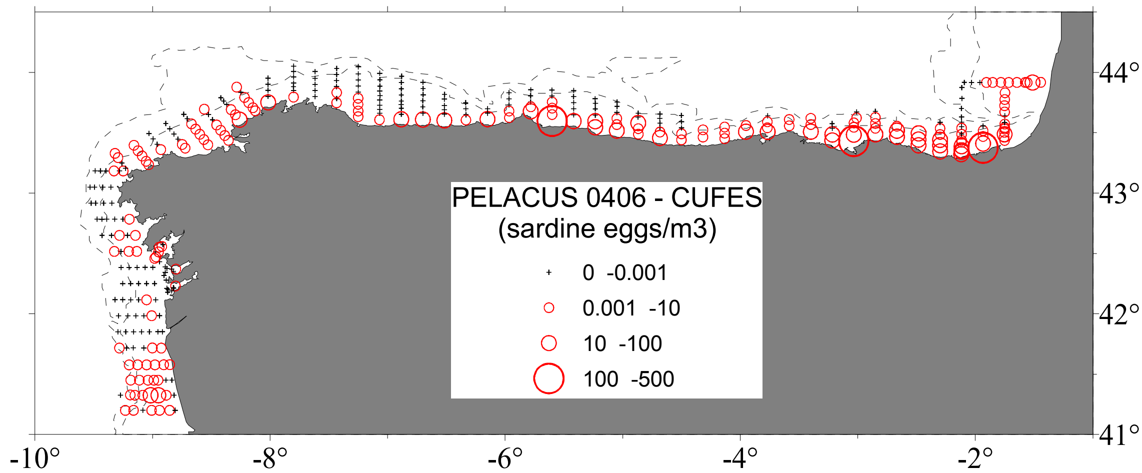


Figure 2.3.1.1.1.1. Sardine egg distribution and abundance (eggs/m^3) found during PELACUS 0406 survey by CUFES.

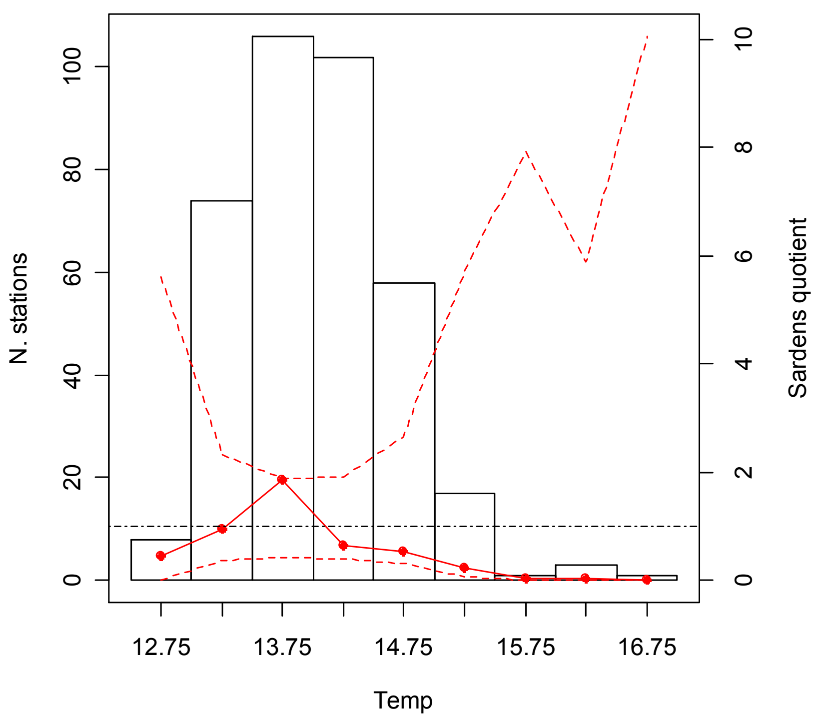


Figure 2.3.1.1.1.2. Quotient analysis of sardine egg density (eggs /m3) in relation to sea surface temperature (ºC) during PELACUS 0406 survey.

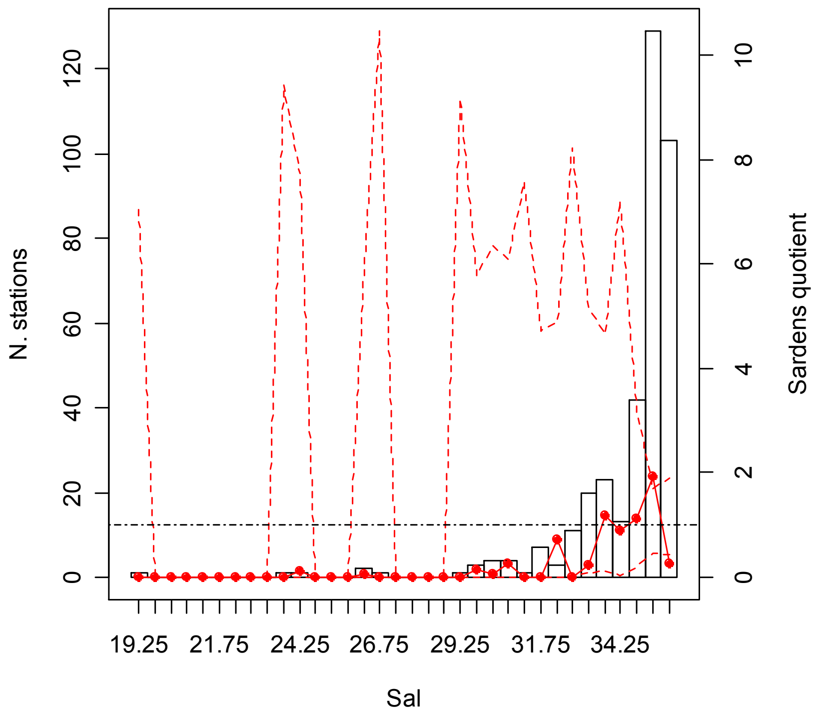


Figure 2.3.1.1.1.3. Quotient analysis of sardine egg density (eggs /m3) in relation to sea surface salinity (psu) during PELACUS 0406 survey.

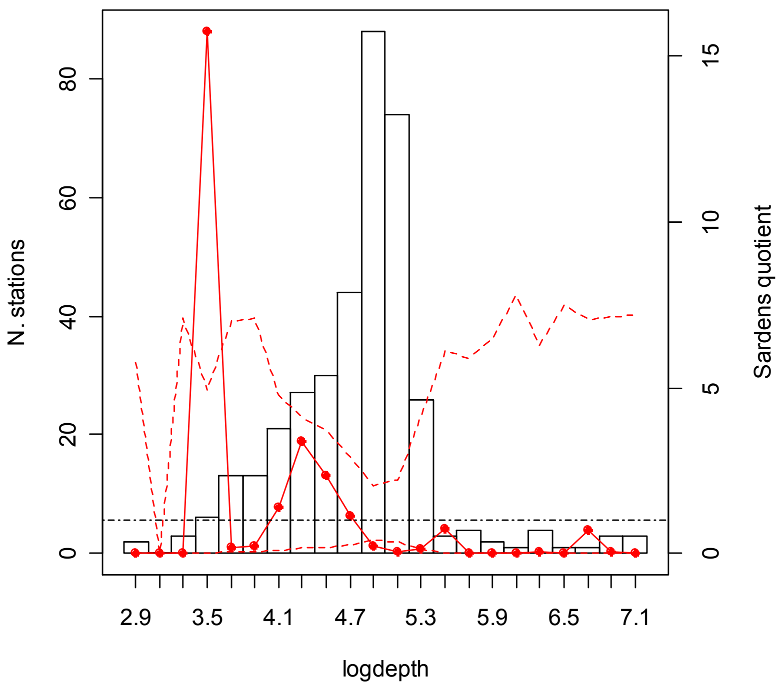


Figure 2.3.1.1.1.4. Quotient analysis of sardine egg density (eggs /m3) in relation to bottom depth (transformed to logarithm scale) during PELACUS 0406 survey.

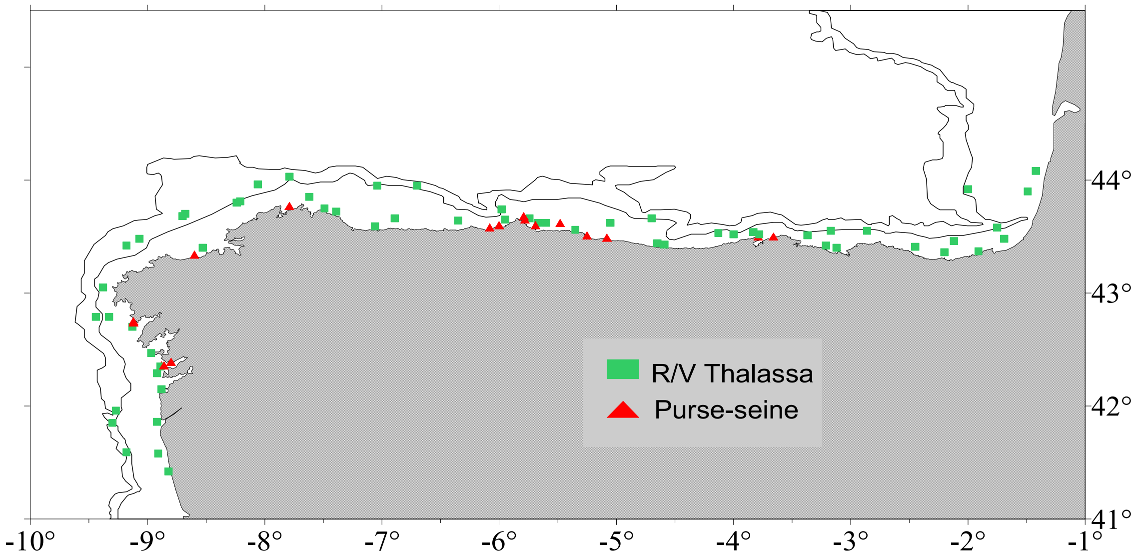


Figure 2.3.1.3.1.1. Location of hauls during PELACUS 0405 survey.

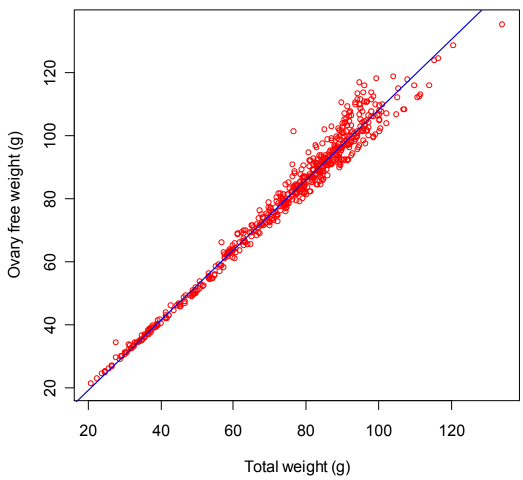


Figure 2.3.1.3.1.2. Relation between total female sardine weight and ovary-free weight from non-hydrated female sardine.

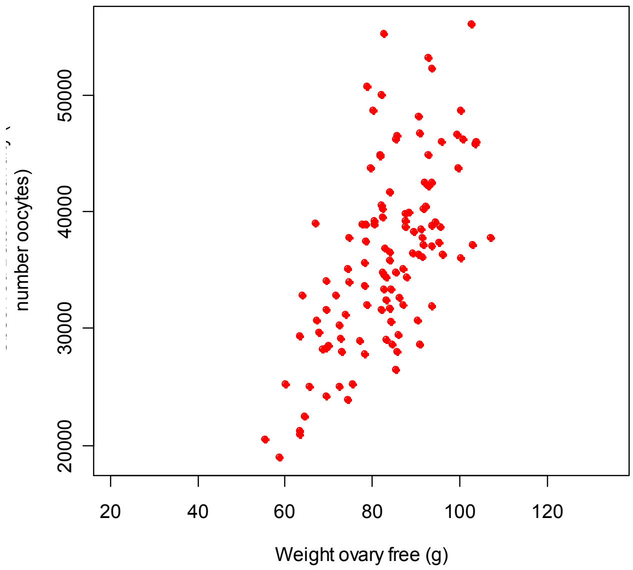


Figure 2.3.1.3.1.3. Batch fecundity (number oocytes) vs. gonad free weight (Weight ovary free) for the hydrated sardine females

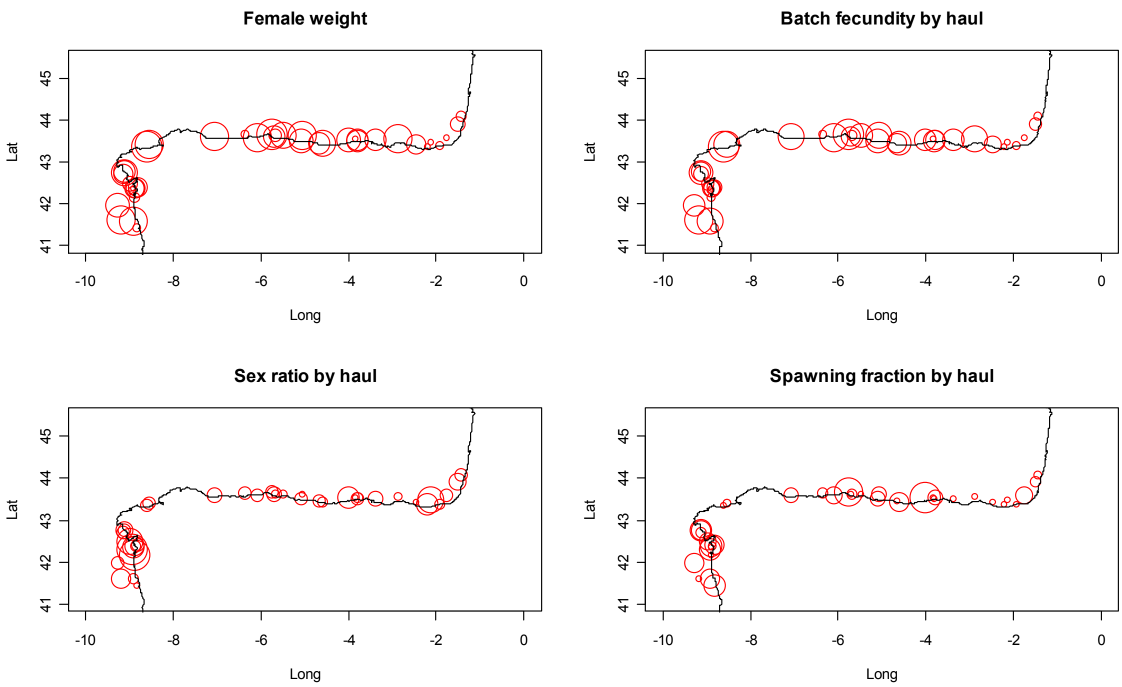


Figure 2.3.1.3.1.4. Spatial distributions of sardine adult parameters in PELACUS 0405 survey.

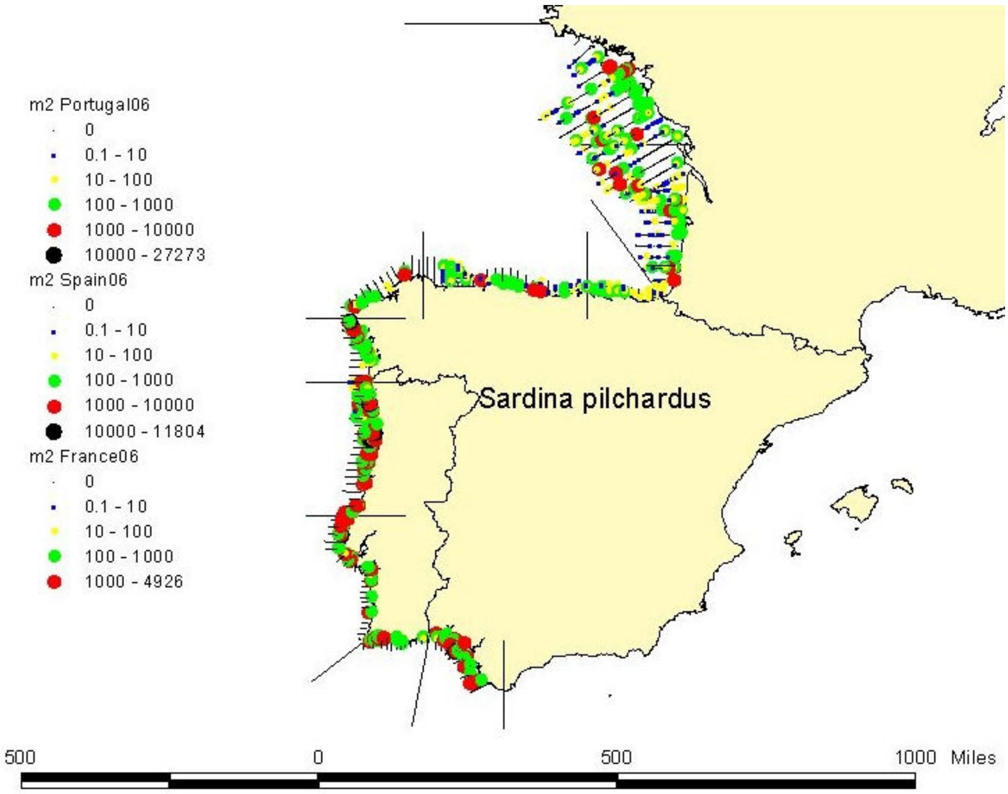


Figure 2.3.2.1.1. Acoustic energy in s_A (m^2/mn^2, Nautical Area Scattering Coefficient: NASC) attributed to sardine (*Sardina pilchardus*). Data comes from the acoustic surveys carried out in spring in this area (Portugal, Spain and France).

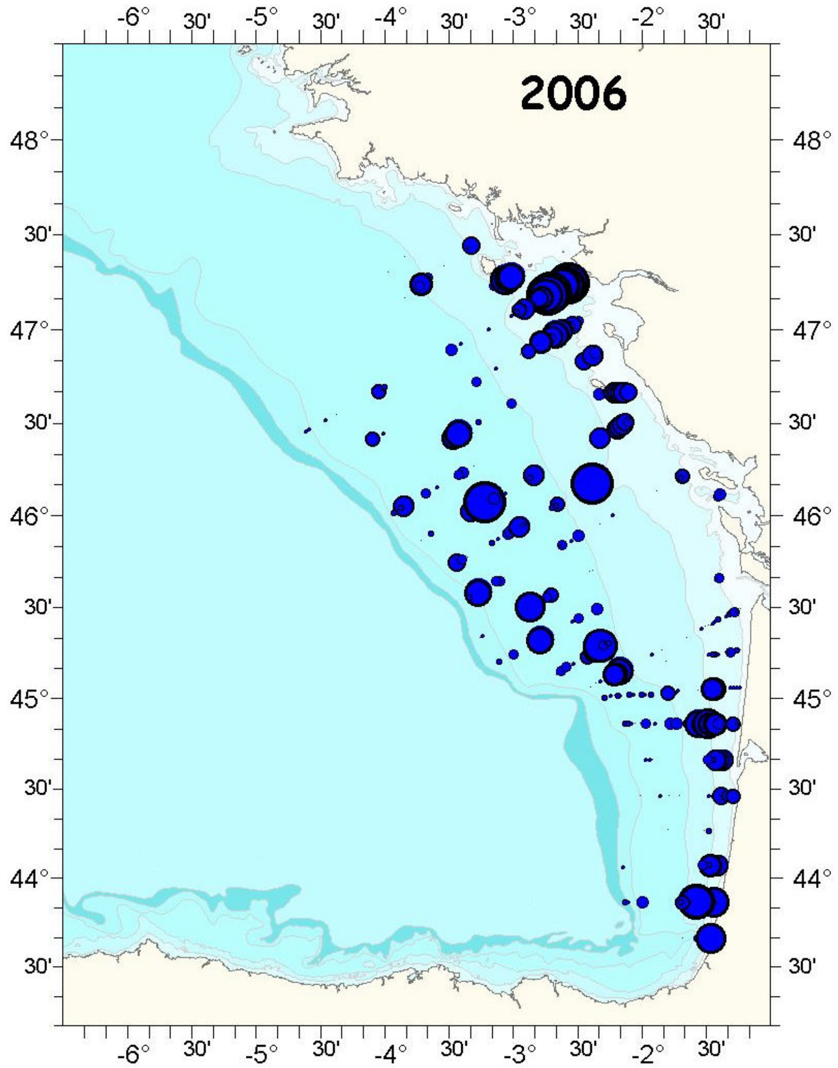
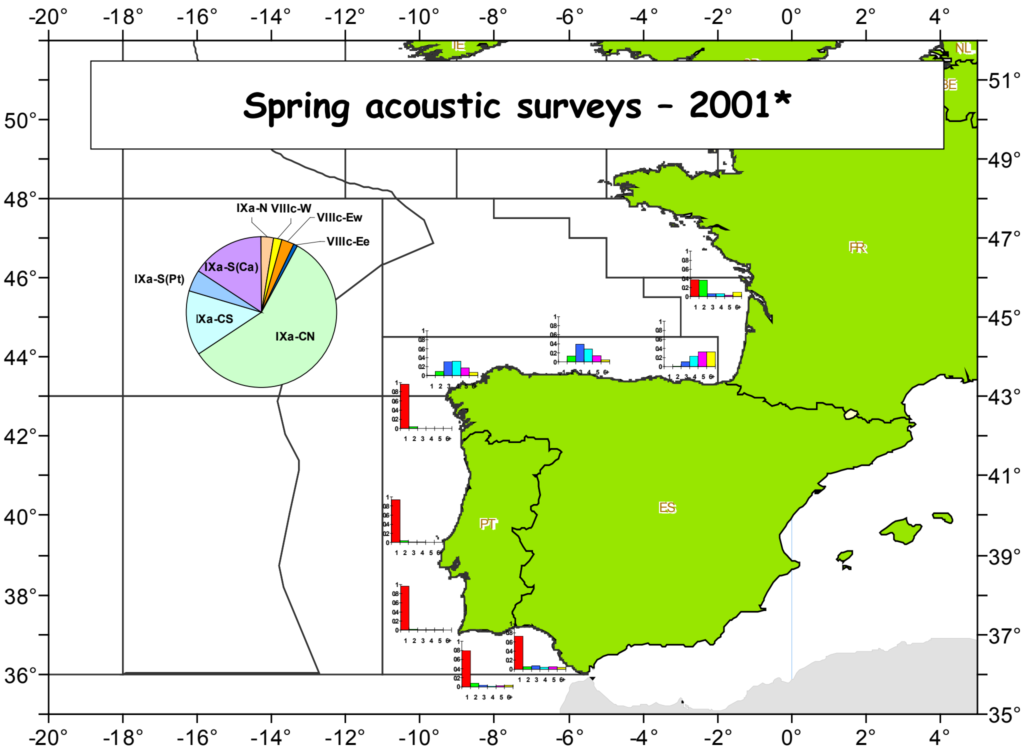


Figure 2.3.2.2.1.1. Sardine distribution in the Bay of Biscay as observed during the PELGAS06 acoustic survey.



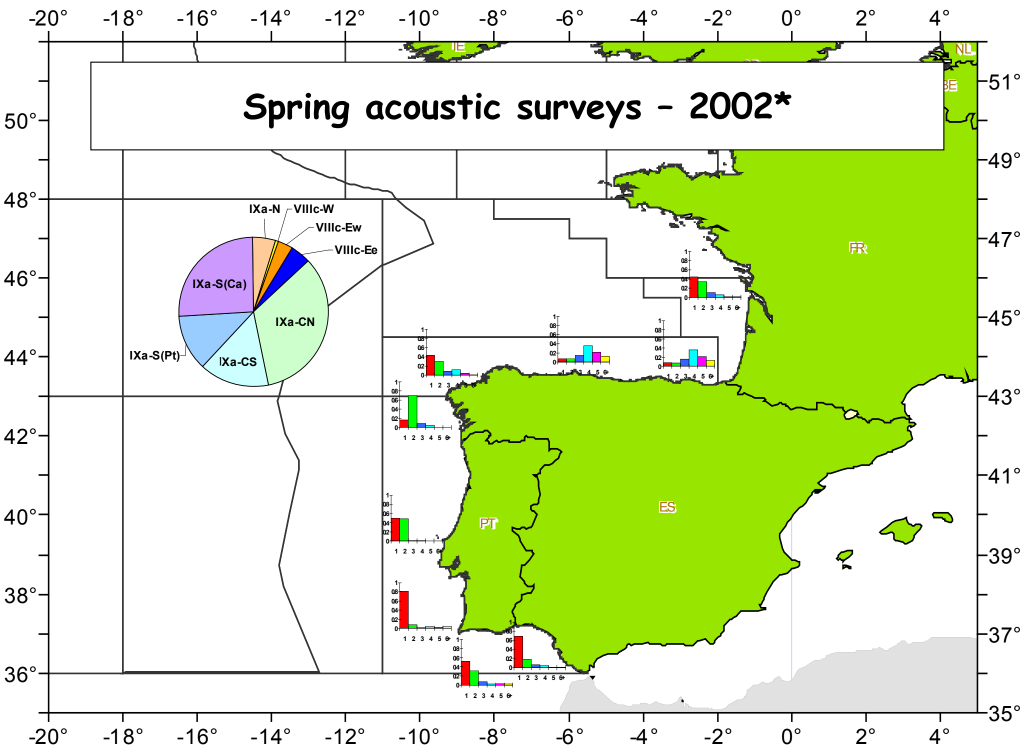
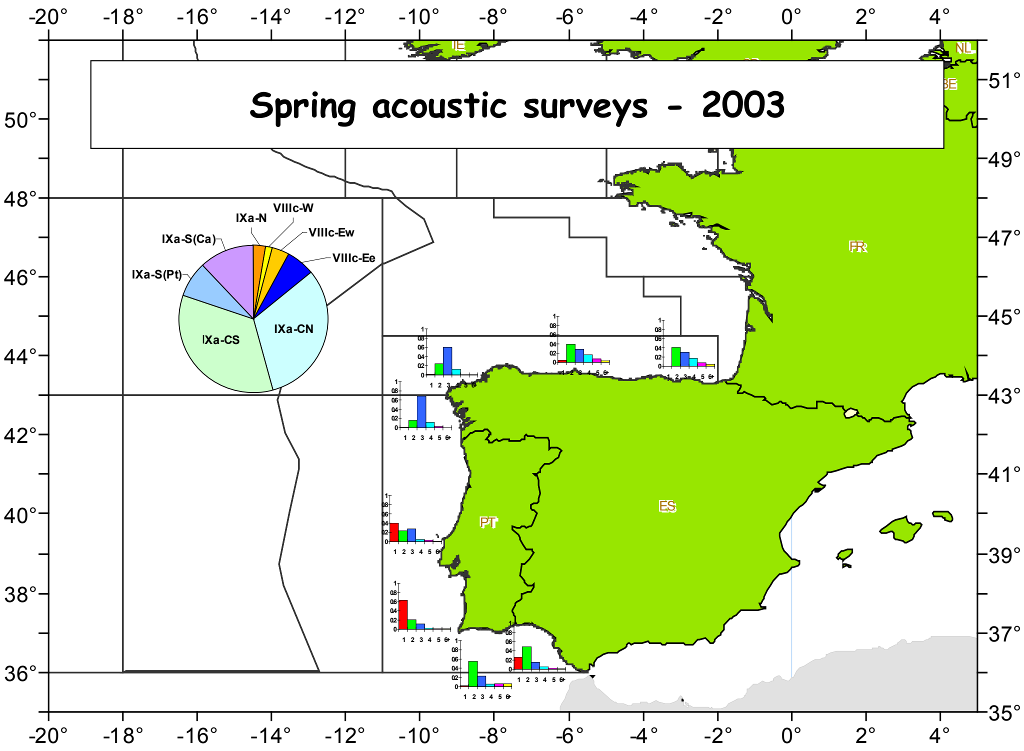


Figure 2.3.2.1.2. Distribution of sardine biomass by age (small histograms) in the different ICES subareas, as well as global importance in biomass of the different areas (pie chart). Each histogram has its own scale while the pie chart gives the comparative biomass level across areas.



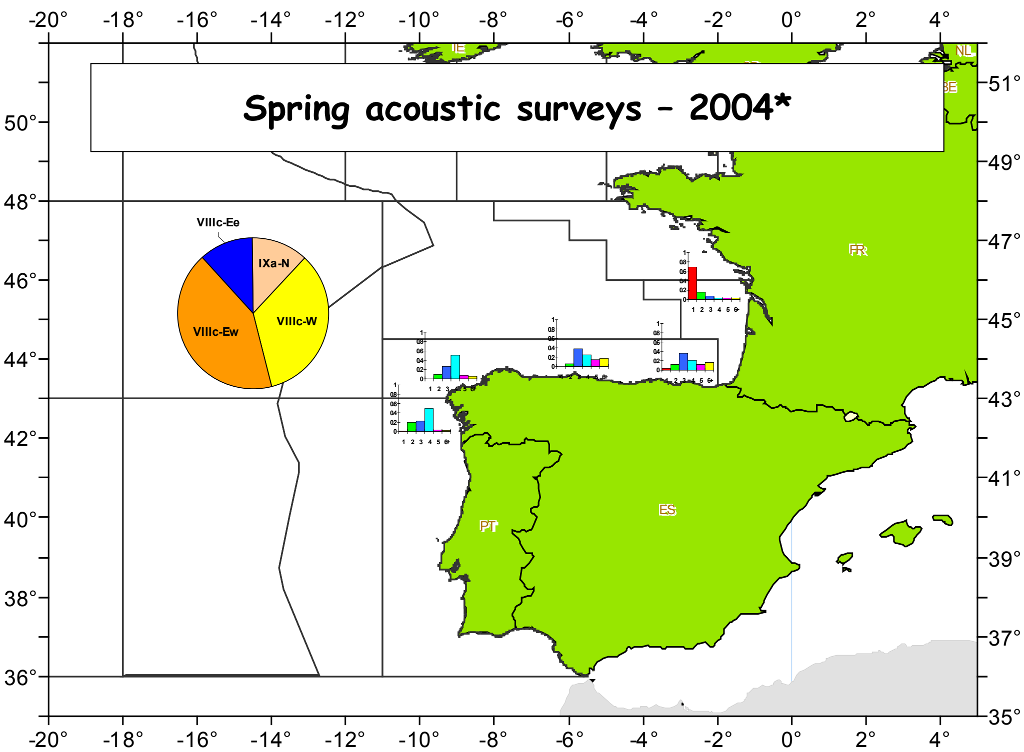
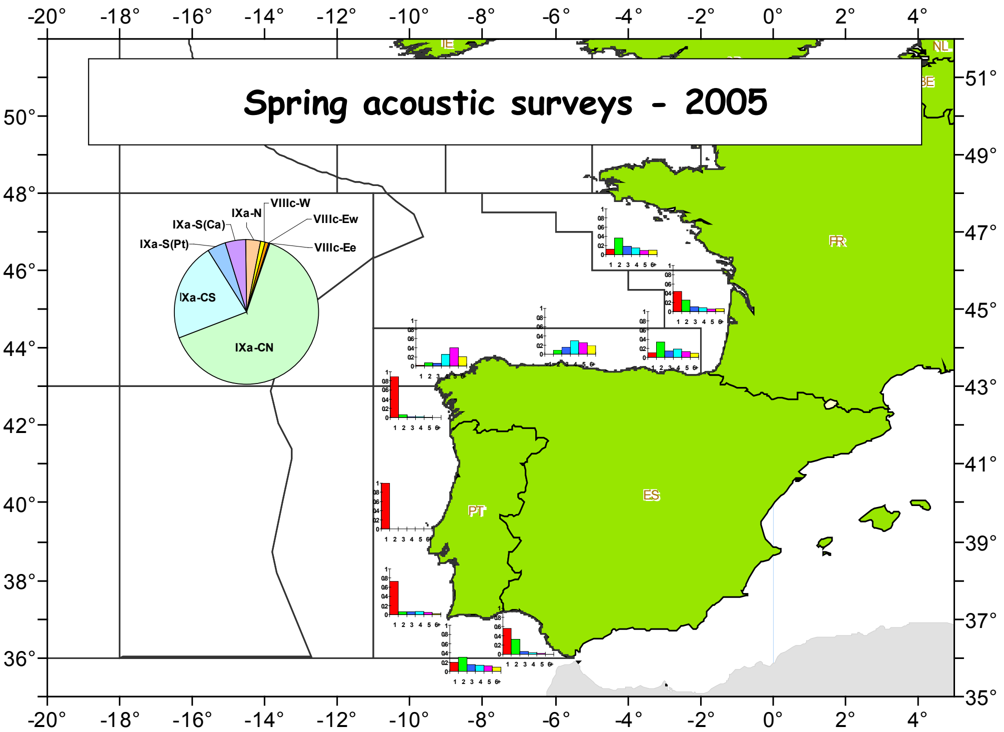


Figure 2.3.2.1.2 (cont): Distribution of sardine biomass by age (small histograms) in the different ICES subareas, as well as global importance in biomass of the different areas (pie chart). Each histogram has its own scale while the pie chart gives the comparative biomass level across areas.



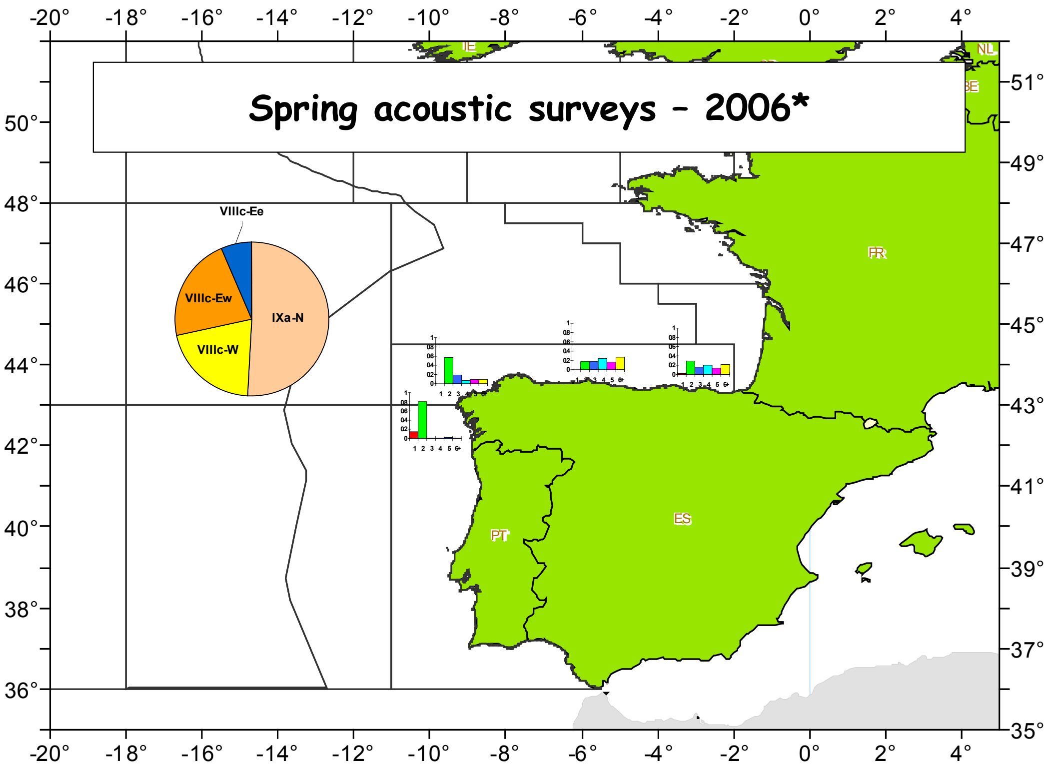


Figure 2.3.2.1.2 (cont): Distribution of sardine biomass by age (small histograms) in the different ICES subareas, as well as global importance in biomass of the different areas (pie chart). Each histogram has its own scale while the pie chart gives the comparative biomass level across areas.

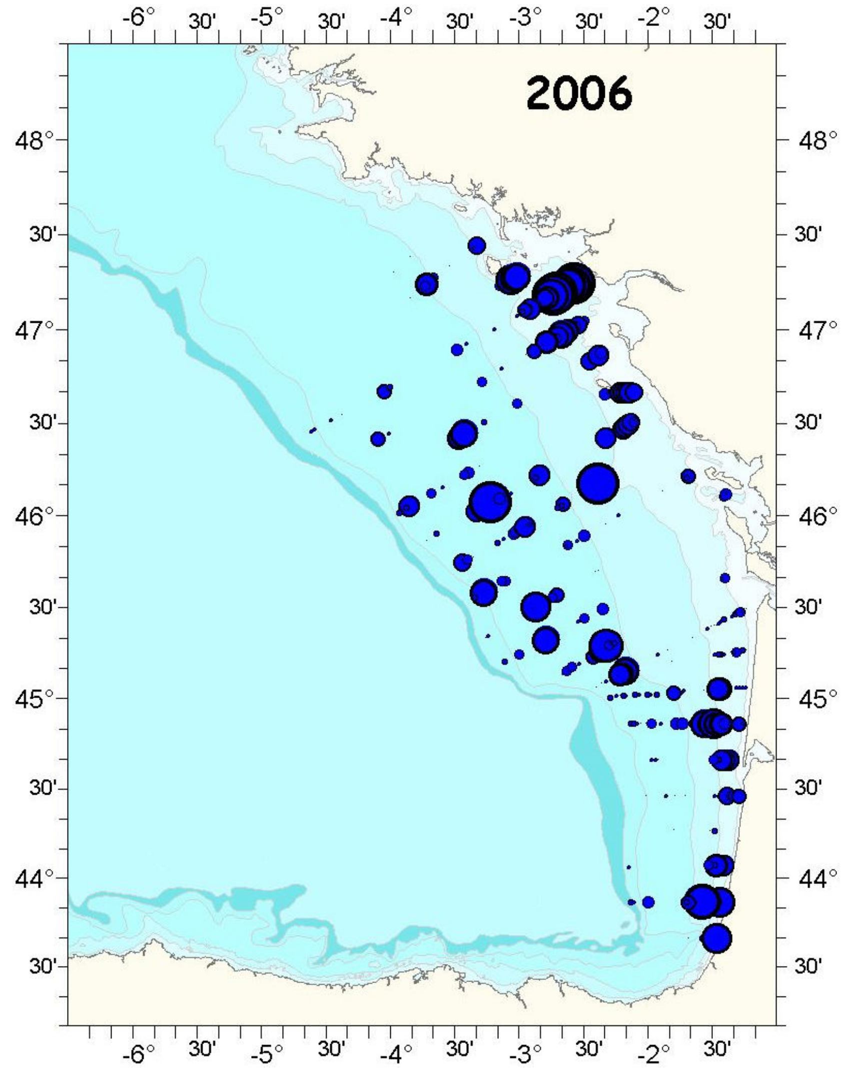


Figure 2.3.2.2.1.1. Sardine distribution in the Bay of Biscay as observed during the PELGAS06 acoustic survey.

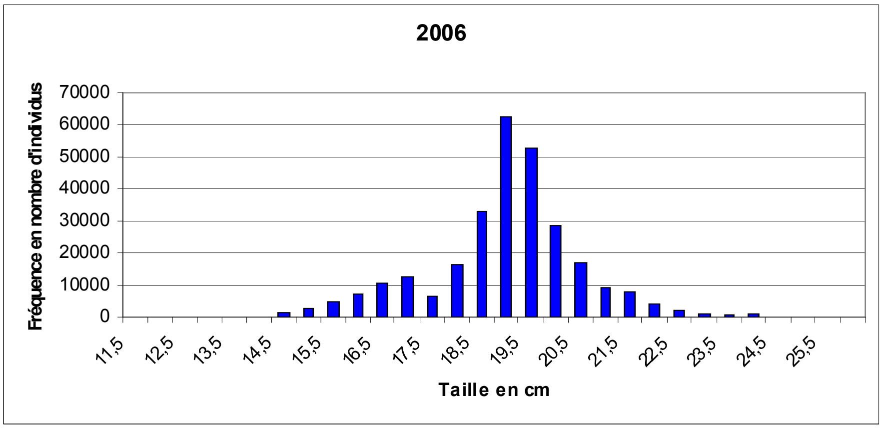


Figure 2.3.2.2.1.2. Sardine length distributions as observed during PELGAS06.

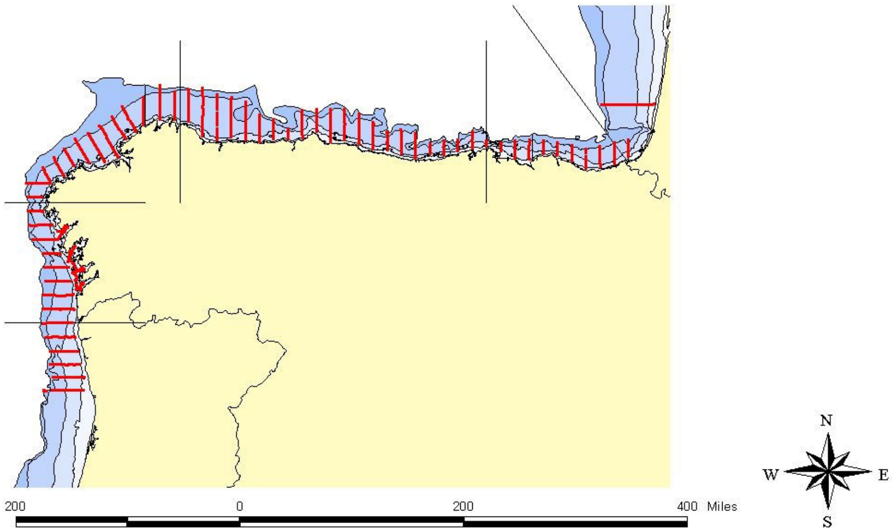


Figure 2.3.2.2.2.1. Survey design of Pelacus0406 acoustic survey.

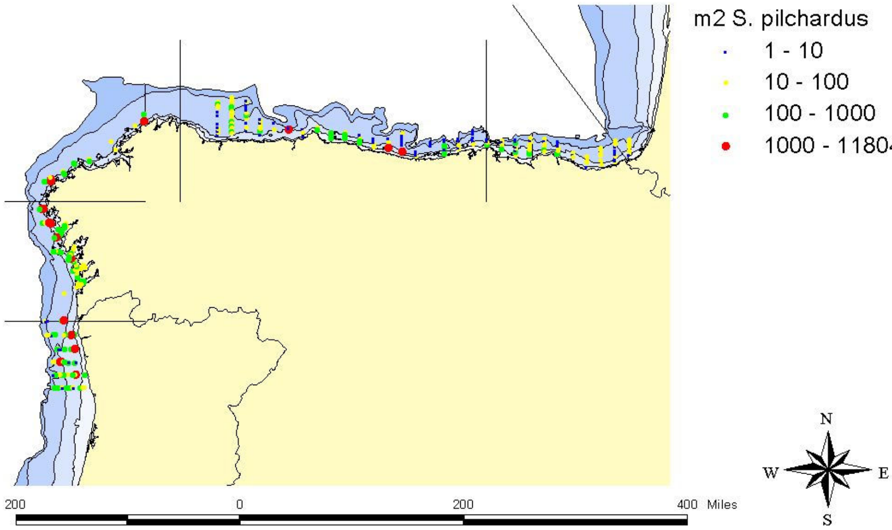


Figure 2.3.2.2.2.2. Total sardine NASC (nautical acoustic scattering coefficient, m2/mni2) detected during the Pelacus0406 acoustic survey.

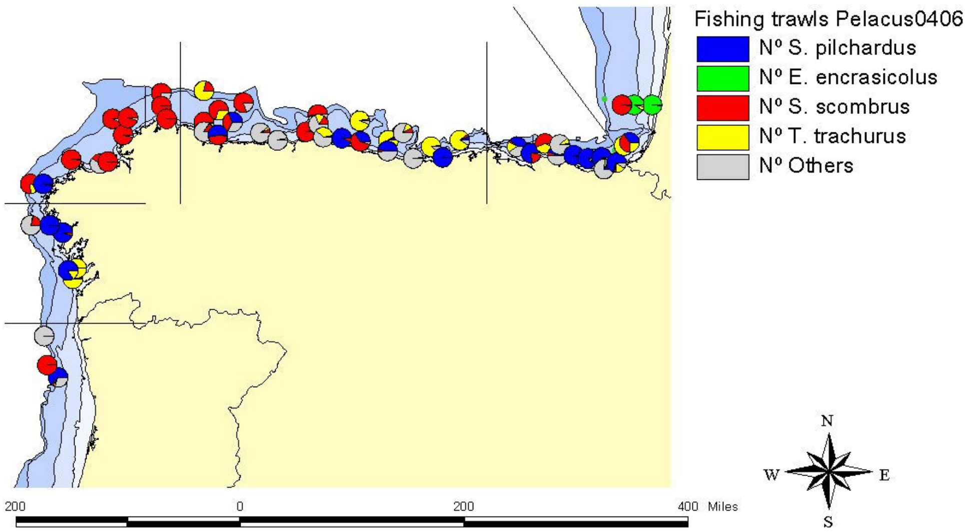


Figure 2.3.2.2.2.3. Total fishing trawls (n= 61) carried out during the Pelacus0406 acoustic survey.

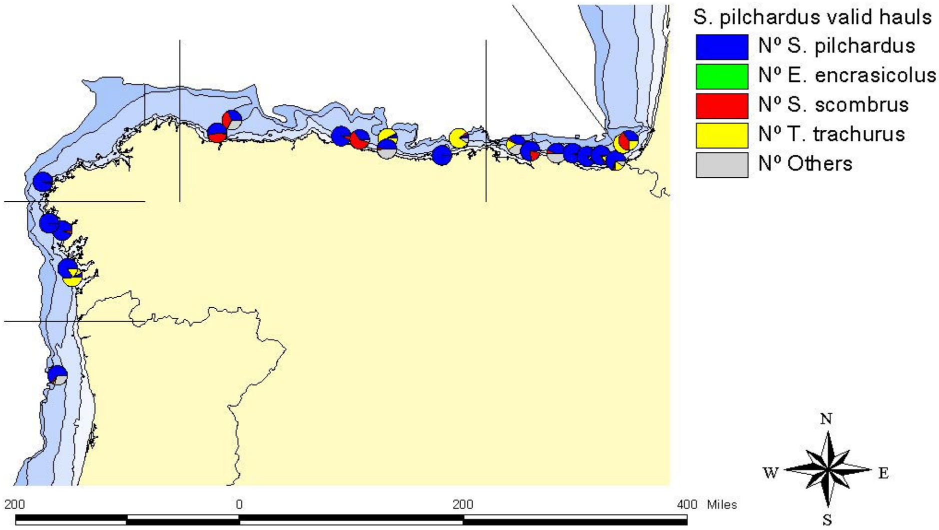


Figure 2.3.2.2.2.4. Sardine valid fishing trawls carried out during Pelacus0406 acoustic surveys. Charts represent percentage in number of species individuals in each fishing trawl.

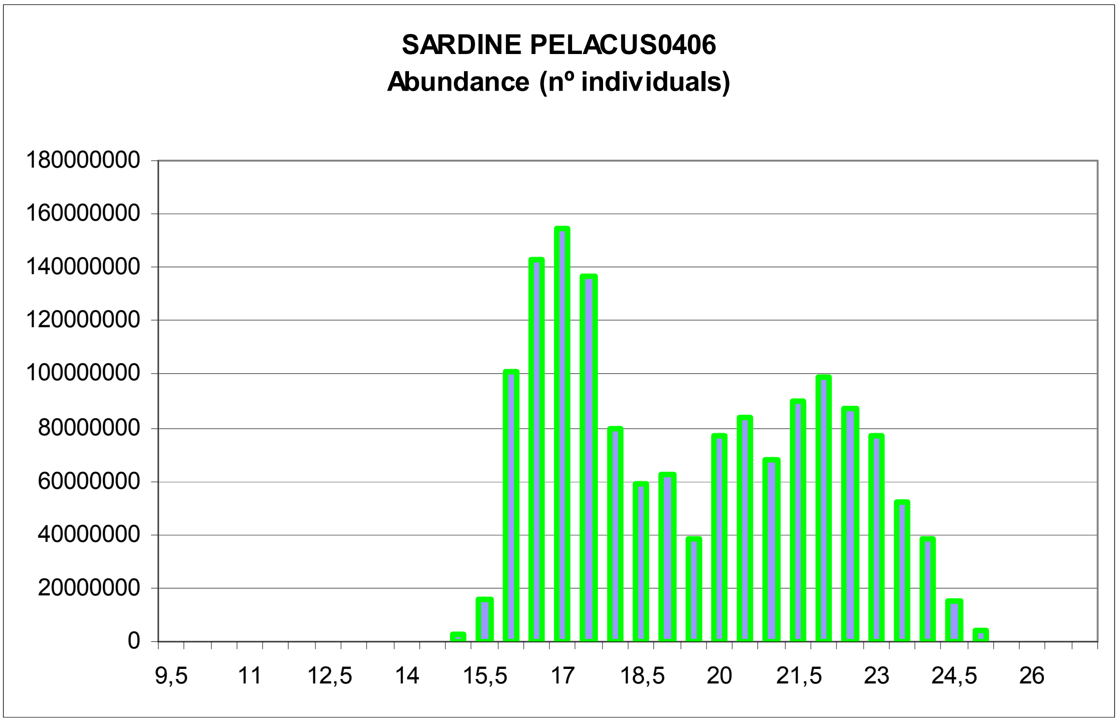


Figure 2.3.2.2.2.5. Sardine abundance (nº individuals) by length estimated during the Pelacus0406 acoustic survey.

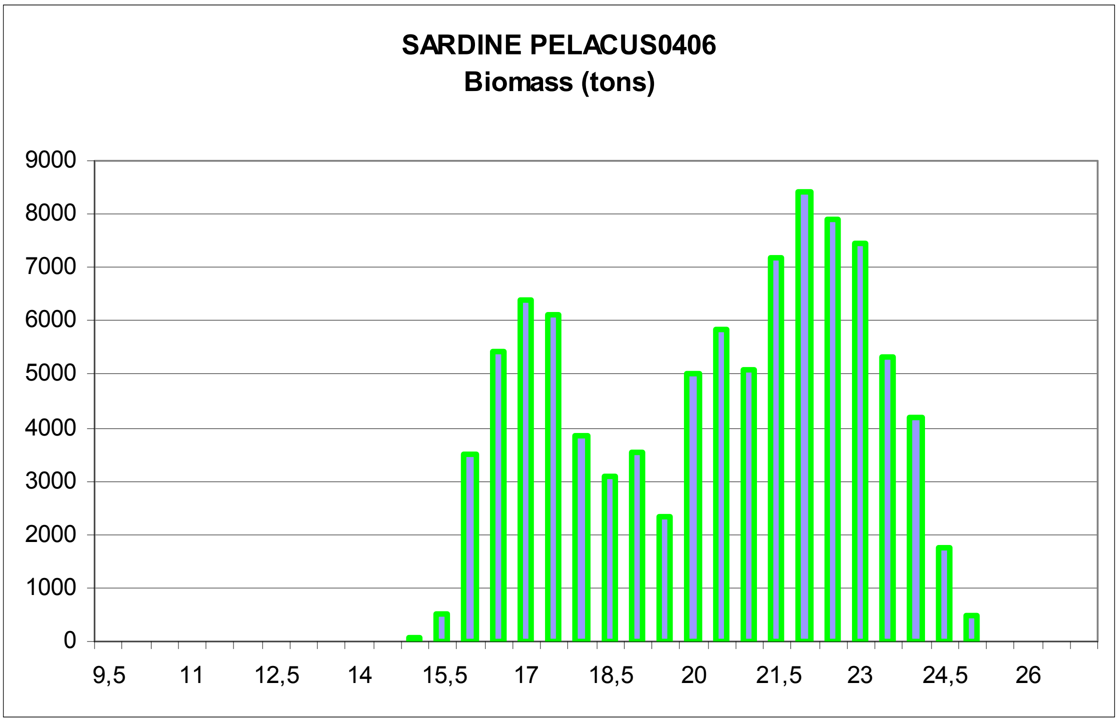


Figure 2.3.2.2.2.6. Sardine biomass (tons) by length estimated during the Pelacus0406 acoustic survey.

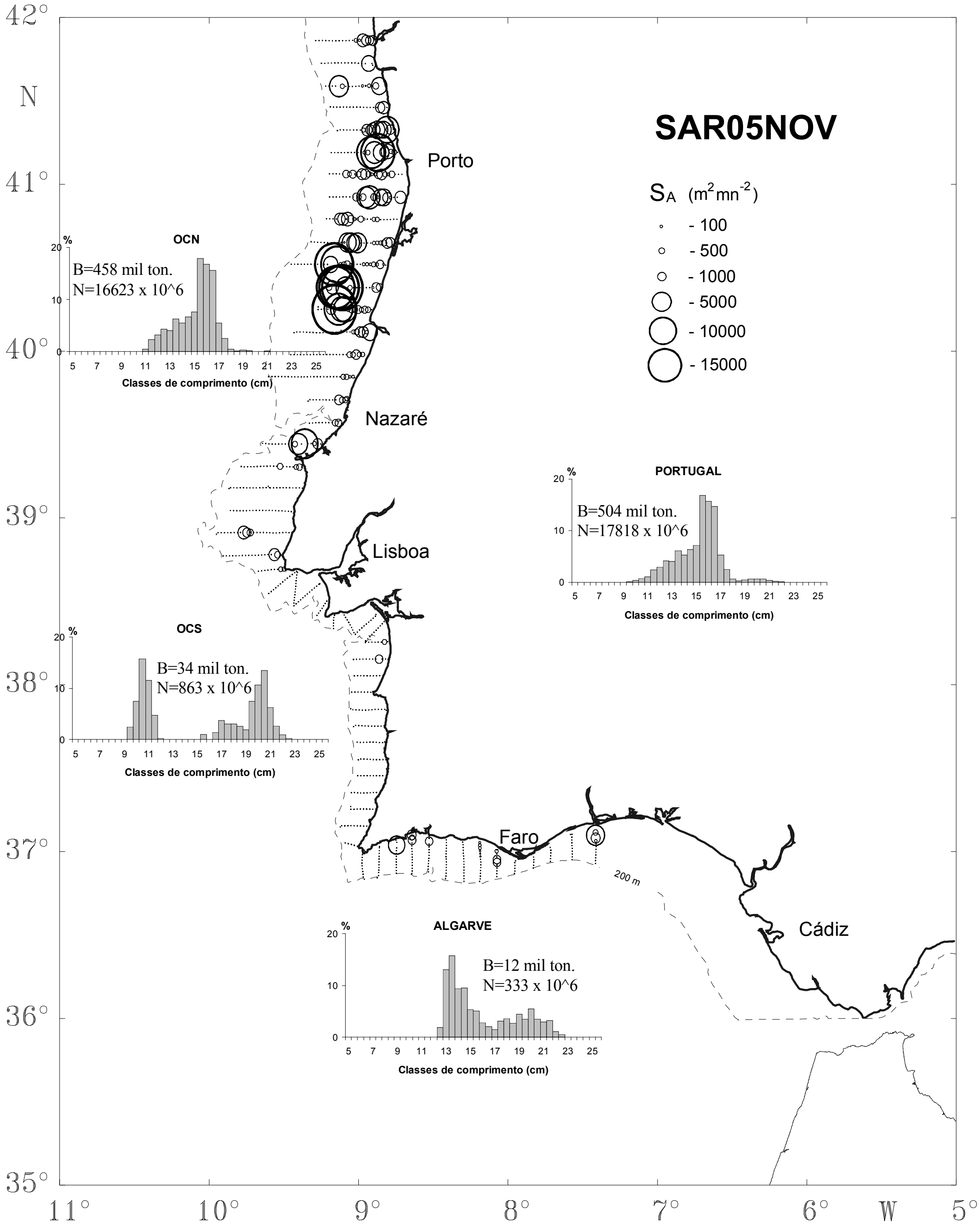


Figure 2.3.2.2.3.1. Sardine in Division IXa: acoustic energy distribution per nautical mile during the November 2005 Portuguese survey. Circle diameter is proportional to the acoustic energy (S_A: m^2/nm^2). Sardine abundance and length structure for each zone.

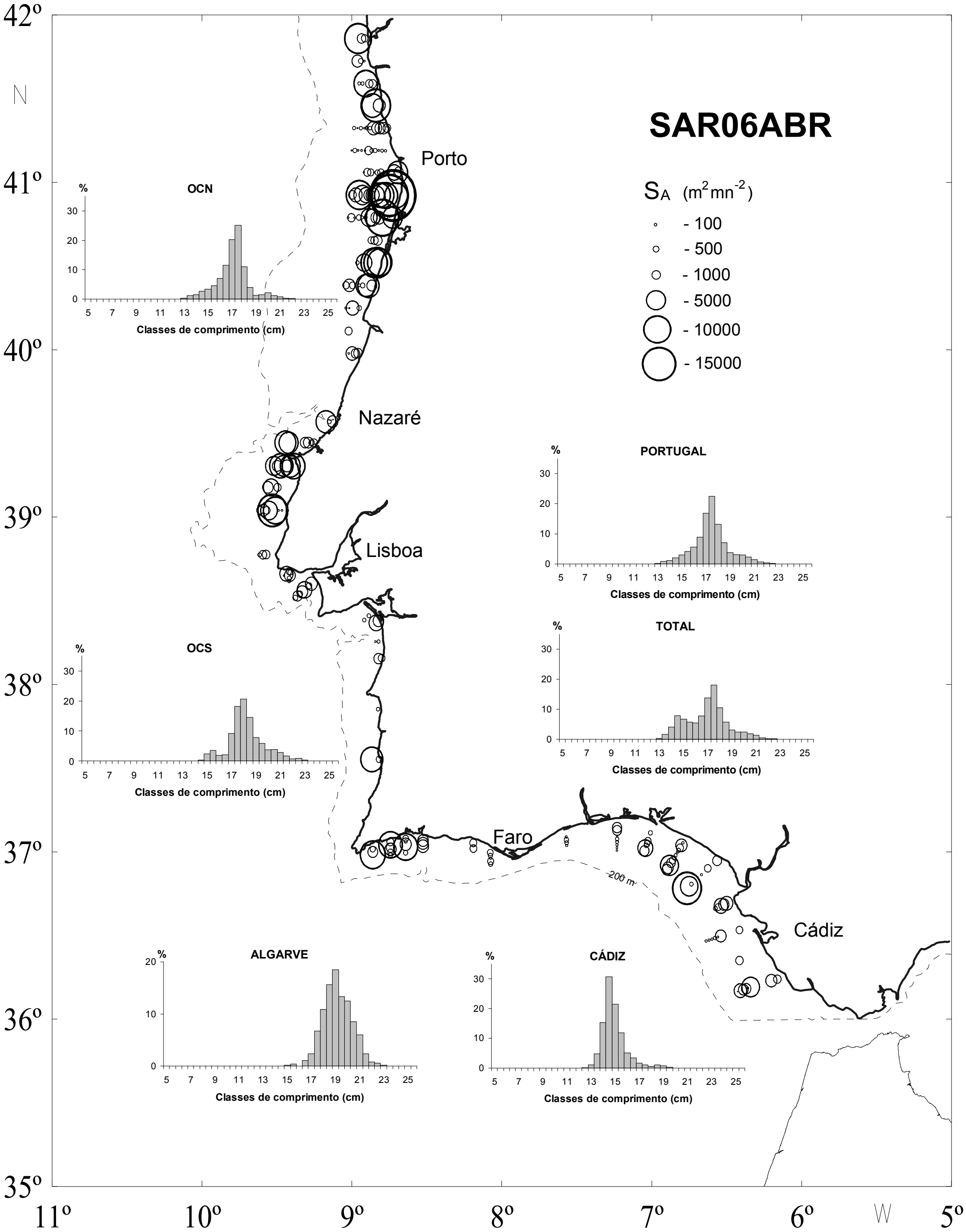


Figure 2.3.2.2.3.2. Sardine in Division IXa: acoustic energy distribution per nautical mile during the April 2006 Portuguese survey. Circle diameter is proportional to the acoustic energy (S_A: m^2/nm^2). Sardine abundance and length structure for each zone.

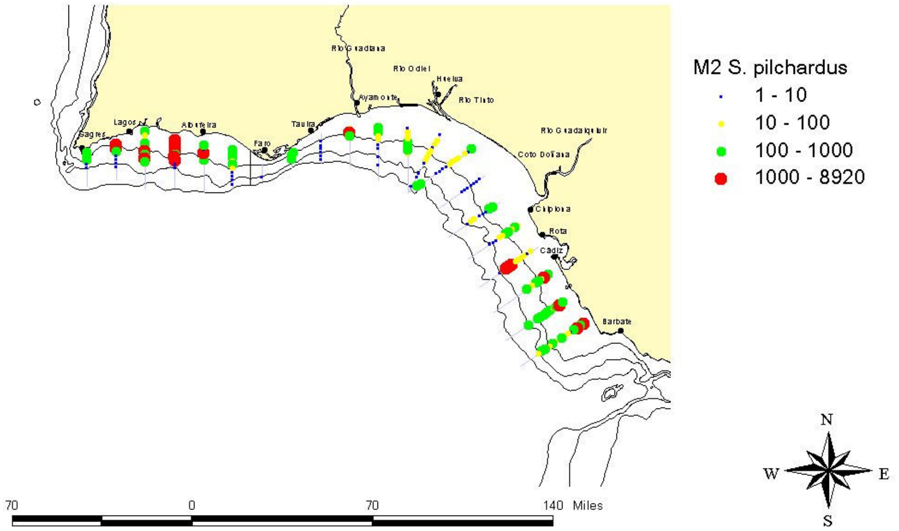


Figure 2.3.2.2.3.3. Sardine in Subdivision IXa South: acoustic energy distribution per nautical mile during the June 2006 Spanish survey. Circle diameter and colour scale are proportional to the acoustic energy (S_A). Homogeneous size-based post-strata used in the biomass/abundance estimates are also shown.

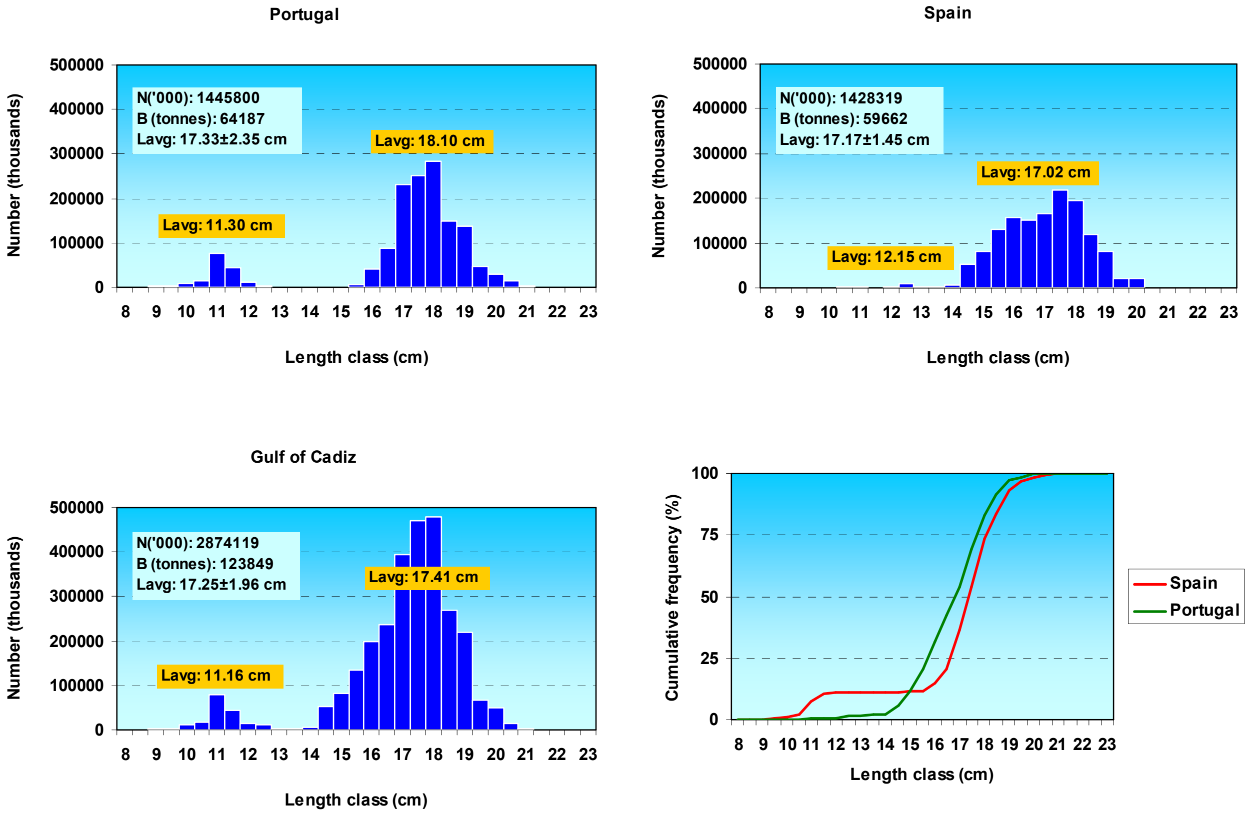


Figure 2.3.2.2.3.4. Sardine in Subdivision IXa South: estimated abundance by length class by region and total area during the June 2006 Spanish acoustic survey. Bottom right: cumulative frequency (%) by length class and region.

3 Planning and coordination of next acoustic and egg production surveys

3.1 Planning and coordination of acoustic surveys in region VIII and IX

3.1.1 Juvenile surveys

Surveys aiming at estimating the abundance and spatial distribution of anchovy juveniles in autumn are of interest in order to try to estimate the expected level of anchovy recruitment.

For the last years, several surveys have taken place, some oriented to the assessment of juvenile distribution and abundance and others to the study of recruitment processes (Annexe Special Request).

The ACFM of ICES: "endorses the STECF conclusions about the need to coordinate surveys aiming at providing juvenile abundance indices. ICES considers that a single successful coordinated acoustic survey on estimating juveniles as age 0 in quarter 4, should be sufficient to forecast recruitment".

The WGACEGG considered that the best coordination of the different institutes to produce a single coordinated survey-project will be one assuring continuity and improvements over the already available acoustic series of anchovy juvenile cruise aiming to provide a recruitment index (2003–2006 for Juvena) (2006 for Pelacus10) –Section 2.2.2.3 . In addition the WG considered that the information on recruitment process that has been collected through different surveys of the area (Juvaga in 2003 and 2005, and Pelacus10 in 2006) is also of great importance and therefore it should be considered and endorsed by any future survey-project.

The Goals of this survey-project will be:

1) Estimating the abundance and spatial distribution of anchovy juveniles in autumn in the Bay of Biscay.
2) Estimating the abundance of the main components of the fish pelagic community in the surveyed area.
3) Study their biological condition (growth, weight) and that of the main accompanying species of the pelagic community.
4) Characterizing the environmental conditions (hydrodynamic and plankton) of the surveyed area.
5) Test and study recruitment processes by directed intensive sampling of selected areas.

According to the aforesaid goals, the WGACEGGS considered that a coordinated survey-project should assure:

a) Geographical surveyed area. The survey-project should be able to cover at least the main potential area occupied by juveniles, that is, east of 5º W and south of 47ºN according to Figure 2.2.2.3.2.1. However, it must be possible to extend this area to the north up to the 48 º N and to the west up to the 6 º W if supplementary information (e.g. provided by the French and Spanish commercial fleets) justifies it. Sampling in those extra areas could be made according to a less intensive, but adaptive, sampling scheme.
b) Surveying period. The preferential temporal window will be as soon as possible in September in order to finish not later than mid of October, for an effective 30 days of work at sea for each vessel, given the large area which is proposed to cover and the proposed goals.
c) Number of vessels. At least two vessels are necessary to assure the foreseen coverage and goals. Small boats have the ability to operate in shallow waters but with limitations in their autonomy or sensitivity to weather disruptions, while big vessels have difficulties in covering the shallowest areas but are more capable to

cope with bad weather conditions and will be able to perform multidisciplinary studies.

d) Fishing operations. The fishing gears must ensure identification of those echo traces found near the surface or close to the bottom.

e) Survey design. For the estimation of the juvenile abundance and spatial distribution, systematic sampling of coastal and off-shelf oceanic grounds by tracks perpendicular to the coast must be carried out. Two different options were proposed:

  i) Both vessels will cover the area simultaneously, following alternate transects, with some common tracks for inter-calibration of their performance. The smaller vessel will in addition assure the coverage of the coastal area whereas the large vessel will focus in the offshore regions. In this way, parallel and joint coverage of the whole area will be made. The proposed inter-space transect distance for each vessel is 24 nm, as a compromise to satisfy the requirements of area coverage and precision of the estimated index, resulting in an effective inter-transect distance of 12 nm when the data for both vessels are pooled together.

  ii) Alternatively, another survey design was proposed, based upon splitting the global area in two regions: a northern and a southern region, with an intermediate area of common coverage for inter-calibration of the vessels (for instance in the Garonne region). The larger vessel could cover the area to the north of 45 ºN, and the smaller vessels could cover the remainder southern region. However, this alternative survey design would not satisfy all the above goals.

The WG considers the first proposal (a) for the survey design is better. Nevertheless, this proposal requires perfect coordination and synchronous survey time allocation among the different boats. If these requirements are not achieved, then the alternative option (b) can be considered.

f) Once the area proposed for the estimation of the recruitment index has been covered, the vessel with extended capabilities for multidisciplinary work will return to the areas where juvenile patches were detected in order to carried out a sampling strategy focused on the relevant ecological processes / mechanisms (i.e. hydrodynamic conditions, behavioural pattern, etc.) relevant for a comprehension of the process of recruitment.

The WG consider this survey will require a strong coordination and a shared project among institutes.

3.1.2 Pelagic community surveys (spring surveys)

Acoustic spring surveys carried out by the different institutes off the Iberian Peninsula are in general regarded as well coordinated. Nevertheless, there is scope for further coordination on the use of the data, the analysis tools and also possibilities to extent some of the common objectives across surveys to improve the knowledge of the pelagic ecosystem, therefore improving the ecosystem approach to pelagic fish communities. Main issues related to planning and coordination of next year acoustic surveys identified during this year WG are:

1) Proposal for a common database to improve the access to acoustic data from the different institutes, and therefore improve the capabilities of shared analysis, intercalibration, etc;

2) Necessity of planning an intercalibration among IPIMAR and IEO in order to ensure comparability of the biomass estimates of sardine and other pelagic fishes.

Also, the comparability and coordination of the different surveys was discussed on regional and national basis;

1) In relation to the northern Iberia and adjacent waters acoustic surveys (carried out by IEO and IFREMER), the two surveys PELGAS (IFREMER) and PELACUS (IEO) are carried out on-board the same vessel (“Thalassa”) and chronological between the beginning of April to the end of May. They cover the global Bay of Biscay from the north of Portugal to Brest following a standardized transects network perpendicular to isobath. The two surveys combine acoustics (5 frequencies), pelagic trawling, CUFES and hydrology. More and more collaboration allow French and Spanish scientist to share tools (LOPC, XBT, nets, …) and competence during both surveys. The WG members discussed the possibility of combining the two surveys in a common project in the near future in order to consider them as a single survey in the near future.

2) In relation to the north Iberia and west and south Iberia acoustic surveys (carried out by IEO and IPIMAR), both surveys are carried out with similar equipment, but on-board different Research Vessels. Also, the strategy to choose the fishing hauls shows some differences, with IPIMAR hauls chosen mainly to identify sardine echo traces, while IEO hauls chosen to cover the depth and longitudinal range of distribution and provide samples from the whole fish pelagic community. An intercallibration of the surveys in the northwest Iberian Peninsula area will be desirable in order to improve the comparability of the surveys used for assessment of the Iberian sardine stock (ICES 2006b). The WG recommends assessing the viability of trying to cover this area at the same time during next surveys. In order to do so, the survey timing should be adjusted, and the WG acknowledges that this may not be easy to achieve for the next year, but could be done in following years.

3) For the surveys carried out in the southern Iberian Peninsula (IPIMAR and IEO), they are carried out in different seasons, as the main target species is sardine (IPIMAR) and anchovy (IEO). The timing of the surveys is regarded as adequate by the WG, and results across surveys, even with the temporal difference, are quite similar for the last years. There is scope for the coordination in autumn, when the northern Portuguese sardine juvenile area is covered by an IPIMAR survey, but the Gulf of Cádiz is not always covered. One possibility discussed will be the option of a coordinated autumn juvenile survey on the west and south Iberian Peninsula, but this idea should be further developed.

Apart from the coordination and planning of next acoustic surveys, the WG have devoted some time to the possibility of defining and using a common database and analysis tools for the acoustic data off the Iberian Peninsula and the Bay of Biscay. In order to standardize procedures between institutes, integrate their survey data and jointly produce regional scale maps of fish distributions a common database for acoustic surveys was suggested. The objective would be also to allow the codification (numerically) of the different expert judgements made in assigning echo traces to species, which is the main questionable criteria from an institute to the other, according to their own experience and particular multispecies communities. This would allow later comparisons between procedures and discussions when scrutinising (interpreting) echograms.

The information necessary for making the acoustic computations could be organized in a generic way using a list of tables. Some tables would contain acoustic information only, others haul information only, others biological information only. The structure of an IFREMER database (BARACOUDA – Coppin *et al*. 2003) was suggested and described (Figure 3.1.2.1. – WD – Petitgas *et al*., 2006) and an example was attempted during the WG with 2 days of survey carried out by IEO in southern Iberia last year. The exercise showed that the database was adaptable to other surveys than IFREMER one and a map of species distributions was realized.

A database of scripts is associated to this BARACOUDA database, in order to perform the acoustic computations for assessment and mapping. The WG agreed to follow up this exercise and try for each Institute to produce the text files which are required for at least one survey for the next WGACEGG.

Once this database structure will be agreed, the different expert coding (scrutinised echo traces) could be analysed and discussed, and therefore could increase the reliability of echogram interpretation. In this objective, inter-calibration workshops for echogram interpretation could be envisaged as it is current practice for otolith readings. Finally, all data would be stored at the same format and maps and biomass estimates would be carried out using the same procedure.

3.2 Planning and coordination of DEPM surveys in region VIII and IX

3.2.1 Planning of next anchovy DEPM survey

The next DEPM survey to estimate the spawning-stock biomass (SSB) of anchovy and the numbers-at-age of the population in the Bay of Biscay will be carried out from the 8–29 May 2007. This year the survey Bioman 07 will be split into two vessels: The RV “Investigador” were the plankton samples will be obtained and the RV “Enma Bardan” or a purse-seiner were the adults will be collected with a pelagic trawl or a purse-seine. Both vessels will be in contact and will navigate in parallel during all the survey. Moreover and in the same manner as in the last years, extra adult samples will be obtained from the fleet (purse-seiners) and from the survey Pelgas 07, conducted by Ifremer, on-board RV “Thalassa” (pelagic trawls).

The next DEPM survey to estimate the SSB of anchovy in Cadiz will be done in 2008.

3.2.2 Planning of next sardine DEPM survey

Next sardine DEPM will be carried out in 2008 and it will be planned in the 2007 WGACEGG meeting.

3.2.3 Towards an application of DEPM for horse mackerel (*Trachurus trachurus*) from the southern stock

Since 2004 (ICES, CM 2005/ACFM:08) a new geographic definition of the horse mackerel southern stock has been adopted, corresponding to ICES Division IXa (from Gibraltar to Finisterre). This new definition was based on research carried out during the EU funded HOMSIR project (ICES CM 2005/G:09 Ref.D).

In addition, as was reported by the WGMEGGS 2006, there are strong and consistent evidences that horse mackerel is an indeterminate spawner (Abaunza, *et al*., 2003, ICES, 2003). During the 2006 WGMEGGS was agreed that the southern stock spawning biomass will be assessed by Portugal and Spain during the spawning season by means of the Daily Egg Production Method (DEPM). In 2007 IPIMAR will be responsible to carry out the first dedicated survey for applying the DEPM to the southern stock of horse mackerel.

Several studies have been carried out at IPIMAR for preparing the application of DEPM for horse mackerel, some results were presented during WGACEGG 2006:

3.2.3.1 Adult phase

The current study shows more evidences that horse-mackerel is an indeterminate spawner (Figure 3.2.3.1.1 and Figure 3.2.3.1.2). The increase of the total number of oocytes per gonad during the spawning season, may be explained by a continuous production of new pre-vitellogenic oocytes what is a characteristic of fishes with an indeterminate reproductive strategy (Greer Walker *et al.*, 1994; Hunter *et al.*, 1985; Hunter and Macewicz, 1985), because the production of pre-vitellogenic oocytes occurs in a continuous series of shorter cycles over a long time period (Greer Walker *et al.*, 1994; Hunter *et al.*, 1985). In indeterminate spawners the mean diameter of vitellogenic oocytes does not increase during the spawning season, which is in accordance with our results (Greer Walker *et al.*, 1994). The observed decrease on the mean diameter of pre-vitellogenic and vitellogenic oocytes may be explained by energetic fatigue as a result of the continuous production of oocytes during a long period of spawning. Another explanation may be the result of a large number of atretic oocytes that are present on the ovaries at the end of the spawning season. These atretic oocytes are in general much smaller than non-atretic which resulted in a smaller mean diameter and larger standard deviation when compared with periods with lower atresia (Greer Walker *et al.*, 1994; Hunter *et al.*, 1985; Hunter and Macewicz, 1985).

The data used in the present study for adult DEPM parameters estimation were collected in the surveys carried out in January of 2002 (sardine DEPM survey), January, February and March of 2004 (horse-mackerel AEPM) and March of 2005 (sardine acoustic survey).

The mean batch fecundity (F) was estimated based on the number of hydrated oocytes present in the gonads as described by Hunter *et al.* (1985) and Watson *et al.* (1992): three pieces of about 0.10g each from one lobe of the ovary were cut and weighed and the number of hydrated oocytes present in these pieces were counted. The weights as well as the number of oocytes of each one were summed and the number of hydrated oocytes extrapolated for the total weight of the ovary. Figure 3.2.3.1.3 shows batch fecundity estimation for each survey. The increase in batch fecundity observed along the spawning season of 2004 is in agreement with the pattern expected for indeterminate spawners. According to Hunter *et al*, 1985, in multiple spawners, the total fecundity increases as the spawning season progresses.

To estimate the spawning fraction (S) three methodologies were applied: migrated nucleus (MN), hydrated oocytes (HO) and post-ovulatory follicles (POFs). The proportion of female gonads presenting each of these three characteristics in the sample was determined.

For this analysis only the presence or absence of POFs in the slides was identified and their proportion in the sample was registered according to three assumptions based on the literature for other species (Ganias *et* al, 2003; Agarwal *et al*, 1992; Contreras and Rodriguez, 1988; Goldberg *et al*, 1982): 1) it is admitted that the presence of POFs in the samples corresponds to three different daily cohorts: day 0, day 1 and day 2; 2) all cohorts have the same probability to be found in the samples; 3) the number of females spawning each day (S), in each sampling station, corresponds to the proportion of females with POFs divided by 3 (the 3 daily cohorts). These assumptions were adopted because the results of the distribution of spawning females along the day revealed that horse mackerel probably does not have a preferential daily hour of spawning. The estimation of the spawning fraction for each cruise using the three methodologies is shown in Figure 3.2.3.1.4.

3.2.3.2 Egg phase

In order to adopt the DEPM for horse mackerel several studies concerning the eggs have been conducted at IPIMAR. Work developed includes:

- elaboration of a 11 stages embryonic development scale (Vendrell *et al.*, 2003)
- revision of all plankton samples (AEPM and DEPM surveys) from 1998–2005 for horse mackerel egg identification and classification in 11 stages (see Table 3.2.3.2.1)
- experiments on egg development at different temperatures (Vendrell, 2005)

Trachurus trachurus egg presence distribution, from all surveys analysed, is shown in Figure 3.2.3.2.1, eggs appeared over the entire shelf and slope of the area considered but to the north of Cape Carvoeiro (north of Lisbon), where the platform is wider, the frequency of occurrence was lower. Egg presence was observed in some stations beyond the 200 m isobath.

Artificial fertilization experiments were undertaken successfully, on-board the research vessel, during 3 surveys and using incubation baths at 6 (4 in one occasion) different temperatures, eggs were collected at fixed time intervals and preserved for staging in the laboratory. Figure 3.2.3.2.2 shows the results from the artificial fertilization experiments conducted during the

2004 egg survey. Egg development through to hatching only occurred within the temperature range 11.7°C –19°C. At 11ºC eggs only developed through to stage IV (the outline of the embryo is clearly discernible and defined in the median line of the embryonic shield) even after 60 hours, dying thereafter. The time of egg development lasted from 46 hours at 19ºC to a maximum of 120 hours at 12ºC.

3.2.3.3 Difficulties related to the application of DEPM to *Trachurus trachurus* from the southern stock

- patchiness of egg distribution and lower abundances than for sardine and anchovy
- little knowledge of the vertical distribution in the area
- estimation of egg mortality
- lack of clear daily spawning synchronicity
- little knowledge of the duration of POFs degeneration that leads to uncertainty in estimating POFs dating
- uncertainties related to the segregation distribution between spawning and non-spawning females

3.2.3.4 Activities for 2007: Horse mackerel DEPM draft survey plan (recommendations)

The survey will be carry out from Finisterre to Gibraltar from January 29 to 4 March, starting from the south to try to be at the peak spawning time in each area.

3.2.3.4.1 Plankton survey strategy

- Vertical PairoVET (2 CalVET). 150µm + CTDF
    - Maximum depth 200 m. In shallower waters 5 m above the bottom.
    - Transects spaced 12 nm, perpendicular to the coast.
    - Stations spaced 3 nm. In the north (over wider shelf) 3 stations after 200 m and in the south 5 stations after the 200 m
- Oblique Bongos (40 cm) 250 µm
    - Maximum depth 200 m. In shallower waters 5 m above the bottom.
    - 3 samples per transect (or alternate transects depending on time availability); coast, 200 m and offshore from the 200 m line

3.2.3.4.2 Adult survey strategy

For the application of DEPM methodology Portugal/IPIMAR will collect from each positive trawl (aim to approximately 20 over the whole area), a simple random sample of at least 300 fishes. Each fish will be measured, weighed and opened. The sex, maturity stage, fat and stomach fullness will be recorded, and in case it is a mature female (maturity stages 3, 4 and 5) the gonad will be carefully removed, and preserved in 4% buffered formalin. The sampling process will continue until at least 100 gonads of maturity stages 3, 4 or 5 are collected. In the case that 100 gonads are collected before the sample size reached 300 individuals, the sampling process continues until 300 individuals are sampled. For the maturity ogive, 30 gonads stages 1 and 2, from the 300 individuals sampled per haul will also be preserved for analysis in the laboratory. For batch fecundity estimation, all stage 4 females will be sampled and the gonads preserved. Hauls with less than 30 fishes will only be sampled for batch fecundity and female total weight; therefore, if less than 30 fishes are caught all fish will be sampled, but only gonads in stage 4 (with hydrated oocytes) will be collected and preserved in formalin.

3.2.3.4.3 Other recommendations (extra activities depending on logistics and time availability)

- Try to complete the results from previous years carrying out fishing hauls during 24 h period in the same area during the survey and parallel captivity experiments to have information in the pre and postspawning condition of the gonad.
- Experiments with the density gradient column on-board to assess the water column position of the eggs.
- Time permitting, conduct vertically stratified plankton hauls (WP2)
- In case the survey doesn't cover the Galician waters due to bad weather try to get the collaboration of IEO to collect the samples during their triennial survey that starts on the 14 March.
- Try to unify criteria for the classification of the POFs between IPIMAR and AZTI.
- Check if other *Trachurus* are spawning; if *T. picturatus* and *T. mediterraneus* are spawning try to carry out fertilization experiments in order to distinguish the eggs from three species.

3.2.3.5 Estimation of the adult parameters for Horse mackerel in the Bay of Biscay in terms of the DEPM

According to what had been decided in the WGMEGGS 2006 (ICES CM 2006/LRC:09): "In 2007 PIMAR and AZTI will undertake DEPM surveys within the context of the triennial survey…..The AZTI survey will be targeted on anchovy in Biscay, however, the opportunity to test DEPM adult sampling and methods for horse mackerel will be taken on this survey", AZTI will attempt to estimate the spawning frequency and the batch fecundity of horse mackerel in the Bay of Biscay during May which can be considered the time and area of peak spawning for this species. This study is done in the context of the supposed indeterminate characteristic of the horse mackerel (Abaunza *et al.*, 2003. ICES, 2003).

In this way AZTI, during the DEPM anchovy survey in May in the Bay of Biscay, will achieve approximately 30 pelagic trawls spread through the survey area. From each trawl a minimum of 100 individuals will be taken randomly registering the following biological parameters: total length, total weight, sex and maturity stage. In case it is a mature female (maturity stages 3, 4 and 5) the gonad will be removed, weighted and preserved in 4% formaldehyde. The objective is to obtain 50 mature females per trawl. When this objective is achieved, if the 100 individuals were not measured yet the sampling will continue until the 100 fish are measured, weighted, sexed and staged the maturity and more ovaries won't be preserved except if hydrated females appear. These ovaries will be kept for batch fecundity analysis.

When having sampled 100 individuals and the objective of 50 mature females hasn't been achieved another 25 fish will randomly be taken until a maximum of 50 is reached.

After the 50 mature females have been collected the rest of the haul will be targeted at hydrated females noting total length, total weight. Gonads should be preserved in 4% formaldehyde distinguishing these samples from those taken randomly.

For the Batch fecundity (F) estimates, the hydrated oocyte method will be followed (Hunter *et al.* - Lasker, 1985) and for the Spawning frequency estimate (S) the methodologies applied by IPIMAR, described above will be studied and applied.

3.2.4 Coordination of DEPM surveys

The Triennial sardine DEPM is carried out around the Iberian Peninsula by IPIMAR and IEO. The Sardine Eggs IEO survey extends as North as Arcachon (44º 40' N). For recent surveys, sardine egg data from the anchovy DEPM survey in the Bay of Biscay have been recovered within the framework of the EU project SARDYN, allowing a synoptic picture of sardine egg distribution within Atlantic European waters.

The working group considered interesting the full extension of the DEPM application to sardine in the Bay of Biscay up to 48º N. This can be accomplished by the inclusion of sardine as a target species for the application of the DEPM in the rest of the Bay of Biscay, being nowadays carried out by AZTI for anchovy every year. This would imply to complete the extension of surveying area for sardine eggs and the study of the Daily Fecundity parameters for this species in the years when DEPM of sardine is carried out. Collaboration with the acoustic parallel surveys in the Bay of Biscay will also help in the provision of adult samples for the daily fecundity estimates.

Implementing such expanded strategy in the Bay of Biscay would require some additional funding for the additional objectives to be included in 2008 (extension of sardine DEPM throughout the Bay of Biscay) in the already existing DEPM applications in the Bay of Biscay.

Table 3.2.3.2.1. Summary of information from the surveys (* sardine, DEPM; + horse mackerel AEPM). N. STAT means number of stations, POSIT STATIONS means positive stations.

	SURVEY	NET	MOUTH NET (CM)	MESH SIZE (μM)	N. STAT	POSIT. STATIONS	TOTAL OF EGGS	EGGS/M3	MAX./M3	EGGS/M2	MAX./M2
1998+	**Jan**	**Bongo**	**60**	**335**	**71**	**22**	**237**	**813**	**147**	**778 61**	**190 75**
1999*	**Jan**	**CalVET**	**25**	**150**	**417**	**98**	**367**	**88 33**	**580**	**7340**	**520**
2001+	**Jan**	**Bongo**	**60**	**335**	**109**	**8**	**251**	**160**	**081**	**195 28**	**94 80**
2002*	**Jan**	**CalVET**	**25**	**150**	**484**	**91**	**236**	**61 14**	**562**	**4720**	**340**
2004+	**Jan**	**Bongo**	**40**	**250**	**118**	**41**	**930**	**10 55**	**321**	**1301 40**	**468 36**
2005*	**Jan**	**CalVET**	**25**	**150**	**407**	**95**	**1342**	**342 38**	**47 35**	**26840**	**2600**

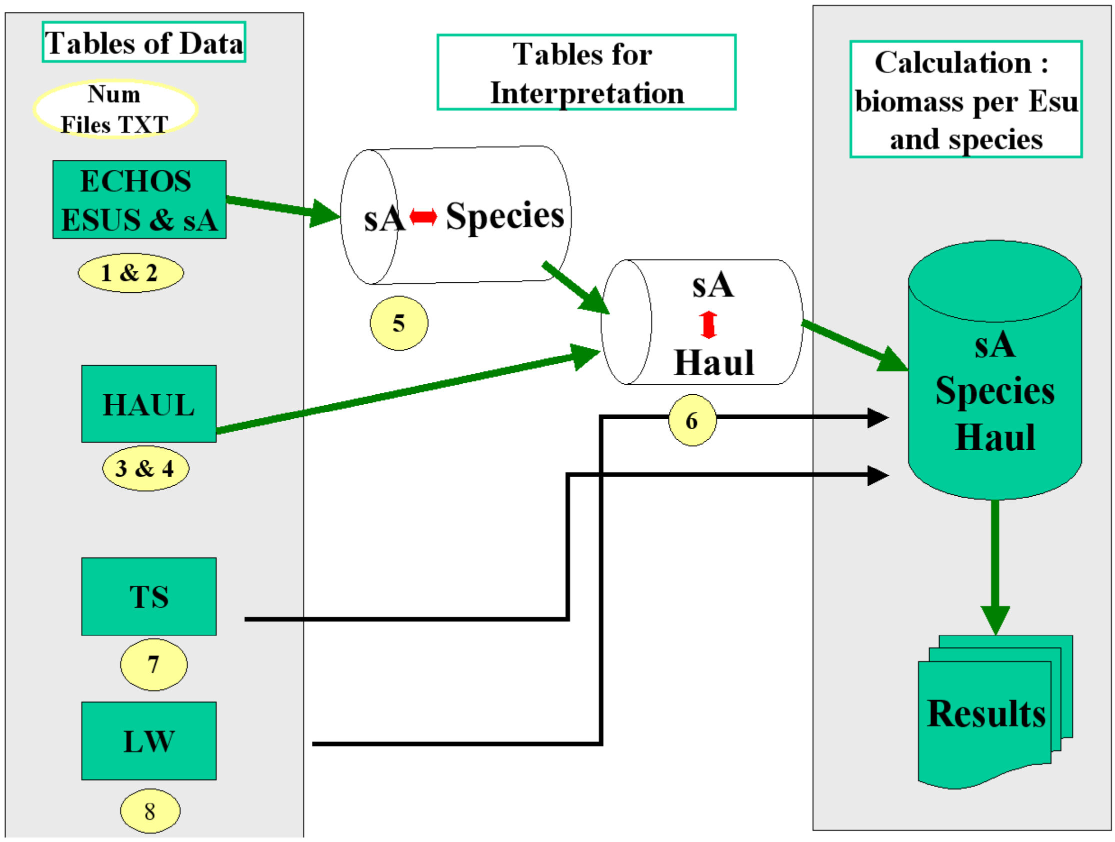
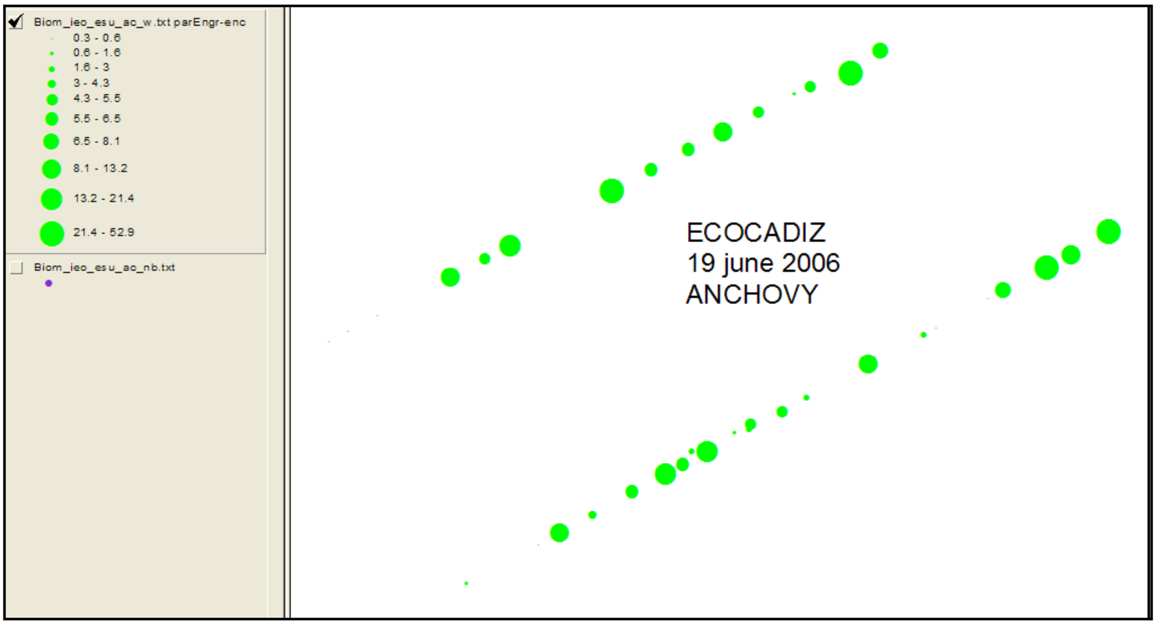


Figure 3.1.2.1. BARACOUDA database structure suggested to store and process acoustic surveys data in the same procedure.



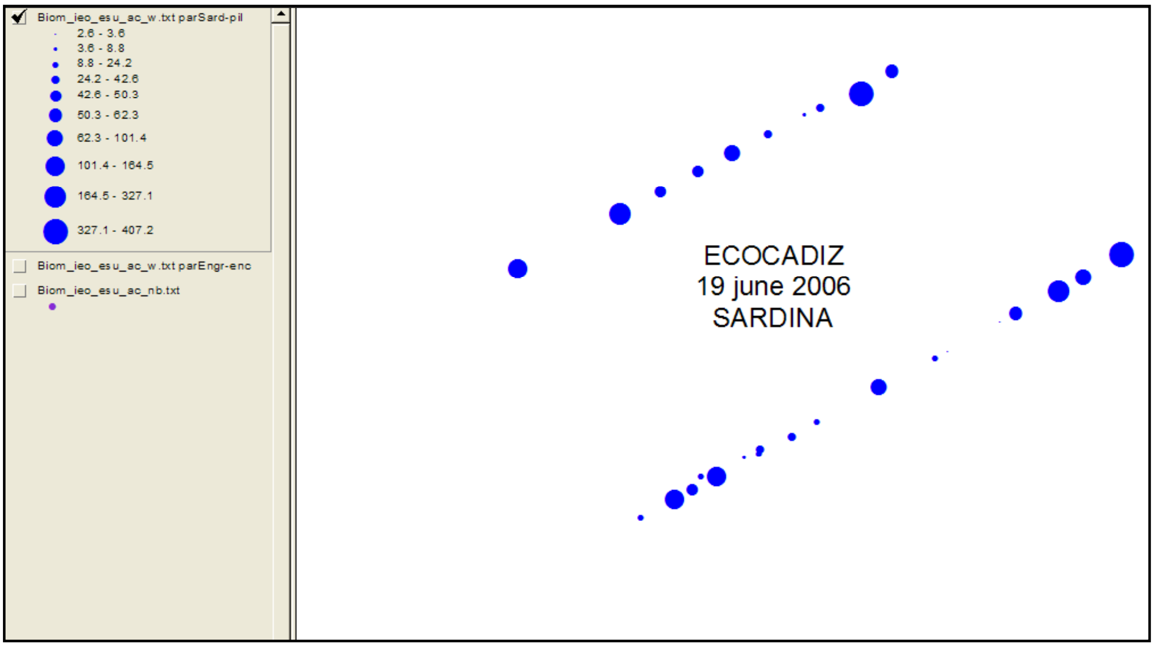


Figure 3.1.2.2. Anchovy (top) and sardine (bottom) distribution as calculated by BARACOUDA after import of IEO acoustic and identification hauls data along the two transects surveyed on 19 June the 2006.

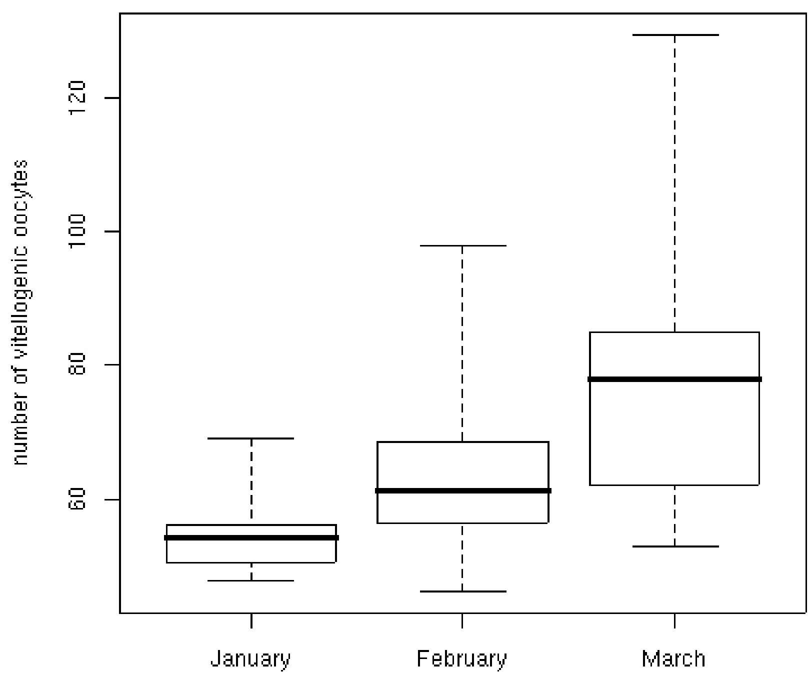


Figure 3.2.3.1.1. Total number of oocytes in the all gonad during the spawning season at three different periods: onset (January), middle (February) and end (March).

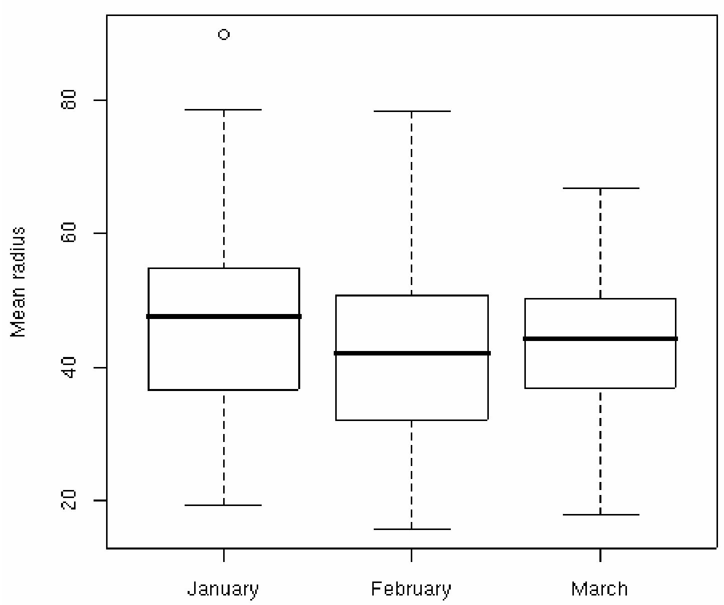


Figure 3.2.3.1.2. Mean radius of pre-vitellogenic oocytes (µm) during the spawning season at three different periods: onset (January), middle (February) and end (March).

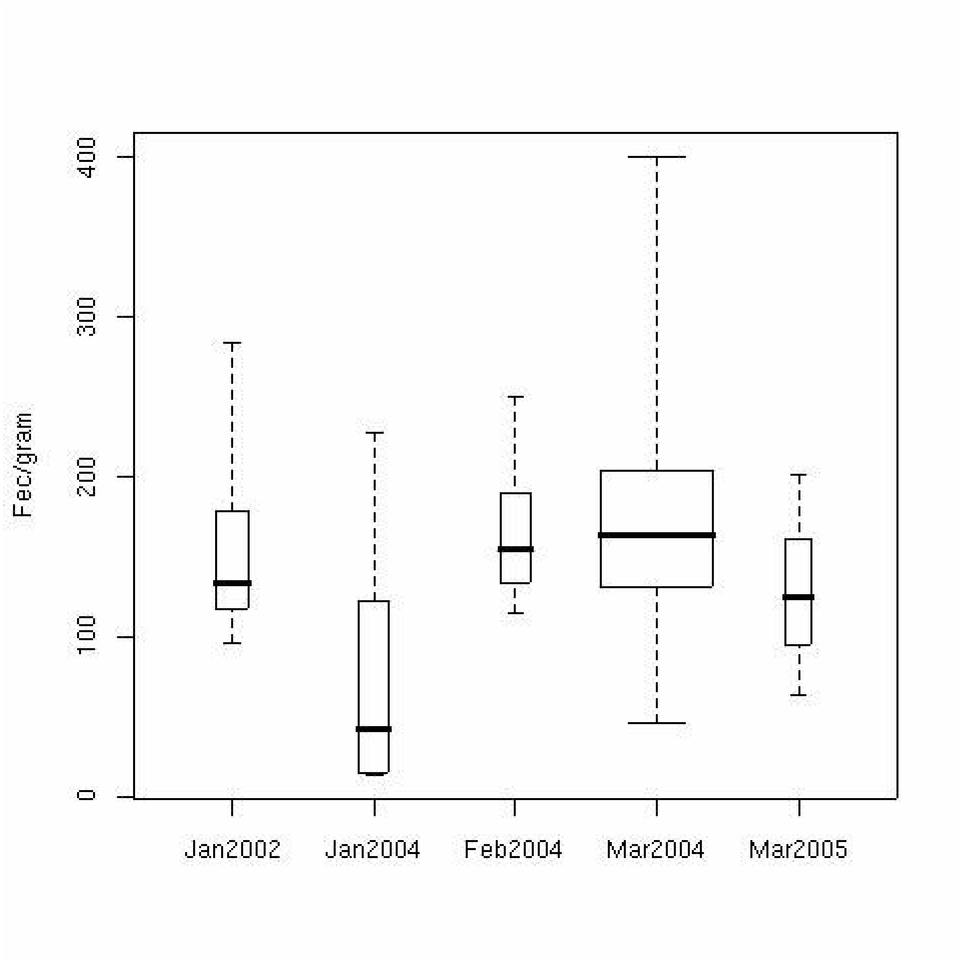


Figure 3.2.3.1.3. Boxplot showing the estimation of fecundity per gram along the five different surveys.

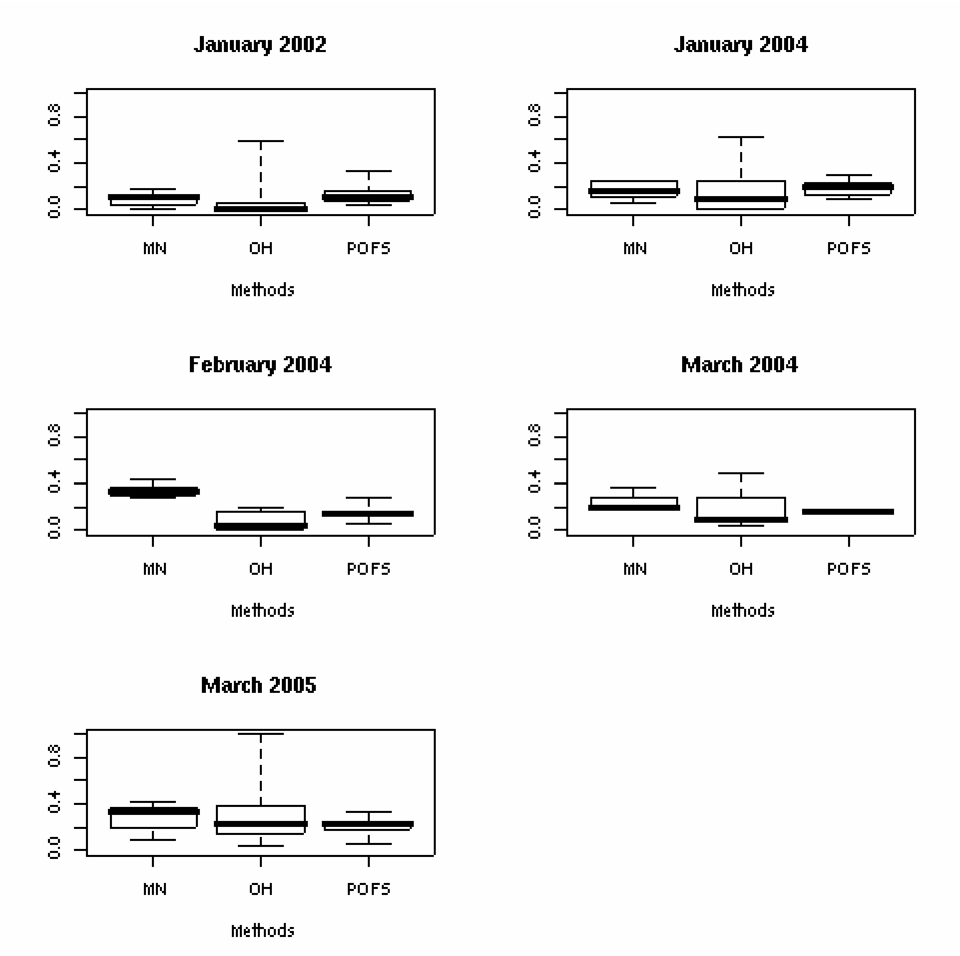


Figure 3.2.3.1.4. Boxplot showing the spawning fraction estimates by the three different methodologies: migrated nucleus (MN), hydrated oocytes (OH) and post-ovulatory follicles (POFs) along the five surveys.

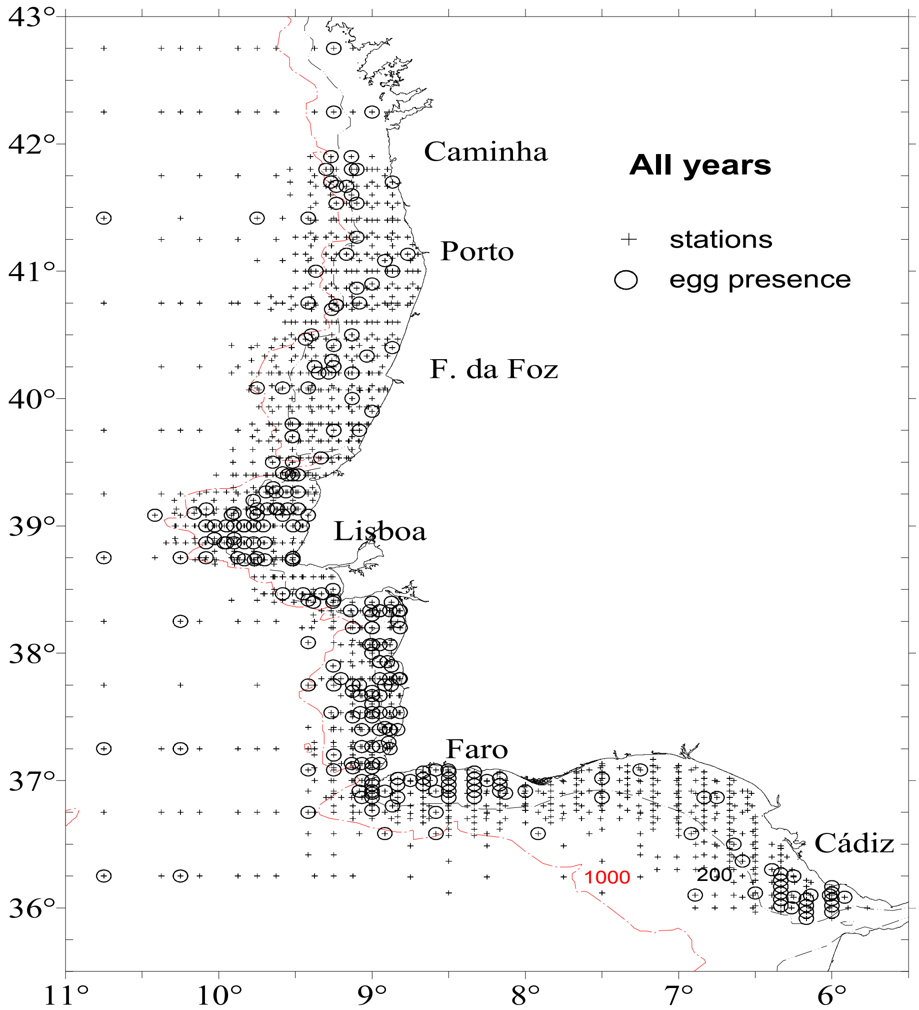


Figure 3.2.3.2.1. Horse mackerel egg presence (circles) and stations carried out (+) from all surveys together (1998, 1999, 2001, 2002, 2004, and 2005).

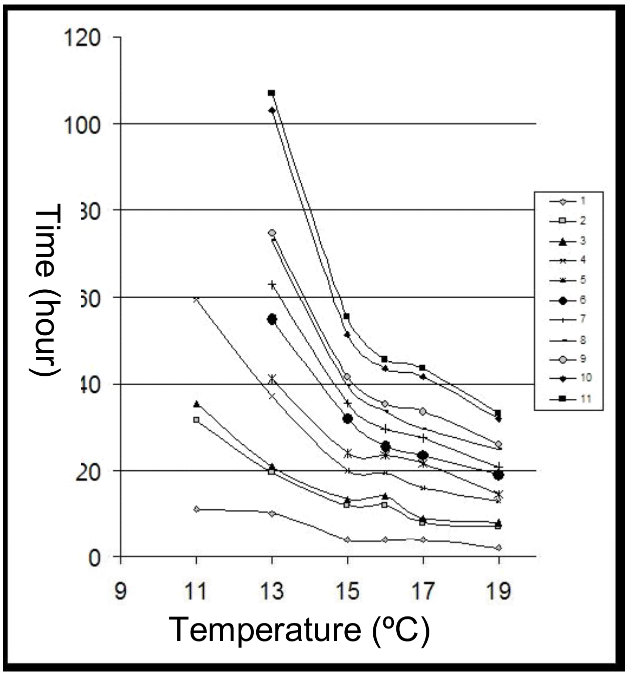


Figure 3.2.3.2.2. Incubation time at 6 different temperatures, 11º, 13º, 15º, 17º and 19ºC, each curve represents a stage from 1 to 11.

4 Recent advances in egg production and acoustic estimation

4.1 Advances in egg production estimates

4.1.1 Mortality curve

One of the steps of the estimation of DEPM-based SSB which produces larger uncertainties in the final estimates, and in which bias can arise, is the estimation of the parameters of the egg mortality curve (Stratoudakis 2006, ICES 2006b). The different sources of uncertainty and bias related to the mortality curve can be classified as those arising from violations of the basic assumptions and/or uncertainties or bias in some of the required parameters, or problems arising from the sampling process. The first category includes uncertainties in the assumption or estimation of the parameters describing the daily spawning synchronicity pattern and variability in the assignation of daily-cohorts to aged eggs. Bias arising from the sampling process includes mainly under-sampling of young and old eggs. Both processes affect the lower and upper tale of the mortality curve and therefore have a large effect on the estimates that can be obtained from the data. Under-sampling of young eggs is believed to be a combination of different effects; violation of the constant daily egg production assumption at spatial scale, low probability of finding large abundance stations, and increased patchiness at young egg ages. The combination of these problems often causes the estimates of egg mortality to appear non significant or even biological impossible (positive mortalities implying increasing number of eggs with age).

One of the possibilities to overcome these problems is to aggregate data at the adequate scale, and therefore obtain data sets with enough information to estimate average mortality on given temporal and spatial strata. Following this philosophy and in order to obtain robust global estimates of egg production off Iberia, and for the different areas of the Iberian Peninsula, a series of strata based on previous works on spawning areas (Bernal *et al.*, *in press*) was establish. The Iberian Peninsula was divided into 3 spatial strata (northern coast, western coast and southern coast), and the available ichthyoplanckton database (1985–2005) was divided into two temporal strata; 1985–1995 and 1996–2005. Using these strata, the following procedure was performed to obtain estimates of egg production:

1) *Spawning synchronicity*: an analysis of daily spawning synchronicity was carried out for each strata and by month, using all available data in order to test for spatial and temporal differences in the daily spawning cycle. Probability of spawning was assumed to show a normal distribution with unknown mean (daily spawning peak) and variance.

2) *Daily egg mortality*: once the parameters describing daily synchronicity for each strata and month were obtained, egg mortality for each strata was estimated by an iterative procedure, in which preliminary ages were assigned to the sampled eggs and a mortality curve fitted to all data within a given strata.

3) *Egg ageing*: once both mortality estimates by strata and spawning pdf's by strata and month were available, sampled eggs for each of the DEPM surveys were aged, taking into account the sampling area, period and survey month for each station.

4) *Spatial egg production estimates*: spatial explicit egg production estimates for each of the DEPM surveys were finally obtained using GAMs with an offset to account both for sampling size and egg mortality.

5) *Global and by region survey production estimates*: global egg production off Iberia, as well as egg production by region, for each of the DEPM surveys were obtained by integration of the predicted egg production model obtained above.

Results of this analysis are still on preliminary phase, although significant biological plausible mortality estimates have been obtained for each temporal and spatial strata (see Table 4.1.1.1 for preliminary estimates of mortality by strata). In comparison with previous attempts (ICES 2005a, ICES 2006b), estimates of mortality for some of the years and areas (2002 Portuguese coast) were not significant. Also, average mortality values obtained using this procedure are regarded as more precise, although can in principle be bias for any specific year across a given period. A final assessment of the results of following this procedure is expected to be ready on the first semester of 2007 and will be thoughtfully analysed in next WG meeting.

4.1.2 Spatial distribution of daily cohorts

The spatial comparison of sardine spawning biomass estimated from two IPIMAR DEPM and acoustic surveys (see Section 2.2) indicated that fish were distributed in a narrower area within the shelf and more inshore than the eggs. These discrepancies in bathymetric distribution are in line with previous observations (Stratoudakis *et al*., 2003; Marques *et al*., 2005; Zwolinski *et al*., 2006) and could be attributed to any of the following four processes:

- A consistent mis-identification of sardine in the echograms at larger depths;
- A bathymetric shift in fish distribution from winter to spring;
- An ephemeral segregation of imminent spawners towards larger depths;
- A rapid dispersion of eggs from the spawning area.

Although none of these processes can be eliminated a priori, existing DEPM data permit to test the hypothesis that the spawning area is narrower and offset further inshore than the entire egg distribution area. Defining the spawning area as the distribution area of spawners and young eggs (considered here as the first 8–12 hours after dusk spawning) and comparing their bathymetric distribution of young eggs with that of older eggs allows to test the above hypothesis and explore its implications in the estimation of daily egg production for sardine in the Iberian Peninsula.

To compare the spatial distribution of egg stages/cohorts, data from the Iberian DEPM ichthyoplankton database were used, including 8 national surveys (IEO and IPIMAR, 1988–2002), 3300 plankton hauls and more than 20000 sardine eggs. Figure 4.1.2.1 shows the modelled bathymetric distribution of sardine eggs by stage and compares it with the modelled bathymetric distribution of sardine spawners during the 2005 acoustic survey (dotted line in the right panel). These results demonstrate that, on average, off the Iberian Peninsula younger sardine eggs (stage II in this case) occur in larger concentrations over a narrower depth range than older eggs (stages VI and X) and that the depth of peak concentration for younger eggs is offset by at least 20 m inshore in relation to that of older eggs (left panel). In addition, within stage II eggs, those that were sampled before 03: 00 (i.e. likely to have an age up to 8 h) have an even more inshore distribution than those sampled after that time (i.e. likely to be older) and their distribution approximates that of spawners are estimated from the 2005 IPIMAR acoustic survey (right panel).

Ageing the above eggs according to the Bayesian procedure assuming a tight N~(19 1) daily spawning probability density function, confirms the bathymetric differences observed in the stage data and suggests that the largest differences in bathymetric distribution are detected within the first 12 h of life (Figure 4.1.2.2). This Figure also demonstrates that the depth pattern with egg age is detected also when the IPIMAR and IEO surveys are considered separately, thus being persistent across regions with very different topographic and circulation regimes. The differences in topographic regimes are demonstrated in Figure 4.1.2.3, where the cumulative distribution of egg cohorts is plotted against distance from the coast. This Figure shows that the bulk of young eggs is concentrated in a shelf area that is several kms narrower than the area occupied by older eggs. However, in this case there is a larger difference between northern Spain and the remaining Iberian Peninsula, since the wider shelf off northern Portugal and the Gulf of Cadiz lead to differences that can exceed 10 kms within a couple of days in the latter region.

These results seem to confirm that sardine spawning mainly takes place within the inner shelf (up to 100 m depth) and that within the first day of egg life the distribution area rapidly expands to cover large parts of the outer shelf and (especially off northern Spain) the upper slope. Considering the biophysical processes that could lead to these dispersion patterns, three hypotheses come to mind:

- Spatially constant mortality and mild diffusion, with strong offshore advection at the inner shelf and mild advection at the outer shelf;
- Spatially constant mortality and mild offshore advection, with strong diffusion at the inner shelf and milder diffusion at the outer shelf;
- No advection and constantly strong diffusion, with high mortality at the inner shelf and low mortality at the outer shelf.

At this stage, it is not possible to evaluate any of the above hypotheses, but they provide a framework for potential ecological and oceanographic studies that could help to understand the observed patterns of dispersion. This understanding would also help to evaluate the implications of dispersion in the estimation of the daily egg production during DEPM surveys and mitigate their effects. A spawning area that is narrower than the egg distribution area violates the basic DEPM assumption that ichthyoplankton sampling within the survey area has an equal probability of detecting any daily cohort of eggs that has not started to hatch yet (Mangel and Smith 1990) and the degree and direction of ensuing bias will depend on the time scale and direction of the dispersion processes.

At first sight, the above assumption is mainly violated during the early postspawning period (EPSP – considered to be between 19: 00 and 03: 00 in this case), when recently spawned eggs are found in a narrower and more inshore area. To demonstrate the potential effects of such a spatial pattern on egg production estimation, the aged data from the DEPM database were used to estimate an average production and mortality (GLM with a negative binomial distribution) under several situations:

- Global pattern: when all data are used, the mortality estimate (Z = -0.013) is significant and leads to an average production of 60 eggs m^{-1}. However, when only the data collected within the EPSP are used (a third of the total), Z cannot be estimated and production (mean cohort abundance in this case) is lower. On the contrary, outside EPSP, Z estimate is significant and higher, leading to a higher estimate of production (75 eggs m^{-1});
- Pattern outside EPSP: Within the period outside EPSP, both the data collected in the inner shelf (<60 m depth) and those further offshore are able to provide a significant estimate of Z, although the estimated mortality and production are 3 times higher at the inner shelf (Z = -0.038; Po = 180 eggs m^{-1});
- Pattern inside EPSP: Within the EPSP period, the data collected in the outer shelf cannot provide a significant estimate of Z and lead to a low production estimate, whereas the very few data collected within the inner shelf at the EPSP hours (123 hauls or 3.7% of the total) provide a significant estimate of Z and a high production (Z = -0.018; Po = 150 eggs m^{-1}).

These results demonstrate that significant differences between the spawning and egg distribution area can lead to biased DEPM estimates and that the magnitude and direction of bias will depend on the prevailing dispersion patterns. In the case of sardine eggs off Iberia, it is likely that the problem is mainly evident during the early postspawning period, when the narrower bathymetric distribution of young eggs leads to an underestimation of egg production. This mechanism provides an alternative (or complementary) explanation to the potential bias problem presented in Section 4.1.1 and further supports the necessity to eliminate more observations at the lower tail of the egg production curve that currently accepted by the tight spawning probability density function used for routine estimation.

4.1.3 Spawning fraction

The basis for the estimation of the spawning frequency for the Bay of Biscay anchovy (*Engraulis encrasicolus*, L.) was revised by applying a new method by Alday *et al*. (WD to this WG). The new method is based on a total revision of the examination of gonads by which stageing procedures of maturing oocytes and degeneration of POFs are used for the independent identification of pre and postspawning cohorts through the histological analysis of ovaries (*Engraulis encrasicolus*) (Alday *et al*., submitted -- Alday *et al*., 2005). In all, 11.948 females, collected from 1990 to 2005 during the DEPM surveys (Motos *et al*., 2005), were examined for the current revision.

The new method classifies POFs using a 7 histological stages solely based on the degeneration state of POFs, regardless the time of capture or time elapsed since spawning. Ageing those POFs (in hours past since spawning) is made independently in a subsequent step according to a validation achieved by means of several captivity experiments and by analysis of their incidence in field samples (Alday *et al*., 2005). In fact, under the assumption of no mayor influence of the temperature on the degeneration rate of POFs, a time-dependent conversion matrix of POF stages into past spawning cohort is proposed (Table 4.1.3.1, matrices on 2 hour basis). For the definition of the matrices daily spawning cohorts were defined from 0600 hours (GMT) to 0600 hours of the next day, this being so in order to assure that all females (which spawn about midnight – Motos 1996) have finished their spawning and therefore have fully recruited to the first postspawning cohort (day 1, entirely identified by POFs). Therefore Day 1 spawners are those females showing POFs aged between 6–30 hours old; Day 2 spawners: those showing POFs aged 30–54 hours old; and a plus group (Day 3+ spawners) is made of females with POFs aged more than 54 hours old or without any rest of POFs.

Allocation of POFs to past spawning cohorts is simple for the first stages of degeneration, (I to IV) since they last less than a day, but requires some assumptions for the most advanced POFs stages (V, VI and VII) because they last more than a day. For those stages, some overlapping of consecutive spawning cohorts may occur during the recruiting period to those stages and their leaving times. In such cases, for simplicity, symmetrical and gradual transition percentages for the allocation of POFs to past spawning cohorts were assumed, over the overlapping periods.

Additionally, the oocytes have also been examined to determine the incidence of the oocyte maturing stages throughout the day, in order to identify the prespawning cohorts (Figure 4.1.3.1) as made in Motos (1996) and Alday (submitted). As a result of the former analysis, two prespawning cohorts can be identified: Day -1 prespawning cohort: defined from 0600 h to 0600 h (by analogy with the postspawning cohorts). This includes females that would spawn more than 24 hours after their capture (which usually are in early nuclear migration) or in more than 18 hours if caught between 00 and 06 hours (which usually are in early and a few in advance nuclear migration). Day 0 pres-pawning cohort: defined also from 0600 h to 0600h, this includes females that are going to spawn during the next night after capture (containing from early nuclear migration to hydrated stages). In addition day 0 includes those females which just spawned being caught in the first 6 hours of the day (which show the earlier stages of POFs degeneration, stages I-III). Based on the above, a time related (by 2 hour daytime intervals) conversion matrix for allocating maturing oocyte stages into prespawning cohorts was established following the same procedure as done for POFs. (Table 4.1.3.2).

The two conversion matrixes developed for the oocyte stages and for the POF stages allowed for the identification in total of five spawning cohorts (two of them corresponding to pre-spawners – day -1 and 0 - and the others to post-spawners - day 1 to 3+). The incidence of those cohorts, resulting from the application of the matrices to the field samples, are presented in Figure 4.1.3.2 as consecutive cohorts for five days, by 2 hour daytime intervals.

The low incidence of Day -1 is simply due to the incomplete identification of this cohort: it is only about 22 hours before modal spawning time that most of them show already early nuclear migration (at about 02 a.m.). And probably full identification of the prespawning cohort is only achieved after 6–8 a.m. of the day of spawning (as Day 0). The low incidence of Day 3 indicates that most of anchovies already resume into a new spawning 2 days after spawning. This is reflected in the prespawning condition of most of the POFs Day 2 cohort and in their sharp incidence reduction shown after 00: 00h (peak of spawning), being then recruited to Day 0 (00–06 HH) and subsequently to Day 1 (6+ HH) post -spawning cohorts. During the first hours of the day, POFs Day 2 seems to be over-represented, which might be due to some misallocation of females between Day 3 and Day 2. This is a likely consequence of the difficulties in the allocation of the older POF stages (V, VI and VII) to past spawning cohorts for the overlapping periods.

Day 0 and 1 show a rather consistent and homogeneous incidence throughout the day (Figure 4.1.3.3) which suggest that no great over sampling of pre and spawning females is evident, except perhaps at peak spawning time. The maxima from 22: 00 to 02: 00 h of the incidence of Day 0 females might be related the relative minima observed in Day 1 at the same daytime and they both to some over-sampling of the spawning females at this period of the day. For this anchovy, over sampling was first consider to happen from 23: 00 to 13: 00 hours (Santiago and Sanz 1992), and more recently throughout the whole day 0 as defined above (Motos and Uriarte 2001). However this review shows that the effect of this over-sampling is weaker than reported before in literature limiting its occurrence to about 6 hours of the day (between 20 and 01 HH) and with a not too high intensity (with a maximum increase of 13% in the incidence of spawning females at midnight). Based on this, non corrected estimators based on Day 0 or Day 1 can only be used out of this daytime interval.

From Figure 4.1.3.2 it can also be deduced that average spawning frequency for this anchovy could be as high as about 40%. This value is higher than the range previously reported for this anchovy species between 18% and 33% (Santiago and Sanz 1992; Sanz *et al*., 1992; Motos 1994; Motos *et al*., 2005; Somarakis *et al*., 2004). This discrepancy originates from the revision of degeneration rates of POFs, which are a bit faster than previously believed (Alday *et al*. this symposium), and to more objective procedures adopted for the subsequent ageing.

This study shows a good consistency of the first prespawning (Day 0) and postspawning (Day 1) cohorts, which constitute independent estimates of spawning incidence, being both well represented, well identified and balanced. This initially favours the use of both Day 0 and Day 1 cohorts for the estimation of the spawning frequency, instead of using day 1 (and day 2, since 1995) cohorts as it was the practice before. Around the peak spawning time, however, some small correction may be required. Further work on the spawning frequency by samples and years and the influence of covariates, such as temperature or size of anchovies, on this parameter is still underway.

The examination of the indices has allowed testing different estimators of spawning frequency based on day 0, day 1 or both indices of spawning frequency (Figure 4.1.3.4): Non corrected estimators based on Day 0 and Day 1 can only be used out of the daytime intervals, when over sampling of active females occur. Corrected Day 1 estimator (all throughout the day) is more accurate than the non corrected ones, but at the expenses of inventing about 1/3 or more of the information (through replacing day 0 females by the day 1, given the high S values). Due to the high spawning frequencies observed on this population, the over-sampling of hydrated and recent spawned females (day 0, around spawning time) affects largely and inversely to the Day 1 cohort. As a consequence, the study suggest that the addition of both (Day 0 and Day 1) spawning cohorts could be used as a rough estimator of the (double of) the spawning frequency, without introducing any other correction, resulting in the most precise estimate.

This study will continue with the revision of the spawning frequencies estimated during the last years as well as the learn of the influence of the environmental and biological variables on this parameter (age of the anchovies, size, etc.).

The high values of the actually estimated spawning frequencies increase considerably the previously estimated values. As a consequence, the revision of S estimates will lead to a decrease of the SSB levels estimated by the DEPM. The WG considered the convenience of publishing the above results and making the review the whole series of DEPM biomass estimates according to the revision of the spawning frequencies that will arise from this study. Such review is recommended to be finished and reported to the next year WGACEGGS meeting for its revision.

Table 4.1.1.1. Estimates of hourly mortality for sardine off the Iberian Peninsula, across three spatial strata (North, West and South) and two temporal strata (first period: 1985–1995; second period: 1996–2005).

	FIRST PERIOD	SECOND PERIOD
South		−0.019
West	−0.026	−0.011
North	−0.027	−0.010

Table 4.1.3.2. Conversion matrix of oocyte stages, into spawning cohorts, according to time of capture (based upon the knowledge gained in the present study).

Day -1					
	Oocyte stages				
Time interval	4	5	6	7	8
0000–0200h	NA	100%	0%	0%	0%
0200–0400h	NA	100%	100%	0%	0%
0400–0600h	NA	100%	100%	0%	0%
0600–0800h	NA	0%*	0%	0%	0%
0800–1000h	NA	0%*	0%	0%	0%
1000–1200h	NA	0%*	0%	0%	0%
1200–1400h	NA	0%*	0%	0%	0%
1400–1600h	NA	0%*	0%	0%	0%
1600–1800h	NA	100%	0%	0%	0%
1800–2000h	NA	100%	0%	0%	0%
2000–2200h	NA	100%	0%	0%	0%
2200–0000h	NA	100%	0%	0%	0%
Day 0					
	Oocyte stages				
Time interval	4	5	6	7	8
0000–0200h	NA	0%	100%	100%	100%
0200–0400h	NA	0%	0%	100%	100%
0400–0600h	NA	0%	0%	100%	100%
0600–0800h	NA	100%*	100%	100%	100%
0800–1000h	NA	100%*	100%	100%	100%
1000–1200h	NA	100%*	100%	100%	100%
1200–1400h	NA	100%*	100%	100%	100%
1400–1600h	NA	100%*	100%	100%	100%
1600–1800h	NA	0%	100%	100%	100%
1800–2000h	NA	0%	100%	100%	100%
2000–2200h	NA	0%	100%	100%	100%
2200–0000h	NA	0%	100%	100%	100%

Table 4.1.3.1. Conversion matrix of POF's stages, into spawning cohorts, according to time of capture (based upon the knowledge gained in a previous study Alday *et al.*, submitted). Two options for ageing stage VII are provided (one based only on experiments and the other more on the examination of field samples).

Day 0	POF Stages								
Tramo hora	I	II	III	IV	V	VI	VII T*	VII F*	0
(00-02)	100%	100%	100%	100%	-	-	-	-	-
(02-04)	100%	100%	100%	100%	-	-	-	-	-
(04-06)	100%	100%	100%	100%	-	-	-	-	-
(06-08)	-	-	-	-	-	-	-	-	-
(08-10)	-	-	-	-	-	-	-	-	-
(10-12)	-	-	-	-	-	-	-	-	-
(12-14)	-	-	-	-	-	-	-	-	-
(14-16)	-	-	-	-	-	-	-	-	-
(16-18)	-	-	-	-	-	-	-	-	-
(18-20)	100%	100%	-	-	-	-	-	-	-
(20-22)	100%	100%	100%	-	-	-	-	-	-
(22-00)	100%	100%	100%	-	-	-	-	-	-

Day 2	POF Stages								
Tramo hora	I	II	III	IV	V	VI	VII T*	VII F*	0
(00-02)	-	-	-	-	-	-	80%	100%	-
(02-04)	-	-	-	-	-	-	60%	50%	-
(04-06)	-	-	-	-	-	-	50%	30%	-
(06-08)	-	-	-	-	75%	100%	60%	80%	-
(08-10)	-	-	-	-	50%	100%	80%	90%	-
(10-12)	-	-	-	-	25%	100%	90%	95%	-
(12-14)	-	-	-	-	-	100%	100%	100%	-
(14-16)	-	-	-	-	-	80%	100%	100%	-
(16-18)	-	-	-	-	-	60%	100%	100%	-
(18-20)	-	-	-	-	-	40%	100%	100%	-
(20-22)	-	-	-	-	-	20%	100%	100%	-
(22-00)	-	-	-	-	-	-	100%	100%	-

Day 1	POF Stages								
Tramo hora	I	II	III	IV	V	VI	VII T*	VII F*	0
(00-02)	-	-	-	-	100%	100%	20%	-	-
(02-04)	-	-	-	-	100%	100%	40%	50%	-
(04-06)	-	-	-	-	100%	100%	50%	70%	-
(06-08)	100%	100%	100%	100%	25%	-	-	-	-
(08-10)	100%	100%	100%	100%	50%	-	-	-	-
(10-12)	100%	100%	100%	100%	75%	-	-	-	-
(12-14)	100%	100%	100%	100%	100%	-	-	-	-
(14-16)	100%	100%	100%	100%	100%	20%	-	-	-
(16-18)	100%	100%	100%	100%	100%	40%	-	-	-
(18-20)	-	-	100%	100%	100%	60%	-	-	-
(20-22)	-	-	-	100%	100%	80%	-	-	-
(22-00)	-	-	-	100%	100%	100%	-	-	-

Day 3+	POF Stages								
Tramo hora	I	II	III	IV	V	VI	VII T*	VII F*	0
(00-02)	-	-	-	-	-	-	-	-	100%
(02-04)	-	-	-	-	-	-	-	-	100%
(04-06)	-	-	-	-	-	-	-	-	100%
(06-08)	-	-	-	-	-	-	40%	20%	100%
(08-10)	-	-	-	-	-	-	20%	10%	100%
(10-12)	-	-	-	-	-	-	10%	5%	100%
(12-14)	-	-	-	-	-	-	-	-	100%
(14-16)	-	-	-	-	-	-	-	-	100%
(16-18)	-	-	-	-	-	-	-	-	100%
(18-20)	-	-	-	-	-	-	-	-	100%
(20-22)	-	-	-	-	-	-	-	-	100%
(22-00)	-	-	-	-	-	-	-	-	100%

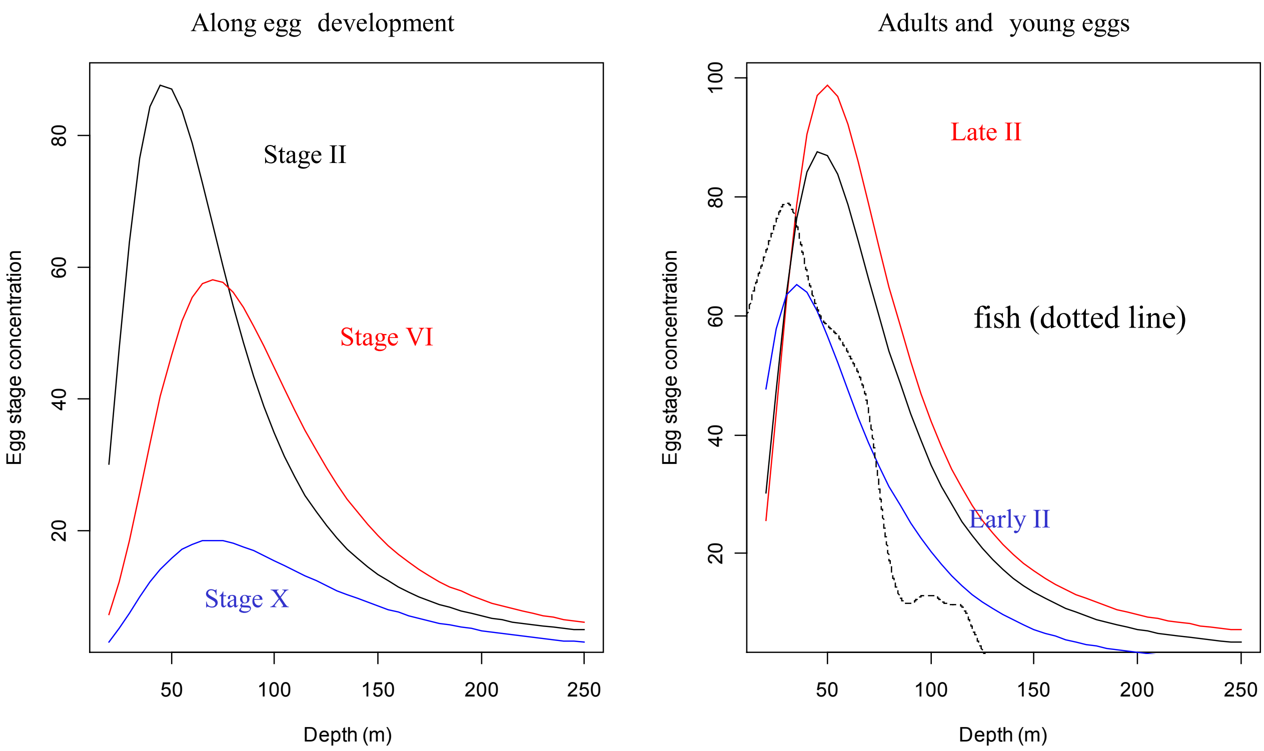


Figure 4.1.2.1. Modelled bathymetric distribution of sardine eggs by stage. Left panel: stages II, VI and X. Right panel: early stage II (sampled until 03: 00), late stage II (sampled after 03: 00) and bathymetric distribution of spawners from the 2005 IPIMAR acoustic survey (dotted line).

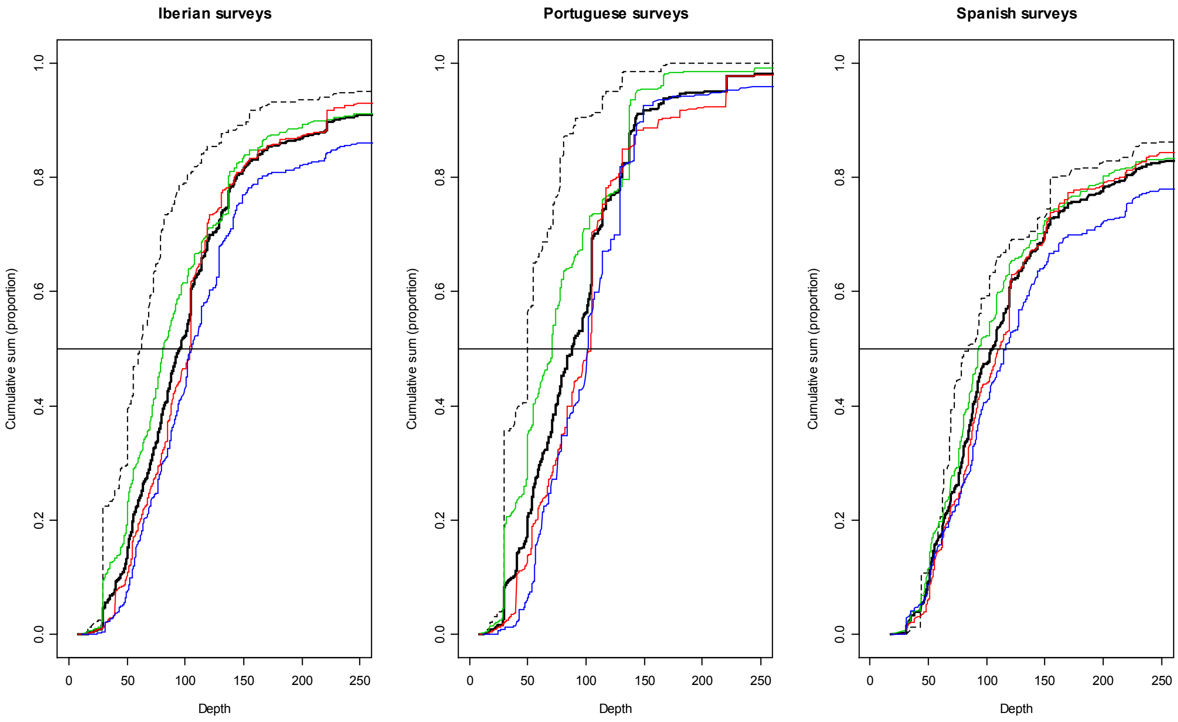


Figure 4.1.2.2. Scaled cumulative depth distribution (up to 250 m) for sardine eggs in the Iberian Peninsula DEPM surveys (left panel) and separately for the IPIMAR surveys (Portugal and Gulf of Cadiz, middle panel) and the IEO surveys (northern Spain, right panel). Black solid line: all eggs; Black broken line: eggs with <12 h; Green line: eggs in the first day of life; Red line: eggs in the second day of life; Blue line: eggs in the third day of life.

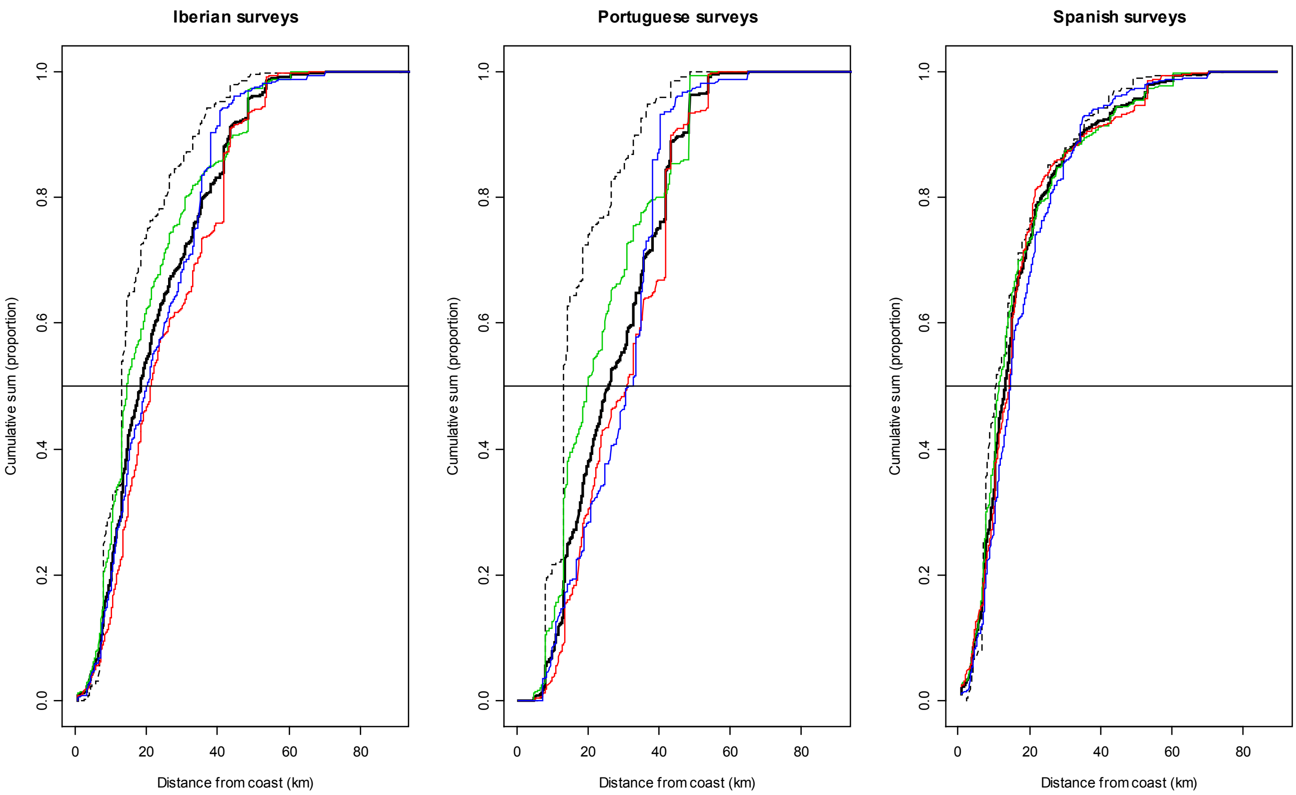


Figure 4.1.2.3. Scaled cumulative distribution of distance to the coast for sardine eggs in the Iberian Peninsula DEPM surveys (left panel) and separately for the IPIMAR surveys (Portugal and Gulf of Cadiz, middle panel) and the IEO surveys (northern Spain, right panel). Black solid line: all eggs; Black broken line: eggs with <12 h; Green line: eggs in the first day of life; Red line: eggs in the second day of life; Blue line: eggs in the third day of life.

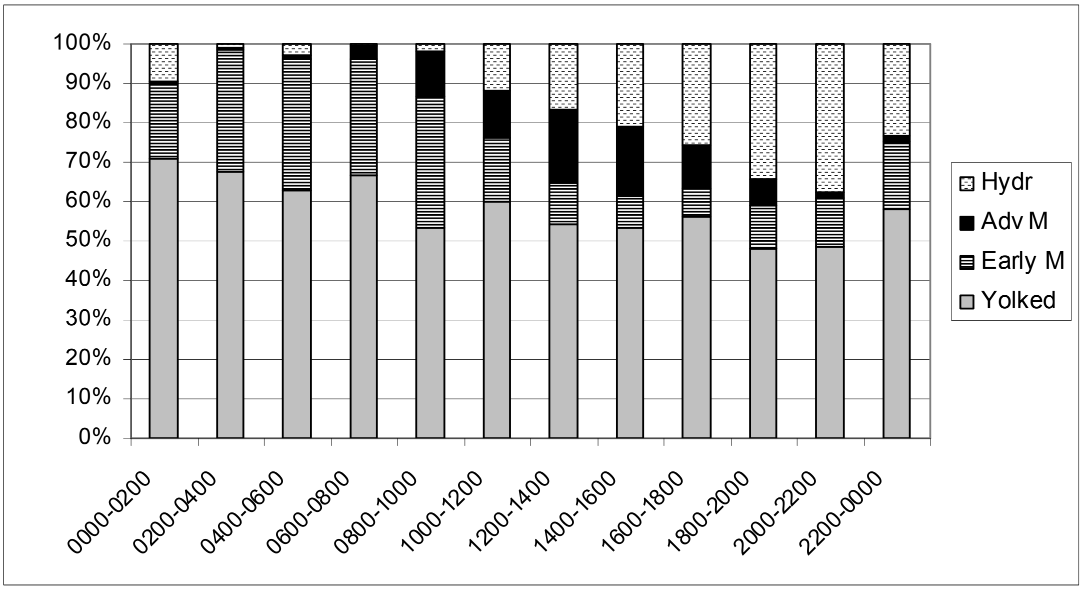


Figure 4.1.3.1. Incidence of the maturing oocytes stages in the 11.948 females available for the Bay of Biscay anchovy.

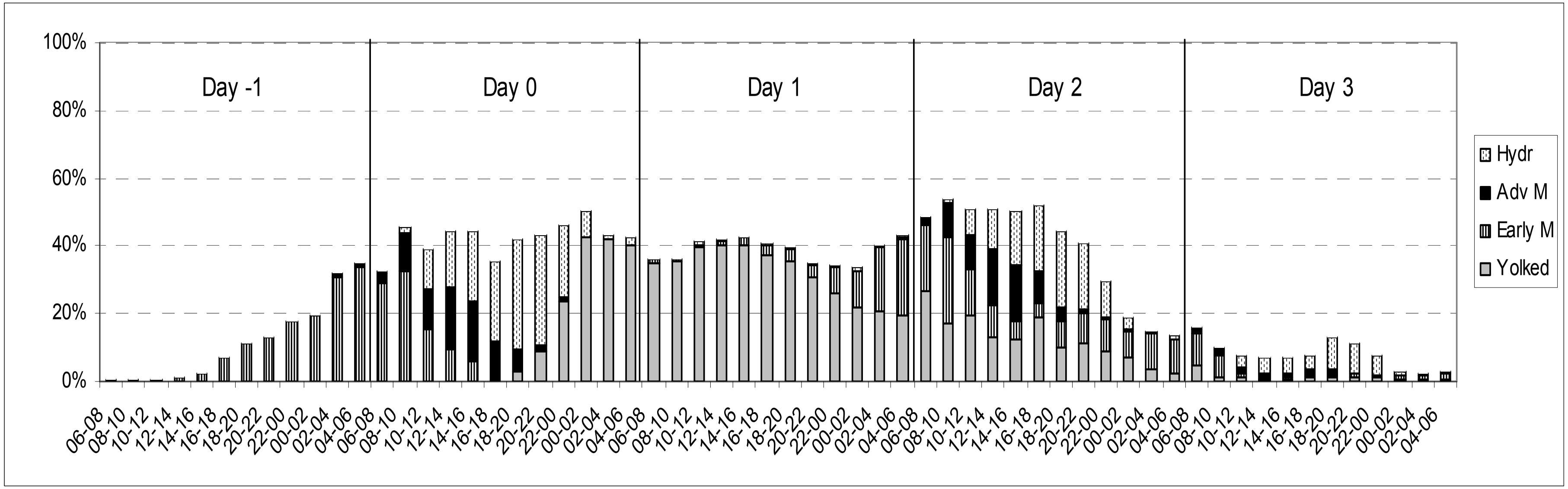


Figure 4.1.3.2. Representation of the incidence of the five spawning cohorts related to the time of the day on 2 hours daytime steps, and including within them the incidence of the different maturing oocyte stages for every daytime interval.

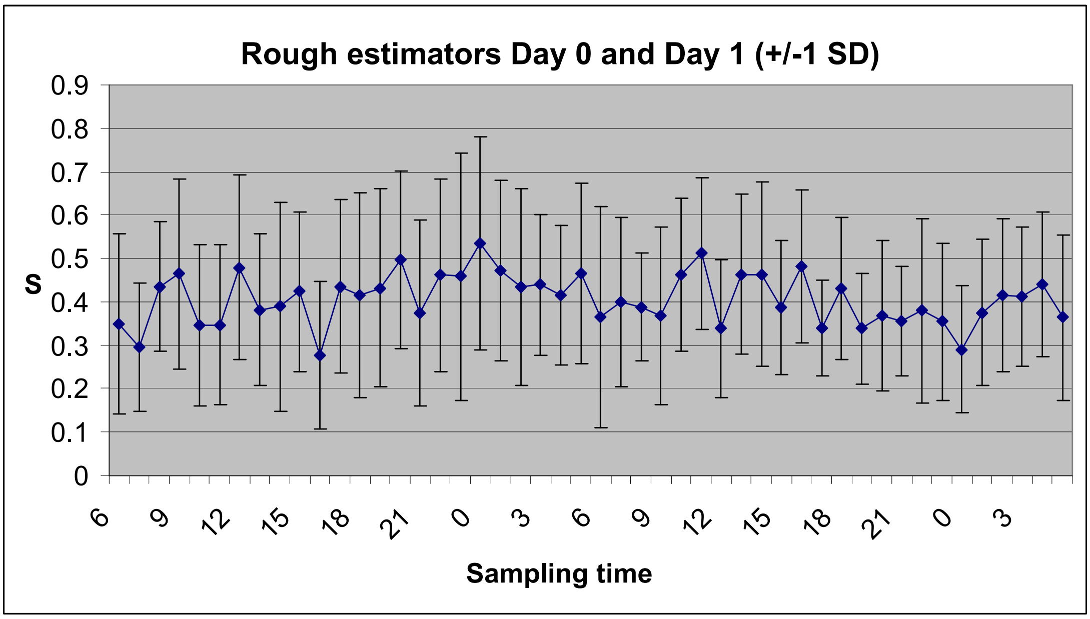


Figure 4.1.3.3. Spawning frequency estimations based on the incidence of day 0 and day 1 spawning cohorts throughout the day (on hourly basis).

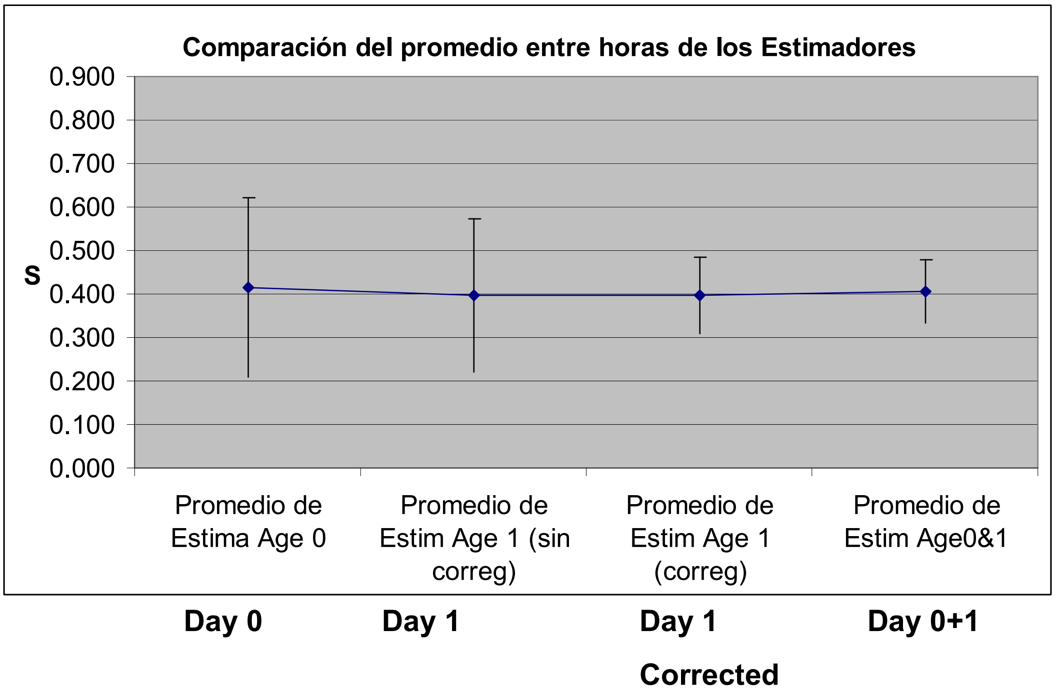


Figure 4.1.3.4. Average Spawning frequency (+/- 1 SD) of the Bay of Biscay anchovy based on the incidence of day 0, day 1, day1 (corrected) and day0+1 spawning cohorts.

4.2 Advances in acoustic estimation

4.2.1 Review of the Target Strength

The acoustic target strength (TS) is an important metric in fisheries and plankton acoustics to inform on fish characteristics and to convert the acoustic energy in biomass units.

$$TS = 20 \log L + b_{20}$$

$$\sigma_{bs} = 10^{TS}/10$$

In the WGACEGG 2005 a revision was done on TS used by every Institution (IPIMAR, IEO, AZTI and IFREMER) (Table 4.2.1.1) in order to standardize methodology. Differences in TS were detected in sardine, anchovy and mackerel. Then, it was recommended to check literature to explore the most suitable TS relationship that could be used for the two target species: *Sardina pilchardus* and *Engraulis encrasicolus.*

In the Report of the Planning Group for pelagic acoustic surveys in ICES Subareas VIII and IX (A Coruña, 30–31 January 1998) was agreed the use of specific TS for every pelagic species in this area (Table 4.2.1.2). The -72.6 db used by sardine and anchovy (IEO, AZTI) was the estimated for the North Atlantic herring (*Clupea harengus*) (Degnbol *et al*., 1985). The -71.2 dB comes from Foote, 1987. ICES, 1997.

For mackerel (*Scomber scombrus*) different TS are used by the Institutes:

- 82 dB (Ifremer and Ipimar): agreed in the Planning Group for pelagic acoustic surveys in ICES Subareas VIII and IX, 1998.
- 84.9 dB (IEO): Edwards *et al*., 1984, recommended by the Planning Group on Aerial and Acoustic surveys for mackerel (ICES, 2002).
- 88 dB (Azti): Clay and Castonguay, 1996.

A difference of 6 dB between the lower and the higher TS corresponds to two times biomass estimate.

During the EcoCádiz acoustic survey carried out in the Gulf of Cadiz (Spain and Portugal areas) during June 2006 the principal pelagic species detected were anchovy, sardine and chub mackerel. Fishing trawls were conducted at day aimed to identify echo traces detected during the track survey. But also 3 fishing stations were carried out at night (Figure 4.2.1.1) in areas were abundant anchovy was detected in order to get data on the anchovy TS. Some work has been done on the estimation of the anchovy TS in an area where still has a big abundance of this species.

The acoustic sampling was carried out with an echosounder EK-500 (38 kHz, split-beam transducer), and a SonarData Echoview software was the tool for the post-process of data. The split-beam method for single target echo detections was used (Figure 4.2.1.2). The trawls were performed near the surface at night with a pelagic trawl of 20 m vertical opening and a speed of 3–4 knots. Results from this three hauls were presented in Table 4.2.1.3.

The preliminary anchovy TS results are:

- Haul 16: b_{20} = -77.21
- Haul 21: b_{20} = -76.15
- Haul 22: b_{20} = -75.02

Preliminary results obtained from this experience shows a TS for anchovy similar to the TS estimated for *Engraulis capensis*, in South Africa by Barange *et al*., 1996. Being *Engraulis capensis* and *Engraulis encrasicolus* the same species with a b_{20} = -76.1.

There is a necessity of standardize species TS if results from different acoustic surveys must be compared or compiled. Then, some studies to determine the TS “in situ” of sardine and anchovy in this areas must be carried out.

The EcoCádiz surveys undertaken in June 2004 and June 2006 have been evaluated using two different TS for anchovy (-71.2 and -72.6) and results are shown in Tables 4.2.1.4 and 4.2.1.5.

4.2.2 Sampling improvements

Sampling strategies are compatible from Brest to Cadiz, with parallel transects grids perpendicular to the bathymetry. Transects intervals are different from one survey to the other but are adapted to the local species. Nevertheless, the WG recommended proceeding to appropriate study areas when possible in order to improve sampling by a geo-statistic approach.

Between 2002 and 2006, IFREMER progressively adapted its trawl settings and have now really impressive results when echoes are very close to the surface. This solves the problems encountered in the past and identification can be considered as really efficient during the last two years in the whole water column.

An effort has been done in the Spanish surveys (Pelacus and EcoCadiz) to increase the number of pelagic trawls in order to improve the identification of the echo traces, due to the multispecific character of these areas.

Usually, the objectives of institutes are to have a multi-specific population approach; nevertheless, because of a too short duration of survey, IPIMAR is constrained to privilege identification hauls on target species which is sardine.

Both IFREMER and IEO (on-board “Thalassa”) perform acoustic acquisition with 5 split-beam frequencies. This progress will allow a multi-frequency classification in the future in order to have a better identification when the method will progress.

Table 4.2.1.1. Target strengths (b_{20}) adopted by Institutions (WGACEGG05) in order to estimate abundance of pelagic species from data acquired during acoustic surveys. In bold discrepancies between Institutes.

	IFREMER	AZTI	IEO-N	IEO-S	IPIMAR
Sardine	**-71.2**	**-72.6**	**-72.6**	**-72.6**	**-72.6**
Anchovy	**-71.2**	**-72.6**	**-72.6**	**-71.2**	**-71.2**
Horse mackerel	-68.5	-68.7	-68.7	-68.7	-68.7
Mackerel	**-82**	**-88**	**-84.9**	**-84.9**	**-82**
Chub mackerel	-68.7		-68.7	-68.7	-68.7
Bogue			-67	-67	-67
Sprat	-71.2				-71.2
Blue whiting	-67	-67	-67	-67	-67
Snipe fish			-80	-80	-80

Table 4.2.1.2. Target strengths for pelagic species agreed in the Planning Group for pelagic acoustic surveys in ICES Subareas VIII and IX (A Coruña, 30–31 January 1998).

SPECIES	SCIENTIFIC NAME	B_{20}
Sardine	*Sardina pilchardus*	-72.6
Sprat + clupeids	*Sprattus sprattus*	-71.2
Anchovy	*Engraulis encrasicolus*	-71.2
Horse mackerel	*Trachurus spp.*	-68.7
Mackerel	*Scomber scombrus*	-82
Chub mackerel	*Scomber japonicus*	-68.7
Bogue	*Boops boops*	-67
Blue whiting	*Micromesistius potassou*	-72.8*
Other gadoids		-67

*** This corresponds to a relationship in which log L is multiplied by 21.8.**

Table 4.2.1.3. Species composition in nº of individuals of 3 hauls carried out during the EcoCadiz acoustic survey carried out in June 2006 in the Gulf of Cadiz.

- Trawl haul 16:
  - Nº of individuals:
    - Anchovy: 2284 (92%). Mode: 12 cm.
    - Sardine: 116. Mode: 17 cm.
    - Chub mackerel: 46. Mode: 22 cm.
    - Mackerel: 29. Mode: 22 cm.
- Trawl haul 21:
  - Nº of individuals:
    - Anchovy: 176 (43%). Mode: 12 cm.
    - Chub mackerel: 58. Mode: 22 cm.
    - Mackerel: 153. Mode: 22 cm.
- Trawl haul 22:
  - Nº of individuals:
    - Anchovy: 4594 (82%). Mode: 10 cm.
    - Sardine: 505. Mode: 17 cm.
    - Chub mackerel: 128. Mode: 21.5 cm.
    - Mackerel: 75. Mode: 31.5 cm.
    - Horse mackerel: 38. Mode: 17.5
    - Others: 246.

Table 4.2.1.4. EcoCádiz 2004: estimation with different TS for anchovy.

	ABUNDANCE (MILLION INDIVIDUALS)			BIOMASS (TONS)		
Species	**TS= -72.6**	**TS= -71.2**	**Dif(%)**	**TS= -72.6**	**TS= -71.2**	**Diff(%)**
Anchovy	2053	1656	-10 69	28801	23246	-10 67
Sardine	2111	1992	-290	73336	69855	-243
Tonino	554	514	-366	52440	49222	-317
TOTAL	**4718**	**4162**	**-625**	**154577**	**142323**	**-413**

Table 4.2.1.5.- EcoCádiz 2006: estimation with different TS for anchovy.

	Abundance (million individuals)			Biomass (tons)		
Species	**TS= -72.6**	**TS= -71.2**	**Dif (%)**	**TS= -72.6**	**TS= -71.2**	**Dif (%)**
Anchovy	3211	2487	-12 71	35539	27769	-12 27
Sardine	2952	2893	-102	126382	123942	-097
Chub mackerel	524	456	-693	35580	29979	-854
TOTAL	6688	5836	-680	197501	181688	-417

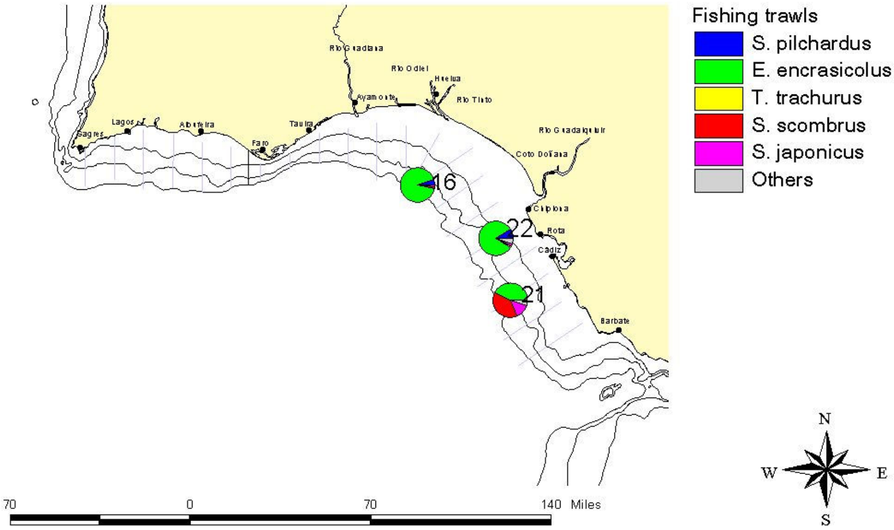


Figure 4.2.1.1. Anchovy fishing trawls performed at night when pelagic species are dispersed and near the surface in order to estimate the anchovy TS "*in situ*".

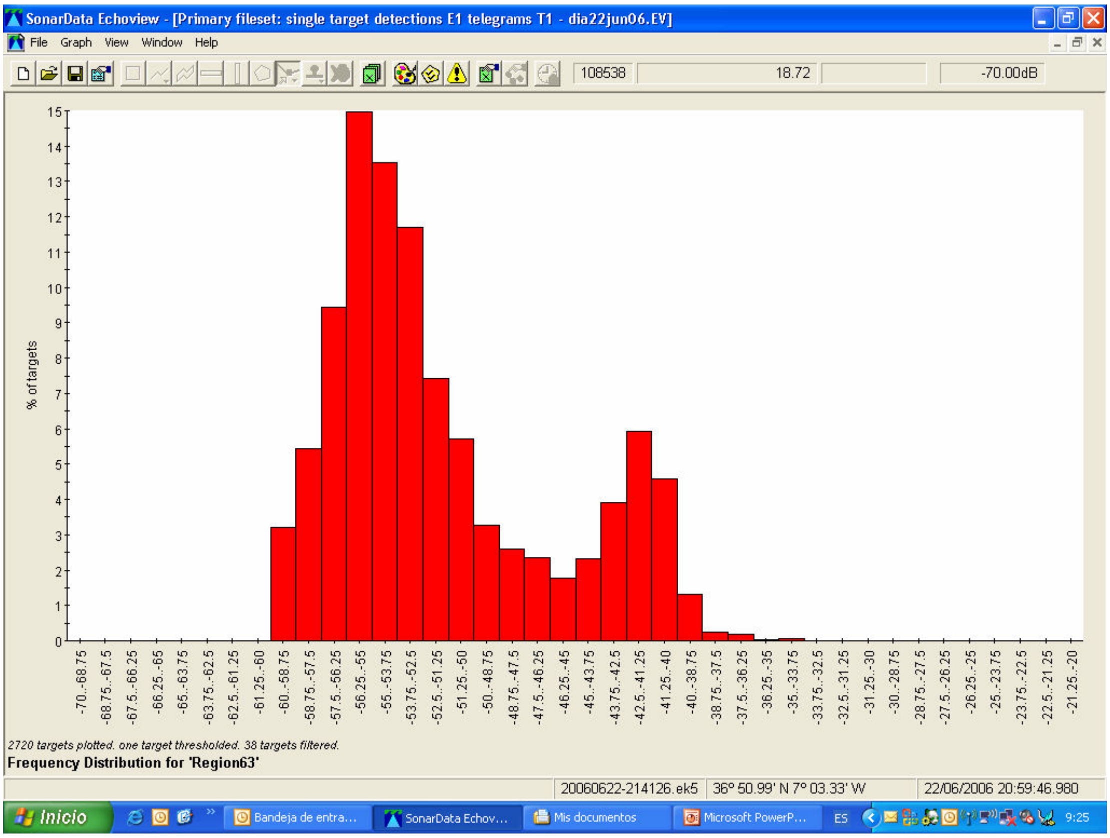


Figure 4.2.1.2. Single target detections of haul nº 16, where anchovy individuals represent a 92% of the total. See data in Table 6.2.1.3.

5 Comparison and integration of acoustic and egg production surveys

5.1 Global comparisons

Various comparisons of global estimates from acoustics and DEPM have been presented in previous meetings of the WGACEGG as well as in WGMHSA (ICES, 2006).

Figure 5.1.1 shows the comparison of the Iberian sardine SSB estimates from acoustic and DEPM surveys. Results are in general comparable and acoustic point estimates are within the confidence intervals of the DEPM – based SSB estimates. Estimates from acoustics are in general larger than those from the DEPM, except in 2005, where due to the largest abundance estimated off the northern coast, the DEPM based SSB estimates are larger than the acoustic ones.

For the case of the Bay of Biscay anchovy, in general, except for 1998, 1994 and 1992, the acoustic biomass estimates are larger than the DEPM estimates (Figure 5.1.2). Especially, this seems to happen systematically since year 2000. However the order of magnitude of the differences changes across years. For instance, in 2003 both estimates are very close each other whereas in 2000 the differences are larger than 50%.

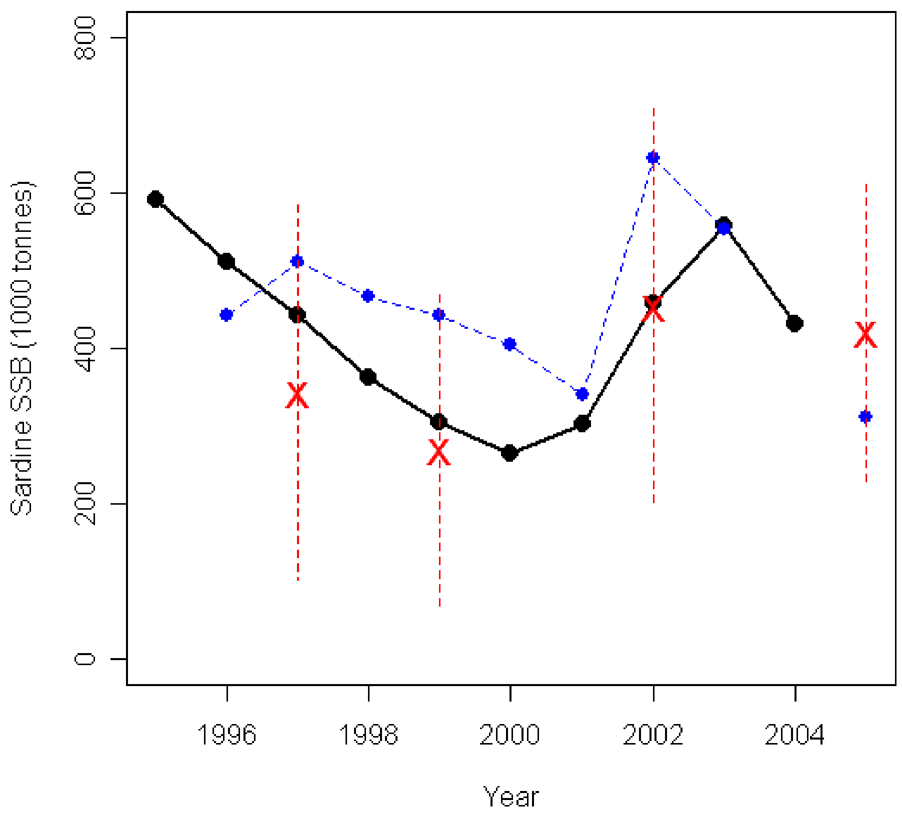


Figure 5.1.1. Acoustic (blue) and DEPM (red) based Iberian sardine SSB estimates. The black solid line represent current ICES assessment estimates (ICES 2005), while the vertical dashed red lines represent the confidence limits of the DEPM based estimates.

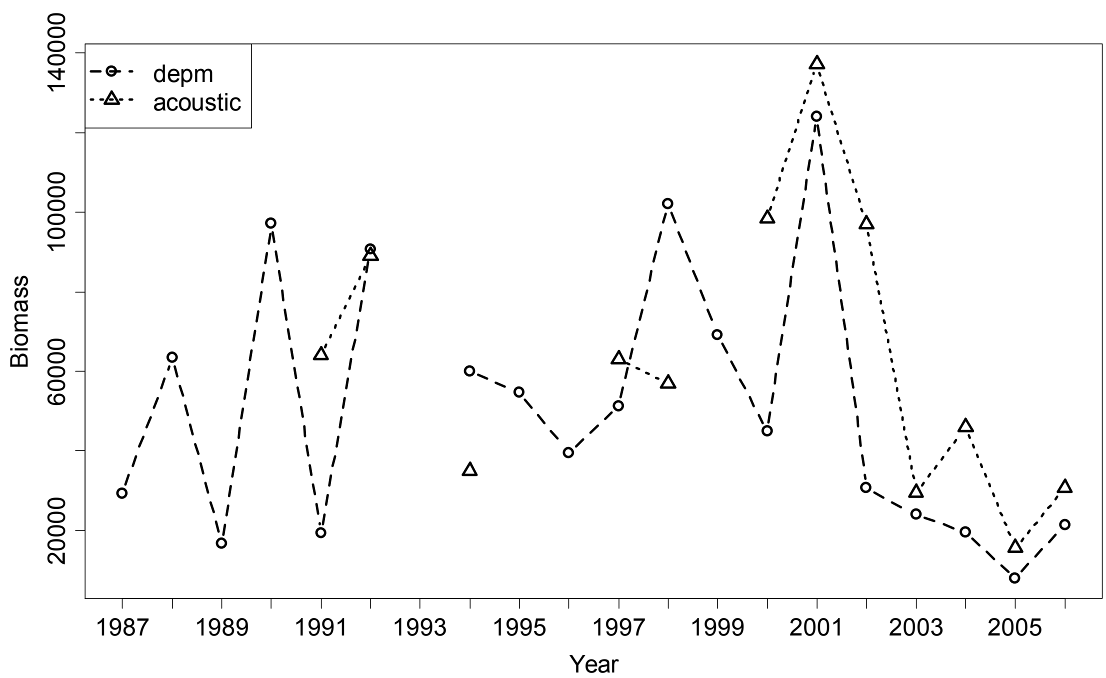


Figure 5.1.2. Acoustic (triangle points) and DEPM (circle points) based Bay of Biscay anchovy SSB estimates.

5.2 Spatial comparisons

The IPIMAR 2002 and 2005 DEPM and acoustic surveys were used to compare in space for the first time the spawning biomass (SB) of sardine estimated by the two methods. The comparison was performed using GAM-based estimates of SB by the two methods on a refined (1nm^2 of grid point area) spatial grid regularly covering the survey area (Portuguese coast and the Gulf of Cadiz). Mean depth on the grid points was estimated with linear interpolation from the IPIMAR acoustic and DEPM database, thus providing less reliable estimates for the edges of the continental shelf and the upper slope. SB for the DEPM surveys was estimated using the procedures described in ICES (2004) and Stratoudakis *et al*. (2006). The resulting total SB estimates were highly influenced by the choice of the spawning probability density function (N~(19, 2.5) in this case) selected during the ageing procedure (see Section 4.1) and thus the estimates should not be considered definitive but are mainly used to compare the spatial distribution of SB (see Table 5.2.1). SB for the acoustic surveys were obtained by the following procedure (J. Zwolinski, per. com.):

- Fitting a 2-stage GAM (presence/absence and abundance given presence) to the sardine energy values obtained during the traditional acoustic estimation;
- Predicting sardine energy on the regular grid;
- Estimating numbers at length at each grid point using the sardine target strength and the length frequency distribution in the closest fishing station within the survey;
- Estimating biomass at length and total biomass using an average length-weight relationship from the survey;
- Estimating mature and active fish abundance and biomass by applying a maturity ogive and a probability of being active at length, separately for the western and southern region (Silva *et al*., 2006).

This procedure permitted the estimation of sardine abundance at length and biomass (total, spawning and actively spawning) on a regular grid in space, facilitating the comparison between acoustic and DEPM estimates and providing a framework for estimating the variance components of all estimation steps other than the allocation of energy to species. The modelled estimates of sardine SB were similar to the traditional acoustic estimates for sardine (94% of the latter in 2002 and 91% in 2005) and had a comparable regional distribution (Table 5.2.1).

Figures 5.2.1 and 5.2.2 show the spatial distribution of acoustically estimated sardine biomass (total, spawning and actively spawning) in 2002 and 2005 respectively. In both years, modelled total biomass adequately reflected the spatial distribution of acoustic energy allocated to sardine (left panels), indicating the adequacy of the selected spatial models. Although total sardine biomass was very similar in the two years (574 kt in 2002 and 570 kt in 2005), its distribution between the western and southern regions was very different (48% in the latter region in 2002 and only 17% in 2005). In addition, while most fish were mature in 2002 (SB 81% of the total biomass), in 2005 SB only contributed 44% of the total. This was mainly due to the presence of a large number of juveniles off northern Portugal following the strong 2004 recruitment in that area. This is also reflected in the proportion of fish that were still spawning during the spring surveys (actively spawning biomass) that was 39% in 2002 and only 19% in 2005. In both years, actively spawning biomass during spring was lowest off northern Portugal, possibly indicating that the spawning season there ends slightly earlier than in the more southerly areas. These regional and interannual differences are well reflected in the distribution patterns of sardine eggs in winter (CalVET and CUFES of DEPM surveys) and spring (CUFES of acoustic surveys) and the SB regional estimates of DEPM, suggesting that both methods adequately reflect the main dynamics of the spawning season within the study area.

The distribution patterns in the above Figures also indicate that, despite the regional agreement by the two methods, the bathymetric distribution of SB suggested by acoustics and DEPM is different. SB distribution in the acoustics (driven by the distribution of sardine energy) is mainly contained within the inner shelf, while SB distribution in the DEPM (driven by the distribution of eggs) is considerably wider and peaks at the mid-shelf (Figure 5.2.3a). This difference cannot be attributed to a marked change in the bathymetric distribution of fish between winter and spring, since the bathymetric distribution of the probability of CUFES to detect sardine eggs was very similar in the two periods (Figure 5.2.3b). A plausible explanation for this discrepancy is that the spawning area (i.e. the area where spawners and young eggs are found) is narrower than the total distribution area of eggs. This hypothesis and its implications to egg sampling and production estimation in DEPM were further explored in Section 4.1.2 of this report.

Table 5.2.1. Sardine spawning biomass estimates (thousand tones) by region (western Portugal – WP and southern Iberia – SI) and overall (total) for the 2002 and 2005 DEPM and acoustic surveys based on traditional and model-based estimation (GAM).

YEAR	SURVEY	METHOD	WP	SI	TOTAL
2002	DEPM	Traditional	281	122	403
		GAM	328	102	430
	Acoustics	Traditional	236	258	494
		GAM	242	223	465
2005	DEPM	Traditional	216	48	264
		GAM	224	95	319
	Acoustics	Traditional	178	97	275
		GAM	160	91	251

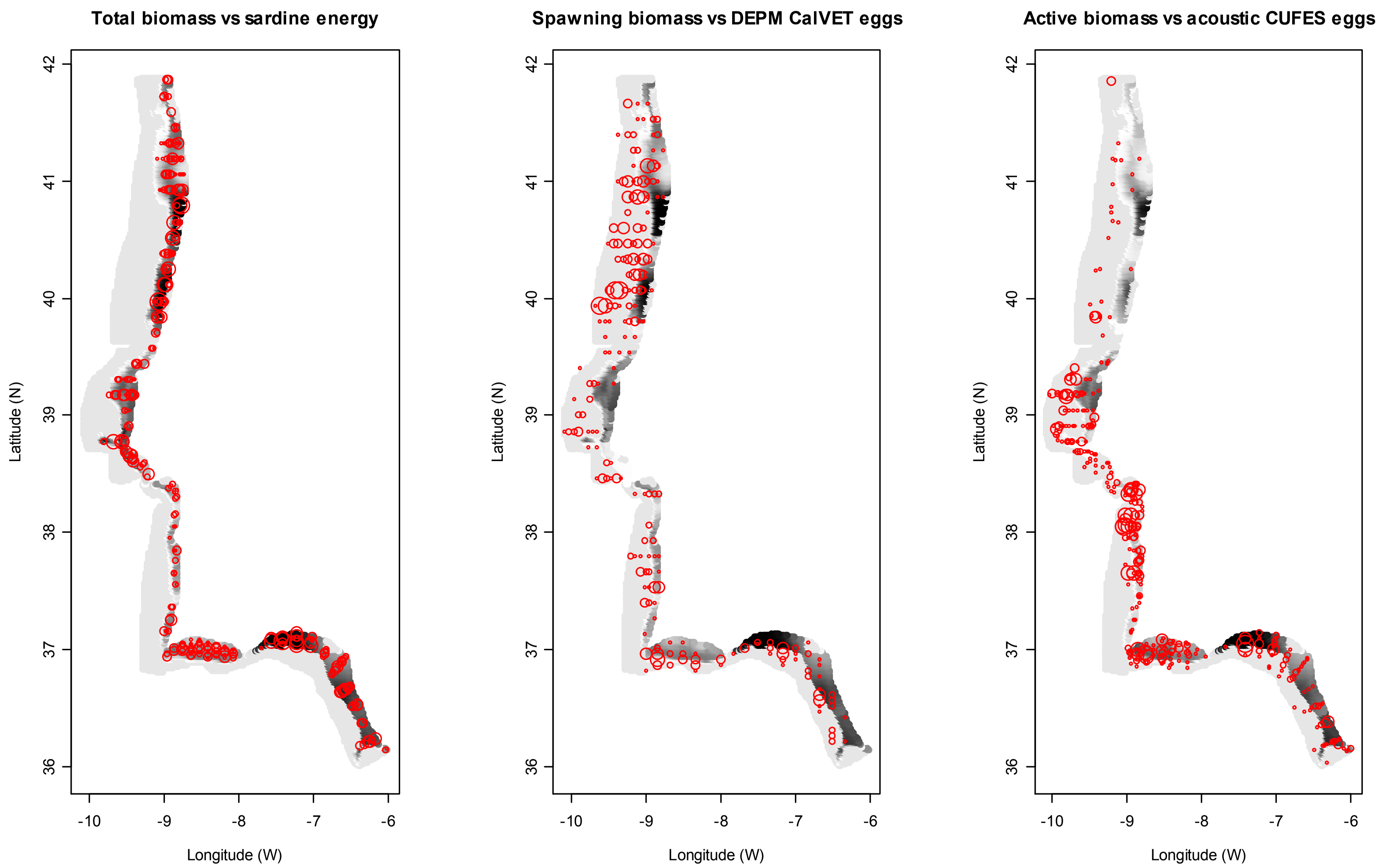


Figure 5.2.1. Spatial distribution (grey scale plot) of total, spawning and active biomass of sardine during the 2002 acoustic survey. Superimposed on the total biomass is the acoustic energy of sardine by EDSU and on the active biomass the concentration of sardine eggs in the CUFES samples.

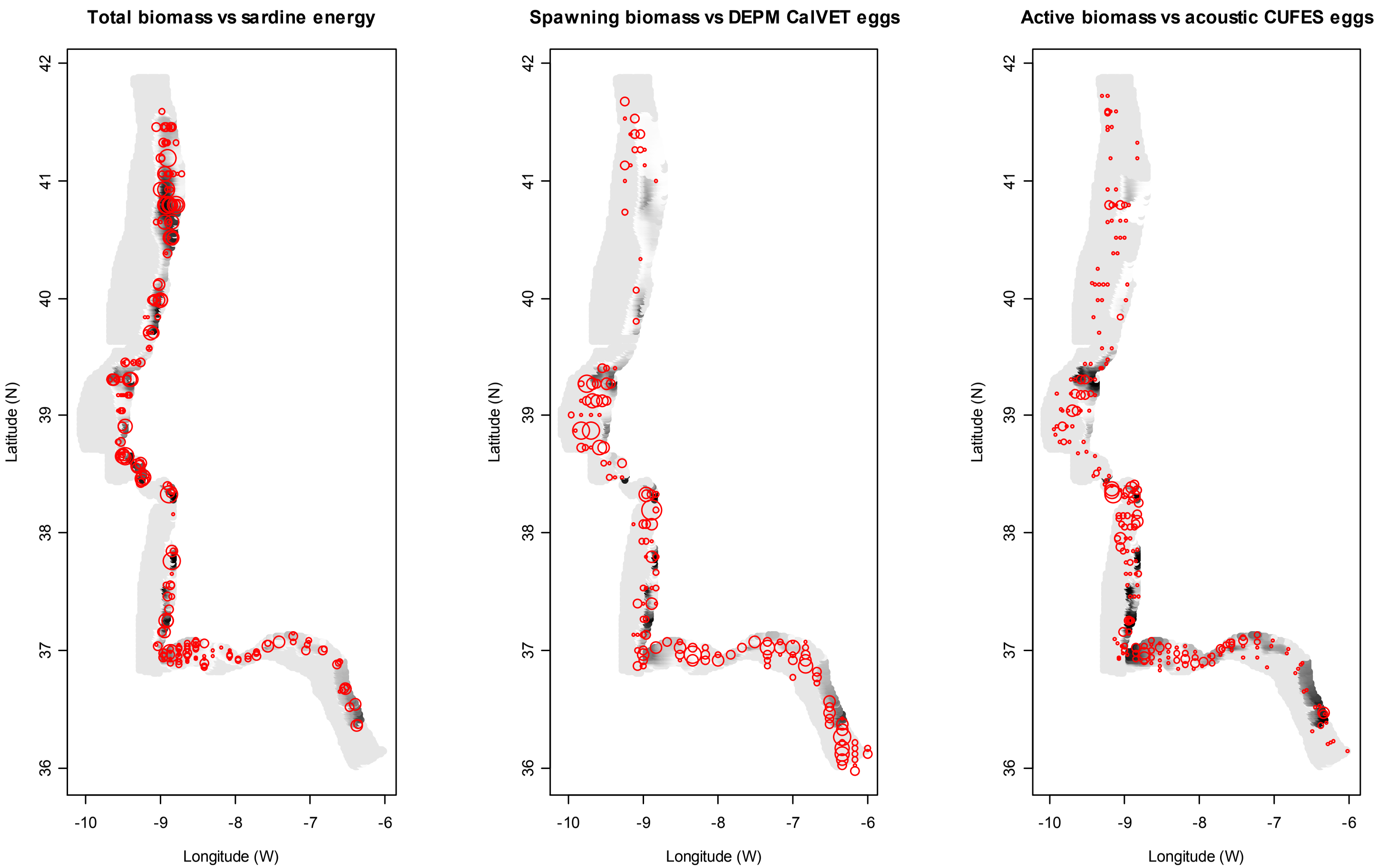


Figure 5.2.2. Smoothed bathymetric distribution of acoustic (April, in black) and DEPM-based (February, in red) SSB (left) and probability of egg presence in CUFES (right) in the Portuguese 2005 surveys.

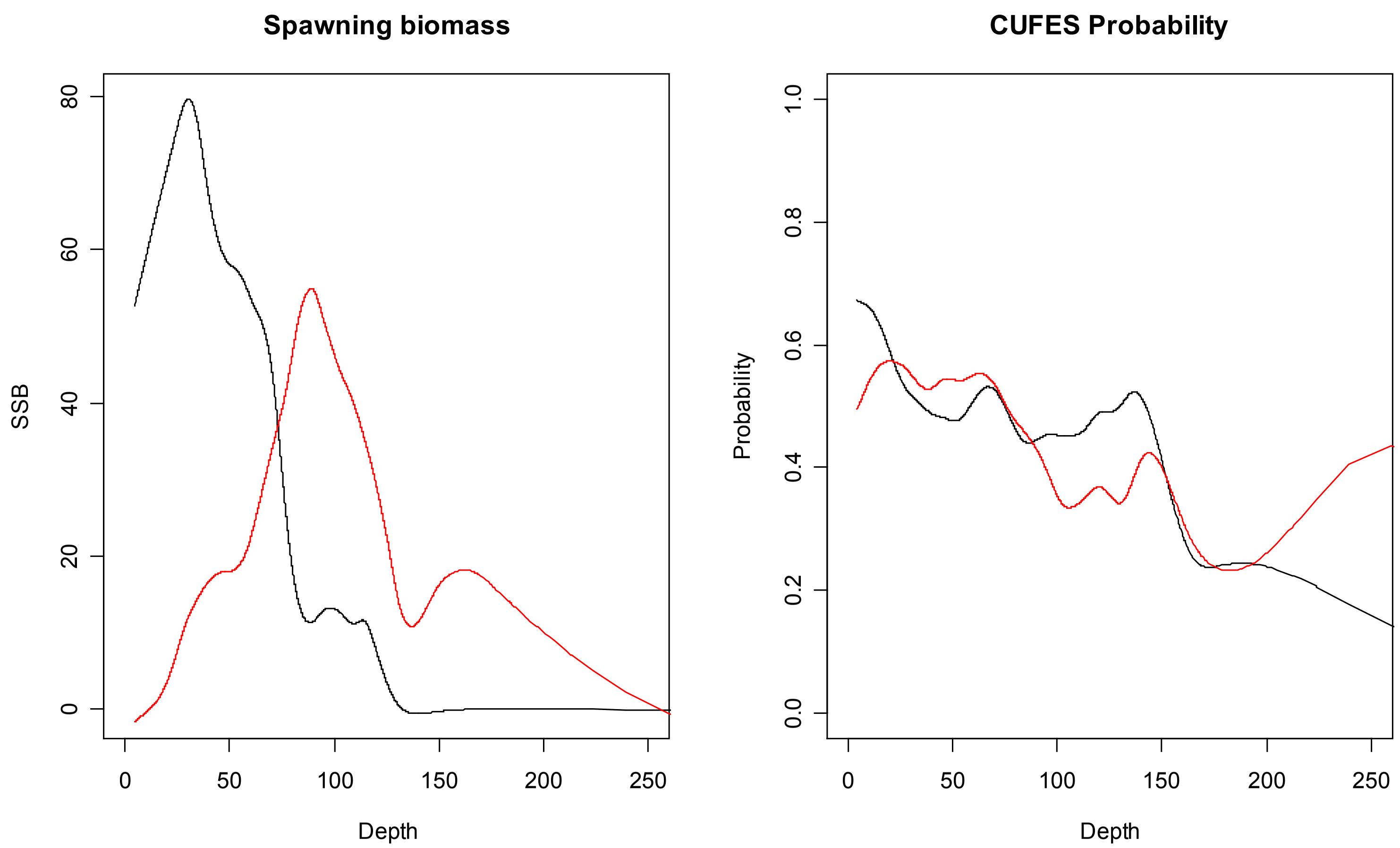


Figure 5.2.3. Smoothed bathymetric distribution of acoustic (April, in black) and DEPM-based (February, in red) SSB (left) and probability of egg presence in CUFES (right) in the Portuguese 2005 surveys.

5.3 Fisboat approach

FISBOAT (Fisheries Independent Survey Based Assessment Tools) is an EU project within the 6 th Framework Programme. The main objective of the project is the development of stock assessment tools based only on survey data and the evaluation of their performance. The project has developed methods and tools to obtain direct estimates and correspondent error estimates of population abundance, mortality, spatial occupation and length and maturity-at-age. Then, the project has set up two approaches to perform diagnostics: an analytical approach and an indicator-based approach. In the analytical approach, direct estimates of abundance-at-age will feed assessment population models that will be tested on a simulation framework. In the indicator based approach, the many indicators relative to vital traits, spatial distribution and abundance will be compiled in comprehensive diagnostic tables that evidence combined trends or changes from reference period means.

The project also deals with comparing different survey methods providing direct assessment. The Acoustic and DEPM surveys for the Bay of Biscay anchovy are part of the case-studies of the project. In order to provide adequate - diagnostics for this species, it is necessary to analyse the differences and similarities found between these two surveys. In this section, two approaches that are in development within the project are described. The first one consists on a comparison of both surveys (named catchability analysis). The second one presents an assessment model that integrates both surveys estimates in order to deliver synoptic population abundance estimates independent of the commercial catch data.

5.3.1 Comparison

Acoustic and DEPM surveys for the Bay of Biscay anchovy are conducted during the spawning season in spring every year. Both surveys provide overall and spatially explicit spawning-stock biomass (SSB). In particular, the DEPM spatial biomass estimates are computed from generalized additive models (GAMs) for daily egg production assuming constant egg mortality and constant daily fecundity in space.

The comparison (named catchability analysis) between both surveys biomass estimates will be finalized in 2007 and will consist on studying the following statistic:

$$q = I_{ac} / (I_{ac} + I_{depm}),$$

where I_{ac} and I_{depm} represent the biomass estimates of the Acoustics and DEPM methods.

The comparison will be focused on a common survey area and will be conducted at three different scales:

- Overall: Time-series analysis, autocorrelation, trends, correlation with additional variables
- Strata: Time-series analysis, autocorrelation, trends, differences between strata
- Spatial, in a common grid of points: Spatial statistics such as centre of gravity, inertia, for comparing acoustic and DEPM derived maps ; map of the average and variance (across years) of the ratio q, for analysing spatial pattern in consistency or inconsistency

In addition, multivariate analysis will also be considered.

This analysis will help to point out where and when the major differences and similarities between both surveys are found, and whether there are some consistencies in the disagreements in space or time, allowing setting the main hypothesis about them for further and more in-depth analysis.

In this way the major value of the analysis will be that of making explicit consistencies and discrepancies overall and in space such that explanatory hypothesis can be set and tested in order to make understandable, and potentially to resolve, those discrepancies. The results from this analysis will be made available for the next WGACEGGS meeting.

5.3.2 Integration

A method which derives survey based stock estimates and then also determines empirical relative reference points for stock biomass but without making any assumptions about virgin stock levels was suggested during the WG (WD – Trenkel 2006). The underlying population dynamics model used is a two-stage biomass model. The approach was tested for anchovy in the Bay of Biscay.

Surplus production models are used for stock assessment in cases where no detailed age information is available. The best known surplus production biomass model is the Schaefer model and its derivations (Hilborn and Walters, 1992). One step up from this are two-stage models that account separately for adults and recruits. An example for such a model for population abundance is catch-survey analysis (CSA) (Mesnil 2003). All existing simple models, in biomass or numbers, have in common that catches are subtracted, hence need to be known. Here a two-stage delay-difference biomass model was proposed that does not use catch data.

Several model fits were carried out using different data series and assumptions about which survey series acts as an absolute index for total biomass (Table 5.3.2.1 and Figure 5.3.2.1). Models 4 differ from models 3 in that the cv for survey indices were fixed. For the DEPM, the average CV reported in recent years was used (ICES 2006a). For the acoustic indices the average of the CVs estimated by Petitgas et al. (2003) was employed.

Table 5.3.2.1. Characteristics of models fitted to survey indices for Bay of Biscay anchovy. Survey parameters are defined in equations (4) and (5). RSS residual sums of squares (log-scale). Survey 1: DEPM; survey 2: acoustic.

MODEL	DATA SERIES	SURVEY PARAMETERS		RSS	
		fixed	estimated	DEPM n=29	Acoustic n=21
1	DEPM	$q_b^1=1$	q_r^1, cv_i^1	1.3	
2	acoustic	$q_b^2=1$	q_r^2, cv_i^2		0.79
3a	DEPM & acoustic	$q_b^1=1$	q_b^2, q_r^1, q_r^2, cv_i^1, cv_i^2	12.9	15.5
3b	DEPM & acoustic	$q_b^2=1$	$q^1{}_b$, $q^1{}_r$, q_r^2, cv_i^1, cv_i^2	13.2	15.7
4a	DEPM & acoustic	$q_b^1=1$ $cv_i^1=0.2$, $cv_i^2=0.16$	$q^2{}_b$, $q^1{}_r$, $q^2{}_r$	15.7	18.4
4b	DEPM & acoustic	$q_b^2=1$ $cv_i^1=0.2$, $cv_i^2=0.16$	$q^1{}_b$, $q^1{}_r$, $q^2{}_r$	16.0	18.4

The results show that it seems possible to use survey indices either directly or via a stock assessment model, in this case a biomass random effects model to carry out stock assessment and provide advice for anchovy management. Although the proposed model performed satisfactorily for total biomass estimation, the recruitment model could be improved, perhaps by including additional information or some sort of stock-recruitment relationship. The advantage of using a model is that it allows reconciling several survey indices, as demonstrated for the case of anchovy, where two series of survey indices were available, one based on the daily egg production method and the other derived from acoustic data. If required stock projections could be done using expected recruitment from the biomass random effects model or making alternative assumptions about future (relative) recruitment.

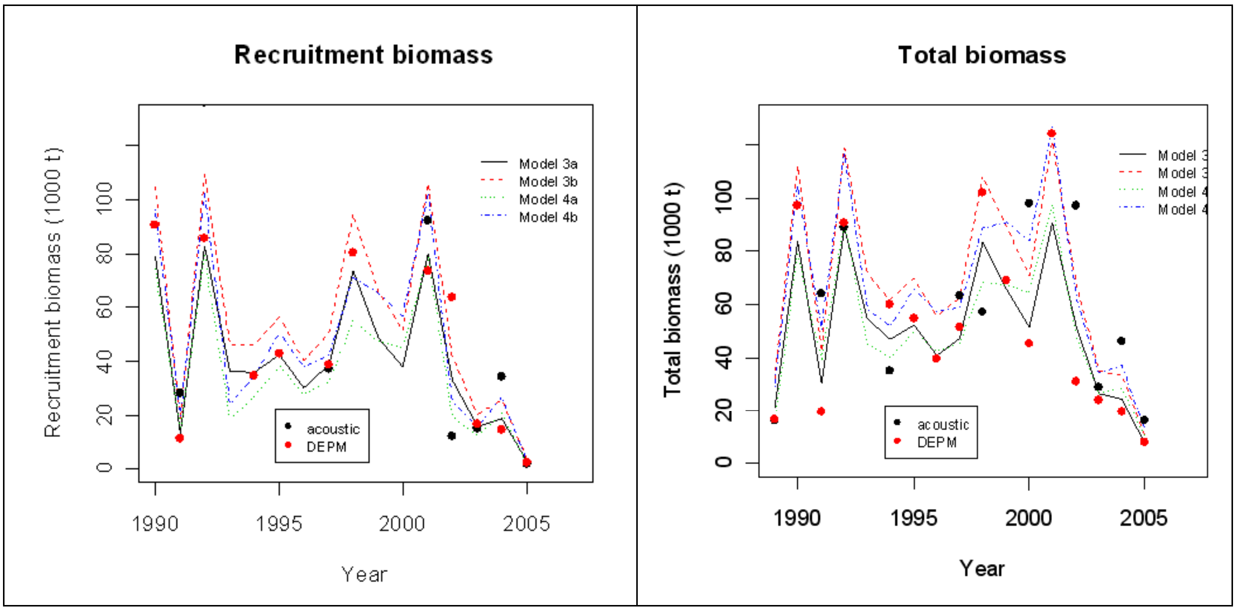


Figure 5.3.2.1. Biomass estimates for recruits (age 1) and total population biomass using Brem. Top row: models 1 and 2; bottom row: models 3a, 3b, 4a and 4b. See Table 5.3.2.1. for model definitions. Points indicate biomass indices.

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Annex 2: Agenda

Monday 27:

15: 00 – Presentation

15: 10 – Overview of last year advances (M. Bernal)

15: 20 - WGACEGGS 06: ToRs, Topics, special request and agenda (M Bernal)

15: 30 – Recent fishery-independent surveys for sardine and anchovy in ICES Areas VIII and IX

DEPM surveys

15: 30 – Anchovy DEPM estimates 2006 in the Bay of Biscay (M. Santos):

16: 00 – GC anchovy DEPM (adults) (Millan, Vila)

17: 00 – Coffee break

DEPM surveys, cont.

17: 30–2005 Cantabrian sea sardine DEPM (adults+ eggs + SSB) (G. Costas)

18: 00–Horse mackerel DEPM – based SSB estimates off Portugal (Murta et al)

Revisions:

18: 30–Comments on problems from the DEPM-based traditional SSB estimation

19: 30–End of day

Tuesday 28:

09: 00 – Juvenile acoustic surveys

09: 00 - PELACUS 1006 results (E. Nogueira)

09: 30 - Juvena 06 survey results (G. Boyra)

10: 00 – Discussion on juvenile methodologies and results

11: 00 – Coffee break

11: 30 – Discussion on the reply to special request

TOPICS (more detailed agenda to be set up)

Anchovy juvenile surveys: current objectives, importance for the fishery, current coordination, survey plan, coordination

Other surveys: importance for the assessment, current degree of coordination, references to other fisheries worldwide

13: 30 - Lunch break

14: 30 – Adult acoustic surveys: Anchovy

14: 30 - Gulf of Cádiz (GC): Results on the acoustic assessment and distribution of the main pelagic fish species in the ICES Subdivision IXa South during the ECOCÁDIZ 0606 Spanish survey (June 2006) (F. Ramos *et al.*)

15: 00 - Bay of Biscay (BoB): PELGAS 0606 (J. Masse)

15: 30 – Adult acoustic surveys: Sardine

15: 30 - Portuguese area: IPIMAR 06 (please confirm the name, sorry!)

16: 00 - Galicia and Cantabric: PELACUS 0406

16: 30 – Coffee break

17: 00 - A review on small pelagics TS; some results from GC anchovy (M. Iglesias) (followed by discussion) + Lit review by Vitor

17: 30 – WGACEGG Acoustic common database

17: 30 – Proposal for a common format and the use of a database software to analyse

acoustic data in common (J. Masse and P. Bellois)

18: 00 – Subgroups work:

Acoustic subgroup:

- Discuss results of this year juvenile survey, critical review, special request.

- Discussion on common acoustic database + plan for WGACEGG06

- Discussion on TS review

Eggs subgroup: - SSB estimates (work with data if necessary) (sub-subgroup)

- Discussion on 2005 results

- Discussion on horse mackerel problems and suggestions

Wednesday 29:

09: 00 – Additional work on ichthyoplanckton and acoustic surveys

09: 00 - Spawning frequency Estimator of the Bay of Biscay anchovy (A Uriarte)

09: 30 - Typology of anchovy juvenile schools in the Juvena series, Lezama, A.

10: 00 - Review of the PELACUS acoustic survey time-series: Spatial school structure and its effects in variance (P. Carrera)

10: 30 - Review on Gulf of Cádiz CUFES results (G. Costas and MP Jimenez)

11: 00 – Coffee break

11: 30- DEPM vs.acoustics SSB estimates

11: 30 – A critical review on the assumptions of egg production estimate (Bernal)

12: 00 – Comparison between acoustic and DEPM SSB estimates off Portugal (Stratoudakis)

12: 30 - Results on the comparison between DEPM and acoustic SSB from FISBOAT

13: 00 - Combining acoustic and DEPM survey indices in the biomass random

effects model for stock assessment (Masse)

13: 30 – Lunch break

14: 30 – Plenary:

14: 30 – Discussion on the draft of the reply to the special request.

15: 00 – Organization of the report, work to be done on subgroups.

15: 30 – Subgroup meetings

16: 30 – Coffee break

17: 00 – Plenary; Update of subgroup objectives and advances

19: 00 – End

Thursday 27:

09: 00 – Plenary; Update of timetable until the end of the meeting

09: 30 – Subgroup meetings

11: 00 – Coffee break

14: 00 – Lunch break

15: 00 – Plenary; Report structure (II), responsibilities by section and timetable for report discussion

16: 00 – Subgroup meeting and Report writing

16: 30 – Coffee break

17: 00 – Subgroup meetings and Report writing

18: 00 – Plenary; Discussion on conclusions by subgroups (I) (order of subgroup to be determined)

19: 00 – End

Friday 28 (Plenary)

09: 00

14: 00

Annex 3: WGACEGG Terms of Reference 2006

The **Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VIII and IX** [WGACEGG]. (Chair: M. Bernal, Spain) will meet in Palma de Mallorca, Spain from the 26–30 November 2007 to:

a) plan and coordinate egg surveys in ICES Areas VIII and IX and standardize analysis procedures;

b) plan and coordinate acoustic surveys in ICES Areas VIII and IX and standardize analysis procedures;

c) develop a framework to cross-validate egg production and acoustic methods for the estimation of Spawning-stock biomass and its distribution;

d) explore the possibilities to integrate egg production and acoustic based Spawning-stock biomass estimates;

e) finalize new egg production procedures and associated software developed under SGSBSA;

f) integrate biological/environmental information from surveys and additional sources to study the relationships between sardine and anchovy and the pelagic community in ICES Areas VIII and IX.

WGACEGG will report by 21 December 2007 for the attention of the Living Resources Committee.

Supporting Information

PRIORITY:	The Group has high priority as it will be responsible for providing integrated advice for two major and depleted stocks (sardine and anchovy) in this area. These stocks are distributed across national boundaries. The most important part of its work will be to standardize, plan and analyse all the relevant surveys and to integrate these together to give the best possible advice to the WGMHSA for assessment purposes. It will also capitalise on the successful work of SGSBSA and of the EU project PELASSES.
SCIENTIFIC JUSTIFICATION AND RELATION TO ACTION PLAN:	ToR a) Plan and coordinate egg surveys in ICES Areas VIII and IX and standardize analysis procedures. Egg surveys for sardine and anchovy have been carried out since 1988 in Spain and Portugal, and since 1997 surveys were coordinated within different projects and the SGSBSA. A continuation of this planning and coordination, as well as analysis methodology standardization, will be carried out within WGACEGG. Also, attention will be paid to the coordination, planning and standardization of CUFES surveys through all VIII and IX ICES Areas. [Action Numbers 1.11; 1.13]. ToR b) Plan and coordinate acoustic surveys in ICES Areas VIII and IX and standardize analysis procedures. Planning and coordination of acoustic surveys in ICES Areas VIII and IX have been attempted within the EU project PELASSES. WGACEGG is expected to improve planning and coordination between Spanish (IEO, AZTI), Portuguese (IPIMAR) and France (IFREMER) acoustic surveys, as well as standardizing methods and analysis procedures between these countries/institutes. [Action Numbers 1.11; 1.13]. ToR c) Develop a framework to cross-validate egg production and acoustic methods for the estimation of Spawning-stock biomass and its distribution. Both egg production and acoustic methods allow estimation of Spawning-stock biomass and stock distribution by using different assumptions and techniques. Cross-validation of these methods should be performed in a broad framework, allowing the comparison and validation of each method basic assumptions and identification of possible sources of discrepancy and its impact on the estimates. [Action Numbers 1.2; 1.11; 1.13]. ToR d) Explore the possibilities of integrating egg production and acoustic based Spawning-stock biomass estimates. Building from the knowledge of differences and sources of uncertainty/bias in each of the methods, obtained in ToR c) above, WGACEGG will explore the possibility of using both methods to obtain an integrated estimate of SSB. [Action Number 1.11].

Scientific Justification and relation to Action Plan (continued)	ToR e) Finalize new egg production procedures and associated software developed under SGSBSA. Both newly developed DEPM and traditional egg production methods have been explored in SGSBSA, and associated robust and user-friendly software to perform egg production estimates is under development. WGACEGG will continue to support this attempt, by validation and testing of these methods, with the aim of producing a complete manual with associated software for performing such analysis. [Action Number 1.10] ToR f) Integrate biological/environmental information from surveys and additional sources to study the relationships between sardine and anchovy and the pelagic community in ICES Areas VIII and IX. Information obtained from the spatial structure of the sardine and anchovy communities, together with associated environmental information would be integrated, with the scope of improving the understanding of the pelagic community, using both sardine and anchovy as key species of this community. [Action Numbers 1.2; 4.11].
Resource Requirements:	None
Participants:	15–20
Secretariat Facilities:	None
Financial:	None
Linkages to Advisory Committees:	ACFM
Linkages to other Committees Groups:	WGMHSA, WGLESP
Linkages to other Organizations:	Other countries/institutions applying the DEPM, or carrying out integrated acoustic-egg surveys worldwide.

Annex 4: Recommendations

RECOMMENDATION	ACTION
1. To review Sardine Spawning fraction (S) off North Atlantic Spanish Coast in 2005.	To review Sardine Spawning fraction (S) off North Atlantic Spanish Coast in 2005.
2. To establish a procedure for standardized analysis of the mortality on the egg phase, in order to avoid years with positive estimates of mortality.	To analyse the possibility of use information from the database for each species and stock in order to obtain mean mortality estimates.
3. To provide a development model for anchovy eggs in the Gulf of Cadiz.	To carry out an egg incubation experiment, in Cadiz for anchovy.
4. To further investigate the development of POFs in anchovy and sardine	1- To identify the best location and design and carry out a captivity experiment in order to know the POFs degeneration process to improve sardine Spawning frequency estimates in the Iberian Peninsula. 2- To carry out a captivity experiment in live bait tanks in order to know the POFs degeneration process to improve anchovy Spawning frequency estimates in the Gulf of Cadiz
5. To intercalibrate the spring acoustic surveys.	IPIMAR will try to accommodate the agenda of the IEO surveys carried out with the RV "THALASSA"
6. To use a common database (BARRACOUDA) to compare result from acoustic surveys and produce regional scale maps of fish distributions from all the acoustics surveys carried out along the Atlantic.	To conduct a Workshop before next WGACEGG meeting in order to test and produce regional scale maps using BARRACOUDA
7 To further scrutinize and compare the results of the 2006 autumn juvenile surveys for anchovy in the Bay of Biscay	To carry out a workshop in Nantes at the end of February
8. To use the same TS for both sardines and anchovies, given the variability in TS estimations for similar species in the bibliography, and until further studies on in situ estimation of TS length relationship for sardine and anchovy are done.	Each country tries to allocate some survey time to measure sardine and anchovy TS relationships during the acoustic surveys.
9. To improve the coordination of juvenile anchovy surveys, in order to improve coverage and precision of the estimates, and to improve the knowledge of the recruitment process in order to link juvenile abundance and recruitment	To adopt the proposed coordination for juvenile sampling

Annex 5: List of Working Documents and Presentations

List of WG Documents:

F. Baldó, A. Lago de Lanzós, C. Franco, G. Costas, and M. Bernal. Update of sardine daily egg production off the Northern coast of Spain in April 2005.

G. Boyra, U. Martínez, U. Cotano and A. Uriarte. Acoustic surveying of anchovy Juveniles in the Bay of Biscay: JUVENA 2006 Survey Report.

Costas G., and M. P. Jiménez. Review on CUFES results in the Gulf of Cadiz.

Jiménez M. P., G. Costas, M. Bernal y E. García-Isarch. Estimation of the Anchovy Daily egg Production (P_0) in the Gulf of Cadiz using R.

Millán M., Y. Vila, F. Ramos, M. Bernal, J. Tornero. Revision and updating of Gulf of Cadiz anchovy adult parameters estimates from the BOCADEVA0605 DEPM survey (June 2005).

Nogueira E., J. Miquel Batle, B. Villamor, J. Cabal, M. Bernal, B. Santos, C. González-Pola, R. Revilla (1) Informe General. Abundancia y distribución espacial de pequeños pelágicos en el Golfo de Vizcaya y su relación con las condiciones oceanográficas y las distribuciones de otros componentes del sistema pelágico.

Nogueira E., B. Villamor, J. Miquel Batle, J. Cabal, B. Santos, M. Bernal, C. González-Pola, R. Revilla (2) Abundancia y distribución espacial de juveniles de anchoa en el Golfo de Vizcaya.

Petitgas P., J. Massé, P. Beillois and F. Coppin. Proposition for a common database structure for acoustic surveys.

Santos M., L. Ibaibarriaga, A. Uriarte. Estimates of the Spawning Stock Biomass of the Bay of Biscay anchovy (*Engraulis encrasicolus*, L.) applying the DEPM.

Trenkel V. M. Combining acoustic and DEPM survey indices in the biomass random effects model for stock assessment.

List of WG Presentations

Alday A., A. Uriarte, M. Santos, L. Motos. Spawning frequency estimator of the Bay of Biscay Anchovy (*Engraulis encrasicolus* L.)

Boyra G., U. Martínez, U. Cotano y A. Uriarte. Juvena Survey Report 2006

Carrera P. Habitat-acoustic.

Costas G., A. Lago de Lanzós, F. Baldó, J. R. Pérez, C. Franco and M. Bernal. Estimates of the Spawning Stock Biomass of sardine (Sardina pilchardus, W.) off the North Atlantic Spanish applying the DEPM.

Costas G., and M. P. Jiménez. Review on CUFES results of the Gulf of Cadiz (2004–2006).

Goncalves P., A. Costa and A. Murta. DEPM applied to Horse Mackerel (Trachurus trachurus). Estimation of Adult Parameters.

Iglesias M., J. Miquel, M.Bernal, C. Porteiro, D. Oñate, B. Santos, N. Diaz. Pelacus 0406 acoustic survey sardine estimation.

Iglesias M., J.Miquel, F. Ramos. A review on small pelagic TS; anchovy (Engraulis encrasicolus): Preliminary results.

Jiménez M. P. Anchovy SSB estimation in the Gulf of Cadiz (2005).

Marques V. Anchovy TS Problem: Is anchovy's individual TS higher than sardine?

Marques V. Surveys for sardine and anchovy, November 2005- April 2006 off Portuguese coast and Gulf of Cadiz.

Massé J. PELGAS06 survey.

Millán M., Y. Vila, M. Bernal, F. Ramos, J. Tornero. Revision and updating of Gulf of Cadiz anchovy adult parameters estimates from the BOCADEVA0605 DEPM survey (June 2005).

Nogueira E. PELACUS-1006. Anchovy juveniles in the southern Bay of Biscay. Relationship with hydrographic conditions and other components of the pelagic ecosystem.

Petitgas P., J. Massé, P. Beillois and F. Coppin. Proposition for a common database structure for acoustic surveys.

Ramos F., J. Miquel, M. Millán, M. Iglesias, D. Oñate, and N. Díaz. Results on the acoustic assessment and distribution of the main pelagic fish species in the ICES Subdivision IX a South during the ECOCÁDIZ 0606 Spanish survey (June 2006).

Santos M., L. Ibaibarriaga and A. Uriarte. Anchovy DEPM estimates 2006 in the Bay of Biscay.

Stratoudakis Y, Zwolinski J, Angelico MM, Marques V, Nunes C, Silva A: DEPM versus acoustic estimation of sardine abundance in space.

Stratoudakis Y., and M. Bernal. Sardine spawning biomass estimates from Iberian DEPM surveys, 1997–2005.

Trenkel Verena. Combining acoustic and DEPM survey indices for anchovy in the biomass random effects model for stock assessment.

Uriarte A., J. Massé. Proposal for the catchability analysis of the Acoustics and DEPM surveys for the Bay of Biscay anchovy within Fisboat.

Vendrell C., M. M. Angelico, E. Cunha, A. Murta. Applying DEPM to Horse Mackerel.

ICES. Working Group on acoustics and egg surveys for sardine and anchovy in ICES Areas VIII and IX.

Annex 6: Answer to EU special request on anchovy surveys

WGACEGG has been asked by ICES to deal with an EU special request on Anchovy surveys in the Bay of Biscay. In relation to this issue, the WG has discussed the different surveys carried out for this stock, taken into consideration former discussion that took place both in WGMHSA and in the ACFM. In this annex, the WG provides some further information on the use of fishery-independent abundance and recruitment index in anchovy and in other small pelagic fisheries over the world. The information includes a critical review of the strengths and problems of the juvenile surveys that have been carried out in the area and that were detailed in the ACFM initial response to the reply (Table 7.3.3.1.1, ACFM report 2006).

The WG endorses WGMHSA conclusion that a) indices of stock biomass in spring and b) indices of recruitment based on surveys on autumn are required to assess the state of the anchovy stock. Below, a detailed review of the different methods and surveys used is discussed, and a discussion of their importance and recommendations for improving coordination are presented.

1. Spring Stock biomass cruises

Both DEPM and acoustic methods are used worldwide to assess and manage stocks and fisheries of small pelagic fishes in general and anchovy in particular (see examples in Stratoudakis *et al*., 2006; Barange *et al*., 2006 and references herein).

DEPM and acoustic spring cruises targeting the anchovy stock have been carried out in the Bay of Biscay (BoB) since the late 1980s. They are used to estimate the historical evolution of the stock as a tuning index for stock assessment by the WGMHSA. At present, in relation to anchovy in the BoB two spring cruises are carried out: a DEPM + CUFES survey (BIOMAN by AZTI) and acoustic + CUFES (PELGAS by IFREMER).

The WG considers that these cruises are well coordinated. Besides, this coordination has been strengthening through the work performed within the WGACEGG. However, within the ICES paradigm of the ecosystem approach and at the scale of regional seas of Southern Europe, the current surveys can be further coordinated with other surveys carried out with similar / complementary objectives in this region. Thus, the WG recommends that the cruises that are currently carried out in spring should continue, and suggestion for wider scope and further coordination with other surveys presented in Section 3 of the 2006 WGACEGGS Report.

2. Autumn anchovy juveniles cruises

The anchovy biomass is directly related to yearly recruitment. For management purposes, it is necessary to know or forecast the level of recruitment. Recruitment studies are currently carried out by targeting the juvenile spatial distribution and abundance in autumn, as well as the ecological and hydrodynamic processes which affect the recruitment process. The ultimate scope of these surveys is to obtain a time-series of data which can provide an index of next year recruitment to the fishery. The same types of surveys are currently carried out in other parts of the world with similar objectives.

The WG considers that acoustic-fishing surveys should continue to be carried out in the period September/October. These cruises should have two main objectives:

1) The estimation of abundance and spatial distribution of anchovy juveniles in order to provide an index of abundance of recruits that could improve the assessment for the management of this fishery, and

2) The study of the ecological mechanism involved in the process of recruitment of the juveniles into the fishery, in order to understand the observed fluctuations of this stock.

The WG considers that these two objectives are complementary, since the knowledge of the recruitment process (objective 2) is necessary to increase the reliability of the recruitment index (objective 1), and can be fulfilled in the frame of a single, coordinated project-survey designed jointly among the different countries / research Institutes involved in the study of this stock. The basic lines of coordination are documented in Section 3.1.1 of the WGACEGGS Report.

3. Critical review of the existing juveniles cruises in the BoB

JUVENA (Spain, AZTI).

This cruise has been carried out since 2003. Its main objective is the provision of an index of recruits (objective 1), although environmental information is also acquired in order to get insights in the ecological processes that can be involved in the recruitment process, thus satisfying partly objective 2. It provides the longest time-series of juvenile abundance estimates, aiming to provide a recruitment index (4 years up to now), and during this period has incorporated the recommendations by the STECF SGRST WG on Anchovy in the Bay of Biscay in order to improve the quality of the recruitment index. It covers the area where it is consider that the bulk of juveniles can be found (approximately east of 5º W, south of 46º N); although for the last years area coverage has expanded until 47.30 through the planned adaptive sampling design. It also uses additional information provided by the commercial fleet.

The adaptive enlargement of the surveyed area in the last two years cause warnings about the comparability of the results concerning the comparability of the percentage of the potential distribution area covered through the time-series. Former surveys did not have the ability of sampling bottom detections (only purse-seiner sampler), although other research projects point out that juveniles are mainly located on the surface at the selected survey period. Time constraints impose a survey resolution which is considered to be low (i.e. around 15 nautical miles between transects). The survey did not include a multi-specific approach.

JUVAGA (France, IFREMER)

This cruise has been carried out in 2003 and 2005 (and partially in 2006 –see PELACUS-10 paragraph). Its main objective is the study of the mechanisms involved in the process of recruitment (objective 2). During the cruise, information is acquired on different aspects of the pelagic ecosystem, from hydrodynamics (i.e. release of drifting buoys to feed the coupled hydrodynamic-biological, individual-based model) to components of the pelagic ecosystem (i.e. from plankton to other pelagic fish species).

This survey does not provide an index of recruitment and the sampling strategy is opportunistic and therefore there is no consistent spatial coverage for assessment purposes. In 2006, this cruise has been assimilated within the objectives of the PELACUS-10 cruise.

PELACUS-10 (Spain, IEO; second leg, in coordination with IFREMER)

This cruise has taken place for the first time in 2006. It tries to fulfil both the estimation of a recruitment index (objective 1) and insights in the recruitment process (objective 2). For this, the cruise is split in two parts: one devoted to systematic sampling in order to estimate juvenile abundance, the other focused on process studies. It provides information on different ecosystem aspects, from hydrodynamics to different components of the pelagic ecosystem, from picoplankton to other pelagic fishes. The second part of the cruise has been coordinated with IFREMER.

This survey does not provide information on the coastal component of juveniles (i.e. no possible acoustic exploration, nor fishing operation was possible in areas shallowest that 30 m depth), and could not cover the northern limit of the potential juvenile distribution. It is the first of the time-series. The resolution of the acoustic-fishing exploration is considered to be relatively low (12 nm inter-transects). The need to fulfil the two objectives and the available time goes in detrimental of the exploration of all the potential distribution area of juveniles.

CENTINELA

This cruise is carried out by commercial fishing boats to provide qualitative information of the spatial distribution / abundance of juveniles in the southern part of the BoB in autumn.

These surveys are ad hoc cruises; the methods and equipment used for exploration are not quantitative; they are not organized following an scientifically-based approach, and its results are currently not being used in assessment / scientific WG.

Recommendations

The WG recommend coordinating the different cruises that are currently carried out in the BoB in order to produce a reliable recruitment index (objective 1) from a joint survey and improve the knowledge of the recruitment process (objective 2). This coordination should also assure continuity and comparability of former surveys on juveniles of anchovy in BoB. This can be done trough the formalisation of a single project-survey, based on the agreement among the partners (AZTI, IFREMER and IEO) on sampling strategies, methodologies, logistics, etc. The WG also encourages the use of other methodologies (i.e. coupled hydrodynamic-biological model-based outputs) and additional information from other sources (i.e. captures by the commercial fleet) which can lead to a model-based recruitment index. This common project must provide quality information on environmental conditions and other ecosystem components.

A proposal for a coordination of a possible single survey of juveniles in the Bay of Biscay can be found in Section 3.1.1.