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Report of the Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES areas VIII and IX

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Conseil International pour l'Exploration de la Mer

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Contents

1 Executive summary

The Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES areas VIII and IX (WGACEGG) met for the first time in Vigo, Spain from the 24–28 October 2005. The main aims of the WG are: i) to act as the forum for reporting recent acoustic and ichthyoplankton surveys targeting sardine and/or anchovy in Atlantic Iberian waters and off the Armorican shelf; ii) to report new improvements in survey planning and analysis; to improve coordination between institutions, as well as between different pelagic surveys carried out in these areas; iii) to provide both comparison and cross-validation between acoustic and ichthyoplankton based estimates of abundance and distribution; and to create a framework for a possible integration of direct assessment provided by these methods. During this first WG meeting a detailed description of the methods used, the methodological and analysis differences between institutes and/or species and a list of available time series of surveys were produced. Also, data from different institutes have been pooled together in order to be able to produce a broader scale coverage and to provide a larger spatial and environmental contrast in the data. A framework for future comparison and integration of acoustic and egg production based estimates of biomass and distribution has been set up, by detailed description of the inherent sources of bias and uncertainty in both methods. Coordination and standardisation of survey plans and analysis techniques have been found to be generally good, although further improvements in coordination are still desirable, especially for the anchovy juvenile surveys, and for the collection of additional data from the pelagic community from acoustic and ichthyoplankton surveys. Specific main points of required methodological improvements include the selection of appropriate species specific Target Strength values, as well as improvement of Post Ovulatory Follicles ageing/datation methods.

Results from recent acoustic and ichthyoplankton surveys for sardine and anchovy in all covered areas, some of which were already presented at the WGMHSA meeting, were presented during this meeting. Preliminary results of some of the 2005 surveys have been reported directly to this WG, which has speed up the reporting procedure specially for egg production estimates (usually provided for next year assessment). Preliminary results for the 2005 egg production estimation of sardine from IEO and IPIMAR, as well as adult parameter estimates for sardine by IPIMAR, and preliminary results for the 2005 egg production survey of anchovy performed on June 2005 were presented to the WG. Also, final results of the Bay of Biscay anchovy – egg production survey – already presented to WGMHSA- and preliminary results of Gulf of Cádiz egg production surveys were presented. For acoustics, spring survey results were already presented to the WGMHSA, but results from the 2005 anchovy juveniles surveys, finished immediately before the meeting, were reported directly to this WG. Preliminary results from the juvenile anchovy distribution in ICES area VIII suggest a larger abundance than that found in 2004 but, with a more oceanic distribution. Nevertheless, these results are only qualitative as only preliminary results are available and the survey time series is too short. Preliminary results of the egg production survey in the Gulf of Cádiz show a slight increase in the spawning area in relation to 2004, although with lower mean egg density. Biomass levels of anchovy in the Bay of Biscay are very low, in relation to its time series, and similar to the ones observed in the Gulf of Cádiz. Preliminary sardine egg production estimates are higher than those for 2002 but still not at the level of the maximum values observed in the time series (as could have been suggested by the biomass levels estimated by WGMHSA). Acoustic estimation of sardine off Portugal shows a large recruitment off the Portuguese coast, but low abundance in the Gulf of Cádiz area.

The WG has also established some criteria to provide next year WGMHSA with a complete update of the DEPM-based SSB estimates for sardine, and a protocol for data preparation before the meeting in order to speed up the presentation of results.

2 Introduction

2.1 Rationale for the group

WGACEGG has been created within the ICES Living Resources Committee to continue the work of SGSBSA and to extend it to acoustic based estimation of sardine and anchovy abundance and distribution in the Atlantic European southern area. The scope of the group is broad in relation to the previous scope of SGSBSA, as it includes two different direct observational methods – acoustic and ichthyoplankton – and two different species, and involves four different institutes. Nevertheless, the rationale for such a WG relies on the underlying similarities between both methods and species. Both sardine and anchovy are pelagic species with pelagic eggs and are assessed and studied with similar methods. In the Iberian Peninsula and adjacent waters, both species share similar habitats, although anchovy shows a more restrictive distribution area. Acoustic and ichthyoplankton based methods for studying the pelagic community show some important similarities. Both methods rely on an intensive spatial sampling grid, and thus involve a great deal of spatial statistics to produce reliable and unbiased estimates. The development of spatial-based egg production methods (ICES 2004, 2005) increases the similarities of the analysis of both methods and also increases the scope for further comparison and integration between them. Ichthyoplankton and acoustic surveys are also carried out usually at the same point in the yearly life-cycle of the target species; at the spawning period. They both aim to study the spawning population, but both do so by relying on indirect indices of the adult abundance; the total number of sampled eggs or the total number of registered acoustic energy. These indices should be corrected first for the percentage of the whole that the target species represents (either by sorting eggs or by adult sampling and species composition in hauls) and then should be raised by some factor to estimate population abundance, either by adult fecundity (egg production methods) or by target strength (acoustic methods). As acoustic methods do not require the individuals to produce eggs, they can also provide, although with increasing levels of uncertainty and methodological problems, estimates of juvenile abundance and distribution.

The aims of this WG are therefore to provide the more reliable estimates of spawning biomass and its distribution from both ichthyoplankton and acoustic based methods, abundance and distribution of juveniles from acoustics, and to understand the ecological/biological inherent similarities/differences between acoustic and ichthyoplankton methods in order to be able to compare/integrate them in the most comprehensive way.

2.2 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) has met in Vigo, Spain from 24–28 October 2005 to:

a) plan and coordinate egg surveys in ICES areas VIII and IX and standardise analysis procedures;

b) plan and coordinate acoustic surveys in ICES areas VIII and IX and standardise 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) finalise 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.

2.3 Links with other ICES WG and international Projects

WGACEGG has direct links to other ICES SG/WG and a number of international projects. In terms of ecological processes, WGACEGG relates to ICES SGRESP and GLOBEC SPACC project, although WGACEGG deals with ecological process mainly in what they may affect the spatial structure and the availability of the fish population to the acoustic and ichthyoplankton surveys. In terms of the comparison and integration of direct observational methods for small pelagics, WGACEGG relates to the recently carried out Workshop on Survey Analysis and Design (WKSAD), although comparison on the survey was mainly done between acoustic and bottom trawl surveys, and the EU project FISHBOAT. Also, WGACEGG has largely benefited from the incoming results of the EU project SARDYN, as well as previous projects like PELASSES and GAM.

WGACEGG has also an important link with the small pelagic assessment working group (WGMHSA), as this WG should provide the assessment WG updated and revised estimates of both acoustic and DEPM based spawning stock biomass. Also, one of the long term ToR of WGACEGG is to provide not only revised estimates of SSB from acoustics and DEPM surveys, but also to provide ways of comparing both estimates and ultimately to integrate both estimates in a unique SSB estimator.

2.4 Report structure

The report structure for this WG meeting has been organised in order to summarize the topics both of this first WG meeting and to outline a general report structure to be used in next WG meetings. Some of the sections of the report will remain in future WG reports, in order to cover the long term ToRs, while other sections are expected to disappear in following WG meetings.

Chapters 1 and 2 are the introductory chapters of the report, while Chapter 3 includes all information obtained from recent ichthyoplankton and acoustic surveys for both sardine and anchovy.

As this is the first meeting of WGACEGG, both the later survey -in most cases carried out during 2005– and previous recent surveys are reported in the different subsections of Chapter 3. Section 3.1 introduces the general methods used in both icthyoplankton (Section 3.1.1) and acoustic (3.1.2) surveys, highlighting the similarities and differences between institutes. Section 3.1.3 introduces the sampling and analysis methods used to gather and explore complimentary data obtained mainly through the acoustic and ichthyoplankton surveys (hydrographic data, cetaceans and seabirds composition and distribution, etc). Section 3.1 is especially important for this first WGACEGG meeting, although it is expected to become less important in successive meetings.

Section 3.2 shows a general distribution of the pelagic species through the most recent survey, in order to put in context the distribution and importance of sardine and anchovy in ICES areas VIII and IX. Sections 3.3 and 3.4 deal with the results of anchovy and sardine respectively. For the case of anchovy, the populations from the Bay of Biscay and from the Gulf of Cádiz are treated separately (Sections 3.3.1 and 3.3.2 respectively) while sardine is treated globally (Section 3.4). Each of these three sections (anchovy VIII; Section 3.3.1, anchovy IX; Section 3.3.2, and sardine 3.4) is divided in two subsections, one for egg production surveys and another for acoustic surveys. Also, each methodology subsection is divided in different subsections, containing the basic sources of information required to calculate the abundance estimates. For the case of egg production, this comprises egg distribution and estimates of egg production, adult parameters and spatial estimates of egg production based Spawning stock biomass. For the case of acoustics, this comprises species distribution and length composition, and energy allocation to the target species.

Chapter 4 deals especially with ToRs a) and b); planning and coordination of next acoustic and egg production surveys, including the anchovy juvenile acoustic surveys.

Chapter 5 reports on advances in both the egg production and the acoustic methods, and thus relates to ToR e)

Chapter 6 includes what the WG believes are the pre-requisites for dealing with ToRs c) and d). In this Chapter, a detailed description of the inherent sources of bias of the different observation layers underneath each method, as well as the precision of the parameters required in obtaining estimates of abundance and distribution from each of them is presented. This chapter is expected to disappear for next WG meeting reports.

Chapter 7 lists the available ichthyoplankton and acoustic surveys which will be used for the comparison and integration of acoustic and egg production surveys (ToRs c and d), as well as a short outline of proposed research lines for future WGACEGG meetings.

Finally Chapters 8 and 9 present the WG conclusions and recommendations.

3 Recent fisheries independent surveys of sardine and anchovy stocks in ICES areas VIII and IX

3.1 Introduction

During this first WG, an effort to list the similarities and differences between the various institutes applying acoustic and ichthyoplankton methods to each of the species was carried out. Standardisation of the methods and analysis procedures has been carried out using the SGSBSA (ICES, 2005) for ichthyoplankton methods, and the EU project PELASSES for acoustic methods. In this introductory part of Section 3, a summary of the characteristics of the ichthyoplankton based methods, acoustic observation, hydrography and other sampling of the pelagic communities within these surveys are briefly reviewed, and the main results obtained from the last surveys are presented for each species.

Ichthyoplankton methods are used by all the involved institutes and for both species, although IPIMAR and IEO surveys in the North and West Iberian Peninsula target sardine populations, while IFREMER, AZTI and Gulf of Cádiz IEO surveys target anchovy populations. Acoustic sampling is also used by all institutes, but only AZTI uses this method to evaluate anchovy juvenile abundance. IFREMER targets both the anchovy adult population and carries out an anchovy juvenile behaviour survey, while only IEO and IPIMAR only carry out surveys at spawning time to evaluate the adult population. Again, IEO and IPIMAR acoustic surveys in the North and West Iberian Peninsula target mainly sardine, although they evaluate all the pelagic community available to the survey, while Gulf of Cádiz IEO acoustic survey targets anchovy populations.

3.1.1 Sampling methodology and analysis techniques in egg production surveys

3.1.1.1 Ichthyoplankton sampling and egg production estimates

The DEPM was applied for the first time in 1988 by Portugal (IPIMAR) and Spain (IEO) in order to estimate the spawning biomass of Atlanto-Iberian sardine. In 1990 it was only applied by Spain off the north Iberian coast. In 1997 it was again applied by both Spain and Portugal and since 1999 DEPM surveys have taken place triennially covering the entire continental shelf of the Atlantic-waters of the Iberian Peninsula. For anchovy the DEPM has annually been applied since 1987 in the Bay of Biscay by Spain (AZTI) and it was used for the first time during spring 2005 in the Gulf of Cadiz by the IEO.

The survey methodology has been standardized in order to increase the coordination of egg surveys. Table 3.1.1.1-1 summarises the main characteristics of the surveys. In addiction, different analysis techniques have been used to age the eggs and to estimate egg production according to the development of new statistical methodologies. Table 3.1.1.1-2 summarises the analysis techniques applied each year.

3.1.1.2 Adult sampling

In 2005, four DEPM independent surveys were conducted in the Iberian Peninsula (ICES areas VIII and IX) by the Spanish (IEO Vigo, IEO Cadiz, AZTI) and the Portuguese (IPIMAR) institutions to estimate the spawning population biomass of either the sardine or the anchovy as main target species (IEO Vigo: areas West VIIIc and North IXa; IEO Cadiz: area South IXa; AZTI: areas VIIIa, VIIIb and VIIIc; IPIMAR: area IXa). The most important characteristics of these latest surveys are summarized in the Table 3.1.1.2_1: the methodology used for the adults sampling and for the estimation of the adult's parameters is compared between the institutions. More detailed information on these methodological issues is discussed further in this report. Despite the observed differences in adult sampling, the group considered that most of them are minor, not preventing comparison between results of the surveys (see also Section 6.2.1.2 on the potential sources of bias as, e.g., the effect of sampling time of the day on the estimation of S).

Some topics of the current year's methodology have also changed since the previous DEPM surveys. Concerning sardine (IEO, IPIMAR), the changes over time of the methodological issues are described in detail in the 2002 ICES Report of the SGSBSA (ICES, 2002) and the *ICES Cooperative Research Report* on the Daily Egg Production Method (ICES, 2004). Concerning anchovy, Table 3.1.1.2_2 shows the characteristics (sampling and analysis methods) of the historical series of the DEPM surveys conducted by AZTI since 1987.

3.1.2 Sampling methodology and analysis techniques in acoustic surveys

3.1.2.1 Survey strategies and energy allocation to species

In this section, an outline of the main methods used by each institute is produced, and their differences and similarities reported. Main characteristics of the acoustic survey by institute and region are shown in Table 3.1.2.1.1.

IPIMAR

The Portuguese acoustic surveys are mainly directed to sardine and anchovy.

The survey track follows a parallel grid, with transects perpendicular to the coastline. The acoustic energy in the inter-transect track is not taken into account. The transects are spaced by 8 nm in the west coast, 6 nm in Algarve and around 10 nm in the Cadiz area. Acoustic data from 38 kHz are stored with MOVIES+ software as standard HAC files along the transects. Trawl hauls are performed whenever significant amounts of fish are found but mainly targeting sardine and anchovy. Trawl data are used to:

- identify the echotraces
- obtain the length structure of the population
- obtain the species proportion
- get biologic samples

The identification of the echo traces is made by eye, with the aid of the trawl hauls. If it is not possible to separate the species schools by eye, the energy of the ESDUs (Elementary Sampling Distance Unit) is split using the haul species proportion, in number, and taking into account the target strength and the species length compositions.

The weight of the hauls is always the same, since a post stratification is made and the overall area is divided into small homogeneous areas, with similar length composition. To partition the acoustic energy by species, using the trawl species proportion, the hauls are not weighted by the energy around the haul, assuming that the species mixture is independent of the acoustic energy density. The acoustic energy is extracted from the EK500 echograms, school by school, using MOVIES+ software. Plankton and very small schools are rejected.

For each species, the acoustic energy is also partitioned by length classes according to the length structure found in the trawl hauls. The biomass is derived from the number of individuals, applying the weight/length relationship obtained from the haul samples.

IEO

During IEO surveys ESDU is fixed at 1 nm. Fish abundance estimation is only done for the 38 kHz frequency using the Nakken and Dommasnes method. Nevertheless, echograms from 120 kHz were used to visually discriminate between fish and other scatter organisms such as zoo or phytoplankton or to distinguish different fish according to the strength of the echo at different frequencies.

In order to avoid “noise” from other scatter organisms than fish, the threshold for integration was set at –60 dB. This threshold cuts most of the plankton backscattering energy while retains most of the fish backscattering energy. Nevertheless this threshold is believed to cut as well part of the backscattering energy from low dense mackerel layers.

Backscattering energy was allocated into fish species by means of a step-wise procedure using ECHOVIEW software:

a) analysis of the fishing stations. For each fishing station, length distribution and total catch for each fish specie is represented by both length frequency histogram and catch proportion pie charts. Then, fishing stations are grouped according to depth and proximity criteria. For each group, the “best” representative fishing station is chosen mainly on account the continuity in the probability density function (PDF) of the length distribution for all fish species in that fishing station which had a species diversity similar to the overall group diversity

b) visual scrutiny of the echograms. This is done directly over the screen. Both 38 and 120 kHz are used. Once main features of the echogram are arranged in order to avoid counts from either bottom, surface bubbles or ping errors, echotraces are allocated on account of two different procedures:

- direct allocation: This method is mainly used on schools. Echo-traces are directly attributed to a single fish species. This method accounts for the prior knowledge on the schools characteristics (i.e. energetic, morphological and environmental –geographical position, depth, distance to the coast, 200 m isobath or river plumes among others) which are also corroborated on almost monospecific fishing stations. In the case of mackerel, the 120 kHz echogram was used as well as the results of the nearest fishing stations.
- allocation on account of representative fishing station. EDSU’s are grouped on account of similarities in both echo-traces and environmental data, mainly on geographical position, mean depth and also the presence/absence of sardine and anchovy eggs. Each group of similar EDSU’s is represented by a representative fishing station as explained before (point a). When similar EDSU’s were able to be characterised for more than one representative fishing station and if the fishing stations are closer, then all these ESDU’s are

characterised by these fishing stations. In this case, no weighting factors are used and each fishing station has the same weight.

As well as the number of fish by length class for each fish species, the following TS/Length relationships were used:

Species	b_{20}
Sardine	−72.6
Anchovy	−72.6 (north) and −71.2 (south)
Hake and other gadoids	−67.0
Bogue	−67.0
Boar fish and longsnipe	−80.0
Mackerel	−84.9
Horse mackerel	−68.7
Chub mackerel	−68.7

Once backscattering energy is allocated into fish species, acoustic assessment is done separately for each fish species. The area covered by a single fish species is calculated as follows: isolate polygons are constructed when there is a lack of spatial continuity on either two transects or 4–5 empty EDSU's in the same transect. These main polygons can be also split into different strata. These areas (i.e. post-strata) are chosen on account of both the similarity in length distributions obtained from the fishing stations (K-S test) over the main polygon and the PDF of the acoustic energy. Post-strata areas have chose aiming at minimizing both K-S test results among fish length distributions and the skewness of the acoustic backscattering energy. For each post-strata, a mean backscattering value and a single "synthetic" length distribution obtained from the combination of all fishing stations performed inside the post-strata (with equal weight for all length distributions) and the total surface expressed in nm are used to calculate the abundance. Then, results either by length classes or age groups are presented by ICES Subdivision.

IFREMER

Acoustic data are collected and stored using MOVIES+ software from 1 to 5 frequencies along the time series. Only 38 kHz data were collected from 1989 to 1998, then progressively up to 5 frequencies (12, 38, 70, 120 and 200 kHz) in 2005.

Since 2000 acoustic data are collected along systematic parallel transects perpendicular to the French coast, from Brest to the Spanish coast. The length of the ESDU is always 1 nautical mile and the transects are uniformly spaced by 12 nm covering the continental shelf from 25 m depth to the shelf break.

Acoustic data are collected only during the day because of global fish behaviour in this area. The species are usually rising close to the surface during night and most of them "disappear" in a blind layer for the echo sounder (between the surface and 10 m depth) or are mixed with dense plankton concentration which makes them difficult to separate.

One of the characteristics of the species composition in the Bay of Biscay echo-traces is the presence of several species, the principal ones being:

- sardine
- anchovy
- sprat
- mackerel
- horse mackerel
- hake

- blue whiting

As most of the time, it is not possible to identify echo-traces using objective criteria, especially concerning multispecies structures, fishing operations are carried out to separate the energies into species using the proportions of different species observed in catches from mid-water trawl hauls.

Hauls are systematically made using the following criteria:

- along a transect, each time echo traces were observed regularly along several ESDU's if very dense echo-traces were observed during only one ESDU;
- along the same transect, another haul was necessary if the echo-trace appearance (shapes, frequency or level in the water layer) was changing;
- along the adjoining transect even if the echo trace appearance was the same

Acoustic energies (S_A) are cleaned by sorting the only fish energies (excluding bottom echoes, parasites, plankton, etc.) and classified into several categories of echo-traces according to their shape, size and vertical distribution in the water column. At least 4 categories are generally considered for each survey:

- D1 – energies attributed to horse mackerel and gadoids corresponding to cloudy schools or layers close to the bottom or of small drops in a 10m height layer close to the bottom.
- D2 – energies attributed to anchovy, sprat, sardine and mackerel constituted by schools, mainly situated between the bottom and 50 meters above. These echoes are typical of coastal areas and sometime more offshore. They are well designed and often dense.
- D3 – energies attributed to cloudy echo-traces often observed offshore all along the shelf break, constituted of blue whiting and myctophids.
- D4 – energies attributed to sardine, mackerel or anchovy corresponding to small and dense echoes, very close to the surface.

Then complementary classes (*Dn*) may be designed to separate special aggregation patterns according to some year particularities.

When the echo-traces are well characterised (for example when sardine appears alone as large shoals very close to the coast, or as dense small surface schools offshore), the corresponding energies may be directly attributed to the species (according to pure species catches in such cases).

For energies where identification is not possible using objective criteria, especially concerning multispecies structures (most of the cases), the global area is splitted into several strata where coherent communities are observed (species associations) in order to minimise the variability due to the variable mixing of species.

For each strata, energies are converted into biomass by applying catch ratio (weighted by TS of present species at mean length), length distributions and weighted by abundance of fish in the haul surrounding area. Surface hauls are exclusively applied to D4 (surface echo traces) and "classical" hauls (close to the bottom) to D1 and D2 echo-traces inside these strata.

To minimise the error in length and age distributions at ESDU, the nearest haul length composition is used, independently of strata.

AZTI

AZTI acoustic anchovy surveys target on the juvenile component of the population, and thus show some different inherent methodological problems. Also, oppositely to the surveys carried out by the other institutes, AZTI acoustic surveys are carried out using commercial vessels.

Acoustic data are recorded with a 38 and 120 KHz Simrad EY60 split-beam, scientific echo sounder system (Kongsberg Simrad AS, Kongsberg, Norway), calibrated using Standard procedures (Foote *et al.,* 1987). The sampling area covers the waters of the Bay of Biscay (being 5º W and 46º N the limits). Sampling starts in the southern part of the sampling area, the Cantabrian Sea, and moves gradually to the North to cover the waters in front of the French coast, both on the shelf and offshore. The acoustic sampling is performed during the daytime, when the juveniles are supposed to aggregate in schools (FAIR CT 97-3374) and can be distinguished from plankton structures. The vessel follows parallel transects, spaced 17.5 nm, perpendicular to the coast along the sampling area. Each transect is continued towards offshore waters until the juvenile area is assumed to be completely covered.

Transducers are installed looking vertically downwards, 2.5 m deep, at the end of a tube attached to the side of the boat. The water column is sampled to depths of 100 m. A threshold of -80 dB is applied for data collection and -70dB for processing purposes. Acoustic back-scattered energy by surface unit (S_A) is recorded for each geo-referenced nautical mile (1852 m). This energy is cleaned of multiple bottom echoes, bubbles and other noise sources (but not plankton). Fish identity and population size structure are obtained from fishing hauls and echotrace characteristics. The vessel uses purse seine nets of about 400 m of perimeter and 75 m height to fish the samples to depths of about 40 m.

The hauls are grouped by stratum of homogeneous species and size composition. Inside each of these homogeneous stratum, the echo-integrated acoustic energy is allocated to species by the contribution of each species according to the weighted average composition of the hauls, being the weighting factor the acoustic energy found in the vicinity (2 nm) of each haul.

3.1.3 Sampling methodology and analysis for complimentary data

Sardine and anchovy form part of the pelagic community, which includes a series of commercially exploited and non exploited species, together with potential predators such as marine mammals, seabirds, prey species and competitors, all of which will influence the growth and survival of sardine and anchovy. Appropriate management of any component of the pelagic ecosystem requires an understanding of the structure of the whole community and the abiotic environment. As the understanding of marine communities and ecosystems increases, it becomes possible to move from single species TACs and quotas, towards integrated management with more emphasis on species interactions. To inform management decisions, we need to understand the dynamics of the food chains and flows of energy within the ecosystem and to identify indicators of ecosystem health and function that could be used in combination with the more traditional biological indicators for fished stocks.

This integrated management approach, based on an ecosystem rather than on individual species is endorsed by the European Commission as part of the revised Common Fisheries Policy and is promoted by the UN Food and Agriculture Organisation (FAO). It is emerging as a feature of marine fisheries management worldwide.

Dynamics of marine ecosystems are notoriously difficult to study. A proposed approach is the use of indicator species, which population levels should not decrease below established thresholds. These indicator species are best exemplified by “top predators” since they are at the end of the energy (and pollutant) flows within the ecosystem. These species include seabirds, seals, cetaceans and some of the larger fish. It is clear that not only information on indicator species is needed. Environmental information (climatic, meteorological, hydrographic and trophic) can define the habitat experienced by eggs, larvae, juveniles and adult fishes and other components of the community. From the characterisation of the ambient environment we can establish the existence of hydrographic features, such as fronts, river plumes or eddies, and define the nutrient status of the ecosystem (i.e. available preys) relevant to explain the distribution of the different stages in the life cycle of pelagic fishes.

3.1.3.1 Hydrography

The environmental information that can be gathered during the egg/acoustic assessment and/or ecological surveys that focus on eggs, larvae, juveniles and adult fish populations is:

- Climatic variables to define the large-scale scenario. Indices such as the North Atlantic Oscillation (NAO) or the Eastern Atlantic (EA) upwelling index from geostrophic winds and cumulative river runoff from the main drainage basins could be useful indicators of interannual variability and/or large-scale trends.
- Meteorological variables to characterise local conditions during the surveys. This information can be gathered from the on-board meteorological station and/or from fixed stations on land and/or at sea. The variables that can be acquired are air temperature, wind speed and direction and precipitation. This information is useful to explain the physical environment at sea.
- Basic hydrographic variables (salinity, temperature and fluorescence) to establish environmental conditions at sea for eggs, larvae, juveniles and adults, in order to infer the thermohaline environment, the direction of the flow and the presence of converge-divergence zones associated to hydrographic features such as eddies, fronts (thermohaline and tidal), upwelling filaments or river plumes. These variables could be acquired both at the surface, from the continuous underway systems on board, and for the whole water column at selected hydrographic stations using CTD-F (conductivity-temperature-depth-fluorescence) probes. From the surface hydrographic fields, it would be possible to located frontal areas, river plumes, upwelling filaments or eddies. It is possible and desirable to complement the measured surface hydrographic fields with satellite-derived information, such as SST (sea surface temperature), dynamic-height from altimetry data and sea surface colour (chlorophyll and continental inputs). From hydrographic profiles, apart from the features mentioned above, it is possible to conduct water masses characterisation and to define the position/persistence of poleward slope flowing currents along-shore, the mixed layer depth (MLD) and the distribution of chlorophyll in the water column in relation to the position of the thermo- and halocline (surface and/or sub-surface chlorophyll maximum).
- Components of the plankton community in order to define the trophic environment. The basic variables that are usually acquired during egg/acoustic surveys are fluorescence, from which the distribution of phytoplankton could be inferred, and water column integrated zooplankton biomass from WP2 hauls at selected stations to derive total or size-fractionated zooplankton biomass and/or taxonomic composition. The size-fractionated plankton biomass could be also inferred from state-of-the-art automatic probes such optical plankton counters (OPC).

3.1.3.2 Others

Given the need for a better monitoring of the marine ecosystem, the platforms of opportunity provided by the surveys for both acoustic and DEPM estimates could be used to provide important information on the distribution, local abundance and species relationships of other components of the pelagic community, not only on the target species.

On its spring cruises IFREMER uses three observers from CRMM (Centre de Recherche sur les Mammifères Marins) that record presence and species identification for both marine mammals and seabirds. Observers record the number of cetaceans on the track lines (stopping when the boat starts fishing) with the ultimately goal of been able to obtain an estimate of absolute population numbers for the most common species. Ancillary information on other species is collected on the hauls. Observers have been collecting these data since 2001.

IPIMAR has also 2 observers from SPEA (Sociedade Portuguesa para o Estudo das Aves) onboard their spring acoustic surveys as part of a LIFE project, collecting the same information as those of IFREMER. Observers started in 2004.

IEO is only at the moment, carrying observers on the survey that is conducted in the Gulf of Cadiz, which has carried an observer since 2004 to collect information on the presence of turtles, seabirds and cetaceans.

Since 2003 AZTI carries on board an observer to record the presence of marine mammals and identify their species. However, these observations are opportunistic and cannot be used to get abundance estimates.

Information will not only be available on distribution and abundance of top predators but stomach contents of stranded and by-catch individual marine mammals and in some cases seabirds are routinely collected along the Portuguese, Spanish and French coasts. Stomach contents of some fish species are also sometimes collected on the surveys as part of other studies. Information on stomach contents provides data on trophic interactions between the different components of the pelagic community and can give indications of the impact of the predators on the stocks of sardine and anchovy or on the stocks of other fish, which predate on both species.

Table 3.1.1.1-1: Summary of survey methodology.

	SARDINE		ANCHOVY	
	Portugal	**Spain (IEO)**	**Spain (IEO)**	**Spain (AZTI)**
Years	1988,1997,1999,2002 and 2005	1988,1990,1997,1999, 2002 and 2005	2005	1987 to 2005
Survey area	Portugal and Gulf of Cadiz	Northern Spain	Gulf of Cadiz	Bay of Biscay
Survey period	January/February/March	March/April	June	May/June
Survey direction	S-N	W-E	E-W	S-N
Sampling grid (miles x miles)	8 x 3 (from 2002)	8 x 3 (from 2002)	8 x 3	15 x 3 (7.5 x 3 intensive)
Sampler	PAIROVET	PAIROVET	PAIROVET	PAIROVET
Mesh size (µm)	150	150	150	150 (from 1989)
Weight on sampler (Kg)	20–30	20	20	45
Type of haul	Vertical	Vertical	Vertical	Vertical
Sampling depth (m)	150	100	100	100
Towing speed (m/s)	1	1	1	1
Max acceptable angle	20º	20º	20º	15º
Sampling depth sensor	Minilog / CTD* (from 2005)	Minilog	Minilog	Sensor
Temperature sensor	Minilog / CTD* (from 2005)	Minilog / CTD (from 2002)	CTD	Termosalinometer / CTD*
Depth of incubation temp (m)	10	10–5	5	10
Flowmetter	Y	Y	Y	Y
Clinometer	Y	Y	Y	N
CTD	Y (from 2005)	Y	Y	Y
Samplers used	1	1	1	2 (1 from 1989 to 1992)
Stages eggs (nº egg)	all	all	all	50 / 75 / all
Use CUFES	Y (from 2000)	Y (from 2000)	Y	Y (from 1998)

*** CTD coupled to PAIROVET**

Table 3.1.1.1-2: Summary of egg ageing and egg production methodologies applied each year.

SARDINE	**AGEING**	**EGG PRODUCTION**
Portugal		
1988, 1997 and 1999	Stageage (Lo, 1985)	NLR
2002, 2005	Bayesian (ICES, 2004)	GLM
Spain (IEO)		
1988, 1990 and 1997	Stageage (Lo, 1985)/ Bernal (2001)	NLR /GAM
1999	Stageage (Lo, 1985)/ Bernal (2001)	NLR /GLM*
2002	Bayesian (ICES, 2004)	GLM*
2005	Bayesian (ICES, 2004)	GLM
ANCHOVY		
Spain (AZTI)		
1987 to 2003	Stageage (Lo, 1985)	NLR
2004 and 2005	Bayesian (ICES, 2004)	GLM
Spain (IEO)		
2005	Bayesian (ICES,2004)	GLM

***1999, 2002 Transects were used as the sampling unit**

Table 3.1.1.2.1: Sampling and adult parameters estimation methodology used in the 2005 egg production surveys

2005 DEPM SURVEYS	IEO VIGO	IPIMAR	AZTI	IEO CÁDIZ
Target species	sardine	sardine	anchovy	anchovy
R/V	"Thalassa"	"Capricórnio"	"Thalassa" and "Vizconde de Eza"	"Cornide"
Gears	Pelagic trawl and purse seine	Bottom trawl	Pelagic trawl and purse seine	Pelagic trawl and purse seine
Survey period	1 April–1 May	30 Jan.–23 Feb.	8–28 April	10–23 June
Sampling period (survey)	During the day hours	During the day hours	During the whole day	During the day hours
Complementary samples	Commercial purse seiners rented (night samples)	Samples from harbours (commercial purse seiners) (during the whole day)	Commercial purse seiners rented and the fleet (during the whole day)	Commercial purse seiners rented (night samples)
Biological sampling: - Survey - Commercial	- On fresh material, on board of the R/V - On fresh material, on board of the R/V	- On fresh material, on board of the R/V - On frozen material, at the institution laboratory (1 lobe of the gonad preserved immediately on the harbour)	- On fresh material on board RV "Vizconde" or on preserved material from RV "Thalassa" at the institute lab - On preserved material at the institute lab	- On fresh material, on board of the R/V - On fresh material, on board of the R/V
Preservation	Buffered formaldehyde 4% (distilled water)	Buffered formaldehyde 4% (seawater)	Buffered formaldehyde 4% (tap water)	Buffered formaldehyde 4% (distilled water)
Conservation	In formalin	In alcohol 70º	In formalin	In formalin
Histology: - Embedding material - Stain	- Resin - Haematoxilin-Eosin	- Paraffin - Haematoxilin-Eosin	- Resin - Haematoxilin-Eosin	- Resin - Haematoxilin-Eosin
S estimation	Day 1 and Day 2 POFs (according to Pérez *et al.*, 1992a)	Day 1 and Day 2 POFs (according to Pérez *et al.*, 1992a)	Day 1 and Day 2 POFs (according to Motos 1994)	Day 1 and Day 2 POFs (according to Motos 1994)
R estimation	The observed weight fraction of the females	The observed weight fraction of the females	Theoretical expected values considering 1:1 numbers and the females and males sample mean weights	The observed weight fraction of the females
F estimation	On hydrated females (without POFs), according to Pérez *et al.*, 1992b	On hydrated females (without POFs), according to Pérez *et al.*, 1992b	On hydrated females (without POFs), according to Hunter and Macewicz 1980	On hydrated females (without POFs), according to Hunter and Macewicz 1980

Table 3.1.1.2.2: Historical series of the DEPM surveys conducted by AZTI (Legend: R: Research, C: commercial, P: Pelagic trawl, S: Purse seine).

YEAR	APPLICATION CODE	SAMPLES (ORIGIN)	FISHING GEAR	NUMBER SAMPLES	SAMPLING TIMES	SAMPLES FOR S	POFS CATEGORIES	BF MEASURE	NH HYDR. FEMALES	REMARKS
1987	BIOMAN87	C	S	35	Night		Day 1	Hydrated	62	Opportunistic sampling
1988	BIOMAN88	C	S	82	Night		Day 1	Hydrated	167	Opportunistic sampling
1989	BIOMAN8905	R+C	P+S	35	24 hours		Day 1	Hydrated	111	Mixed strategy of sampling
1989	BIOMAN8906	R+C	P+S	13	24 hours		Day 1	Hydrated	158	Mixed strategy of sampling
1990	BIOMAN9005	R+C	P+S	49	24 hours		Day 1	Hydrated	194	Mixed strategy of sampling
1990	BIOMAN9006	R+C	P+S	46	24 hours		Day 1	Hydrated	131	Mixed strategy of sampling
1991	BIOMAN91	R+C	P+S	29	24 hours		Day 1	Hydrated	50	Mixed strategy of sampling
1992	BIOMAN92	R+C	P+S	31	24 hours		Day 1	Hydrated	122	Mixed strategy of sampling
1994	BIOMAN94	R+C	P+S	28	24 hours		Day 1+Day 2	Hydrated	111	Mixed strategy of sampling
1995	BIOMAN95	R+C	P+S	30	24 hours		Day 1+Day 2	Hydrated	102	Mixed strategy of sampling
1996	BIOMAN96			none	24 hours		Day 1+Day 2	Hydrated		Mixed strategy of sampling
1997	BIOMAN97	R+C	P+S	60	24 hours	40	Day 1+Day 2	Hydrated	121	Mixed strategy of sampling
1998	BIOMAN98	R+C	P+S	47	24 hours	47	Day 1+Day 2	Hydrated	73	Mixed strategy of sampling
1999	BIOMAN99	R+C		none						
2000	BIOMAN2000	R+C		none						
2001	BIOMAN2001	R+C	P+S	47	24 hours	36	Day 1+Day 2	Hydrated	60	Mixed strategy of sampling
2002	BIOMAN2002	R+C	P+S	35	24 hours	35	Day 1+Day 2	Hydrated	81	Mixed strategy of sampling
2003	BIOMAN2003	R+C	P+S	36	24 hours	36	Day 1+Day 2	Hydrated	125	Judgement sampling
2004	BIOMAN2004	R+C	P+S	47	24 hours	30	NA	Hydrated	66	Mixed strategy of sampling
2005	BIOMAN2005	R+C	P+S	30	24 hours	20	Day 1+Day 2	Hydrated	47	Mixed strategy of sampling

Table 3.1.2.1.1: Acoustic parameters used by the different Institutions in the surveys conducted since 2000

Parameter	IFREMER	AZTI	IEO-N	IEO-S	IPIMAR
Vessel	RV "Thalassa"	Commercial purse seiner	RV "Thalassa"	RV "Cornide de Saavedra"	RV "Noruega" and RV "Capricornio"
Transects	Perpendicular to bathymetry	Perpendicular to bathymetry	Perpendicular to bathymetry	Perpendicular to bathymetry	Perpendicular to bathymetry
Inter-transect distance (nm)	12	17.5	8	8	8
EDSU (nm)	1	1	1	1	1
Bottom depth (min; m)	20	10	20	20	20
Echo sounding depth (min; m)	7	5	7	5	7
Echo sounding depth (max; m)	400	200	200	200	200
Fishing gear	Pelagic trawl	Purse seine	Pelagic trawl and purse seine	Pelagic Trawl	Pelagic and bottom trawl
Geographic area	N Spain up to Brest	N Spain up to Gironde estuary	N Portugal up to East Cantabrian Sea	Algarve and Gulf of Cádiz	Portugal and Gulf of Cádiz
Target species	Anchovy	Anchovy juveniles	Sardine	Anchovy and sardine	Sardine and anchovy
Other species	Sardine, horse mackerel and sprat		Anchovy, horse mackerel and mackerel	Sardine, horse mackerel, mackerel and chub mackerel	
Echo sounder	EK500 & EK60	EY60	EK500 & EK60	EK500	EK500
Frequency for assessment (kHz)	38	38	38	38	38
Complementary frequencies (kHz)	18, 70, 120 and 200	120	18, 70, 120 and 200	120	120
Pulse duration (ms)	1	1	1	1	1
Threshold for acquisition (dB)	-80	-80	-80	-80	-60
Threshold for assessment (dB)	-60	-70	-60	-60	-60
File format	*.hac	*.hac	*.hac	*.hac	*.hac
Applied TS (dB)					
Sardine	-71.2	-72.6	-72.6	-72.6	-72.6
Blue whiting	-67.0	-67.0	-67.0	-67.0	-67.0
Anchovy	-71.2	-72.6	-72.6	-71.2	-71.2
Horse mackerel	-68.5	-68.7	-68.7	-68.7	-68.7
Mackerel	-82.0	-88.0	-84.9	-84.9	-82.0
Chub mackerel	-68.7		-68.7	-68.7	-68.7
Bogue			-67.0	-67.0	-67.0
Sprat	-71.2				-71.2
Snipe fish			-80.0	-80.0	-80.0

Legend: EDSU, elementary distance sampling unit; TS, target strength

3.2 General view of species distribution 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 during 2005 can be observed in Figure 3.2.1. 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 Cádiz. These species are accompanied by other pelagic species like mackerel, predominantly off the North Iberian coast, horse mackerel, spread through the Iberian Peninsula, the Armorican shelf and beyond, a local population of sprat in the Bay of Biscay, and other species. The distribution of these species shows the different dynamics, which can be described within the context proposed by SGRESP (ICES, 2005).

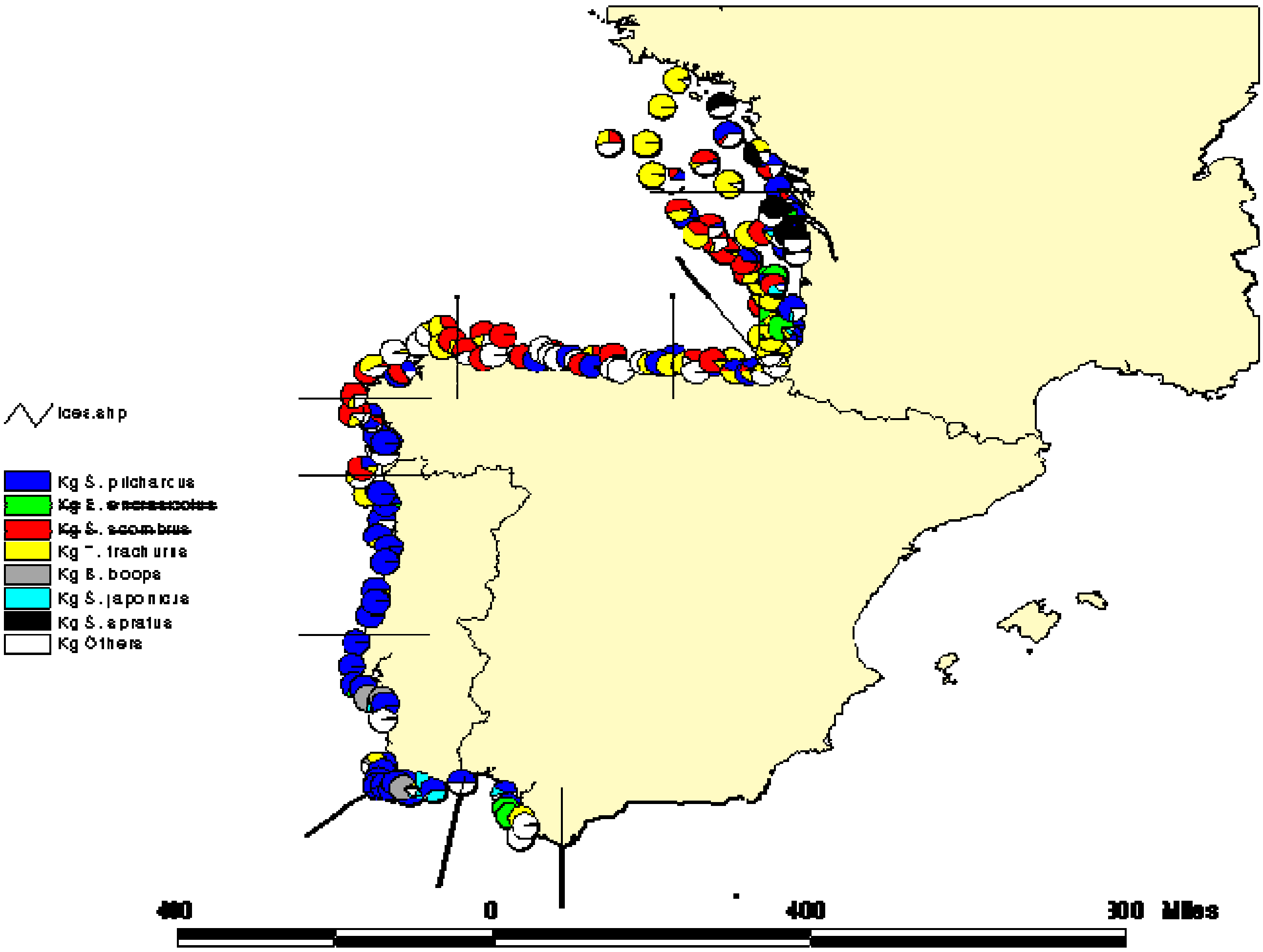


Figure 3.2.1: Distribution of the different species caught in the adult sampling of the acoustic surveys in 2005.

3.3 Anchovy surveys in areas VIII and IX

3.3.1 Anchovy surveys in areas VIII

3.3.1.1 Distribution and abundance of spawning population from egg production surveys

3.3.1.1.1 Egg distribution and estimates of egg production from CUFES and pairovet samplers

The DEPM survey BIOMAN05 was conducted by AZTI on board RV "Vizconde de Eza" from 8–28 May on the Bay of Biscay during the main spawning area and period for anchovy. A total of 415 vertical tows were carried out using a Pairovet net 150µm (double CalVET nets, Smith *et al.*, 1985) from which 146 and 3003 were positive for anchovy and sardine respectively. Onboard, a total of 1,011 anchovy and 8,015 sardine eggs were sorted out. On the other hand, a total of 830 CUFES (Continuous Underway Fish Egg Sampler) samples were obtained. These samples were checked immediately after sampling so that presence/absence of anchovy eggs was detected in real time. These data were used to define the outer limit of the spawning area in the oceanic part of the survey area and to continue/discontinue the Pairovet sampling schedule or to intensify/relax the sampling intensity.

The methodology used to process egg samples are given in detail in previous papers (see for example, MOTOS *et al.*, 1991) and follow standard procedures (LASKER, ed., 1985).

Figure 3.3.1.1.1_1 shows the egg abundance distribution (number of eggs per $0.1m^2$) found during the 2005 survey in the Bay of Biscay and the limit of the positive area 27,863 Km^2 (solid line). The total area survey area was 61,619 Km^2.

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. In some pre-selected points, water was filtered from the surface to obtain chlorophyll samples.

Anchovy eggs were concentrated in the area of Arcachon at 44º30'–50'N and 2ºW, between the depth lines of 100 and 200m and at costal areas in the Gironde region. Egg abundance was low across the whole area, with an average of 7 eggs per positive station. The maximum value found in a station was 73eggs/$0.1m^2$. As a result, the total egg production estimate, 0.443 10^{12} eggs, is the lowest of the DEPM series (Table 3.3.1.1.1_1).

The anchovy eggs staged in the laboratory were transformed into daily cohort abundances using the ageing Bayesian method developed within the GAM Project (Study project n. 99/080). Daily egg production (P_0) and mortality (z) rates were estimated by fitting an exponential mortality model to the egg abundance by cohorts and corresponding mean age. The model was fitted in two manners: a) as a weighted Non Linear Regression model; and b) as a generalised linear model (GLM) with negative binomial distribution and log link. The ageing process and the GLM fitting were repeated until the value of z converged.

In both cases the calculations were done in the positive strata and the eggs younger than 4 hours and older than the 90% of the incubation time (3.72 days) were removed to avoid bias.

Finally, the total egg production was calculated multiplying the daily egg production by the positive area.

Table 3.3.1.1.1_1 shows the resulting daily egg production (P_0) estimates (eggs / 0.1 m^2 per day), the daily egg mortality rates (z) and the total egg production (P_{totegg})(eggs/day*10^{12}) with the correspondent variance and CVs.

The results adopted were those arising from the exponential mortality model fitted using GLM with negative binomial distribution and log link and the mortality (z) was estimated using an iterative approach because this is more robust statistically.

In addition, an analysis to estimate P_{tot} by regions was performed. In one of the regions the z obtained was positive which is not acceptable biologically, so a unique area was considered to estimate $P_{tot.}$

3.3.1.1.2 Distribution and estimates of adult parameters

To estimate Spawning Stock Biomass, apart from the total egg production and the spawning area, it is necessary to estimate the daily fecundity (DF) of adult anchovies. For that reason it is necessary to obtain adult samples.

Adult samples were obtained from 4 different sources: samples taken directly during the egg survey on board RV "Vizconde de Eza", opportunistic samples from the commercial fleet, samples from the French acoustic survey conducted by IFREMER on board RV "Thalassa" and samples from a survey PROA carried out specifically to find out adult anchovies due to the low abundance of anchovy this year. From all the adult samples collected, 20 of them were selected to do the analysis depending on the synchronicity in time and space to the egg survey. (Figure 3.3.1.1.2_1)

The method used to calculate each adult parameter to estimate DF is described in the working document by Santos *et al.,* 2005.

The mean weights of anchovies around the Garonne area were found to be smaller than those in the remainder southern shelf region (Figure 3.3.1.1.2_2).

Two sub-strata were defined to estimate the adult parameters according to the distributions of egg abundances and of the female mean weight and percentages at age: the Garonne stratum from 45º08'N to the north and the South strata from 45º08'N to the south. (Table 3.3.1.1.2_1). An analysis was also performed to check if there were differences in batch fecundity in the two strata defined. Results from this analysis showed significant differences and these were taken into account for the SSB estimate (Figure 3.3.1.1.2_3).

3.3.1.1.3 Spatial distribution and biomass estimates of the target species

Although an estimate by stratum was considered (as showed in Section 3.3.1.1.2) to check whether or not the parameters to estimate the Daily Fecundity (DF) were different, only the batch fecundity (BF) was found to be statistically different. Because of this, only BF was considered differently by stratum in the estimation of the SSB. As mentioned in Section 3.3.1.1., an analysis to estimate P_{tot} in each of the regions defined was performed. However, in the Garonne region the mortality was positive which is not acceptable biologically, so a unique area was considered to estimate P_{tot} and therefore to estimate the spawning stock biomass. In spite of this, a weighting factor for the biomass estimates (proportional to spawning biomass by area) was still considered (proportional by regions to the respective egg abundance divided by their respective daily fecundity) (Table 3.3.1.1.3_1).

The Biomass estimated over the total area was 8,033 tonnes with a CV of 19% (Table 3.3.1.1.3_2).

3.3.1.1.4 Numbers at age

Otolith readings were taken to produce population at age estimates of the 20 anchovy samples available. In analogy with the DF parameter estimates, the adult sampling can not be considered to be balanced between the two sub-strata (see above) and differential weighting factors were applied to each sample originating from one or the other sub-stratum for the purposes of the number at age estimates (seventh row of Table 3.3.1.1.3_1). Estimates of anchovy mean weights and proportions at age in the adult population were computed as a weighted average of the mean weight and age composition per sample where the weights were proportional to the number of individuals per kilogram.

The proportion by age and population at age estimates over the whole surveyed area are given in Table 3.3.1.1.4_1. The percentage of individuals of age 2 is larger than those of age 1. This is atypical in the case of the anchovy population where age 1 individuals are usually more abundant. Therefore, this is evidence of a new recruitment failure in 2005.

3.3.1.1.5 Historical context of current survey

From a historical point of view the current final biomass estimate (8,033 t) is the lowest of the whole series (Figure 3.3.1.1.5_1). Certainly, the egg spatial distribution (Figure 3.3.1.1.5_2), the daily fecundity (Figure 3.3.1.1.5_3) and the age composition (Figure 3.3.1.1.5_4) of the population demonstrate that the current low biomass levels are due to a failure of recruitment. According to the most recent ICES assessment (ICES, 2005) this is the fourth consecutive recruitment failure of the Bay of Biscay anchovy population. Thereby, the current survey results confirm that this anchovy population is passing for the last 4 years a period of low productivity (with a negative global balance) which has finally led the anchovy population to the current minimum levels of biomass, well below B_{lim} (set by ICES at 21,000 t).

3.3.1.2 Distribution and abundance of population from acoustic surveys

3.3.1.2.1 Species composition in the area and length/age composition of the target species

A French acoustic survey (PELGAS) is routinely carried out each year in spring in the Bay of Biscay and information on sardine distribution and abundance is available since 2000. The 2005 survey (PELGAS05) took place from the 3 May –1 June on board the RV “Thalassa”. The objective is the same since 2000, to study the abundance and distribution of pelagic fish in the Bay of Biscay and to study the pelagic ecosystem as a whole. The target species were mainly anchovy and sardine but were considered in a multi-specific context.

To assess an optimum horizontal and vertical description of the area, two types of actions were combined: i) continuous acquisition by storing acoustic data from four different frequencies and pumping sea-water under the surface, in order to evaluate the number of fish eggs using CUFES system (Continuous Under-water Fish Eggs Sampler) and ii) discrete sampling at stations (by trawls, plankton nets and CTD).

Satellite imagery (temperature and sea colour) and modelization were also used before and during the survey to characterise the main physical and biological structures and to improve the sampling strategy. Concurrently, a visual counting and identification of cetaceans and of birds (by onboard observers) was carried out in order to catalogue the top predators of the pelagic ecosystem.

A total of 2300 nm were prospected during the survey and 41 pelagic hauls were carried out for identification of echo-traces (Figure 3.3.1.2.1.1). As in previous years, after echogram scrutiny, the global area was splitted into strata where coherent communities (species associations) were observed in order to minimise the variability due to the variable mixing of species. Allocation to species was therefore done using the standard method (Massé, 2001) and anchovy, sardine sprat and horse mackerel biomass were estimated for five separated areas (Figure 3.3.1.2.1.2):

- A total of 2300 nm were prospected during the survey and 41 pelagic hauls were carried out for identification of echo-traces (Figure 3.3.1.2.1.1). As in previous years, after echogram scrutiny, the global area was splitted into strata where coherent communities (species associations) were observed in order to minimise the variability due to the variable mixing of species. Allocation to species was therefore done using the standard method (Massé, 2001) and anchovy, sardine sprat and horse mackerel biomass were estimated for five separated areas "Adour": the southern area from the French coast to the shelf breaks with anchovy, horse mackerel and sardine (of minor importance);
- "Gironde": closed to the coast in front of the Gironde where mainly sprat, sardine and anchovy (of minor importance) were seen;
- "Offshore": off the Gironde area until the shelf break characterised by more surface echotraces where horse mackerel, mackerel and sardine were predominant;
- "North offshore": where depth was above 100 m and few echotraces appeared attributed to sardine and mackerel;
- "North coast": coastal area in front of the Loire river plume where pelagic echotraces were mainly represented by sardine and sprat.

The respective biomasses were therefore calculated and are presented in the table below:

	Ardour	**Gironde**	**Offshore**	**North coastal**	**North offshore**	**Total**
Anchovy	10 660	4 787	156			15 603
Sardine	41 358	88 520	154 052	12 573	133 018	429 521
Sprat		56 596		32 330		88 926
Horse mackerel	22 310		15 116	26 470	119 366	183 262

The distribution of anchovy observed during this survey was not totally atypical, as on the one hand the two main areas with the higher biomass are traditional spawning areas (Figure 3.3.1.2.1.3) and on the second hand small fish were found closer to the coast, mainly in front of the Gironde and bigger fish in the Adour area (Figure 3.3.1.2.1.4). Nevertheless, the abundance was very low and the predominance of big fish indicates a very low level of recruitment (1 group fish from 2004 year class) (Figure 3.3.1.2.1.5).

Hydrological observations showed surface temperatures rather similar to those from previous years but well visible upwellings along the Landes coast. The river plumes were narrow and rather cold at the surface, showing a recent flow of fresh water in agreement with the proceeding dry winter. Nevertheless, temperatures at 40 m depth were very cold (< 11°), even 2° below the coldest registered since 2000.

The number of 1 year old anchovy was estimated at a level of 127 million fish. When applying a usual M factor of 1.2 (only on the 5 first months of the year) this estimate would correspond to a number of about 200 million fish of G1 on the 1st of January. This level of recruitment is very low and even far below the lowest recruitment index observed since 1987 (1000 million fish in 1989). Nevertheless, the combination of the information provided by the CUFES, the acoustics and the pelagic trawl hauls shows that the Gironde spawners were certainly very close to the coast and might be under-estimated.

The anchovy biomass in the Bay of Biscay in May 2005, as estimated by the survey, was of 15 603 tonnes. Biomass estimates for the whole surveyed area and by Subareas VIII a and VIII b is listed in the text table on the next page:

in numbers	AREA (NM²)	G 1	G 2	G 3+	TOTAL
Gironde	2226	78 080 361	151 622 696	25 219 051	254 922 108
Offshore	4176	2 632 269	4 968 393	825 757	8 426 419
Adour	2456	46 920 080	244 806 289	75 631 252	367 357 622
Total	8858	**127 632 711**	**401 397 378**	**101 676 060**	**630 706 149**
%		**20.24**	**63.64**	**16.12**	100
in tonnes	**area (nm²)**	**G 1**	**G 2**	**G 3+**	**Total**
Gironde	2226	1 283	2 962	542	**4 787**
Offshore	4176	45	94	16	**156**
Adour	2456	1 077	6 983	2 600	**10 660**
Total	8858	**2 405**	**10 039**	**3 158**	**15 603**

3.3.1.3 Distribution and abundance of juveniles from acoustic surveys

Currently, there are two surveys devoted to anchovy juveniles in the Bay of Biscay. The first one, JUVENA, is conducted annually by AZTI and aims at estimating juvenile anchovy biomass and their spatial distribution; the second one, JUVAGA, is conducted by IFREMER and has an ecological approach (i.e. interactions between the fish and their environment) on juvenile behaviour.

A preliminary report, quickly produced after the JUVENA 2005 survey, was presented during the WGACEGG meeting, based in the working document previously presented at the ICES Working Group on the assessment of mackerel, horse mackerel, sardine and anchovy, held in Vigo, Spain from 06 – 15 September 2005. According to this report, significant numbers of anchovy juveniles were seen in the Bay of Biscay during the JUVENA 2005 cruise, indicating a good recruitment for the current year that should provide higher abundance for 2006 in comparison with the one estimated in 2005.

The survey JUVENA is conducted annually since 2003 onboard commercial fishing vessels to study the abundance of anchovy juveniles in the Bay of Biscay with the aim of giving scientific advice for the assessment of the fishery. The particular objectives of the survey are the following:

- Determine the relative abundance and spatial distribution of anchovy juveniles each year in autumn in the Bay of Biscay.
- Determine the condition of the juveniles (size, size-weight ratio)
- Study the environmental factors that may affect their survival
- Long term: obtain a recruitment index (by comparison with following year abundances of 1st year adults)

A preliminary report, quickly produced after the JUVENA 2006 survey, was presented during the WGACEGGS meeting, which summarised the findings of JUVENA surveys in 2003 and 2004 as reported in a previous working document presented at the ICES Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine and Anchovy, held in September 2005 (Boyra *et al.*, 2005). The conclusions of the 2005 survey were:

- Wider coverage (to the North) than previous years
- More fishing hauls (85) provided a more accurate fish species composition

The general conclusions obtained after three years of campaigns were summarized as follows:

- The abundance estimation methodology is almost ready
- TS of juveniles still waiting for a general discussion
- For the first two years of results (2003 and 2004) there has been a consistent parallel decrease in the abundance of juveniles in autumn and the abundance of one year old anchovies in the next springs. Results are thus encouraging about the potential utility of this survey for the forecast of recruitment.

Also, according to JUVENA 2005 preliminary results, significant abundances of anchovy juveniles were seen in the Bay of Biscay during September October 2005, which seemed to be of an order of magnitude rather similar to the one recorded in 2003 (and well above 2004). However, the implications of this 2005 estimate on the 2006 recruitment at age 1 is highly uncertain, not only because no quantitative estimate was available for this meeting but also because the short series of JUVENA (3 years of age) surveys precludes so far any predictive use of their results. A minimum of 4–5 years of comparisons between JUVENA acoustic estimates of juveniles and the recruitment at age 1 in the following year is advisable in order to decide on the utility of this survey indices for recruitment forecast. In the meanwhile only a qualitative use of these results can be made.

JUVAGA05 was carried out from 5–17 October 2005, and focused on juveniles of anchovy in the Bay of Biscay, as a part of a series of research cruises of IFREMER initiated in 2003 and conducted every 2 years on board RV “Thalassa”, which objectives are:

- the validation of an IBM larvae drift growth and survival model designed to provide an early juvenile index
- the understanding of the mechanism of juveniles recruiting to the adult stock
- the hydro-plankton characterisation of juvenile habitats
- the characterisation of the conditions in which juveniles can be reliably observed and evaluated at sea with acoustic methodology

The area surveyed and the pelagic hauls which were carried out during JUVAGA05 are presented in Figures 3.3.1.3.1 and 3.3.1.3.2**.**

First conclusions of the JUVAGA cruise included:

- The outer ocean area off the shelf South of 45°10N (45°10N – 43°35N, 2°W – 3°40W) comprised small age-0 anchovy only, with length ranging from 4to 9cm. These juveniles were independent of the adult stock (i.e. still not recruited to the stock) and no adult fish age-1+ were observed in that area.
- There was a concentration of small juveniles off the Spanish shelf break (43°35N – 43°55N, 2°25W – 3°W). Echotraces of these small age-0 anchovies were typically subsurface aggregations (0–30m) by day and night. They were more visible at night and mixed with Euphausidae and/or Myctophidae. Scenes of predation by birds and tuna were frequently seen at the surface.
- Other areas in which age-0 juveniles were observed were coastal waters on the French shelf: Adour, Gironde, Brittany. In these areas age-0 anchovy had always a length greater than 8cm and was observed mixed with the adult anchovy age-1+. In the catches, anchovy length ranged from 8cm to 15cm. These juveniles displayed a day/night schooling behaviour as did the adult fish. They were recruited to the adult stock age-1+.
- As mentioned above, there was a trend in the length of age-0 fish with coastal age-0 fish been larger than off-shelf fish. In addition a south to north trend was also observed with the largest age-0 fish been found in Brittany.
- On the shelf centre (around isobath 100 m), age-0 anchovy was not encountered, meaning that nearly all the age-0 had already recruited to the adult stock, except for the small anchovy still present off the shelf south of 45°10N.

- In the Northern border of the Brittany area (north of 47°40N and west of 4°W, following the isobath 100 m), large anchovy was observed (length > 16cm) alone, not mixed with juveniles. These fish could represent a different component of the stock with a different behaviour.
- On the shelf and in coastal waters, anchovy was mixed with other species, mainly horse-mackerel, mackerel and sardine. Anchovy represented a small part of the catch in nearly all the hauls. In these areas subsurface echo-traces were not specific to anchovy juveniles.
- Generally a large range in the length of age-0 fish was observed indicating that different spawning periods have been successful in providing off-springs. But anchovy catches in the trawl hauls were not abundant, meaning that the acoustic backscattered energy is not to be attributed in large amounts to the anchovy.
- Combining the above information there is no obvious signal in the JUVAGA cruise of a strong year class entering the depleted population.

Table 3.3.1.1.1_1: P_0 (Daily Egg Production per surface unit), z (Daly mortality of eggs) and P_{tot} (Total Daily Egg Production of the Population) estimates fitting a Non linear regression model and a GLM with CV (Coefficient of variation)

BAYESIAN + N LINEAR REGRESSION			BAYESIAN + GLM	
Parameter	Estimate	CV	Estimate	CV
P_0	1.582	0.16	1.591	0.09
z	0.197	0.45	0.172	0.26
P_{tot}	0.440*E+12	0.16	0.443*E+12	0.09

Table 3.3.1.1.2_1: Estimates of adult parameters by strata and by whole area with correspondent coefficient of variation (C.V.). R (Sex ratio), S (Spawning frequency), F (Batch fecundity), Wf (female mean weight), DF (Daily fecundity), Wt (total mean weight, considering male and female), Pa (proportion at age 1, 2 or 3).

	SOUTH		GARONNE		TOTAL (WEIGHT AVERAGE)	
Parameter	estimate	CV	estimate	CV	estimate	CV
R'	0.5457	0.0080	0.5707	0.0228	0.5505	0.0084
S	0.2598	0.0416	0.2707	0.0785	0.2621	0.0364
F	11,994.3	0.1229	12,876.8	0.1877	12,172.0	0.1129
Wf	33.21	0.0664	24.76	0.1069	31.51	0.0615
DF	51.21	0.094	80.35	0.129	55.74	0.0970
Wt	29.34	0.0567	21.56	0.0891	27.46	0.0541
Pa 1	0.2718	0.1571	0.4858	0.1663	0.3237	0.1308
Pa 2	0.6909	0.0531	0.5106	0.1545	0.6472	0.0583
Pa 3	0.0373	0.3656	0.0036	1.3593	0.0291	0.3667

Table 3.3.1.1.3_1: Balance of the adult sampling to egg abundance by two regions in the Bay of Biscay: Garonne and southern region. The 7º row corresponds to the weighting factor of each of the samples by regions to obtain estimates of the adult parameters by strata.

SUB_ESTRATA	SOUTH	GARONNE	ADDITION
Total egg abundance	9.82.E+11	3.50.E+11	1.33.E+12
Daily Fecundity per Sub_Strata	**51.21**	**80.35**	
Anchovy abundance by Sub_Strata	1.92.E+10	4.36.E+09	2.35.E+10
% Anchovy biomass by Sub-Strata	81%	19%	**1.00**
Nº of adult samples	14	6	20
Anchovy abundance% /adult sample	0.06	0.03	
M'i proportion to biomass scaled to Garonne	1.89	1.0	
Mean Weight of anchovies	28.34	22.25	
Standard Deviations	5.55	4.47	
CV	20%	20%	

Table 3.3.1.1.3_2: DEP, adult parameters and SSB estimates in the total area with correspondent Standard error (S.e.) and coefficient of variation (c.v.).

Parameter	estimate	S.e.	CV
DEP	4.43E+11	4.12E+10	0.0930
R'	0.5505	0.0046	0.0084
S	0.2621	0.0095	0.0364
F	12,172.0	1374.7	0.1129
Wf	31.51	1.9372	0.0615
DF	55.74		0.0970
BIOMASS	8,033	1079.226	0.1343

Table 3.3.1.1.4_1: SSB 2005 estimate and proportion by age and population at age estimates with the correspondent standard error (S.e.) and coefficient of variation (CV).

PARAMETER	ESTIMATE	S.E.	CV
BIOMASS	8,033	1079.23	0.1343
Wt	27.46	1.48	0.0541
POPULATION	293.5	42.9	0.1462
Pa 1	0.3237	0.0423	0.1308
Pa 2	0.6472	0.0377	0.0583
Pa 3	0.0291	0.0107	0.3667
N age 1	96	21.3	0.2226
N age 2	190	27.4	0.1445
N age 3	8	2.9	0.3453

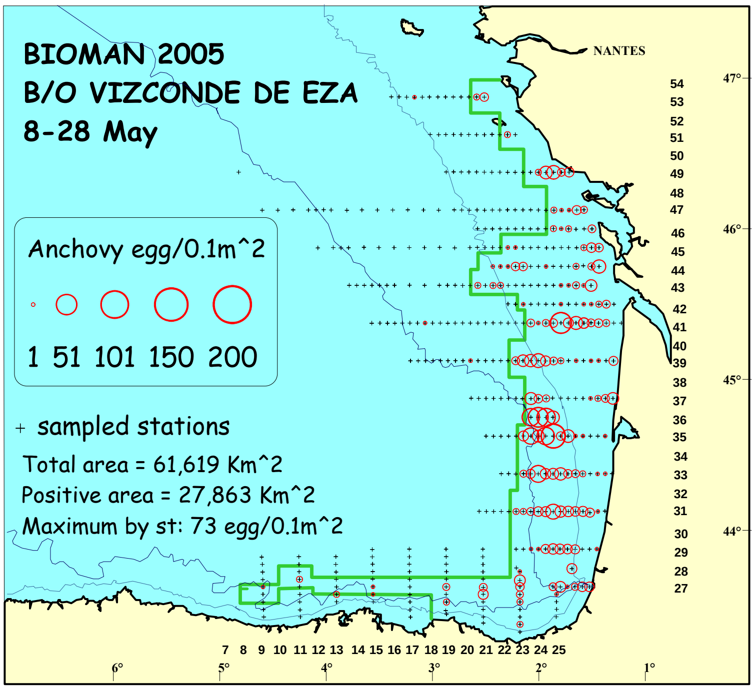


Figure 3.3.1.1.1_1: Anchovy egg distribution and abundance (egg/0.1m²) found during BIOMAN 2005. Solid line encloses the positive spawning area.

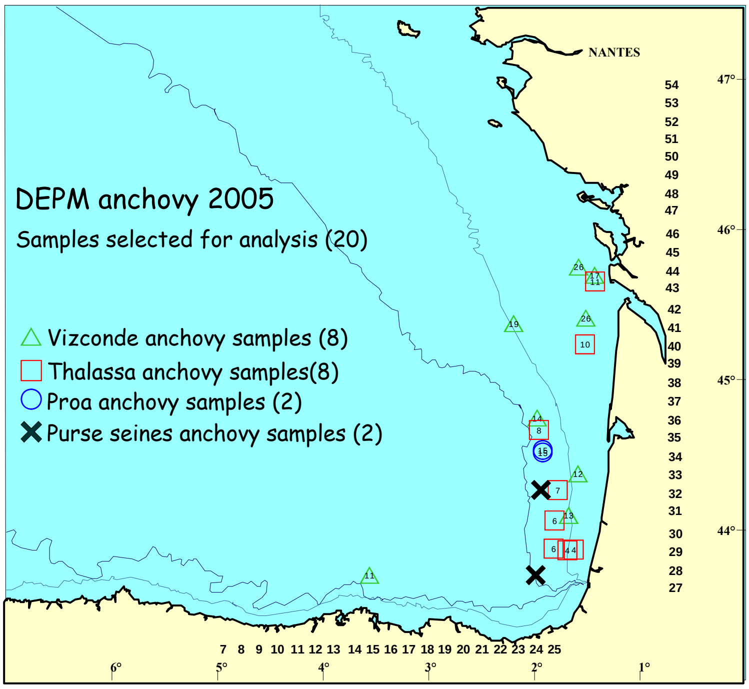


Figure 3.3.1.1.2_1: Anchovy adult samples selected for the SSB estimate.

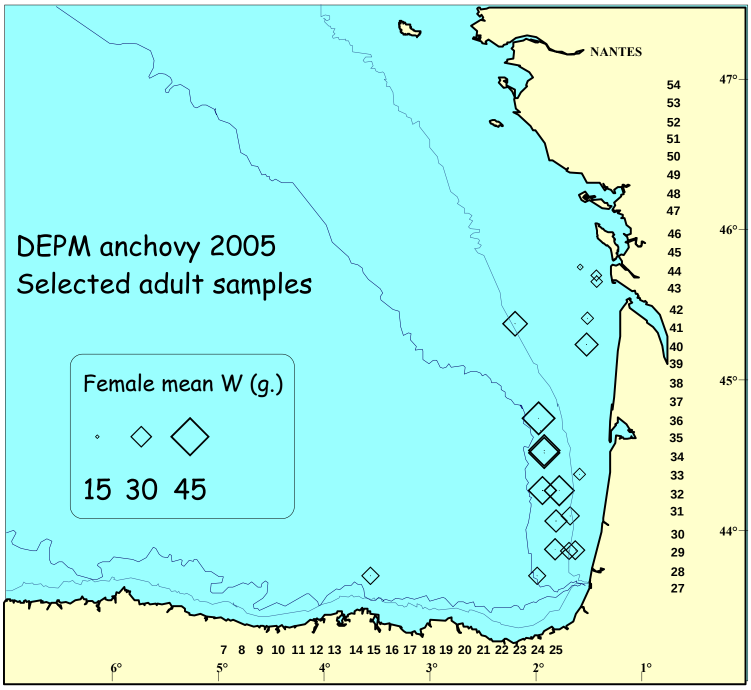


Figure 3.3.1.1.2_2: Spatial distribution of females mean weight per haul from selected samples.

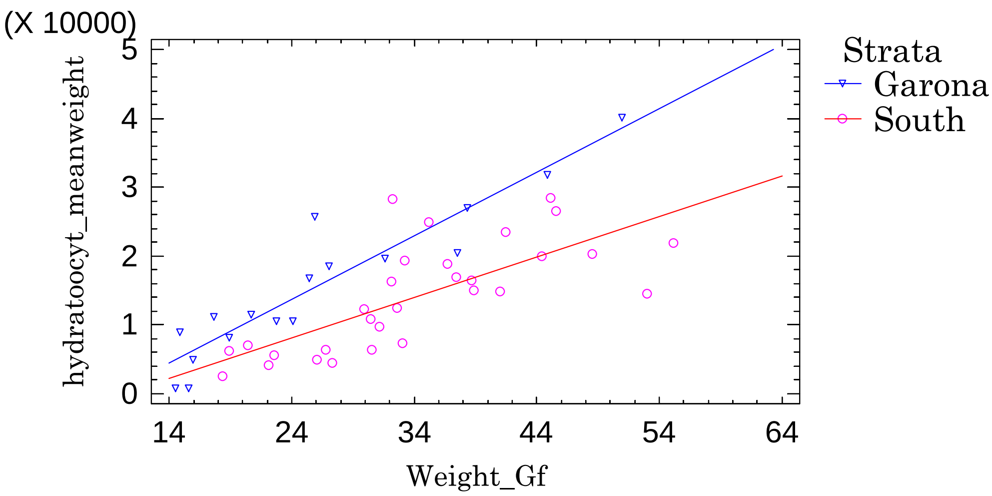


Figure 3.3.1.1.2_3: Comparison of regression lines for the batch fecundity by the two strata defined.

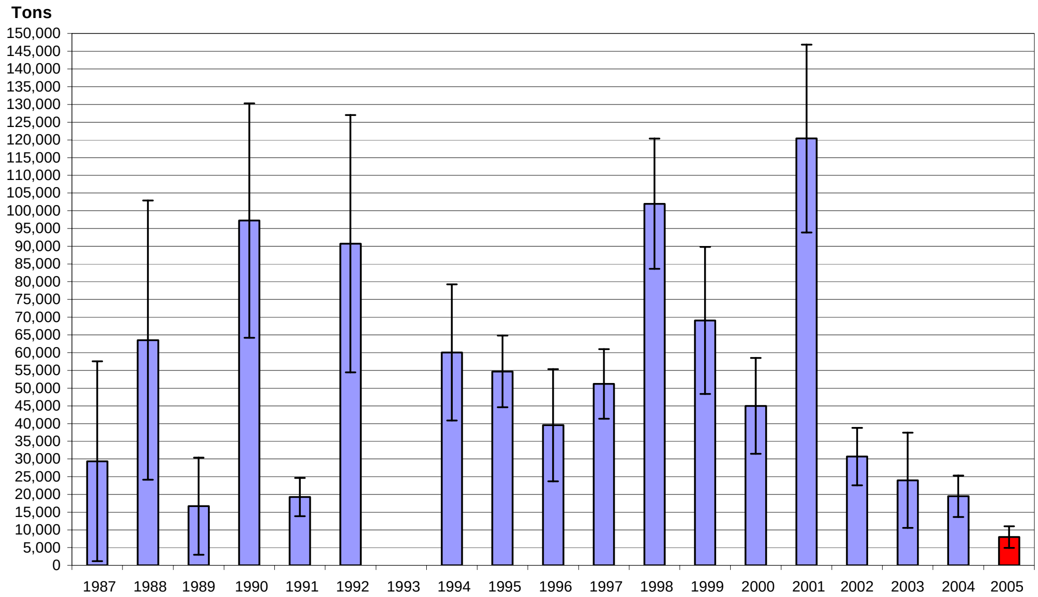


Figure 3.3.1.1.5_1: Series of Biomass estimates (tons) obtained from the egg surveys since 1987. Most of them are full DEPM estimates, except in 1996, 1999 and 2000, which were deduced indirectly from the relationship of biomass with the spawning area and P_0.

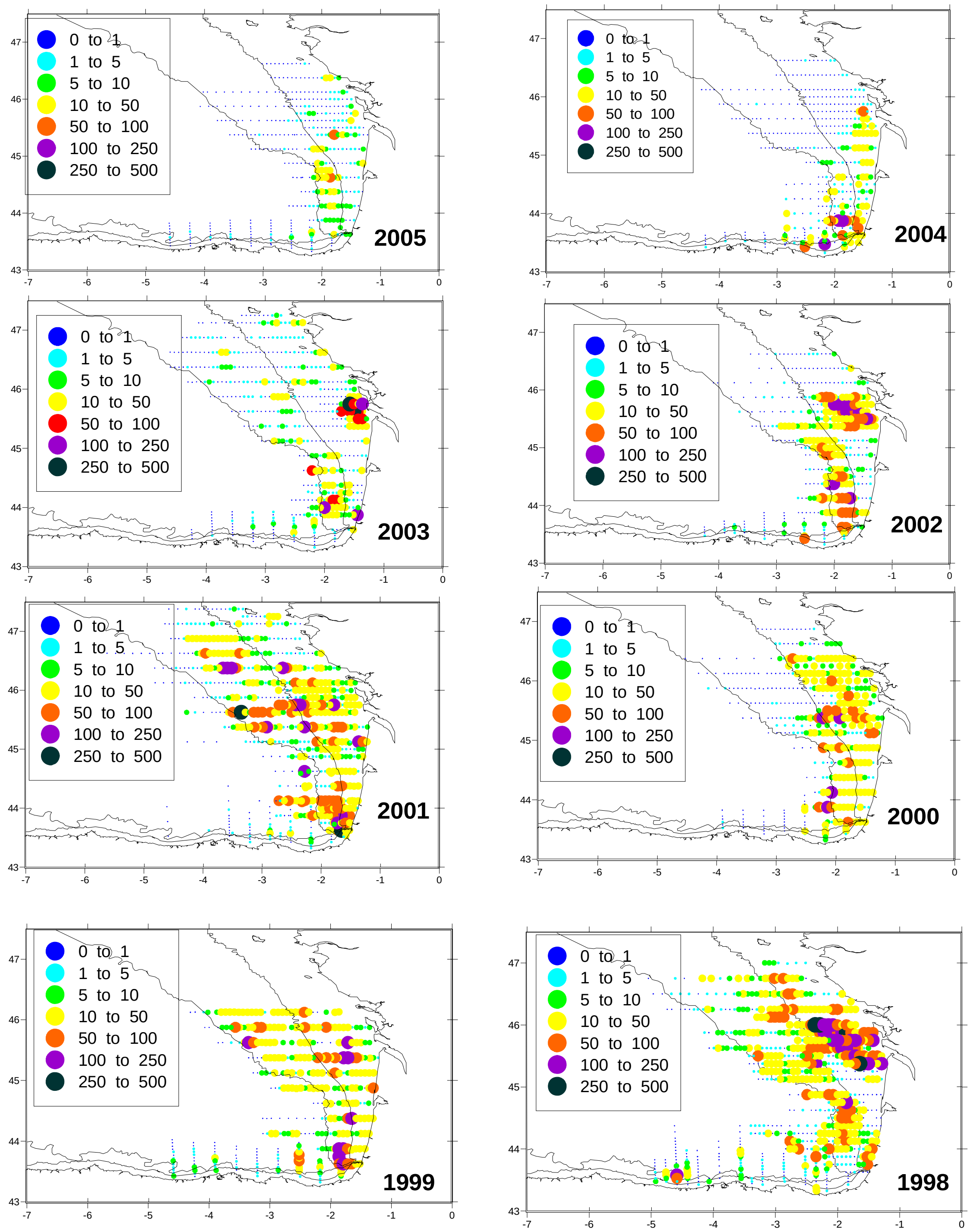


Figure 3.3.1.1.5_2: Spatial distribution of anchovy egg abundances in the last 8 egg surveys for the DEPM implementation.

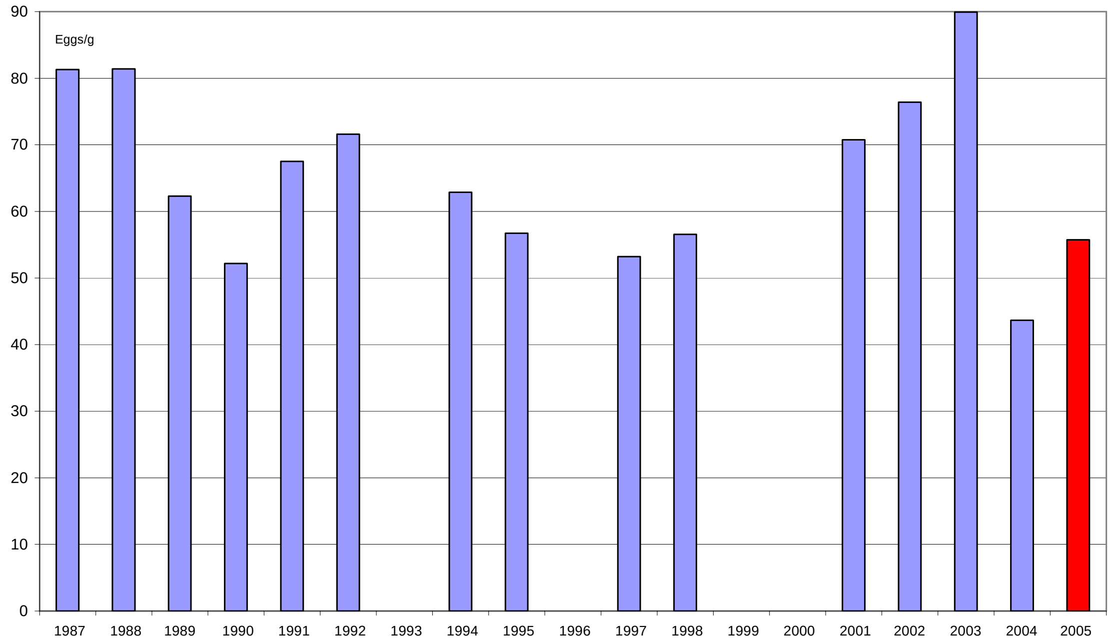


Figure 3.3.1.1.5_3: Historical series of Daily Fecundity (eggs/gram) estimates of the population obtained from the surveys since 1987.

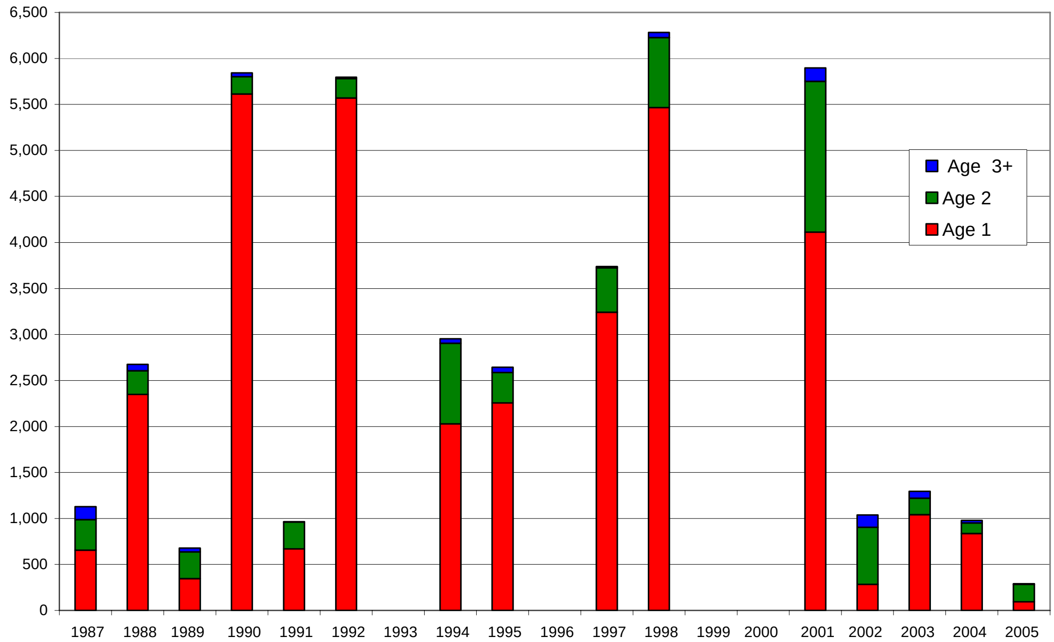


Figure 3.3.1.1.5_4: Historical series of population at age estimates obtained from the surveys since 1987.

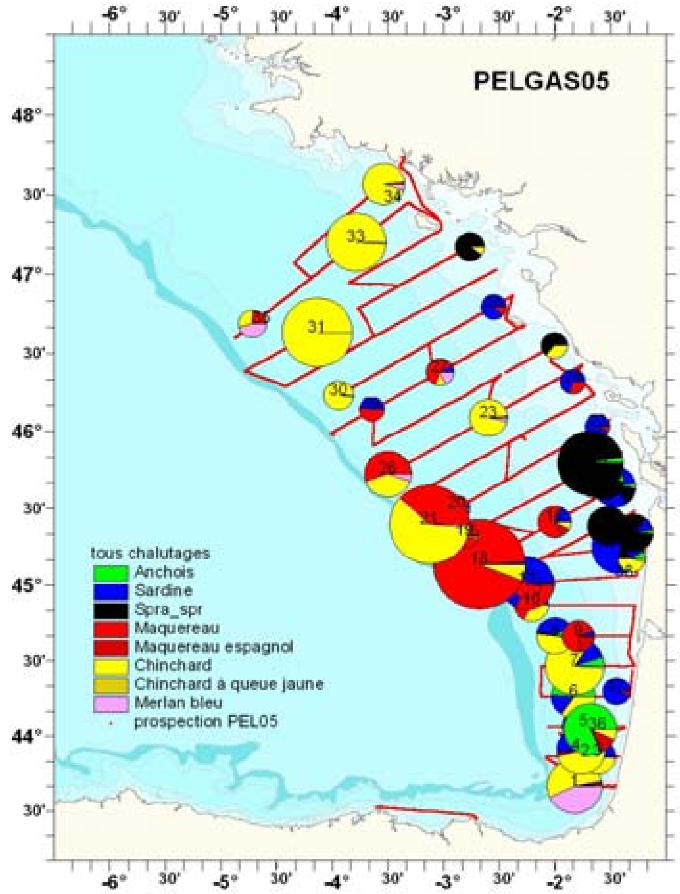


Figure 3.3.1.2.1.1: Prospected transects by acoustics and species compositions of catches obtained from identification hauls into during PELGAS05.

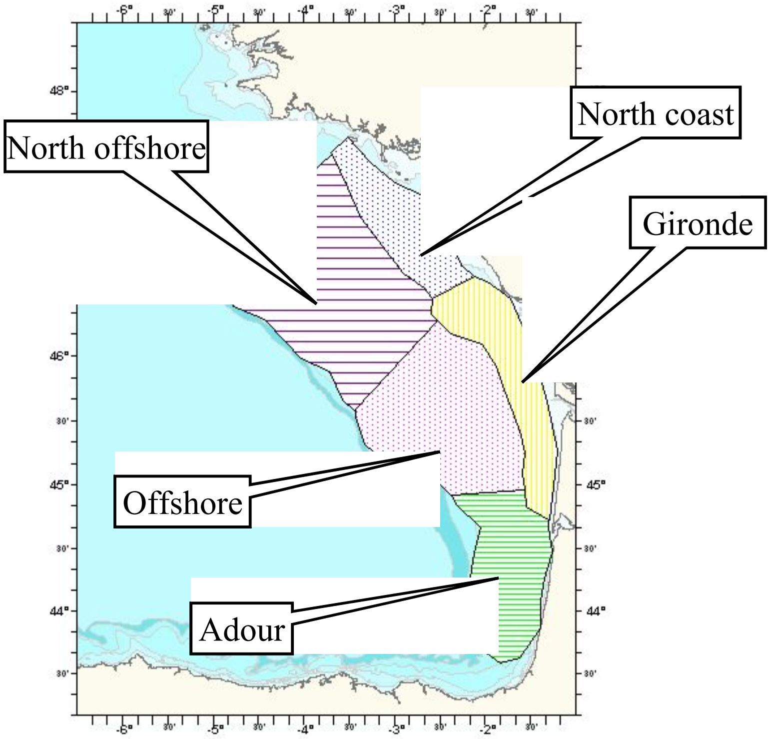


Figure 3.3.1.2.1.2: Area considered for biomass estimates from acoustics during PELGAS05 survey.

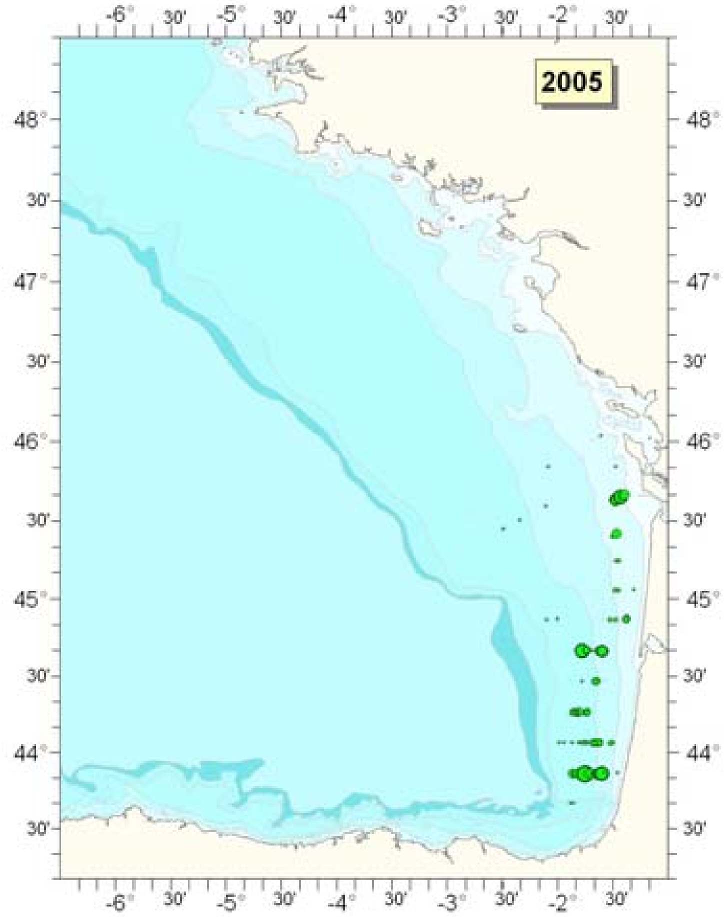


Figure 3.3.1.2.1.3: Distribution of anchovy in biomass per ESDU.

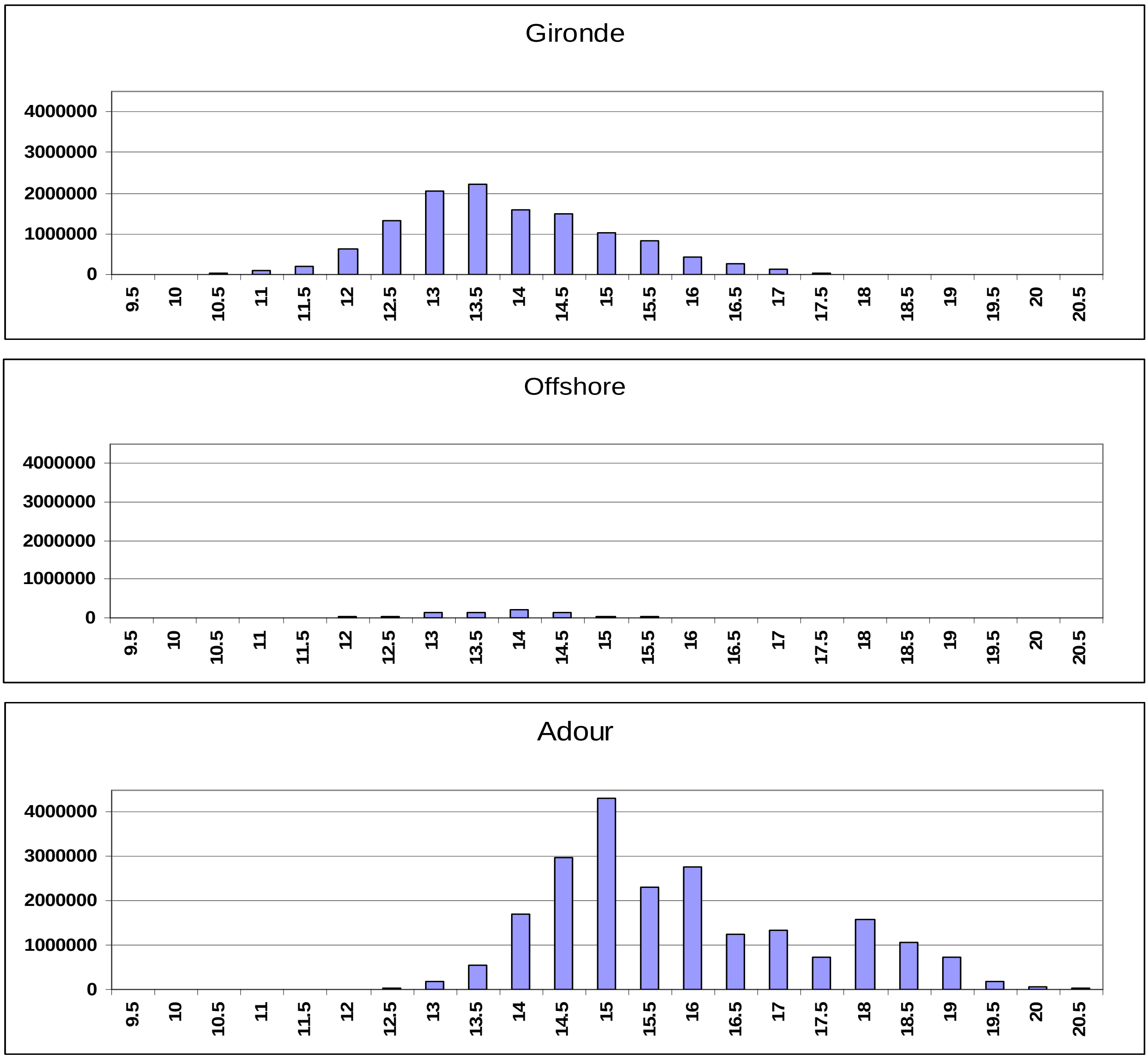


Figure 3.3.1.2.1.4: Length distribution of anchovy observed during PELGAS05 (sum of numbers-/nm² of each ESDU) survey by areas.

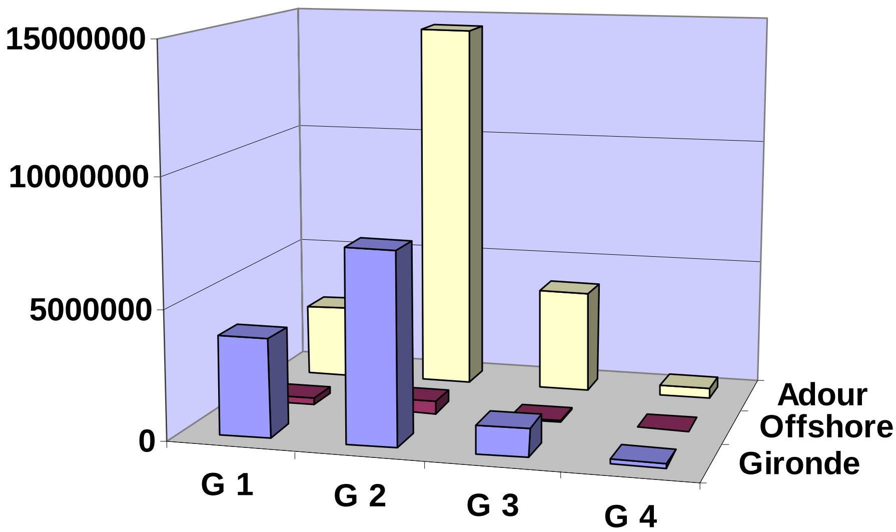


Figure 3.3.1.2.1.5: Number of anchovy per age group during PELGAS05 in numbers (sum of numbers/nm² per ESDU).

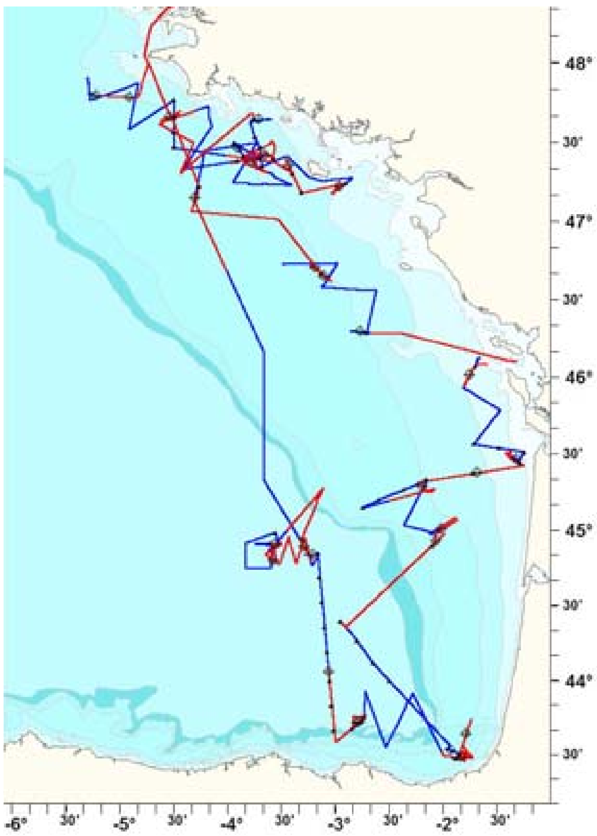


Figure 3.3.1.3.1: Cruise track by day (red) and night (blue) Depending on echo-traces trawl hauls were performed near bottom or at surface between 07:00 and 23:00 local time.

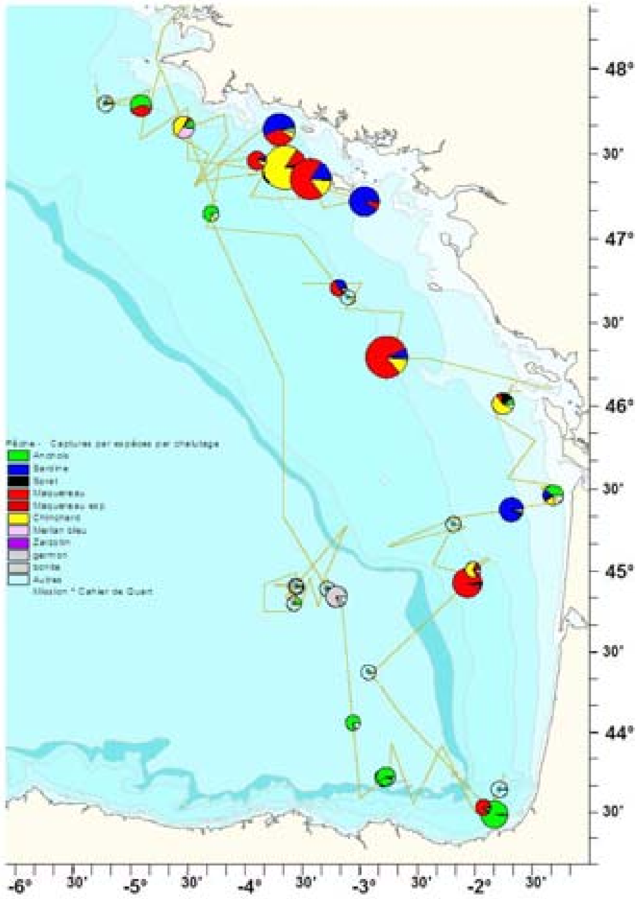


Figure 3.3.1.3.2: Proportion in weight of species in the catches (green: anchovy, blue: sardine, red: mackerel, yellow: horse-mackerel, black: sprat).

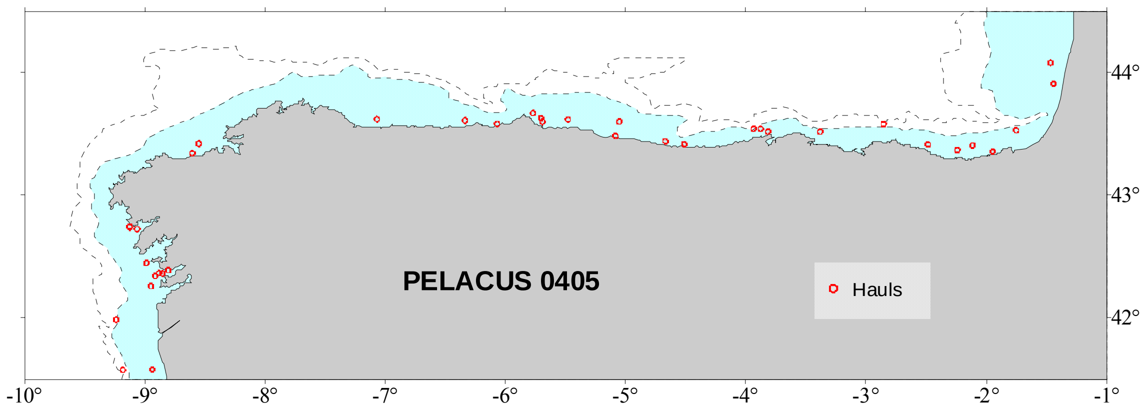


Figure 3.4.1.4.1.1: DEPM Sardine Adults samplings Hauls in Pelacus 0405 (Subdivisions IXa North and VIIIc).

3.3.2 Anchovy surveys in area IX

3.3.2.1 Distribution and abundance of spawning population from egg production surveys

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

BOCADEVA-0605 survey covered the continental shelf of the Gulf of Cadiz (ICES Subdivision IXa South) from Trafalgar Cape to San Vicente Cape. A total of 109 CUFES and 119 PAIROVET egg stations along 21 radials (11 in Spanish waters and 10 in Portuguese waters) were carried out. Hydrographical sampling was accomplished with CTD profile (*Sea-Bird SBE 25*) in every PAIROVET station. In addition, continuous measurements of temperature, salinity and fluorescence (at 5 m depth) in periods of 1 minute were also taken (*Sea-Bird SBE 21*).

CUFES and PAIROVET densities

Table 3.3.2.1.1.1 shows results obtained from both samplers. Most of the eggs were found in Spanish waters (79 % and 93 % of CUFES and PAIROVET eggs respectively).

CUFES registered anchovy eggs in all but two radials. Larger abundances were found near the Bay of Cadiz (Figure 3.3.2.1.1.1). PAIROVET registered anchovy eggs in all but four radials, three of them in the most western part of the study area (Table 3.3.2.1.1.2; Figure 3.3.2.1.1.2). The radial 5 (in front of Guadalquivir River mouth) was the one with most eggs. The 50 % of the total number of eggs was taken in this radial. Station 33 (204 eggs) was the PAIROVET station with the highest number of eggs. This station was sampled at 70 m depth, in front of the town of Chipiona at 6:30 hours GMT. In Portuguese waters anchovy eggs were only found in 6 radials and in small amounts.

Staging eggs (PAIROVET samples)

Table 3.3.2.1.1.2 shows total eggs found by area, radial and development stage. The 94 % of the total sampled eggs were classified into different development stages (ICES, 2003). All stages are represented in the samples except stage XI (Figure 3.3.2.1.1.3). Most abundant stages are: II, III and IV (21.1, 26.2 y 18.9 %, respectively).

Current extension of the anchovy spawning area in the ICES Subdivision IXa South

Results presented in this subsection are preliminary. All results have been estimated with the PAIROVET samples, and the statistical "R" software (*eggsplore, geofun* and *shachar* packages). Total surveyed area was 12328.9 km^2 (Figure 3.3.2.1.1.4). This area represents a 24% increase from the area surveyed in 2004 survey. The area represented by each PAIROVET sampling station is shown in Figure 3.3.2.1.1.5. The analysis of the positive area (besides other differences in egg abundances and adults parameters presented below) shows two well defined spawning regions: Region 1 in Portuguese waters: 2062.4 km^2; Region 2 in Spanish waters: 5217.3 km^2 (Figure 3.3.2.1.1.6).

Anchovy daily eggs production (P_0)

Daily eggs production had been estimates independently for the two regions (Table 3.3.2.1.1.3). Reasons for this stratification were:

- very different egg abundances found between the two regions
- different female mean weight: bigger in Portuguese waters (2004 and 2005 survey results)

- different batch fecundity (2004 survey results) (see Millán *et al*., WGACEGG Working Document)
- different abundances (2004 survey results: acoustic assessment) (Ramos *et. al.* 2004).
- Different yields (number/hour) = 489 in Portugal and 4015 in Spain (2005 survey results).

ABUNDANCE	PORTUGAL	SPAIN	TOTAL
Number (millons)	91	804	894
Biomass (tonnes)	1793	11376	13168

3.3.2.1.2 Distribution and estimates of adult parameters

Adult anchovy samples for DEPM purpose were obtained from pelagic trawls (concurrently with the plankton survey) during both 2004 acoustic surveys (Millán *et al*., WD 2004) and 2005 anchovy DEPM survey in the Gulf of Cadiz onboard the RV "Cornide de Saavedra". In 2005, additional adult samples were collected from the commercial purse-seiner. Fishing stations were opportunistic during each day although in order to obtain the necessary adult samples for DEPM purpose, fishing took place mainly at dawn and at dusk (Tables 3.3.2.1.2.1 and 3.3.2.1.2.2).

In 2004, only 9 samples were available (two from Portuguese waters and seven off Spain; depth range: 39–121 m). In 2005, 31 anchovy samples (10 from Portuguese waters and 21 off Spain, depth range: 43–276 m) were obtained (Figures 3.3.2.1.2.1 and 3.3.2.1.2.2).

Random samples of 40 (in 2004) or 60 (in 2005) fish were selected onboard the research vessel and their biological parameters were recorded (length, weight, sex, maturity stage and otoliths). For the first 20 (in 2004) or 30 (in 2005) non-hydrated females (NHF), the gonads were immediately preserved in 4% buffered formaldehyde for the estimation of the spawning fraction (S). If not enough NFH females were found in the original samples, sampling continued up to a maximum of 80 (in 2004) or 120 (in 2005) sexed anchovies. When hydrated spawning females (HF) appeared, an additional sampling was carried out to obtain 20 HF (in 2004) or 30 HF (in 2005) per haul for the estimation of batch fecundity (F). Samples collected by the commercial vessel in the 2005 survey were transferred to the R/V after their catch and subjected to the same sampling protocol.

Laboratory processing and histological analyses of samples were performed according to the standard established for the species (Hunter *et al*., 1985; Motos, 1996)

Sex ratio (R): was estimated as the percentage (in weight) of females in the mature population. In total, 476 mature fish were used for the estimation of sex ratio in the 2004 survey and 2194 in the 2005 survey.

This sex ratio for the whole area was 0.566 (CV= 33%) in 2004 and 0.530 (CV= 46%) in 2005. The CV for the 2005 estimate was higher than the one estimated in 2004 in spite of the higher number of both fishing stations and sampled fish per haul.

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

$$\mathbf{W = -0.3969 + 1.0848 * Wgf \quad n = 193, R^2 = 99.8\% \ (2004)}$$

$$\mathbf{W = -0.2275 + 1.0785 * Wgf \quad n = 789, R^2 = 99.6\% \ (2005)}$$

In 2004, the mean female weight for the whole Gulf of Cadiz was 16.94 g (CV = 22%, n = 248), using data from 9 hauls.

In 2005, using data from 31 hauls, this parameter was estimated for the whole surveyed area at 19.22 g (CV= 21%, n= 962). The 2005 estimate is higher than the 2004 one, but the coefficients of variation are similar for both surveys.

The mean female weight per haul showed an east-west gradient in both surveys, with the heaviest anchovies being more abundant in the westernmost limit of their distribution (Figures 3.3.2.1.2.3 and 3.3.2.1.2.4).

Batch fecundity (F): In 2004, a total of 83 hydrated females (from 9.13 to 35.94 g gonad-free weight) without POFs were used for the estimation of batch fecundity (Table 3.3.2.1.2.3). Two different post-strata were considered for this parameter given the spatial distribution observed for the mean female weight: an eastern (E) stratum, from Cabo Trafalgar to the Guadiana River, and a western one (W), from Cabo de Sta María to Cabo de S. Vicente. The suitability of this post-stratification was tested by considering 4 generalised linear models (GLM) to check for differences between strata in the gonad-free weight and batch fecundity relationships (Table 3.3.2.1.2.4). The analysis confirmed that a post-stratification was necessary since significant differences between the two stratum were found (ANOVA, α=0.01, Figure 3.3.2.1.2.5). The resulting linear regression model (Figure 3.3.2.1.2.6) was:

$$\mathbf{F = 661.25 * Wgf_E + 550.69 * Wgf_W \quad (R^2 = 0.46)}$$

The batch fecundity per mature female estimates in each stratum was:

- Stratum E : 9076 eggs/batch (CV= 0.31);
- Stratum W: 13416 eggs/batch (CV= 0.27).

In the 2005 survey, 306 hydrated females from 11 samples were preserved for the batch fecundity estimation from the whole surveyed area (Table 3.3.2.1.2.5). Occurrence and abundance of hydrated females was higher than in 2004. Furthermore, hydrated females in 2004 were captured in a narrower time interval (19:33-20:46 GMT) than in 2005 (14:45–20:23 GMT). The 2005 estimates are not yet available since histological processing and analysis of samples are still in progress.

Spawning fraction (S): Spawning fraction was estimated using the females showing Day 1 and Day 2 follicles. The value per sample was the average between those two estimates (Picquelle *et al*., 1985).

In the 2004 survey a total of 178 ovaries (length range: 101–177 mm) from 8 hauls were considered (Table 3.3.2.1.2.6). The estimated spawning fraction for the whole surveyed area was 0.278 (CV= 27%).

In the 2005 survey a total of 793 non-hydrated ovaries (length range: 100–178 mm) were initially collected from 30 individual samples (Table 3.3.2.1.2.7). The histological analysis of these samples is still in progress and therefore the estimate of the spawning fraction is not yet available

3.3.2.1.3 Spatial distribution and biomass estimates of the target species

An estimate of anchovy spawning stock biomass (SSB) in 2005 is not yet available. Egg parameters for 2005 have been estimated and presented, but adults parameters for 2005 are not yet ready (adult parameters are only available for 2004).

3.3.2.1.4 Historical context of current survey

BOCADEVA-0605 is the first anchovy DEPM survey carried out in the Gulf of Cadiz. It aims to be the beginning of an IEO historical series. Although an acoustic assessment of pelagic resources survey (*BOCADEVA-0604)* was carried out in 2004 including a DEPM pilot experience, it only focused on exploratory activities related to knowledge of certain aspects of anchovy spawning ecology, spawning area delimitation and adult parameters estimation.

Both surveys took place in the same area, dates and with the same methodology. CUFES results for both surveys are presented in Table 3.3.2.1.4.1 and Figures 3.3.2.1.4.1 and 3.3.2.1.4.2.

Anchovy positive area (= egg presence) estimated in 2005 was 2328 km^2 larger than the one estimated in 2004. Total and mean density by station were higher in 2004 for anchovy eggs.

Table 3.3.2.1.1.1: *BOCADEVA-0605*. Egg sampling.

	CUFES	PAIROVET
Total stations	109	119
Total positive stations	50	46
% positive stations	45.9	38.7
Total number eggs	2995	583

Table 3.3.2.1.1.2: Total eggs captured by area, 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 3.3.2.1.1.3: Anchovy eggs parameters (Gulf of Cádiz).

Eggs Parameters	Region 1	Region 2
Temperature range (ºC)	20.7-22.9	19.6-22.4
Total spawning area (km^2)	2062.3	5217.2
P_0 (eggs/m^2/day)	43.1138	308.916
Total P_0 (eggs/day)	8.89E+10	161.17E+10
Z (eggs/day/hour)	-2.14%	-5.90%

Table 3.3.2.1.2.1: ***BOCADEVA 0604*** **survey. Descriptive characteristics of the anchovy fishing stations in 2004.**

FISHING STATION	DATE	START		END		GMT TIME		DEPTH (M)		ZONE
		Latitude	Longitude	Latitude	Longitude	Start	End	Start	End	
01	07/06/04	36º 23.527' N	6º 24.650' W	36º 23.212' N	6º 25.092' W	14:41	14:49	48	49	Cádiz
02	07/06/04	36º 23.166' N	6º 25.864' W	36º 25.626' N	6º 23.217' W	15:39	16:19	52	43	Cádiz
04	08/06/04	36º 35.301' N	6º 38.757' W	36º 32.128' N	6º 42.600' W	13:44	14:38	68	102	Chipiona
05	08/06/04	36º 39.565' N	6º 48.365' W	36º 41.660' N	6º 43.720' W	19:33	20:36	105	65	Coto de Doñana
06	09/06/04	36º 55.559' N	7º 04.408' W	36º 55.679' N	7º 08.172' W	11:43	12:30	89	94	Pta. Umbría-El Rompido
07	09/06/04	36º 49.131' N	6º 48.876' W	36º 50.764' N	6º 46.372' W	19:43	20:15	56	39	Matalascañas
09	10/06/04	36º 52.430' N	7º 17.212' W	37º 02.352' N	7º 20.917' W	09:16	10:27	91	63	Isla Cristina
11	10/06/04	36º 57.438' N	7º 46.054' W	37º 58.888' N	7º 46.315' W	20:24	20:46	83	63	Fuzeta
13	11/06/04	36º 51.472' N	8º 05.951' W	36º 54.519' N	8º 06.184' W	09:42	10:28	103	73	Quarteira

Table 3.3.2.1.2.2: *BOCADEVA 0605* survey. Descriptive characteristics of the anchovy fishing stations in 2005.

Fishing station	Date	Start		End		GMT Time		Depth (m)		Zone
		Latitude	Longitude	Latitude	Longitude	Start	End	Start	End	
01	11/06/05	36º 22.560' N	6º 27.155' W	36º 24.550' N	6º 23.600' W	18:11	19:07	63	50	Santi Petri
02	11/06/05	36º 28.500' N	6º 27.002' W	36º 30.700' N	6º 28.900' W	22:09	22:55	50	50	Cádiz
03	12/06/05	36º 35.541' N	6º 38.719' W	36º 37.188' N	6º 35.304' W	07:12	08:05	72	51	Rota
04	12/06/05	36º 35.566' N	6º 38.399' W	36º 37.193' N	6º 35.350' W	18:06	18:54	71	50	Rota
05	12/06/05	36º 41.427' N	6º 44.946' W	36º 42.712' N	6º 42.649' W	20:23	21:00	80	56	Coto de Doñana
06	13/06/05	36º 55.000' N	7º 00.200' W	36º 56.279' N	7º 02.545' W	08:55	09:44	85	84	Matalascañas
07	13/06/05	36º 41.375' N	6º 45.072' W	36º 43.211' N	6º 41.707' W	14:45	15:38	81	49	Sanlúcar
08	13/06/05	36º 37.646' N	6º 42.832' W	36º 39.420' N	6º 39.524' W	16:42	17:32	84	57	Chipiona
09	14/06/05	36º 52.835' N	6º 55.321' W	36º 50.177' N	6º 52.601' W	15:04	16:00	77	79	Matalascañas
10	14/06/05	36º 43.527' N	6º 46.522' W	36º 45.522' N	6º 43.099' W	18:09	19:04	79	45	Sanlúcar
11	15/06/05	36º 56.883' N	7º 03.665' W	36º 58.066' N	7º 07.469' W	14:22	15:17	81	81	Huelva
12	15/06/05	37º 00.487' N	7º 10.137' W	37º 00.478' N	7º 14.177' W	16:01	16:57	64	72	El Rompido
13	15/06/05	37º 00.720' N	7º 19.168' W	37º 02.558' N	7º 22.269' W	19:10	20:00	78	70	Isla Cristina
14	16/06/05	36º 28.474' N	6º 33.999' W	36º 30.537' N	6º 30.097' W	06:08	07:08	79	55	Cádiz
15	16/06/05	36º 23.713' N	6º 27.935' W	36º 25.602' N	6º 24.383' W	08:19	09:17	63	51	Chiclana
17	17/06/05	37º 01.424' N	7º 23.380' W	37º 01.986' N	7º 26.191' W	18:30	19:07	85	86	Ayamonte
19	18/06/05	36º 49.264' N	8º 05.892' W	36º 51.954' N	8º 05.888' W	15:43	16:29	276	104	Faro
20	18/06/05	36º 54.077' N	7º 59.877' W	36º 54.146' N	8º 03.903' W	18:07	18:59	83	87	Quarteira
21	18/06/05	36º 52.708' N	8º 05.934' W	36º 55.411' N	8º 06.097' W	19:40	20:26	101	53	Faro
22	19/06/05	37º 00.733' N	8º 25.329' W	36º 56.429' N	8º 25.258' W	06:50	08:00	43	93	Alfanzina
23	19/06/05	36º 55.456' N	8º 15.474' W	36º 58.466' N	8º 15.533' W	16:02	16:51	81	49	Albufeira
24	19/06/05	36º 56.971' N	8º 25.303' W	37º 00.272' N	8º 25.386' W	19:10	20:03	87	43	Ponta do Altar
26	20/06/05	37º 00.343' N	8º 45.143' W	36º 56.698' N	8º 44.848' W	08:22	09:22	65	108	Burgau
27	20/06/05	36º 56.732' N	8º 23.388' W	36º 56.212' N	8º 19.483' W	11:29	12:24	82	89	Albufeira-Alfanzina
28	20/06/05	36º 54.828' N	8º 13.710' W	36º 54.522' N	8º 11.030' W	13:15	13:54	85	76	Ponta dos Castelos
29	21/06/05	37º 00.052' N	7º 19.684' W	36º 59.338' N	7º 16.686' W	07:16	07:58	89	87	Guadiana River
31	21/06/05	36º 42.298' N	6º 40.587' W	36º 39.703' N	6º 38.262' W	15:56	16:51	48	52	Guadalquivir River
P-S 1	14/06/05	36º 32.437' N	6º 35.733' W	36º 32.421' N	6º 35.701' W	03:50	05:00	60	60	Cadiz
P-S 2	15/06/05	36º 43.011' N	6º 44.750' W	36º 43.036' N	6º 44.880' W	23:31	01:20	62	62	Sanlucar
P-S 3	15/06/05	36º 42.928' N	6º 44.783' W	36º 42.915' N	6º 44.004' W	02:00	03:30	63	63	Chipiona
P-S 4	15/06/05	36º 42.773' N	6º 44.827' W	36º 42.773' N	6º 44.837' W	04:00	05:30	65	65	Sanlucar
P-S 5	16/06/05	36º 47.658' N	6º 48.511' W	36º 47.658' N	6º 48.511' W	21:55	00:15	60	60	Coto de Doñana

Table 3.3.2.1.2.3: *BOCADEVA 0604 survey*. Description of adult anchovy samples for estimation of batch fecundity in 2004.

Fishing station	Zone	Depth range (m)	GMT time	Size range (mm)	Nº
05	Coto de Doñana	65–105	19:33–20:36	125–136	7
07	Matalascañas	39–56	19:43–20:15	117–149	64
11	Fuzeta	63–83	20:24–20:46	147–181	11

Table 3.3.2.1.2.4: *BOCADEVA 0604* survey. Alternative generalised linear models (GLMs) considered for the estimation of anchovy batch fecundity in 2004.

```
Analysis of Deviance Table

Model 1: Total.huevos ~ -1 + Strato + Ptotsingon:Strato
Model 2: Total.huevos ~ Ptotsingon:Strato
Model 3: Total.huevos ~ -1 + Ptotsingon:Strato
Model 4: Total.huevos ~ -1 + Ptotsingon


  Resid. Df Resid. Dev Df  Deviance    F    Pr(>F)
1        78  448392219
2        79  448576467 -1   -184248 0.0321 0.858380
3        80  449819852 -1  -1243385 0.2163 0.643175
4        81  507265591 -1 -57445739 9.9930 0.002238 **
---
Signif. codes:  0 `***' 0.001 `**' 0.01 `*' 0.05 `.' 0.1 ` ' 1


R2 of model 3 (final model) = 0.46 (46%)


Final Model:

Call:
glm(formula = Total.huevos ~ -1 + Ptotsingon:Strato, data = fecundidad)

Deviance Residuals:
     Min        1Q    Median        3Q       Max
-5379.24  -1595.50    -68.16   1697.51   6728.23

Coefficients:
                       Estimate  Std. Error t value  Pr(>|t|)
Ptotsingon: Stratum E   661.25      17.53   37.72   <2e-16 ***
Ptotsingon: Stratum W   550.69      29.82   18.47   <2e-16 ***
---
Signif. codes:  0 `***' 0.001 `**' 0.01 `*' 0.05 `.' 0.1 ` ' 1

(Dispersion parameter for gaussian family taken to be 5622748)

    Null deviance: 1.0366e+10  on 82  degrees of freedom
Residual deviance: 4.4982e+08  on 80  degrees of freedom
AIC: 1511.2
```

Table 3.3.2.1.2.5: *BOCADEVA 0605* survey. Description of adult anchovy samples for estimation of batch fecundity in 2005.

Fishing station	Zone	Depth range (m)	GMT time	Size range(mm)	Nº
01	Santi Petri	63–50	18:11–19:07	152	1
02	Cádiz	50–50	20:09–20:55	120–136	10
04	Rota	71–50	18:06–18:54	114–151	16
05	Coto Doñana	80–56	20:23–21:00	121–162	42
07	Sanlúcar	81–49	14:45–15:38	121–162	48
08	Chipiona	84–57	16:42–17:32	126–144	15
10	Sanlúcar	79–45	18:09–19:04	110–153	43
12	El Rompido	64–72	16:01–16:57	137–160	12
13	Isla Cristina	78–70	19:10–20:00	134–170	42
17	Ayamonte	85–86	18:30–19:44	154	1
20	Quarteira	83–87	18:07–18:59	145–166	9
24	Albufeira-Alfanzina	87–43	19:10–20:03	138–178	50
31	Guadalquivir River	48–52	15:56–16:51	100–143	29

Table 3.3.2.1.2.6: *BOCADEVA 0604* survey. Description of adult anchovy samples for estimation of spawning fraction in 2004.

Fishing station	Zone	Depth range (m)	GMT time	Size range (mm)	Nº
01	Cadiz	48–49	14:41–14:49	120–146	32
02	Cadiz	43–52	15:39–16:19	119–146	33
05	Coto Doñana	65–105	19:43–20:36	105–132	19
06	P. Umbria	89–94	11:43–12:30	130–177	23
07	Matalascañas	39–56	19:43–20:15	103–128	9
09	Isla Cristina	63–91	9:16–10:27	131–157	27
11	Fuzeta	63–83	20:24–20:46	133–165	16
13	Ponta Sagres	73–103	9:42–10:28	130–165	19

Table 3.3.2.1.2.7: *BOCADEVA 0604* survey. Description of adult anchovy samples for estimation of spawning fraction in 2005.

FISHING STATION	ZONE	DEPTH RANGE (M)	GMT TIME	SIZE RANGE (MM)	Nº
02	Cadiz	50–50	20:09–20:55	117–136	12
03	Rota	72–51	07:12–08:05	100– 153	30
04	Rota	71–50	18:06–18:54	108–155	25
05	Coto Doñana	80–56	20:23–21:00	108–152	32
06	Matalascañas	85–84	08:55–09:44	136–161	30
07	Sanlúcar	81–49	14:45–15:38	111–153	32
08	Chipiona	84–57	16:42–17:32	111–144	13
09	Matalascañas	77–79	15:04–16:00	127–155	36
10	Sanlúcar	79–45	18:09–19:04	107–145	27
11	Huelva	81–81	14:22–15:17	132–158	47
12	El Rompido	64–72	16:01–16:57	120–155	27
13	Isla Cristina	78–70	19:10–20:00	128–162	21
14	Cadiz	79–55	06:08–07:08	125–162	30
15	Chiclana	63–51	08:19–09:17	130–161	30
17	Ayamonte	85–86	18:30–19:44	130–153	30
19	Faro	276–104	15:43–16:29	140–176	40
20	Quarteira	83–87	18:07–18:59	155–163	20
21	Faro	101–53	19:40–20:26	142–171	17
22	Alfanzina	43–93	06:50–08:00	140–166	23
23	Albufeira	81–49	16:02–16:51	134–168	30
24	Albufeira–Alfanzina	87–43	19:10–20:03	131–154	4
26	Burgau	65–108	08:22–09:22	154–175	4
27	Albufeira-Alfanzina	82–89	11:29–12:24	141–171	30
28	P. dos Castelos	85–76	13:15–13:54	140–166	14
29	Guadiana River	89–87	07:16–07:58	128–178	30
31	Guadalquivir River	48–52	15:56–16:51	103–140	21
P-S 1	Cadiz	60–60	03:50–05:00	123–157	35
P-S 2	Sanlucar	62–62	23:31–01:20	115–168	38
P-S 3	Chipiona	63–63	02:00–03:30	113–151	30
P-S 4	Sanlucar	65–65	04:00–05:30	115–147	31

Table 3.3.2.1.4.1: CUFES results from BOCADEVA 2004 and 2005 surveys.

CUFES Anchovy eggs	*BOCADEVA-0604*	*BOCADEVA-0605*
Total surveyed area (km^2)	9345	12329
Total positive area (km^2)	4952	7280
Number stations	99	109
Positive stations (egg presence)	53 (54%)	50 (46%)
Total number	14946	2955
Maximum number by station	2513	407
Number average by station	282	30
Total density (egg/m^3)	1336	256
Maximum density by station	206	39
Density average by station	14	3

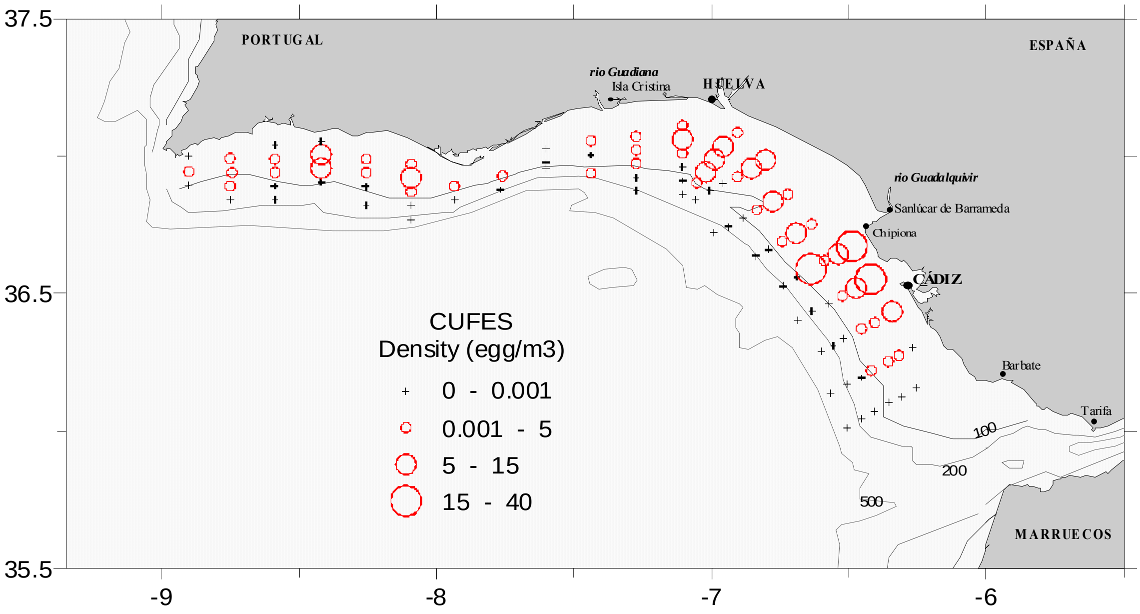


Figure 3.3.2.1.1.1: ***BOCADEVA-0605*. Anchovy egg densities (nº/m^3) by CUFES.**

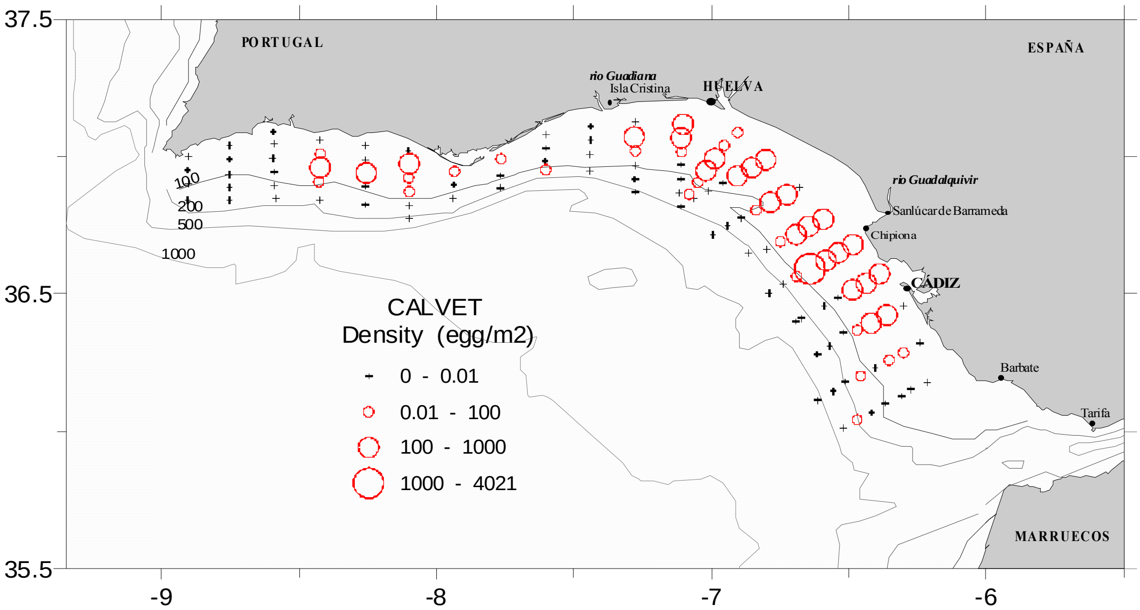


Figure 3.3.2.1.1.2: ***BOCADEVA-0605*. Anchovy egg densities (nº/m^2) by PAIROVET.**

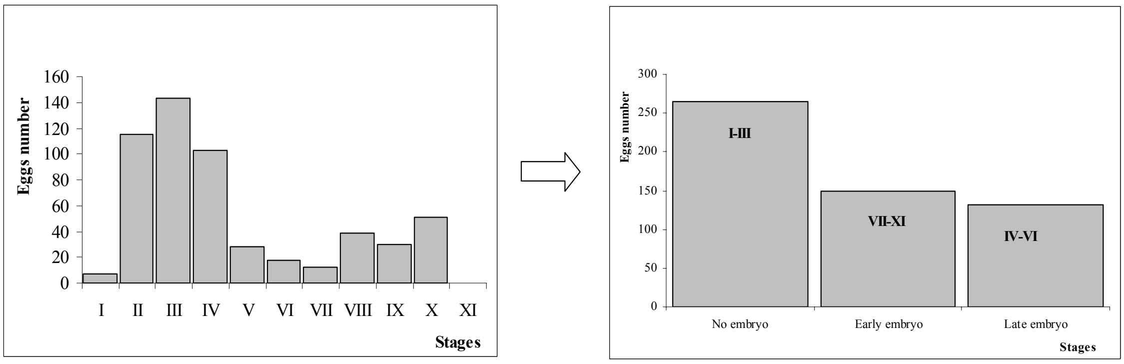


Figure 3.3.2.1.1.3: Relative importance of the anchovy eggs development stages captured by PAIROVET. The second graph represents the same data grouped in the three CUFES categories.

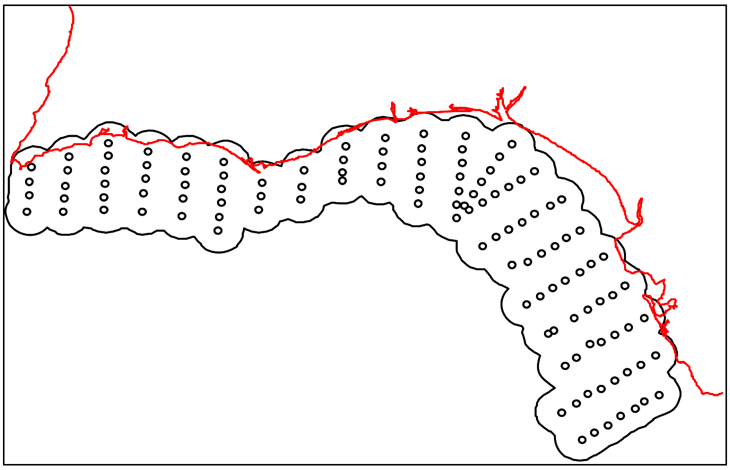


Figure 3.3.2.1.1.4: Total surveyed area. The circles correspond to PAIROVET stations.

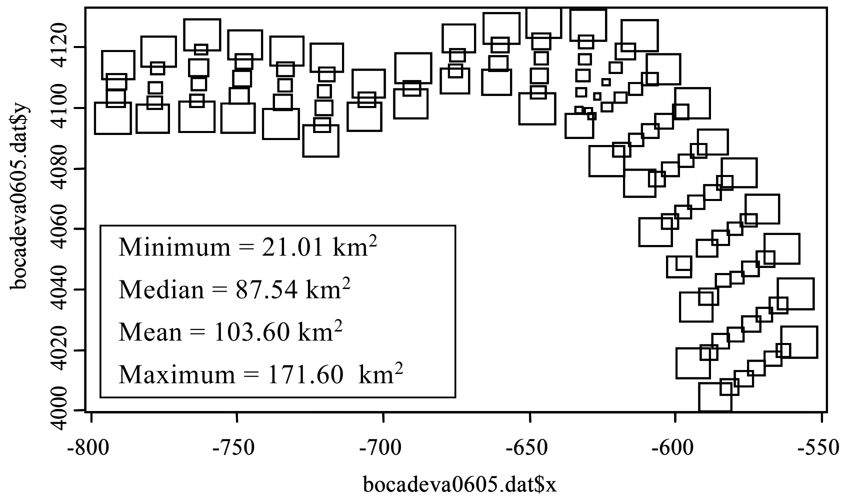


Figure 3.3.2.1.1.5: Area represented by PAIROVET stations.

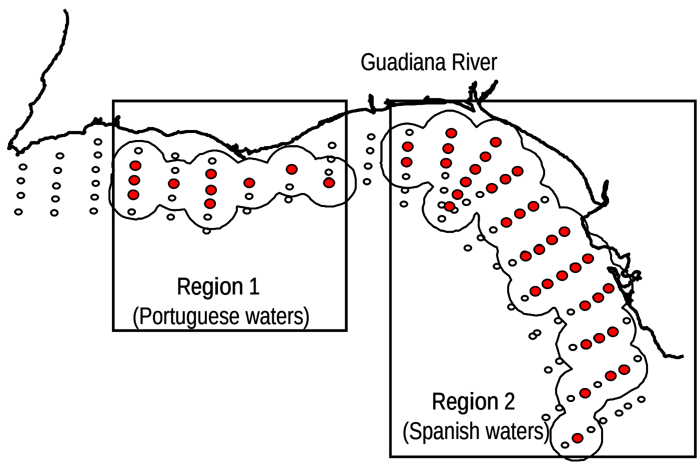


Figure 3.3.2.1.1.6: Anchovy spawning regions in the Gulf of Cadiz (= positive areas).

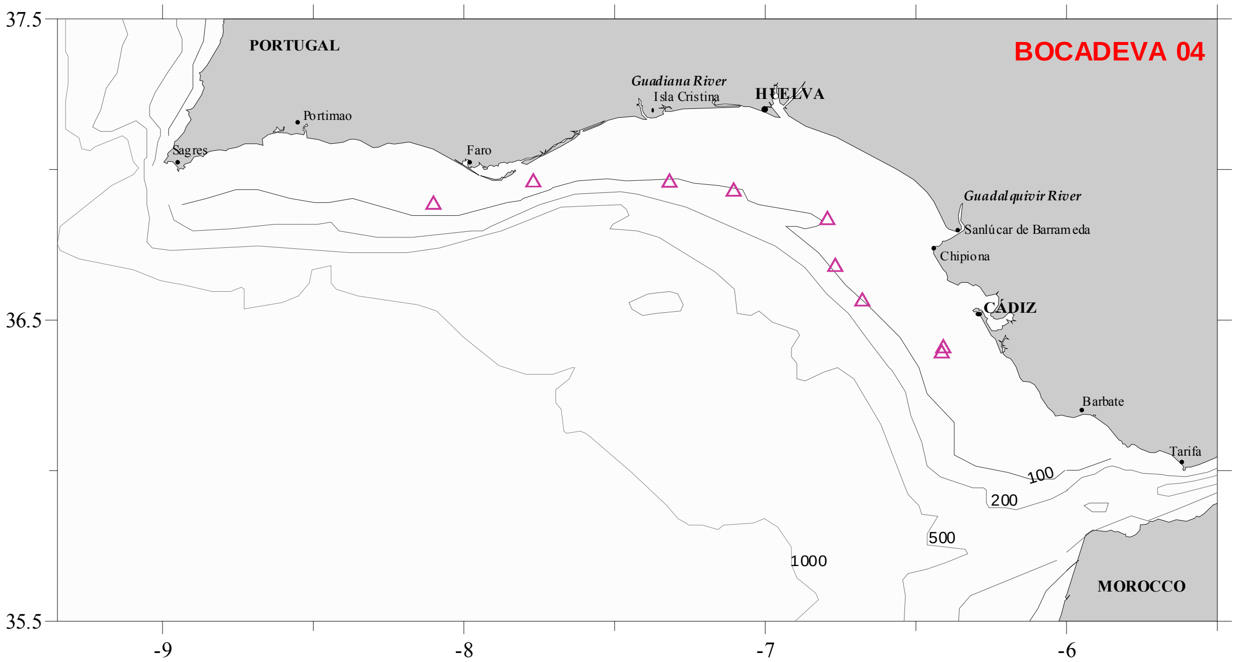


Figure 3.3.2.1.2.1: ***BOCADEVA*** **0604 survey. Location of adult samples obtained by RV "Cornide".**

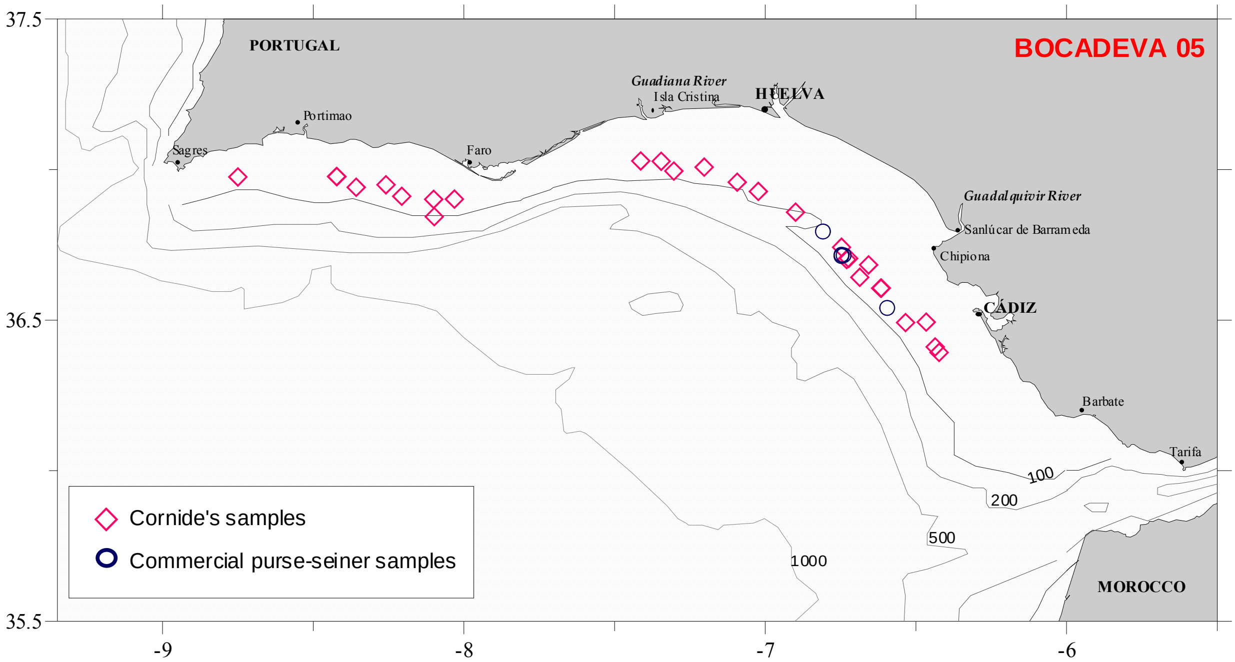


Figure 3.3.2.1.2.2: ***BOCADEVA 0605*** **survey. Location of adult samples obtained by RV "Cornide" (in red) and commercial purse-seiners (in black) for the estimation of anchovy adult parameters in 2005.**

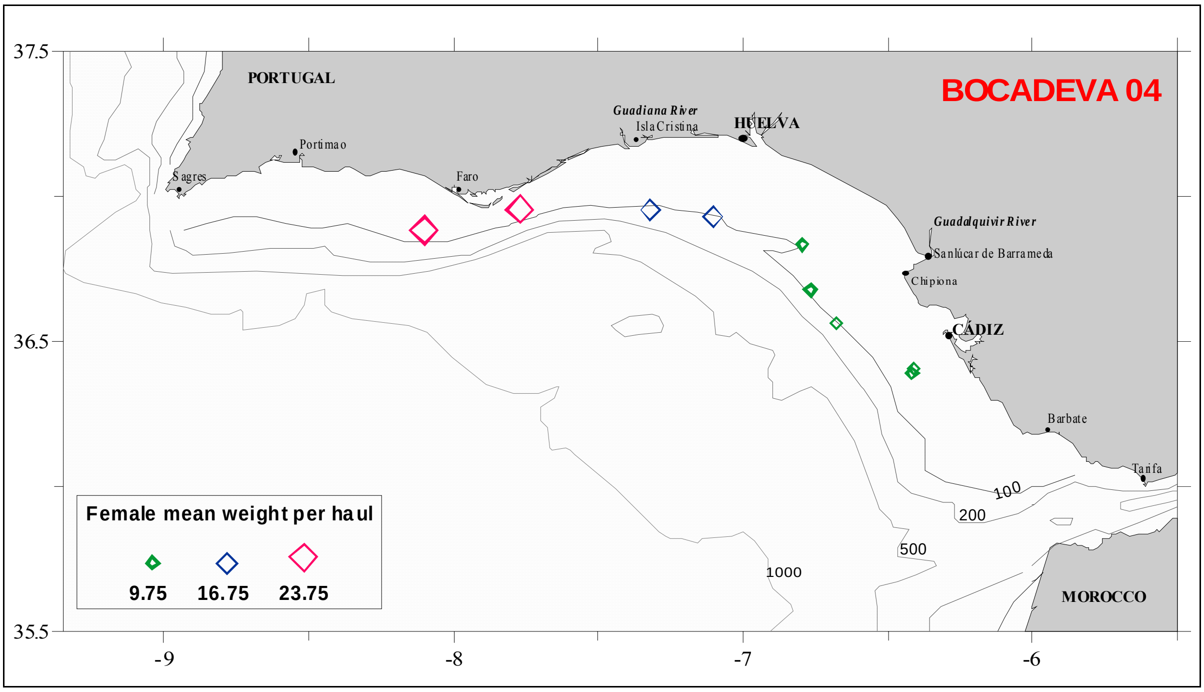


Figure 3.3.2.1.2.3: *BOCADEVA 0604* survey. Spatial distribution of mean female weight for Gulf of Cadiz anchovy in 2004.

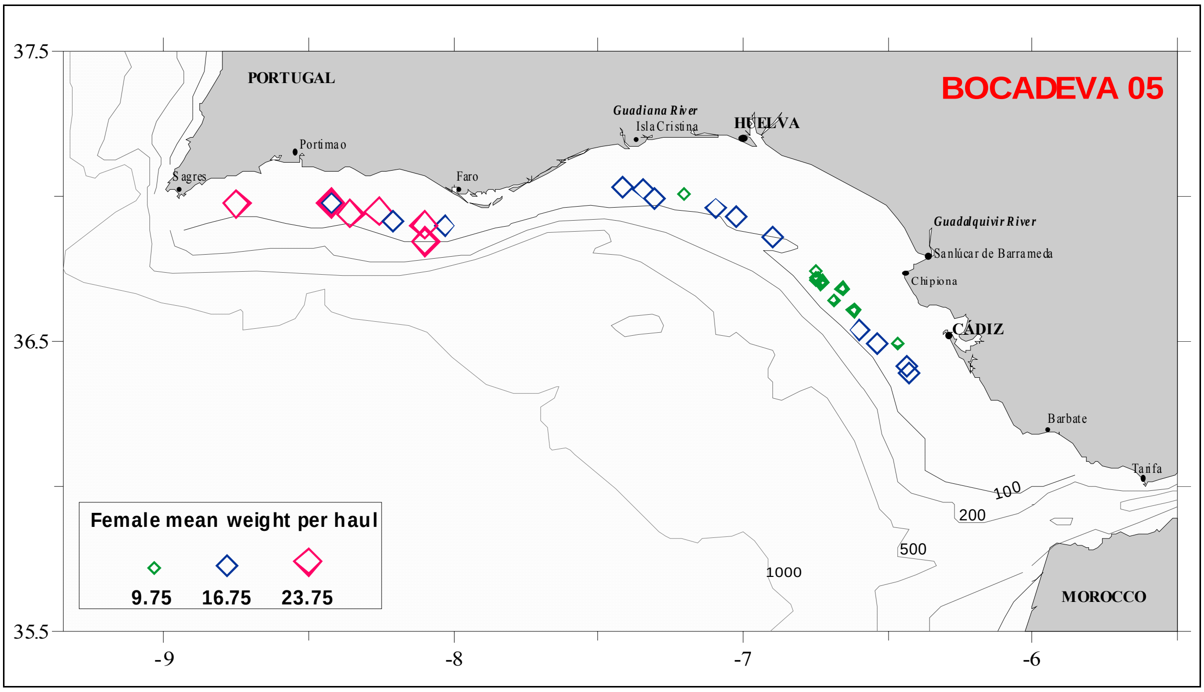


Figure 3.3.2.1.2.4: *BOCADEVA 0605* survey. Spatial distribution of mean female weight for Gulf of Cadiz anchovy in 2005.

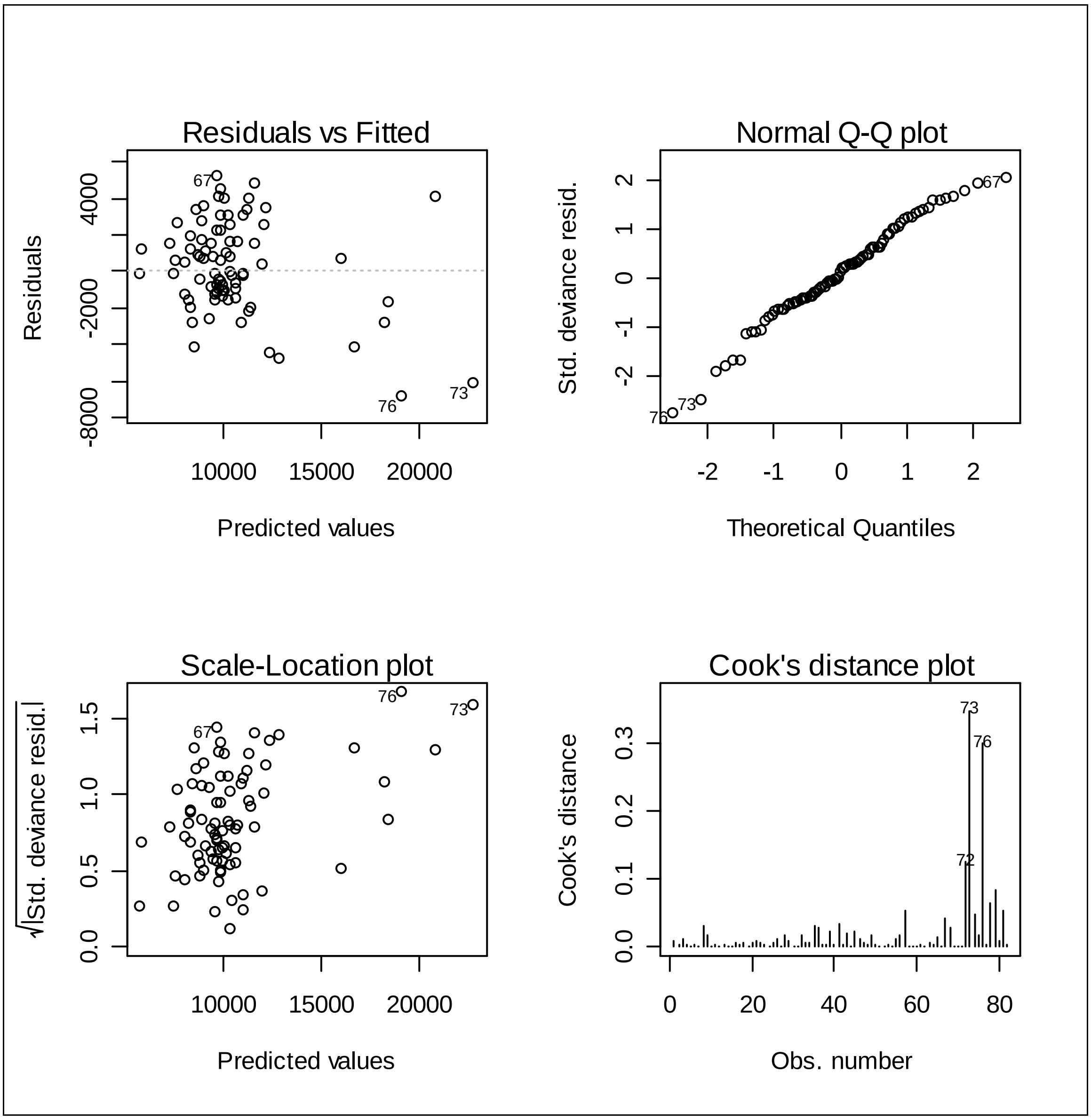


Figure 3.3.2.1.2.5: Residual inspection plots for generalized linear model (different slopes and intercept in the origin) fitted to anchovy batch fecundity data from the 2004 Spanish survey (n=82).

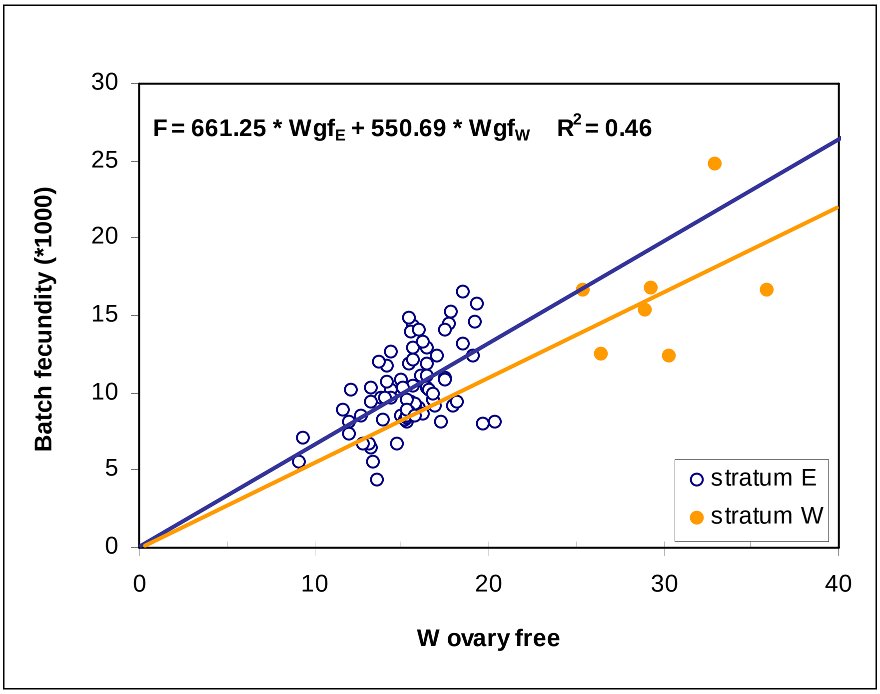


Figure 3.3.2.1.2.6: Batch fecundity vs. gonad free weight for the hydrated females. A regression line was fitted separately to each stratum (blue and orange lines represent the GLM fitted to the E and W stratum respectively).

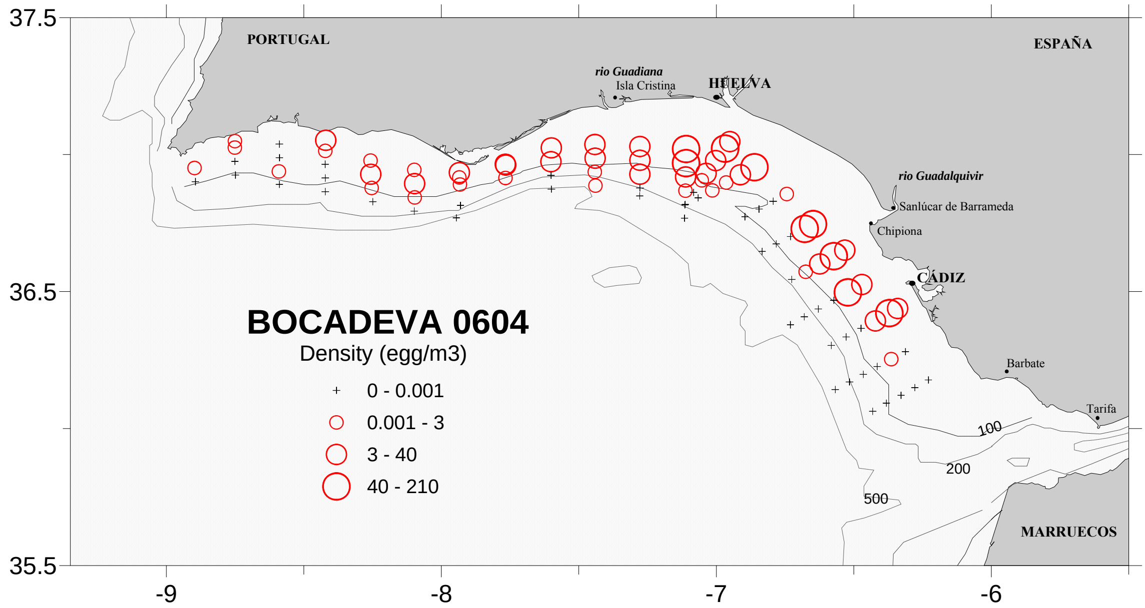


Figure 3.3.2.1.4.1: ***BOCADEVA-0604.*** **Anchovy egg densities (egg/m^3) by CUFES.**

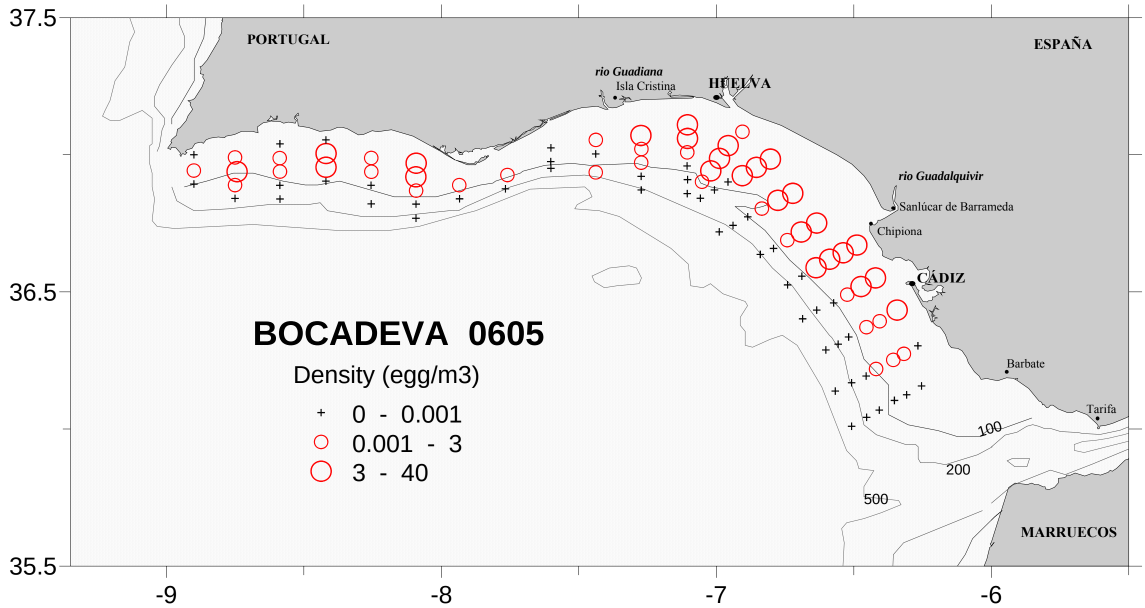


Figure 3.3.2.1.4.2: ***BOCADEVA-0605.*** **Anchovy egg densities (egg/m^3) by CUFES.**

3.3.2.2 Distribution and abundance of spawning population from acoustic surveys

3.3.2.2.1 Species composition in the area and length/age composition of the target species

June 2004 Spanish survey (*BOCADEVA 0604*)

A new acoustic survey was conducted with the RV "Cornide de Saavedra" (*BOCADEVA 0604*) in June 2004. This survey aims to be the first one within a new Spanish acoustic survey series in the area. The surveyed area included the whole of the Subdivision IXa South, between 30 and 200 m depth. The shallowest depth limit of the surveyed area was set at 30 m as a security measure for the navigation of the R/V. This fact entailed that a part of the coastal zone between the Guadalquivir and Guadiana River mouths was not acoustically sampled. The survey was aimed at the acoustic estimation of the anchovy SSB in the study area hence the survey season was decided in accordance.

From a total of 20 fishing operations, only 13 hauls could be considered as valid fishing stations according to correct gear performance and resulting catches. From the more frequent species in these valid hauls stood especially out the chub mackerel (present in 12 out of the 13 hauls), followed by anchovy and mackerel (10 hauls), and sardine (8 hauls) (Figure 3.2.1).

The population anchovy size composition in this survey showed a clear distribution pattern, with the largest (-oldest) anchovies being more abundant in the westernmost limit of their distribution. Anchovy sizes in the Portuguese waters ranged between 12 and 18 cm (mode at 14 cm, mean length at 14.19 cm). In the Spanish waters the size range oscillated between 9 and 17.5 cm (mode at 13 cm, mean length at 12.73 cm), with anchovies smaller than 12 cm accounting for 28% of the estimated abundance in this region (Figure 3.3.2.2.1.1). Around 61% of the total of 2-year old anchovies estimated for the whole surveyed area was concentrated in Portuguese waters (Table 3.3.2.2.1.1).

April 2005 Portuguese survey (*SAR0505*)

A Portuguese acoustic survey was carried out during April 2005 with the RV "Noruega". The surveyed area included the waters of the Portuguese continental shelf and those of the Spanish Gulf of Cadiz (Subdivisions IXa Central-North, Central-South, and South), between 20 and 200 m depth. The objectives of the survey were to estimate the spatial distribution and the abundance of sardine (*Sardina pilchardus*) and anchovy (*Engraulis encrasicolus*) by length classes and by age groups (only for sardine), in the surveyed area. All the 69 planned acoustic tracks took place. In order to identify species and collect biological samples, 41 trawl stations were performed.

Sardine was present in 30 trawl hauls being the dominant species in the West Coast between Caminha and Cape Espichel (Figure 3.2.1). In the remaining Portuguese coast three species were frequently found together: sardine, chub mackerel (*Scombrus japonicus*) and bogue (*Boops boops*). Anchovy was present in nine trawl hauls but was only caught in significant numbers in the Gulf of Cadiz. As usual this last area was characterised by a higher species mixture.

The anchovy population size composition for each sub-area is presented in Figures 3.3.2.2.1.2. and 3.3.2.2.1.3. Anchovy size in the OCS sub-area (Subdivision IXa Central-South) ranged between 12 and 17 cm, showing a right skewed distribution with a mode at 13 cm. Sizes of Gulf of Cadiz anchovy ranged between 9 and 15 cm, with a distribution showing two modal classes, the smaller mode at 10.5 cm and the larger one at 13 cm.

3.3.2.2.2 Distribution of acoustic energy allocated to anchovy

June 2004 Spanish survey (*BOCADEVA 0604*)

Survey results showed that anchovy was mainly distributed in the Spanish waters off the Gulf, with higher densities occurring between 40 and 80 m depth. In Portuguese waters the species was restricted to the easternmost area only (Figure 3.3.2.2.2.1).

April 2005 Portuguese survey (*SAR0505*)

As usual during the April 2005 survey anchovy was found in two major areas in the Division IXa. The main concentrations were found in the Gulf of Cadiz (Subdivision IXa South) and in front of the Tagus estuary (Lisbon, Subdivision IXa Central North), (Figure 3.3.2.2.2.2). In the Spanish waters of the Gulf of Cadiz anchovy was mainly found within plankton layers creating extra difficulties in assigning the acoustic energy to this species. In order to solve this problem the echograms were analysed using a threshold of –55dB and in some situations –50 dB. Even adopting this procedure it was not easy to distinguish anchovies from plankton and due to this reason the abundance estimates presented in this document must be considered with some caution.

3.3.2.2.3 Biomass estimates of the target species

June 2004 Spanish survey (*BOCADEVA 0604*)

The total estimated biomass for anchovy in Subdivision IXa South was 13,168 thousand tonnes (894.4 million fish), with fish in Spanish waters accounting for the 86.4% of the total biomass (11,376 tonnes), (see Table 3.3.2.2.4.2). Such estimates, however, should be considered as preliminary since a possible underestimation might result from an inappropriate acoustic sampling coverage of the shallowest depths. Anchovy S_a values showed an increasing inshore gradient, with the highest back-scattering values being recorded close to the shallowest limit of the sampled area (30-m depth). Probably, the prolongation of the acoustic sampling to 20-m depth (as planned in the Portuguese surveys) could have resulted in somewhat higher estimates that those herein presented. However, even so, a relatively large coastal area extending between the Guadalquivir and Guadiana rivers was not covered by either the Portuguese or the Spanish survey. It is therefore not possible to determine the magnitude of the anchovy population in these areas.

April 2005 Portuguese survey (*SAR0505*)

Anchovy biomass for the whole surveyed area was estimated at 15,103 t (1,364 million fish), (see Table 3.3.2.2.4.1). These biomass and abundance estimates are the lowest ever recorded from Division IXa throughout the historical series. Although Gulf of Cadiz anchovy accounted for the 93% (14,041 t) of the estimated total biomass, the estimates from this area (and hence for the whole area) were affected by the occurrence of anchovy within plankton layers. In the remaining areas only small concentrations were detected in front of Lisbon (IXa Central-South), with the northernmost waters being devoid of anchovy.

3.3.2.2.4 Historical context of current surveys

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 3.3.2.2.4.1 and 3.3.2.2.4.2.

The estimates from those surveys covering the whole southernmost subdivision show that the bulk (≥90% of both the total abundance and biomass) of the anchovy population is concentrated in the Spanish waters of the Gulf of Cadiz throughout the time series. Nevertheless, in some years the anchovy population shows a more spread pattern across the survey area (in bold face in Tables 3.3.2.2.4.1 and 3.3.2.2.4.2). Differences in both the survey season and in the magnitude of the resulting estimates suggest that such increases in the area occupied by anchovy are driven by other factors than seasonal and/or density-dependence related ones (Ramos *et al*., WD 2005).

For comparative purposes, Figure 3.3.2.2.4.1 shows the available series of anchovy acoustic estimates from Subdivision IXa South obtained in Portuguese surveys together with the estimates from the 2004 late spring (June) Spanish survey (coloured estimates in the tables above). The depicted data series shows 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 ranged between 21 and 34 thousand tonnes; however, available estimates in the last two years have decreased down to 13-14 thousand tonnes, evidencing a possible decline in the population level. However, the picture of an alarming decreasing trend just in 2004-2005 should be initially considered with caution for several causes. Firstly, the estimates themselves in such years seem to be affected by problems related either to the sampling coverage of shallow waters (2004 Spanish survey, Ramos *et al*., 2004 and this WG) or to the echo-traces discrimination between fish and plankton (2005 Portuguese survey, Marques *et al.*, 2005 and this WG). Secondly, the survey season for the 2004 Spanish survey (June) entailed a 3 months delay relative to the usual March Portuguese survey series. Such a delay makes hardly comparable the June 2004 estimates with those ones from the March surveys because of an additional 3-months mortality affecting the population estimates and a probable different population structure. In this last case, recruits in the ‘March’ surveys constitute a relatively important proportion of the sampled population, which relative importance diminishes in late spring, when spawners configure the bulk of the population.

Table 3.3.2.2.1.1: Anchovy in Subdivision IXa South: estimated abundance (thousands of individuals) and biomass (tonnes) by age groups in the June 2004 Spanish acoustic survey.

AGE CLASS	ALGARVE	CÁDIZ	TOTAL
	Number	Number	Number
0	0	0	0
I	82348	798175	880523
II	8423	5423	13846
III	0	0	0
TOTAL	90771	803598	894369
Age class	ALGARVE	CÁDIZ	TOTAL
	Weight	Weight	Weight
0	0	0	0
I	1546	11224	12771
II	246	151	398
III	0	0	0
TOTAL	1793	11376	13168

Table 3.3.2.2.4.1: Anchovy estimated abundance (millions) and biomass (tonnes) in Division IXa from Portuguese acoustic surveys by area and total. Regional and total estimates for the Sub-division 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

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

**** Corrected estimates after detection of errors in the S_A values attributed to the Cadiz area (Marques and Morais, 2003).**

Table 3.3.2.2.4.2: 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**		

*** Estimates should not be considered because problems found with the performance of the echo-sounder transductor.**

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

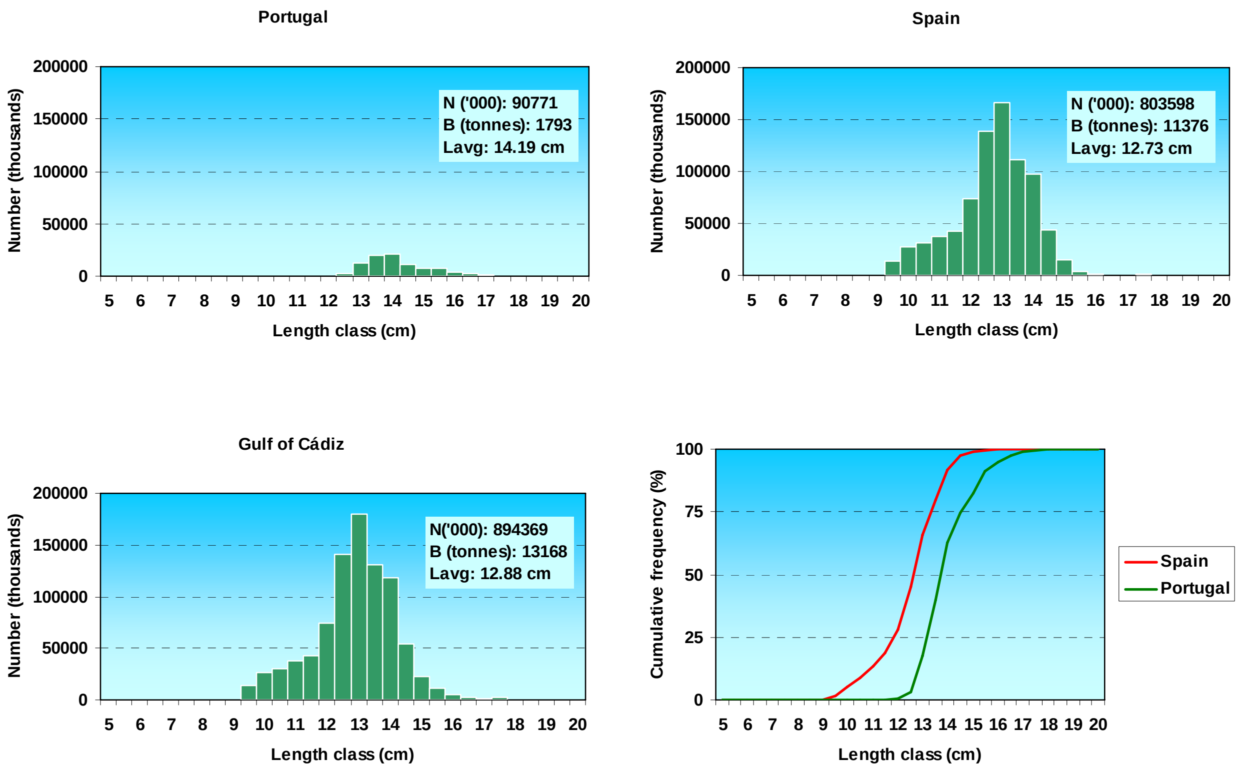


Figure 3.3.2.2.1.1: Anchovy in Subdivision IXa South: estimated abundance by length class by region and total area during the June 2004 Spanish acoustic survey. Bottom right: cumulative frequency (%) by length class and region.

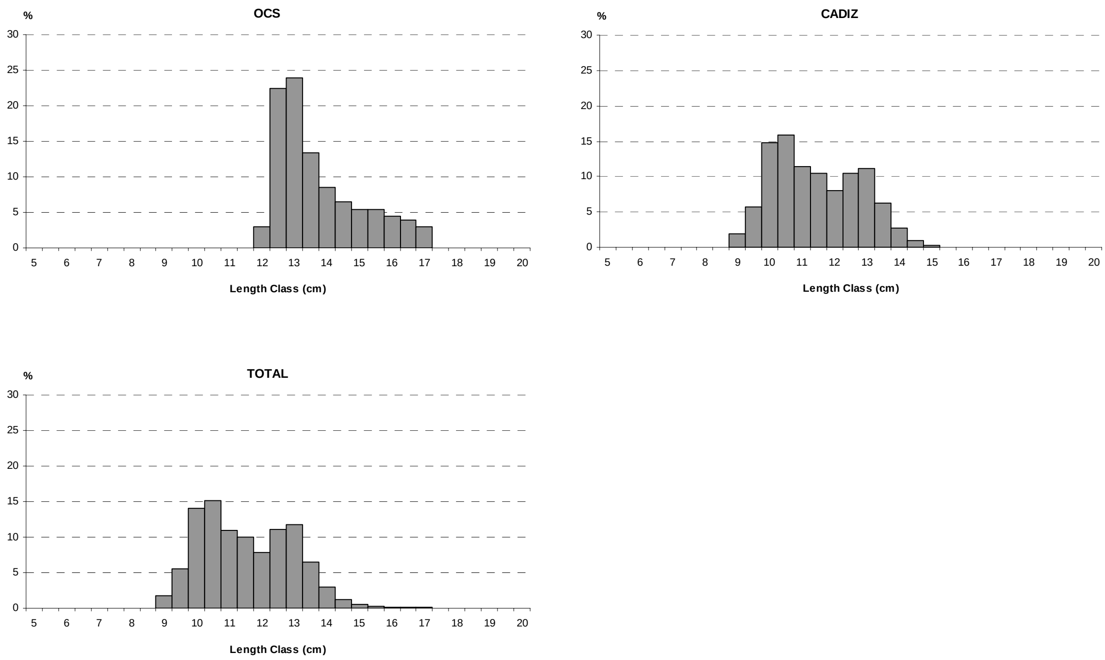


Figure 3.3.2.2.1.2: Anchovy in Division IXa: Distribution of length class frequency (%) by region and total area during the April 2005 acoustic Portuguese survey.

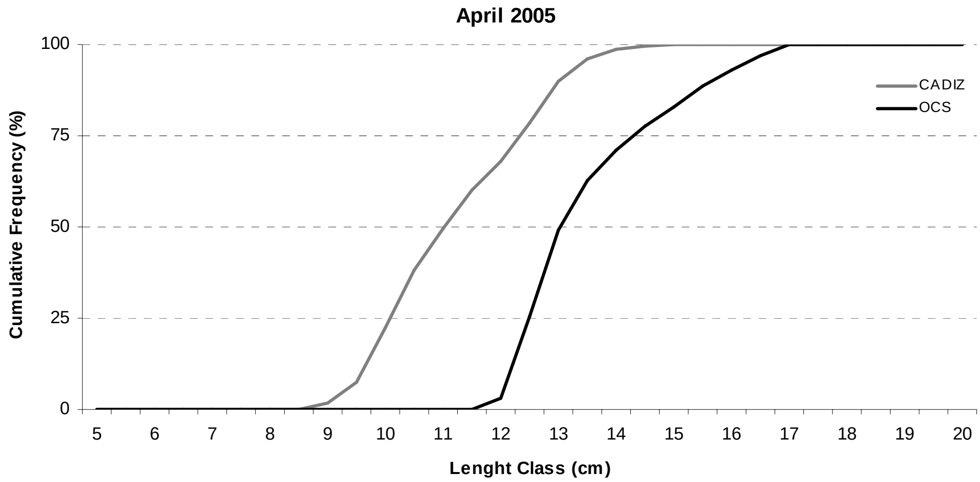


Figure 3.3.2.2.1.3: Anchovy in Division IXa: cumulative frequency (%) by length class and region during the April 2005 acoustic Portuguese survey.

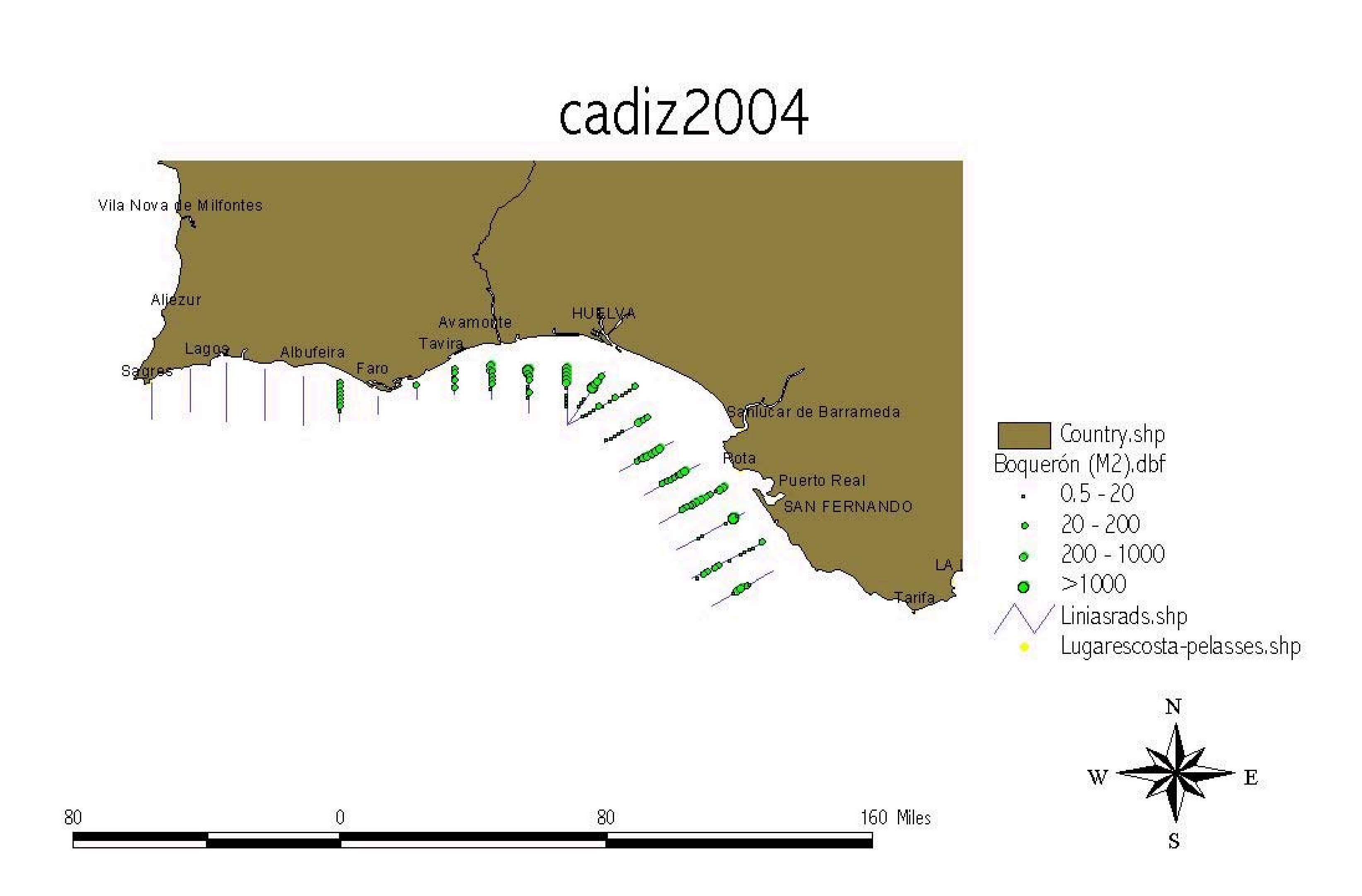


Figure 3.3.2.2.2.1: Anchovy in Subdivision IXa South: acoustic energy distribution per nautical mile during the June 2004 Spanish survey.

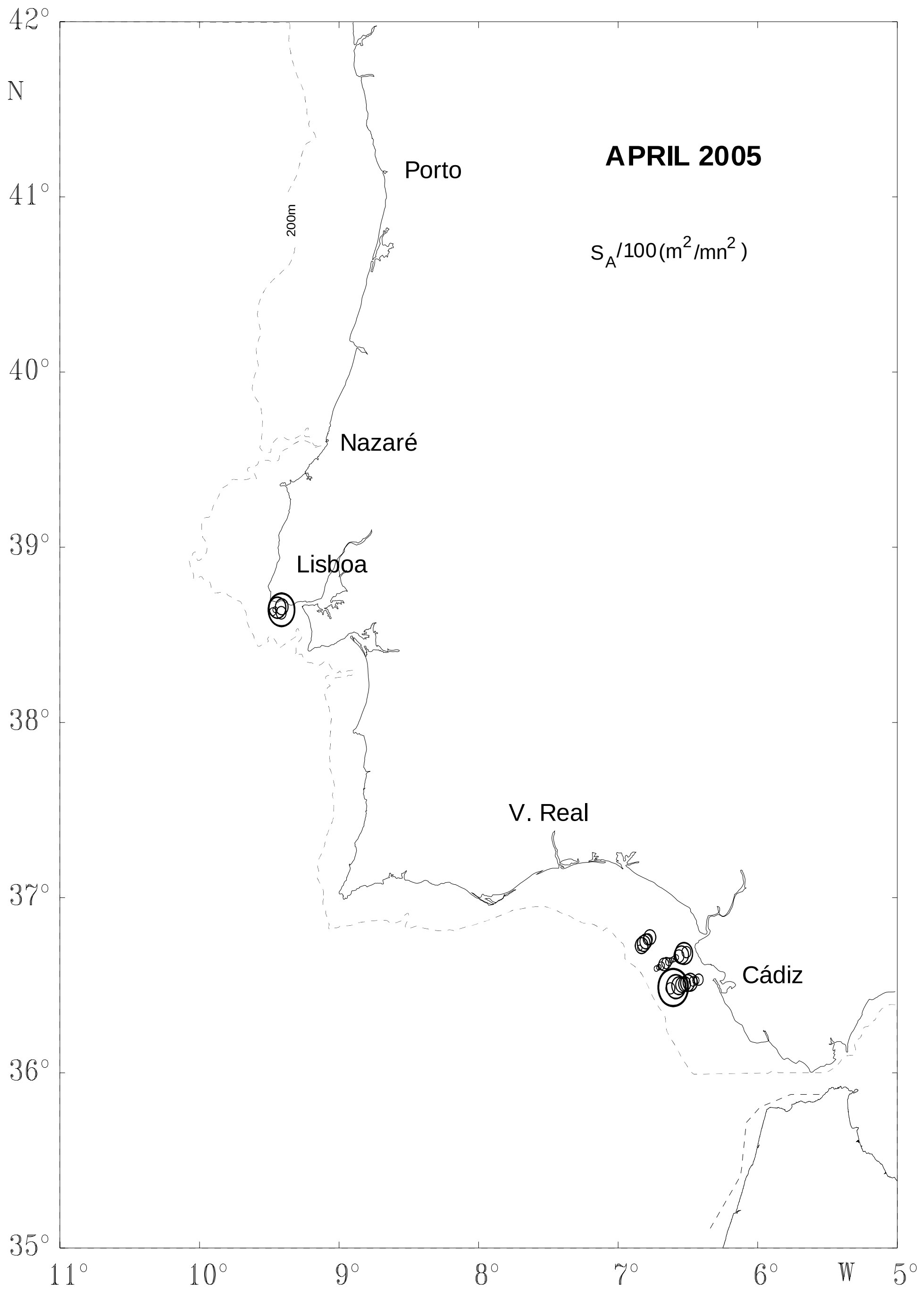
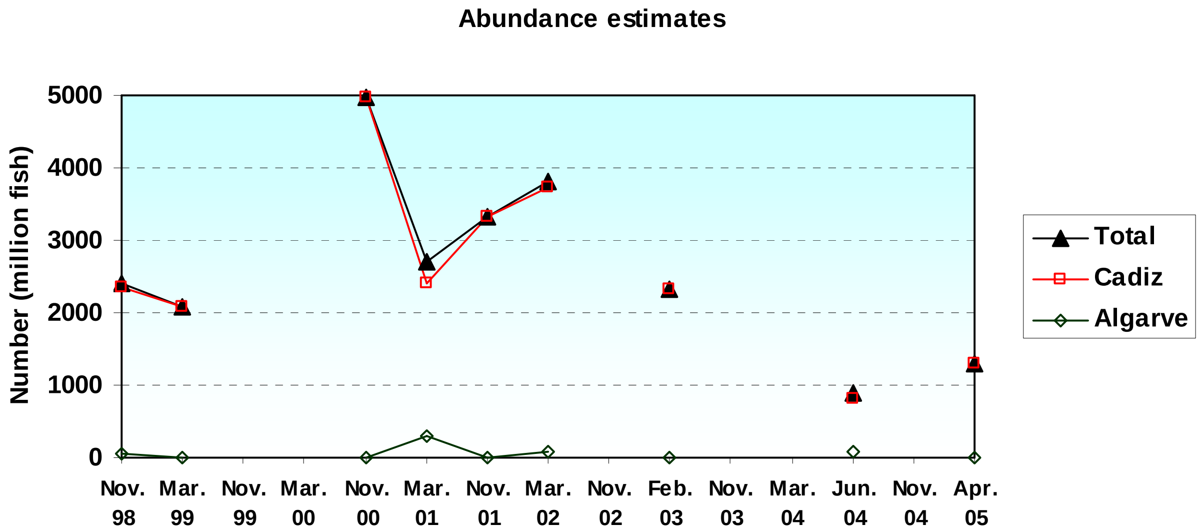


Figure 3.3.2.2.2.2: Anchovy in Division IXa: acoustic energy distribution per nautical mile during the April 2005 Portuguese survey. Circle diameter is proportional to the square root of the acoustic energy (S_A).



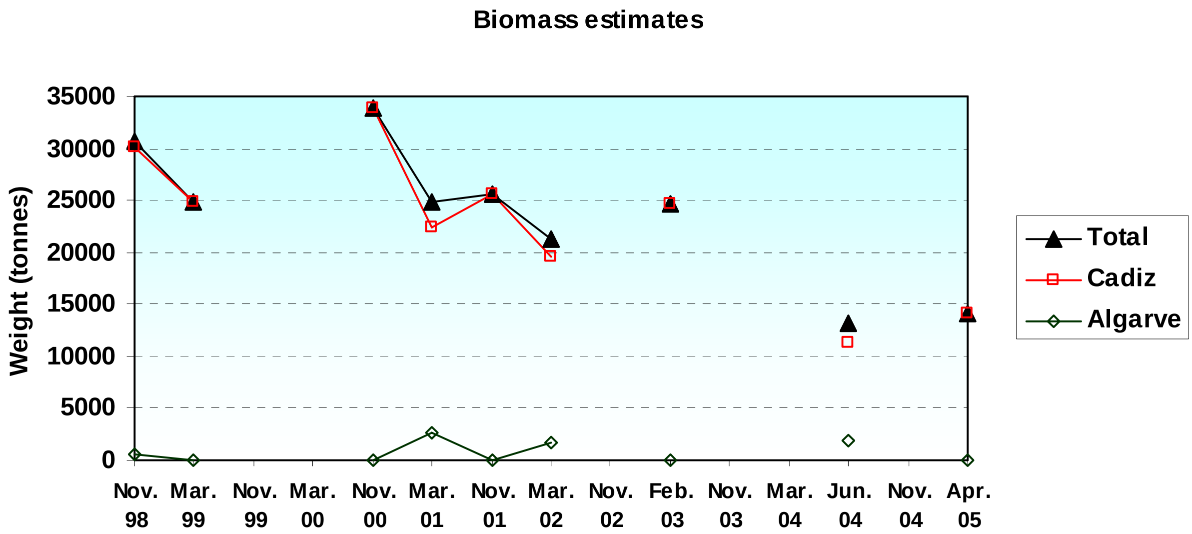


Figure 3.3.2.2.4.1: Anchovy in Subdivision IXa South: Historical series of acoustic estimates from Portuguese surveys (SAR series. Data for June 2004 correspond to the Spanish acoustic survey (BOCADEVA 0604).

3.4 Sardine surveys in areas VIII and IX

3.4.1 Distribution and abundance of spawning population from egg production surveys

3.4.1.1 Distribution of eggs in areas VIII and IX from PAIROVET samples

Distribution of sardine eggs in the 2005 surveys across the Iberian Peninsula and the southern Bay of Biscay can be observed in Figure 3.4.1.1.1. Sardine eggs are spread throughout all the sampled area, although an area devoid of eggs can be observed in the north-west coast of the Iberian Peninsula, and an area of low densities can be observed in the Spanish – French border. Main spawning areas in 2005 are located in front of the Gironde mouth, off the Cantabric coast, in South West Portugal and in the Gulf of Cádiz.

3.4.1.2 Estimates of egg production by area

3.4.1.2.1 Estimates of egg production in North Spanish waters

The 2005 DEPM ichthyoplankton survey off the northern coast of Spain was carried out on board the RV "Cornide de Saavedra" from 13 April – 3 May. A total of 375 and 379 samples were taken with a PAIROVET net (double CalVET) and a CUFES sampler, respectively. A total of 94 CUFES stations and 123 CalVET stations were positive for sardine eggs. From the total of 56 transects, only 7 (located in the western sector) did not register positive CalVET stations. Most sardine eggs were collected along the Cantabrian Sea. Nevertheless, as in previous surveys, a few eggs were found off the western coast of Galicia. A total of 3230 sardine eggs were sorted out from the CalVET samples, with an average of 26 egg/station in the positive area. The largest numbers of eggs (maximum of 195) was collected in one of the innermost stations. Sardine eggs were hardly ever found at stations over 200 m depth.

A CTD (Sea Bird 25) profile was carried out in each PAIROVET station and a continuous record of temperature, salinity and fluorescence (at 3 m depth) was obtained using a sensor Sea Bird 21. Sea surface temperature and salinity in the area ranged from 12.4 to 16ºC and from 33.9 to 35.8 PSU respectively during the survey (Figures 3.4.1.2.1-1 and 3.4.1.2.1-2). Warmer waters and lower salinities were found in the innermost sector of the Bay of Biscay due to the influence of the Gironde River. On the contrary, warmer waters but with higher salinities were found off the western coast due to the influence of the Eastern North Atlantic Central Water (sub-tropical origin). Quotient analysis shows that the preferred ranges of temperature and salinity for sardine spawning during the survey were 13 to 15ºC and 34.4 to 35.2 PSU.

Very recent versions of the R packages *geofun*, *eggsplore* and *shachar*, produced within SGSBSA and updated in a Sourceforge free software project (http://sourceforge.net/projects/ichthyoanalysis) were used to carry out a preliminary analysis of the data. A total sampling surface area of 41019 km^2 and a total spawning (positive) area surface of 17917 km^2 have been estimated. The estimate of daily egg production was obtained using an iterative estimation of mortality (negative binomial distribution for the mortality curve fitting) and multinomial egg ages (Bayesian ageing method). The Bayesian ageing method requires a probability function of spawning time. Normal distribution has been assumed with peak of spawning activity at 19:00 GMT and 2 h standard deviation. A mortality of -0.0094 h^{-1} and a daily egg production of 162.9 egg/m^2 have been estimated in this way. The total egg production in the area has been preliminarily estimated as 2.92 10^{12} egg/day (CV = 26%). Nevertheless, egg production could have been overestimated since some problems have been detected in the R packages used (β versions). A revision of the estimates will be carried out.

3.4.1.2.2 Estimates of egg production in Portuguese and South Spanish waters

The 2005 sardine DEPM survey off Portugal and the Gulf of Cadiz took place between the 26 January and 25 February 2005 onboard the RV "Capricornio". The survey was executed according to the plan decided during the last SGSBSA meeting (ICES, 2005). Ichthyoplankton sampling with PAIROVET was performed in 408 stations distributed along 57 parallel transects, covering the entire area planned for the survey (45.1 km^2). CUFES (525 stations) was used as an auxiliary sampler to adjust density of PAIROVET stations within transects and to determine the outer limit of transects. Ichthyoplankton and environmental sampling (hydrology) in fixed stations was coupled by the use of a combined PAIROVET-CTD structure. The performance of the new sampler for sardine eggs was compared with the traditional PAIROVET during the survey and did not demonstrate significant changes in the sampling performance.

Overall, 3657 sardine eggs were found in 148 out of the 525 stations (36% of the total), distributed mainly in the inner shelf (<100m) over the entire survey area south of the Canyon of Nazaré. Very few eggs were found in the northern Portuguese coast. Sea surface temperature during the survey was lower than in previous years (range 11.6 – 15.5; mean 14^o C). Salinity and fluorescence values were similar to previous years, although the freshwater signal around river mouths was considerably reduced in comparison to previous years due to the reduced rainfall in the winter of 2004. Figure 3.4.1.2.2.1 shows the distribution of hydrological variables and sardine egg abundance obtained by CUFES during the survey.

Staged sardine eggs were aged according to the Bayesian ageing method and the multinomial incubation model, assuming a daily spawning probability function with a mean at 20:00 hours and a standard deviation of 1.5 hours. Preliminary egg production estimation was performed with a GLM assuming a negative binomial distribution. The logarithm of the sampler effective area (estimated from the cosine of the angle departure from verticality) was used as an offset while the survey area attributed to each station was used as a weight (divided by the mean survey area per station). The fitted model provided a significant estimate of egg mortality (0.016 per hour) and an estimated daily egg production of $4.1 * 10^{12}$ (CV=24%). This estimate of egg production is approximately double that of the one estimated in the last survey (January 2002) and similar to the 1997 estimate.

3.4.1.3 Distribution of adult parameters in areas VIII and IX

In the 2005 sardine DEPM survey in the Iberian Peninsula, sampling effort for adults was similar to the one in 2002 (around 100 fishing stations) but higher than previous years. About 60 of the fishing stations were performed onboard the RV "Thalassa" (pelagic trawl) and RV "Capricornio" (demersal trawl), while the remaining samples were obtained from purse seiners (chartered to accompany the R/V or during commercial operation). This intensification of adult sampling was deemed necessary to explore spatial patterns in demography and daily fecundity and to allow the application of GAM-based estimation of spawning biomass.

Figure 3.4.1.3.1 shows the distribution of sardine female weight (after the removal of immature and hydrated fish) during the 2005 DEPM survey. All samples from Northern Spain are mapped (R/V and purse seiner) while in the Portuguese coast only the R/V samples are shown. Samples span the entire Iberian Peninsula (for the area north of Lisbon commercial purse seine samples exist but they are not depicted) and, for the first time in recent years, western Galicia was also adequately sampled (likely due to an increase in local abundance). Figure 3.4.1.3.2 shows the predicted mean female weight based on a GAM with a normal distribution, using a Lat/Long bivariate smooth (87% of deviance explained). The weight distribution is very similar to the one observed in previous DEPM surveys (ICES 2004), revealing considerable spatial structure in demography. Mean weight in the Cantabrian Sea is approximately double the value than in the rest of the Iberian Peninsula (indicating presence of bigger/older fish), while minimum weights are found off Northern Portugal and the Gulf of Cadiz (recruitment areas, with a strong 2004 year class off Northern Portugal already verified).

Although analysis of adult samples for the 2005 survey is still underway, the number of fishing stations available indicates that similar models could be applied to the other adult parameters and permit a GAM-based estimation of daily fecundity and spawning biomass.

3.4.1.4 Estimates of adult parameters by area

3.4.1.4.1 Estimates of adult parameters in North Spanish waters

Spain (IEO) carried out 37 hauls (trawl and purse seine) to estimate DEPM adult's parameters in ICES Sudivisions IXa North and VIIIc. The hauls were made on board the RV "Thalassa" (PELACUS 0405) and additional samples were obtained in collaboration with a purse seiner (Figure 3.4.1.4.1.1).

Random adult samples and complementary hydrated samples were collected. A total of 809 ovaries were fixed for histological processing (identification of maturity stages), estimation of batch fecundity and spawning fraction. The samples are being processed at the moment. (Tables 3.4.1.4.1.1 to 3.4.1.4.1.1.3).

3.4.1.4.2 Estimates of adult parameters in Portuguese and South Spanish waters

Adult sampling during the 2005 sardine DEPM survey off Portugal and the Gulf of Cadiz relied on fishing stations performed by the RV "Capricornio" during the ichthyoplankton survey and additional samples provided by commercial purse seiners operating off the main Portuguese ports (Matosinhos, Peniche, Setubal, Sines, Portimão and Olhão). In total, 34 fishing stations were performed by the RV (all demersal trawls) and 32 purse seine samples were also obtained, providing a total number of sardine samples comparable to those obtained in 2002. So far, biological sampling has been performed for all samples (including macroscopic stomach fullness and colour determination and the collection of otolith samples for the preparation of ALKs) and histological preparation of the RV samples has been completed. Of the 100 hydrated females collected for batch fecundity estimation, 50 samples have been so far analysed for detection of POFs and count of hydrated oocytes.

For the purposes of this meeting, preliminary estimates of all adult parameters were provided based on the samples of the RV. Figure 3.4.1.4.2.1 shows the relationship between batch fecundity and gonad-free female weight based on the fish samples analysed so far. Batch and relative fecundity in 2005 are higher than in 2002, a year that showed the lowest fecundity values in the series (ICES, 2004). The preliminary batch fecundity estimate (F=17100 eggs) is close to the values observed in earlier years. Approximate spawning fraction estimation (S=9%) was based on histological examination of samples from 20 hauls by the RV, showing once more values higher than in 2002 and closer to earlier surveys. It should be noted however that considerable levels of spatial variation are detected in spawning fraction, with very few mature females demonstrating evidence of recent spawning off northern Portugal. Mean female weight and sex ratio were slightly lower than in previous surveys (W=41.6 g and R=0.46). Overall, these preliminary results lead to an average daily fecundity estimate of 17 (a value considerably higher than in 2002 but still lower than 1999) and a spawning biomass estimate of 242 thousand tonnes. Although this biomass estimate is close to the SSB estimated in the acoustic survey during the spring of 2005 (around 275 thousand tonnes), this DEPM estimate was only provided as a rough early indication. A final estimate for 2005 based on all adult samples will be provided together with the revised Portuguese series of 1997-2002 (due to the revision of all histological preparations for S estimation) for the benchmark sardine assessment in September 2006.

Table 3.4.1.4.1.1: *Pelacus 0405* adult parameters, hauls, distribution by time and deep.

SHIP	GMT	HAUL	LAT	LONG	DEEP M.
Thalassa	6:39	2	41.57	-9.18	102
Thalassa	9:03	3	41.58	-8.94	60
Thalassa	6:50	6	41.98	-9.24	142
Thalassa	16:02	7	42.26	-8.95	73
Purseine	8:30	8	42.36	-8.88	15
Purseine	3:44	9	42.39	-8.80	10
Thalassa	8:02	10	42.34	-8.91	45
Thalassa	17:11	12	42.45	-8.99	59
Cerquero		13	42.36	-8.85	40
Thalassa	13:33	14	42.72	-9.06	56
Cerquero	4:32	15	42.75	-9.12	32
Purseine	5:49	16	42.74	-9.12	36
Purseine	2:17	22	43.34	-8.60	28
Thalassa	6:36	23	43.42	-8.55	92
Thalassa	9:55	34	43.62	-7.07	83
Thalassa	16:03	38	43.61	-6.33	60
Purseine	20:45	40	43.58	-6.07	25
Thalassa	10:59	43	43.67	-5.77	56
Thalassa	18:11	45	43.63	-5.70	45
Purseine	0:05	48	43.60	-5.69	30
Purseine	5:10	49	43.62	-5.48	90
Thalassa	15:50	51	43.60	-5.05	189
Purseine	22:25	53	43.48	-5.08	47
Thalassa	13:37	55	43.44	-4.67	70
Thalassa	15:44	56	43.42	-4.51	55
Thalassa	11:26	59	43.54	-3.94	118
Thalassa	15:44	60	43.52	-3.81	50
Thalassa	17:43	61	43.54	-3.88	74
Thalassa	10:11	63	43.52	-3.38	87
Thalassa	7:08	67	43.58	-2.85	189
Thalassa	12:21	68	43.42	-2.48	82
Thalassa	16:41	69	43.37	-2.24	87
Thalassa	7:27	70	43.41	-2.11	130
Thalassa	10:53	71	43.36	-1.95	56
Thalassa	14:33	72	43.53	-1.75	153
Thalassa	6:15	74	44.08	-1.46	41
Thalassa	16:20	76	43.91	-1.44	41

Table 3.4.1.4.1.2: *Pelacus 0405* biological samples and sex.

Sex	
Male	Female
891	809
TOTAL	1700

Table 3.4.1.4.1.3: *Pelacus 0405* complementary hydrated sardine females to batch fecundity estimation.

HAUL	HIDRAT
3	2
12	10
43	20
45	9
59	3
61	65
63	20
68	20
69	30
70	9
Total general	188

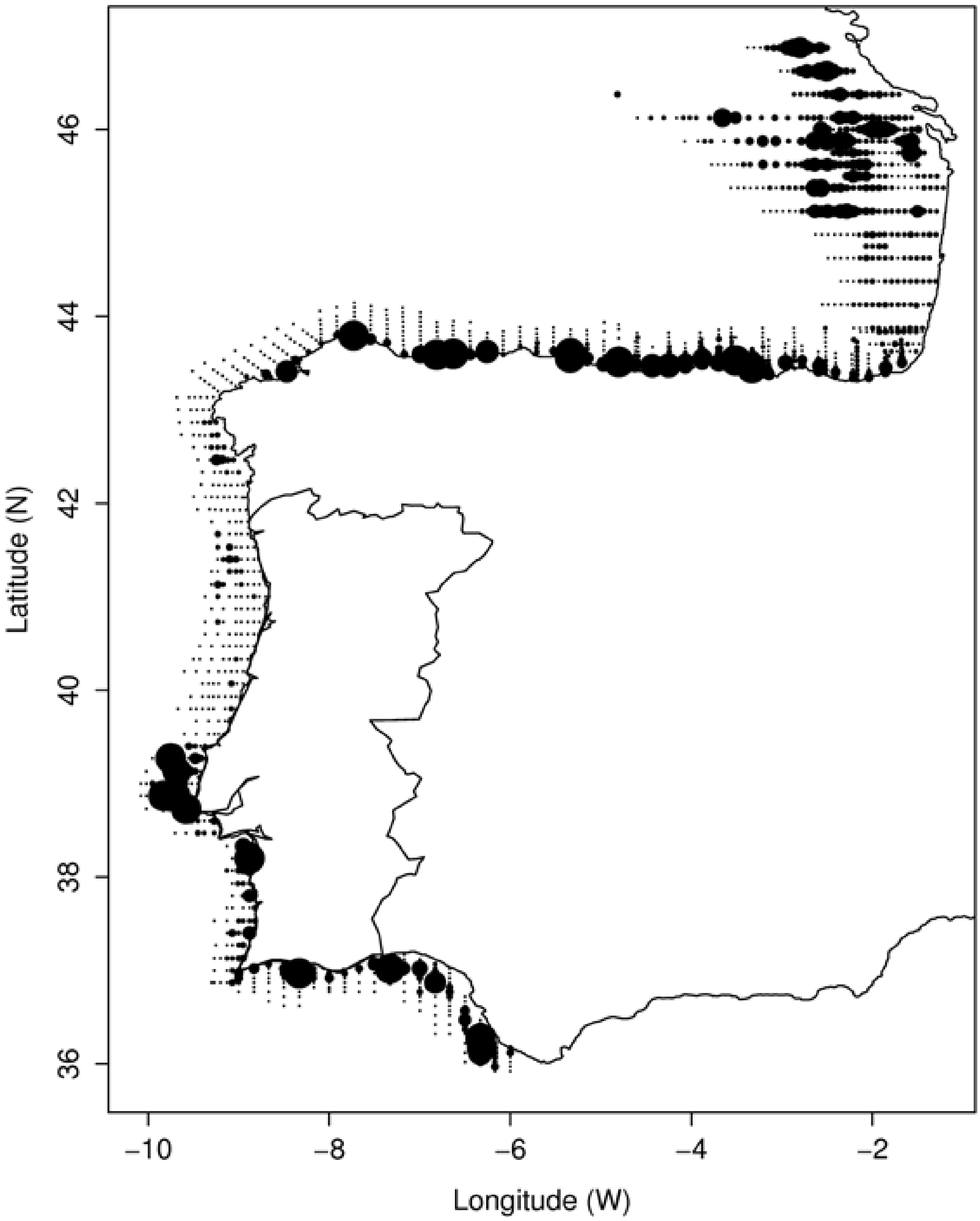


Figure 3.4.1.1.1: Distribution of sardine eggs from the CalVET samples of the combined 2005 ichthyoplantkon surveys. Small dots represent stations without eggs; bubbles represent stations with eggs, bubble size proportional to sardine egg density.

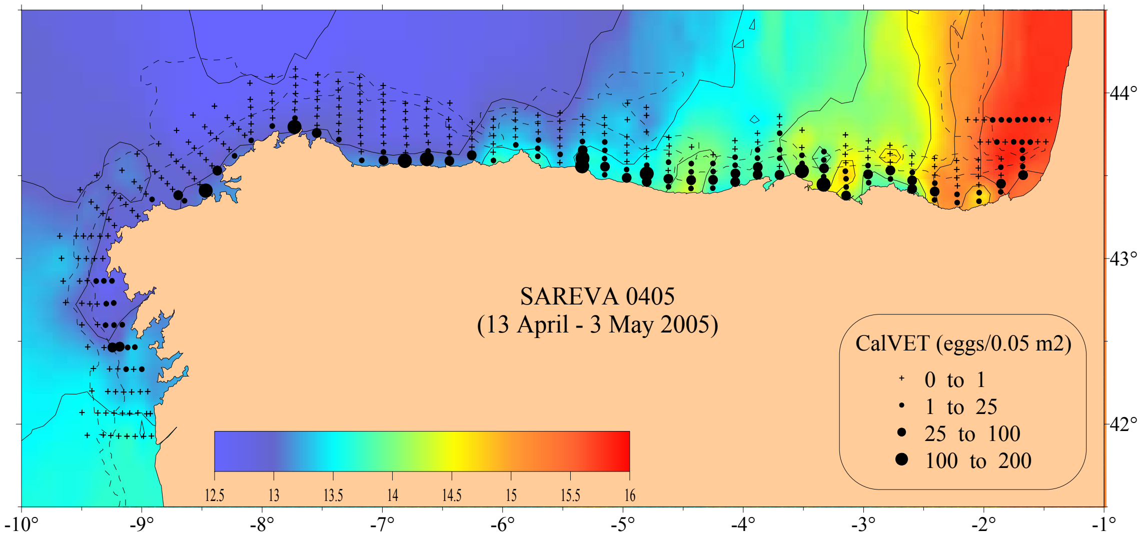


Figure 3.4.1.2.1-1: Temperature at 5 m depth (ºC, CTD data). Size of circles is proportional to egg abundance in CalVET stations.

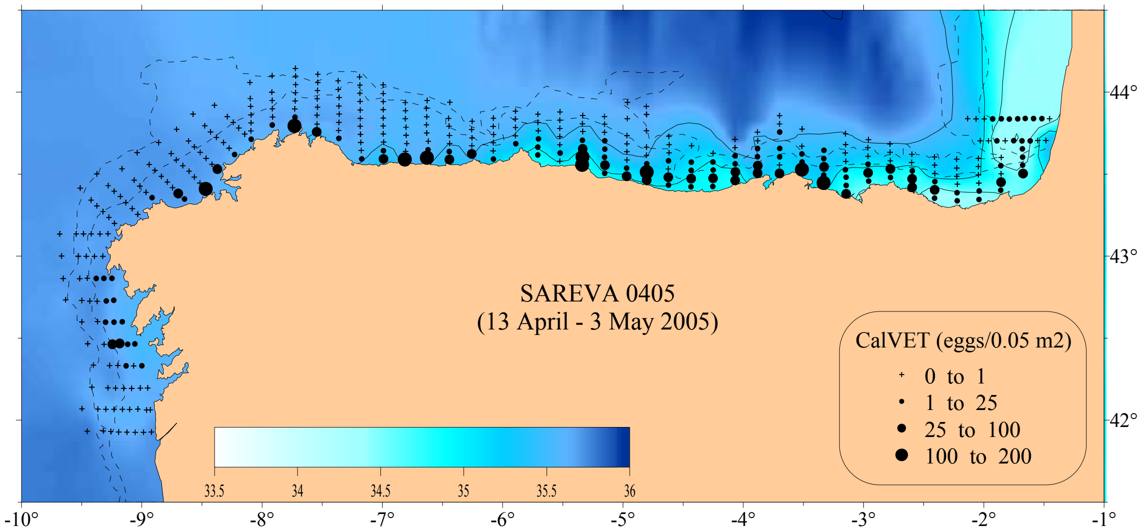


Figure 3.4.1.2.1-2: Salinity at 5 m depth (PSU, CTD data). Size of circles is proportional to egg abundance in CalVET stations.

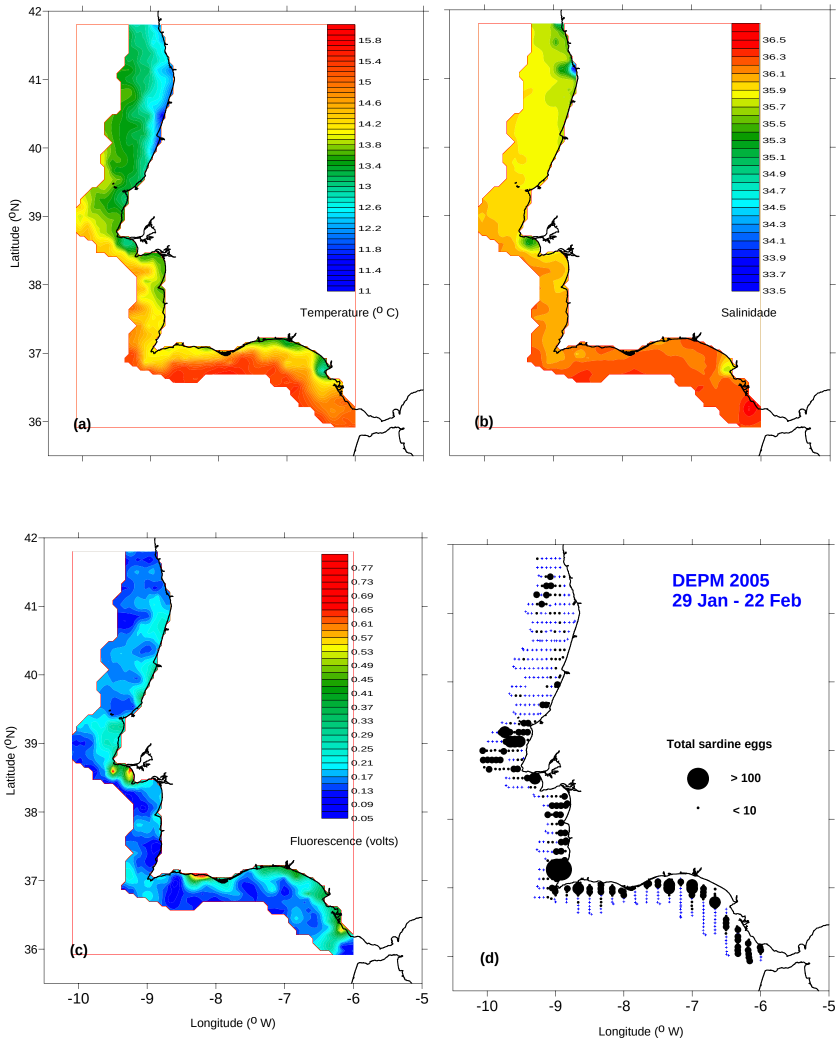


Figure 3.4.1.2.2.1: Distribution of surface temperature (top left), salinity (top right), fluorescence (bottom left) and sardine egg abundance from the CUFES samples collected during the 2005 DEPM survey off Portugal and the Gulf of Cadiz (n=525).

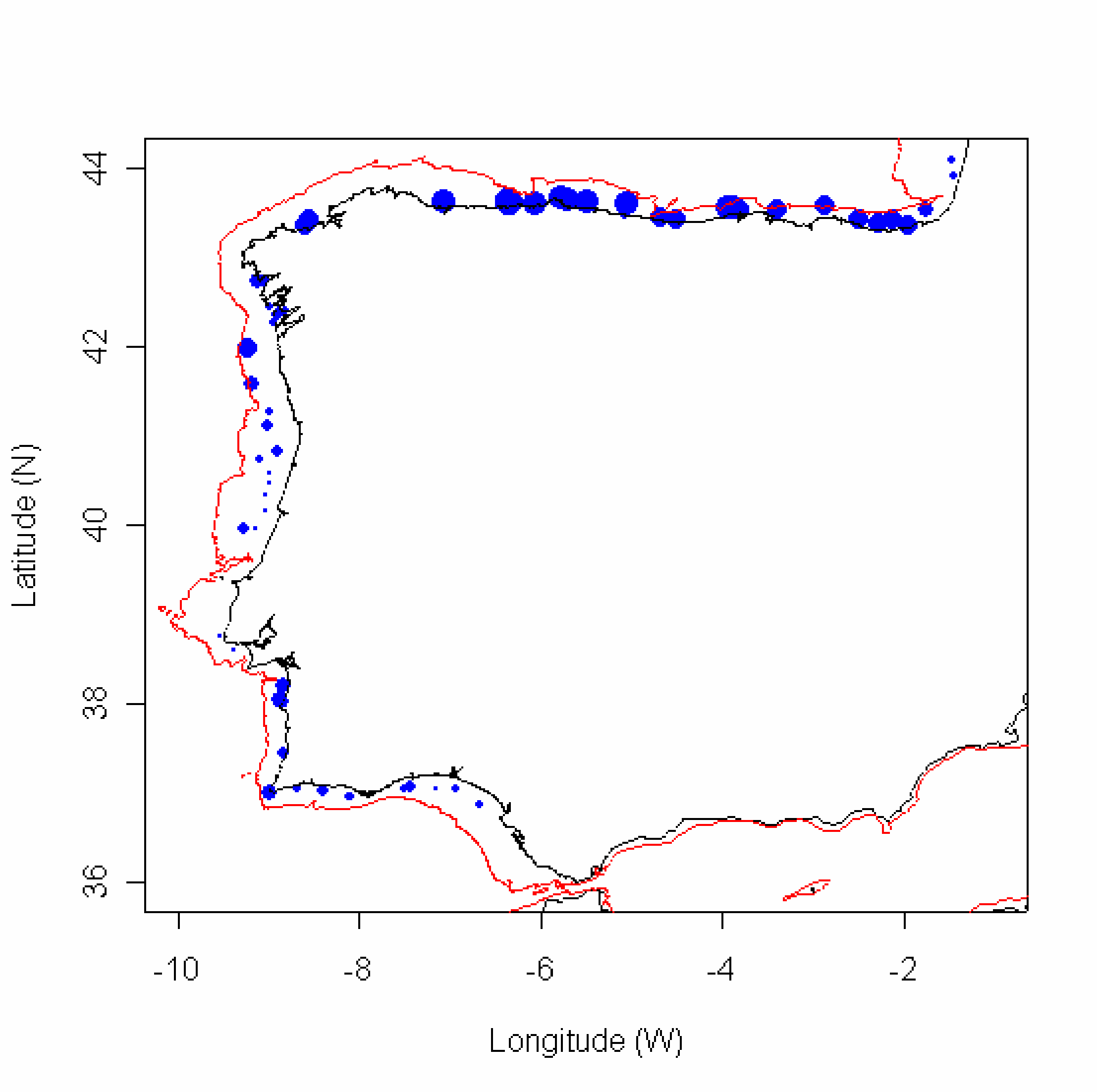


Figure 3.4.1.3.1: Distribution of sardine female weight off the Iberian Peninsula during the 2005 DEPM survey (preliminary estimates based on 55 observations). Weight proportional to circle diameter (smallest = 10 g; largest = 100 g). Solid red line indicates the 200 m isobath.

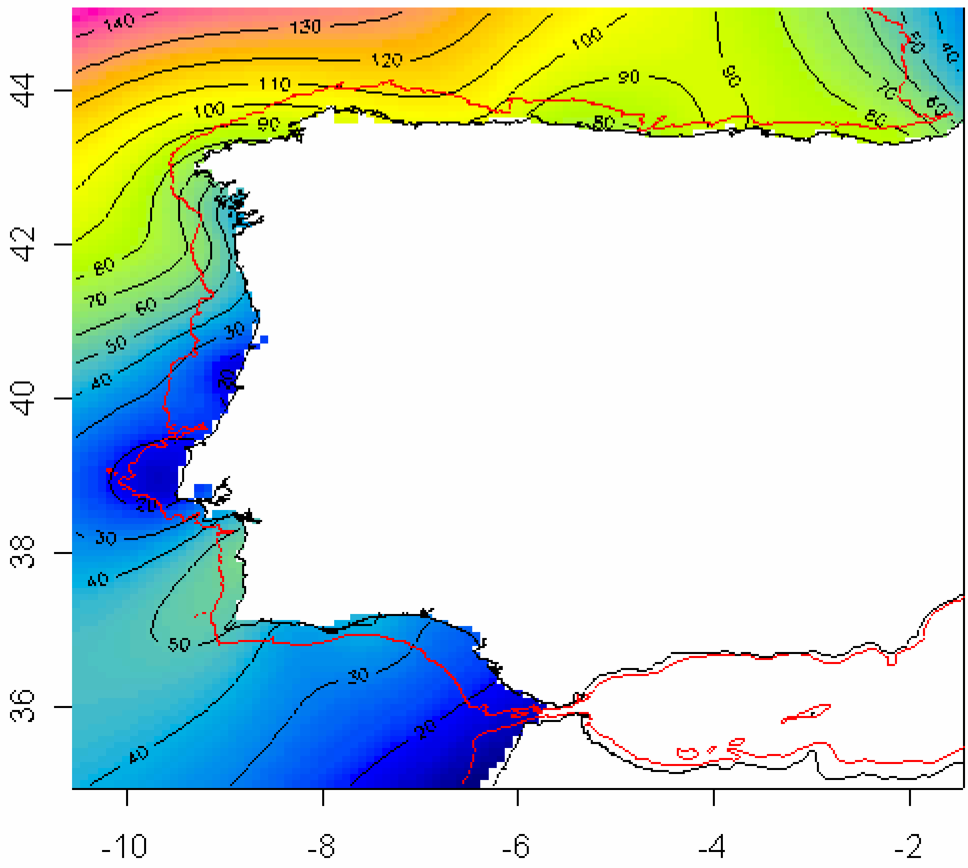


Figure 3.4.1.3.2: Predicted surface of sardine female weight off the Iberian Peninsula during the 2005 DEPM survey (preliminary estimate based on 55 observations). Solid red line indicates the 200 m isobath.

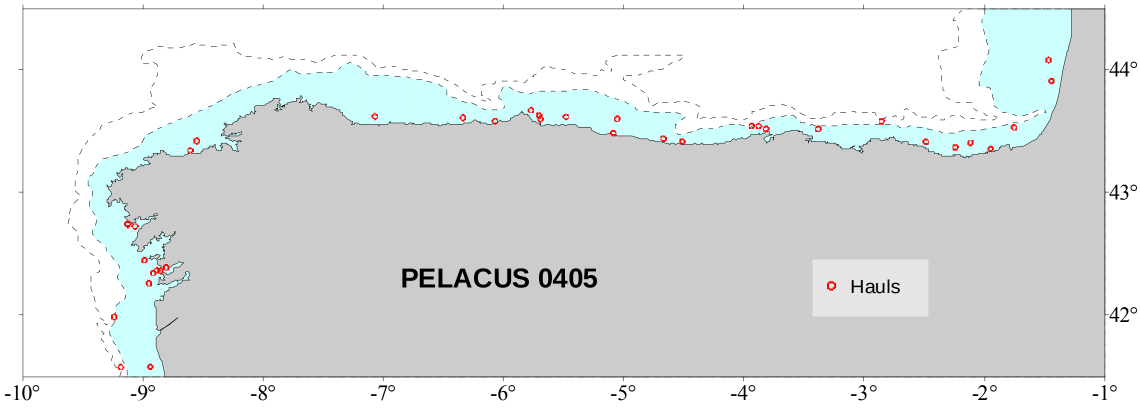


Figure 3.4.1.4.1.1: DEPM Sardine Adults samplings Hauls in Pelacus 0405 (Subdivisions IXa North and VIIIc).

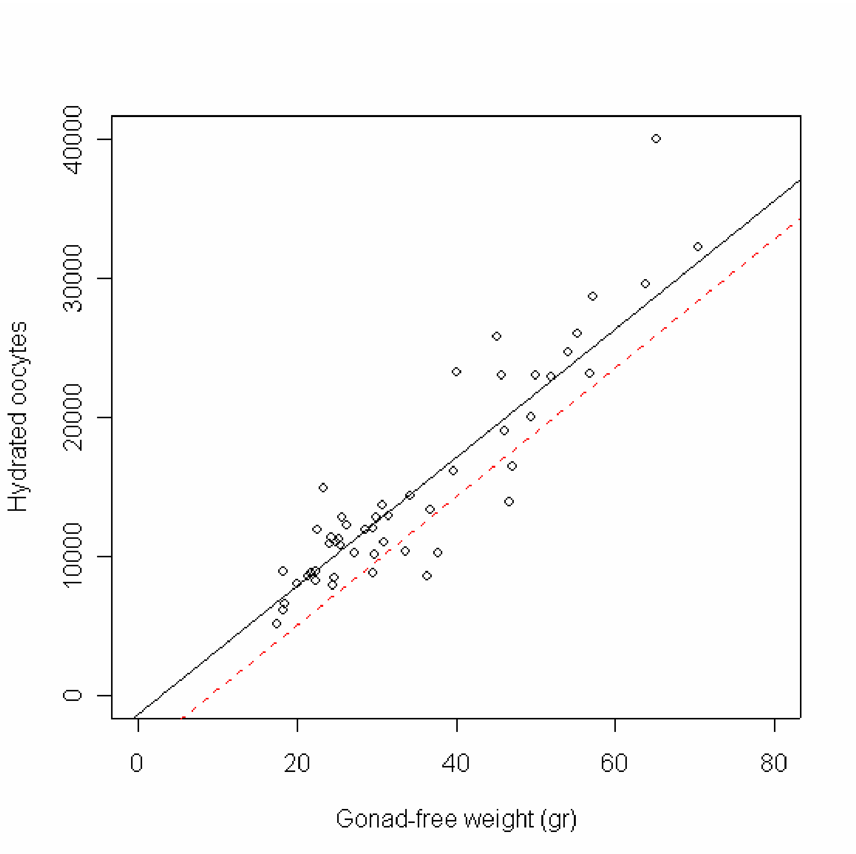


Figure 3.4.1.4.2.1: Relationship between sardine batch fecundity and gonad-free fish weight from the 2005 (black solid line) and the 2002 (red broken line) DEPM survey off Portugal and the Gulf of Cadiz (n=50, fitted lines based on GLM with a Gamma distribution and an identity link).

3.4.2 Distribution and abundance of population from acoustic surveys

3.4.2.1 General view of spatial distribution of energy allocated to sardine

Figure 3.4.2.1-1 shows the combined distribution of energy allocated to sardine throughout all the acoustic surveys in 2005. Acoustic energy was not standardised across surveys, and thus the sizes of the bubbles may not be comparable between surveys. In comparison with the egg distribution (Figure 3.4.1.1-1) adult sardines are not present in the inner part of the Bay of Biscay, off the North Spanish coast, and only in low abundances in the Gulf of Cádiz, while the North-West Iberian corner present large abundance of sardines.

3.4.2.2 Estimates of fish abundance and biomass by area

3.4.2.2.1 Estimates of fish abundance and biomass in French waters

Estimates of sardine abundance were obtained for the PELGAS05 survey. PELGAS methodology, distribution of hauls and post-stratification were described in Section 3.3.1.2.1.

During PELGAS05, sardine was present all over the Bay of Biscay (Figure 3.4.2.2.1.1). It appeared usually as small dense schools in mid-water, mostly between the coast and 100m depth, often mixed with sprat (*Sprattus sprattus*), except in front of the Loire river plume. In more offshore areas and mainly in the centre of the Bay of Biscay, sardine was sometimes observed as small echoes, mixed with mackerel and horse mackerel in a layer between the bottom and 50m above, but mainly as small echotraces between the surface and 30m below, mixed with mackerel. In the northern offshore area, sardine was mainly observed at the surface and always mixed in the catches with mackerel. It should be noted that for this last area, a reduced number of fishing stations was sampled at the surface and therefore the corresponding estimated biomass must be taken with caution.

The sardine biomass in the Bay of Biscay in May 2005, as estimated by the survey, was of 429521 tonnes. Biomass estimates for the whole surveyed area and by Subareas VIII a and VIII b are listed in the table below:

VIIIB (ADOUR, GIRONDE, OFFSHORE)	VIIIA (NORTH OFFSHORE, NORTH COAST)	TOTAL
283930 t	145591 t	429521 t

Abundance (in numbers) estimates have not been available for this WG and therefore they are not presented.

Length distributions and age distributions have been calculated for areas VIIIa and VIIIb in 2005 and are shown in Figures 3.4.2.2.1.2 and 3.4.2.2.1.3.

3.4.2.2.2 Estimates of fish abundance and biomass in North Spanish waters

The Spanish acoustic survey (PELACUS 0405) took place from 1 April – 1 May 2005 on-board the RV “Thalassa”, covering Spanish waters in 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 cruise, in addition to standard acoustic transects, sampling is also carried out for the characterisation of the egg, plankton and primary production distribution.

The survey covered a total of 61 acoustic tracks, 54of which took place in Spanish waters. As in previous years, fishing stations were sampled by both the RV “Thalassa” (pelagic trawl) and by a chartered purse seiner.

A total of 72 fishing stations were sampled during the cruise, 66 in Spain (49 by the RV “Thalassa” and 17 by the purse seiner). Higher sardine density in Spanish waters was detected in IXa North, followed by VIIIc West while low sardine presence was found in ICES Subdivion VIIIc east.

The abundance estimated in 2005 in the North Spanish area is 1,471 million fish, which represents a decrease of 30% with respect to the 2004 value (2,097 million fish). Regarding biomass, the 2005 survey estimated a total of 68 thousand tonnes (a decrease of 55% with respect to the 2004 figure of 149 thousand tonnes).

For the total surveyed area, age 1 fish represents 56% of the total abundance in number and 26% of the total biomass. The second most abundant age group is age 5, which corresponds to the 2000 strong year class (12% of the total abundance in number and 23% of the total biomass). Age 4 is also important, accounting for 11% of the total abundance. These three age groups comprise the 80% of the abundance in number of the total survey and the 68% of the total biomass.

The 62% of the total abundance in numbers correspond to area IXa North, mainly due to the huge importance of the age 1 group in this area (90% in abundance and 80% in biomass). Age 5 is the most abundant age group in area VIIIc West, representing 41% of the abundance in number in that area.

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

The Portuguese acoustic survey was carried out during April 2005 with the RV "Noruega". The objectives of the survey were to estimate the spatial distribution and the abundance of sardine (*Sardina pilchardus*) and anchovy (*Engraulis encrasicolus*) by length classes and by age group, in the surveyed area. All the 69 planned acoustic tracks were performed. In order to identify species and collect biological samples, 41 trawl stations were made.

The total estimated sardine biomass was 587 thousand tonnes corresponding to 25229 million fish (Table 3.2.2.3.1). Off the Portuguese coast the abundance (547 thousand tonnes; 16900 million) was one of the largest ever found, only surpassed by the November 2000 survey, mainly due to the contribution of the OCN zone. On the contrary, in Cadiz area sardine was scarce, being estimated only 39.5 thousand tonnes (1229 million fish), the lowest biomass in this area since 1995.

Table 3.2.2.3-1: Estimated abundance (million) and biomass (thousand tonnes) for each area, for all Portugal and for the total area.

	OC. NORTH	OC. SOUTH	ALGARVE	CADIZ	PORTUGAL	TOTAL AREA
Sardine (number)	16900	5900	1200	1229	24000	25229
Sardine (biomass)	286	199	62	40	547	587

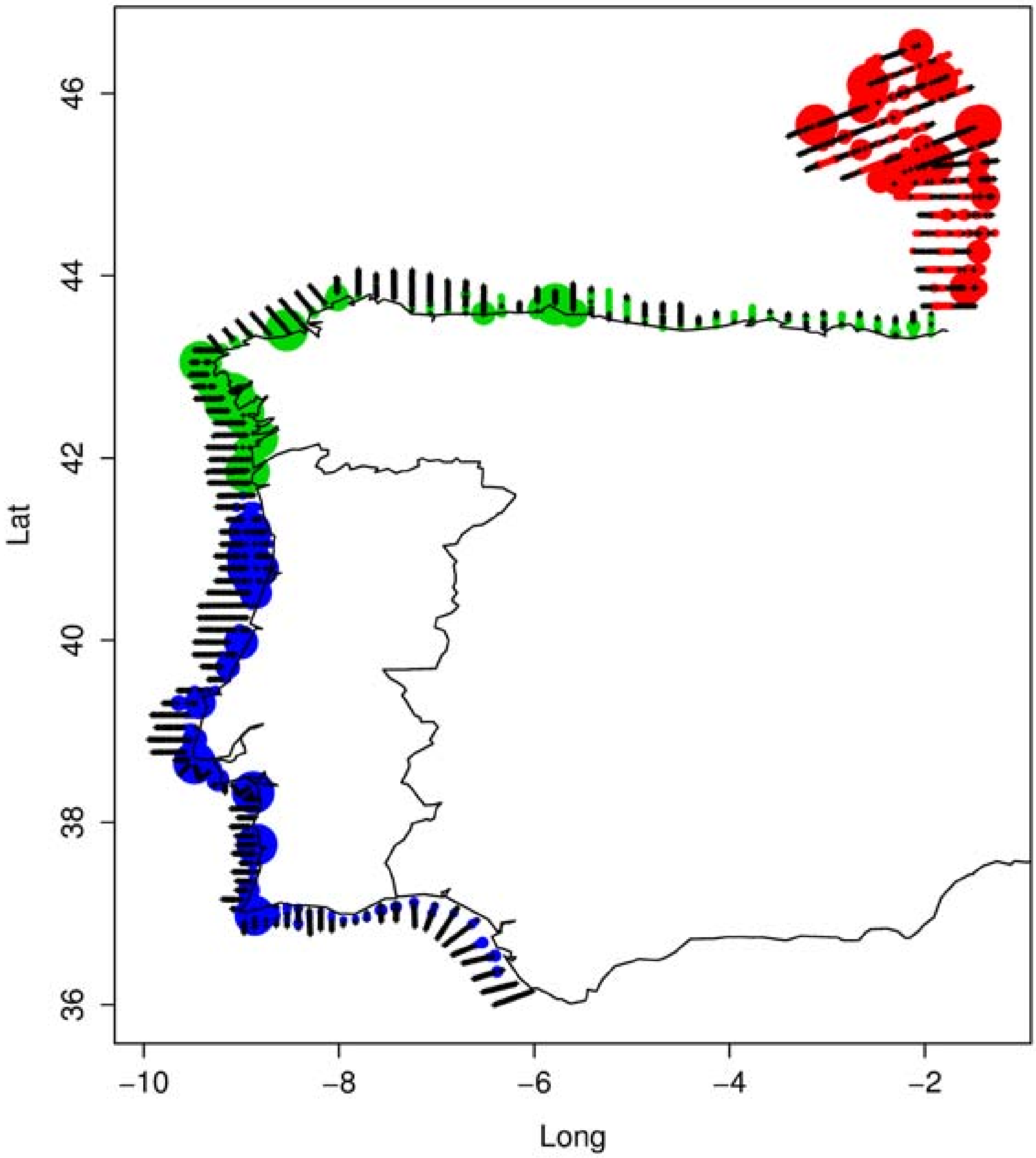


Figure 3.4.2.1-1: Distribution of acoustic energy allocated to sardine. Crosses represent stations without eggs, while circles represent positive stations, circle size proportional to acoustic energy. Colours represent the different countries, and acoustic energy is not standardised across countries.

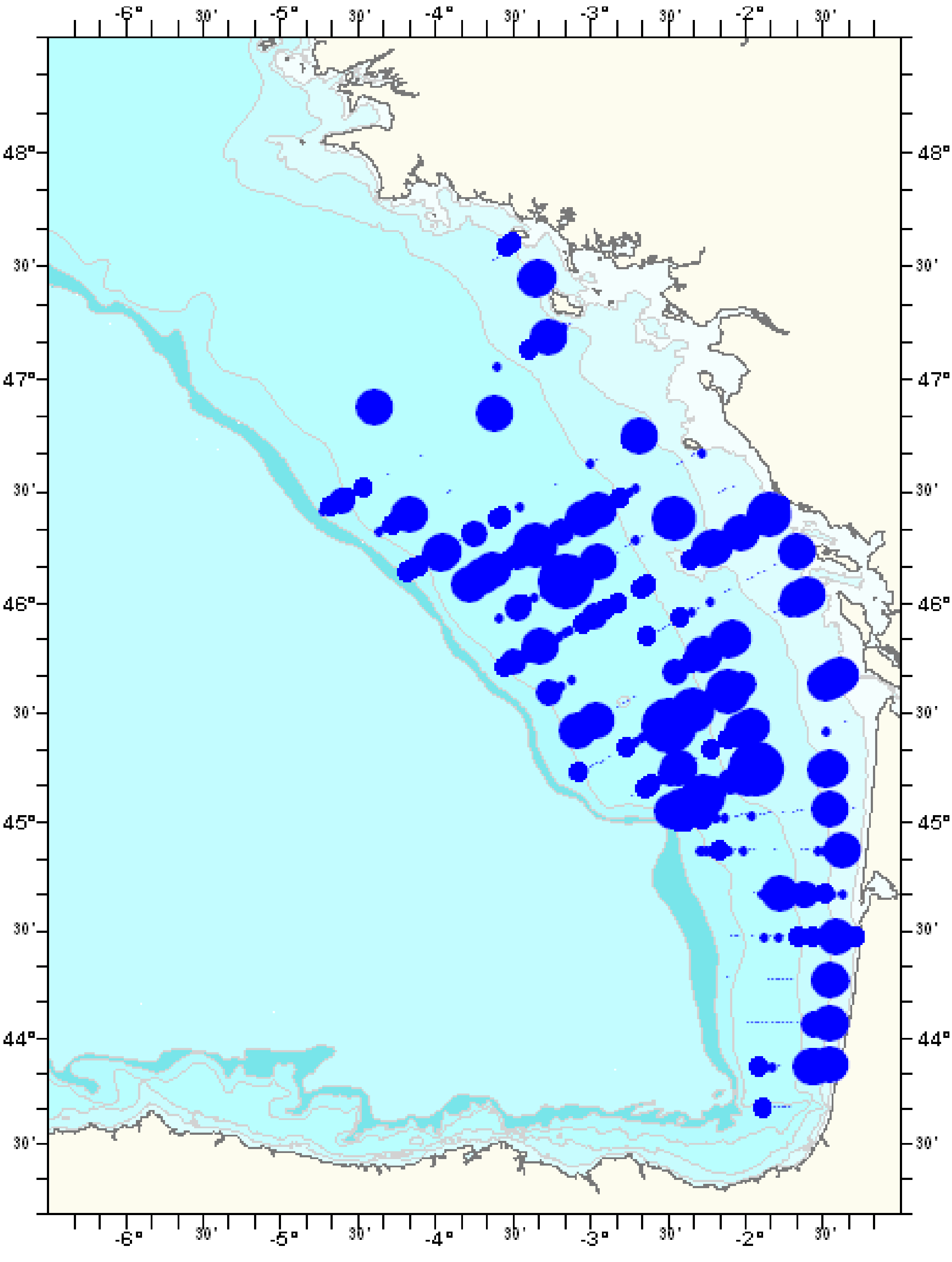


Figure 3.4.2.2.1.1: Distribution of sardine as observed during the acoustic survey PELGAS05. Sardine is predominant in the central offshore area, mainly close to the surface and all along the coast except in front of Loire river plume. The northwest area was not surveyed this year.

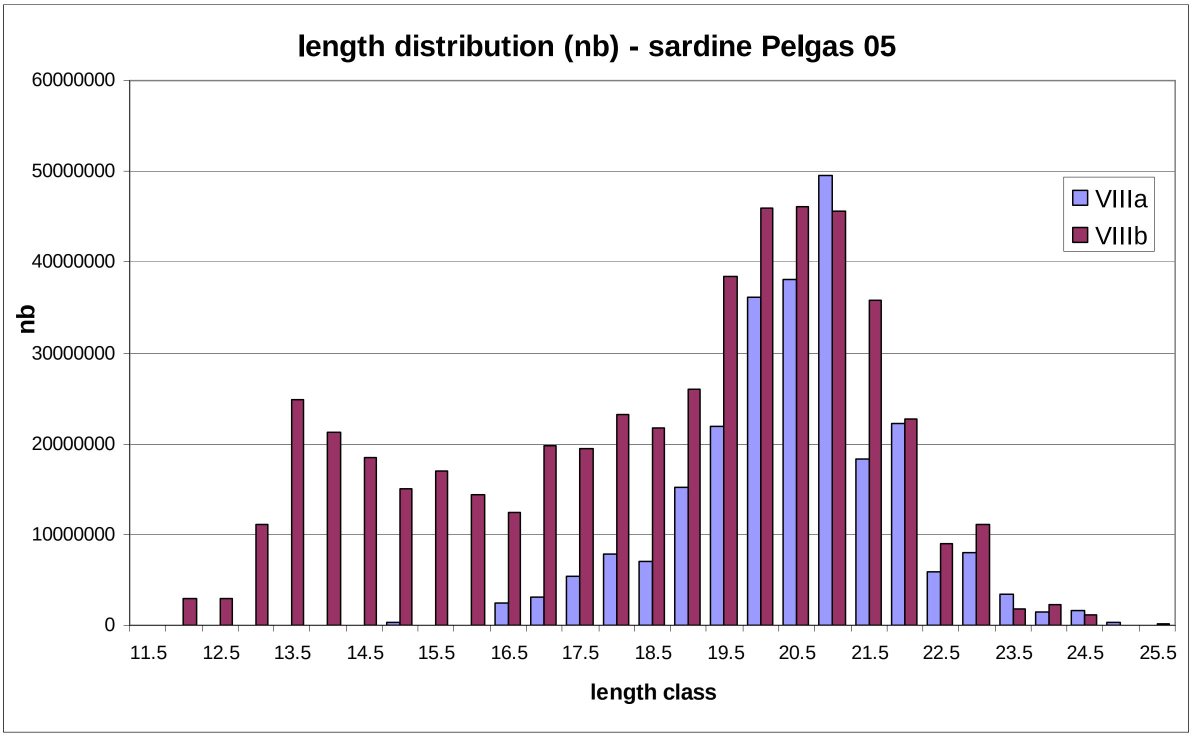


Figure 3.4.2.2.1.2: Length distribution of sardine in numbers of fish as observed during the acoustic survey PELGAS05 separated for divisions VIIIa and VIIIb.

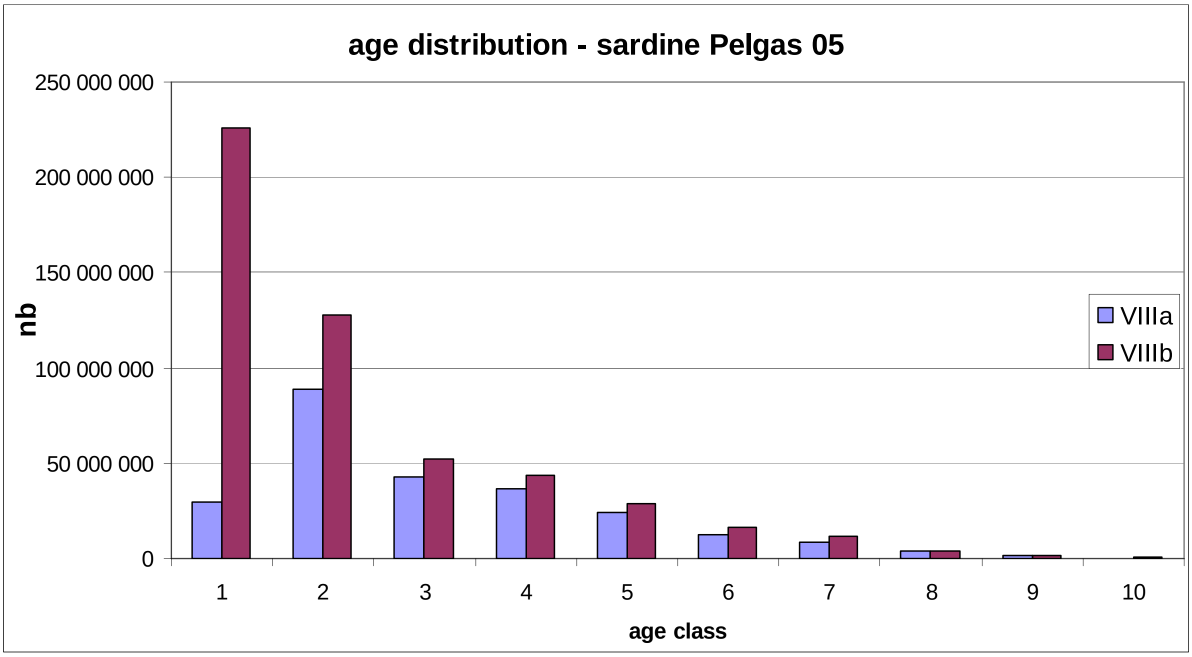


Figure 3.4.2.2.1.3: Age distribution of sardine in numbers of fish as observed during the acoustic survey PELGAS05 separated for divisions VIIIa and VIIIb.

4 Planning and coordination of next acoustic and egg production surveys

4.1 Planning and coordination of acoustic surveys in areas VIII and IX

4.1.1 Juvenile surveys

The JUVENA surveys are carried out by AZTI since 2003 in autumn with the aim of assessing the population of the Bay of Biscay juvenile anchovies. Identification hauls are always carried out by purse seiners The JUVAGA surveys were carried out by IFREMER in 2003 and 2005 in autumn with the aim of studying the process by which juvenile anchovies join the adult population. It is not an assessment survey and therefore the sampling strategy is opportunistic in order to collect the maximum amount of data related to the presence/absence of juveniles (e.g. temperature, salinity, plankton abundance, fluoremetry, etc.). If an extra autumn survey is planned for 2006 it should not deal with assessment, since that is already covered by JUVENA, but it could continue the JUVAGA programme by gathering additional information on the recruitment processes through the study of juvenile distribution and the compilation of environmental information for a better understanding of the ecosystem functioning. According to previous knowledge, juveniles are usually in the same area than macrozooplankton (e.g. euphausids, jellatinous fish and jellyfish) which produces dense echotraces. These echotraces are not always easily distinguishable from the anchovy ones. Therefore, plankton sampling of the water column at different depth strata are needed and to carry this out a multinet open-close system coupled with the LOPC is recommended.

To obtain the maximum benefit from the combination of surveys, it is important that the timing will be adequate, i.e. JUVENA should take place first according to the time series. In this way, information on distribution and length composition of juveniles will be available at the beginning of the following survey. If possible, it is recommended to have an intercalibration exercise between acoustic and fishing characteristics. Each vessel is using different gears for sampling (purse seine vs pelagic trawl) which could induce different gear selectivity for juveniles and the placement of the transducer at different depths may induce different accessibility to juvenile aggregations.

Distance between transects in the JUVENA survey is set as 17.5 nm. This distance may be too large. To study this possibility, it is suggested to analyze the historical data with geostatistics in order to define the range of distribution of juvenile anchovy. Other changes in the methodology used in this survey were suggested during the meeting, as the subtraction of plankton noise from the echograms before echo-integration and the change of the echo-integration threshold to -60dB. In addition, during the complementary survey which does not have assessment constrains, some fine scale grid could be surveyed when juveniles are present.

Special attention will be given to temporal variability at two different scales: day/night and across days in specific areas to be chosen according to JUVENA observations.

The data collected by these juvenile surveys could be therefore related to the adult observations gathered during PELGAS surveys next spring.

4.1.2 Pelagic community surveys

The spring assessment surveys from the south to the north and in sequence are: SAR (IPIMAR), PELACUS (IEO) and PELGAS (IFREMER). In addition, there is ECOCADIZ which takes place in late spring in the Gulf of Cadiz (IEO). As described previously, methodologies are similar and it is therefore possible to combine the data to have a global coverage of the target species.

Since PELACUS and PELGAS are carried out in the same RV “Thalassa” and using the same tools (echosounder, CUFES, CTD, LOPC, pelagic trawl, etc.) we plan to strengthen this collaboration in the future. The coordination between these surveys and the IPIMAR survey has been assured by previous European projects and Acoustic Planning Groups (e.g. PELASSES).

For all surveys, strong standardization has been carried out following the recommendations of FAST (Fisheries and Acoustics Science and Technology) over the past 10 years.

However, some differences still remain in the methodology and this is due to practical reasons or to the characteristics of the local pelagic community (i.e. temporal changes in distribution and behaviour). The group greatly benefited from the share of knowledge, experiences and tools of all participants. Due to its multidisciplinary character (acoustics, eggs, environmental variables, etc.), this WG appeared to be the right forum to increase our understanding of the ecology of pelagic communities and to carry out more detailed studies on communities (e.g. species associations). This would be in line with the ecosystem approach to fisheries management endorsed by the EU, ICES and FAO.

The Working Group recommends that detailed information on the particularities of the methodology used in each survey is presented in the WG in order to be discussed and validated among all participants.

4.2 Planning and coordination of egg production surveys in areas VIII and IX

The next sardine DEPM survey will take place in 2008 covering the area from the Gulf of Cadiz to the inner part of the Bay of Biscay (Atlanto-Iberian stock). The region from the Gulf of Cadiz to the northern Portugal/Spain border (Miño River) will be surveyed by IPIMAR while IEO will cover the north-western Iberian Peninsula and the inner part of the Bay of Biscay. Anchovy DEPM surveys will take place annually in the Bay of Biscay by AZTI covering the usual spawning grounds in the Spanish eastern Cantabrian Sea and the southern French coast (ranging at least from 5ºW to 47ºN). In the Gulf of Cadiz, an anchovy DEPM survey will take place in 2008 by IEO. Thus in 2008, both sardine and anchovy egg production surveys will be carried out in regions VIII and IX, so coordination will be planed in detail in the 2007 meeting of the WGACEGG. Even though the state of survey coordination is in general good and survey plans and analysis methods have been discussed in previous SGSBSA meetings, the improvement and standardization of CUFES sampling procedures across institutions is encouraged. In addiction, the possibility of expanding DEPM throughout the French shelf is also desirable.

5 Recent advances in egg production and acoustic estimation

5.1 Advances in estimation from egg production surveys

Since the last SGSBSA meeting, a review of egg production methods built from conclusions of the SGSBSA but advancing in the review of improvements made through the world-wide application of these methods have been produced (Stratoudakis *et al.* i*n press*). Here the main advances related both to egg production and adult parameter estimates for anchovy and sardine in ICES areas VIII and IX are reported.

5.1.1 Advances in egg production estimates

Advances in egg production estimates since the last SGSBSA have been small since there were a large number of possible improvements and the time between the SGSBSA and this first WG meeting was mainly devoted to publication of reviews and preparation of manuscripts describing new methods. New advances in egg production estimates include:

- definition of an ad-hoc protocol for dealing with not significant or positive mortality values
- definition of desirable properties of the egg production estimation software
- update of software for analysis of ichthyoplankton surveys
- advances in the future use of CUFES as semi-quantitive or quantitative egg production tool (see Section 6.2.3.1 below).

Protocol for dealing with non-significant or positive mortality values

The protocol provides a series of rules to avoid using positive mortality (appearance of eggs for increasing age) in the egg production estimate. Non-significant and positive mortality values are not uncommon when fitting egg production models, due to large small-scale spatial variability, and large variability in the observed cohort abundance. The protocol to avoid using those estimates is as follows:

- plausible range of mortality values (z range) is to be establish for each species and if possible in different regions in space. This range can be estimated ideally from information independent of the egg production survey, but it can also be either estimated from the ichthyoplankton series with well defined mortality estimates (significant and negative), or from literature values
- once defined, a common z across all the survey is to be estimated. If not significant, or positive, then this common z is to be set at the minimum value of assumed z range
- if post-stratification is desired, estimates of z obtained for each strata are only to be used if their differences are statistically significant, and they are all negative. If not, the common mortality value (estimated as previously described) is to be used across all strata.

This should be used both for the traditional egg production estimation procedures and the spatial based methods. The WG concluded that data and methods currently available do not allow for the estimation of spatially dependent smooth models of mortality.

Definition of desirable properties of the egg production estimation software

A list of desirable improvements of the available software for ichthyoplankton analysis (ICES 2005, see subsection software below) was also discussed at the WG. These improvements include:

- possibility of both data-based estimation of spawning times probability density function (pdf) or user assumed pdf (based on *a priori* information) in the spatial explicit egg production estimation modules
- larger flexibility in mortality estimation in spatial modelling: fixed (assumed) mortality, strata-based mortality, constrained spatial smooth mortality
- possibility of modelling under sampling of young eggs.

Software for analysis of ichthyoplankton surveys

Software for analysis of ichthyoplankton surveys was developed under SGSBSA and previous EU projects. Since then, a project in the open software community hosting site Sourceforge has been created, and software is available for downloading at http://sourceforge.net/projects/ichthyoanalysis. The software is regularly updated (on a 6 month basis) and manuals and scripts will be available in successive updates. Also, a home web page with examples of its use by different institutes (it has been used at least by 5 different countries – Germany, South Africa, Chile, Spain and Portugal– and in stocks of 4 different species) is expected to be developed soon.

5.1.2 Advances in adult parameter estimates

Improvements in the ageing of POFs have been achieved for both anchovy and sardine.

5.1.2.1 Advance in POF datation for anchovy

Alday *et al*. (2005) reports on the application of a 7-stage of POFs degeneration to examination of anchovy gonads for a better dating of POFs. This is achieved by a better comprehension of the duration of POF stages, through the analysis of the results from experiments of anchovies kept in tanks and from field samples (Figure 5.1.2.1.1). Overall these results show that the degenerative stages of POFs of Alday *et al.* (2005) (Table 5.1.2.1-1) seem suitable for the analysis of degeneration of anchovy POFs in time, given that the first four stages clearly last less than a day. The three other stages, despite their duration of about a day or more, show maxima and minima in 24 hours in field samples which can be related to the recruitment and leaving periods to/from those stages. POFs full absorption takes place in about 60 hours.

This new procedure indicates that day 1 is more discrete and easy for unique identification of spawning cohorts than day 2, because the stages corresponding to the day 2 may last for more than a day and therefore can be partly confused with day 3 POFs (Figure 5.1.2.1.1). The additional characterization of these old POFs according to their major area and diameter can help in the separation of POFs into past day 2 and day 3 cohorts (as pointed out for sardine by Kostas *et al.*, WD2005).

The fast absorption of POFs in the ovary (in less than 3 days), the few females with no signs of past spawning (stage 0) and the fast cycle of oocyte maturation suggest higher spawning frequencies than those reported for this anchovy population in the past (of about 25% on average). Although the changes that the new perception of degeneration of POFs will induce in spawning frequency estimates are still uncertain until a proper study taking into account disturbances caused by over sampling of most active spawning females (Santiago and Sanz 1992) is undertaken.

AZTI is working on the application of the new staging procedure of POFs to the whole collection of gonad samples from the series of anchovy DEPM surveys since 1989. However, the procedures for correcting over sampling of actively spawning females (hydrated or recently spawning females) have to be checked. The new series of spawning frequency estimates and spawning biomass is planned to be produced before the next working group meeting.

5.1.2.2 Advance in POF datation for sardine

In the last meeting of the SGSBSA, a POFs classification scale composed of 7 stages, was presented for sardine, based essentially on morphological (shape) and cytological (granulosa and theca layers) criteria (ICES 2005). Furthermore, based on the knowledge of the assumed peak spawning time for sardine (19–20h) and the fish sampling hours, a possible elapsed time from the spawning event could be inferred and thus each POFs stage could be preliminarily allocated to a daily spawning cohort. However, while the Day 0 and Day 1 cohorts corresponded to several morphological stages (1 to 5), the last two stages could not be related to clearly delimiting daily cohorts, which could introduce imprecision in the S estimate. It was therefore attempted to develop other criteria – different from the morphological and histological ones – to improve the accuracy of POFs identification.

POFs are reabsorbing structures and thus undergo significant reduction in size throughout time, until complete resorption. Therefore, considering a more or less constant rate of shrinkage, the size of the POFs could also give an indication of their age and consequently the daily cohort to which it could be allocated. To test this hypothesis, histological slides from previous DEPM surveys (1997, 1999) and some from 2005 were used. Digital images of POFs located at the edges of gonad lamellae were taken and both the surface area of the whole POF and the POF diameter (at the lamellae edge) were measured using image analysis software. The effect of several factors (time, temperature, and embedding material) on the POF surface area was tested using GLM analysis with over dispersed Poisson models.

The results showed that POF diameter increased significantly with POF surface area (Figure 5.1.2.2_1). Furthermore, if we consider the allometric relationship $SA = a \times D^b$, (SA: surface area and D: diameter), b differed significantly from 2 (b<2) indicating that POF resorption in sardine is not isometric, i.e. the shape of POFs changes throughout degeneration, the observed morphological transition of POFs being from the irregular to the rectangular and then triangular shapes (Figure 5.1.2.2_2).

Considering the factors affecting the size of POFs, the results showed that POFs shrink exponentially with time in such a way that every day the surface is reduced in size by almost 50% (Figure 5.1.2.2_3a). The rate of POF resorption was not found to be significantly different between the two embedding materials; however, absolute POFs sizes are significantly higher for resin (Figure 5.1.2.2_3a). Concerning the accuracy in POF scorings, both resin and paraffin seemed to provide similar results (results not shown). GLM analysis showed that temperature affects significantly the rate of POF degradation (Figure 5.1.2.2_3b): an increase of 1ºC in environmental temperature would accelerate the rate of POF resorption by almost 3% (Table 5.1.2.2_1). The range of 5ºC observed in all CUFES casts from all DEPM surveys would thus correspond to 15% difference, or a maximum of 8hrs lag, in POF resorption.

In conclusion, as sardine POFs shrink each day to almost half their size, differences between the daily classes are large enough to ensure correct age attribution and therefore POF size can also be used as a criterion to identify the daily cohorts, in addition to the morphological and histological ones. We thus propose, in complement to the POFs classification scale presented last year (ICES 2005), the ageing key shown in Table 5.1.2.2_2. Moreover, the present results indicate that for relatively small inter-annual and regional differences of temperature, this factor is not expected to introduce serious bias in the correct classification of POFs and to subsequently affect accuracy of S estimates. In order to fully validate this last result, the same method of using the POFs size as an identification criterion should be tested for other species and in other stock areas.

5.2 Advances in estimation from acoustic surveys

Since the seventies, acoustics has increasingly been applied to study the geographic distribution and assess the stocks of pelagic fish. Both tools and methods have continued to progress and results are more and more accurate.

From a technical point of view, it can be noticed that the use of multi-beam technology (split or dual beam) is now generally adopted. Digitalisation of data has allowed computer storage and automatic analysis of the acoustic signal. Thanks to these advances, a better approach to T.S. definition has increased our knowledge on specific back scattering energy.

As the identification of echoes remained the major source of bias in acoustic assessments, most of the recent improvements have dealt with this objective. The digitalisation of data gave the possibility to sort echoes according to their vertical distribution or to their aggregating characteristics. The schooling behaviour approach becomes a privileged trend in classification of aggregations according to species or group of species. Although this approach did not result in a reliable tool to identify targets, classifications are now currently applied by all users.

Progress is now being achieved with technical developments such as multi-beam or multi-frequencies echo-sounders. A recent European project (SIMFAMI) showed that responses to several frequencies could be significantly different between groups of species and could therefore be used to characterize the species. Mackerel for instance, has a higher echo with high frequency than with low frequency. The comparison between frequencies seems also to be significantly different between physoclist (i.e. fish whose swimming bladder is closed) or physostom (fish whose swimming bladder is connected by a tube to the gut) fish. These specific properties associated to aggregation pattern classifications are considered today as full of promise.

Other improvements in acoustics being considered nowadays are: the development of multi-beam echo-sounders to minimise the blind layer close to the bottom, the use of a 3D approach to fish aggregations and the combination of other observation tools such as video or LIDAR (LIght Detection And Ranging with a technology similar to RADAR consisting of a laser scanner, a GPS and an inertial navigation system generally mounted on an small aircraft).

Table 5.1.2.1.1: Summary characteristics of the POF's degeneration stages (Alday *et al.* 2005).

STAGES POST OVULATORY FOLLICLES		I	II	III	IV	V	VI	VII
SIZE		Large	Large	Smaller size	Smaller size	Small	Very small	POF remains
LOOK		Form loose folds or loops	More tightly folded	Slightly reduced	Notably reduced	Few folds and a more regular form	Very deteriorated	Long or polygonal remains between oocytes
GRANULOSA	Cells	Arranged, columnar slightly hypertrophied	Marked alignment characteristics	Alignment characteristics still visible	Noticeable disorder	Complete disorder	Absence of cell walls	Absence of cells
GRANULOSA	Nuclei	Very large	Prominent few of them pycnotics	Mostly pycnotics	Pycnotics	Pycnotics	Scarce Pycnotics	Very scarce Pycnotics
GRANULOSA	Vacuoles	Absence	Few	Small Affecting to <50% of the cells	Medium Affecting to >50% of the cells	Big Massive abundance	Big Few	Absence
THECA		Noticeable Separated from the granulosa	With capillaries Separated from the granulosa	Noticeable Adheres to the granulosa	Becomes thinner and more closely adhered to granulosa	Still visible Pycnotic nuclei	Less distinct incorporating to stroma	Not visible
LUMEN		Large irregular with granular material	Large with granular material More regular	Easily visible Granular material still possible	Reduced	Very reduced – Absence	Absence	Absence

Table 5.1.2.2_1: Summary statistics of the GLM fitted to POF area. All parameter estimates are tabulated at the scale of the linear predictor (the intercept for resin as an increment).

Variable	Estimate	SE	t-value	p
Age (h)	-0.021	0.0004	-46.78	< 0.001
Temp (C)	-0.030	0.012	-2.44	0.016
Intercept (paraffin)	-3.344	0.197	-16.98	< 0.001
Intercept (resin)	0.71	0.027	25.90	< 0.001

Table 5.1.2.2_2: Summarization of morphological characteristics of different POF age-classes.

Age (d)	Shape	Material	Surface area (mm2)	State of granulosa
<1	Irregular	paraffin	16404±427	Thick and looped
		resin	35486±1472	
1–2	Rectangular	paraffin	9272±255	One well formulated layer
		resin	17650±468	
2–3	Triangular	paraffin	5910±187	A thin layer or only some remnants
		resin	12620±303	
>3	Triangular	paraffin	4160±197	Completely reabsorbed, only some residual vacuoles
		resin	7234±373	

		0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
Time past	HH	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
Daily	HH	0	2	4	6	8	10	12	14	16	18	20	22	24	2	4	6
POF stage	I	32%	13%	6%	0%		0%	0%	0%		0%	0%		0%	0%	0%	0%
	II	25%	19%	22%	0%		0%	0%	0%		0%	0%		0%	0%	4%	0%
	III	11%	31%	22%	38%		33%	21%	18%		0%	0%		2%	0%	21%	25%
	IV	0%	0%	6%	31%		67%	36%	31%		0%	0%		2%	0%	8%	0%
	V	6%	19%	3%	13%		0%	25%	24%		38%	58%		44%	17%	4%	6%
	VI	9%	6%	33%	6%		0%	7%	10%		44%	25%		47%	58%	50%	31%
	VII	6%	6%	8%	0%		0%	0%	16%		6%	17%		5%	25%	13%	19%
no fps	0	11%	6%	0%	13%		0%	11%	0%		13%	0%		0%	0%	0%	19%
	Experiments	V522, V631	V632	V522,V610**	V631, V632		V522	Aq2	Aq1, V632, V522		V631, V632	V522		Aq2, V631, V632	V522	V610	V631,V631

		32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62
Time past	HH	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62
Daily	HH	8	10	12	14	16	18	20	22	24	2	4	6	8	10	12	14
POF stage	I		0%	0%	0%	0%	0%		5%	0%		0%		0%		0%	0%
	II		0%	0%	0%	0%	0%		0%	0%		10%		0%		0%	0%
	III		8%	0%	0%	0%	0%		0%	0%		10%		0%		0%	0%
	IV		0%	5%	0%	0%	0%		0%	4%		0%		17%		13%	6%
	V		25%	9%	3%	5%	0%		5%	0%		5%		0%		0%	0%
	VI		42%	36%	34%	50%	13%		25%	8%		15%		17%		0%	0%
	VII		25%	50%	55%	30%	88%		50%	52%		35%		42%		39%	9%
no fps	0		0%	0%	7%	15%	0%		15%	35%		25%		25%		48%	86%
	Experiments		V522	Aq2 , V631	Aq1	V610, V522	V631		V610, V522	Aq2, Aq2		V522, V631		V522		Aq2, V610	Aq1, V522

Figure 5.1.2.1.1: Summary results of the tank experiments to estimate the duration of anchovy POFs stages (redrawn from Alday *et al.*, 2005).

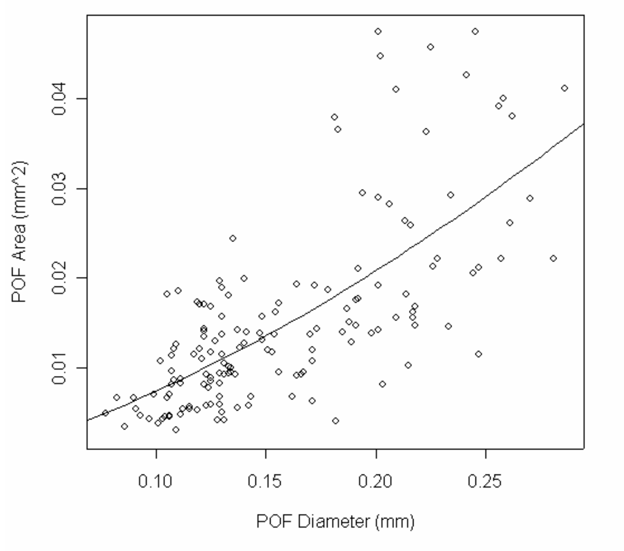


Figure 5.1.2.2_1: Allometric relationship between POF diameter and POF surface area.

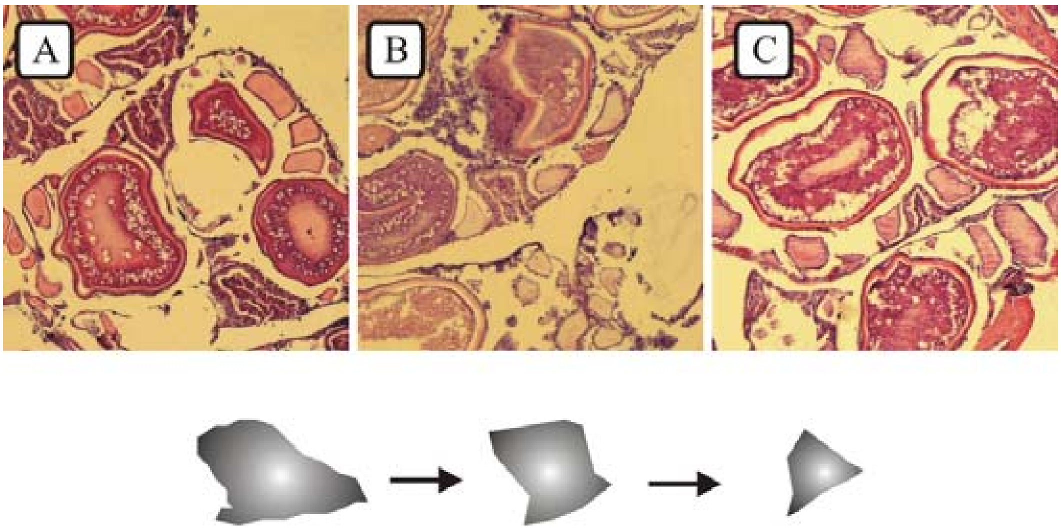


Figure 5.1.2.2_2: Upper panel: Microphotographs showing the evolution in POF size and shape. Lower panel: surface areas of postovulatory follicles from the respective microphotographs. The scale between the images and between the drawings in each panel is the same.

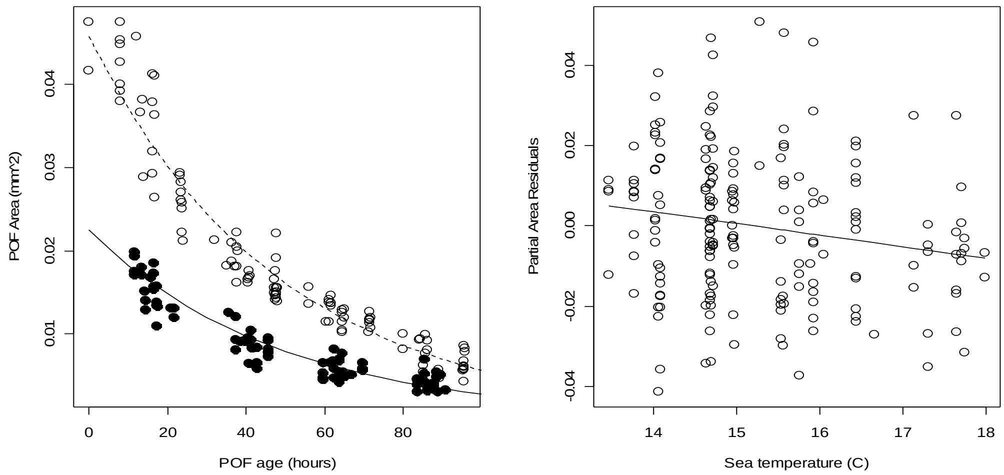


Figure 5.1.2.2_3: A: evolution of POF surface area with time elapsed from spawning (POF age); open circles: resin; dark circles: paraffin. B: effect of ambient temperature on POF area.

6 Requirements to compare estimates from acoustic and egg production surveys

In order to compare two observational methods of the pelagic community such as acoustics and ichthyoplankton surveys, first it is necessary to know all potential sources of bias and uncertainty in both techniques and how they can differentially affect each methodology, depending on given environmental scenarios and biological properties of the stock. Sampling methods for additional data (hydrographic sampling, adult sampling, etc) required to perform either acoustic or ichthyoplankton based abundances and distribution are in some cases very similar or identical for both methods, but the sampling uncertainties and/or bias may have different effects on the estimation of the required parameters. For example, adult sampling provides (in some cases at the same time) species and length composition for acoustics and samples for the estimation of adult fecundity parameters for egg production methods. Although the sampling method is the same (fishing hauls), the implications for parameter estimation of problems of the under-sampling of young fish or over-sampling of pre-spawning females differs. In this section, potential sources of bias and uncertainty in ichthyoplanctkon and acoustic based methods are reviewed.

Additional sources of information such as CUFES data, hydrograpy and other pelagic communities' observations will also be required to advance in the comparison between acoustic and ichthyoplankton based methods. Of these, both CUFES and hydrography data are of direct use and great importance to allow for the comparison and integration of acoustics and ichthyoplankton surveys. CUFES data shares some of the sources of variability of other ichthyoplankton surveys, with the inherent problems of bias due to partial sampling of the water column. At the end of this section, problems and advances in relation to the CUFES data are described.

6.1 Potential sources of bias and uncertainty in acoustic and egg production surveys

6.1.1 Potential sources of bias and uncertainty in egg production surveys

6.1.1.1 Egg production estimates

Potential bias may arise during the estimation of daily egg production per surface unit area (P0) from the estimation of mortality of eggs (Z). Due to the noisy nature of the data on egg abundance from the individual CALVET samples, it is not unusual that estimates of mortality of eggs through the regression (GLM or non linear) method become 0 or even positive (i.e. egg abundance seems not to decrease or even increases with egg age). Biologically positive Z is impossible and a 0 value is extremely unlikely. These situations reveal how noisy Z estimates can be. Given that Z has to be negative, accepting a 0 or positive value will bias the result. For those cases it is considered convenient to obtain a range of meaningful Z values (either from past application of the DEPM to the same population or from the literature) so as to substitute the too low (not significantly different from 0) estimate of Z by a minimum meaningful value. This leads to assume a minimum value of Z when the estimates are too low.

Figures 6.2.1.1.1 and 6.2.1.1.2 show (as examples) the impact of moving a Z=0 to any upper value on the final anchovy and sardine P_{tot} estimates from the 2005 DEPM applications in Bay of Biscay and Portugal, respectively. The impact of adopting that assumption for Z is noticeable for P_{tot} estimates and therefore the potential bias is high.

The regression estimates of Z assume both constancy of that value in space and in time. If those assumptions are not valid the final P_{tot} estimates can be biased. For instance, in the SGSBSA (ICES2005) report it was shown that if Z changes between regions (for equal P0) the final estimate of P0 tends to be biased downwards. On the other hand, if Z is higher during the first hours after spawning (higher vulnerability to predation due to higher aggregative distribution), the usual regression estimate of Z will lead as well to a downward bias of the P0 estimate.

In cases of spatial heterogeneity of Z among regions when there is need for stratification according to adults, it is suggested the adoption of the particular strata based Z estimates whenever they both are significantly different between them and both different from 0. If this is not the case, the overall global (non stratified and significant) Z estimate should be adopted for both strata. In any case, sensitivity to the stratification and adoption of regional Z estimates on P_{tot} and SSB should be discussed.

Incorrect spawning time assumptions (pdf) may induce bias as well, particularly when too wide pdf distribution is assumed, some under-estimation of P_{tot} is suspected (ICES CM 2005/G:02). The spawning time pdf and partial recruitment of young eggs (as for instance the stage I of sardine which does not appear in samples, either due to their vertical distribution making them unavailable to the sampling gear or large patchiness etc.) can also lead to bias in the P_{tot} estimate if not taken into account (ICES CM 2005/G:02). Partial recruitment requires the elimination of very young cohorts of eggs (cutting the tail at the beginning). This can be achieved by changing the pdf standard deviation as to cut off the range of young egg ages until full recruitment has occurred or alternatively pdf can be a narrow distribution but an additional cutting point is made afterwards. The lower tail of the egg age distribution (old ages) should also be cut to assure that hatching eggs do not bias the egg abundance of old ages. In cases of spatial heterogeneity of Z among regions and potential differences in incubation temperature in these areas, in order to minimize the risk of bias (ICES 2005/G:02) and for the traditional regression P0 estimate, the WG suggests applying the rule of cutting the old range of ages as corresponding to the warm temperature region.

6.1.1.2 Potential sources of bias and uncertainty in adult parameter estimates

Under traditional DEPM estimation, the spatial allocation of sampling effort for adult fish can influence the precision and introduce bias in spawning biomass estimation. When sampling is not proportional to fish abundance and there is spatial structure in daily fecundity, the mean estimate of daily fecundity can be biased (Stratoudakis and Fryer, 2000), leading to biased estimates of spawning biomass. In most cases, adult sampling effort allocation has an opportunistic element, although samples are usually allocated proportionately to previous knowledge of local abundance or according to the relative abundance of eggs in the ichthyoplankton survey. However, the resulting sampling effort allocation usually deviates from allocation proportional to size, so weighting factors can be applied *a posteriori* to avoid the introduction of bias (see application to anchovy). The presence of spatial structure in daily fecundity can also affect the precision of estimated spawning biomass, when spatial trends are not taken into account. In the simplest case, precision can be improved by post-stratification into strata with homogeneous daily fecundity properties, or, alternatively, GAMs can be used to model the spatial pattern in daily fecundity. To guarantee that post-stratification is based on defensible criteria, it is recommended that any *ad-hoc* decision for post-stratification is tested statistically and is only applied when significant for at least one adult parameter.

Time of adult sampling during the daily cycle is another aspect that can introduce bias and reduce precision in the estimation of daily fecundity. Sardine and anchovy species around the world are commonly known to form ephemeral spawning aggregations in the hours around the daily spawning peak (Stratoudakis *et al*., in press). During that period of the day, a disproportionate amount of females about to spawn (gonads with hydrated oocytes), running (hydrated oocytes and recent POFs), or recently spawned (recent POFs) segregate from the rest of the population, often associated with a large number of males. As a result, fishing stations performed during this period of the day are likely to provide extreme sex ratios (usually male-dominated) and biased estimates of spawning fraction for the cohort that spawns during the sampling day. When adult sampling cannot avoid the hours of ephemeral spawning aggregations, sex ratio estimation is likely to be less precise. If historic data support the 1:1 numeric ratio for males and females, sex ratio estimation can avoid the use of these samples and simply rely on the mean weight ratio of females and males under an assumed 1:1 numeric ratio. To avoid the introduction of bias in spawning fraction estimation, the delimitation of daily spawning cohorts is often not performed in relation to the time of peak spawning activity, but in relation to the time of the day where ephemeral aggregations are believed to cease. As a result, spawning fraction is estimated from the daily cohorts of spawners from previous days (one or two days before), after correcting for the disproportional presence of fish that are spawning during the sampling day.

6.1.2 Potential sources of bias and uncertainty in acoustic estimates

6.1.2.1 Echosound integration

Fish echo integration is affected by several factors, the main being:

- reduction in acoustic backscatter energy due to the movement of the acoustic beam (hull mounted transducers without stabilised platform) and due to air bubbles at the sea surface, especially with bad weather
- separation between sea bed and fish, when the schools are near rocky bottoms
- acoustic blind zones, near the surface (due to the ship draft) and near the bottom.

6.1.2.2 Adult sampling

The type and characteristics of the sampling gear affects the sample species composition and length structure, due to different gear catchability. The different institutes use different gears (bottom trawl, pelagic trawl and purse seine) with different sizes.

6.1.2.3 Energy partition

The species acoustic energy allocation suffers from the uncertainties in the species echo identification, in the species Target Strength (TS) and in the catchability of the sampling gear. For some species with low TS (e.g. mackerel) and in some areas with dense plankton layers it is also difficult to separate between fish and plankton.

Some advances appear in the use of several frequencies as it has been revealed during the European project SIMFAMI. Algorithms have been adjusted particularly to separate plankton from fish, or to isolate fish without swimbladder, physoclist or physostom fish. These new processing methodologies still require improvement before being use routinely during acoustic surveys and the use of identification hauls is still needed at present.

6.1.3 Integration of other sources of data to advance in the comparison

6.1.3.1 CUFES data

CUFES data offers a good source of information for comparing acoustic and egg production surveys, as it is often used in both. Nevertheless, problems of bias and precision can affect the performance of the CUFES and thus its usefulness for improving the comparison and/or validation of other samplers. These problems are associated to partial sampling of the water column and variable environmental properties that can affect the vertical distribution of eggs. In this section, a review of some of the lines followed by the WG members in order to define and reduce the sources of bias and uncertainty in the CUFES data is presented.

6.1.3.1.1 Permeability of sardine eggs and density of anchovy eggs

Some recent experiments on anchovy and sardine egg density could improve the models of vertical egg distribution.

AZTI presented a relationship obtained for sardine eggs between the permeability of the chorion and the external water density (Rueda *et al*., submitted). According to it, the permeability value of sardine eggs decreases when external densities differ from their natural environmental conditions. This relationship was validated with settling velocity experiments in a density gradient column (n= 9).

IFREMER presented a preliminary vertical egg distribution model. *In situ* egg density measurements seem to show a possible relationship between the anchovy egg density and the hydrographic parameters. However, further information is required to validate this relationship.

6.1.3.1.2 CUFES comparison between vessels

A comparison between the CUFES samplers on board the RV "Thalassa" and the RV "Cornide de Saavedra" was carried out by IEO in order to calibrate both samplers. On the RV "Thalassa", samples are taken at 3m depth while on RV "Cornide de Saavedra" samples are taken at 5m depth. A total of 14 samples were collected simultaneously by both vessels cruising in parallel along 2 transects of 21 nm. The analysis of these samples is currently in progress.

6.1.3.1.3 Validation experience CUFES-PAIROVET (Gulf of Cadiz Anchovy eggs)

Validation was carried out during *BOCADEVA-0604* IEO survey in radials spreading throughout the whole sampling area. CUFES and PAIROVET samples were collected every 3 nm but with a 1.5 nm interval between them (i.e. each PAIROVET station had two (before and after) CUFES stations). Eleven out of the 26 PAIROVET stations carried out on 7 radials (Figure 6.2.3.1.1) were positive, accounting for 151 eggs (mean = 13.7 eggs/station). Two very shallow stations (7 and 8) in front to the National Park of Doñana registered the largest number of eggs (Figure 6.2.3.1.2). Largest CUFES egg densities were found in the same area (Figure 6.2.3.1.3). Nevertheless, the main differences between samplers were also found in this area (PAIROVET stations 7 and 8) where CUFES abundances were lowest.

To carry out the validation, CUFES and PAIROVET egg densities were fitted using a linear model. Stations 7 and 8 are the outliers of a clear relationship represented in Figure 6.2.3.1.4. Possible causes of these differences could be the water column stratification, the bottom depth or recently spawned eggs. Temperature and salinity CTD data and the shallow character of these stations exclude the first two causes. Since anchovy spawning occurs close to the bottom and the eggs found in stations 7 and 8 were in an early stage of development (83% and 67% respectively were classified as stage II) the third hypothesis may explain the observed differences.

A general conclusion from this validation experience is that CUFES and PAIROVET egg density results are comparable outside the daily spawning time range (when eggs are distributed in deeper waters than those sampled by CUFES). Tables 6.2.3.1.1–6.2.3.1.2 and Figure 6.2.3.1.5 show two fitted models including or not including these stations.

Table 6.2.3.1.1: Model 1: CUFES *vs* PAIROVET anchovy egg densities lineal relationship (all the stations).

Residuals				
Min	1Q	Median	3Q	Max
-61.835	-8.192	-8.131	-2.366	137.423
Coefficients				
	Estimate	Std. Error	T value	Pr(>t)
(Intercept)	819.179	707.227	1.158	0.2581
Anchovy dens	0.06319	0.02661	2.374	0.0259*

Signif. codes: 0 `***' 0.001 `' 0.01 `*' 0.05 `.' 0.1 ` ' 1**
Residual standard error: 33.03 on 24 degrees of freedom
Multiple R-Squared: 0.1902, Adjusted R-squared: 0.1565
F-statistic: 5.638 on 1 and 24 DF, p-value: 0.02592

Table 6.2.3.1.2: Model 2: CUFES *vs* PAIROVET anchovy egg densities lineal relationship (without the stations 7 and 8, taking these as outliers).

Residuals				
Min	1Q	Median	3Q	Max
-39.3142	-0.8124	-8.124	3.8048	27.5410
Coefficients				
	Estimate	Std. Error	T value	Pr(>t)
(Intercept)	0.81236	2.6146	0.311	0.759
Anchovy dens	0.31576	0.02221	14.22	1.43e-12***

Signif. codes: 0 `***' 0.001 `' 0.01 `*' 0.05 `.' 0.1 ` ' 1**
Residual standard error: 11.91 on 22 degrees of freedom
Multiple R-Squared: 0.9019, Adjusted R-squared: 0.8974
F-statistic: 202.2 on 1 and 22 DF, p-value: 1.432e-12

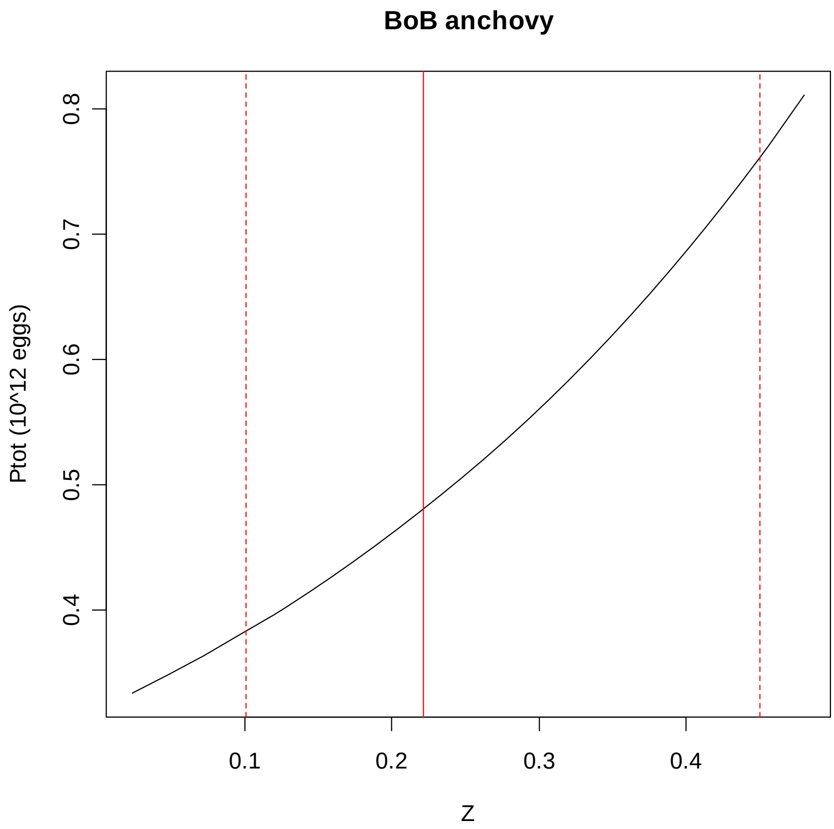


Figure 6.2.1.1.1: Relationship between assumed daily mortality rate for anchovy eggs and resulting GLM estimate of daily egg production for the 2005 Bay of Biscay DEPM survey.

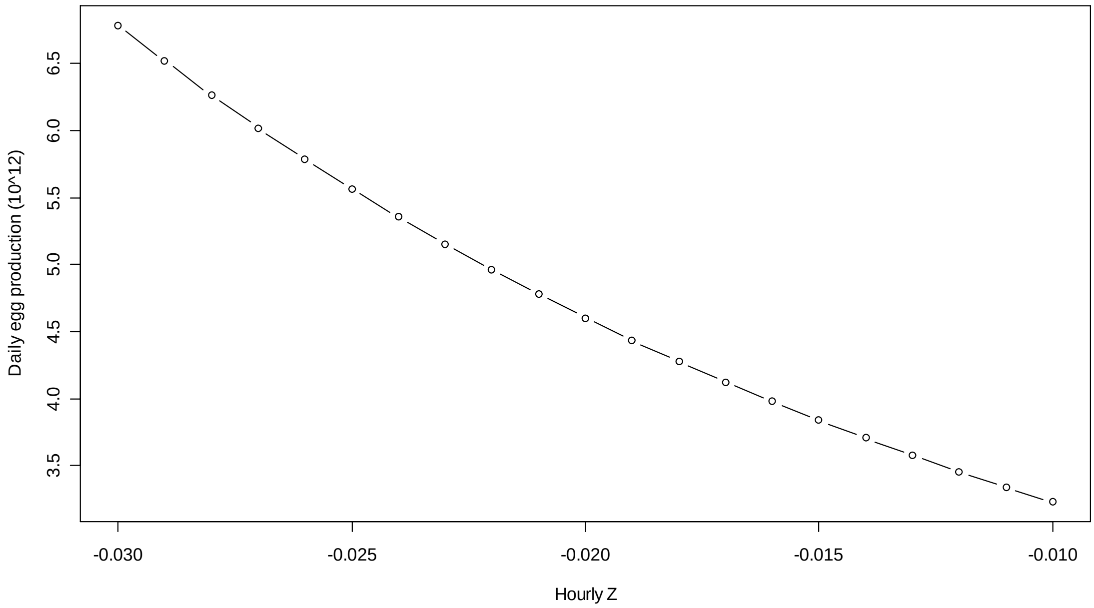


Figure 6.2.1.1.2: Relationship between assumed hourly mortality rate for sardine eggs and resulting GLM estimate of daily egg production for the 2005 Portuguese DEPM survey.

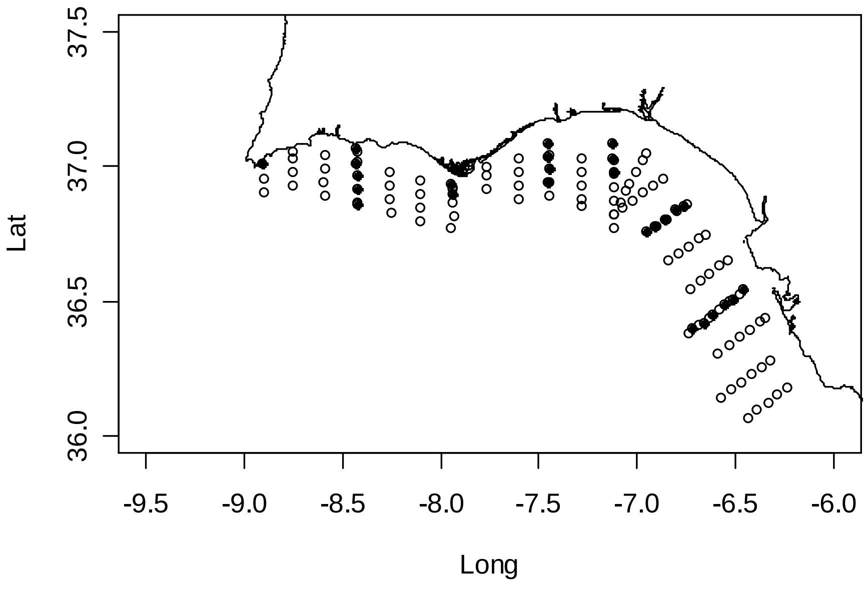


Figure 6.2.3.1.1: *BOCADEVA-0604.* Survey area, (○) CUFES and (●) PAIROVET stations.

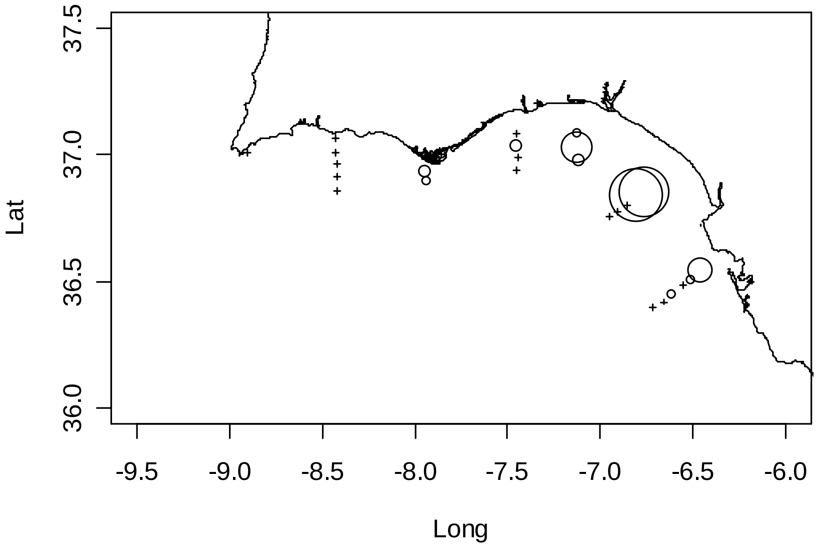


Figure 6.2.3.1.2: ***BOCADEVA-0604.*** **Anchovy egg abundances (eggs/m^2) by PAIROVET.**

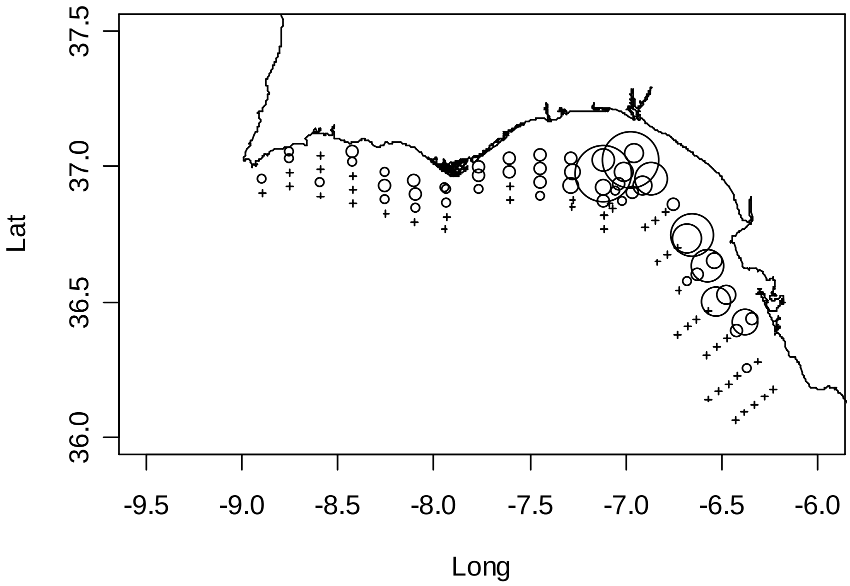


Figure 6.2.3.1.3: ***BOCADEVA-0604.*** **Anchovy egg abundances (eggs/m^3) by CUFES.**

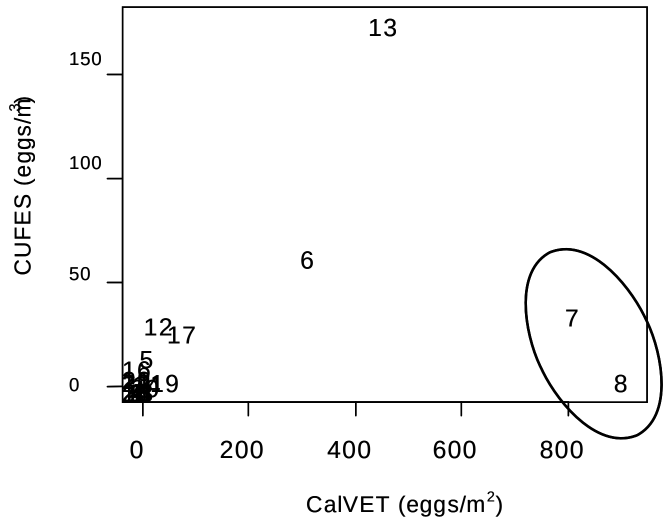


Figure 6.2.3.1.4: *BOCADEVA-0604.* Lineal relationship among the anchovy egg densities by CUFES *vs* PAIROVET.

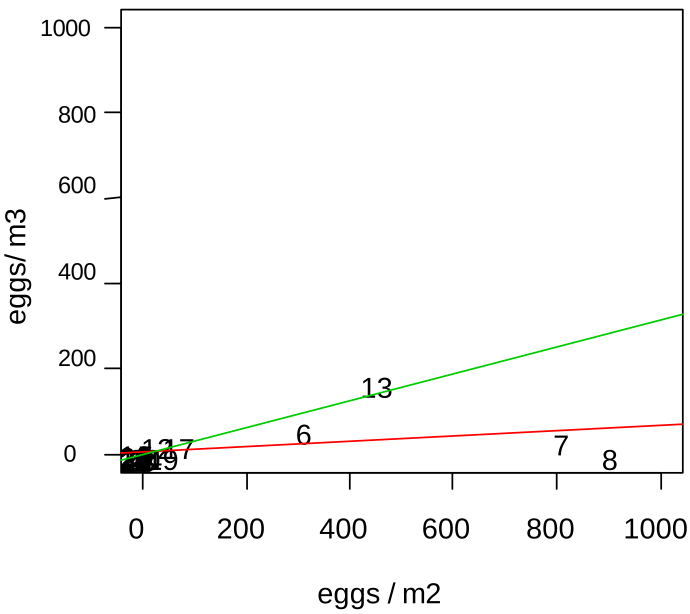


Figure 6.2.3.1.5: *BOCADEVA-0604.* Lineal relationship among the anchovy egg densities by CUFES *vs* PAIROVET. Model 1 in red; Model 2 in green.

7 Comparison and integration of acoustic and egg production surveys

7.1 List of available surveys

Table 7.1.1.1 shows the time series of acoustic and basic hydrographic data by seasons and Institutions, while Table 7.1.1.2 shows the time series of ichthyoplankton surveys collected during the SARDYN project. Ichthyoplankton surveys are triannual from 2002 onwards for IEO and IPIMAR sardine surveys and will be triannual from 2005 for the Gulf of Cádiz anchovy. Surveys are annual since 1998 for the Bay of Biscay anchovy.

7.2 Research lines for the comparison of both methods

During this first WG meeting, the WG defined a series of lines to advance in the comparison of both acoustic and ichthyoplankton based surveys and estimation methods. These lines include:

- comparison of spawning areas defined from acoustic and ichthyoplankton surveys, both in terms of absolute estimates of spawning area and in distribution;
- comparison of spatial distribution of biomass derived from both methods, and interpretation of results in relation to environmental/oceanographic conditions;
- intermediate approaches between pure acoustic/ichthyoplankton based estimation procedures:
  - i) comparison between species allocation from hauls to egg proportions (when targeting species at spawning time);
  - ii) comparison of total energy allocated to a single species with total egg production of the same species.

Table 7.1.1.1: Time series of acoustic and basic hydrographic data by seasons and institutions.

IFREMER: Acoustic and hydrographic data base

		83	84	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05
Sp	Ac		X	X	X	X	X		X	X	X	X					X	X		X	X	X	X	X	X
	H		4	4	4	4	4		4	4	4	4					5	5		5	5	5	5	5,6	5,6
Su	Ac												X												
	H												4												
Au	Ac													X				X	X				X		X
	H													4									5,6		5,6

AZTI: Acoustic and hydrographic data base

		83	84	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05
Sp	Ac																								
	H																								
Su	Ac																								
	H																								
Au	Ac																						X	X	X
	H																						4	4,6	4,6

IEO-North: Acoustic and hydrographic data base

		83	84	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05
Sp	Ac					X	X	X		X	X	X	X			X	X	X	X	X	X	X	X	X	X
	H					2	2	2		2	2	2	2			2	2	2	2	5	5,6	5,6	5	5	5
Su	Ac																								
	H																								
Au	Ac	X	X	X	X	X																			
	H	2	2	2	2	2																			

Table 7.1.1.1 Continued.

IEO-S: Acoustic and hydrographic data base

		83	84	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05
Sp	Ac												X									X		X	
	H																					4		4	
Su	Ac																								
	H																								
Au	Ac																								
	H																								

IPIMAR: Acoustic and hydrographic data base

		83	84	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05
Sp	Ac					X		X							X	X	X	X	X	X	X	X	X	X	X
	H																		1	1	1	1	1	1	1
Su	Ac				X	X	X	X								X			X						
	H																		1						
Au	Ac			X	X	X	X					X					X	X	X	X	X		X		
	H																		1	1	1		1		

Legend:

Season: Sp, Su and Au (spring, summer and autumn cruises respectively)

Ac: acoustic data base

X: acoustic data on paper

X: acoustic digital data

H: hydrographic data base

Code for the hydrographic data base: (1) sea surface fields from the continuous underway sampler on board; (2) sampling at hydrographic stations (CTD profiles); (3) zooplankton samples by means of WP2; (4) sea surface fields from the continuous plus CTD profiles at selected stations; (5) sea surface fields from the continuous + CTD profiles at selected stations + WP2 (or similar) for zooplankton sampling; (6) other variables (e.g. size-fractionated particle distribution, OPC or LOPC).

[For further details of the variables measured on the hydrographic database see ICES SGRESP 2004 report].

Table 7.1.1.2: Ichthyoplankton files available from the SARDYN database (* Efsurf fixed, ** Temperature not available).

	Lat Range		Long range		N. Obs	Max Dens	Mean D.	Joint file
ring1185.portugal	36,65	41,83	-10,23	-7,42	72	627	16	
ring0186.portugal	36,65	41,83	-10,35	-7,42	112	613	31	
ring0386.portugal	36,65	41,83	-10,35	-7,42	113	7714	131	
sareggs88.portugal	36,68	41,82	-10,15	-7,51	309	1680	81	Sareggs88
sareggs88.spain	41,92	44,32	-9,72	-1,97	516	2758	140	
sareggs90.spain	41,92	44,72	-9,58	-2,33	475	2063	62	
bongos1090.portugal *	36,38	41,83	-9,95	-7,42	86	401	15	
calvet0591.spain	43,32	46,62	-5,12	-1,28	538	2295	106	
bongos1091.portugal *	36,67	41,83	-10,2	-7,42	84	1105	29	
bongos0392.portugal	36,67	41,83	-10,2	-7,42	86	308	47	calbon92
calvet0492.spain	41,87	44,47	-9,9	-3,92	437	2451	119	
calvet0592.spain	43,32	46,87	-5,62	-1,28	651	1139	22	
bongos1092.portugal */**	36,67	41,17	-10,2	-8,42	45	753	62	
bongos0393.portugal */**	36,38	41,83	-10,08	-7,42	92	1515	107	bongos93
bongos0493.spain	41,98	44,17	-9,67	-1,9	43	956	38	
bongos0394.spain **	42	47,76	-9,72	-1,75	113	148	6	
bongos0395.portugal	36,12	42,75	-10,75	-6,75	69	3713	122	bongos95
bongos0395.spain	39,25	44,88	-10,76	-1,75	112	96	8	
bongos0595.spain	43,38	46,88	-8,75	-1,74	121	834	14	
sareggs97.portugal	35,97	41,83	-10,17	-5,77	373	5569	77	Sareggs97
sareggs97.spain	41,97	44,32	-9,83	-1,88	515	5381	57	
bongos0198.portugal	36,12	42,75	-10,75	-6,5	71	431	14	
indices98.dat	36,12	59,25	-15,78	-1,25	1334	16911	40	indices98
sareggs99.azti	43,32	46,13	-4,61	-1,22	344	62	2	sareggs99
sareggs99.portugal	36	41,9	-10,29	-5,77	417	13431	228	
sareggs99.spain	41,89	44,08	-9,6	-1,96	398	3616	116	
calvet1199.portugal	36,12	41,86	-10	-6,15	127	3220	108	
calvet0300.azti	43,67	47,87	-5,43	-1,26	133	2820	213	pelasses0300
calvet0300.portugal	36,44	41,86	-10	-6,38	121	6360	165	
calvet0300.spain *	41,95	50,18	-9,67	-1,73	112	460	22	
sareggs00.azti	43,33	46,88	-4,53	-1,22	442	949	100	
bongos0400.spain	42,25	44,63	-9,9	-1,75	103	1321	44	
bongos0500.spain	42,25	44,62	-9,9	-1,75	130	370	23	
bongos0301.spain	42,25	45,75	-10,25	-1,32	95	5592	120	
sareggs01.azti	43,32	47,38	-5,62	-1,22	614	1691	41	
bongos0401.spain	42,24	45,75	-10,25	-1,32	123	976	82	
calvet0301.portugal	36,12	41,86	-10	-6,15	117	2184	48	pelasses0401
calvet0401.spain *	40,39	44,05	-9,97	-1,74	248	1500	153	
calvet0501.azti	43,66	50,02	-7,24	-1,26	106	1019	66	
sareggs02.azti	43,33	46,63	-4,24	-1,29	376	1808	137	sareggs02
sareggs02.portugal	35,97	41,8	-10,34	-6,33	484	4640	105	
sareggs02.spain	42,06	44,28	-9,52	-2	313	1896	102	
bongos0303.spain	41,98	44,05	-9,55	-1,75	40	2246	209	

8 Conclusions

During this first WG meeting, a series of advantages and disadvantages of both the ichthyoplankton and acoustic based methods have been identified. Both methods are used for direct assessment of the Spawning Stock Biomass, and they are routinely used for tuning of analytical assessment methods (e.g. ICA or AMCI). Also, both methods allow for the spatial understanding of the population structure, and thus allow the production of distribution maps and to study the relationship between population distribution and other environmental/biological variables.

For the egg production based estimation of adult abundance, the method is theoretically unbiased if each biological parameter used in the estimation is unbiased. As each of the parameters represent a biological property of the population, the bias and precision of each parameter can, in principle, be measured, and thus the bias and precision of the final estimate can also be estimated. Nevertheless, this theoretically unbiased property does not prevent the relative high imprecision of the egg production methods, especially when any of the parameters that conform the adult fecundity is low. Apart from total estimates of spawning stock biomass, egg production based methods allow for the breakdown of total estimates of biomass into age structure biomass or abundance estimates, mapping of the spawning areas of the target species and concurrent spawning species (ecological studies). The method requires – and thus implies- a detailed knowledge of the reproductive biology and spawning dynamic (spawning frequency, batch fecundity, maturity ogives, etc.) of the target species, as well as some understanding of the interaction of these parameters with the environment (biological studies and reproductive ecology). Nevertheless, this detailed information is very expensive to achieve and it is generally restricted to the target species, while limited information from other species is usually achieved. Standardisation of sampling and analysis in egg production methods for both sardine and anchovy applied in ICES areas VIII and IX is believed to be good.

Main important problems of the Daily Egg Production Methods applied to sardines and anchovies remain on:

- The estimation of spawning frequency requires a detailed knowledge of spawning dynamics (risk of bias if incorrectly done). Over sampling of actively spawning females require corrections in the standard procedures to avoid biased estimates
- Inhomogeneous adult Daily Fecundity (DF) parameters in the context of unbalance sampling (sampling probability not proportional to size) can lead to bias estimates of overall DF and total SSB.
- Inhomogeneous mortality of eggs in space or time (throughout the egg life) can lead to bias estimates of daily egg production.
- Partial recruitment of early egg stages and cluster aggregation of these stages, lead to imprecise estimates of mortality and risk of biasing the Z and egg Production estimates.
- For sardine, SSB and total biomass relationships can be difficult to reconcile if maturity ogives are not accurate and spatially explicit.

Acoustic sampling remains a more cost/efficient method to produce SSB indices of abundance, and thus have been chosen in some parts of the world as the preferred method. As a side advantage due to the economical preference of this method, acoustic sampling often offers longer and more frequent time series. Nevertheless, validation of some of the assumptions, as well as estimation of bias in some of the assumed parameters for the acoustic methods remains a difficult issue, mainly due to the fact that some of the parameters do not have a direct biological meaning and thus can only be stated through empirical experiments. Estimation of precision of some of the parameters and thus of global estimates suffer from similar problems. Acoustic sampling for sardine and anchovy, and in general for the pelagic community, in ICES areas VIII and IX have gradually taken into account progress both in acoustic tools and in analysis methods, and standardisation across institutes is believed to be in general good. The inherent multispecies possibilities of the acoustic method allow studying species interactions, especially in terms of space occupation, as well as to observe changes in the species behaviour, and thus monitor possible ecosystem changes.

Main important remaining problems of the acoustic methods are:

- species identification continues to be the main difficulty because of different aggregation patterns according to the geographical areas and the school composition (mono or multi-specific) and in addition, there is indication that school behaviour evolves over time;
- allocation methods continue not to be automatic but are used by participants according to their experience and biological reality and it seems to be the best for the time being;
- real uncertainties exist about allocation, mainly when big schools are concerned;
- all participants tried to update their methodologies according to the progress gathered during the last 10 years (school characterisation/classification and the use of complimentary frequencies). Nevertheless, these improvements in the methodology are used as auxiliary tools and the process continues not to be automatic;
- the group has expressed doubts on the usefulness of the value for the standard TS proposed for clupeids (−71.2 dB) by the 1998 Planning Group on Acoustics. It recommends checking the literature to explore the most suitable TS relationships that could be used for the two target species (sardine and anchovy). A revised relationship will be suggested at the next WG meeting.

As for the comparison and integration of both acoustic and egg production methods, this first WG has concluded that main research lines to establish a framework in which to compare both methods are:

- comparison of spawning areas defined from acoustic and ichthyoplankton surveys, both in terms of absolute estimates of spawning area and in distribution;
- comparison of spatial distribution of biomass derived from both methods, and interpretation of results in relation to environmental/oceanographic conditions;
- intermediate approaches between pure acoustic/ichthyoplankton based estimation procedures:
  - iii) comparison between species allocation from hauls to egg proportions (when targeting species at spawning time),
  - iv) comparison of total energy allocated to a single species with total egg production of the same species.

9 Recommendations

In relation to egg production based methods;

- the WG recommends that POFs ageing for the anchovy in Bay of Biscay should be revised as soon as possible before the next meeting
- the WG recommends an analysis of the effect of ephemeral spawning females on the spawning frequency estimates for both sardine and anchovy.
- the WG recommends that the protocol proposed to overcome the problems of P0 estimation in the context of spatial heterogeneity of the egg and adult parameters is followed until further clarification of these problems is achieved.
- the WG recommends that an exploration of the influence of a spatially changing Z on the final Ptot should be pursued together with an evaluation of the

improvement that can be achieved through the application of GAM spatial modelling of Z.

- the WG recommends standardizing the integration of CTD in the CALVET towing system (fast CTD recording systems).
- the WG recommends studies on the vertical distribution of sardine and anchovy eggs (both observations and modelling), in order to deal with the egg incubation temperature and use of CUFES as an unbiased egg sampler.

In relation to acoustic estimation:

- the WG recommends checking the literature to explore the most suitable TS relationships that could be used for the two target species (sardine and anchovy), and that a revised relationship should be suggested at next WG meeting
- the WG recommends to do as many as possible fishing operations when echo-traces are present, even if they are not thought to be the target species
- the WG recommends to store all available frequencies if possible. Minimum acquisition threshold to be kept at −80dB. For processing fish abundance the threshold will be −60dB
- the WG recommends to store acoustic data at standard HAC format in order to be able to come back on historical data as soon as new techniques or processing tools are becoming available (multi-frequency, multi-beam, AICASA, etc.)

In relation to other variables collected both in the acoustic and ichthyoplankton surveys, the WG recommends:

- to standardise the environmental data continuously recorded in relation to the CUFES sampler
- a minimum set of environmental variables must be acquired during the surveys, ensuring maximum degree of synopticity, for example using multiprobe instruments. This set of variables should include:
  - i) meteorological information during the cruise from the meteorological station on board
  - ii) surface temperature, salinity and fluorescence from the continuous underway sampler on board
  - iii) temperature, salinity and fluorescence profiles at selected hydrographic stations
  - iv) plankton samples from WP2 (with 80 and 200 µm) to obtain depth-integrated (from the surface down to 5 m above the bottom) plankton biomass and taxonomic composition (at the level of genera could be enough). It would be desirable to obtain size-fractionated biomass for at least <200, 200–2000 and >2000 µm)
- if possible, an extended series of other relevant variables should be acquired:
  - i) by means of a rosette sampler it is possible to obtain water samples at certain depths for the analysis of nutrient salts and pico- and phytoplankton composition (at least to define the relative ratios among the main phytoplankton groups). This information is relevant to define the nutrient status of the ecosystem (position of the nutricline, oligo- to eutrophic conditions)
  - ii) it would be desirable to obtain zooplankton samples at specific depths by means of multinet system with an automatic open-close mechanism. This will provide information about the distribution of zooplankton groups in the water column, that can be relevant for instances in relation to the behaviour of fish schools and aggregation of larvae and juveniles and, in more-oriented methodological-technical issues such as the discrimination of plankton in the echotraces.
- The WG recommends to the participants the collection of data on top predators in the pelagic community. These data are already being collected by CRMM (Centre

de Recherche sur les Mammifères Marins) in collaboration with IFREMER and SPEA (Sociedade Portuguesa para o Estudo das Aves) in collaboration with IPIMAR but not by IEO in the PELACUS survey at present.

In general terms, the WG recommends:

- exchange of acoustic and egg data from surveys before next meeting, in order to produce synoptic images of the different surveys at a global and similar scales and of their estimates in space
- to ensure that comparable auxiliary information in both acoustic and egg surveys is obtained to facilitate the comparison of the results from both methods (such as information from CUFES and hydrographic and environmental data). Particularly the use of CUFES is recommended as a common additional sampler for both methods.

9.1 WGACEGGS 2006 meeting

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 Lisbon, Portugal, from 27 November – 1 December 2006 to:

c) plan and coordinate egg surveys in ICES areas VIII and IX and standardise analysis procedures;

d) plan and coordinate acoustic surveys in ICES areas VIII and IX and standardise analysis procedures;

e) develop a framework to cross-validate egg production and acoustic methods for the estimation of Spawning Stock Biomass and its distribution;

f) explore the possibilities to integrate egg production and acoustic based Spawning Stock Biomass estimates;

g) finalise new egg production procedures and associated software developed under SGSBSA;

h) 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 22 December 2006 for the attention of the Living Resources Committee, and ACFM.

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 standardise, 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 standardise 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 standardising 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) Finalise 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, SGRESP
Linkages to other Organizations:	Other countries/institutions applying the DEPM, or carrying out integrated acoustic-egg surveys worldwide.

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Annex 1: List of participants

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Annex 2: List of Working Documents and Presentations

List of WG Documents:

G. Costas, A. Lago de Lanzós, F. Baldó, C. Franco and P. Cubero. Comparison of CUFES and CALVET results in SAREVA 0405.

K. Granias, C. Nunes and Y. Stratoudakis. Structural changes during the degeneration of the postovulatory follicles of sardine and factors which affect it.

A. Lago de Lanzós, Baldó F., Franco C., Cubero P., Costas G., Cabanas J.M., Reguera I. and Bernal M. Preliminary Results of Sardine Daily Egg Production off the northern coast of Spain in April 2005.

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Mª Paz Jiménez, M. Bernal and G. Costas. Anchovy DEPM survey in the Gulf of Cadiz: BOTSDEVA-0605. Egg Sampling: Methodology and Preliminary results.

Mª Paz Jiménez, G. Costas and M. Bernal. Characterization of the Anchovy Spawning Area in the Gulf of Cadiz. (not yet ready !!!).

M. Santos, L. Ibaibarriaga, P. Alvarez and A. Uriarte. Anchovy DEPM estimates 2005 in the Bay of Biscay.

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