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Report of the Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VIII and IX (WGACEGG)

22-26 November 2010

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CIEM Conseil International pour l'Exploration de la Mer

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Executive summary

The Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VIII and IX (WGACEGG) met at Palma de Mallorca, Spain, 22–26 November 2010, being hosted by M. Iglesias of the Spanish institute of Oceanography (IEO) and chaired by A. Uriarte (Spain). There were 21 participants from 4 countries (France, Portugal, Spain and UK) contributing to the ToRs of the meeting. Prior to this meeting a Joint AcousMed project / ICES WGACEGG Workshop on Geostatistics (WKACUGEO), chaired by Marianna Giannoulaki, Greece, and Pierre Petitgas, France, took place for 2 days (20–21 November). And in addition at the start of WGACEGG a joint session with AcousMed project was carried out on reviewing target strength of sardine and anchovy and on Day-Night differences in acoustic sampling. These initiatives seek for expanding the cooperation of WGACEGG with similar groups dealing with acoustic and egg surveys of small pelagics in the Northeast Atlantic, in order to share knowledge and experience among the members of these groups. As such, AcousMed project, which aims at the harmonization of the acoustic data in the Mediterranean, was contacted to close cooperation through workshops and joint sessions on acoustics. Given the positive result of this experience the WG endorsed the continuation of these common initiatives at least every two years.

WGACEGGs pursues to plan, coordinate and review acoustic and egg surveys in ICES Areas VIII and IX and standardize analysis procedures; this includes updating on innovations on sampling and estimation methods for DEPM and acoustics: and, in the long term, to develop a framework to cross-validate and integrate egg production and acoustic methods for the estimation of Spawning stock biomass (ToRs 1 to 3).

The surveys reported to the WG are in the text Table below. In spring 2010, there was a complete coverage of the pelagic ecosystem by acoustic surveys of IPIMAR, IEO and Ifremer from Cadiz to French Brittany. As in previous years, the surveys reveal that sardine abundance is about an order of magnitude higher than that of anchovy across the whole subareas IX and VIII. Sardine abundance is similar in subarea VIII as in last year 2009, but shows a decreasing trend in Portuguese waters form 294,000 t in 2009 to 179,000 t in 2010 (particularly in the southwestern region). For anchovy, the surveys suggest a recovery of biomass levels compared with previous years in the Bay of Biscay, a positive tendency which was also observed in the DEPM (BIOMAN) in this region. However in Cadiz a drop was noticeable both in the Portuguese acoustic survey, as in the Spanish ECOCADIZ survey. This is the third year of consecutive drop in anchovy biomass.

This year these acoustic surveys were partly expanded to the North by an experimental acoustic survey which was carried out by Cefas focusing on the population dynamics of anchovy and sardine in the Celtic Sea shelf area and western Channel (VIIe-j). It was yet experimental and therefore only qualitative description of sardine distribution was made available from the survey. Cefas will undertake a dedicated acoustic research survey in the area in 2011 which should serve to expand the current coverage from Cadiz up to Subdivisions VIIe-h, j.

In autumn 2010, the acoustic survey for juveniles in the Bay of Biscay, recorded the highest abundance of anchovy juveniles since the beginning of their series (Section 4.4). In addition results of the ECOCÁDIZ-RECLUTAS 1009 survey were reported which showed its capability to a successful assessment of the juveniles of sardine anchovy in the Gulf of Cadiz.

Coordination for the 2011 acoustic and DEPM surveys was made (Section 5), including now the Triennial egg survey for Sardine, which will be this time expanded to the whole area VIII thanks to a concerted action of AZTI and IEO. The spring acoustic surveys will include the new survey made by Cefas, PELTIC11, in Subdivisions VIIe-j, h. In autumn, JUVENA survey will be the sole survey on the assessment of anchovy juveniles. The standard procedures for the implementation of the acoustic and DEPM surveys have been summarized respectively in two annexes to this report (Annex 6 and 7).

Since 2008, this working produces a common Regional database (from the Acoustic+CUFES and Pairovet sampling) of the Spring and Autumn surveys, with common format (spatial resolution or grids, units etc), in or order to allow a synoptic regional representation (by maps and graphics) of the spatial distribution, abundance and population structure of sardine and anchovy in relation to the pelagic ecosystem for ICES areas VIII and IXa (see Section 4.4, answering Long ToRs 4 and 5). A joint publication of the results of these surveys in the period 2005–2010 along with a crossed analysing of results concerning the spatial distribution of these species will be pushed ahead by the group during 2011.

In order to assure the quality of the surveys, several methodological issues for acoustic and DEPM methods were discussed during the meeting: For the DEPM: Updates on the revision of the series of Biomass from the DEPM surveys for anchovy in the Bay of Biscay and for sardine around the Iberian Peninsula were reported, but the work is to be finished for the next WG. For the Acoustics: Progress on the Intercalibrations of the RV "Thalassa" and RV "Noruega", off northern Portugal which took in April 2008 and in 2009 were reported, along with the inter-ship calibration during JUVENA2010 survey and the Inner calibration of Portuguese acoustic survey by Echo-integration of selected parts of bottom transects along the whole time-series. Advances in abundance estimation and morphological description of surface fish shoals achieved by using the ME70 multibeam echosounder were described. Dedicated workshops to go through the revisions of the DEPM and acoustic calibration issues are foreseen for next year.

WGACEGG will answer during 2011 the required input for methods for delivery information about the length structure of stocks in response to the MSFD requirements of GES (Good environmental status) descriptor 3.3, besides some advance discussion is presented.

Table: Surveys covered in WGACEGGs during 2010 meeting.

Country	Spring Acoustic Surveys	Month	Divisions and SubDivisions
UK	PELTIC 10	6	VIIe-j.
France	PELGAS 10	5	VIIIa, VIIIb, VIIIc (East)
Spain	PELACUS0410	4	IXa Noth, VIIIc
Porgual	PELAGO 10	4	IXaCentral N., S., IXa South
Spain	ECOCÁDIZ-COSTA 0709	7	Ixa South
Spain	ECOCÁDIZ 0710	7	Ixa South

Country	Spring DEPM Surveys	Month	Divisions
Spain	BIOMAN 2010	5	VIIIa , VIIIb, VIIIc (East)

Country	Autumn Acoustic Surveys	Month	Divisions
Spain	JUVENA 2010	9	Subarea VIII
Spain	ECOCÁDIZ-RECLUTAS 1009	10	Ixa South

1 Opening of the meeting

The 2010 meeting of WGACEGG was opened at Palma de Mallorca (Spain), on the morning of Monday 22 November with a Joint session with AcousMed project (second Meeting) on Target Strength estimation (WP3.1).

The meeting had been preceded by a Joint AcousMed project / ICES WGACEGG Workshop on Geostatistics (WKACUGEO), chaired by Marianna Giannoulaki, Greece, and Pierre Petitgas, France, at Palma de Mallorca, Spain, 20–21 November.

WGACEGG took place in parallel for the first three days with the meeting of AcousMed (Project Coordinator: Marianna Giannoulaki HCMR), which is a project that aims at the "Harmonisation of the acoustic data in the Mediterranean 2002–2006". For this reason, members of WGACEGG working mainly on acoustics past most of their times in Monday and Tuesday attending AcousMed meeting, as their objectives are common to those of WGACEGG. These two days were used by the rest of the members of WGACEGG to go over the DEPM issues of WGACEGG.

A total of 21 attendees (Annex 1) followed WGACEGG meeting. More people (24) attended the joint session with AcousMed project.

The presentation of this year ToRs and the discussion of the draft Agenda (Annex 2) were made on the afternoon of the same day.

2 Adoption of the agenda

The Agenda for WGACEGG 2010 meeting was adopted by consensus and it was used to organize the WG scientific presentations, discussions and report writing (see Annex 2 cont… for the actual agenda).

3 Introduction

3.1 Terms of Reference

Long-term Terms of Reference:

1) Plan, coordinate and review acoustic and egg surveys in ICES Areas VIII and IX and standardize analysis procedures;

2) Update on innovations on sampling and estimation methods for DEPM and acoustics;

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

4) Produce an annual synoptic overview of distribution, abundance and population structure of sardine and anchovy in relation to the pelagic ecosystem for ICES areas VIII and IXa;

5) Integrate biological/environmental information from surveys and additional sources to improve the understanding of the spatial distribution and dynamics of sardine and anchovy in relation to the pelagic ecosystem in ICES Areas VIII and IXa.

2010 Short Terms of Reference:

a) Compare Intra and Inter survey variations in bottom integration, with repeated measurements of the same bottom subset and if possible at different speeds (including the intercalibration between "Thalassa" and "Noruega" in 2008 and 2009);

b) Consolidate the database for 2008–2010 and to prepare a joint publication on the spatial distribution of the small pelagics in the South East of Europe;

c) Report on the results of the 2010 surveys: Acoustics (Sardine and anchovy all areas) and DEPM (Anchovy in the Bay of Biscay Spring), and for juveniles (with acoustics for anchovy in BoB in autumn);

A final ToR was added as requested by SICOM:

d) Prepare methods for delivery of the following information to assessment working groups in 2012:

  i) Proportion of fish larger than the mean size of first sexual maturation

  ii) Mean maximum length of fish found in research vessel surveys

  iii) 95th % percentile of the fish length distribution observed

3.2 Links with other groups

WGACEGG is placed in ICES within the SCICOM in the context of the Steering Group on Ecosystem Surveys Science and Technology (SSGESST), but in addition it is naturally linked with other groups:

It provides/revises abundance estimates from surveys (acoustics and DEPM) and standardizes protocols. This work has a strong link with WGANSA, which deals with assessment of sardine and anchovy within ACOM. The fact that WGANSA meets prior to WGACEGG and makes use of survey estimates prior being reviewed by WGACEGGs, pushes the latter group to report more on protocols and methods because many estimates are in advance delivered in the former group. According to that, standardization, documentation and incorporation of any improvements of methods applied on Acoustic and DEPM surveys has to be one of the basic goals one of the WGACEGGs, assuring the quality of inputs for assessment and coordination of surveys related to WGANSA. Given the strong link between the two Working Groups, methods of surveys and justification for changes and revisions of survey series should be better allocated to and referenced from the WGACEGG report.

A major objective of WGACEGG is to plan surveys and standardize protocols at regional scale for egg and acoustic surveys as well as provide ways for integration of these. There are potential links with WGFAST in particular acoustic methodological questions. There are also potential links with PGEGGS and WGMEGGS on matters that are cross-cutting for egg surveys. A Working Group TGISUR has been set up in ICES to steer all survey groups and WGACEGG could therefore actively contribute to TGISUR work.

WGACEGG also compiles data at regional scale on fish and egg distributions as well as on basic environmental parameters (CTD).This work has a strong input to ecological analysis dealing with habitat mapping (in particular spawning habitats), climate change, species interactions, physical-biological interactions. On these topics the list of groups for potential interaction is ample, as for instance: WGFE, WGOOFE, SGCC, WGPBI, and the new Standards in Ichthyoplankton Surveys (SIPS). And from 2010 onwards the following group will start operating with which a natural collaboration can be expected to happen: WGEAWESS: ICES Working Group for Ecosystem Assessment of Western European Shelf Seas.

The working group discuss and agree to cooperate with SGSIPS in the elaboration of synthesis paper about the "Standardizing ichthyoplankton surveys: review of methods" for which due coordination was established with the Chair of that group (Cindy van Damme). In addition the WG endorses the recommendation of SGSIPS numbers 3 and 4 about the Manuals of the different ichthyoplankton surveys to update them regularly and place them in an ICES public folder (see recommendations).

Among the groups outside ICES there are two which deserve special attention to WGACEGG give the strong coincidences in their area of interests, and for which cooperation is desired and progressing at different stage:

DCR/MEDIAS Acoustic methods standardization Actions: Common participants and Attendees and Chairs in contact. As such, there was an initiative within WGACEGGs to carry out a joint workshop on the use of geostatistics for acoustics variance prior this WGACEGG 2010. The Joint AcousMed project / ICES WGACEGG Workshop on Geostatistics (WKACUGEO), chaired by Marianna Giannoulaki, Greece, and Pierre Petitgas, France, took place at Palma de Mallorca, Spain, 20–21 November, just prior to our ordinary meeting. And the report of the workshop is made apart of this WG report.

In addition the connections with this project (AcousMed) were strengthened by sharing part of the meeting session of our groups. As such, WGACEGG took place in parallel for the first three days with the meeting of AcousMed (Project Coordinator: Marianna Giannoulaki HCMR), which is a project that aims at the "Harmonisation of the acoustic data in the Mediterranean 2002–2006". For this reason, members of WGACEGG working mainly on acoustics past most of their times in Monday and Tuesday attending AcousMed meeting, as their objectives are common to those of WGACEGG. Given the successful development of the joint sessions, it is the intention of both WG to continue this type of collaboration, considering the potential for repeating the experience every two years by meeting in a common place and sharing joint sessions.

COST/FRESH DEPM reproductive parameters, which has a lot of synergies with WGACEGG in all related with reproductive biology of relevance to the application of the DEPM. As such, in 2010 a joint workshop took place as a result of prior coordinated initiatives arising from COST and WGACEGGs: ICES-FRESH Joint Workshop on Egg Production Methods for Estimating Fish Biomass (WKEPM). Heraklion, Crete, Greece, 10–13 March 2010 (see report in ICES CM 2010/SSGESST:04.)

3.3 Report structure

The report is structured in six big blocks:

- First the introductory chapters (1–3) appear up to here concerning the agenda, terms of reference and links with other groups, setting the role of the working group within ICES or even the connections with groups beyond ICES. In addition, in this introductory section we described the coordinated activities we have carried out during this year with project ACOUSMED: a) The Joint AcousMed project / ICES WGACEGG Workshop on Geostatistics (WKACUGEO), chaired by Marianna Giannoulaki, Greece, and Pierre Petitgas, France, which is briefly summarized in Section 3.4 and b) the Joint sessions with AcousMed on TS and fishing hauls during Acoustic surveys, which is mentioned briefly in Section 3.2 (and afterwards reported in Section 7.2.5).

- Next the Acoustic and Egg surveys are described in Chapter 4, including here the structure of the database being generated at this working group (Section 4.4) according to **short ToRs c**. Acoustic surveys in the first half of 2010 (Section 4.1) are followed by the description of the DEPM surveys applied in the same period (Section 4.2) and finally by the acoustic surveys in autumn 2010 Section 4.3. This serves to answer **Long ToRs 1**, **4** and **5 in 2010**. The Common Data base from Surveys on pelagics in Subareas VIII and IX is presented in Section 4.5 along with grid common maps. And finally experimental sentinel French surveys are presented in Section 4.5.
- Chapter 5 detail the Planning and coordination of surveys in 2011 (including in addition to the acoustic surveys the coordination for the triennial DEPM survey for sardine in 2011; **Long ToRs 1**)
- In chapter 6 Any Revision or update of survey's time-series estimates is presented (**Long ToRs 1**).
- In Chapter 7 goes the review on methodological progress and improvements achieved for the DEPM and Acoustic surveys (in Sections 7.1 and 7.2 respectively), answering thus **Long ToR 2**. In this chapter there are subsections for reporting the Inter-calibration of acoustic surveys (**short ToRs a**) and the Joint sessions with AcousMed on TS and fishing hauls during Acoustic surveys (Section 7.2.5). Finally sections for reporting on the progress to produce on Indicators from Pelagic Surveys on length structure of pelagic populations for GES monitoring (Section 7.3) and about the sardine benchmarking foreseen for 2012 (Section 7.4) are presented.
- And in chapter 8 the Progress in Cross-validation and integration of acoustic and egg production surveys are reported. This shows the work towards answering **Long ToR 3**, although no further work was made in 2010 and no advances can be reported.

Finally the conclusions and references follow. And in **Annex 4** the Recommendations are provided. Finally **Annexes 6** and **7** deal with the Protocols for the implementation of acoustic and DEPM surveys for sardine and anchovy in the subareas VIII and IX.

3.4 WKACUGEO and Coordination between Atlantic and Mediterranean acoustic surveys

A workshop took place in Palma before the WGACEGG meeting from 20–21 of November, gathering actors from Atlantic and Mediterranean Sea in order to (see WKACUGEO 2010 report):

a) Apply geostatistical tools on case studies;

b) Evaluate the precision of abundance estimates using geostatistics for a list of MEDIAS- and ICES-coordinated acoustic surveys;

c) Suggest how survey designs can be optimized.

Initially, survey characteristics (e.g. area covered, target species, acoustic methodology applied, existing survey design etc) of each Case Study are presented in summary Tables 3.4.1., and 3.4.2., followed by a respective map of the Mediterranean and the Atlantic (Figure 3.4.1.), indicating the existing survey design. In total 11 Case Studies (5 Case Studies from the Mediterranean Sea, 5 Case Studies from the Atlantic waters and 1 from Tasmania waters) were analysed by the WG. Highly skewed distribution of acoustic data, high percentage of zero values and an increased nugget effect, indicating lack of structure, were some of the problems identified in most Case Studies. Results indicated that the precision of abundance estimates under the current spatial sampling explained most of the variability of the time-series in most Case Studies. Taking into account parameters that often prevent alterations in survey design (e.g. limitations on research vessel availability, extent of area covered and time required for the survey), the precision of abundance estimates under the existing survey design following the assumption of different structure in fish aggregations was also examined.

The workshop was an opportunity to encompass the majority of the European case studies on anchovy and sardine acoustic surveys, standardize data analysis methods for the optimization of survey design of acoustic surveys in ICES and Mediterranean waters and take advantage of the long term ICES expertise on the application of geostatistical analysis.

The workshop was the opportunity to standardize data analysis methods for anchovy and sardine acoustic surveys in ICES and Mediterranean waters. The interest in a joint Atlantic and Mediterranean workshop was to encompass the majority of the European case studies on anchovy and sardine acoustic surveys. A first attempt was done to map the sardine and anchovy presence and abundance as seen by all acoustic surveys in 2009 (Figures 3.4.2. and 3.4.3.). A general need to improve anchovy and sardine acoustic survey designs had been identified by members of the EU-funded project ACOUSMED and ICES WGACEGG and to this purpose geostatistics was considered an appropriate tool. Being involved in Spanish surveys in both Atlantic (ICES) and Mediterranean waters, the acoustic survey team of IEO in Palma de Mallorca was well positioned to host the Workshop.

It was agreed to continue the effort to standardize sampling strategies and plan acoustic surveys in order to have a better global ecosystem approach on pelagic ecosystems and resources. In this objective, it was agreed to organize every two years, both WGACEGG and MEDIAS meetings in the same place and at the same period, in order to have a common methodological and processing approach for acoustic surveys and may be for egg surveys in future.

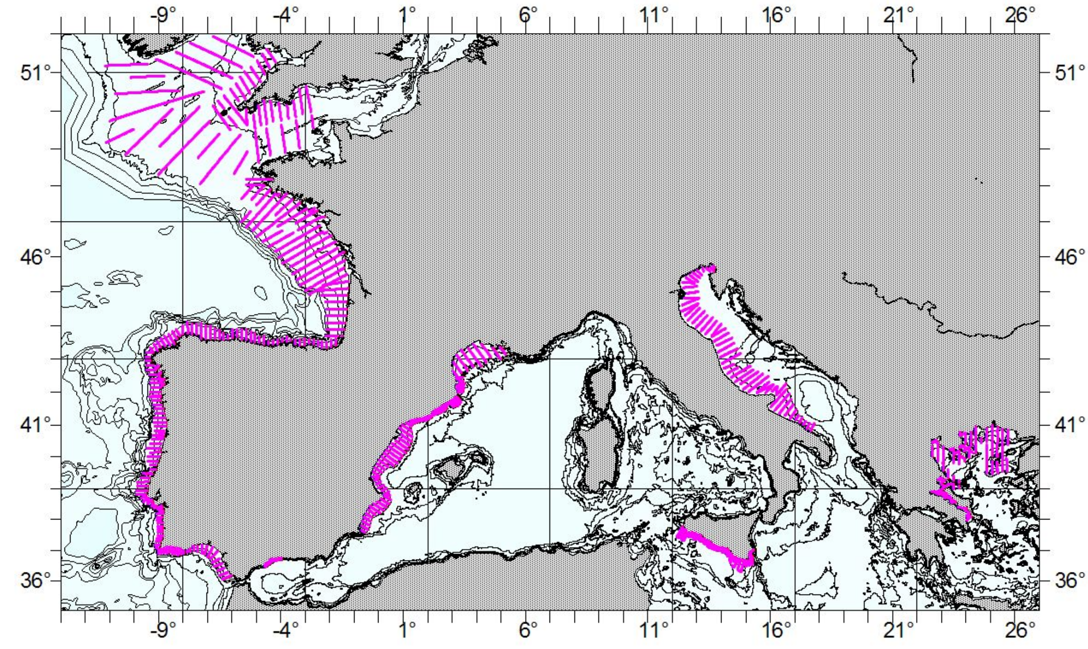


Figure 3.4.1. Transects network of acoustic surveys according to the standardized network already followed by France, Spain, Italy and Greece and planned by UK for 2011.

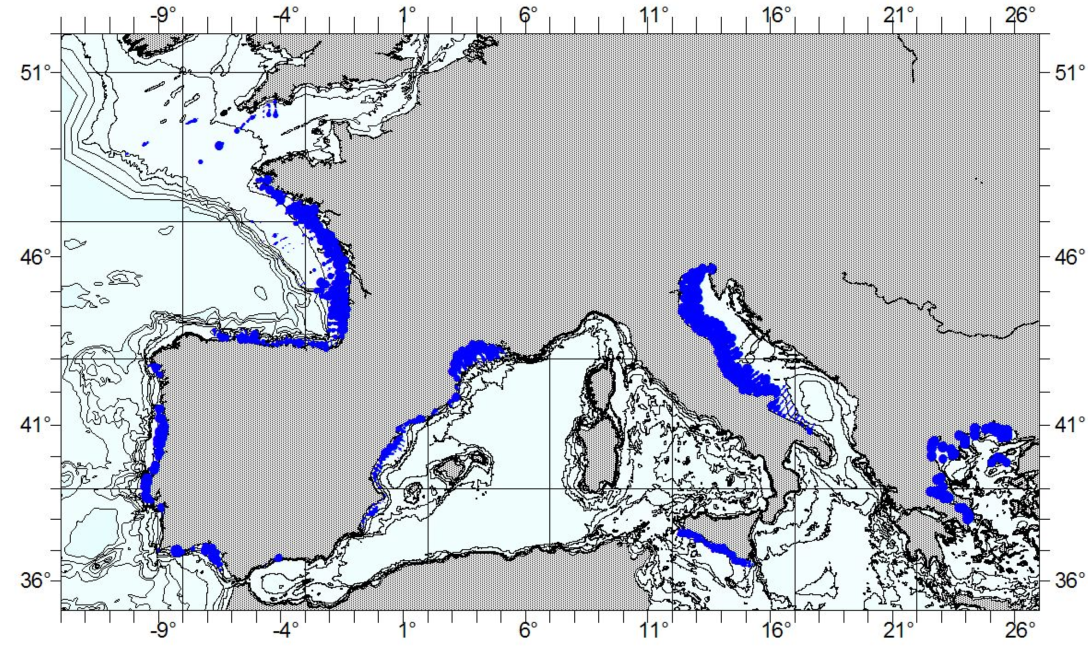


Figure 3.4.2. Acoustic energies (sA in m^2/nm^2) per ESDU attributed to sardine (Sardina pilchardus) during acoustic surveys in 2009 (2010 for Cefas).

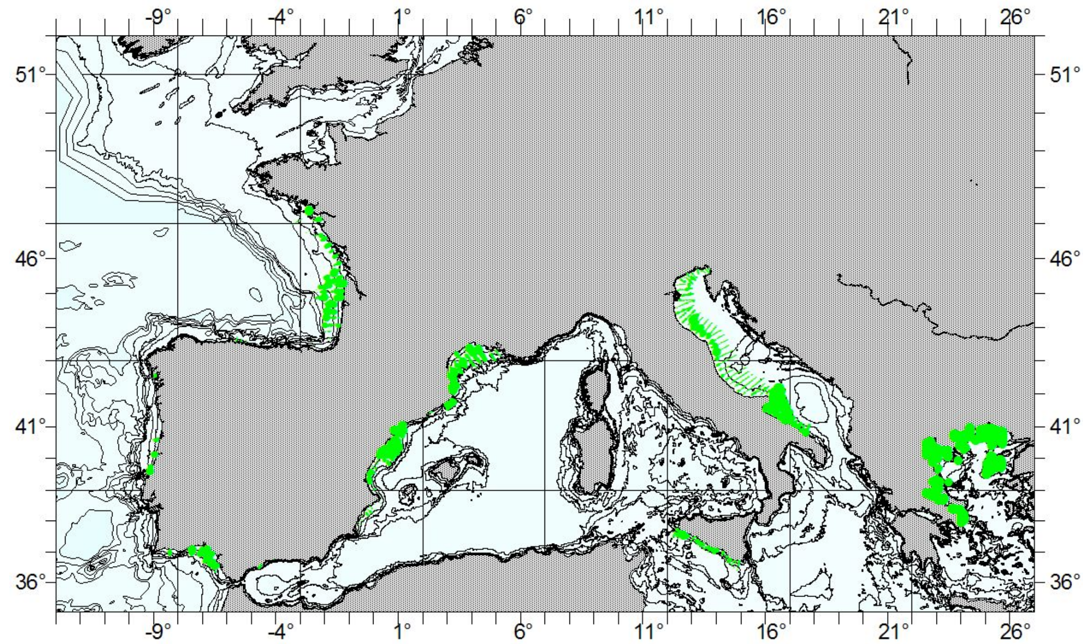


Figure 3.4.3. Acoustic energies (sA in m²/nm²) per ESDU attributed to anchovy (Engraulis encrasicolus) during acoustic surveys in 2009 (2010 for Cefas).

Table 3.4.1. Summary table of case studies in the Mediterranean Sea.

Survey Identity	Greece - Aegean Sea	Italy - Adriatic Sea	Italy – Sicily Channel	France - Gulf of Lions	Spain - Iberian Coast
Geographic area	northern Aegean Sea	Western side (Italy)	Strait of Sicily	Gulf of Lions	Spanish Mediterranean Sea (continental shelf)
Size of Area covered (NM2)	9 000 NM2	About 15000 nm2	2680 nm2	3 300 NM²	23742 Km2
Days at sea	40	41	10	20	31
Period of survey	June-July	July - September	July	July	November-December
Echo sounder	Biosonic DTX (Split-beam)	Simrad EK60 (Split-beam)	Simrad EK60 (Split-beam)	Simrad ER60 since 2006 (Split-beam)	Simrad EK60 (Split-beam)
Frequency for assessment (kHz)	38	38	38	38	38 kHz
Threshold for assessment (dB)	-70	-70	-60	-60	-60 dB
Survey design					
Transects design	Perpendicular to bathymetry, zig-zag inside the gulfs	Parallel grid, perpendicular to the coastline/bathymetry	Parallel transects and perpendicular to bathymetry	Perpendicular to the coastline/bathymetry	Perpendicular to the coast
Inter-transect distance (nm)	10 NM	10 NM and 8 NM in narrow shelf areas	4–8 NM	12 NM	8 NM in wide continental shelf, 4 NM in narrow shelf
Transect length (min – max)	10 – 70 nm				
Time of day for acoustic sampling	Daytime	Daytime and night-time	Daytime and night-time	Daytime	Daytime
EDSU (NM)	1 NM	1 NM	1 NM	1 NM	1 NM
Min Bottom depth sampled (min, m)	10 m	10 m	10 m	10 m	30 m

Survey Identity	Greece - Aegean Sea	Italy - Adriatic Sea	Italy – Sicily Channel	France - Gulf of Lions	Spain - Iberian Coast
Echo sounding depth (max, m) recording.	230	250	300	200	200–220
Vessel speed	7 kn	9–10 kn	9–10 kn	8 kn	10 kn
Echo partitioning into species	Echo trace classification based on echogram visual scrutinisation and allocation on account of representative fishing station	Frequencies comparison, catch of pelagic trawl, TS analysis when needed	Visual analysis of echogram and from results of control trawl	Echo trace classification based on echogram visual scrutinisation and allocation on account of representative fishing station	Allocation on account of representative fishing station (sometimes direct allocation).
Abundance indices estimated	Total fish NASC per EDSU Anchovy, Sardine NASC per EDSU	Total pelagic biomass and biomass per species per area	Total fish NASC per EDSU Anchovy, Sardine NASC per EDSU	Pelagic biomass and biomass per species, Biomass per nautical mile	Total fish NASC per EDSU Anchovy, Sardine NASC per EDSU
Target species	Anchovy Sardine	Anchovy, sardine	Anchovy and Sardine	Anchovy and Sardine	Sardine, anchovy
Other species	Horse mackerel Mackerel Gilt sardine	Sprat, atl. Mackerel, horse mackerel, chub mackerel, bogue, gilt sardine, pickerel	Mackerel, Sardinella, Horse mackerel	All pelagics	Trachurus mediterraneus, bogue, sardinella, Scomber colias and Scomber scombrus.

Table 3.4.2. Summary table of case studies in the Atlantic and Tasmania.

Survey Identity	Gulf of Cadiz – IEO	Atlantic - AZTI	PELACUS - IEO	Bay of Biscay PELGAS - Ifremer	Cefas	Tasmania - CSIRO
Geographic area	Gulf of Cadiz	Bay of Biscay	Atlantic Spanish waters and Cantabrian Sea	Bay of Biscay French shelf	Western Channel - Celtic Sea	Tasmania
Size of Area covered (NM2)	3618 nm2	40000 nm2	6614 nm2	~30000 nm²	~50000 nm2	
Days at sea	10–15	30	20–25	30–40	22	60
Period of survey	June-July	Autumn	March-April	Spring	May-June	June-August
Echo sounder	Simrad EK60 (Split-beam)	Simrad EK60 (Split-beam)	Simrad EK60 (Split-beam)	Simrad ER60 since 2006 (Split-beam)	Simrad EK60 (Split-beam)	Simrad ES60, ES38B 7 degree split-beam transducer
Frequency for assessment (kHz)	38	38	38	18, 38, 70, 120, 200 + multibeam (70 to 120)	38	38
Survey design						
Transects design	systematic grid with tracks perpendicular to coast	Parallel grid, perpendicular to the coastline/bathymetry	Parallel transects and perpendicular to bathymetry	Perpendicular to the coastline/bathymetry	Transects, perpendicular to coastline/bathymetry, stratified	Many opportunistic grid surveys of localized schools and 1–2 broadscale surveys of entire 100 NM spawning grounds
Inter-transect distance (nm)	8 NM	17 NM (2003 – 2005) and 15 NM (since 2006)	8 NM	12 NM	10 and 20 NM	Adaptive, typically between 0.3 and 1 NM
Transect length (min – max)	4- 21 nm	30- 100 nm	4- 27 nm	25 – 95 nm	16–150 NM	3–5 NM
Time of day for acoustic sampling	Daytime	Daytime	Daytime	Daytime	Daytime	Day and Night
EDSU (NM)	1 NM	0.1 NM	1 NM	1 NM	1 NM	0.1 NM
Min Bottom depth sampled (min, m)	20 m	15 m	10 m	20 m	15m	300 m
Echo sounding depth (max, m) recording.	200	200	300	200	200	700 m
Vessel speed	10 kn	7 – 10 kn	10 kn	10 kn	10kn	10 kn

Survey Identity	Gulf of Cadiz – IEO	Atlantic - AZTI	PELACUS - IEO	Bay of Biscay PELGAS - Ifremer	Cefas	Tasmania - CSIRO
Echo partitioning into species	Allocation on account of representative fishing station (sometimes direct allocation).	Allocation on account of representative fishing stations, area stratification based on the homogeneity of the aggregations	Allocation on account of representative fishing station (sometimes direct allocation).	Allocation on account of representative fishing stations and echo types, area stratification based on the homogeneity of the aggregations	Unknown survey will be in 2011.	Visual classification of schools, then assume school regions contain 100% blue grenadier
Abundance indices estimated	Total fish NASC per EDSU Anchovy, Sardine NASC per EDSU	Biomass of anchovy juveniles per EDSU	Total fish NASC per EDSU Anchovy, Sardine NASC per EDSU	Nasc and biomass/esdu/length class/age		Biomass for each survey, maximum biomass in each year then used in assessment
Target species	Anchovy	Anchovy juveniles	Sardine	Anchovy and Sardine	Sardine, Anchovy	
Other species	All pelagics	All pelagics (since 2010)	All pelagics	All pelagics	All pelagics	Blue grenadier (Macruronus novaezelandia)

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

4.1 Spring Acoustic Surveys *(J. Massé et al.)*

4.1.1 Global Overview of Spring Acoustic Surveys: Common methods and sampling approach and general overall maps of species distributions and global results

Three acoustic surveys were carried out from the Bay of Biscay to the Bay of Cadiz during spring 2010:

- PELAGO10 by IPIMAR from the Bay of Cadiz to the North of Portugal (Section 4.1.2).
- PELACUS0410 by IEO from south of Galicia to the south of Bay of Biscay (Section 4.1.3).
- PELGAS10 by Ifremer from the south of the Bay of Biscay to south of Brittany (Section 4.1.4).

This year these acoustic surveys were partly expanded to the North by an experimental acoustic survey – PELTIC10- which was carried out by Cefas, focusing on the population dynamics of anchovy and sardine in the Celtic Sea shelf area and western Channel (VIIe-j). It was yet experimental and therefore only qualitative description of sardine distribution was made available from the survey. This is reported in Section 4.1.5.

In addition there was a summer acoustic survey in Cadiz performed by IEO in June 2010 which will be reported in Section 4.1.6 ECOCÁDIZ0710 (Subdivision IXa South).

The Protocols for these acoustic surveys are described concisely in WGACEGG report 2009 (Annex 6 in 2009 also included in this report**)** for each survey**.**

As the first three surveys (PELAGO10 PELACUS10 and PELGAS10) covered successively from South to North the whole region a synoptic overview of them is made in this introductory section: Acoustic energies, catches and number of eggs (CUFES) were gathered before and during the working group in order to have a joint overview of the results of these surveys. Transects are presented in **Figure 4.1.1.1**. Pelagic hauls were performed in order to identify species according to observed echoes. Catches are presented in **Figure 4.1.1.2**.

Number of nautical miles surveyed and hauls carried out during each survey are presented in **Table 4.1.1.1**. The biomass estimates resulting from acoustic and hauls data are gathered in **Table 4.1.1.2**.

Table 4.1.1.1. Number of nautical miles surveyed and number of identification hauls carried out during spring acoustic surveys (PELAGO10 PELACUS10 and PELAGS10) in 2010.

	NB NAUTICAL MILES	NB HAULS	RATIO
PELGAS10	1 972	103	19.15
PELACUS10	919	62	14.82
PELAGO10	1 032	26	39.69
Total	3 923	191	20.54

Table 4.1.1.2. Biomass estimates calculated for main species during spring acoustic surveys in 2010. The addition in the last lines was done admitting that TS values applied for some species were different in some areas. Coding of the species: PIL-*Sardina pilchardus*, ANE-*Engraulis encrasicolus*, MAC-*Scomber colias*, HOM-*Trachurus trachurus*, MAS-*Scomber scombrus*, SPR-*Spratus spratus*, BOG-*Boops boops*, HMM- *Trachurus mediterraneus*, JAA- *Trachurus picturatus, BWH – Micromesistius poutassou*

	PIL	ANE	MAC	HOM	MAS	SPR	BOG	HMM	BWH	JAA
PELGAS10	457 081	86 354	2 781	11 662	NA	67046	0-	2 853	48 141	0
PELACUS10	41 241	225	957 471	50 382	3 717	-	21 038	3 388	10 429	917
PELAGO10	179 000	8 583	NA	NA	NA	NA	NA	NA		NA

A Synoptic overview of the survey results are shown as follows:

Figure 4.1.1.1. Transects surveyed by PELAGO, PELACUS and PELGAS surveys during spring 2010.

Figure 4.1.1.2. Catches from identification pelagic hauls during PELAGO, PELACUS and PELGAS surveys in spring 2010.

Acoustic energies (sA in m^2/nm^2) per ESDU attributed to adult species:

Figure 4.1.1.3. – anchovy (*Engraulis encrasicolus*)

Figure 4.1.1.4. – sardine (*Sardina pilchardus*)

Figure 4.1.1.5. – Sprat (*Sprattus sprattus*)

Figure 4.1.1.6. – mackerel (*Scomber scombru*s)

Figure 4.1.1.7. - chub mackerel (*Scomber colias*)

Figure 4.1.1.8. – horse mackerel (*Trachurus trachurus*)

Figure 4.1.1.9. – blue chub mackerel (*Trachurus picturatus*)

Figure 4.1.1.10. – (*Trachurus mediterraneus*)

Figure 4.1.1.11. – Blue whiting (*Micomesistius poutassou*)

Figure 4.1.1.12. – Bogues (*Boops boops*)

Number of eggs (nb/m3) per ESDU (3 nautical miles)

Figure 4.1.1.13. – Anchovy eggs

Figure 4.1.1.14. – Sardine eggs

Environmental parameters

Figure 4.1.1.15. – Surface temperature

Figure 4.1.1.16. – Surface salinity

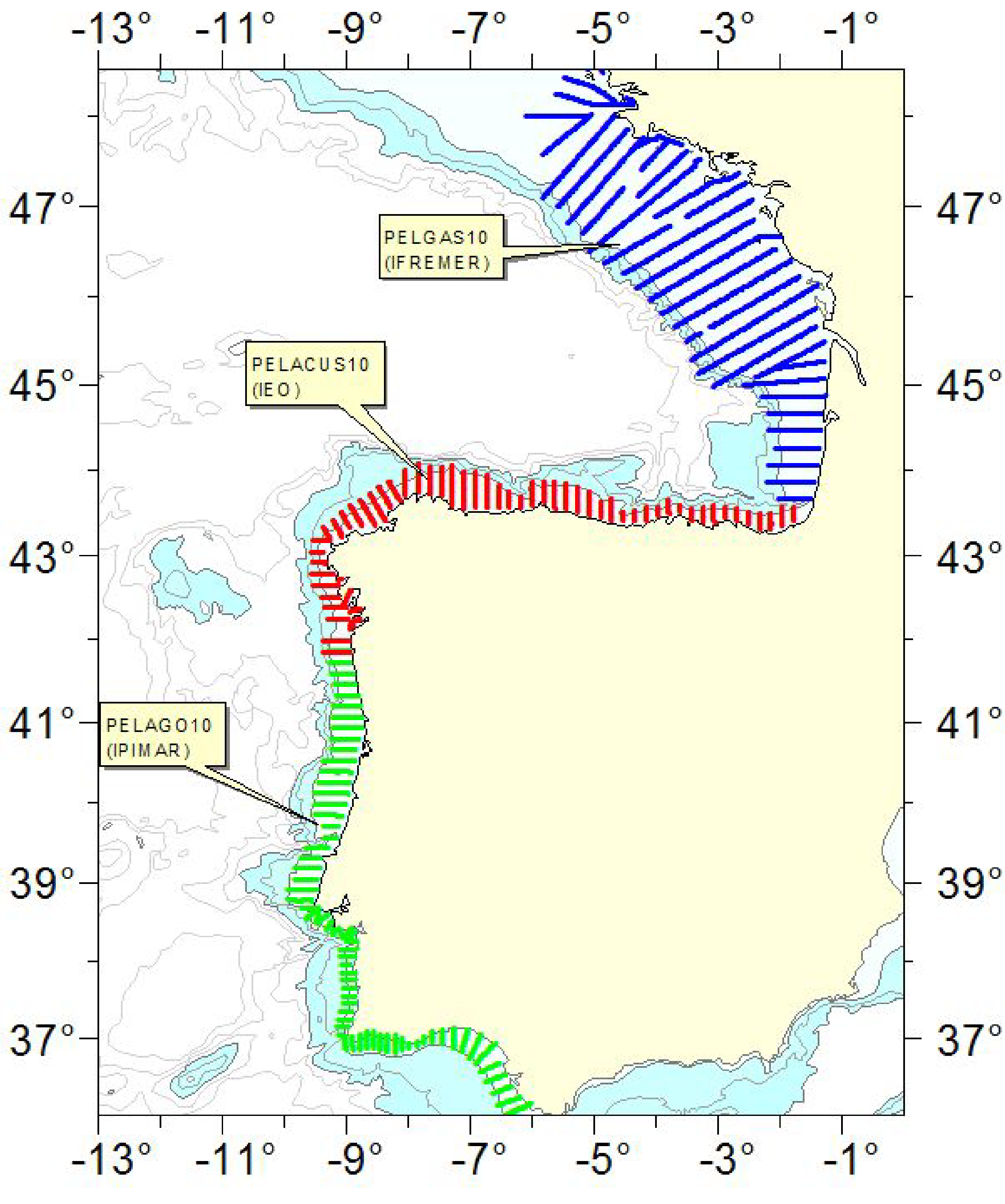


Figure 4.1.1.1. Transects surveyed by PELAGO, PELACUS and PELGAS surveys during spring 2010.

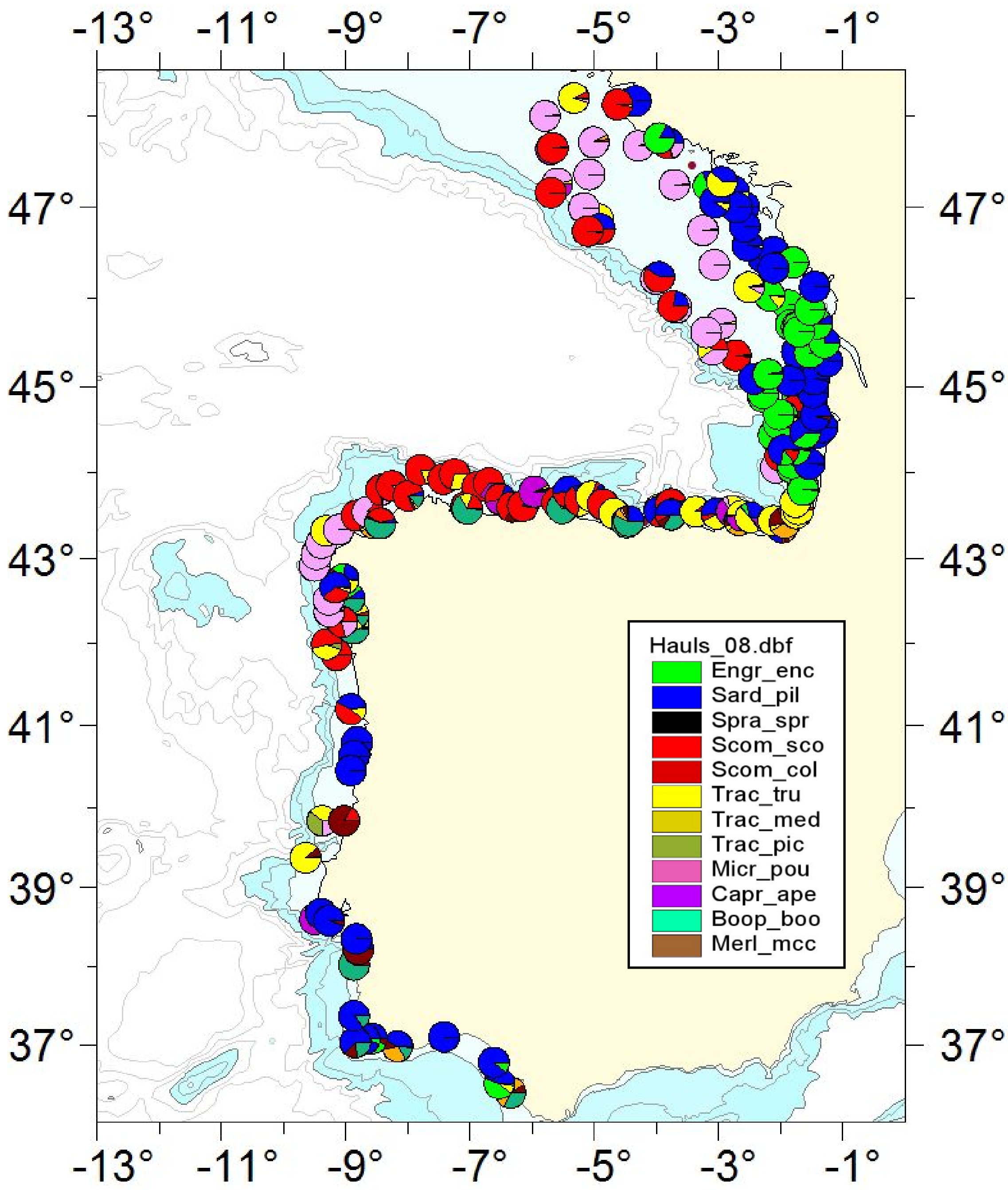


Figure 4.1.1.2. Catches from identification pelagic hauls during PELAGO, PELACUS and PELGAS surveys in spring 2010.

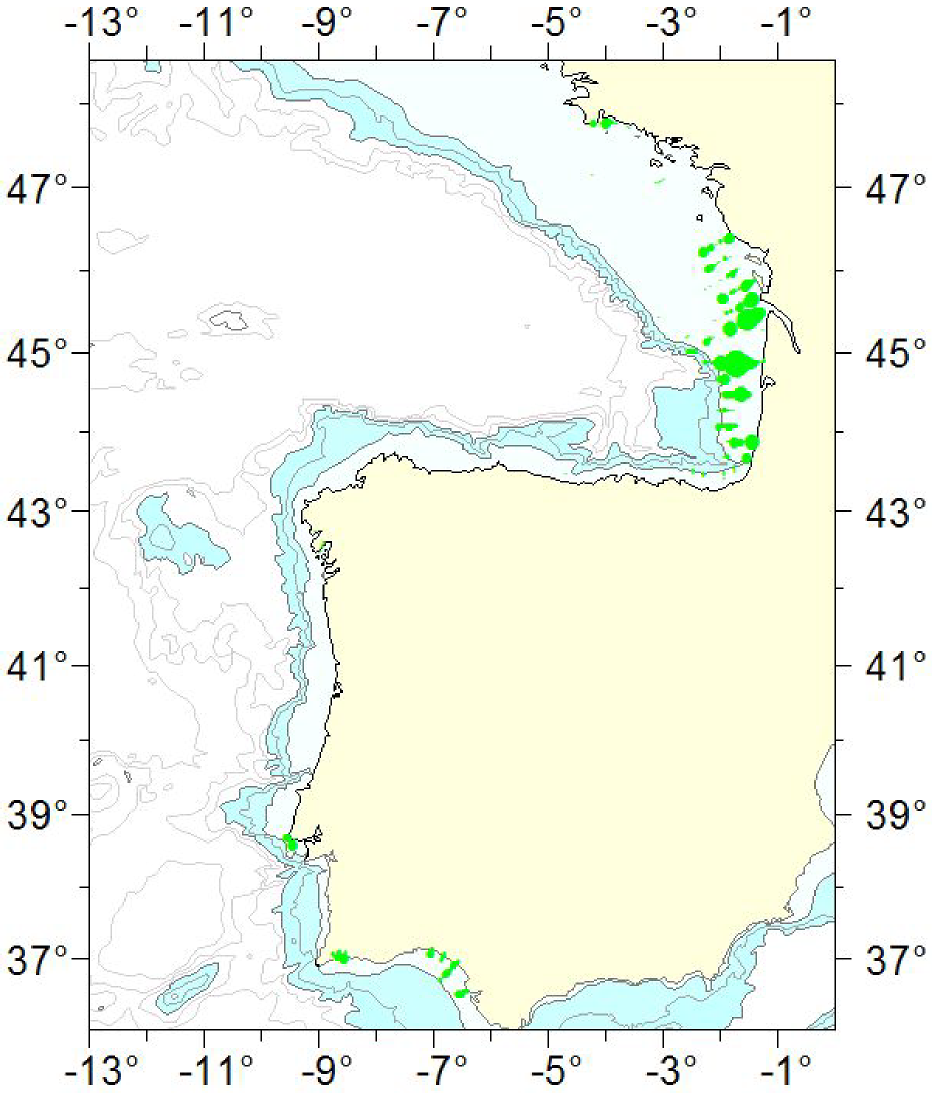


Figure 4.1.1.3. Acoustic energies (sA in m²/nm²) per ESDU attributed to anchovy (*Engraulis encrasicolus*) during PELAGO, PELACUS and PELGAS surveys in spring 2010.

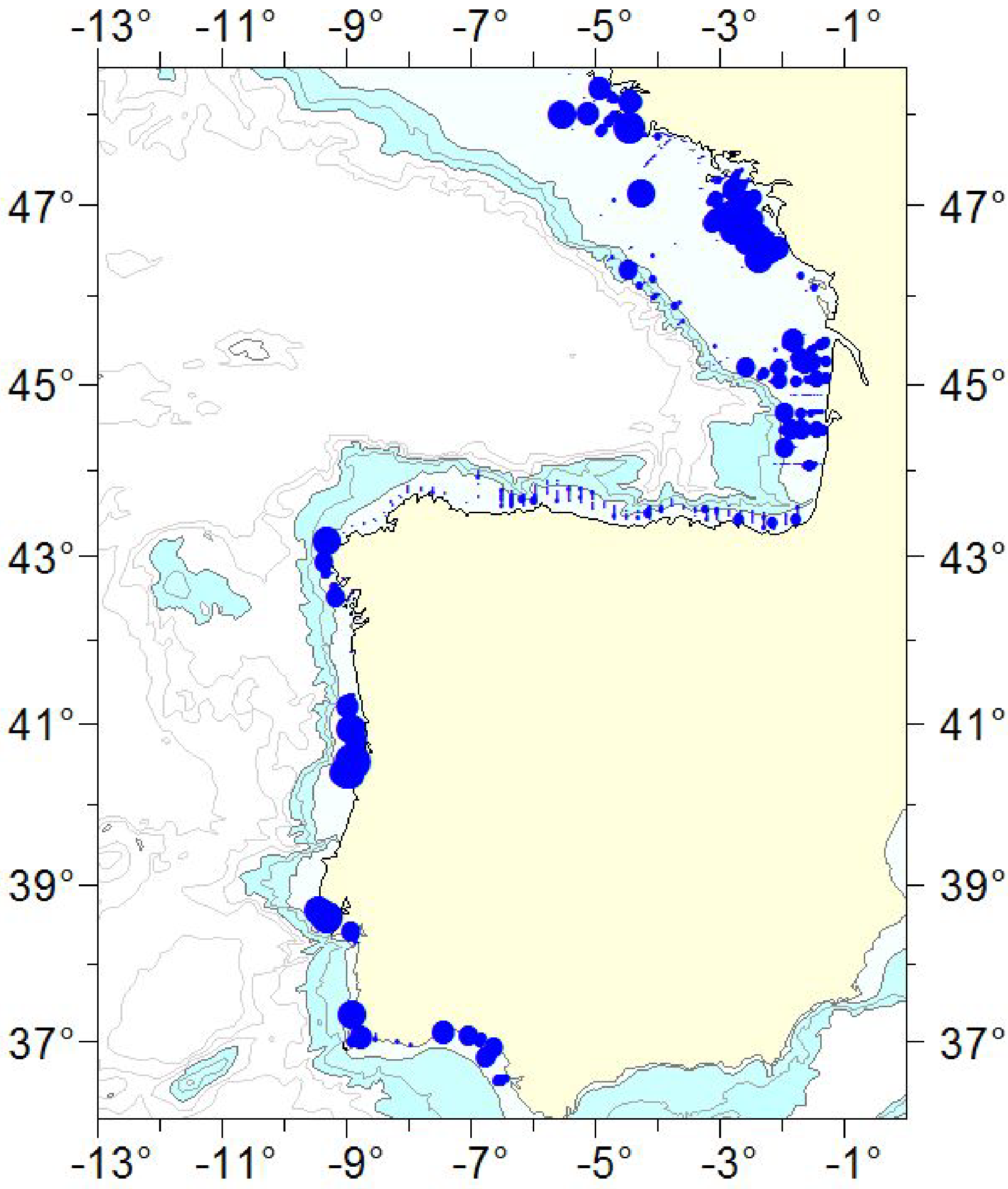


Figure 4.1.1.4. Acoustic energies (sA in m²/nm²) per ESDU attributed to sardine (*Sardina pilchardus*) during PELAGO, PELACUS and PELGAS surveys in spring 2010.

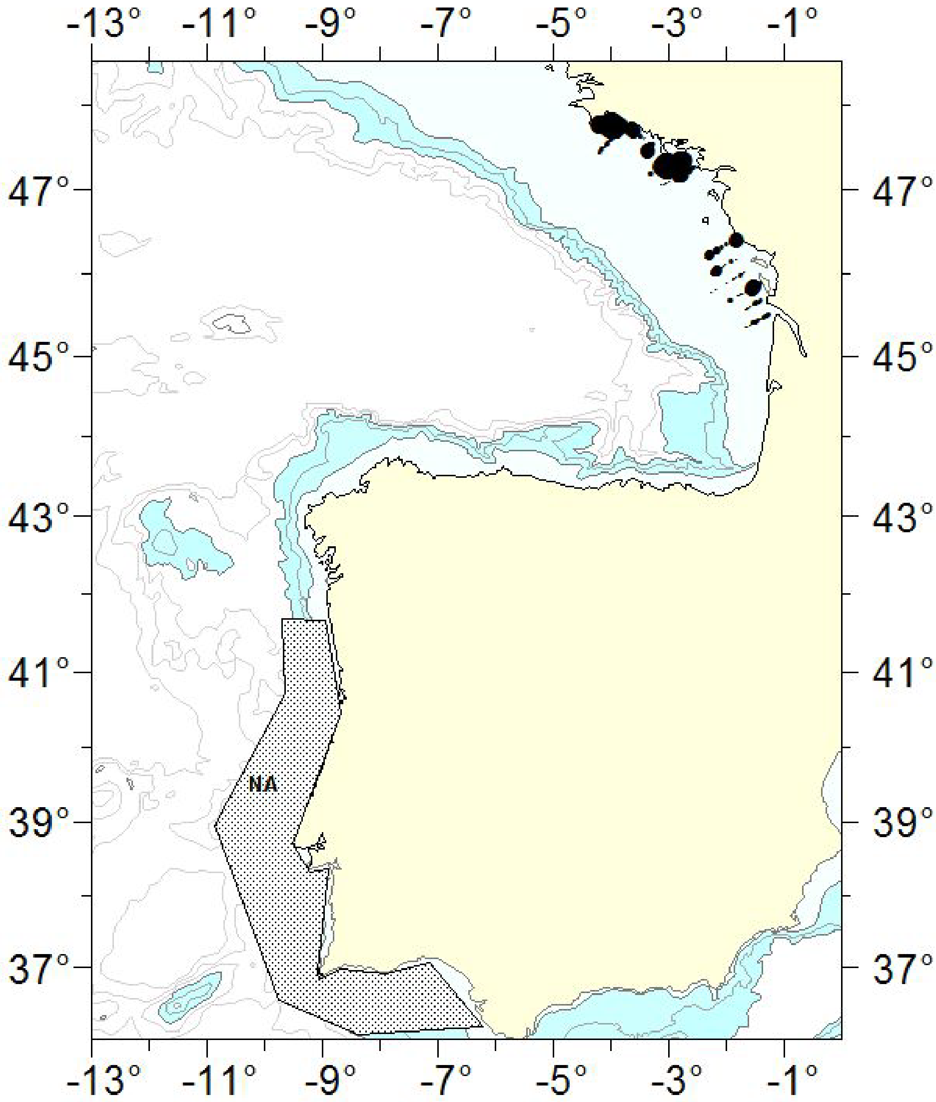


Figure 4.1.1.5. Acoustic energies (sA in m²/nm²) per ESDU attributed to Sprat (*Sprattus sprattus*) during PELACUS and PELGAS surveys in spring 2010 (NA = no available data because of insufficient identification hauls in 2010).

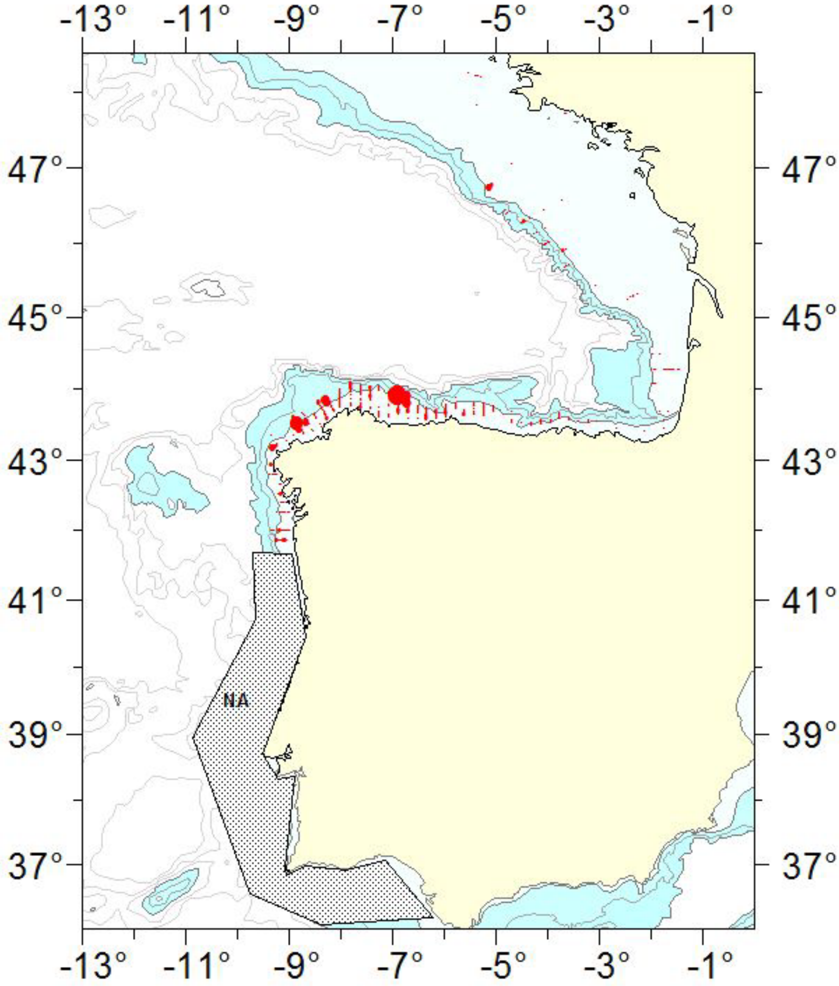


Figure 4.1.1.6. Acoustic energies (sA in m²/nm²) per ESDU attributed to mackerel (*Scomber scombrus*) during PELACUS and PELGAS surveys in spring 2010 (NA = no available data because of insufficient identification hauls in 2010).

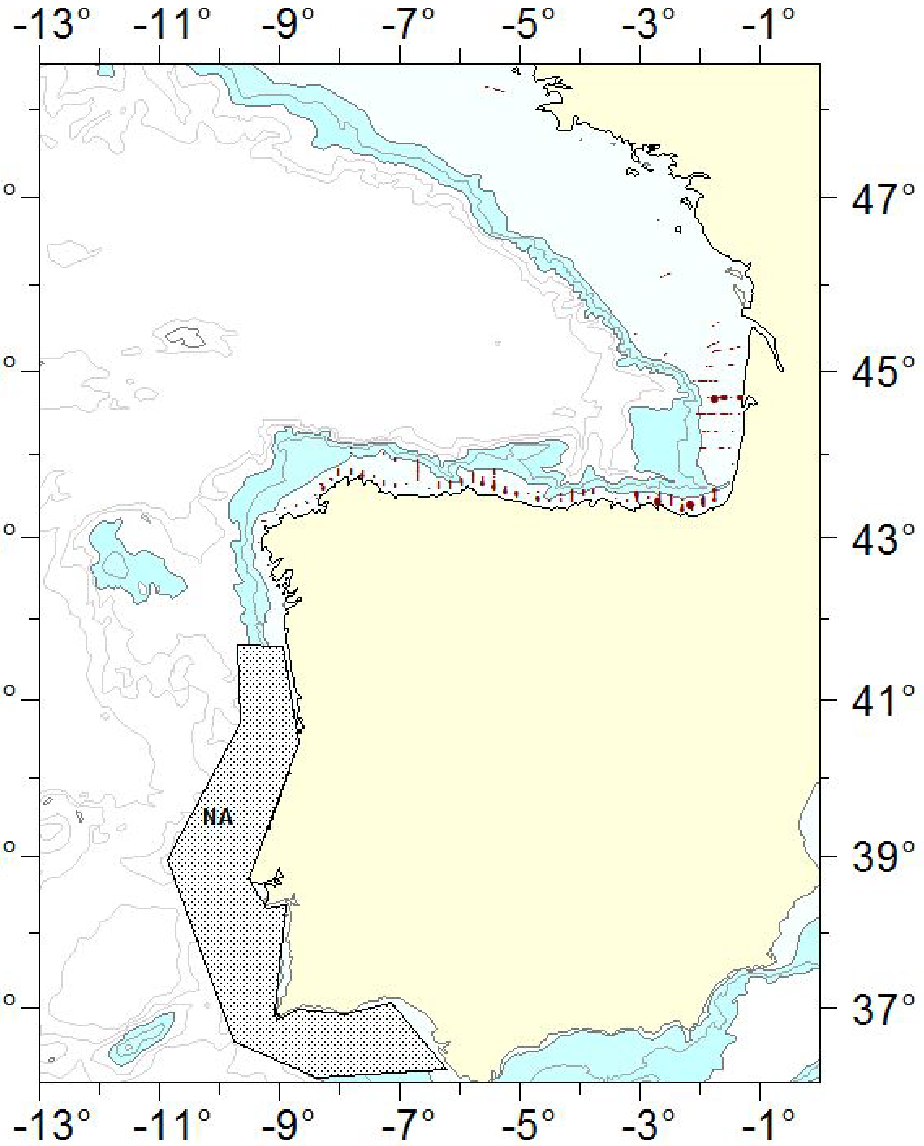


Figure 4.1.1.7. Acoustic energies (sA in m²/nm²) per ESDU attributed to chub mackerel (*Scomber colias*) during PELACUS and PELGAS surveys in spring 2010 (NA = no available data because of insufficient identification hauls in 2010).

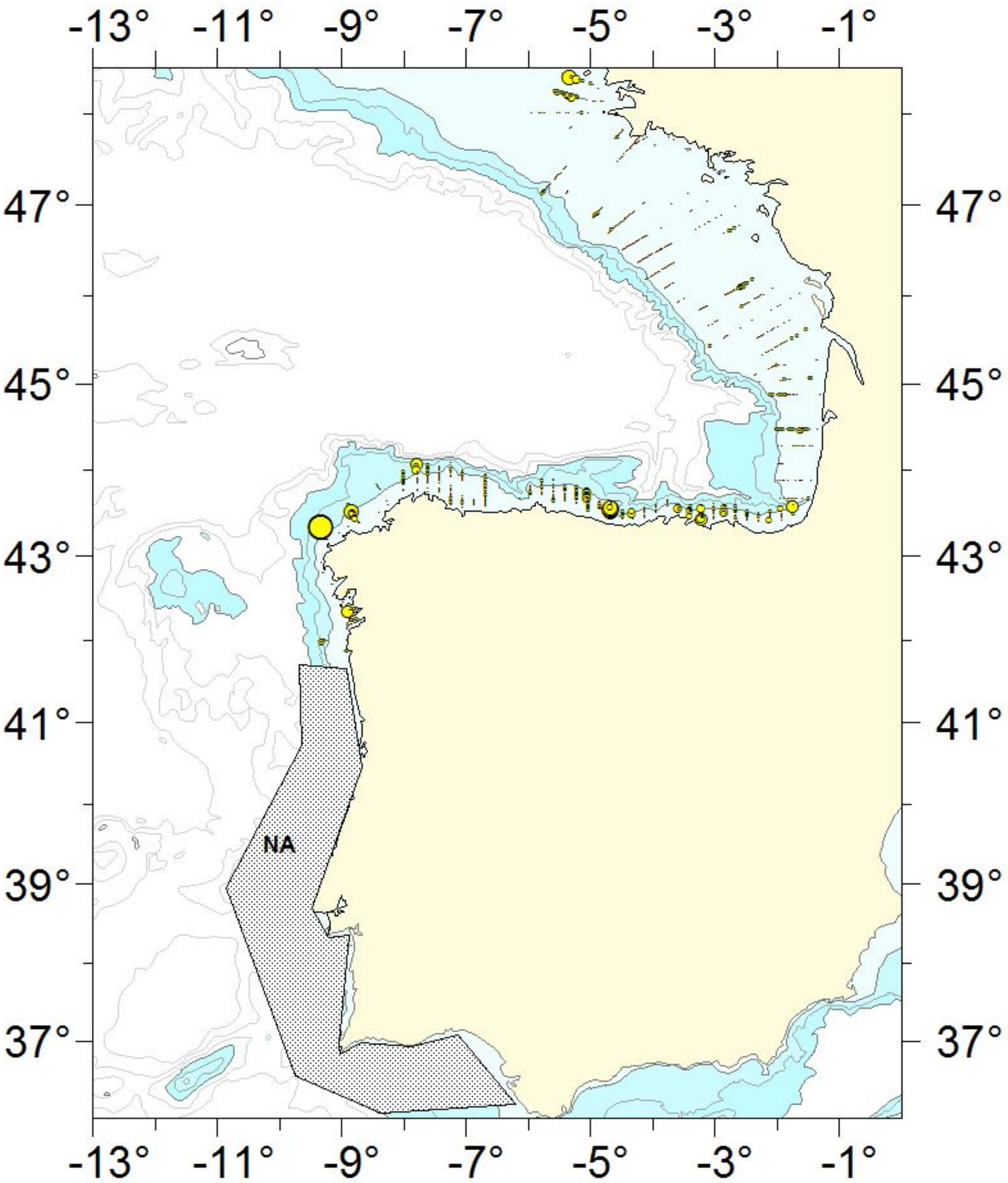


Figure 4.1.1.8. Acoustic energies (sA in m²/nm²) per ESDU attributed to horse mackerel (*Trachurus trachurus*) during PELACUS and PELGAS surveys in spring 2010 (NA = no available data because of insufficient identification hauls in 2010).

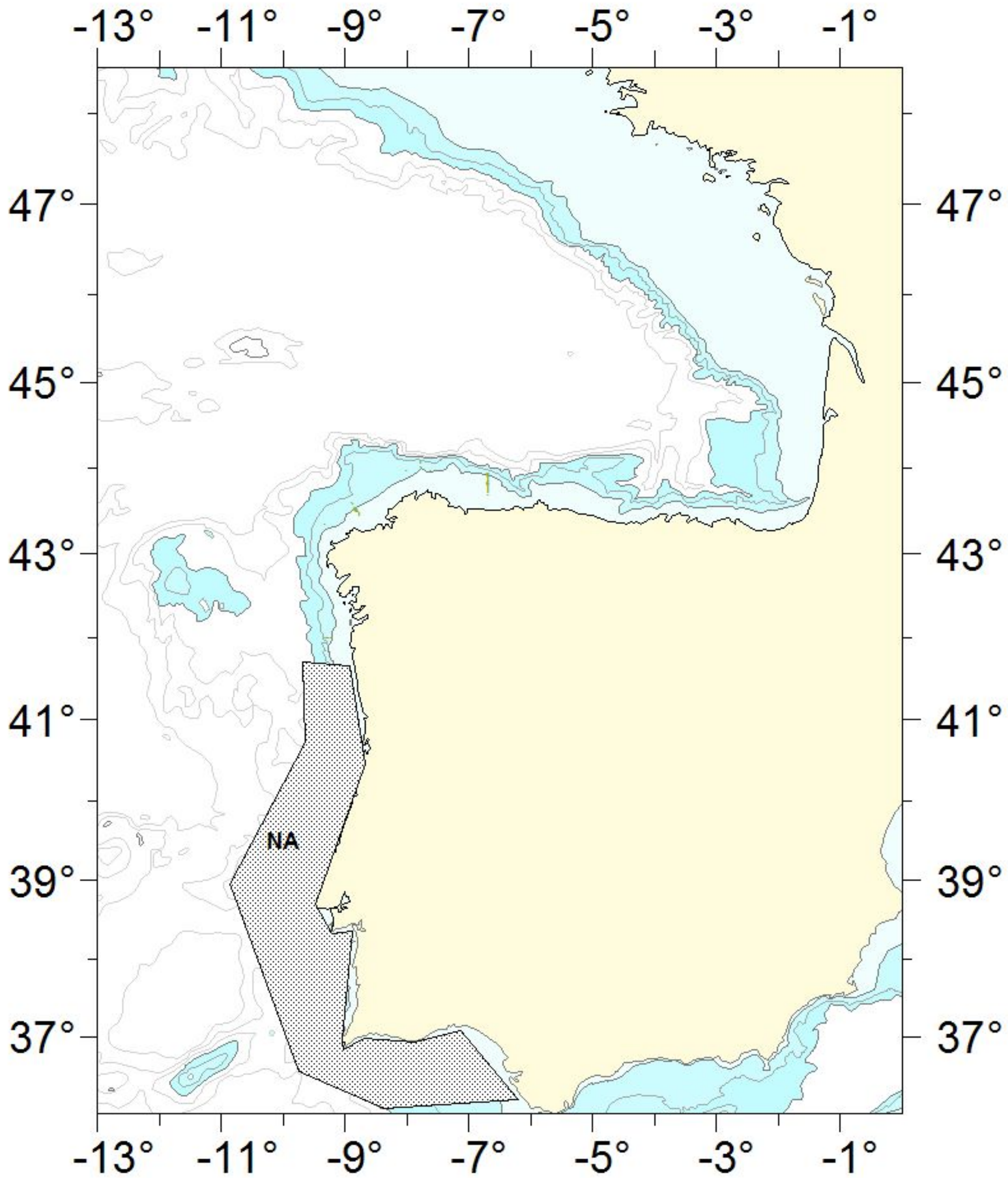


Figure 4.1.1.9. Acoustic energies (sA in m²/nm²) per ESDU attributed to blue chub mackerel (*Trachurus picturatus*) during PELACUS and PELGAS surveys in spring 2010 (NA = no available data because of insufficient identification hauls in 2010).

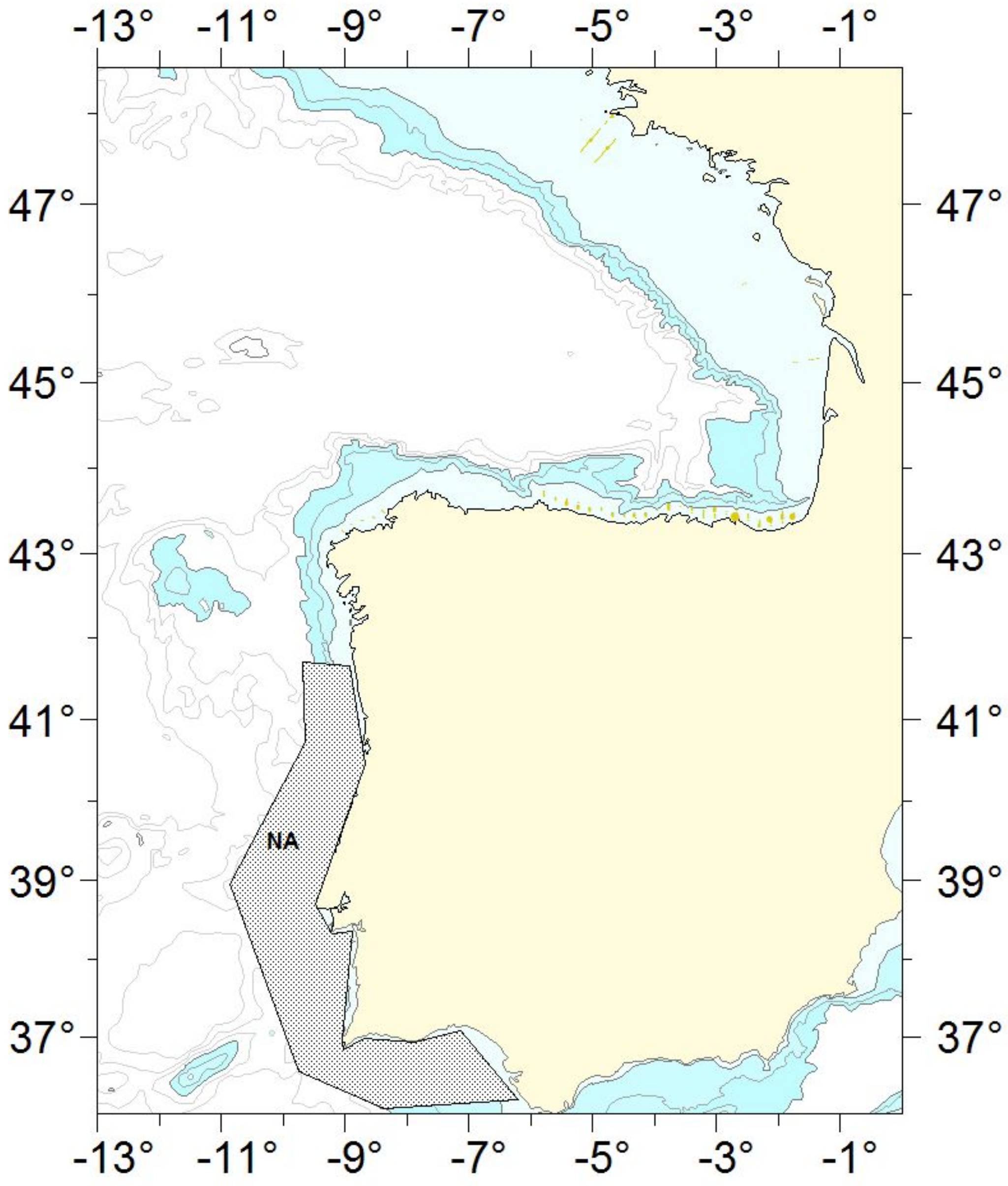


Figure 4.1.1.10. Acoustic energies (sA in m²/nm²) per ESDU attributed to (*Trachurus mediterraneus*) during PELACUS and PELGAS surveys in spring 2010 (NA = no available data because of insufficient identification hauls in 2010).

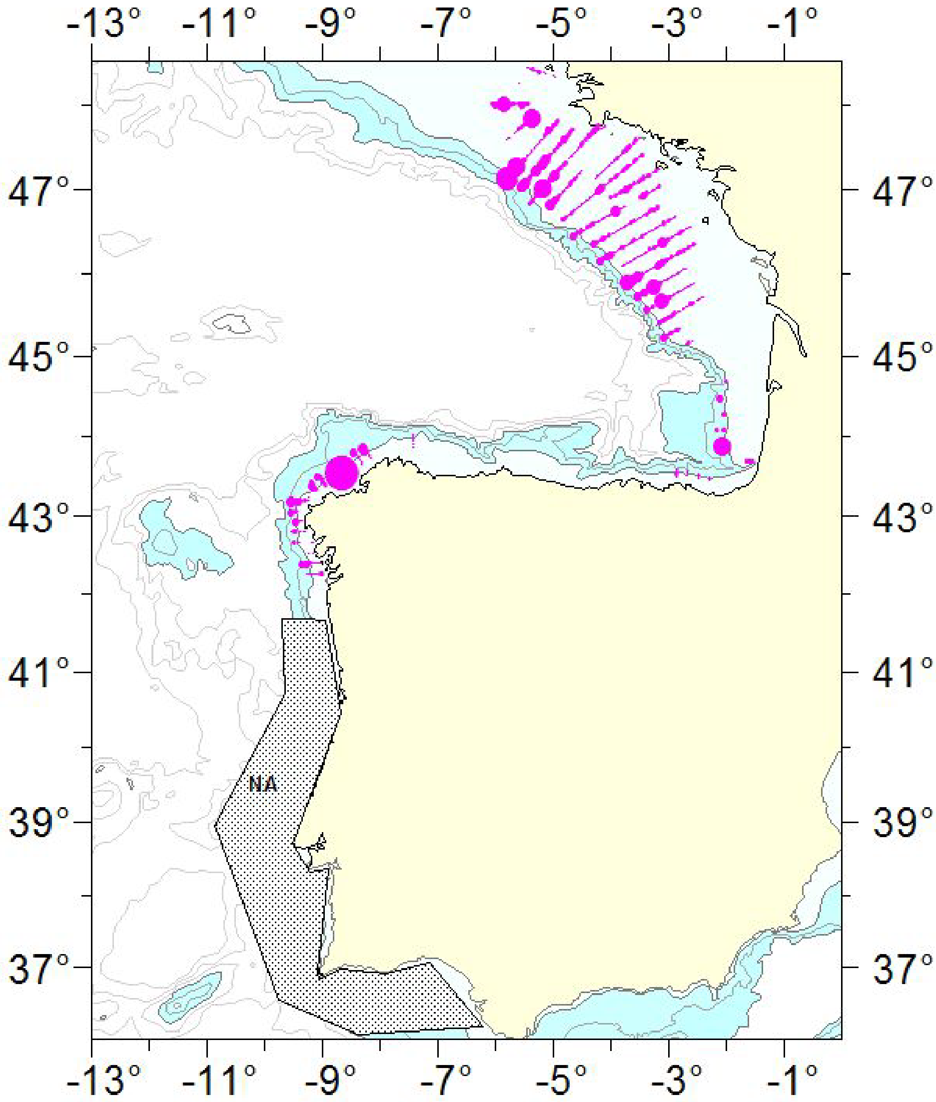


Figure 4.1.1.11. Acoustic energies (sA in m²/nm²) per ESDU attributed to Blue whiting (*Micomesistius poutassou*) during PELACUS and PELGAS surveys in spring 2010 (NA = no available data because of insufficient identification hauls in 2010).

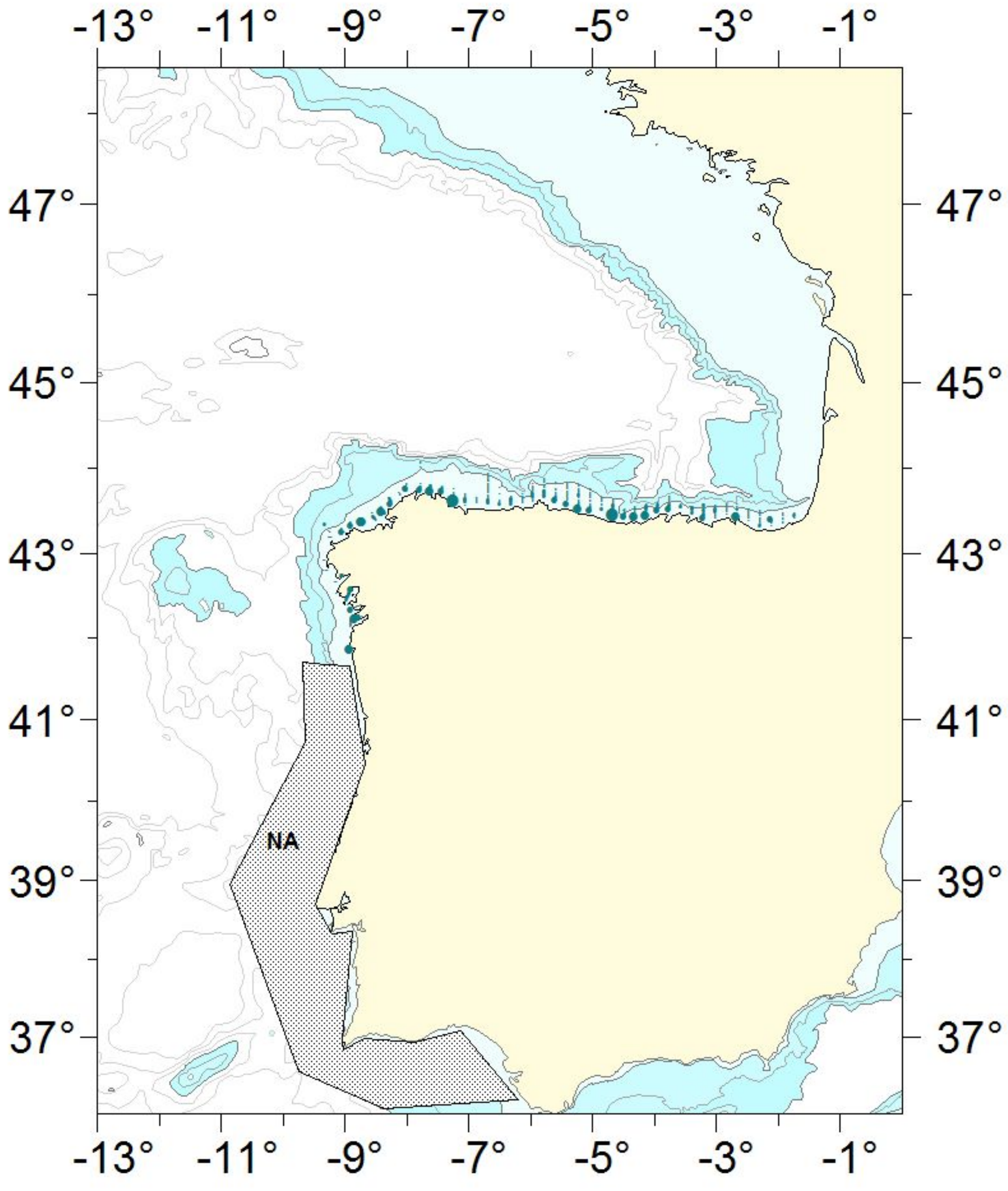


Figure 4.1.1.12. Acoustic energies (sA in m²/nm²) per ESDU attributed to bogues (*Boops boops*) during PELACUS and PELGAS surveys in spring 2010 (NA = no available data because of insufficient identification hauls in 2010).

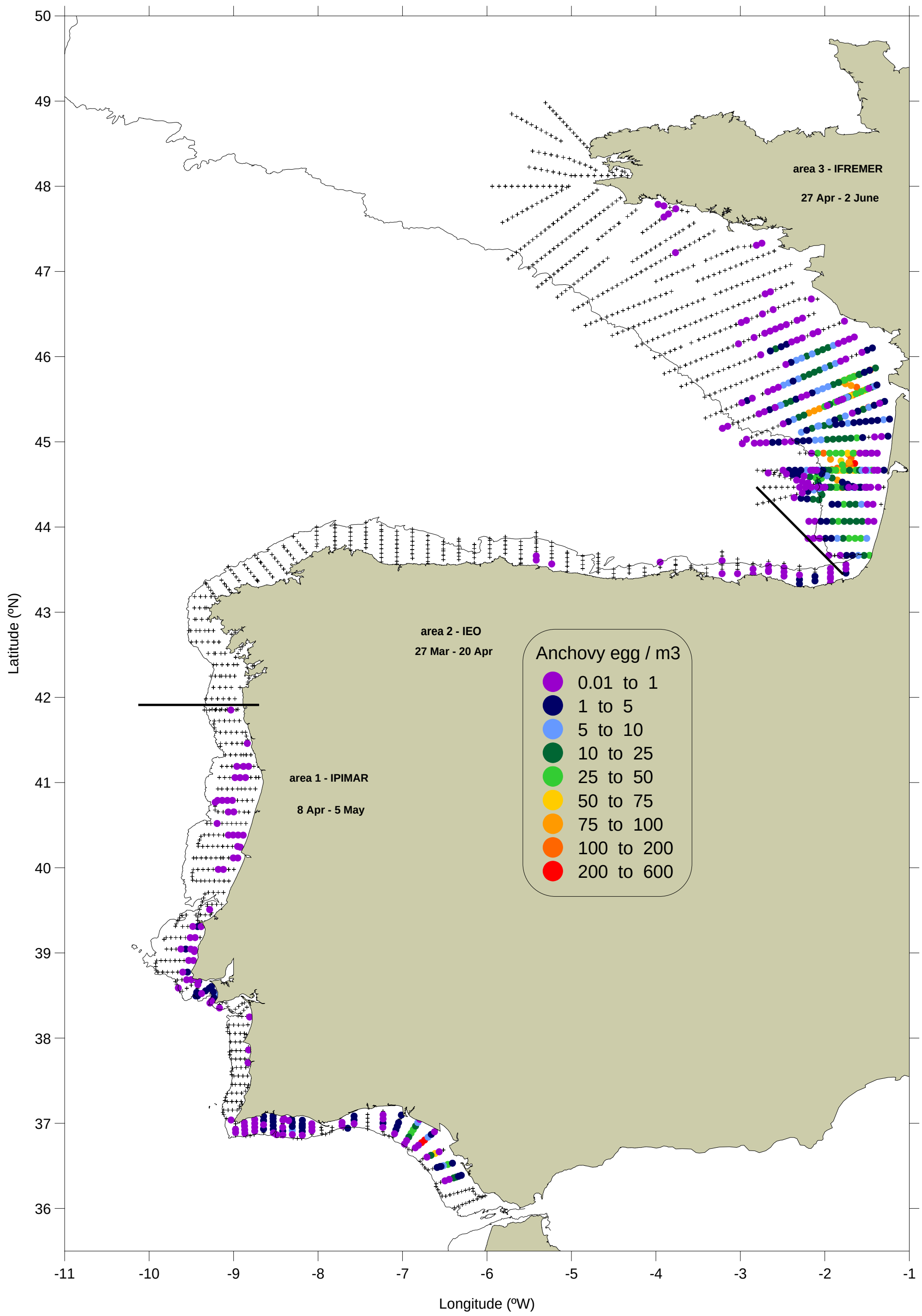


Figure 4.1.1.13. Anchovy egg distribution from CUFES sampling (eggs/m³; sampling unit 3 miles) during PELAGO, PELACUS and PELGAS surveys in spring 2010.

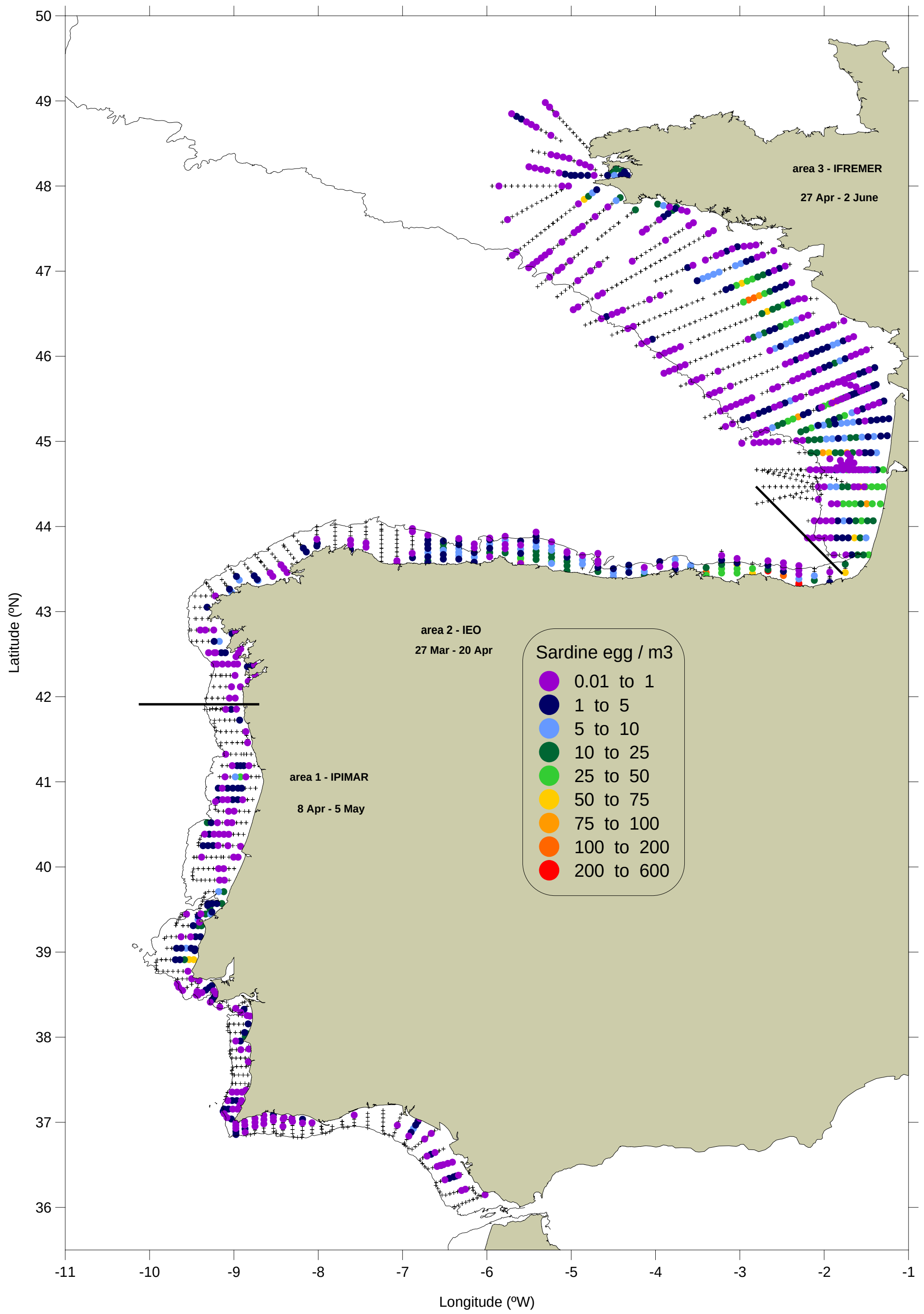


Figure 4.1.1.14. Sardine egg distribution from CUFES sampling (eggs/m³; sampling unit 3 miles) during PELAGO, PELACUS and PELGAS surveys in spring 2010.

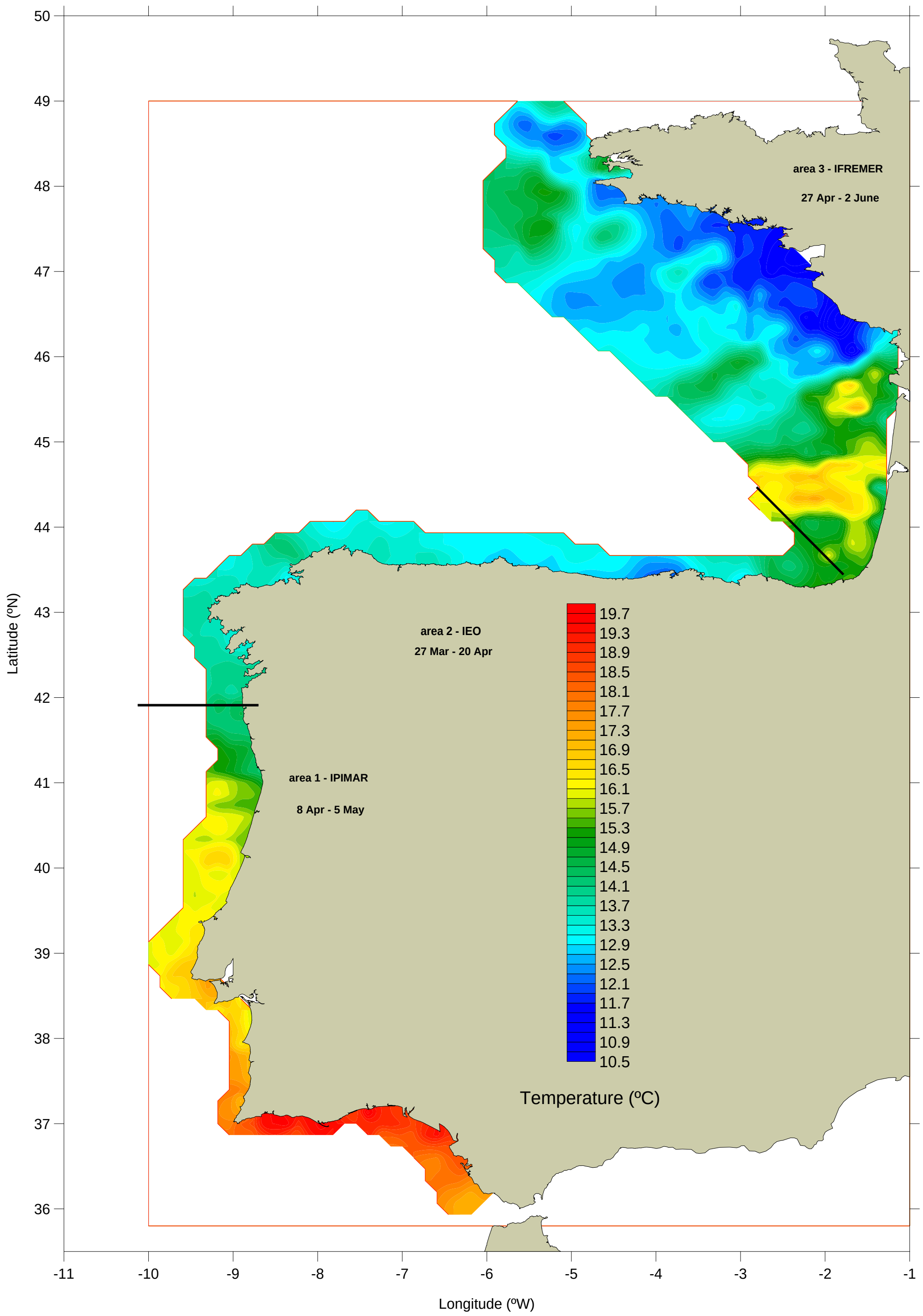


Figure 4.1.1.15. Surface temperature from surveying during PELAGO, PELACUS and PELGAS surveys in spring 2010.

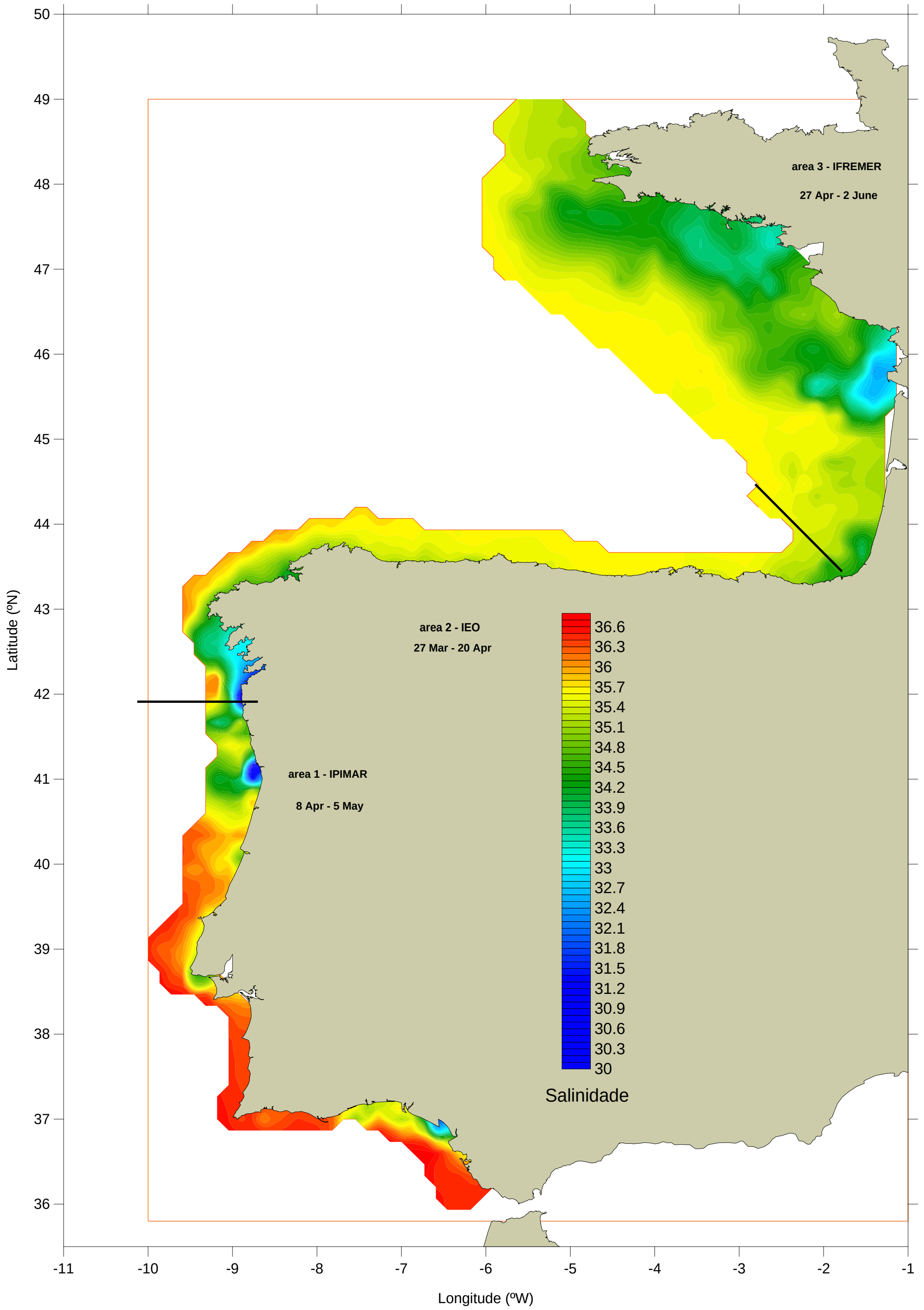


Figure 4.1.1.16. Surface salinity from surveying during PELAGO, PELACUS and PELGAS surveys in spring 2010.

4.1.2 Details of the Portuguese Spring acoustic survey: PELAGO10

The Portuguese spring survey was carried out from 6 April to 6 May 2010 on-board RV "Noruega" and covered the ICES area IXa. The survey summary is presented in table 4.1.2.1.

Table 4.1.2.1 - Survey description

Survey Acronym	PELAGO10
ICES areas	IXa
Dates	06/04/2010 – 06/05/2010
Total surveyed area Nm2	7500
Nautical miles sampled (transects)	1032
Number of fishing hauls	26
# Pelagic Trawls	22
# Purse Seines	N/A
# Bottom trawl	4
Research Vessel	Noruega
Other vessels	N/A
# CUFES (or NA)	501
# hydrographic stations	105
# Plancton Hauls	60
Top Predators (Y/N)	N/A

The main results of the Portuguese acoustic survey directed to sardine and anchovy estimates in ICES Subarea IX shows a reduction in sardine and anchovy biomass. The sardine abundance was the lowest of the time-series, following the tendency of the last three years. In the Occidental north zone, the distribution area was very narrow. Age 1 sardines (2009 year class) were predominant in all areas (Figure 4.1.2.1); although this year-class is more abundant than the 2006–2007 year-classes at the same age, it is substantially less abundant than strong year-classes in recent years (2000, 2004). The anchovy abundance suffered a strong reduction in relation to the last years, especially in the Cadiz Bay area.

Surface temperature and salinity were within the usual range found during the spring period. The buoyant plume, usually present off the Douro-Minho region, was particularly noticeable this year due to the rainy winter; higher sardine abundance was registered south of this plume.

Due to problems in the ship engine, only a total of 26 trawl hauls were performed and it was not always possible to identify other species than sardine and anchovy. For that reason it was only estimated the abundance for sardine and anchovy.

For presentation purposes and results comparison, the surveyed area was divided, as usual, into 4 subareas or regions: OCN (from Caminha to Nazaré), OCS (from Nazaré to Cape S. Vicente), Algarve (from Cape S. Vicente to V. R. Santo António) and Cadiz (from V. R. Santo António to Cape Trafalgar).

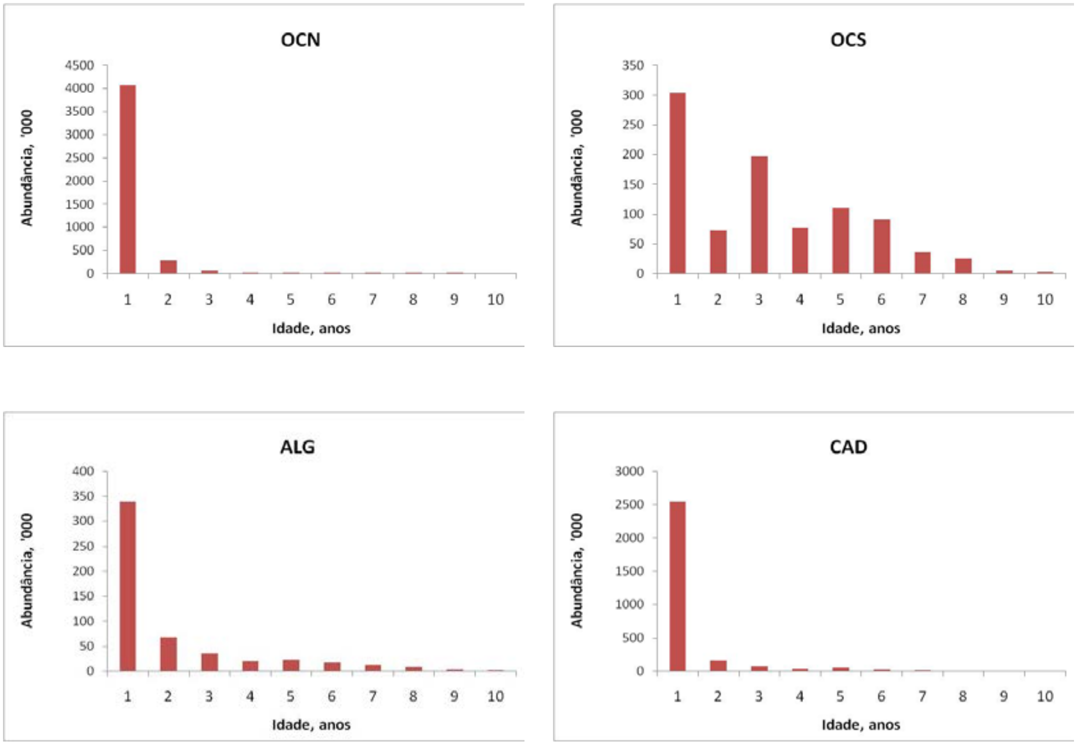


Figure 4.1.2.1. Sardine abundance by age group within each geographical area considered.

TRAWL HAULS

A total of 26 trawl hauls were performed during the survey and sardine was present in 18 of them (see global distribution in Section 4.1.1). Sardine was the dominant species in the West Coast, between Caminha and Cape Espichel. In the remaining Portuguese coast sardine was usually captured together with other pelagic species: horse mackerel (*Trachurus trachurus*), chub mackerel (*Scombrus colias*) and bogue (*Boops boops*). Anchovy was present in 5 trawl hauls, one off Lisbon and the others off the South coast.

SPATIAL DISTRIBUTION

Sardine: As seen in (Figure 4.1.2.2) sardine was mainly distributed over the West coast from Caminha to Cape Espichel. In the OCN area sardine was detected mainly near shore, being more abundant between Porto and Figueira da Foz. In the OCS area, the sardine was scarce. As usual a spot of sardine juveniles was presented off Lisbon. In Algarve the main sardine concentrations were found in the Western part, between Sagres and Portimão, being almost absent in the remaining Algarve area. In the Cadiz Bay sardine was also scarce being absent in the last 3 radials (eastern part)

Anchovy was distributed mainly in the south coast covering Algarve and Cadiz. As usual there was an anchovy spot distribution off Lisbon (Figure 4.1.2.3)

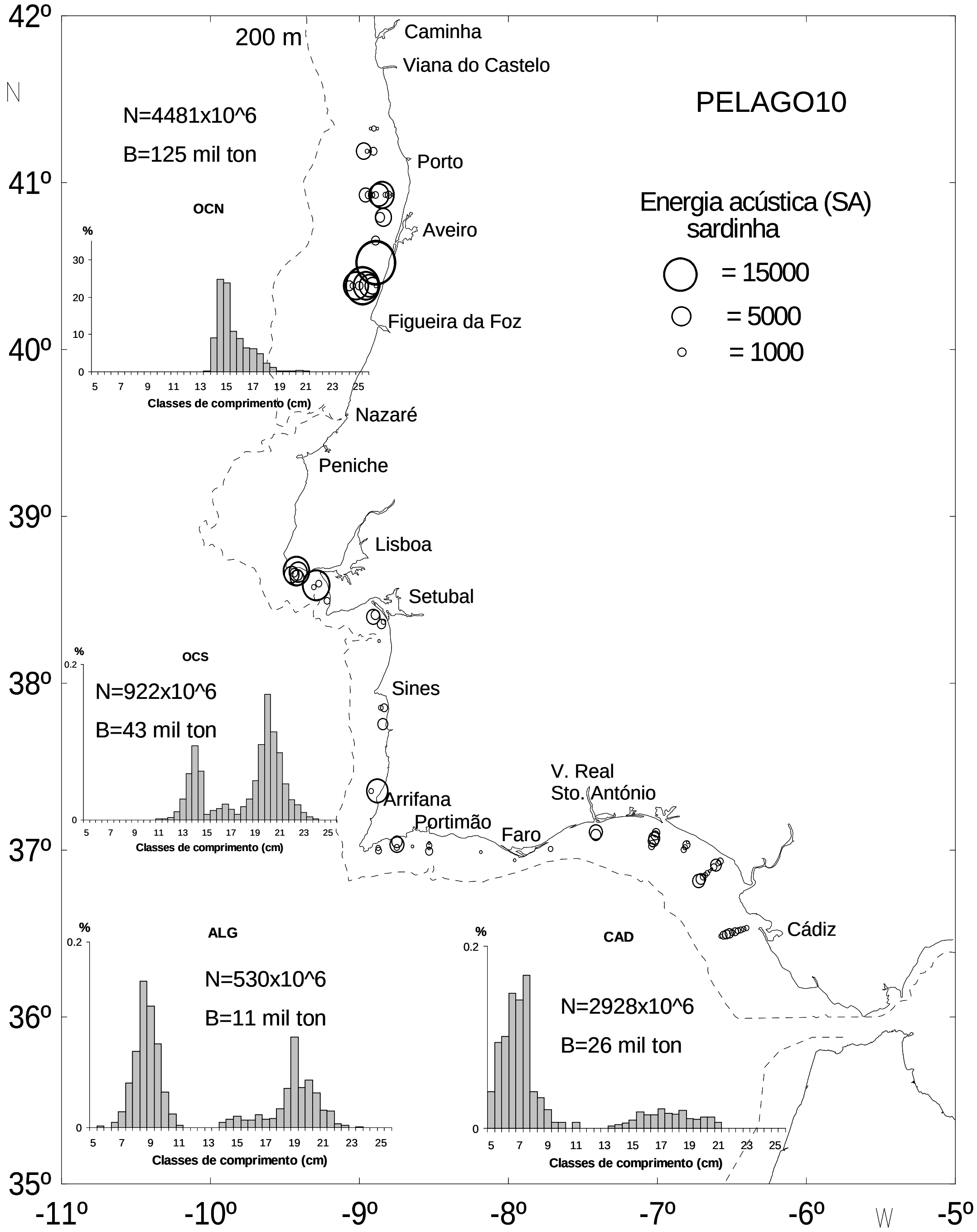


Figure 4.1.2.2. Sardine acoustic energy spatial distribution. Circle area is proportional to the acoustic energy (S_A m²/nm²). Sardine abundance and length structure for each zone.

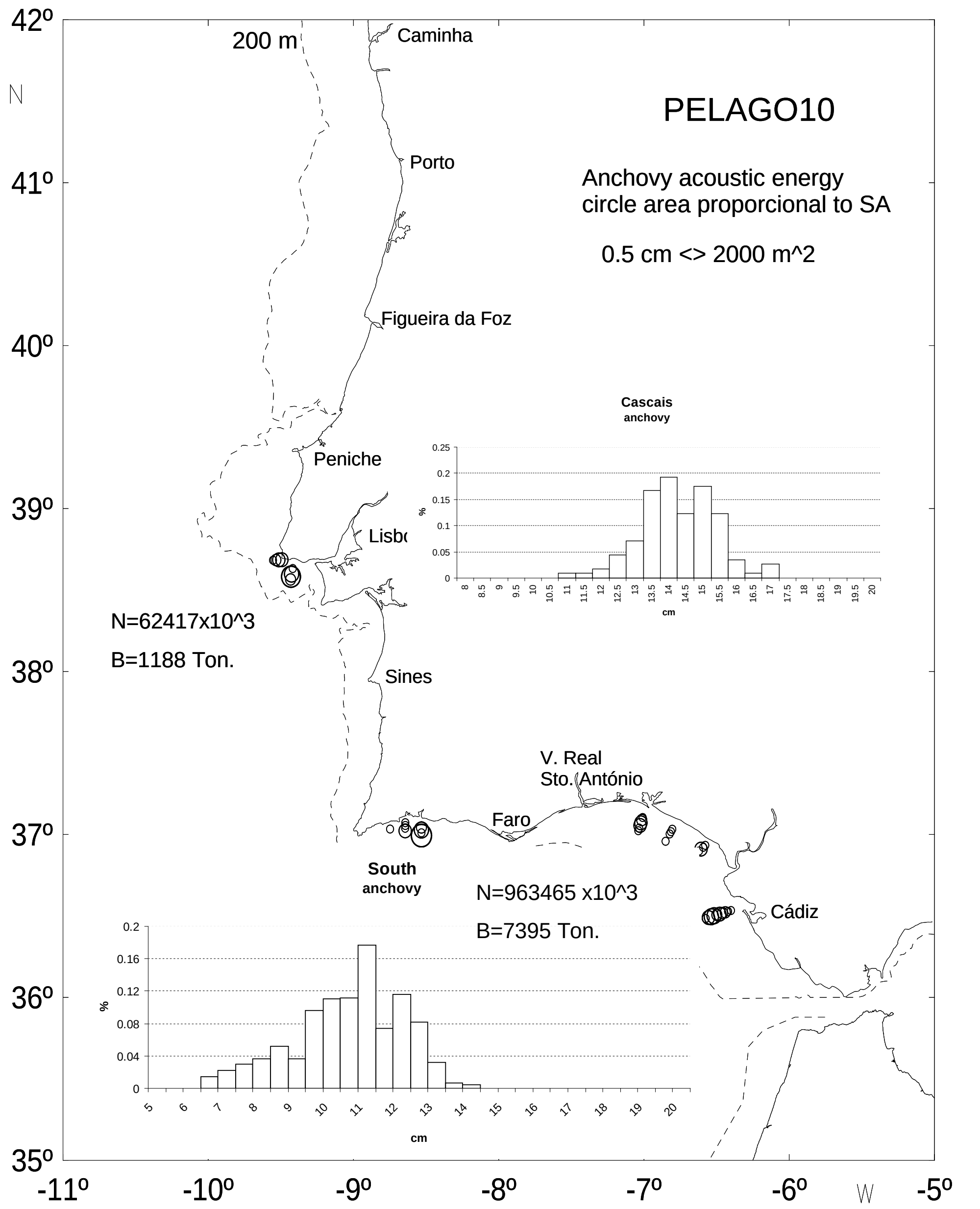


Figure 4.1.2.3. Anchovy acoustic energy spatial distribution. Circle area is proportional to the acoustic energy (S_A m²/nm²). Anchovy abundance and length structure for West and South areas.

TEMPERATURE AND SALINITY SURFACE DISTRIBUTIONS

Surface temperature and salinity data, collected by the sensors associated with the CUFES system in April 2010, are presented in Figure 4.1.2.4. The distribution maps show values within the usual range found in the survey area during the spring period. Surface temperature varied between 14ºC, in the northern region, and 19.5ºC, over the shallow, inner Cadiz Bay. Temperature values in the NW coast were a little higher than in recent years. Also in the northern area (north of Aveiro) the buoyant plume, usually present off the Douro-Minho region, was particularly noticeable during this year´s survey that followed a quite severe rainy winter. Salinity values lower than 34.5, occupying a layer of about 15m depth, was observed across the shelf (CTDF casts data not shown here). Higher sardine abundance was registered south of the less dense plume.

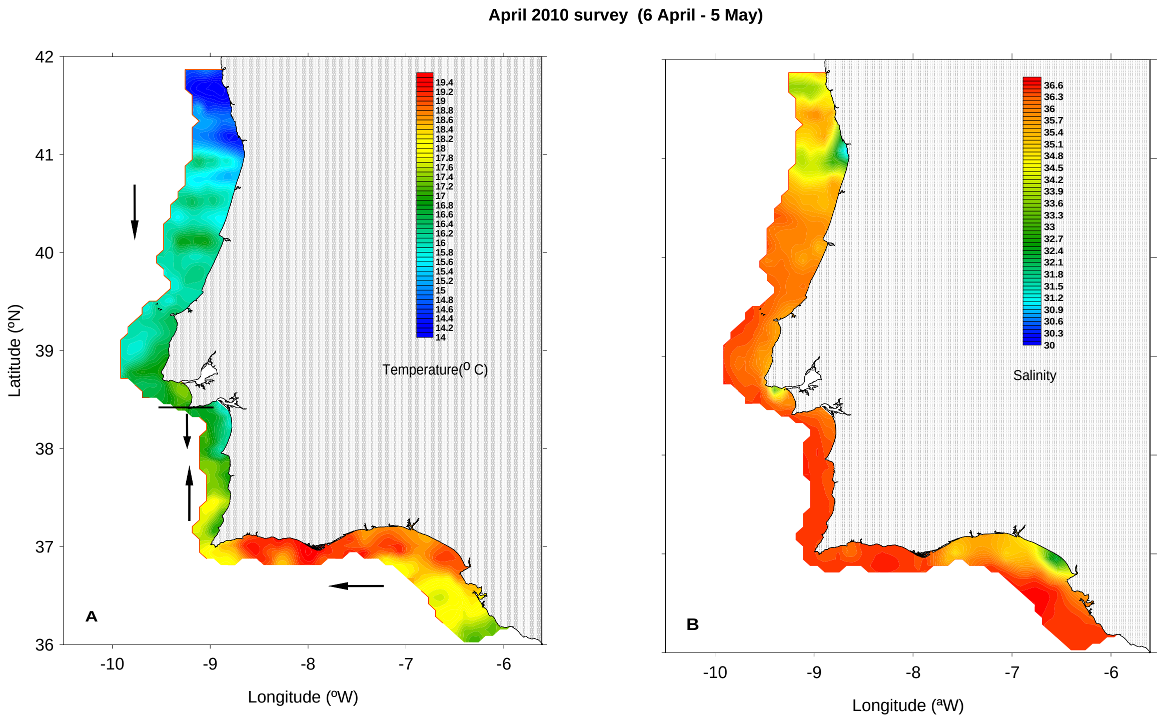


Figure 4.1.2.4. Surface temperature and salinity distributions, from the CUFES sensors.

ABUNDANCE ESTIMATES:

Sardine: The estimated biomass for the Portuguese coast was 179 thousand tonnes corresponding to 5933 million individuals, one of the lowest abundance in the survey series (Figure 4.1.2.5). In the OCN zone the estimated abundance was in the level of the last surveys, but it was concentrate in a few miles only. On the contrary in the OCS zone sardine abundance was one of the lowest of the series (43 thousand tonnes; 922 million individuals). Algarve was also depleted of sardine with an estimation of 11 thousand tonnes (530 million individuals). The sardine abundance in Cadiz area was also very low (26 thousand tonnes; 2928 million individuals).

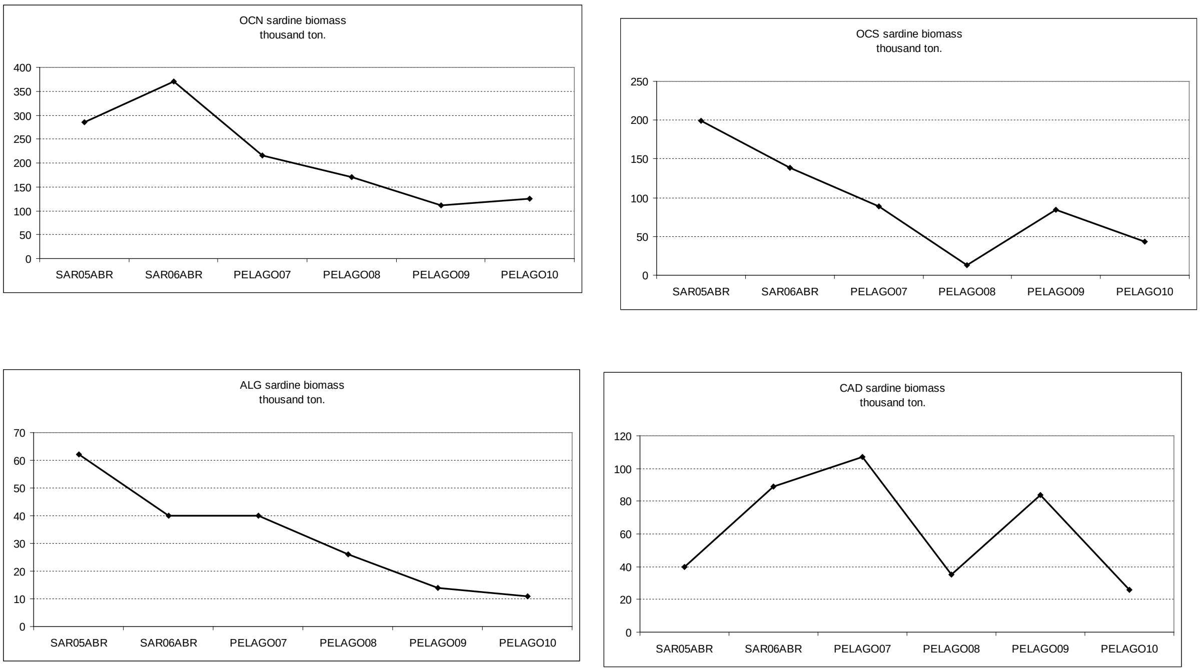


Figure 4.1.2.5. Sardine biomass evolution along the spring survey series, in each subarea.

Anchovy: The total biomass estimated was 8583 tonnes (1026 x 10^6 individuals), which is very low compared with the average value for entire time-series (Table 4.1.2.2). Like in previous years the area with the highest anchovy abundance was Cadiz. In this area a sample (AP15) of anchovy juveniles (10 cm frequency mode) was fished.

Table 4.1.2.2 – Anchovy: Estimated biomass (tonnes) for the West and South (from Cape S. Vcente to Cape Trafalgar) coasts and total area from 1999 to 2010 Spring acoustic surveys.

SURVEY	WEST	SOUTH	TOTAL
April 2010	1188	7395	8583
April2009	2000	24800	26800
April 2008	5500	34200	39700
April 2007	1945	38020	39965
April 2006	0	24082	24082
April 2005	1062	14041	15103
March 2002	1542	21335	22877
March 2001	368	24913	25281
March 1999	596	24763	25359

4.1.3 Particularities of the Spanish Spring acoustic survey: PELACUS0410

PELACUS0410 spring Spanish acoustic survey was carried out from the 27 March to the 20 April with the main aim of acoustically assessing the pelagic resources inhabiting shelf waters in ICES Subdivisions IXaN (south Galicia) and VIIIc (Cantabrian Sea). The survey was carried out on-board the RV "Thalassa" and it was obtained abundance and biomass estimates for all the main pelagic species found in the area not just those of economic value. The survey summary is presented in Table 4.1.3.1.

Table 4.1.3.1 - Survey description

Survey Acronym	PELACUS0410
ICES areas	IXaN (south Galicia) and VIIIc .
Dates	27/03/2010 – 20/04/2010
Total surveyed area Nm^2	6614
Nautical miles sampled (transects)	919
Number of fishing hauls	62
# Pelagic Trawls	62
# Purse Seines	N
# Bottom trawl	N
Research Vessel	Thalassa
Other vessels	N
# CUFES (or NA)	312
# hydrographic stations	125
# Plancton Hauls	125
Top Predators (Y/N)	Y

The results on adult sardine abundance and biomass obtained in PELACUS0410 are in line with those estimated in the previous years and show a downward trend since 2002 for the sardine stock in ICES areas IXa-N and VIIIc (Figure 4.1.3.1). The fish pelagic species more abundant during this survey were Atlantic mackerel (Scomber scombrus) and horse mackerel (*Trachurus trachurs*; Table 4.1.3.2).

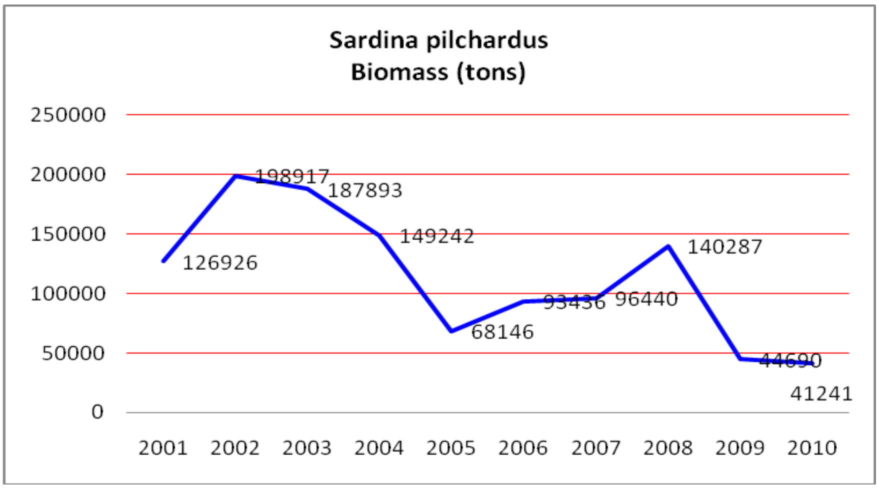


Figure 4.1.3.1. Values of sardine biomass (tons) estimated during the PELACUS spring acoustic surveys (2001–2010).

Table 4.1.3.2. Abundance (in million individuals) and biomass (in tons) acoustic estimates for the different pelagic species assessed in PELACUS0410: Sp = *Sardina pilchardus*, Ee= *Engraulis encrasicolus*, Ss= *Scomber scombrus*, Sc= *Scomber colias*, Tt = *Trachurus trachurus*, Tp = *Trachurus picturatus*, Tm = *Trachurus mediterraneus*, Bb = *Boops boops*, Mp = *Micromesistius poutassou*, Ca = *Capros aper*.

	Sp	Ee	Ss	Sc	Tt	Tp	Tm	Bb	Mp	Ca
Abundance	559	8	3348	23	417	4	33	109	497	449
Biomass	41241	225	957471	3717	50382	917	3388	21038	10429	28027

Sardine

Adult fish was present in 34 of the 63 trawl hauls completed during the survey (62 in Spanish waters, see Figure 4.1.1.2.) although only in 25 cases was the species caught in enough numbers to present a representative length distribution. Sardine abundance was estimated at 559*10^6 individuals, while biomass was estimated in 41,241 tons (Table 4.1.3.2). Sardine biomass was among the third highest of the ten pelagic species assessed in the survey (Table 4.1.3.2). Most fish (33% of the abundance and 31% of the biomass) were found in Galician waters (ICES Subarea IXa-N) very close to the coast. Sardine was also abundant in the Cantabrian area (ICES Subarea VIIIcE-e) were it was found occupying the entire shelf (Figure 4.1.3.2).

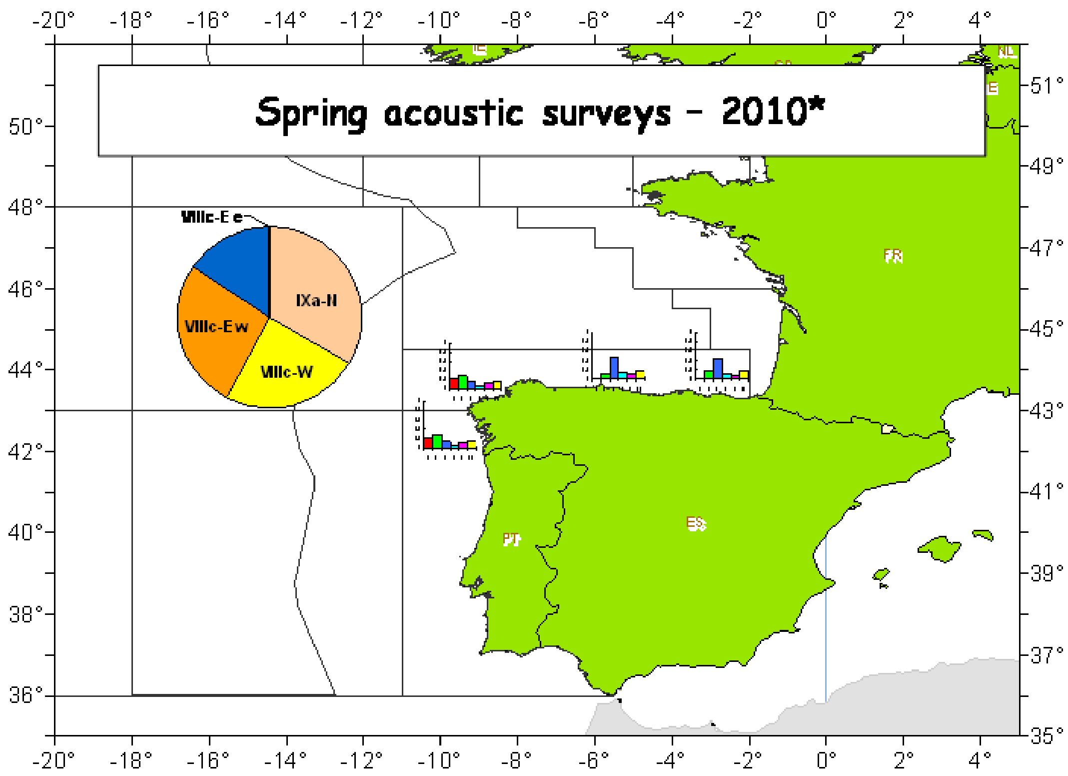


Figure 4.1.3.2. Sardine relative abundance-at-age in each subarea (i.e. the proportion of all age classes within subarea sum to 1) estimated in the PELACUSo410 spring surveys. The pie chart shows the contribution of each subarea to the total stock numbers.

Sardine ranged in length from 13.5 to 25.5 cm with a mode at 21 cm (Figure 4.1.3.3) which corresponds to quite large fish. Applying the ALK obtained from the fish sampled in the survey, most fish (28% of the abundance and 30% of the biomass) in the entire surveyed area were assigned as belonging to the age-class 3 (Figure 4.1.3.2). By subarea, age 2 fish predominated in Galician waters (ICES Subareas IXa-N and VIIIcW), while age 3 fish predominated in Cantabrian waters (almost 45% in biomass and 47% in abundance in VIIIcW and 41% and 43% respectively in VIIIcE-e).

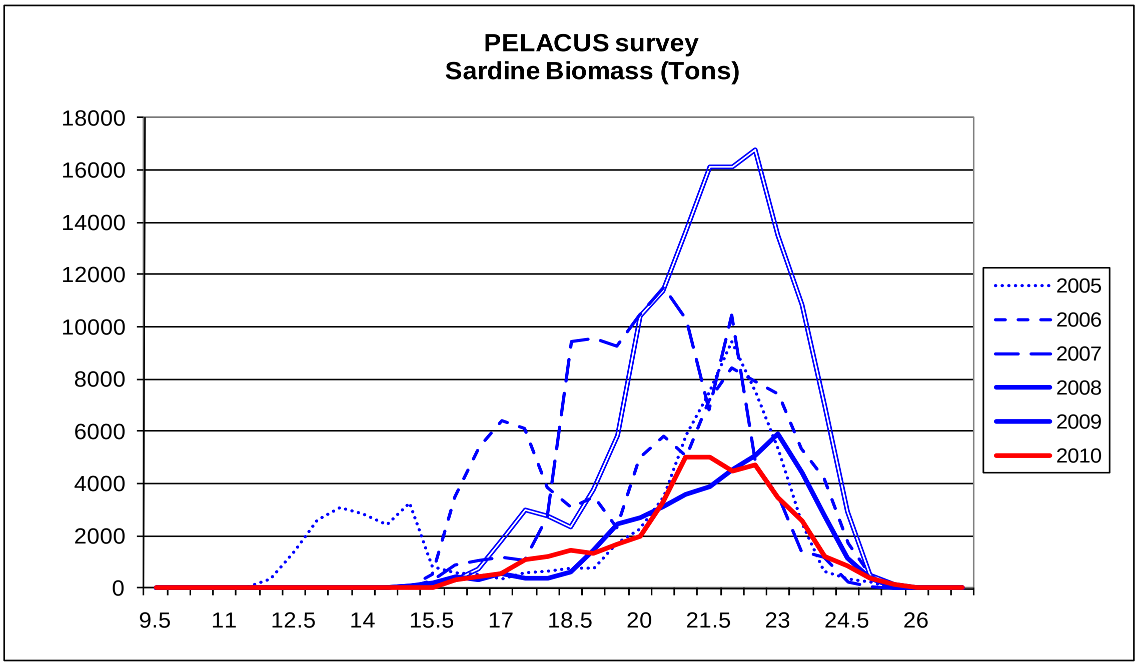


Figure 4.1.3.3. Sardine length distribution in biomass during the PELACUS survey (2005–2010).

Anchovy

Anchovy was found in very few hauls (in only 5 cases was the species caught in enough numbers to present a representative length distribution) predominately in two areas: in the Rías of Arousa and Muros (ICES Subarea IXa-N) and in the Basque Country – French border (ICES Subareas VIIIcE-e and VIIIb respectively; see Figure 4.1.1.2). Anchovy abundance was estimated at 8*10^6 individuals, while biomass was estimated in 225 tons (Table 4.1.3.2). Anchovy biomass was the lowest of the ten pelagic species assessed in the survey (Table 4.1.3.2).

Fish Pelagic community

Up to ten pelagic species were detected in this area during the PELACUS0410 spring survey: S*ardina pilchardus, Engraulis encrasicolus, Scomber scombrus, Scomber colias, Trachurus trachurus, Trachurus picturatus, Trachurus mediterraneus, Boops boops, Micromesistius poutassou* and *Capros aper*. For all of them abundance and biomass were estimated (Table 4.1.3.2).

4.1.4 Particularities of the French spring acoustic survey: PELGAS10

4.1.4.1 Description of survey

The acoustic survey PELGAS10 was carried out in the Bay of Biscay from 26 April to 5 June 2010 on board the French research vessel “Thalassa”. The objectives and methods are described in the attached Working document (Massé and Duhamel - WD 2010. The protocol for these spring surveys is described in Annex 6 (PELGAS sea survey protocol, Doray, Massé, and Petitgas 2009)

Details of the 2010 survey are presented in table 4.1.4.1.

Table 4.1.4.1. Details obtained in the PELGAS acoustic Survey 2010 during the assessment coverage.

Parameters	PELGAS acoustic survey
Survey area	(43º30' to 49º00’N and 1º10’ to 6º00' W)
RV	THALASSA
commercial vessels	Magayant / Tangaroa : 26/04 to 06/05/2010 Morgane / Virginie : 07/05 to 17/05/2010 Etoile pôlaire : 17 and 18/05/2010 Vag a Lamm : 23/05/2010
Date	26/04 – 05/06/2010
Acoustic	**THALASSA**
Miles used for assessment	1 972 NM
Nb of fish measured	27 464
- anchovy	7 091
- sardine	4 702
Nb of otoliths	1 945
- anchovy	928
- sardine	1 017
Nb of trawl hauls	52
- nb of surface and pelagic hauls	3
-Nb of hauls closed to the bottom	46
- nb of cancelled hauls	3
Nb CUFES samples	875
CTD stations	119
consort	**Commercial vessels**
dates	26/04 – 23/05/2010
Number of trawl hauls	51
- nb of surface and pelagic hauls	18
-Nb of hauls closed to the bottom	24
- Nb of purse-seine hauls	4
- nb of cancelled hauls	5
Nb of fish measured	6 222
- anchovy	1 751
- sardine	2 657

As in the 3 previous years a consort survey was organized with French pairtrawlers during the 22 first days and a purse-seiner during 3 days. With this approach, in the continuity of last year's survey, the commercial vessels hauls were used for echo identification and biological parameters at the same level those by "Thalassa".

The collaboration between "Thalassa" and commercial vessels was excellent. It was once more a very good opportunity to explain to fishers our methodology and furthermore, to verify that both scientists and fishers observe the same types of echotraces and have similar interpretations. Some fishing operations were done in parallel by "Thalassa" and commercial vessel in order to check if the catches were well comparable (in proportion of species and, most of the time, in quantity as well). As last year, the fishing operations by commercial vessels were carried out only during daytime (as for "Thalassa") each time it was necessary and preferentially at the surface or in midwater, since the pairtrawlers are more efficient at surface than single back trawlers.

Acoustic data were collected by "Thalassa" along 33 transect (2256 nm) perpendicular to bathymetry, upon which 1972 nautical miles (daylight surveyed selected miles during the global coverage) were used for biomass estimate (Figure 4.1.4.1). A total of 103 hauls were carried out during the assessment coverage, 95 were valid including 49 hauls by "Thalassa" and 46 hauls by commercial vessels (Figure 4.1.4.2).

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

- i) continuous acquisition by storing acoustic data (from five frequencies: 18, 38, 70, 120 and 200 kHz),
- ii) using the CUFES system, pumping seawater under the surface, in order to evaluate the distribution of fish eggs, and
- iii) discrete sampling at stations (by trawls, plankton nets, CTD). Concurrently, a visual census of marine mammals and seabirds took place in order to characterize the top predators of the Bay of Biscay pelagic ecosystem.

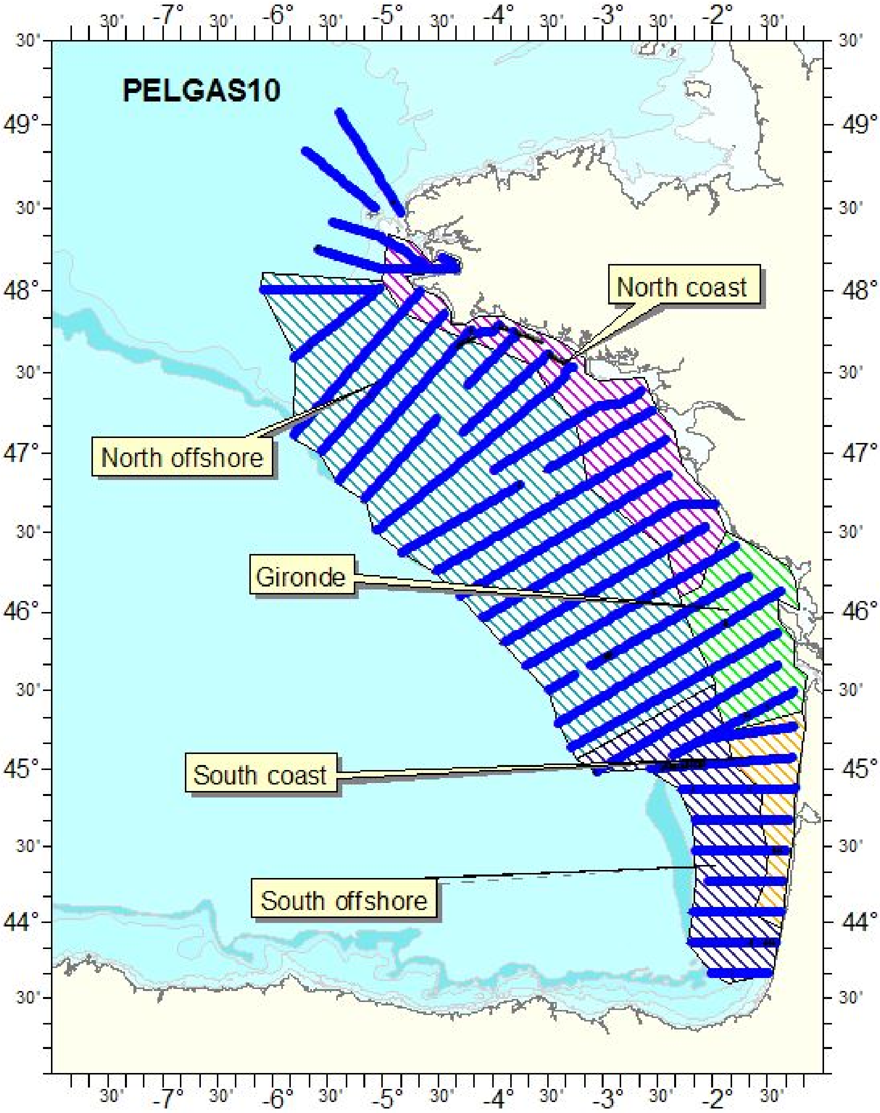


Figure 4.1.4.1. Coherent strata, in terms of echoes and species distribution, taken into consideration for multispecies biomass estimate from acoustic and catches data during PELGAS10 survey.

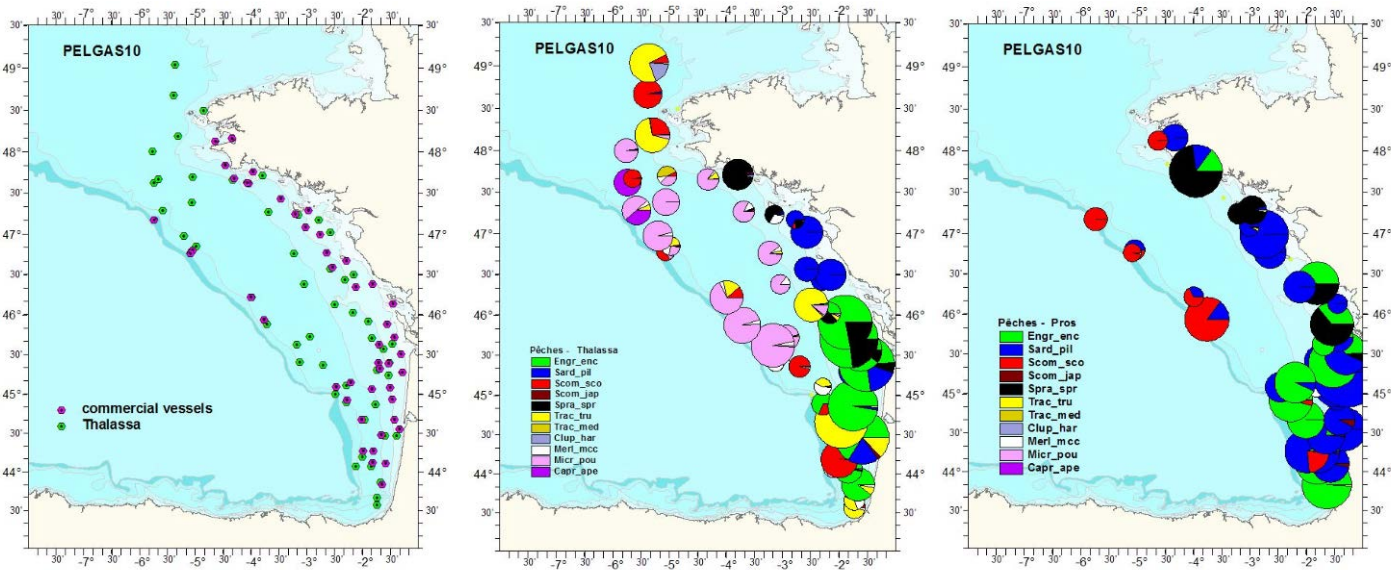


Figure 4.1.4.2. Fishing operations carried out by "Thalassa" and commercial vessels during consort survey PELGAS10.

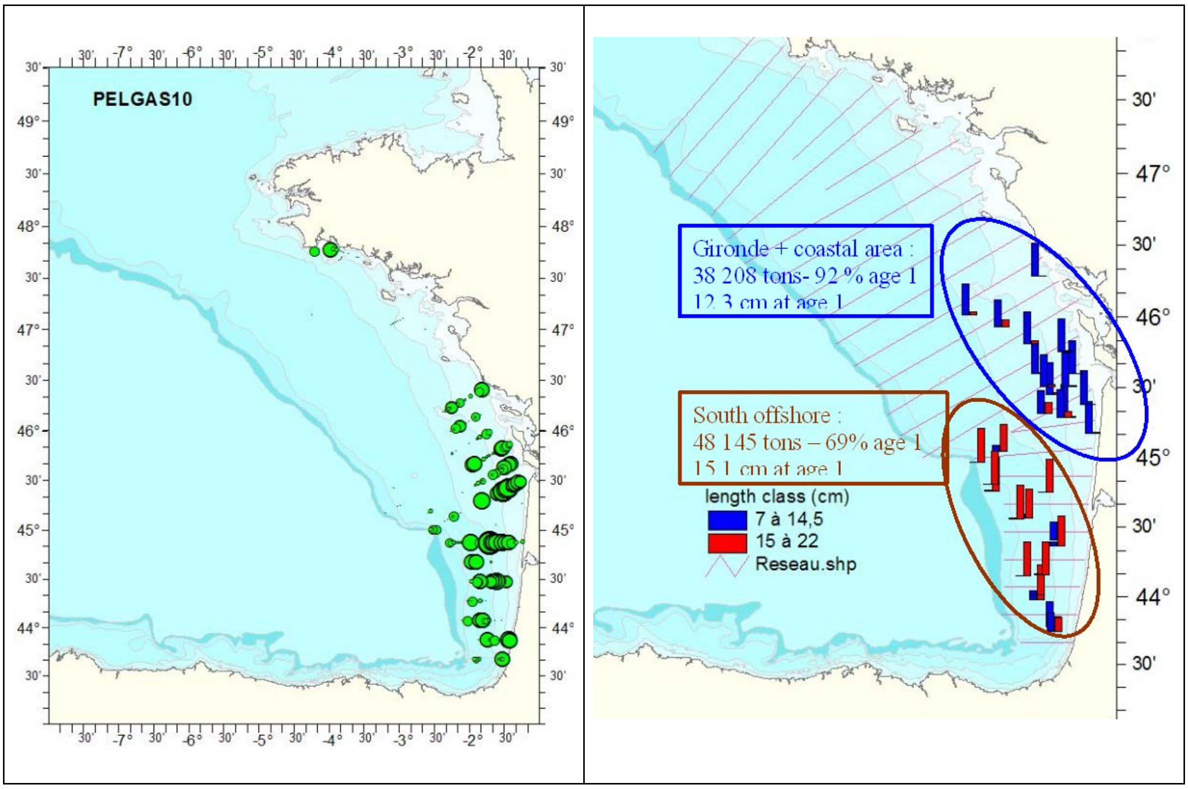


Figure 4.1.4.3. Anchovy distribution (left) observed during PELGAS10 survey and length distributions showing the two groups.

4.1.4.2 Distribution of anchovy and sardine

Globally, anchovy and sardine were well present this year from the south (sardine inshore and anchovy offshore) to the north (sardine quite exclusively offshore). About other species, the main characteristics of this survey is that horse mackerel and mackerel were very rare, unlike blue whiting was permanently present on the platform from 50m depth to the shelf break north of 45° N, scattered in small dots echoes close to the bottom and where numerous hauls identified constantly a mix of blue whiting and hake. Blue whiting was historically present along the shelf break, but very occasionally on the platform.

As last year, two main anchovy concentrations (Figures 4.1.4.3.) were observed:

- Offshore on the southern platform, big anchovy was well present between 100m and 120m depth. They were often mixed with sardine at the surface and with horse mackerel in the water column between the bottom and 50 to 70 m above. Nevertheless, anchovy echotraces this year appeared in a non traditional way. If they were sometimes distributed as soft and small schools in a layer between 20 and 40 m above the bottom, as it is usually the case, most of them appeared this year as very big and dense schools, which is very unusual. Their geographic distribution was therefore not on a continuous way as usual, but as patches of very dense schools.
- Small anchovies were observed in front of the Gironde, from the coast between 45° N and 46° 30 N until 100 m depth. It was, mixed with sardine in the southern end and with sprat in the Northern end.

These two areas were covered in good weather conditions and acoustics and fishing operations were all valid.

Sardine was found (mostly in pure schools) in three main areas: in the southern part of the Bay of Biscay (close to the bottom and near the surface), around the Loire plume, and in the west and southwest of Brittany. In the 2010 survey, sardine was mostly absent from the offshore waters except near the surface around 46°N (farther north than "Fer à cheval"; Figure 4.1.4.9.).

4.1.4.3 Stock estimate

As the previous years, after echogram scrutiny, the global area was split into strata where coherent communities were observed (species associations) in order to minimize the variability due to the variable mixing of species (Figure 4.1.4.1.). Allocation to species was therefore done using the standard method (Massé, J., WD2001 and stock annex) and biomass were estimated for main pelagic species in each strata according to aggregation categories and identification hauls (anchovy and sardine in Table 4.1.4.2. and WD Massé and Duhamel 2010).

The anchovy biomass index was estimated to 86 354 t with a coefficient of variation of 14.7% (the method is detailed in Petitgas *et al*., 2003) meaning that the anchovy biomass index according to acoustic data and pelagic hauls should be between 61 000t and 112 000t. Anchovy distribution is shown in Figure 4.1.4.3 and the time-series of acoustic biomass estimates is in table 4.1.4.4

The anchovy biomass index estimates in tons and in number were processed for each area at age group (table 4.1.4.3.), using length distributions at each closest haul and global age/length key for each of the two zones. Length and age distributions of anchovy are shown in Figures 4.1.4.4., and 4.1.4.5.

Two distinctive strata can be distinguished; the south offshore area with very big anchovies both at the bottom and at the surface and the Gironde and coastal area where smaller fish were observed (see Figure 4.1.4.6). Estimates have been calculated in numbers for each area and percentages and mean weights are shown in Table 4.1.4.3.

Last year 95% of the recruitment was only visible in front of the Gironde. This year it is visible in the whole area with 69% of age 1 (in number) in front of the Gironde and 31% in the south.

In the Gironde area, 92% of the fish was 1 year old (mean length 12.3 cm) and only 7% at age 2. In the south, 70% of the fish was at age 1 (mean length 15.1 cm) and 26% at age 2 (see Figure 4.1.4.7 and table 4.1.4.3.).

The estimated sardine biomass index was 457 081 tons, one of the highest values of the PELGAS series, but very similar to the values estimated in the last 3 years. It should be noted that PELGAS surveys do not cover the whole area of potential presence of sardine and therefore, it is possible that in some years, the species could be also present further north, in the Celtic sea, SW of Cornouailles or Western Channel where some fishery takes place. The PELGAS estimate is representative of the sardine present in the surveyed area at the time of the survey and can be therefore considered as an estimate of the Bay of Biscay (VIIIab) sardine population.

Sardine ranged in length from 11 to 25.5 cm and showed a trimodal distribution (with modes at 12, 16.5 and 19 cm). The smallest fish were found near the Gironde and age 1 was globally at a low level. Age 2 fish (2008 cohort) predominated in the survey and confirms the 2008 strong recruitment. Age 3 fish were also abundant (corresponding to the strong 2007 cohort) that has been apparent also in previous years (Figure 4.1.4.10).

Table 4.1.4.2. Biomass of anchovy and sardine per strata during PELGAS10.

		PELGAS10	Area	anchovy	sardine
Classical	Pel10_1	North offshore	1 679	616	991
	Pel10_2	North coast	3 492	1 821	345 186
	Pel10_3	Gironde	2 313	28 407	26 837
	Pel10_4	South coast	1 227	6	43 358
	Pel10_5	South offshore	3 492	43 426	11 538
surface	Pel10_6	North offshore	1 679		8 615
	Pel10_7	North coast	3 492		1 412
	Pel10_8	Gironde	2 313	7 365	484
	Pel10_9	South coast	1 227		
	Pel10_10	South offshore	3 492	4 714	18 659
		Total		86 354	457 081
		C.V.		0.147	0.091

Table 4.1.4.3. Anchovy age distribution (in numbers and in tonnes) and mean weight during PELGAS10.

AGE	Gironde & coastal (Nb * 1000)	(%)	Mean weight (g)	Abundance index (t)	South offshore (Nb * 1000)	(%)	Mean weight (g)	Abundance index (t)	Total (Nb * 1000)	(%)	mean Weight (g)	Abundance index (t)
1	2 827 453	92.17%	11.96	33 835	1 275 200	69.5%	24.10	30 727	4 102 653	83.69%	15.7	64 562
2	222 605	7.26%	18.00	4 007	479 137	26.12%	29.62	14 194	701 742	14.32%	25.9	18 201
3	16 723	0.55%	20.71	346	66 431	3.62%	38.32	2 545	83 155	1.70%	34.8	2 891
4	731	0.02%	27.06	20	13 411	0.73%	49.25	661	14 142	0.30%	48.1	681
total	3 067 512			38 208	1 834 531			48 145	4 902 043			86 354

Table 4.1.4.4. Acoustic abundance indices since 2000.

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
anchovy	113 120	105 801	110 566	30 632	45 965	14 643	30 877	40 876	37 574	34 855	86 354
CV anchovy	*0.064*	*0.141*	*0.113*	*0.132*	*0.167*	*0.171*	*0.136*	*0.100*	*0.162*	*0.112*	*0.147*
Sardine	376 442	383 515	563 880	111 234	496 371	435 287	234 128	126 237	460 727	479 684	457 081
CV sardine	*0.083*	*0.117*	*0.088*	*0.241*	*0.121*	*0.135*	*0.117*	*0.159*	*0.139*	*0.098*	*0.091*
Sprat	30 034	137 908	77 812	23 994	15 807	72 684	30 009	17 312	50 092	112 497	67 046
CV sprat	*0.098*	*0.155*	*0.120*	*0.198*	*0.178*	*0.228*	*0.162*	*0.132*	*0.268*	*0.108*	*0.108*
Horse mackerel	230 530	149 053	191 258	198 528	186 046	181 448	156 300	45 098	100 406	56 593	11 662
CV HM	*0.079*	*0.204*	*0.156*	*0.137*	*0.287*	*0.160*	*0.316*	*0.065*	*0.455*	*0.09*	*0.18.8*
Blue Whiting	-	-	35 518	1 953	12 267	26 099	1 766	3 545	576	4 333	48 141
CV BW	-	-	*0.386*	*0.131*	*0.202*	*0.593*	*0.210*	*0.147*	*0.253*	*0.219*	*0.074*

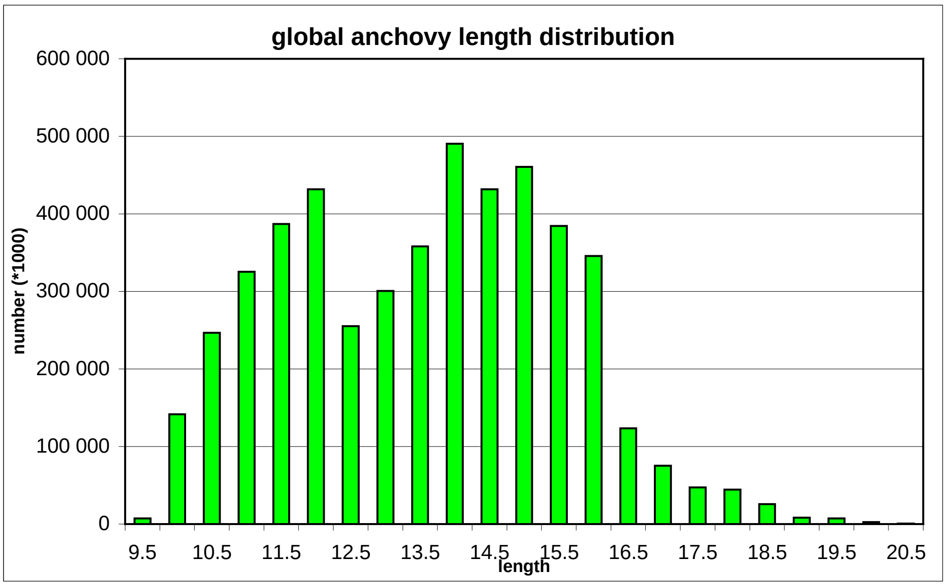


Figure 4.1.4.4. Global length structure of anchovy during PELGAS 09 (in numbers).

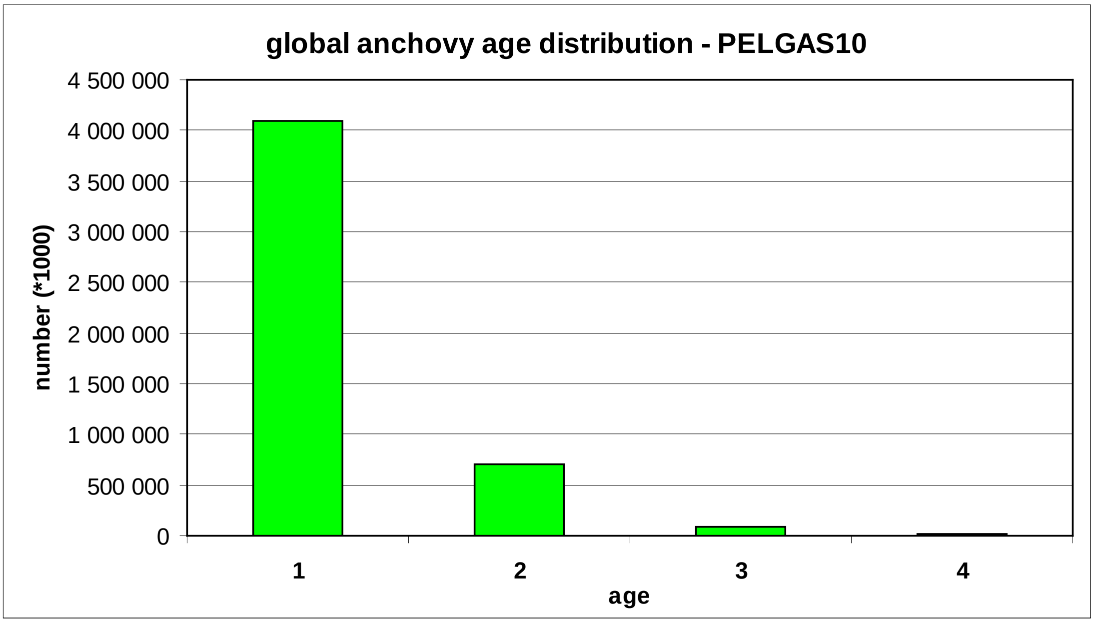
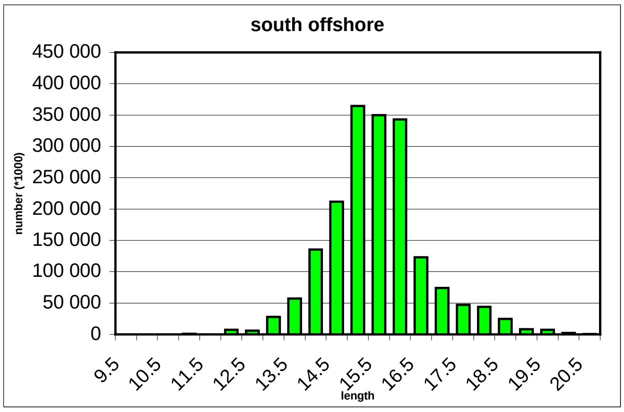


Figure 4.1.4.5. Global age structure of anchovy during PELGAS10 (in numbers).



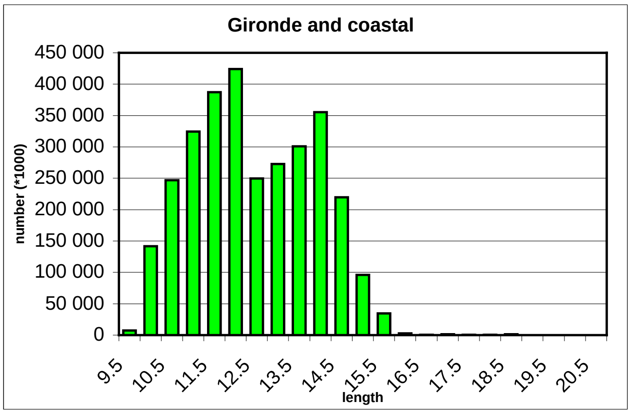


Figure 4.1.4.6. Length structure of anchovy during PELGAS 09 according to the two main areas where anchovy occurred

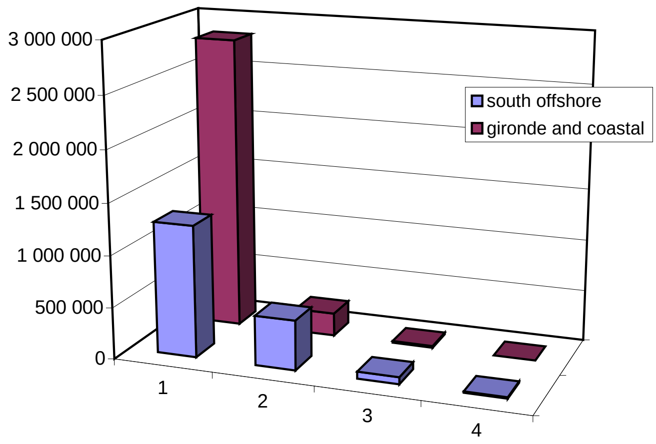


Figure 4.1.4.7. Numbers at age during PELGAS10 according to the two main areas where anchovy occurred.

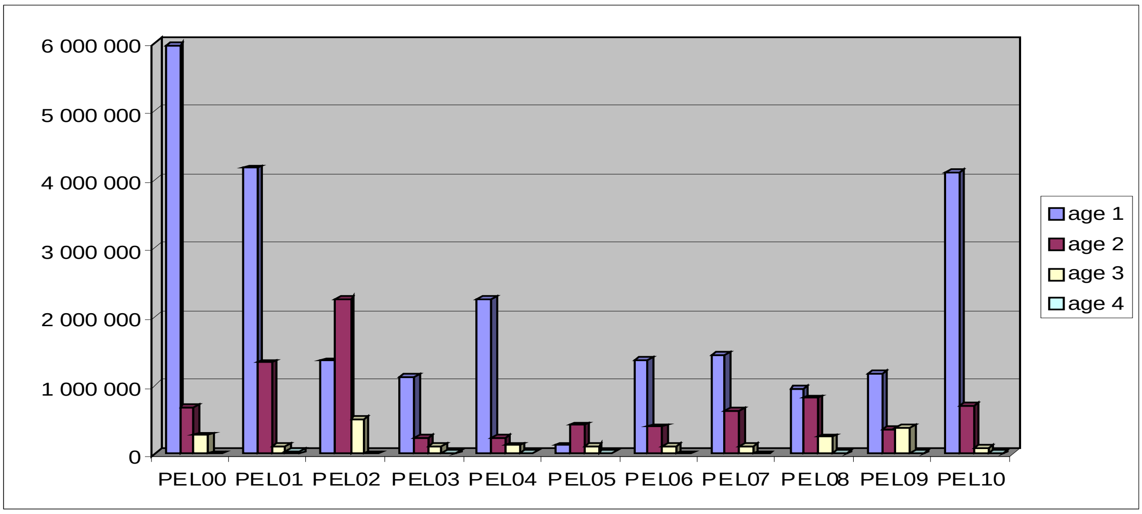


Figure 4.1.4.8. Demographic structure of anchovy in the Bay of Biscay (numbers-at-age) since 2000.

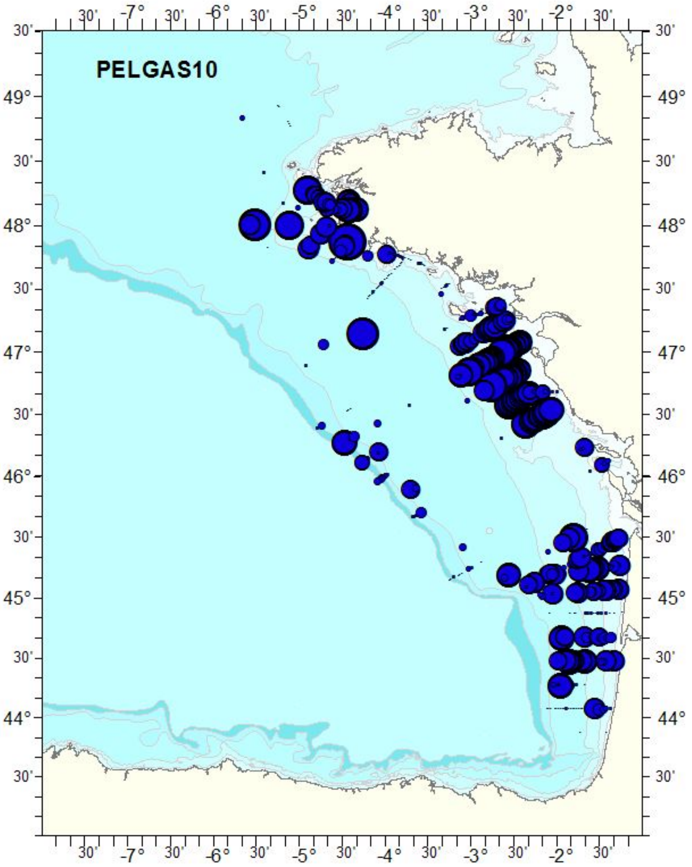


Figure 4.1.4.9. Sardine distribution observed during PELGAS10 survey.

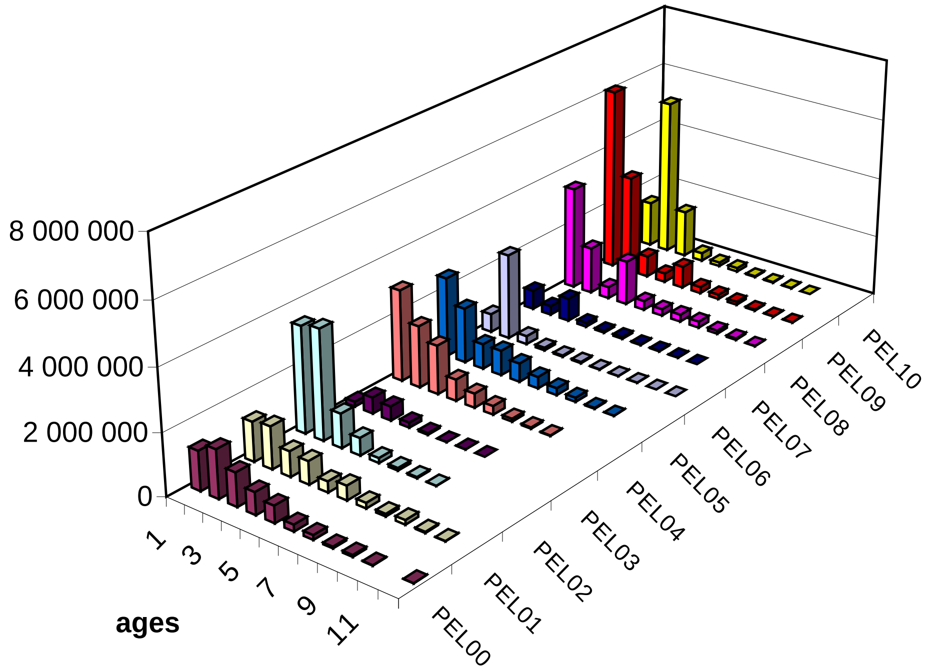


Figure 4.1.4.10. Demographic structure of sardine in the Bay of Biscay (numbers-at-age) since 2000.

4.1.4.4 Conclusion

The anchovy biomass index from the PELGAS10 survey has been estimated at 86 000t with 48 000 t of big anchovies offshore and 38 000 t in the Gironde area. The number of 1 year old anchovies this year seems to be medium (4 100 millions fish against 1174 in 2009 and 960 millions in 2008) compared to good years (about 10 000 millions fish). They represent 75% of the biomass (84% in numbers).

Looking at the numbers-at-ages since 2000 (Figure 4.1.4.8.), the 1 year old class is the first good recruitment since 2001 and 2 years old are still well present considering the low level of 1 year old in 2009.

The sardine biomass index was estimated at 457 081 tons, one of the highest values of the PELGAS series, but the 1 year old fish were not very abundant whereas a high level of 2 years old confirmed the good recruitment observed last year.

4.1.5 The UK summer acoustic surveys in the Celtic Sea: PELTIC10

4.1.5.1 Introduction

Several regionally important pelagic fisheries operate in the Celtic Sea and western Channel (VIIe-j). Traditionally, the main commercially exploited pelagic stocks have included mackerel *Scomber scombrus*, horse mackerel *Trachurus trachurus* and herring *Clupea harengus*. In recent years, however, there has been an increase in both the commercial landings and catches in fishery-independent surveys (Beare *et al*., 2004) of anchovy Engraulis encrasicolus and sardine Sardina pilchardus.

Given concerns about the anchovy stock in Subarea VIII in recent years, and the absence of any fisheries independent data on this species in Subarea VII, studies are required to determine whether they are separate stocks, or whether there has been a northward shift in their distribution. Anchovy is now being taken by UK fisheries, for export to the continent. Sardine has also increased in the Celtic Sea, and is forming the basis of a locally important fishery (Cornish sardine). Limited available information suggests the presence of subpopulations within the NE Atlantic sardine stock. Juveniles as well as eggs are noted in the Cornwall area, and hence there may be relatively local spawning, but data are limited and no dedicated studies have been carried out.

Cefas recently started a two year study focusing on the population dynamics of anchovy and sardine in the Celtic Sea shelf area and western Channel. The study includes a two-part field component: a short reconnaissance survey on-board commercial vessels in June 2010 surveying the British Fishing sector of the Celtic Sea, and a 22 day research survey in May/June 2011 covering the whole of the Celtic Sea shelf and western Channel. Here the results of the 2010 reconnaissance survey are presented.

4.1.5.2 Description of the survey

The Pelagic Pair Freezer Trawlers Wiron 1 and Wiron 2 (length 54.1 m) were chartered for a ten day field programme in 2010. As the area of interest was too large to survey at high resolution in its entirety, a provisional survey plan was drafted (Figure 4.1.5.2.1), which included three grids; one on the south coast of Cornwall (grid 1), one at the edge of the Celtic Sea shelf (grid 2) and one north of Cornwall (grid 3). Two cross-shelf transects (southern and northern) were included to provide information on the areas in between these grids. The survey started on the 11th of June and was aborted in the morning of 14 June, owing to a combination of adverse weather and serious engine problems on Wiron 2. Three parallel equidistant (10 nautical mile) acoustic transects perpendicular to the coast off Plymouth were completed, as well as a single transect to the shelf edge (equivalent to transect south, A) and about 70% of the northern cross-shelf transect (Figure 4.1.5.2.2).

Fisheries acoustic data were recorded continuously using the hull mounted Simrad ES60 echosounders operating at 38, 70 and 120 (split-beam) and 200kHz (single beam). All frequencies were calibrated according to Foote *et al*., 1987 using additional recommendations by Honkalehto and Ryan (2003) specifically for this Simrad system. Two valid tows were made in the mini grid (Figure 4.1.5.2.2) using a pair trawl, with vertical opening of ~35m, but the weather prevented any further trawling activities. Subsamples were taken from the catches and all specimens were measured. At one inshore and one offshore station in grid 1 (Figure 4.1.5.2.2) and a further 11 equidistant (~35nmi) stations along the cross-shelf transects, combined CTD/Plankton vertical dips were made (Figure 4.1.5.2.2). Plankton was sampled using a 1m diameter 200µm mesh ringnet, which was deployed down to the seabed or a maximum depth of 100m (in deeper waters). Vertical temperature and salinity casts were extracted from the CTD.

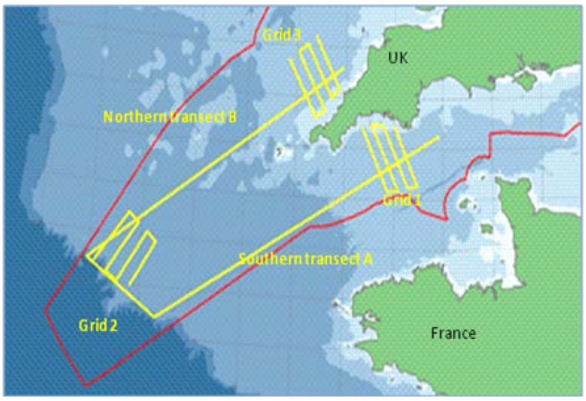


Figure 4.1.5.2.1. Provisional draft design of the PELTIC10 survey (yellow lines) within the UK fishing limits (red polygon).

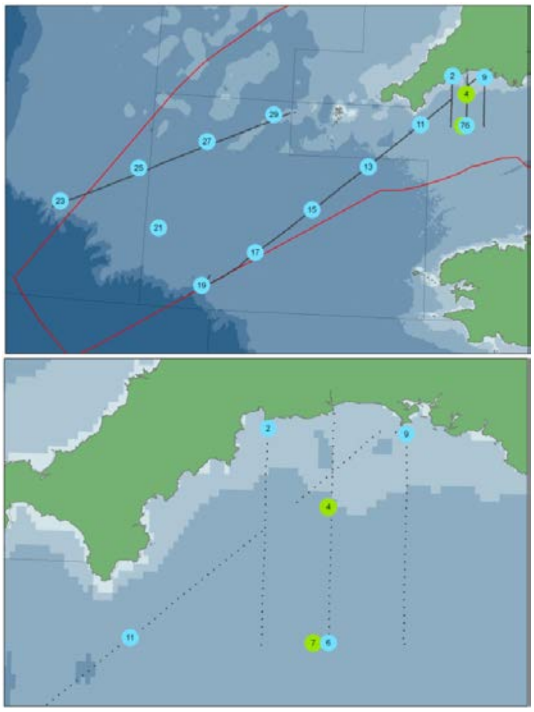


Figure 4.1.5.2.2. Overview of the survey (left) with detail of Plymouth Bay (right) showing the acoustic transects (black dotted lines), plankton/CTD stations (blue) and fishing stations (green).

4.1.5.3 Results

4.1.5.3.1 Sardine

As insufficient ground-truth data could be collected during the survey, it was impossible to confidently attribute species identification to the observed acoustic marks. The results will be further analysed when Cefas undertakes a dedicated acoustic research survey in the area in 2011. Although details on the distribution of adult sardines from the acoustic data were compromised, there was some evidence that frequently occurring small but strong acoustic marks near the surface consisted of this species (Figure 4.1.5.3.1.1) and suggested a distribution across the shelf. Two trawls were made both consisting mainly of horse mackerel (84% and 98% by weight, respectively), some whiting and sardines (~1%). At the first station herring and mackerel were also caught. The sardine lengths ranged from 18.5 to 25.5 cm, with bimodal peaks at 20 and ~23 cm (see Figure 4.1.5.3.1.2). This was comparable to the general length frequency distribution of all available sardine specimens from the western Channel combined. Equal proportions of male and female sardine were found. The preliminary age readings suggest that the sardine population in the western Channel includes fish ranging from 1 to 11 years old, with a peak at 4 and 5 years (Figure 4.1.5.3.1.2). More than half the sardines were ready to spawn (64%) or had recently spawned (23%) and 13% were either immature or developing.

Nine of the 12 valid plankton stations contained sardine eggs (Figure 4.1.5.3.1.1) and eight contained positively identified sardine larvae. The distribution of sardine eggs and larvae overlapped, with largest numbers for both found offshore in Plymouth bay and south of the Scilly Isles on the southern cross-shelf transect, gradually decreasing in numbers towards the shelf edge. Only very few sardine eggs and larvae were found on the northern cross-shelf transect, and only in the deeper parts towards the shelf edge in the west. Horse mackerel and mackerel eggs were also found in large numbers, mainly in the western, deeper areas near the shelf edge (not shown).

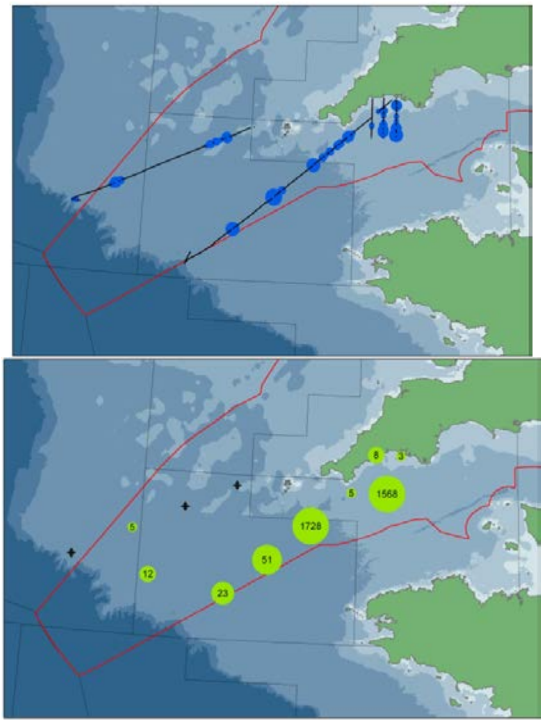


Figure 4.1.5.3.1.1. Overview of the survey with sardine NASC (surface clupeid schools) integrated per 1 nautical mile (left) along the survey tracks (black), and sardine egg numbers (right) from the plankton stations.

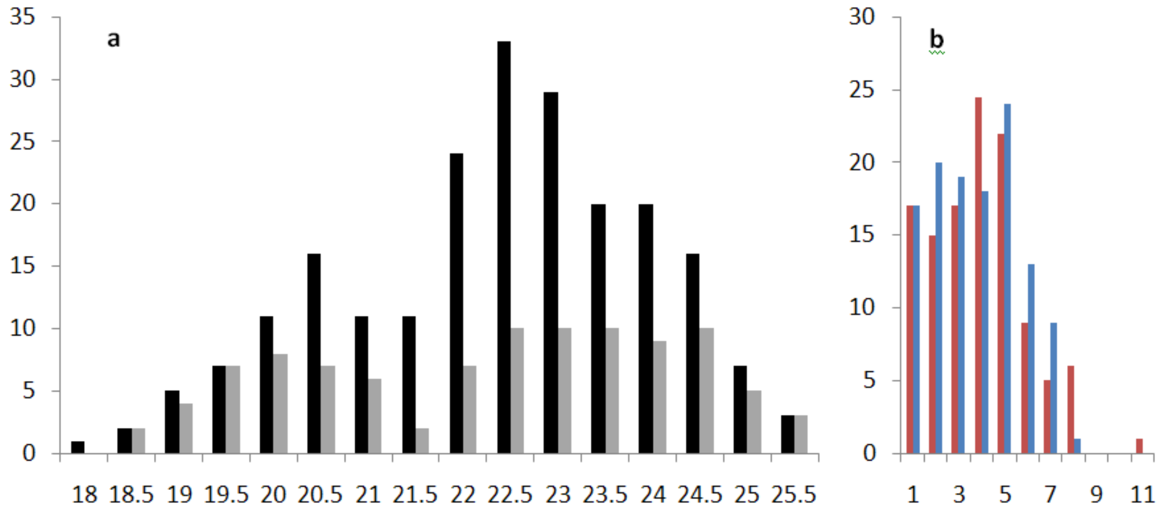


Figure 4.1.5.3.1.2. Length frequency distribution of English Channel sardines, with in grey the samples from the PELTIC10 survey and in black additional samples from the Cornish Sardine fishers (all collected in June-July 2010). B). sardine age distribution by sex, females (red) and males (blue).

4.1.5.3.2 Anchovy

No anchovy adults, eggs or larvae were found during the survey. Anecdotal evidence confirms that anchovy do occur in the Channel, from autumn throughout winter through to early spring. Cefas have obtained anchovy specimens from both the commercial fishery and from bottom-trawl surveys in the area, and will include the biological samples in the analysis that is part of the next stage of this project.

4.1.5.4 Conclusions and future research

As mentioned above, the survey was cut short to three sampling days (plus one day for calibration) instead of the planned ten days. We were therefore not able to meet all the objectives. However, many of the data collected were novel and provided a preliminary insight into some of the unknowns of sardine and anchovy biology.

Of the two target species only sardine was found during the survey. There was clear evidence of sardine spawning activity throughout the area surveyed. Sardine eggs and larvae were present in most plankton station samples and very high concentrations of eggs were found offshore from Plymouth and south of the Scilly Isles, which corresponds to the previously reported distribution from plankton surveys (Wallace and Pleasants, 1972) and continuous plankton recorder (CPR) data (Coombs *et al.*, 2005, 2010). Numbers decreased towards the shelf edge and only a few sardine eggs and larvae were found at the plankton stations of the northern cross-shelf transect. This suggests that sardine spawning, albeit widespread, is largely concentrated in the southern part of the surveyed area. It was not possible to estimate the abundance of sardine, and hence to estimate the fraction of the stock being removed by fishing. However, one of the main fisheries targeting this species is the Cornish sardine fishery, which operates largely within 6 nautical miles of the coast from small vessels, so is likely to remove just a small fraction of the population. However our understanding of, for example, the movements of sardine is still limited and will need to be addressed in future. The age range was large with specimens as old as 11 years and equal numbers of 1–5 year old fish. This suggests a healthy population with fishing pressure at a sustainable level. However, our sample size was small and further collection of age/length data from the larger Celtic Sea shelf area, from different seasons and from consecutive years would shed more light on this. Genetic work could help in further identifying the origin of these Channel (and Celtic Sea) sardines.

Although anchovy are known to live in the English Channel, no anchovy eggs, larvae or adults were caught during the survey. At the nearest confirmed anchovy spawning locations in the Bay of Biscay and Dutch estuaries of the southern North Sea (Boddeke and Vingerhoed, 1996), anchovy spawn from April and May to August, with a peak in June. Limited peer-review as well as anecdotal evidence suggests that anchovy in the north of their distribution spawn in discrete locations and are particularly associated with estuarine habitats. The complete lack of anchovy adults or eggs suggests an absence of anchovy spawning sites in the survey area. However, as the survey mainly covered offshore waters, and coincided with anchovy spawning time, this was expected. Adult anchovy caught in the Channel from autumn through to early spring are likely to be moving there from one of the surrounding spawning populations. One possible local spawning area (based on the preferred habitat) was the Bristol Channel (east of Grid 3, Figure 4.1.5.2.1), but this area was not covered by the 2010 survey. At this point it is unclear from which spawning population they originate, and this would need to be investigated given the implications for management of the species. Cefas have been collecting anchovy specimens from all over the region, and will be analysing the genetic structure to shed more light on this.

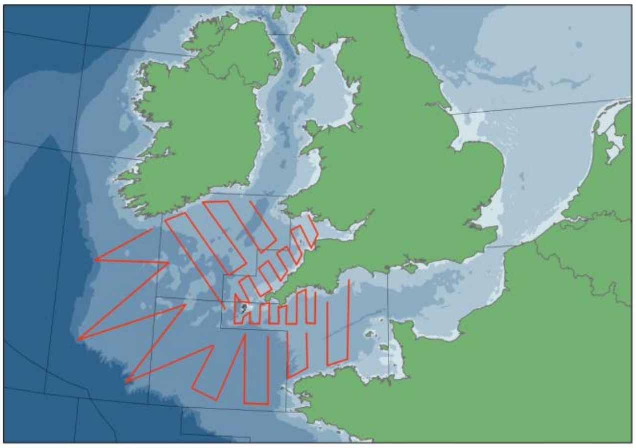


Figure 4.1.5.4.1. Preliminary acoustic survey designs proposed for the 2011 survey (PELTIC11), covering the Celtic Sea shelf area and western Channel.

The results from the current study have helped in better identifying particular areas of focus for next year's PELTIC11 survey. The increased coverage and resolution of that survey (Figure 4.1.5.4.1), both with regards to acoustic transects and plankton stations, is aimed at providing accurate distribution and abundance information of sardine, as well as the exact locations of sardine spawning areas, and age and length information. The fieldwork will also cover part of the Bristol Channel and the southern boundary of the Irish Sea, both potential spawning areas of anchovy (Armstrong *et al*., 1999). The survey will be conducted according to standardized protocols and recommendations from WGACEGG, so that the information can be combined with that of the existing surveys further south. Additional sardine and anchovy specimens will be obtained from the commercial fishers as well as other research surveys to supplement the existing biological samples, aiming at improving the understanding of the biology of these species at the northern boundary of their distribution.

4.1.6 Spanish summer acoustic surveys in the Gulf of Cádiz: ECOCÁDIZ 0609 and ECOCÁDIZ-COSTA 0709

4.1.6.1 Description of the surveys

The ECOCÁDIZ 0710 survey was carried out between 25 July and 1 August 2010 onboard the Spanish RV "Cornide de Saavedra". Because of a shortage of the ship-time available for this survey, the conventional survey area comprising the waters of the Gulf of Cadiz, both Spanish and Portuguese, between the 20 m and 200 m isobaths, was reduced to an area limited by the waters placed between Cape Trafalgar and Cape Santa Maria. The survey design consisted in a systematic parallel grid with tracks equally spaced by 8 nm, normal to the shoreline (Figure 4.1.6.1.1). Methods are described in Annex 6 (protocols for acoustic surveys: IEO-S) and in a summarized survey report provided to this meeting as WD (Ramos *et al*., WD2010a). Fishing stations were carried out using a 20 m-vertical opening pelagic trawl and monitored with a Simrad™ Mesotech FS20/25 trawl sonar. A Continuous Underway Fish Egg Sampler (CUFES, Figure 4.1.6.1.2), a Sea-bird Electronics™ SBE 21 SEACAT thermosalinometer and a Turner™ 10 AU 005 CE Field fluorometer were also used, as usual, during the acoustic tracking to continuously monitor the anchovy egg abundance and to collect some hydrographical variables (subsurface sea temperature, salinity, and *in vivo* fluorescence). This year, an *ad hoc* sampling grid of 11 *Bongo 40* stations arranged in two additional transects was also carried out in order to characterize the ichthyoplankton and mesozooplankton species assemblages in the eastern sector of the study area (Guadalquivir river mouth-Trafalgar) and their relationships with environmental conditions. Vertical profiles of hydrographical variables were also recorded by night from 42 CTD stations (36 foreseen stations plus 6 additional ones from the 57 stations' original grid) by using a *Sea-bird Electronics™ SBE 19 SEACAT* profiler (**Figure 4.1.6.1.2**). Information on presence and abundance of seabirds, turtles and mammals was also recorded during the acoustic sampling by one on-board observer.

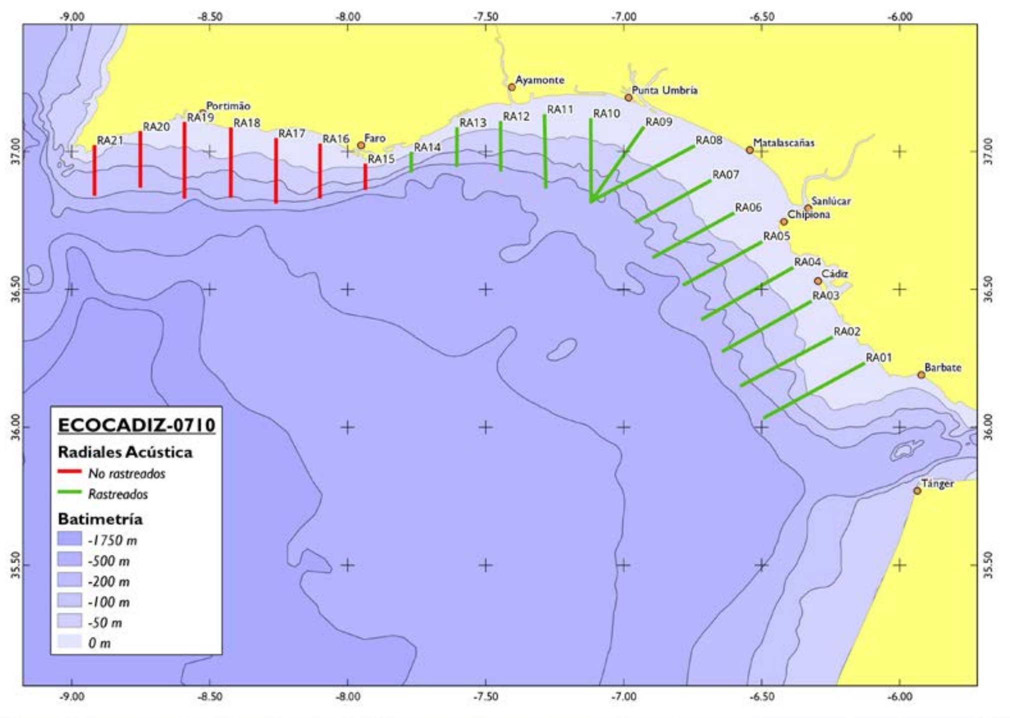


Figure 4.1.6.1.1. *ECOCÁDIZ 0710*. Survey transects. Foreseen grid of transects for acoustic sampling with indication of those ones finally sampled during the survey (in green).

Seventeen fishing stations, all of them valid, were carried out during this survey (**Figure 4.1.6.1.3**). These hauls captured a total of 5343 kg and 236 thousand fish. From the set of small and mid-sized pelagic fish species stood especially out anchovy (present in 15 hauls, 88% of occurrence), followed by sardine and chub mackerel (both occurring in 13 hauls, 76%), mackerel and bogue (in 11 hauls, 65%), horse- and blue jack-mackerel and black sea bream (10 hauls, 59%), and Mediterranean horse-mackerel (5 hauls, 29%).

A total of 229 nautical mile (ESDUs) from 14 transects were acoustically sampled by echo-integration for assessment purposes: 204 nautical mile (11 transects) were sampled in Spanish waters, and only 25 nautical mile (3 transects) in the Portuguese waters (**Figure 4.1.6.1.4**). For the whole "pelagic fish assemblage" was estimated a total of 88389 m^2 nmi^{-2}. The small sampled area of Portuguese waters accounted for 45.6% of this total backscattering energy and the Spanish waters the remaining 54.4%. Thus, given that the number of Portuguese sampled ESDUs was eight times lower than the Spanish one, the (weighted-) relative importance of such a small Portuguese sampled area (i.e. its density of "pelagic fish") is actually much higher.

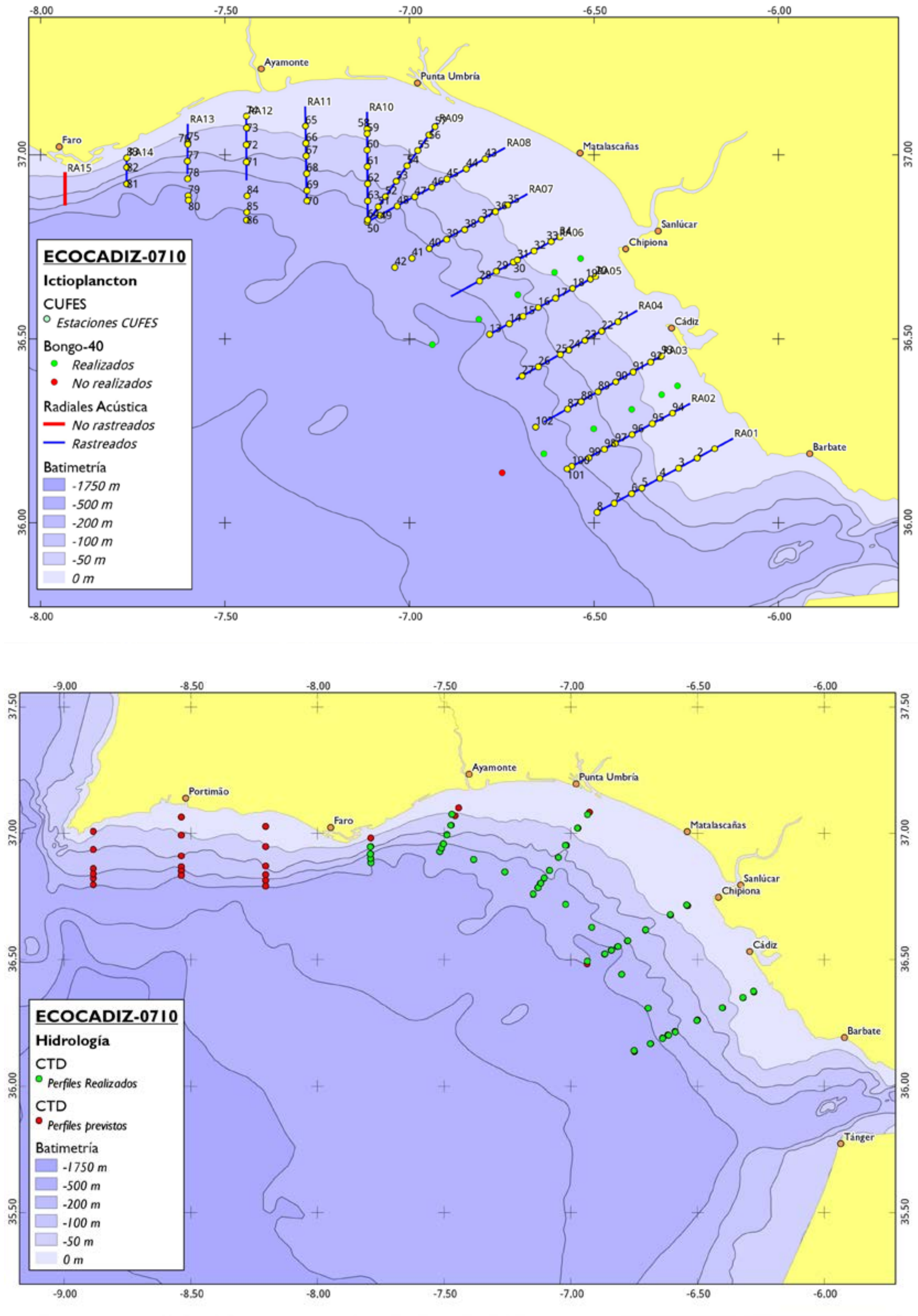


Figure 4.1.6.1.2. ECOCÁDIZ 0710 survey. Top: sampled CUFES stations (anchovy egg sampling) and Bongo 40 sampling grid (ichthyo- and mesozooplankton sampling) with indication of sampled stations (in green). Bottom: foreseen sampling grid of CTD cast stations with indication of those ones finally sampled (in green).

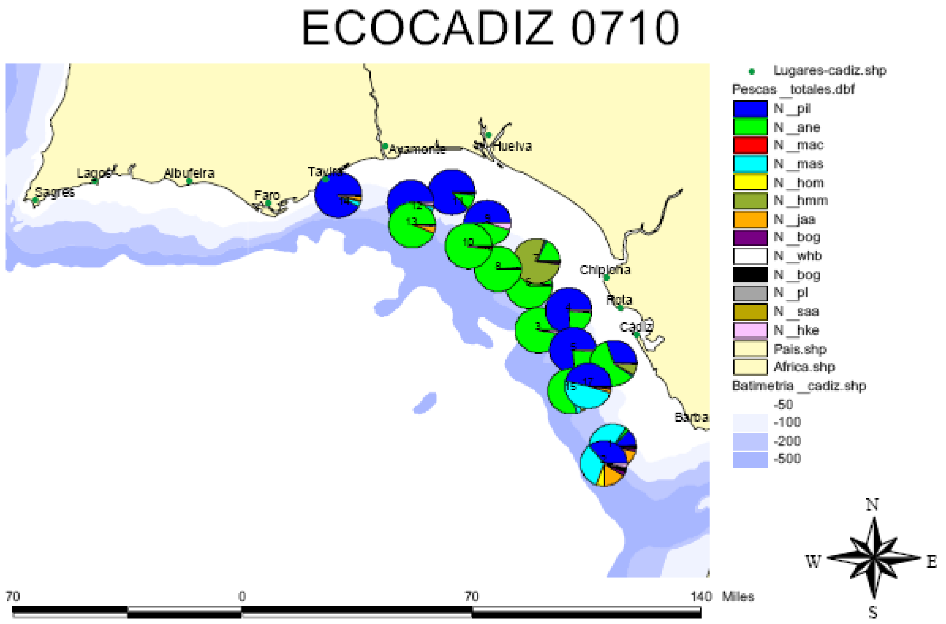


Figure 4.1.6.1.3. ***ECOCÁDIZ 0710*** **survey. Location of valid fishing stations and their species composition (expressed as percentages in number).**

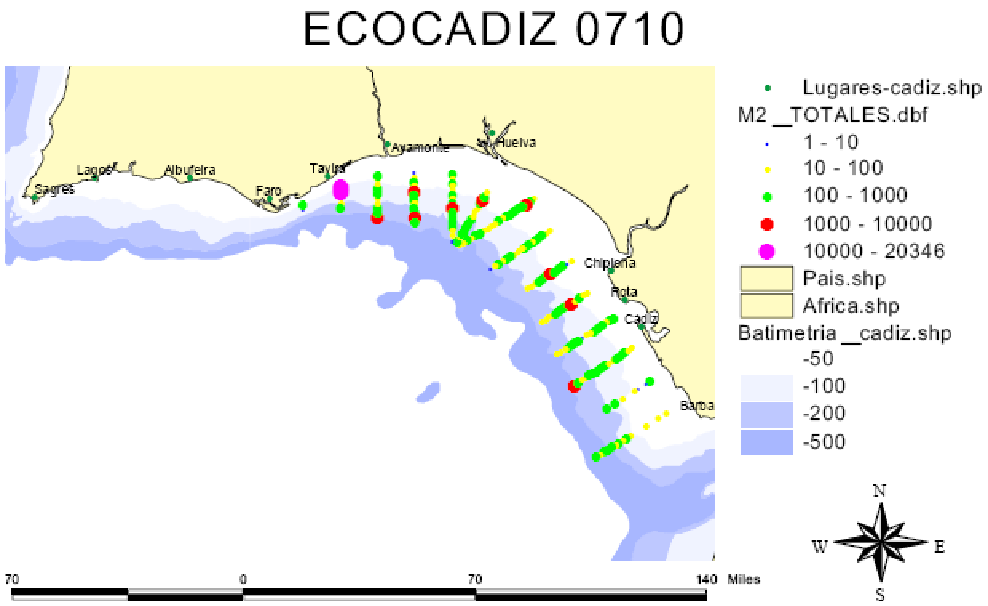


Figure 4.1.6.1.4. ***ECOCÁDIZ 0710*** **survey. Distribution of the total backscattering energy attributed to the pelagic fish species assemblage.**

By species, sardine accounted for 58.5% of this total backscattering energy, a relative importance corroborated by its high frequency of occurrence in hauls. Anchovy only contributed with 19.3%, followed by chub mackerel with 8.8%, blue jack-mackerel with 6.3%, Mediterranean horse-mackerel with 4.7%, horse-mackerel and bogue with values around 1%, negligible energetic contributions by mackerel and null ones by round sardinella. Anchovy, Mediterranean horse-mackerel and bogue showed their higher densities in the Spanish waters, whereas blue jack-mackerel and horse-mackerel did it in the Portuguese ones. The same considerations made for the total energy are also valid for the balanced (but not weighted) regional contributions by other species (e.g. sardine, mackerel and chub mackerel).

Because of the above problems with the acoustic sampling coverage, results from this survey are not directly comparable with those provided by IPIMAR from its *PELAGO10* spring survey, although some inferences on the most recent trends in the population levels of the main species may still be raised at a more local spatial scale. For the same reasons, unlike previous surveys, estimates provided in the present report have not been possible to be shown by each of the 2 subareas or regions usually considered: "Portugal" (from Cape S. Vicente to Vila Real de Santo Antonio) and "Spain" (from Ayamonte to Cape Trafalgar). Instead, estimates from the total area and by "polygon" (i.e. size-based homogeneous region or coherent stratum) are presented.

4.1.6.2 Distribution of anchovy and sardine

4.1.6.2.1 Anchovy

Anchovy occurred all over the shelf of the sampled area, although they showed their highest densities over the middle-outer shelf in the westernmost area (**Figure 4.1.6.2.1.1**).

The size class range of the assessed population varied between 7.5 and 17.5 cm, with two modal classes at 9.5 and 13 cm. In contrast to the persistent pattern observed throughout the survey series, where largest anchovies usually occur in the westernmost waters, this year largest anchovies mainly occurred in the easternmost area. Although westernmost anchovies were of a larger size than in the central part of the sampled area, they did not reach the highest sizes as they are usually recorded. Just in this central part is still recorded the occurrence of the smallest anchovies, coinciding with the location of the main recruitment area close to the Guadalquivir river mouth. Thus, 17% of the whole estimated population was below or equal to 10 cm suggesting a population sustained by smaller anchovies than, at least, in the previous year. This fact may well be a consequence of about one-month delay in the present survey dates, which has allowed to sample the start of the recruiting process to the survey area better than in previous year (**Tables 4.1.6.2.1.1** and **4.1.6.2.1.2**, **Figures 4.1.6.2.1.2** and **4.1.6.2.1.3**).

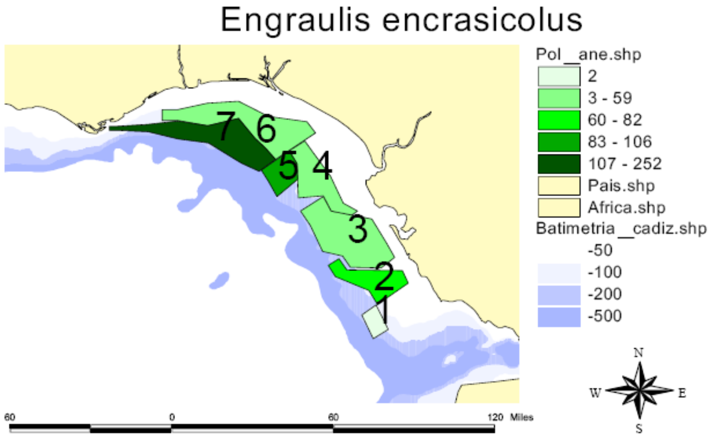


Figure 4.1.6.2.1.1. ***ECOCÁDIZ 0710*** **survey. Anchovy (*Engraulis encrasicolus*). Distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.**

ECOCÁDIZ 0710: **Anchovy (*E. encrasicolus*)**

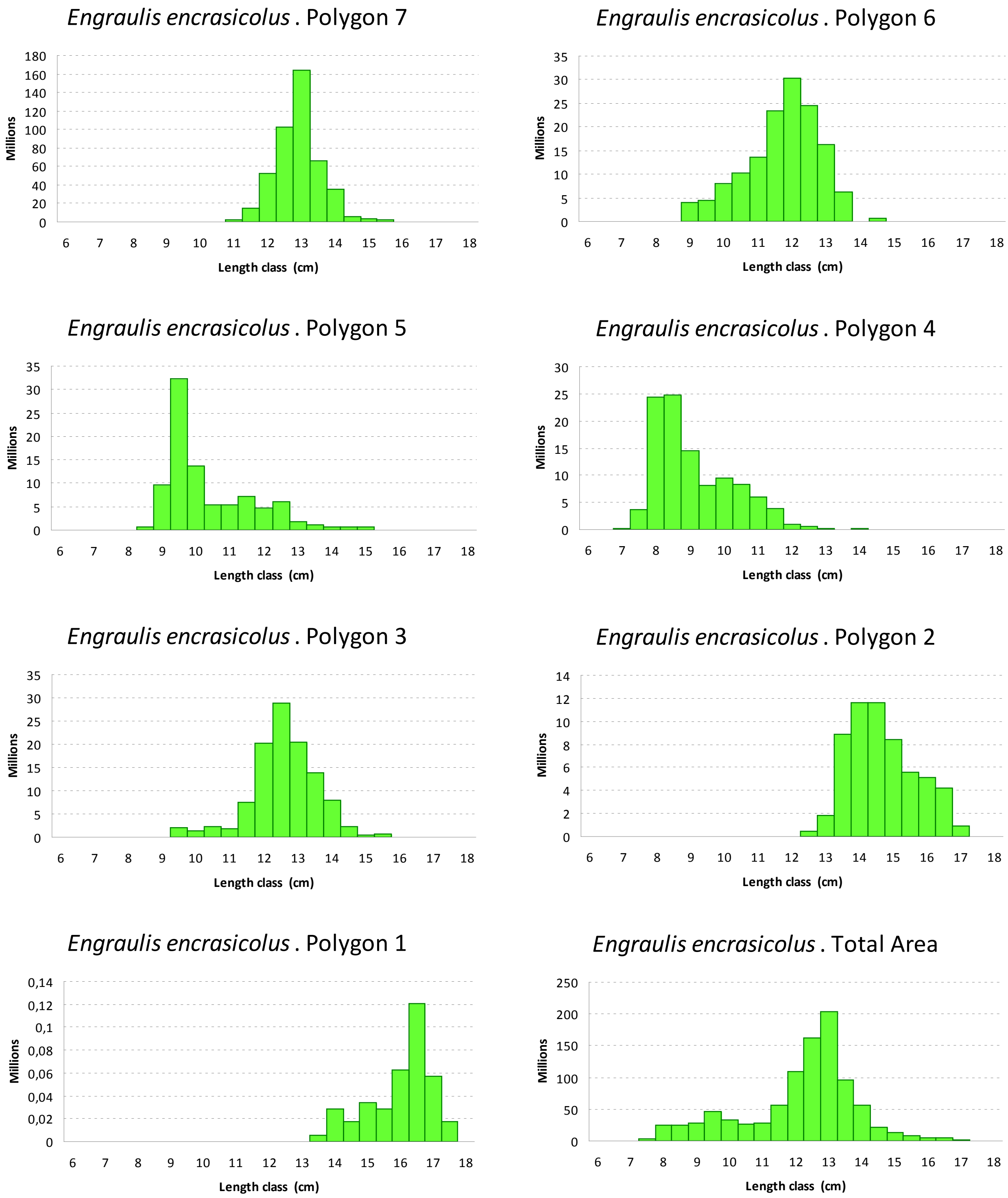


Figure 4.1.6.2.1.2. *ECOCÁDIZ 0710* survey. Anchovy (*E. encrasicolus*). Estimated abundances by length class by homogeneous stratum (ordered from west to east, numeration as in Figure 4.1.6.2.1.1) and total area. Note the different scales in the *y-axis*.

ECOCÁDIZ 0710: Anchovy (*E. encrasicolus*)

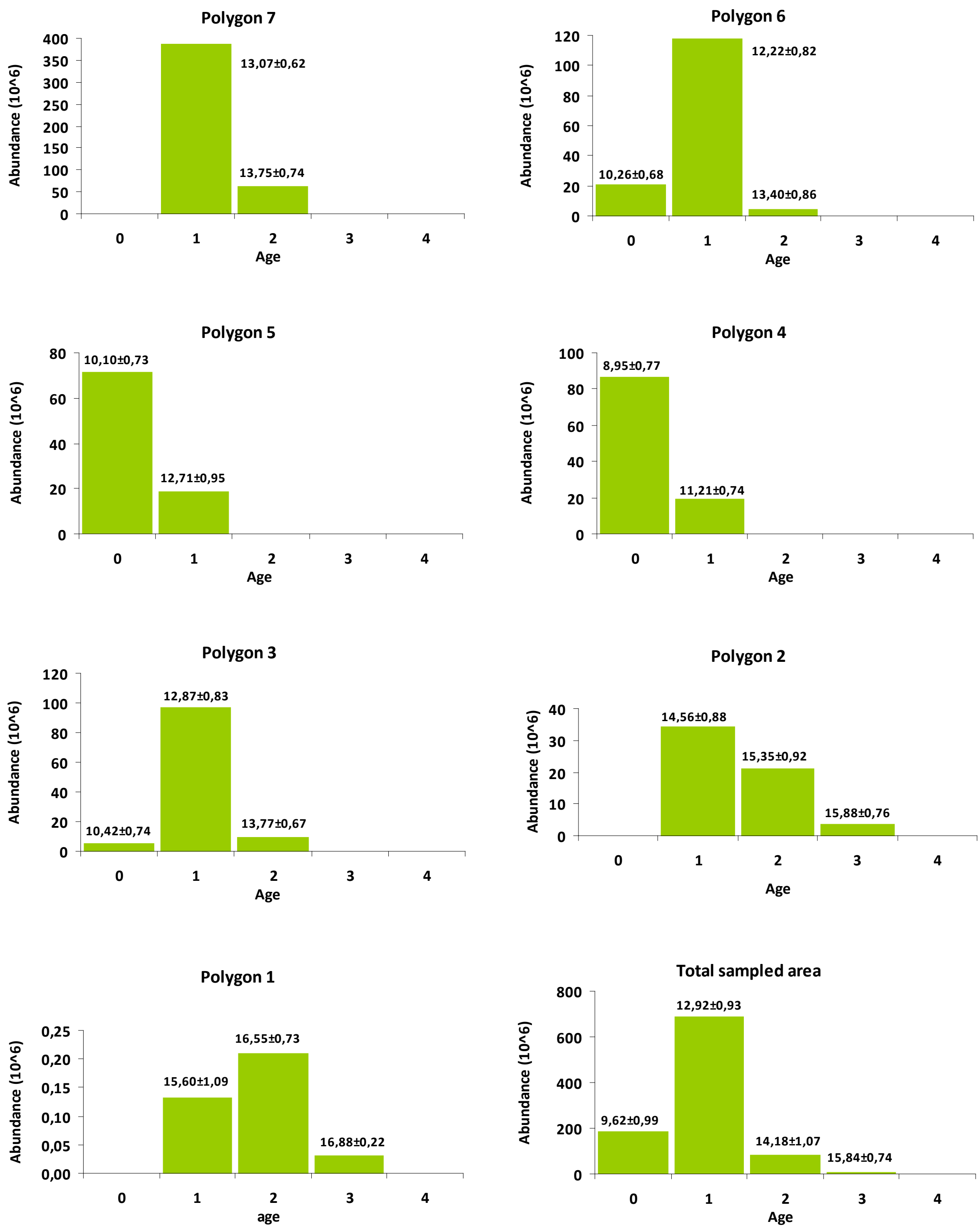


Figure 4.1.6.1.2.3. *ECOCÁDIZ 0710* survey. Anchovy (*E. encrasicolus*). Estimated abundance (millions of individuals) by age group for each homogeneous stratum (ordered from west to east, numeration as in Figure 4.1.6.1.1) and total area. Note the different scales in the y-axis. Mean length (±SD) by age group is also shown.

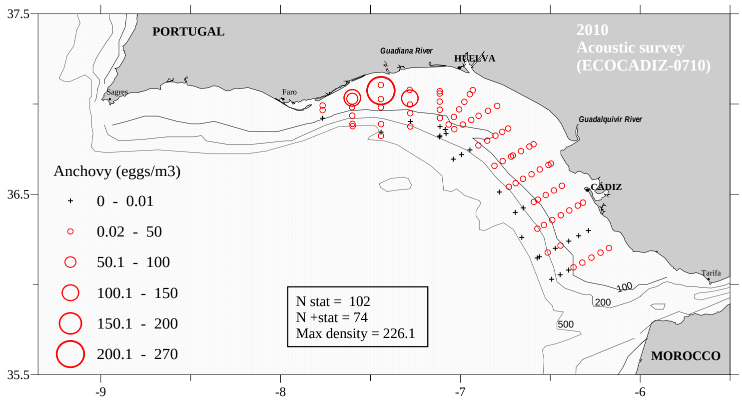


Figure 4.1.6.1.2.4. ***ECOCÁDIZ 0710*** **survey. Anchovy (*****E. encrasicolus*****). Spatial distribution of egg densities (eggs/m³) as sampled by CUFES.**

Anchovy eggs were also recorded in all the surveyed transects. The positive stations (75) with anchovy eggs accounted for 74% of the total number of sampled stations (102). The highest anchovy egg densities (> 100 eggs/m³) were located in a few stations over the middle shelf at both sides of the Portuguese-Spanish border (**Figure 4.1.6.2.1.4**).

4.1.6.2.2 Sardine

Sardine occurred all over the inner-middle shelf, in shallower waters than anchovy, and also showing the highest densities in the westernmost coastal waters of the sampled area (**Figure 4.1.6.2.2.1**). The size range of the assessed population ranged between 9 and 22.5 cm size classes, with a two modal classes at 11.5 and 18.5 cm. The size composition of the surveyed population evidences that the central coastal area might correspond to a recruitment area for the species (**Table 4.1.6.2.2.1, Figures 4.1.6.2.2.1** and **4.1.6.2.2.2**).

4.1.6.3 Stock estimates

4.1.6.3.1 Anchovy

Seven sectors have been differentiated according to the S_A values distribution and the size composition in the fishing stations. The acoustic estimates by homogeneous stratum and total area are shown in **Tables 4.1.6.2.1.1** and **4.1.6.2.1.2**, and **Figures 4.1.6.2.1.2** and **4.1.6.2.1.3**. A total of 12339 t and 954 millions of fish have been estimated for this species for the whole surveyed area.

4.1.6.3.2 Sardine

Six size-based homogeneous sectors were delimited for the acoustic assessment. The acoustic estimates by homogeneous stratum and total area are shown in **Table 4.1.6.2.2.1** and **Figure 4.1.6.2.2.2**. Sardine was the most important species in terms of both biomass and abundance: 66964 t and 2068 millions of fish have been estimated for this species for the whole surveyed area.

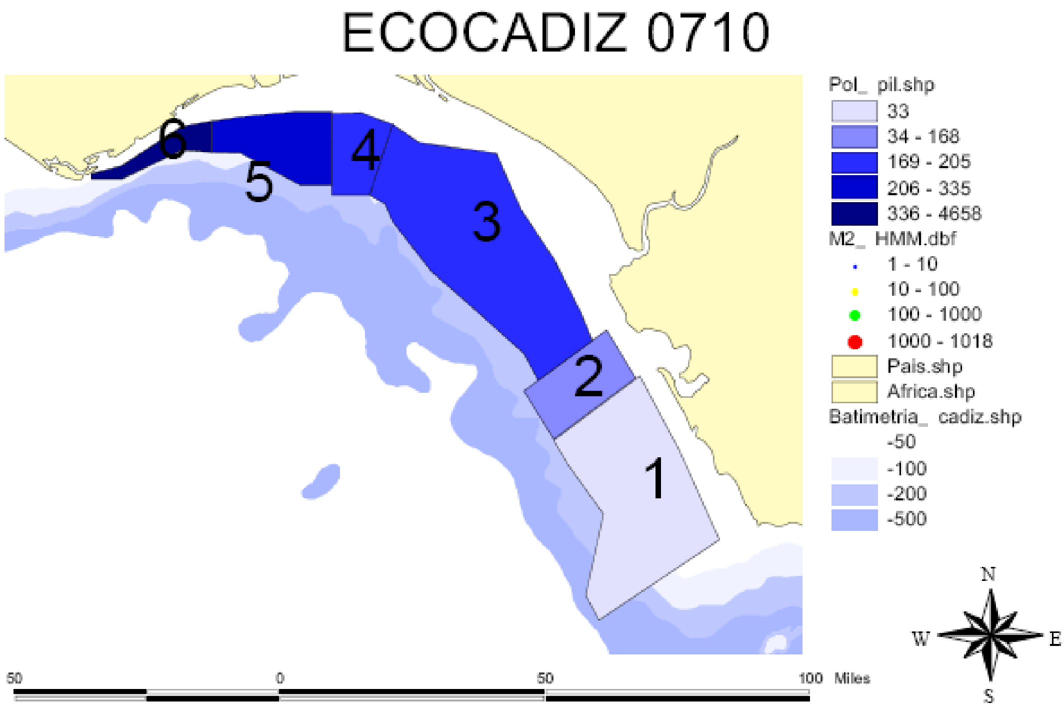


Figure 4.1.6.2.2.1. *ECOCÁDIZ 0710* survey. Sardine (*Sardina pilchardus*). Distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

4.1.6.4 Conclusion

Figure 4.1.6.4.1 shows the recent trends in biomass of anchovy, sardine and chub mackerel, the 3 most important species in the area so far. The values from the 2010 survey can hardly be compared with the previous ones because of the differences in the spatial coverage of the survey's area. However, a comparison of the species-specific acoustic estimates derived from the same area surveyed both in this survey as in the last year's *ECOCÁDIZ 0609* is shown in **Table 4.1.6.4.1**. Regarding total biomass and abundance estimated in each survey we can observe that the computed values are relatively very similar (94909 t and 2137 million fish in 2009, 91354 t and 3177 millions in 2010), although the allocation by species differs enormously. Thus, sardine was the most important species both in terms of numbers (2 068 millions) and weight (66964 t) this year, showing a relatively good recruitment. As compared with the last year, for a similar surveyed area, the species has doubled the biomass and it has multiplied by a factor of four its abundance. Anchovy was the second most important species (12339 t, 954 million fish), showing an abundance similar than the estimated one last year from the same area, although sustained by a lower a biomass, evidencing, therefore, a smaller mean size. Chub mackerel, a species always abundant in the surveyed zone (together with sardine and anchovy), has suffered this year an enormous diminution both in biomass (2861 t) and abundance (only 43 million fish). Finally, blue jack- and Mediterranean horse-mackerel slightly increased this year their biomasses and abundances in relation to the last year in the area under comparison, whereas horse mackerel and bogue showed drastic reductions in their populations.

ECOCÁDIZ 0710: Sardine (*S. pilchardus*)

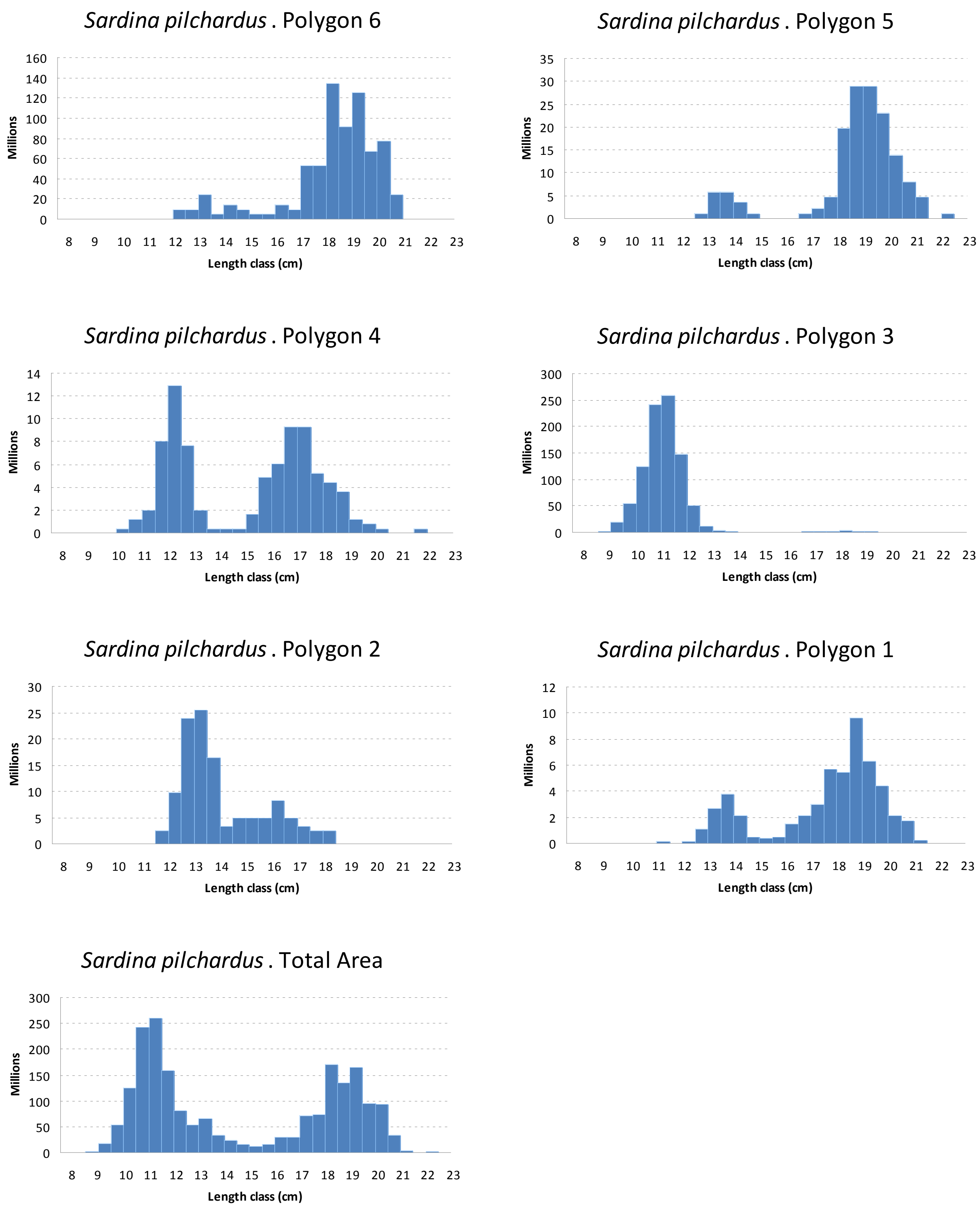


Figure 4.1.6.2.2.2. *ECOCÁDIZ 0710* survey. Sardine (*Sardina pilchardus*). Estimated abundances by length class by homogeneous stratum (ordered from west to east, numeration as in Figure 4.1.5.2.2.1) and total area. Note the different scales in the *y-axis*.

*ECOCÁDIZ s*urveys. Biomass trends (in tons)

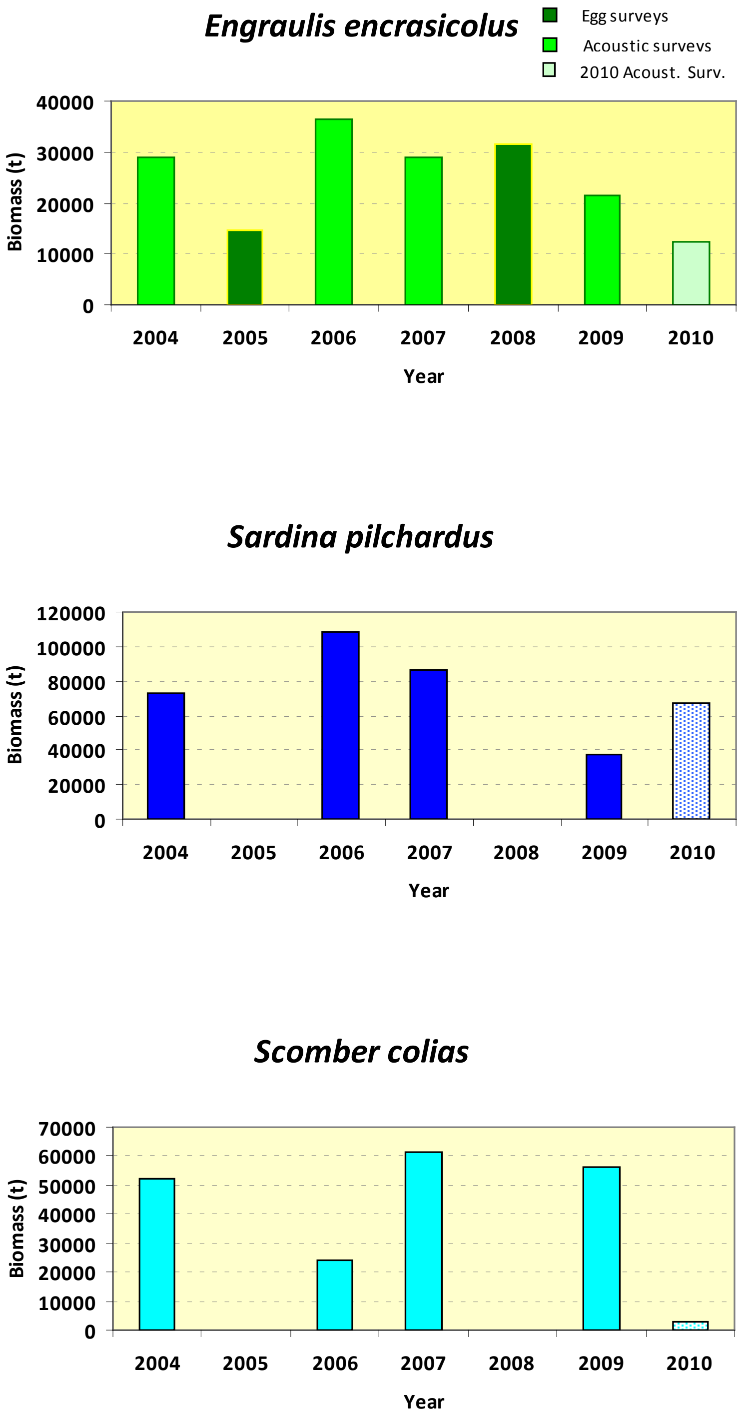


Figure 4.1.6.4.1. ***ECOCÁDIZ*** **surveys series. Recent trends in biomass estimates (in tons) for the main assessed species. Note that gaps in 2005 and 2008, when the Gulf of Cádiz anchovy DEPM survey (*BOCADEVA* triennial surveys series) is carried out. For anchovy such gaps has been filled with DEPM estimates. Also note that the 2010 survey only partially covered the whole study area.**

4.2 DEPM Surveys

4.2.1 Anchovy 2010 DEPM survey in the Bay of Biscay

4.2.1.1 Environmental data

In the Bay of Biscay during BIOMAN 10 survey mean sea surface temperature registered was 13.8ºC, in a range between 11.6 and 16.1 ºC. (**Figure 4.2.1.1.1**)

Mean sea surface salinity was 35 PSU with a range between 28.5 and 37.2 PSU. The lowest salinity was found in the area of influence of the Adour and Gironde rivers where the majority of eggs were found. (**Figure 4.2.1.1.2**)

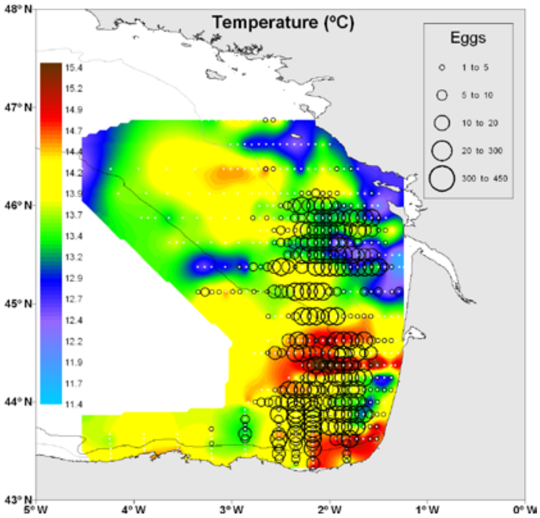


Figure 4.2.1.1.1. Sea surface temperature (SST) (ºC) and anchovy egg abundance (egg/0.1m²) obtained during Bioman 10.

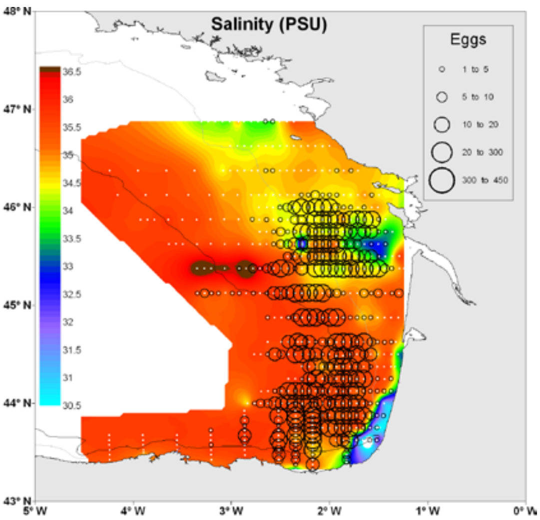


Figure 4.2.1.1.2. Sea Surface Salinity (SSS; PSU) and anchovy egg abundance (egg/0.1m²) obtained during Bioman 10.

4.2.1.2 Egg data

The collection of plankton samples was carried out on board RV "Investigador" from the 5–20 May 2010. The area covered was the southeast of the Bay of Biscay, which corresponds to the main spawning area and peak of spawning of anchovy. The survey started at transect 11 at west of Santander covering the Cantabrian Coast eastwards. The western limit of the spawning area was located at 3º12′W(transect.17) The survey continued to the North, until the northern limit of the spawning area was found at 46º15′N. When the egg abundances found were relatively high, additional transects separated by 7.5 nm were done to intensify the sampling.

The anchovy eggs were concentrated principally in the area of the French continental shelf between Cap Breton and Arcachon mostly between the isoline of 100m depth and crossing the shelf brake until 35nm after and the area of influence of the Gironde river between 45º22′N and 46ºN (**Figure 4.2.1.2.1**)

From 484 PairoVET, 309 were positive for anchovy eggs (64%) with an average of 12 eggs/0.1m² per station and a maximum of 126 eggs/0.1m² in a station. A total of 5,588 anchovy eggs were encountered and classified.

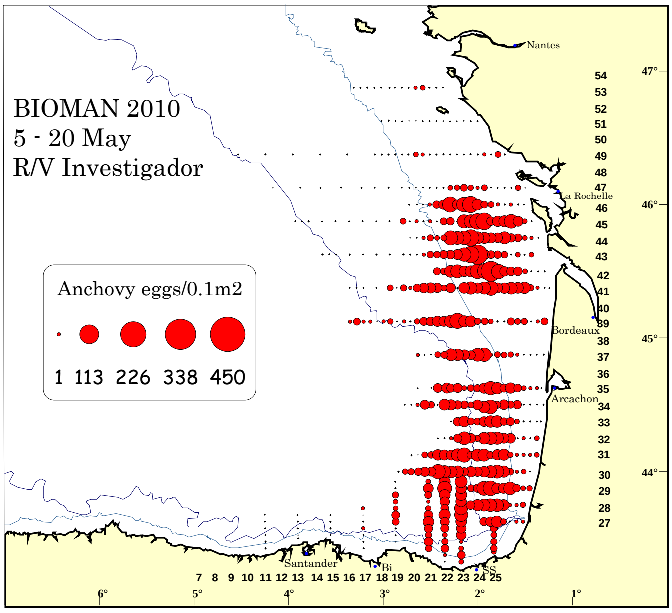


Fig .4.2.1.2.1. Plankton stations and egg abundance from DEPM survey BIOMAN10 obtained with PairoVET (eggs/ 0.1m²).

CUFES was used to record the eggs found at 3m depth. The samples obtained were immediately checked under the microscope so that presence/absence of anchovy eggs was detected in real time. This allowed knowing whether there were anchovy eggs in the area. In consequence, transects were left when no anchovy eggs were found in 6 consecutive CUFES samples in the oceanic area. A total of 1,156 CUFES samples were obtained. The distribution of anchovy obtained with this sampler was the same as the one obtained with the PairoVET. The quantity of anchovy eggs was recorded but not the total sampled eggs of other species. The eggs obtained with CUFES were not classified in stages.

A standard PairoVET sampling station represented a surface of 45 nm² (i.e. 154 km²). Since the sampling was adaptive, the area per station changed according to the sampling intensity and the cut of the coast. The total area was calculated as the sum of the area represented by each station. The spawning area (SA) was delimited with the outer zero anchovy egg stations although it could contain some inner zero stations embedded. The spawning area was computed as the sum of the area represented by the stations within the spawning area.

The total area surveyed was 61,940 Km^2 and the spawning area was 37,633Km^2

Once the staged eggs were transformed into daily cohort abundances using the Bayesian ageing method, daily egg production (P_0) and daily mortality (z) rates were estimated by fitting an exponential decay mortality model to the egg abundance by cohorts and corresponding mean age using a Generalised Linear Model with a negative binomial distribution and log link (**Figure 4.2.1.2.2**). The ageing and the model fitting were repeated until convergence of the daily mortality rate. Eggs younger than 4 hours and older than 90% of the incubation time were removed from the model fitting to avoid any possible bias. Results are in t**able 4.2.1.2.1.**

Total daily egg production (P_{tot}) was calculated as the product between the daily egg production (P_0) and the spawning area (SA) estimates.

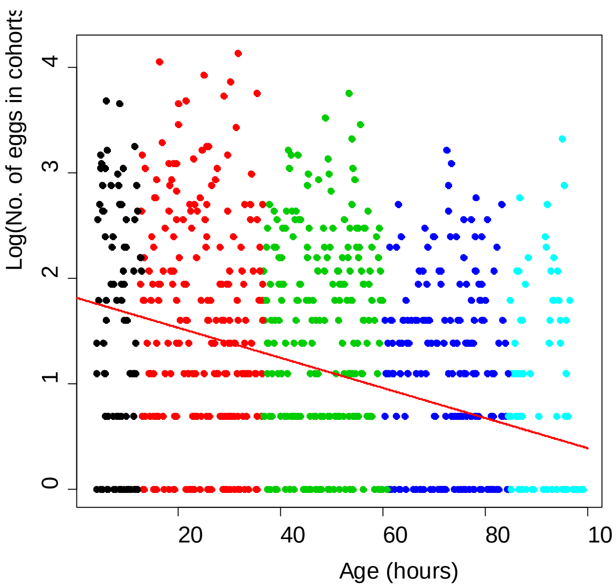


Figure_4.2.1.2.2: Log scale of number of eggs in cohorts (each cohort is represented by a colour) by age (hours) and the exponential mortality model adjusted using a GLM.

Table_4.2.1.2.1: P0 (Daily Egg Production per surface unit, eggs /0.1m2), z (egg daily mortality rates, Exp(-z)) and Ptot (Total Daily Egg Production, Eggs/day*10E-12) estimates and their corresponding, variance, standard error (s.e.) and coefficient of variation (CV)

Parameter	Value	S.E.	CV
P0	61.70	7.71	0.12
z	0.34	0.002	0.16
Ptot	2.32.E+12	3.E+11	0.12

4.2.1.3 Adult data

In the Bay of Biscay during BIOMAN 10 survey, the adult samples were obtained on board a pelagic trawl: RV "Emma Bardán", from the 6–20 May coinciding with the plankton sampling in time and space. The spatial distribution of the fishing hauls are shown in **Figure 4.2.1.3.1**. The hauls are spread all along the spawning area and represent well the whole anchovy population. Overall, 34 pelagic trawls were performed, from those 30 had anchovy and were selected for the analysis. This year the fishery was reopen with a TAC of 7,000t. 9 Samples were obtained from the purse-seine fleet. From those 6 were selected for the analysis. Spatial distribution of samples and their species composition is showed in **Figure 4.2.1.3.1.** There were found anchovy adults were the anchovy eggs were found.

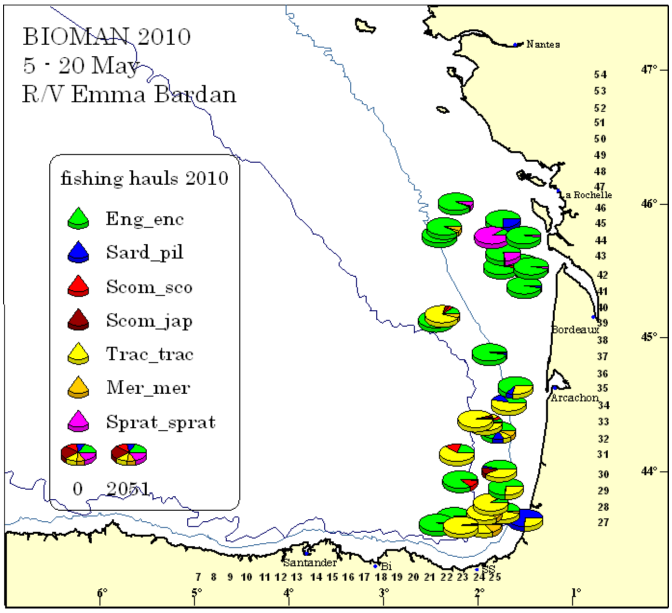


Figure_4.3.1.3.1. Spatial distribution of pelagic trawls and their species composition from RV "Emma Bardán" during BIOMAN 10.

In each haul immediately after fishing, anchovy were sorted from the bulk of the catch and a sample of near 2 Kg was selected at random. A minimum of 1 kg or 60 anchovies were weighted, measured and sexed and the gonads of 25 non-hydrated females (NHF) were preserved. If the target of 25 NHF was not completed 10 more anchovies were taken at random and proceed on the same manner. Sampling was stopped when more than 120 anchovies had to be sexed to achieve the target. Moreover, otoliths were extracted and read on the laboratory to obtain the age composition per sample. The same was done for sardine. In addition in each haul 100 individuals of each species were measured and the gut content of anchovy, sardine, mackerel and horse mackerel were analysed.

Figure 4.2.1.3.2 represents the spatial distribution of anchovy mean weight showing a clear difference between the heaviest anchovies offshore and lightweight inshore. The anchovy size range was in the total area between 10.1 and 20.1 cm. The mean size distribution of anchovy per sample is shown in **Figure 4.2.1.3.3**. This figure shows again the same pattern of small anchovies inshore and big offshore.

Total weight of hydrated females (W_f) was corrected for the increase of weight due to hydration. Data on gonad-free-weight (W_{gf}) and correspondent total weight (W) of non hydrated females was fitted by a linear regression model. The result Wf was 22.90g.

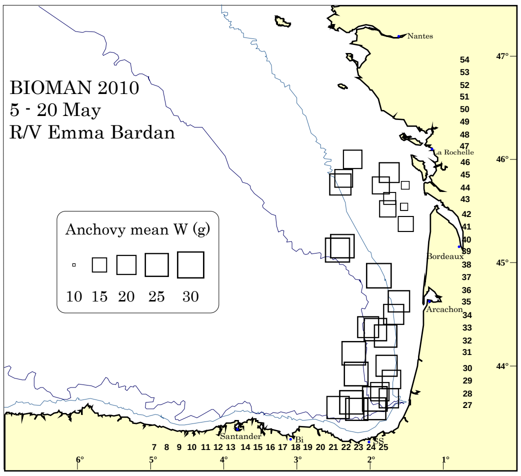


Figure_4.2.1.3.2. Spatial distribution of anchovy mean weight during Bioman 10.

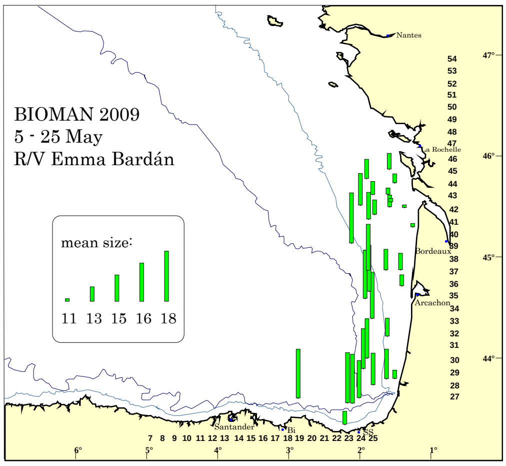


Figure_4.3.1.3.3. Spatial distribution of mean size of anchovies per haul during Bioman 10.

Sex Ratio (R) was estimated as the average ratio between the average female weight and the sum of the average female and male weights of the anchovies in each of the samples. The value obtained in that manner was 53% of females with a CV 0.0044.

Batch fecundity (F) was estimate applying a GLM with a Gamma distribution and "identity" link to the hydrated females, gonad free weight, that had not start spawning and the oocyte per female, as last years. Moreover, an analysis was conducted to verify if there were differences in the batch fecundity in the 2 regions defined: North and South. No significant differences were found, so a unique stratum was considered to estimate the batch fecundity

For **spawning frequency (S)** until the new series of spawning frequency (S) is accepted and a revision of all the parameters of the DEPM is completed, a preliminary

SSB estimate is provided based on the average S of the historical series. The resulted S in that manner was 24.68 with a CV of 3.53%.

The adult parameters and SSB estimates are shown in **table 4.2.1.3.1.**

SSB estimates for the Bay of Biscay anchovy resulted in **42,979 t** with a **CV** of **15%.** The one estimated in June for WGANSA 2010 was 36,627 with a CV of 22%

Table_4.2.1.3.1. DEPM 2010 estimates with the total daily egg production, the adult parameters and SSB in the total area with correspondent Standard error (S.e.) and coefficient of variation (CV).

Parameter	estimate	S.e.	CV
Ptot	2.32E+12	2.90E+11	0.1249
R'	0.53	0.0023	0.0044
S	0.25	0.0087	0.0353
F	9,394	635	0.0676
Wf	22.90	0.89	0.0387
DF	54.02	4.02	0.0744
BIOMASS	**42,979**	6,249	0.1454
Wt	19.79	1.24	0.0627

Figure 4.2.1.3.4 shows the distribution of anchovy age composition in space. Age one was the predominant in most of the samples. The proportion by age, population at age and mass at age estimates are given in **table 4.2.1.3.2**.

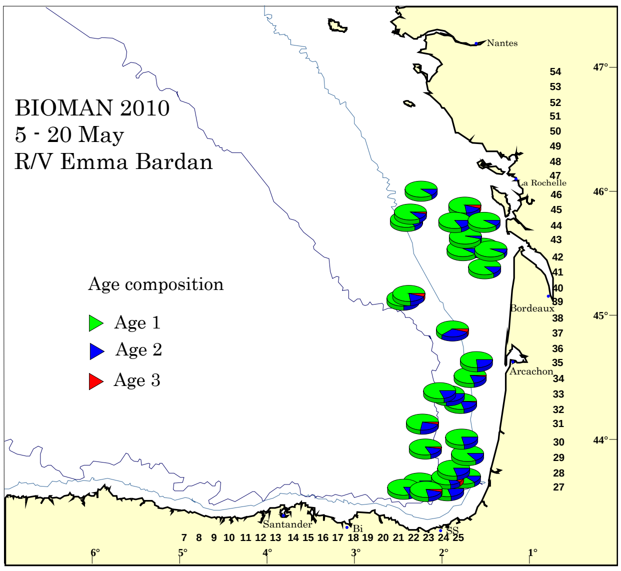


Figure_4.2.1.3.4. Spatial distribution of anchovy ages during Bioman 10.

Table_4.2.1.3.2: SSB 2010 estimates and the correspondent standard error (S.e.) and coefficient of variation (CV) of the percentage by age, numbers by age, mean weight by age and Spawning Stock Biomass by age estimates, with the class.

Parameter	estimate	S.e.	CV
BIOMASS (Tons)	**42,979**	6,249	0.1454
Tot. Mean W (g)	19.79	1.24	0.0627
Population (millions)	2,181	351	0.1607
Percent. age 1	0.84	0.02	0.0202
Percent. age 2	0.15	0.02	0.1036
Percent. age 3	0.01	0.00	0.2545
Numbers at age 1	1,833	302	0.1647
Numbers at age 2	330	59	0.1797
Numbers at age 3	19	5	0.2835
W age 1	17.7		
W age 2	24.7		
W age 3	40.5		
SSB at age 1	32,441		
SSB at age 2	8,142		
SSB at age 3	759		

4.2.1.4 Historical series

The DEPM surveys to estimate the SSB in the Bay of Biscay have been implemented from 1987 to 2010, with a gap in 1993. The whole series of DEPM biomass estimates are presented in **Figure 4.2.1.4.1** and **Table 4.2.1.4.1** (acronyms in **Table 4.2.1.4.2**). Maps of egg abundance for the whole series are in **Figure 4.2.1.4.2**. A total of 23 years of SSB estimates and 20 years of population at ages (**Figure 4.2.1.4.3**) estimates are available for the assessment of this anchovy.

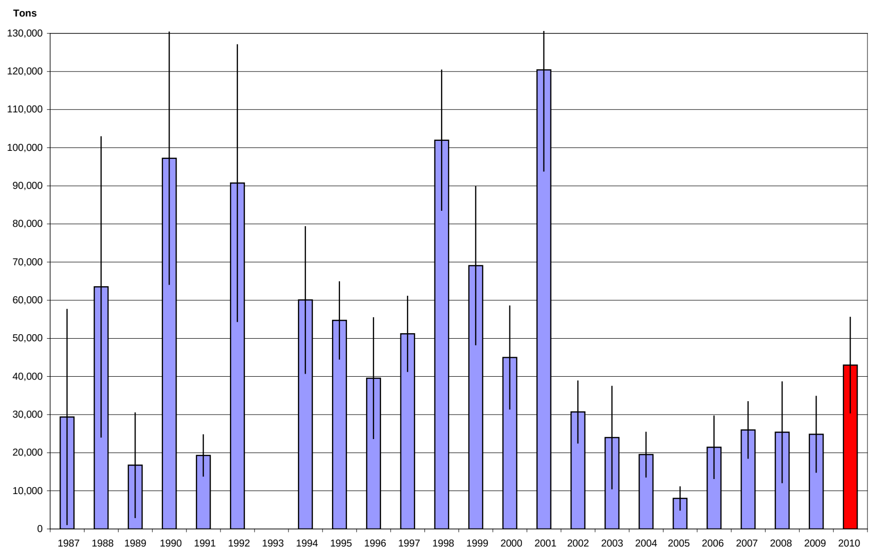


Figure_4.2.1.4.1. Series of Biomass estimates (tonnes) obtained from the DEPM since 1987. Most of them are full DEPM estimates, except in 1996, 1999 and 2000, which were deduced indirectly.

The SSB has suffered a strong decrease since 2001 DEPM estimate (124,000 t). The reason of such decrease arises from a weak recruitment occurring since 2001 which has led to low age 1spawners. This year there was a good recruitment. (**Figure 4.2.1.4.3**).

Table 4.2.1.4.1. Egg and adult parameters estimates from past series of DEPM surveys and 2010 estimates.

Year	Actual dates	SSB	cv	Ptot	cv	P0	cv	Z	cv	Abtot	SA	DF	cv	SST[a]
1987	2 - 7 Jun	29,365	0.48	2.199	0.39	4.61	0.32	0.26	0.78	3.41	23,850	81.30	0.36	16.4
1988	21 - 28 May	63,500	0.31	5.010	0.24	5.52	0.21	0.18	0.68	10.41	45,384	81.40	0.23	16.5
1989	10 - 21 May	11,861	0.41	0.730	0.40	2.08	0.27	0.18	0.99	0.90	17,546	62.30	0.13	16.6
1989	14-24 Jun	10,058	0.55	0.83	-	1.50	0.30	0.94	0.41	0.79	27,917	54.80	0.28	20.8
1990	4 - 15 May	97,237	0.17	4.52	0.15	3.78	0.20	0.34	0.39	7.84	59,757	52.20	0.36	16.9
1990	29 May- 15 Jun	77,254	0.19	7.24	-	5.21	0.13	0.62	0.31	8.05	69,471	90.10	0.12	17.7
1991	16May-07Jun	19,276	0.14	1.24	0.06	2.55	0.22	0.22	0.65	3.18	24,264	67.50	0.15	15.6
1992	16May-13Jun	90,720	0.20	5.79	0.14	4.27	0.14	0.22	0.65	13.09	67,796	71.60	0.24	17.7
1994	17 May-3Jun	60,062	0.17	3.83	0.14	3.93	0.19	0.11	-	11.33	48,735	62.85	0.07	15.8
1995	11 - 25 May	54,701	0.09	3.09	0.07	4.96	0.12	0.19	0.34	8.75	31,189	56.72	0.06	14.2
1996	18 - 30 May	-	-	2.77	0.16	4.87	0.19	0.31	0.41	5.95	28,448	-	-	15.3
1997	9 - 21 May	51,176	0.10	2.70	0.07	2.69	0.14	0.19	0.47	7.12	50,133	53.21	0.06	15.1
1998	18 May - 8 Jun	101,976	0.09	5.59	0.05	3.83	0.12	0.28	0.25	11.96	73,131	56.54	0.06	16.5
1999	22 May - 5 Jun	-	-	3.59	0.09	3.52	0.08	0.12	0.40	9.06	51,019	-	-	17.1
2000	2- 20 May	-	-	2.61	0.19	3.45	0.28	0.18	1.02	7.95	37,883	-	-	16.5
2001	14-May - 8 Jun	120,403	0.11	8.48	0.09	5.89	0.11	0.45	0.20	12.36	72,022	70.75	0.06	16.8
2002	6 - 21 May	30,697	0.13	2.34	0.13	3.28	0.13	0.13	0.51	6.17	35,980	76.40	0.04	14.7
2003	22 May-9Jun	23,962	0.28	2.15	0.28	2.53	0.28	0.33	0.66	7.30	42,535	89.91	0.04	17.3
2004	2 - 17 May	19,498	0.15	0.84	0.11	1.82	0.11	0.10	-	2.80	23,124	43.64	0.09	13.7
2005	8 - 28 May	8,002	0.19	0.44	0.16	0.79	0.16	0.20	0.45	1.33	27,863	55.74	0.08	14.9
2006	4 - 24 May	21,436	0.19	1.07	0.17	2.16	0.17	0.27	0.40	2.66	24,614	50.14	0.09	15.6
2007	3-23 May	25,973	0.14	1.55	0.04	2.25	0.04	0.20	0.00	4.22	34,449	61.33	0.05	15.4
2008	6-26 May	25,337	0.26	1.78	0.09	2.66	0.09	0.32	0.15	3.58	33,502	67.44	0.04	16.2
2009	5 - 25 May	24,846	0.20	1.70	0.14	3.01	0.14	0.28	0.25	4.03	28,214	68.39	0.15	15.25
2010	5 - 20 May	**42,979**	**0.15**	2.32	0.12	3.08	0.12	0.34	-0.16	5.19	37,633	54.02	0.07	13.76

Table 4.2.1.4.2. Parameters with the acronyms and meaning of the estimates and units.

ACRONYMS	ESTIMATES OF	UNITS
P0	Daily Egg Production per surface unit	Eggs/0.05 m2/day
z	Daly mortality of eggs	Exp(-z) daily mortality
SA	Positive Spawning Area	Km2
Ptot	Total Daily Egg Production of the Population	Eggs/day *10E-12
SST	Sea Surface Temperature	ºC
SSB	Spawning Stock Biomass	tonnes
DF	Daily Specific Fecundity of the Population	eggs/gram
Abtot	Total Egg Abundance in the area surveyed	eggs *10E-12

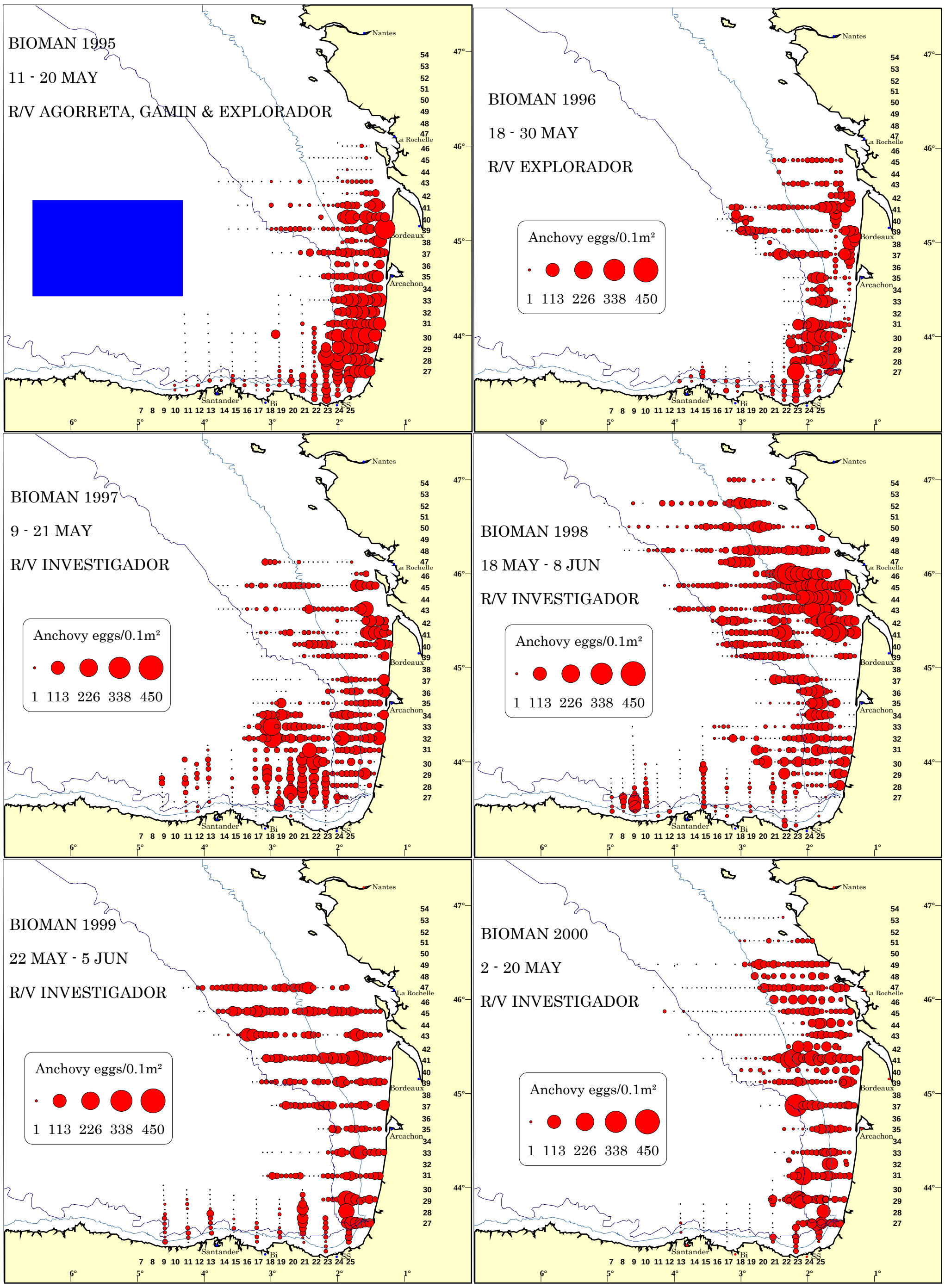


Figure 4.2.1.4.2. Spatial distribution of anchovy eggs from 1995 to 2010.

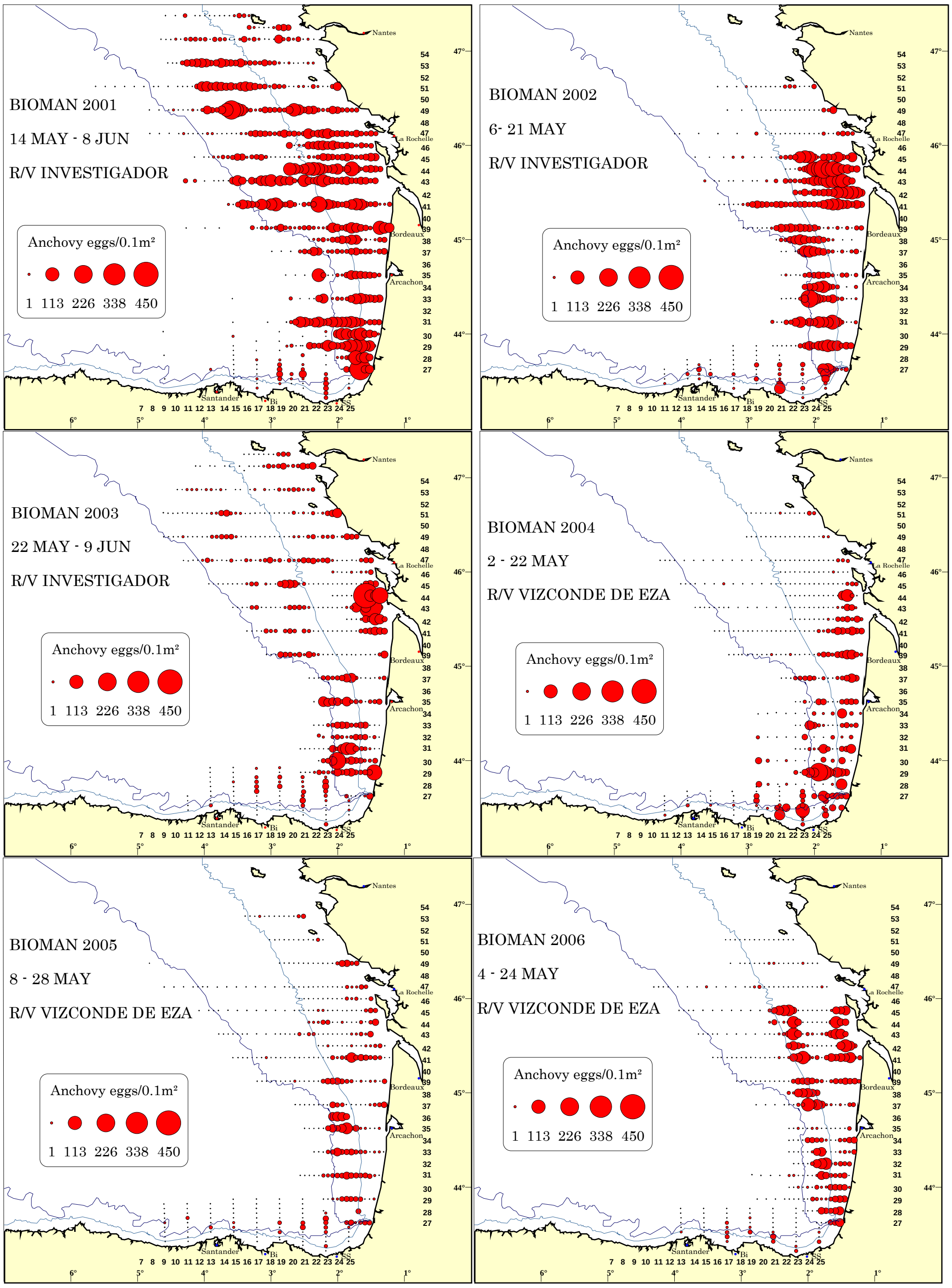


Figure 4.2.1.4.2. Spatial distribution of anchovy eggs from 1995 to 2010 (Cont…)

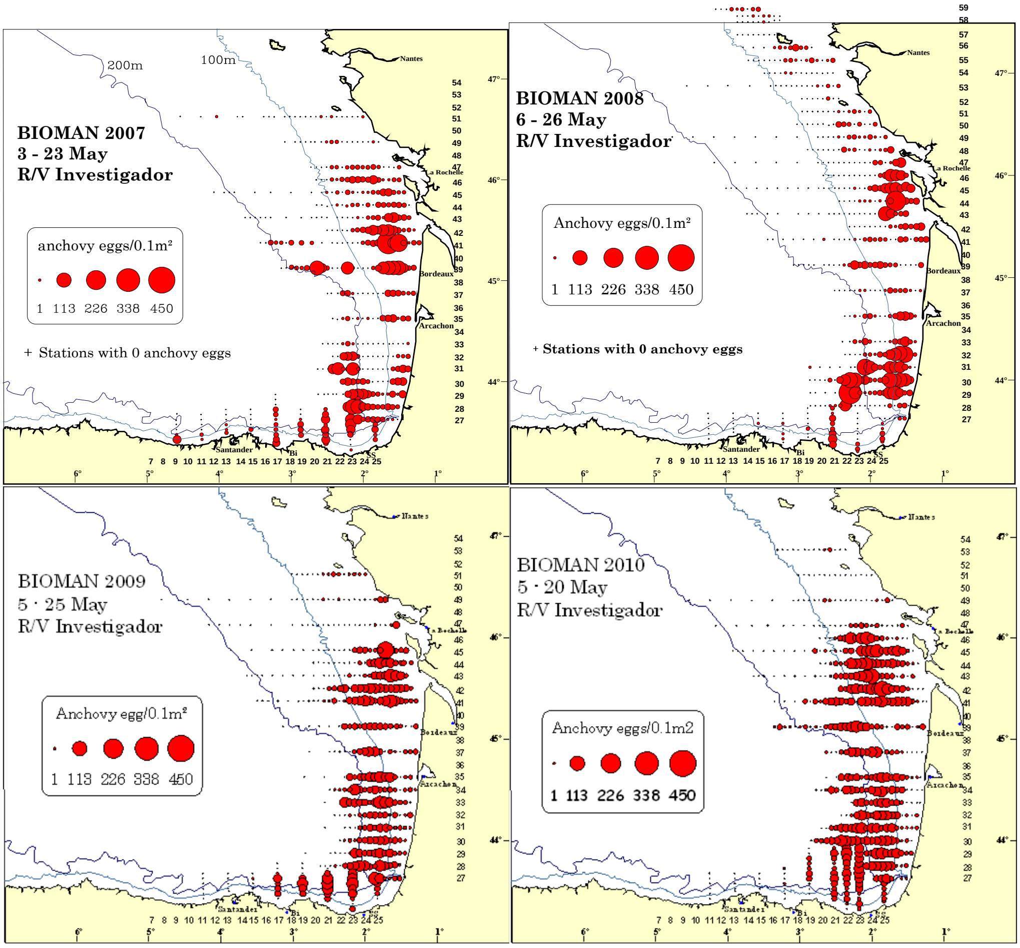


Figure 4.2.1.4.2. Spatial distribution of anchovy eggs from 1995 to 2010 (Cont…)

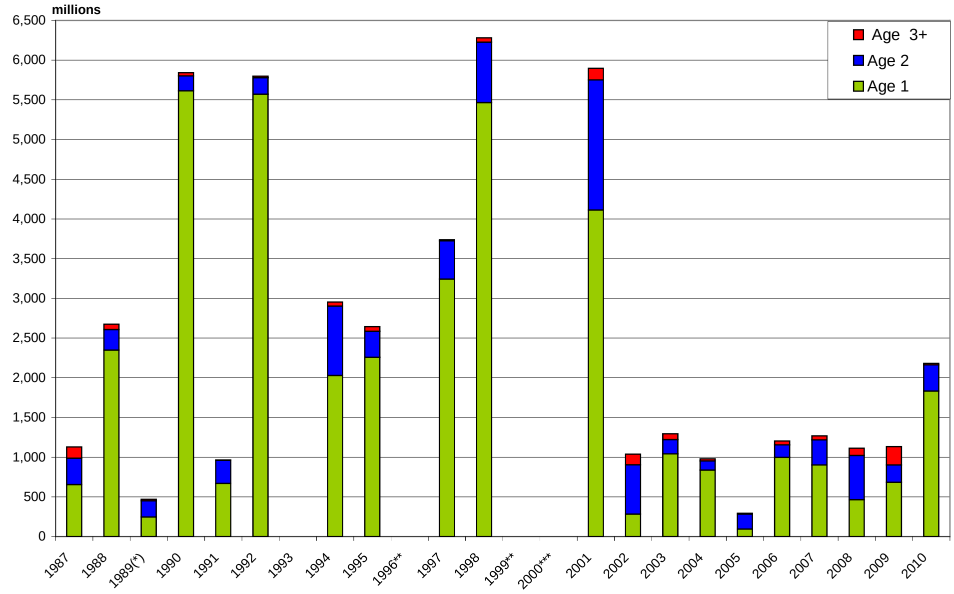


Figure 4.2.1.4.3. Historical series from 1987 to 2010 of numbers-at-age in millions.

4.3 Autumn Acoustic Surveys

4.3.1 Autumn acoustic surveys in Subarea VIII in 2010: Methodologies and results

This year, only the survey JUVENA 2010 conducted by AZTI was carried out to estimate anchovy biomass in the Bay of Biscay in autumn by acoustic methods. Budgetary constraints prevented the execution of the autumn PELACUS cruise.

4.3.2 Autumn acoustic surveys in subarea VIII in 2010: JUVENA2010

The project JUVENA aims at estimating the abundance of the anchovy juvenile population and their growth condition at the end of summer in the Bay of Biscay. The long term objective of the project is to be able to assess the strength of the recruitment entering the fishery the next year. Complementary information of other ecosystem components (i.e. hydrography, plankton distribution, etc.) was also acquired during both cruises (Figure 4.3.2.1).

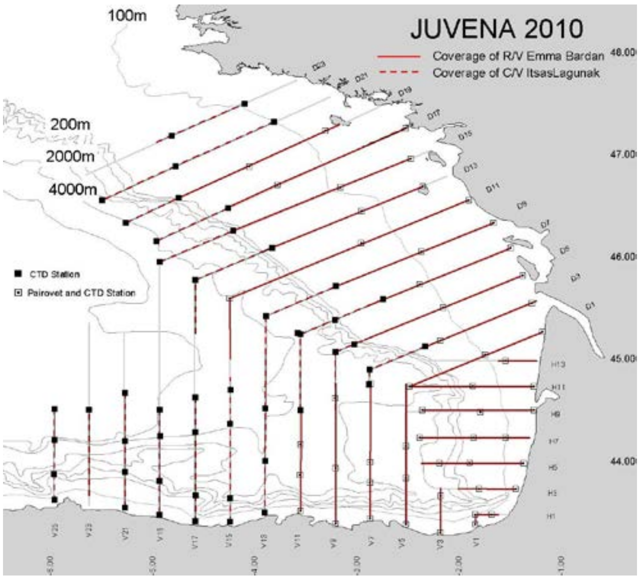


Figure 4.3.2.1. Planned (soft grey line) and actual transects (red solid line for the EB and dashed line for the IL). The CTD stations are also shown (solid squares for IL and empty squares for EB, which included also a vertical plankton haul).

This year 2010 the survey has taken place on-board two vessels equipped with scientific acoustic equipments and with two different fishing gears: purse-seiner "Itsas Lagunak" and pelagic trawler "Emma Bardan" (Table 4.3.2.1). The survey took place during 30 days in September (Table 4.3.2.2), sampling 4,000 nautical mile to reach an effective sampling of 2,700 nautical mile that provided a coverage of about 40,500 nautical mile^2 along the continental shelf and shelf break of the Bay of Biscay, from the 6º W in the Cantabrian area up to 47º 30′ N at the French coast (Figure 4.3.2.1). 79 hauls were done during the survey to identify the species detected by the acoustic equipment, 60 of which resulted positive of anchovy (Figure 4.3.2.2).

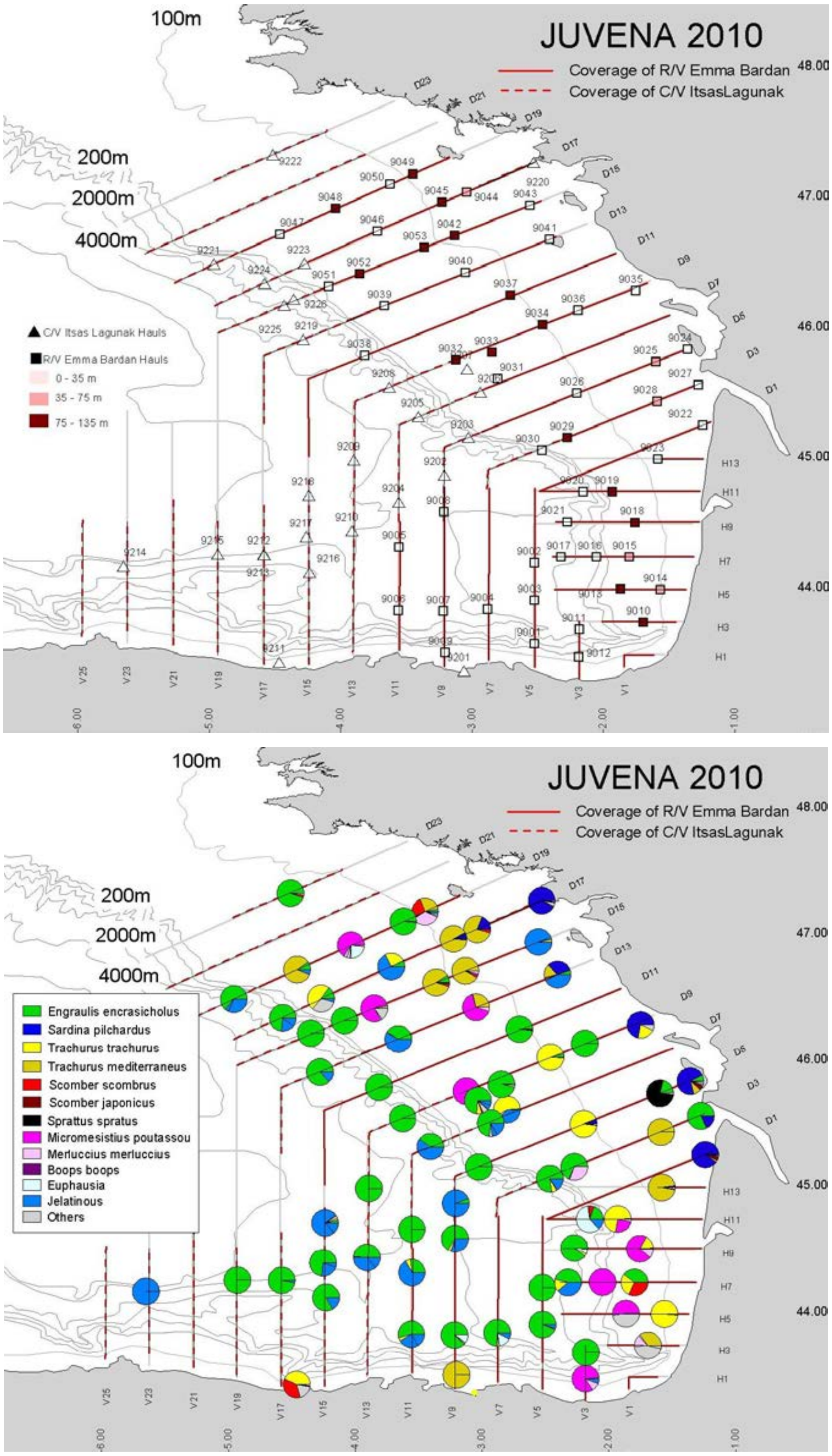


Figure 4.3.2.2. Top panel: position of the fishing stations. Hauls performed by EB (pelagic trawls) are numbered from 9001 to 9053 and the transects are marked with solid lines; hauls performed in the IL are numbered from 9201 to 9226 and the transects are marked with dashed lines. Bottom panel: Species composition of the hauls.

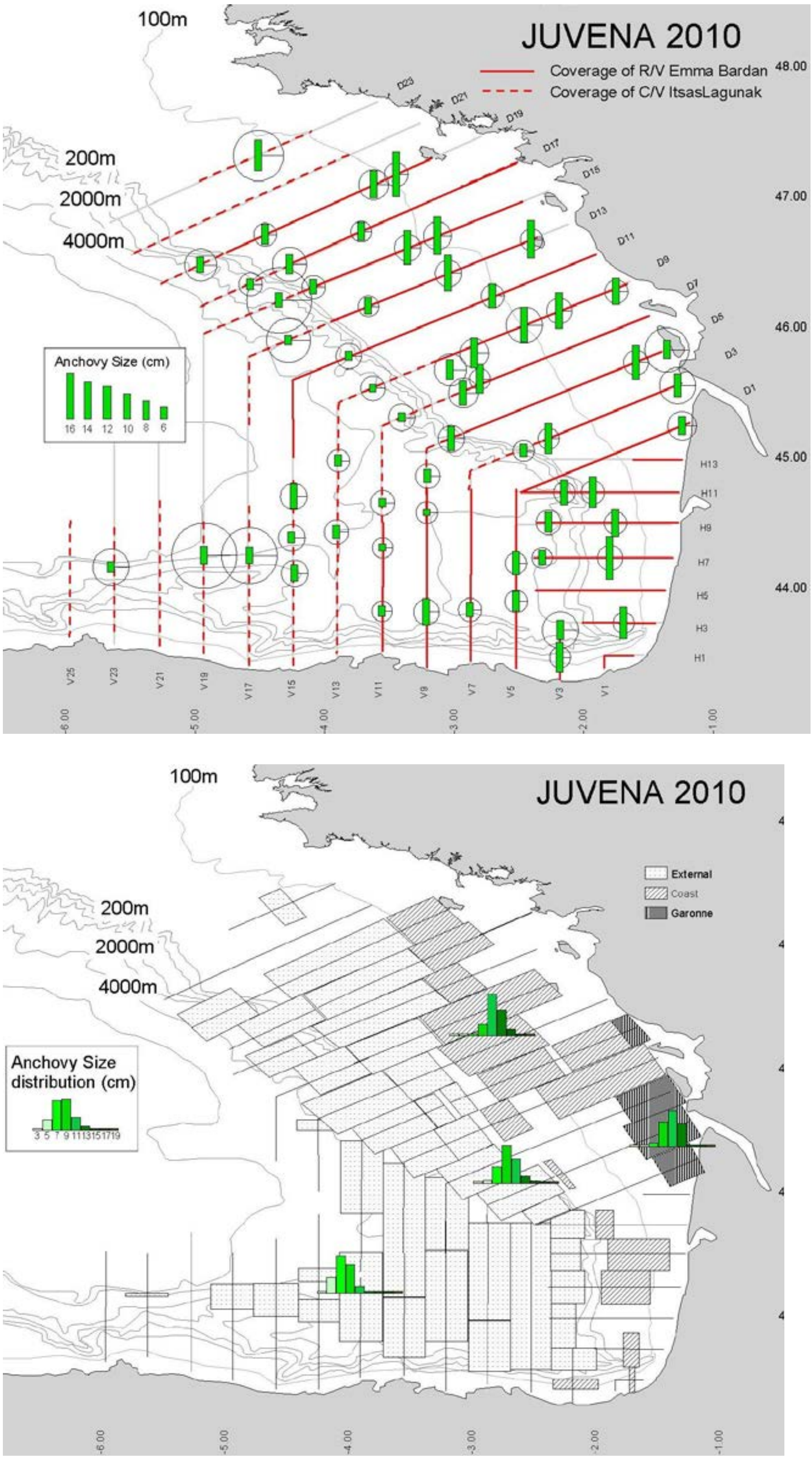


Figure 4.3.2.3: Top panel: Positive anchovy hauls. The diameter of the circles is proportional to the captured weight of anchovy. The length of the bars is proportional to the mode of the size (Standard length) of the captured anchovy. Bottom panel: Average anchovy size distribution in the different areas of distribution of anchovy

Table 4.3.2.1: Dimensions of the two vessels and installed equipment on-board.

	F/V ITSASLAGUNAK	RV EMMA BARDÁN
Length (m)	33	29
Width (m)	8	7.5
Draught (m)	4.2	3.5
Echosounder	Simrad EK60, 38 y 120 kHz	Simrad EK60, 38, 120 y 200 kHz
Sonar	Furuno CSH5L	Simrad SH40
	Purse seine	pelagic (15 m vertical opening)
Fishing gear	dimensiones: (350 x 80 m)	Otter boards: Polyice Apollo
	mesh: 4 mm side	mesh: 4 mm side
Hydrography	CTD	CTD

Table 4.3.2.2. Schedule of the survey.

DATE	EMMA BARDÁN	ITSAS LAGUNAK	OBSERVATIONS
1/09/10	Survey start Calibration		
5/09/10	Santander harbour		Change of crew
8/09/10	Pasaia harbour		Storm
9/09/10	Continue survey		
13/09/10		Survey start	Sounder intalatin
16/09/10	Pasaia harbour		Food and gasoil
17/09/10	Continue survey		
24/09/10	Saint Nazaire harbour	Saint Nazaire harbour	Storm
26/09/10	Continue survey	Continue survey	
29/09/10	End survey	Calibration	
30/09/10		End of survey Uninstalation of echosounders	

This year we have found anchovy distributed along two different strata: an external stratum, located at the outer part of the continental shelf and slope waters, and an internal located at the inner part of the continental shelf and coastal waters (Figures 4.3.2.3 and 4.3.2.4):

- **External stratum**: In this stratum, anchovy was located in the uppermost part of the water column forming the typical superficial aggregations of pure juvenile anchovy (Figure 4.3.2.2), mixed in occasions with smaller proportions of juvenile horse mackerel, gelatinous species and krill. In order to simplify description, we can divide this stratum in two areas, to the South and North of latitude 45ºN.
  - **External-south**: in this area, anchovy was distributed mainly on the Cantabrian slope waters, from 5º45′ to 2º50′ W, being widely distributed from 43º30′ to 45º N in the Eastern part, gradually reducing the latitudinal extension of the area to the West above 3º40′ W, until practically disappear after 5º W (Figure 4.3.2.4). The sizes varied in a broad range between 5 and 12 cm (Figure 4.3.2.3).

- **External-north**: in this area, the superficial aggregations of juvenile anchovy were extended along a strip about 40 nautical miles wide around the shelf break edge, from 45º to 47º N. In the southern part, aggregations were located mainly off-the-shelf, gradually entering towards the shelf as they moved to the North. Sizes in this area varied also in a broad range between 5 and 12 cm showing bigger sizes when approaching to the coast (Figure 4.3.2.3). The superficial aggregations of anchovy were composed by a majority of juvenile anchovy, mixed with small quantities of horse mackerel, meduse and salp.

- **Coast stratum**: Anchovy size in this stratum was bigger, between 11 and 15 cm (Figure 4.3.2.3), a mix of adult and juvenile (Figure 4.3.2.4), and was detected in schools close to the bottom, mixed also with larger proportions of other species, mainly small sardine in the most coastal area, and horse mackerel and blue whiting on the mid continental shelf.
    - **Garonne:** Around the plume of the Gironde River, a positive area was found extending from the coast to about 50 m isobath. Here anchovy included both adults and juveniles, and was found mixed with sardine, spratt, horse mackerel and other species (Figure 4.3.2.2), distributing along the whole water column. The hauls provided typical examples of the so called "beach anchovy" by the Spanish fishers, that shows some morphologic differences with the rest. The sizes ranged from 8 to 13 cm (Figure 4.3.2.3).

The biomass of juveniles estimated for this 2010 is 599,990 tonnes, which is the highest value in the temporal series, a 237% higher (more than the triple) than the next value in this ranking, corresponding to the year 2009 (Figure 4.3.2.5). The area of occupation of the juvenile anchovy has also been the largest in the series (60% higher than the next one, in 2009, see Figure 4.3.2.6); the size of the captured juveniles has also been large, 8.3 cm of mean size, above the average of the series. All these facts point towards a probable raise of the recruitment level of anchovy for the year 2011, above the levels observed in the last seven years.

The objectives of this year survey have been reached. The extension of the area of occupation of juvenile anchovy has been located with high degree of certainty, both in the southern and in the northern areas. The correct assignation of acoustic echoes is assured by the large number of fishing hauls. Being also the results of the survey coherent with the estimates of the other anchovy juvenile survey and with the information collected from the live bait fleet between summer and autumn, that is also presented in the report.

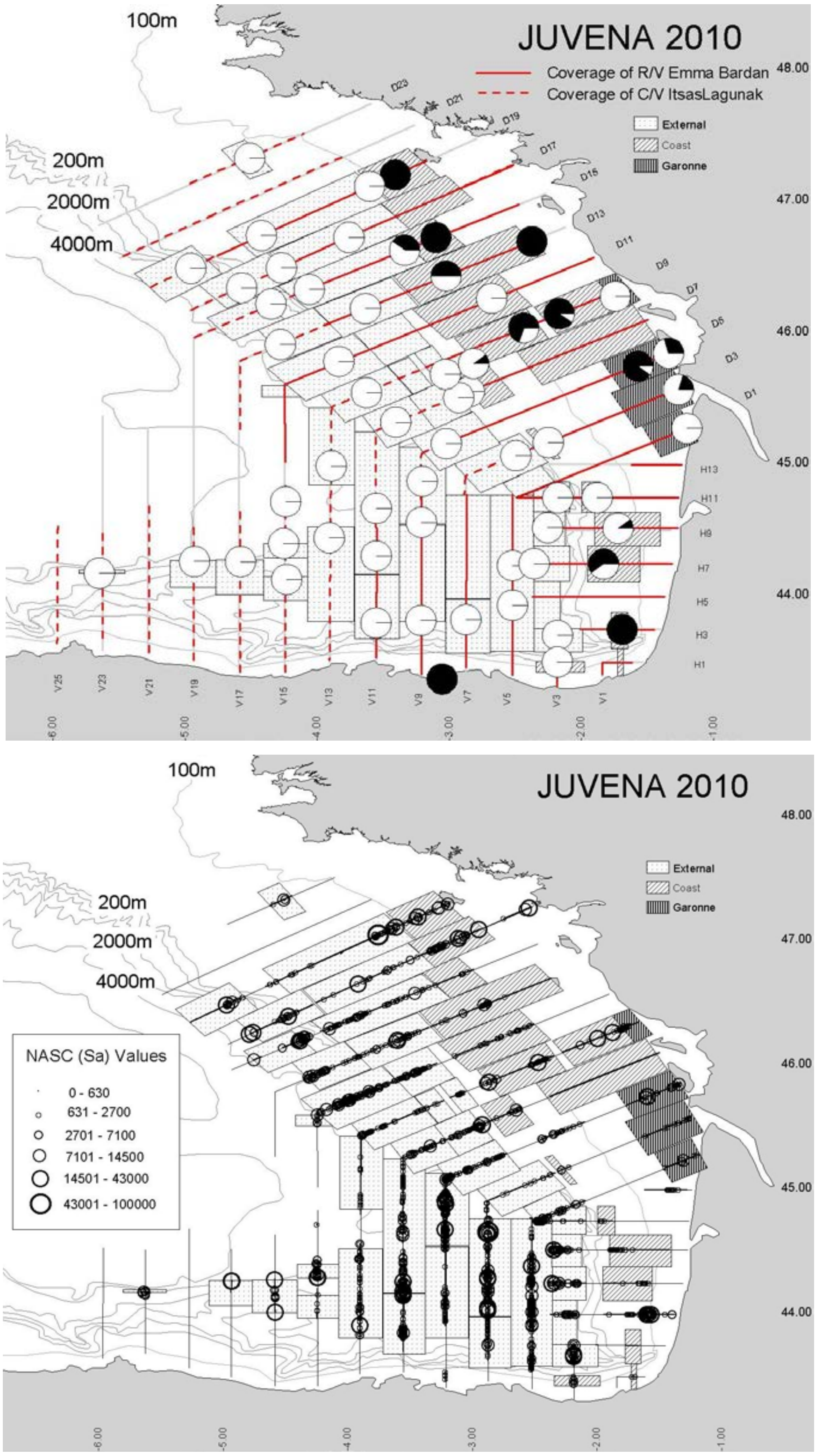


Figure 4.3.2.4. Top: positive area of distribution of anchovy. The pie charts show the percentage of juveniles (white) and adults (black) in the fishing hauls. Bottom: total acoustic energy (NASC) of all the identified species and the three subareas of the positive area for anchovy.

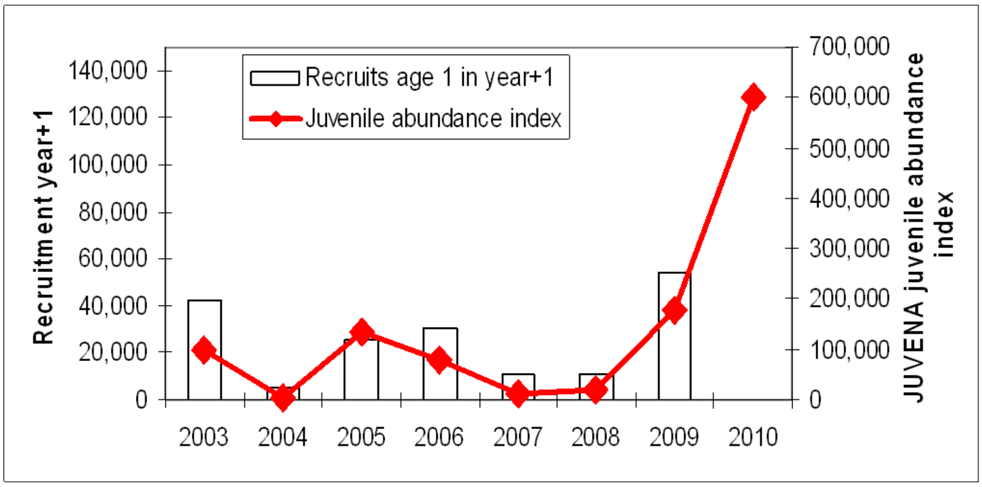


Figure 4.3.2.5. Temporal series of the estimated abundances of anchovy juveniles (continuous line) against the Bayesian Based Model synthetic estimated abundances of age 1 anchovy next spring (based on PELGAS and BIOMAN surveys plus the catches).

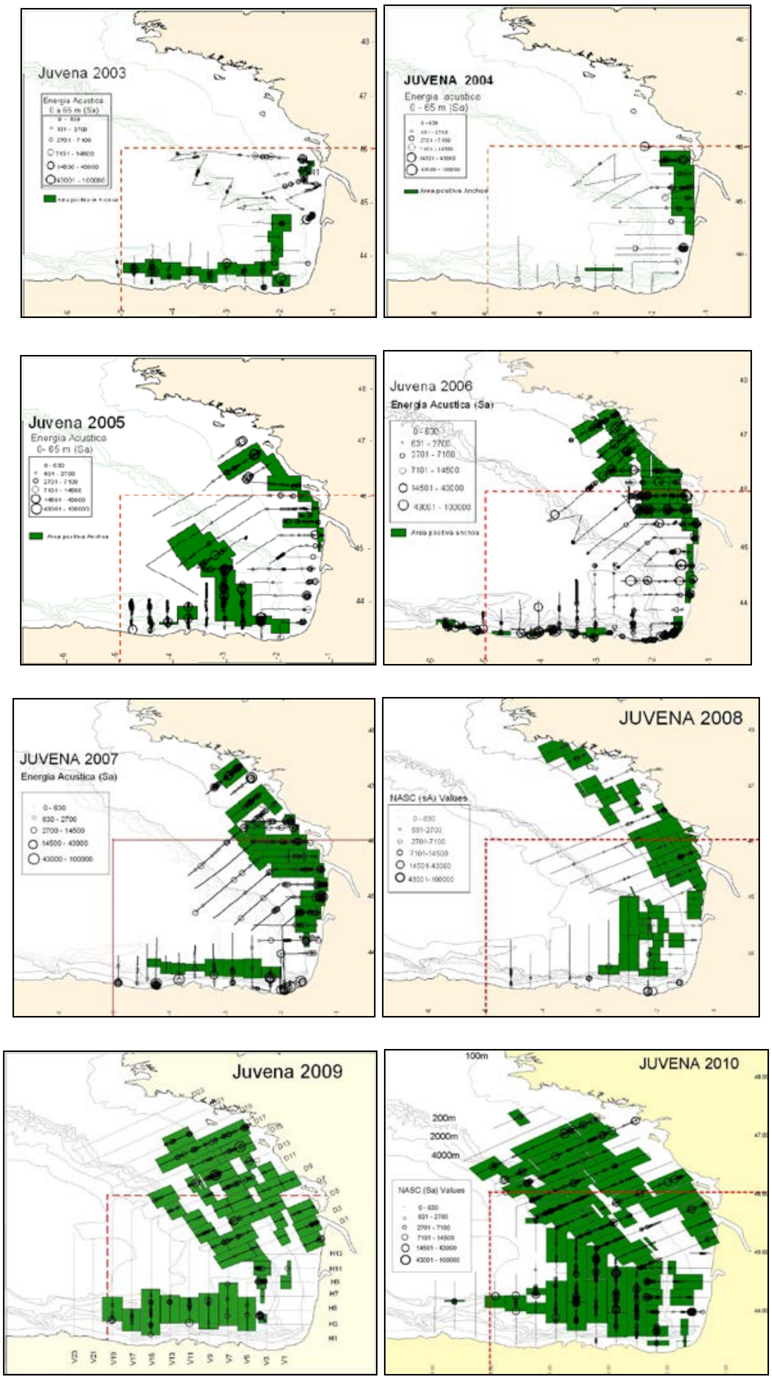


Figure 4.3.2.6. Positive area of presence of anchovy and total acoustic energy echo-integrated (from all the species) for the eight years of surveys. The area delimited by the dashed line is the minimum or standard area used for inter annual comparison.

4.3.3 Autumn acoustic surveys ECOCÁDIZ-RECLUTAS 1009 Sub Division IXa South

4.3.3.1 General

During the 2007 and 2008 WGACEGG meetings was advanced the possibility of carrying out, since 2009 on, internationally coordinated yearly surveys aimed at the direct estimation of the anchovy and sardine recruitment in the Division IXa (ICES, 2007, 2008). The conduction of such surveys would require, at least in the Gulf of Cadiz, of an appropriate acoustic sampling of the shallowest waters of its central part, an area which the conventional surveys (either Spanish or Portuguese) did not sample but, however, may conform a great part of the recruitment areas of these species.

The ECOCÁDIZ-RECLUTAS 1009 survey is the first attempt by the IEO of acoustically assessing the abundance of anchovy and sardine juveniles in their main recruitment areas off the Gulf of Cádiz (Ramos *et al.*, WD2010b). The survey was carried out between 26 October and 5 November 2009 on-board the Spanish RV "Emma Bardán". The vessel was equipped with a Simrad™ EK60 echosounder working in the multifrequency fashion (38, 120, 200 kHz) at a mean vessel speed of 8.5 knots. In order to achieve a better sampling coverage of juveniles, the acoustic sampling grid was more intensive (4 nm-spaced transects) than the adopted one in the conventional summer surveys (Figure 4.3.3.1.1). Unfortunately, the initially planned survey area limits and the ship-time available (17 transects over waters shallower than 50 m depth between Tavira and Chipiona, and 11 days) showed both insufficient due to a deeper bathymetric distribution of anchovy juveniles than expected and the succession of a series of unforeseen problems. These facts led to drastically reduce the actual sampled area to only 6 transects from the easternmost zone but with their length increased up to 100 m depth.

Vertical profiles of hydrographical variables were recorded by day from quasi-opportunistic CTD stations carried out in both extremes of alternate acoustic transects and after finishing each of the fishing stations by using a Sea-bird Electronics® SBE 25 SEALOGGER profiler.

Fourteen (14) valid fishing operations (total catch of 4795 kg and 89 thousand fish) were carried out using the 10–12 m-vertical opening pelagic trawl Gloria HOD 352 at an average speed of 4 knots. Gear performance and geometry during the effective fishing was monitored with a set of SCANMAR™ Trawl Eye-Vertical Opening-Depth sensors which were operated by a combination of SCANMAR™ portable hydrophone and ScanBas desk unit (Figure 4.3.3.1.2). Because of the echotraces usually occurred close to the bottom, all the pelagic hauls but fishing station 12, were carried out like a bottom-trawl haul, with the groundrope working very close to the bottom, over depths between 24–84 m. From the set of captured small and mid-sized pelagic fish species stood especially out anchovy, sardine, chub mackerel and Mediterranean horse-mackerel, followed quite far by bogue. Mackerel and horse-mackerel showed an even lesser occurrence and abundance in hauls whereas round sardinella and blue jack-mackerel were absent.

A total of 113 nautical miles (ESDUs) were acoustically sampled by echo-integration for assessment purposes yielding for the "pelagic fish assemblage" a total of 126896 m^2 nmi^{-2}. The highest NASC values were recorded in the inner shelf, mainly in front the Guadalquivir river mouth (Figure 4.3.3.1.3). By species, chub mackerel accounted for 35% of this total backscattered energy, followed by Mediterranean horse-mackerel

(33%), sardine (24%) and anchovy (only 7%). These species were those ones finally assessed.

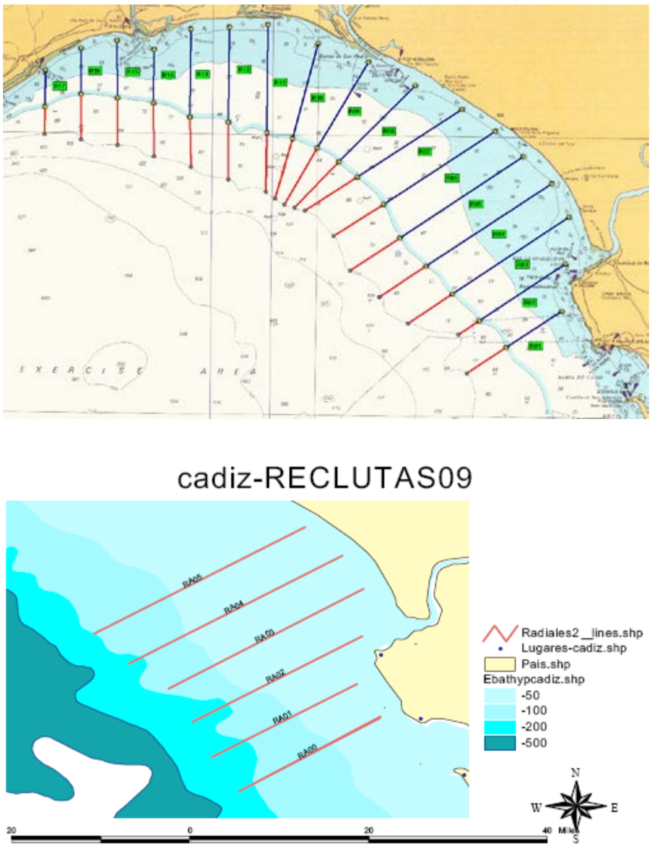


Figure 4.3.3.1.1. ECOCÁDIZ-RECLUTAS 1009 survey. Top: the foreseen grid of 17 transects for acoustic sampling. Transects' segments shallower than 50 m depth in blue. Optional extension of transects up to the 100 m isobath (finally the adopted scheme) in red. Bottom: the acoustically sampled transects including the extra- one RA00 (see text for comments).

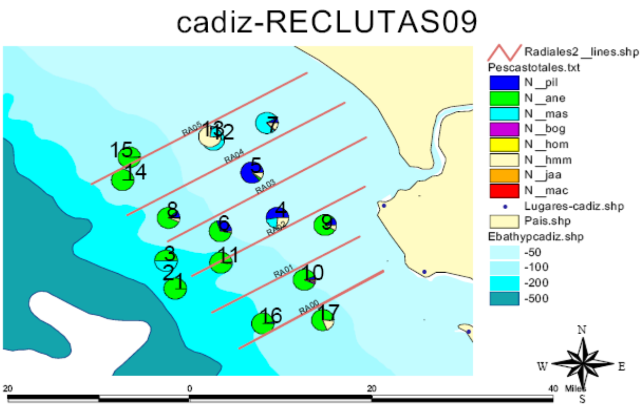


Figure 4.3.3.1.2. ECOCÁDIZ-RECLUTAS 1009 survey. Location of valid fishing stations and their species composition (expressed as percentages in number).

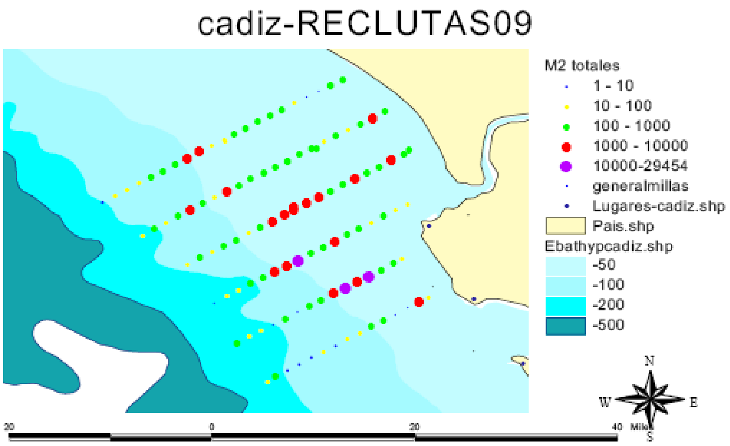


Figure 4.3.3.1.3. ECOCÁDIZ-RECLUTAS 1009 survey. Distribution of the total backscattering energy attributed to the pelagic fish species assemblage.

4.3.3.2 Distribution of anchovy and sardine

4.3.3.2.1 Anchovy

Anchovy was absent in the coastal and inner shelf waters in front of the Guadalquivir river mouth, showing their highest densities just in a relatively small area located at the east of the above zone, also all over the inner shelf (Figure 4.3.3.2.1.1). The above void left by anchovy was occupied by the remaining assessed species. The size class range of the assessed population varied in these waters between 4.5 and 17 cm, with three modal classes at 5.5, 10 (the main one) and 12 cm (Table 4.3.3.2.1.1, Figure 4.3.3.2.1.2).

Table 4.3.3.2.1.1. ECOCÁDIZ-RECLUTAS 1009 survey. Anchovy (*Engraulis encrasicolus*). Estimated abundance (in numbers, left panel) and biomass (in tons, right panel) by size class, homogeneous size-based stratum and total area.

***ECOCÁDIZ-RECLUTAS 1009 . Engraulis encrasicolus* . ABUNDANCE (in number of fish)**					
Size class	**POL01**	**POL02**	**POL03**	**TOTAL n**	**Millions**
4	0	0	0	0	**0**
4.5	1315544	0	0	1315544	**1**
5	6577719	0	0	6577719	**7**
5.5	17103669	0	0	17103669	**17**
6	7893263	0	0	7893263	**8**
6.5	7324207	82417	0	7406624	**7**
7	4482120	123670	0	4605790	**5**
7.5	27939723	183068	0	28122791	**28**
8	40102510	141815	0	40244325	**40**
8.5	55689227	295454	0	55984681	**56**
9	63649626	1424374	0	65074000	**65**
9.5	85978706	4073443	306826	90358975	**90**
10	90654242	8338079	935993	99928314	**100**
10.5	41998299	7427884	1207049	50633232	**51**
11	17500091	4517934	949101	22967126	**23**
11.5	2782943	2598789	975153	6356885	**6**
12	4277516	1811272	1165684	7254472	**7**
12.5	3259288	2050488	1170543	6480319	**6**
13	1018228	1373010	798547	3189785	**3**
13.5	0	869122	254762	1123884	**1**
14	0	355574	223034	578608	**1**
14.5	0	322355	101758	424113	**0**
15	0	89368	19519	108887	**0**
15.5	0	29970	19519	49489	**0**
16	0	0	19519	19519	**0**
16.5	0	0	0	0	**0**
17	0	0	19519	19519	**0**
17.5	0	0	0	0	**0**
18	0	0	0	0	**0**
TOTAL n	**479546921**	**36108086**	**8166526**	**523821533**	**524**
Millions	**480**	**36**	**8**	**524**	

***ECOCÁDIZ-RECLUTAS 1009 . Engraulis encrasicolus* . BIOMASS (t)**				
Size class	**POL01**	**POL02**	**POL03**	**TOTAL**
4	0	0	0	0
4.5	0.760	0	0	0.760
5	5.185	0	0	5.185
5.5	17.896	0	0	17.896
6	10.706	0	0	10.706
6.5	12.623	0.142	0	12.765
7	9.648	0.266	0	9.914
7.5	74.017	0.485	0	74.502
8	129.058	0.456	0	129.514
8.5	215.236	1.142	0	216.378
9	292.447	6.544	0	298.991
9.5	465.368	22.048	1.661	489.077
10	573.309	52.731	5.919	631.959
10.5	308.04	54.48	8.853	371.373
11	147.864	38.174	8.019	194.057
11.5	26.922	25.140	9.433	61.495
12	47.110	19.948	12.838	79.896
12.5	40.655	25.577	14.601	80.833
13	14.316	19.305	11.228	44.849
13.5	0	13.713	4.020	17.733
14	0	6.270	3.933	10.203
14.5	0	6.328	1.998	8.326
15	0	1.946	0.425	2.371
15.5	0	0.722	0.470	1.192
16	0	0	0.518	0.518
16.5	0	0	0	0
17	0	0	0.624	0.624
17.5	0	0	0	0
18	0	0	0	0
TOTAL	**2391.160**	**295.417**	**84.540**	**2771.117**

Table 4.3.3.2.1.2. ECOCÁDIZ-RECLUTAS 1009 survey. Anchovy (*Engraulis encrasicolus*). Estimated abundance (thousands of individuals) and biomass (tons) by age group and homogeneous size-based strata (Polygons POL03 to POL01, ordered from west to east).

Age class	POL03	POL02	POL01	TOTAL
	Number	Number	Number	Number
0	5514	30552	472418	**510077**
I	2598	5556	7129	**13655**
II	54	0	0	**89**
III	0	0	0	**0**
IV	0	0	0	**0**
TOTAL	**8167**	**36108**	**479547**	**523822**

Age class	POL03	POL02	POL01	TOTAL
	Weight	Weight	Weight	Weight
0	47.314	217.041	2304.542	**2587.779**
I	35.737	78.346	86.369	**180.777**
II	1,480	0	0	**0**
III	0	0	0	**0**
IV	0	0	0	**0**
TOTAL	**84.531**	**295.387**	**2390.911**	**2768.556**

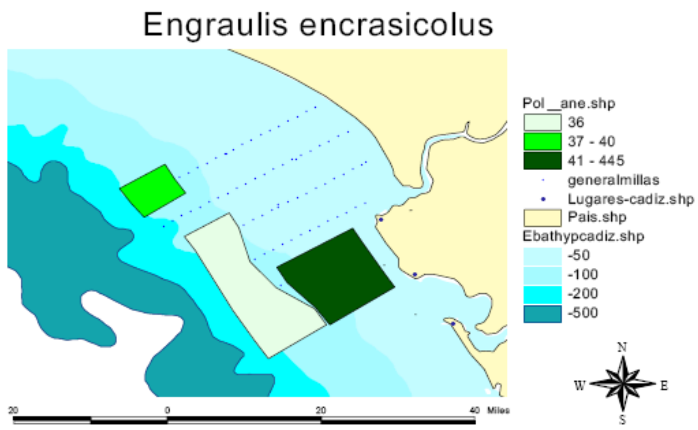


Figure 4.3.3.2.1.1. ECOCÁDIZ-RECLUTAS 1009 survey. Anchovy (*Engraulis encrasicolus*). Distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

***ECOCÁDIZ-RECLUTAS 1009*: Anchovy (*E. encrasicolus*)**

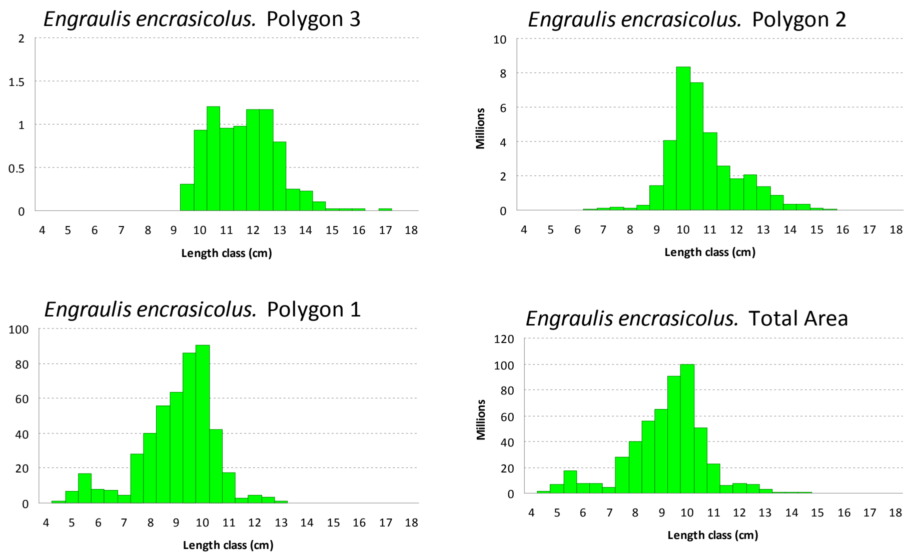


Figure 4.3.3.2.1.2. ECOCÁDIZ-RECLUTAS 1009 survey. Anchovy (*E. encrasicolus*). Estimated abundances by length class by homogeneous stratum (ordered from west to east, numeration as in Figure 4.3.3.3.2.1) and total area. Note the different scales in the *y*-axis.

***ECOCÁDIZ-RECLUTAS 1009*: Anchovy (*E. encrasicolus*)**

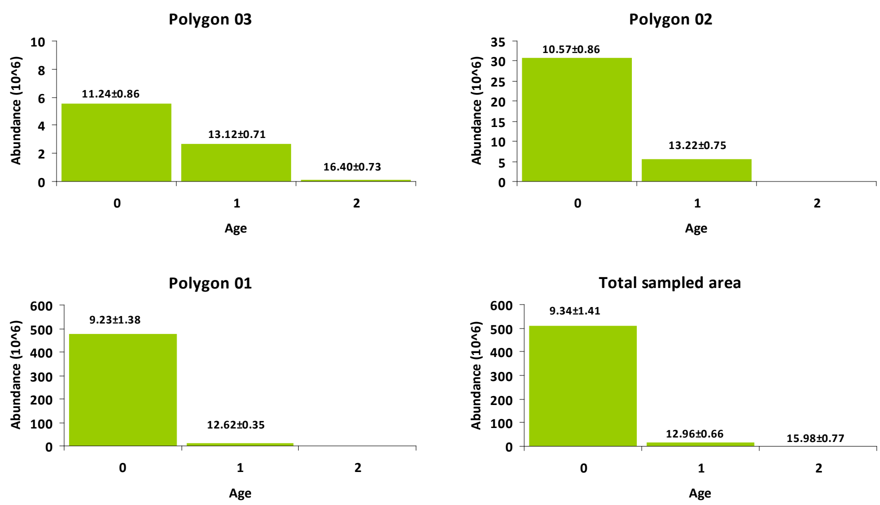


Figure 4.3.3.2.1.3. ECOCÁDIZ-RECLUTAS 1009 survey. Anchovy (*E. encrasicolus*). Estimated abundance (millions of individuals) by age group for each homogeneous stratum (ordered from west to east, numeration as in Figure 4.3.3.2.1.1) and total area. Note the different scales in the y-axis. Mean length (±SD) by age group is also shown.

4.3.3.2.2 Sardine

Sardine showed a more widespread distribution than anchovy, occurring all over the inner-middle shelf and showing the highest densities in deeper waters than the former species (Figure 4.3.3.2.2.1). Sizes of the population in the surveyed area ranged between 10.5 and 23 cm size classes, with three modal classes at 12 (the less abundant mode), 15 (the secondary mode) and 18.5 cm (the main one). This size composition evidences that the central coastal area might correspond to both recruitment and spawning areas for the species (Table 4.3.3.2.2.1, Figure 4.3.3.2.2.2).

Table 4.3.3.2.2.1. ECOCÁDIZ-RECLUTAS 1009 survey. Sardine (*Sardina pilchardus*). Estimated abundance (in numbers) and biomass (in tons) by size class, homogeneous size-based stratum and total area.

ECOCÁDIZ-RECLUTAS 1009 . Sardina pilchardus **. ABUNDANCE (in number of fish)**						
Size class	POL01	POL02	POL03	POL04	TOTAL n	Millions
10	0	0	0	0	0	0
10,5	0	0	155082	0	155082	0
11	0	0	776393	0	776393	1
11,5	0	2795680	1087049	0	3882729	4
12	0	2795680	1863442	0	4659122	5
12,5	0	0	1708360	217811	1926171	2
13	0	1954804	3882458	0	5837262	6
13,5	0	2853600	1863442	653800	5370842	5
14	20529	6977307	4193113	2288667	13479616	13
14,5	50182	11180653	931967	5885668	18048470	18
15	29652	15152319	1242622	8174335	24598928	25
15,5	41056	15243336	931967	6103479	22319838	22
16	34214	11550928	1087049	4577701	17249892	17
16,5	25091	7445839	1087049	2724656	11282635	11
17	27372	7445839	1242622	1853045	10568878	11
17,5	15965	32875877	3882458	2724656	39498956	39
18	11404	47913390	6057046	653800	54635640	55
18,5	6842	53527505	6367702	435989	60338038	60
19	2281	53230664	6057046	0	59289991	59
19,5	0	43401826	2019015	435989	45856830	46
20	0	38119717	1863442	0	39983159	40
20,5	0	26381583	155082	0	26536665	27
21	0	18018331	465738	0	18484069	18
21,5	0	11078258	155082	0	11233340	11
22	0	0	0	0	0	0
22,5	0	975334	0	0	975334	1
23	0	2795680	0	0	2795680	3
23,5	0	0	0	0	0	0
24	0	0	0	0	0	0
TOTAL n	264588	413714150	49075226	36729596	499783560	500
Millions	0,3	414	49	37	500	

ECOCÁDIZ-RECLUTAS 1009 . Sardina pilchardus **. BIOMASS (t)**					
Size class	POL01	POL02	POL03	POL04	TOTAL
10	0	0	0	0	0
10,5	0	0	1,329	0	1,329
11	0	0	7,720	0	7,72
11,5	0	32,046	12,460	0	44,506
12	0	36,724	24,478	0	61,202
12,5	0	0	25,577	3,261	28,838
13	0	33,189	65,916	0	99,105
13,5	0	54,686	35,711	12,529	102,926
14	0,442	150,277	90,311	49,293	290,323
14,5	1,210	269,551	22,469	141,896	435,126
15	0,797	407,372	33,408	219,768	661,345
15,5	1,227	455,409	27,843	182,347	666,826
16	1,132	382,223	35,971	151,477	570,803
16,5	0,917	272,049	39,718	99,551	412,235
17	1,101	299,512	49,985	74,540	425,138
17,5	0,705	1451,953	171,468	120,334	1744,46
18	0,552	2317,283	292,943	31,620	2642,398
18,5	0,361	2828,002	336,423	23,034	3187,82
19	0,131	3065,032	348,766	0	3413,929
19,5	0	2717,648	126,423	27,300	2871,371
20	0	2590,22	126,620	0	2716,84
20,5	0	1941,438	11,413	0	1952,851
21	0	1433,337	37,049	0	1470,386
21,5	0	950,889	13,311	0	964,2
22	0	0	0	0	0
22,5	0	96,971	0	0	96,971
23	0	298,433	0	0	298,433
23,5	0	0	0	0	0
24	0	0	0	0	0
TOTAL	8,575	22084,244	1937,312	1136,950	25167,081

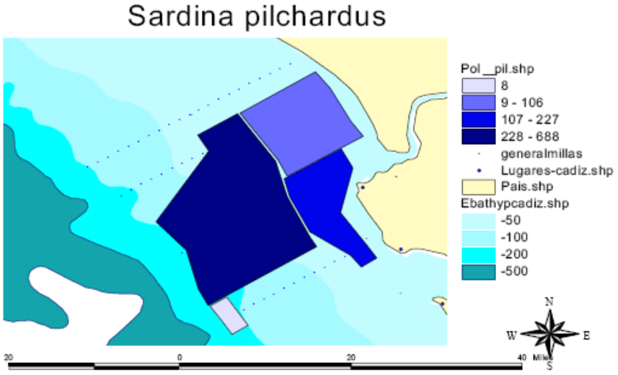


Figure 4.3.3.2.2.1. ECOCÁDIZ-RECLUTAS 1009 survey. Sardine (*Sardina pilchardus*). Distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

***ECOCÁDIZ-RECLUTAS 1009*: Sardine (*S. pilchardus*)**

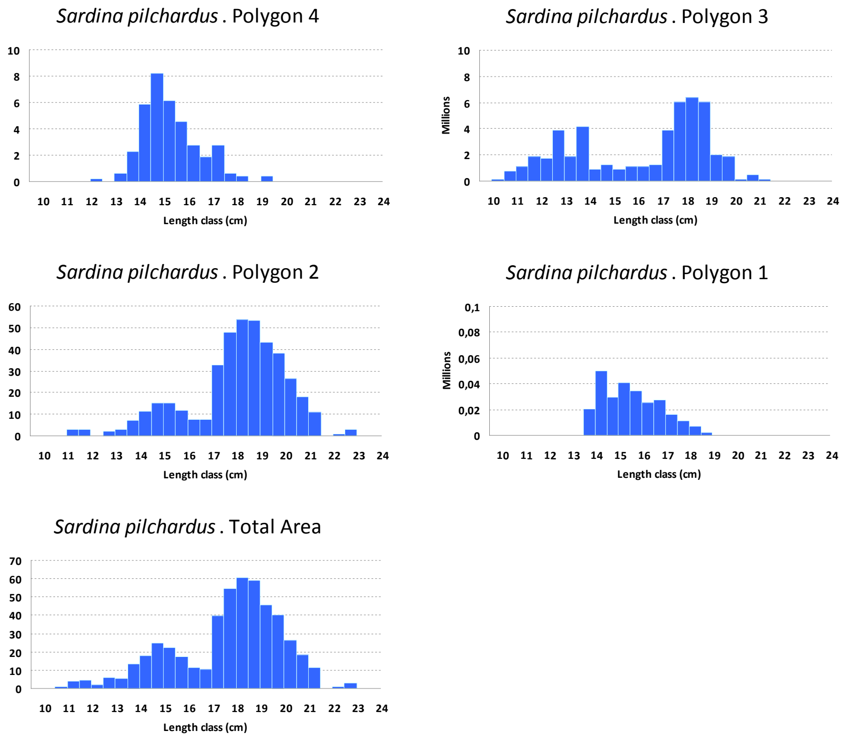


Figure 4.3.3.2.2.2. ECOCÁDIZ-RECLUTAS 1009 survey. Sardine (*Sardina pilchardus*). Estimated abundances by length class by homogeneous stratum (ordered from west to east, numeration as in Figure 4.3.3.3.2.1) and total area. Note the different scales in the *y*-axis.

4.3.3.3 Stock estimates

4.3.3.3.1 Anchovy

Three coherent post-strata were differentiated for the species according to the SA values distribution and the size composition in the fishing stations. The acoustic estimates by each post-stratum and total area are shown in Tables 4.3.3.2.1.1 and 4.3.3.2.1.2, and Figures 4.3.3.2.1.2 and 4.3.3.2.1.3. Anchovy was the most abundant species but, conversely, the species which yielded the lowest biomass of the set of the assessed species. Thus, a total of 2771 t and 524 millions of fish were estimated for this species for the whole surveyed area. The polygon 1, the shallowest one, concentrated the bulk of the assessed (sampled) population. Age structured estimates yielded the following results:

- The abundance and biomass of age 0 anchovies in the surveyed area were estimated at 2588 t and 510 million fish, respectively, i.e. 93% and 97% of the total estimated anchovy biomass and abundance.
- The size of age 0 anchovies ranged between 4.5 and 13 cm size classes, showing two modes at 5.5 cm (secondary) and 10 cm (the main one).
- Age 0 anchovies were more abundant in the abovementioned zone where also showed the highest values of acoustic energy (polygon 1). Here, age 0 anchovies showed a smaller size as well: the size ranged between 4.5 and 12 cm, with modes at 5.5 cm (secondary) and 10 cm (the main one).
- In the remaining post-strata the age 0 anchovies were somewhat larger and showing one only mode at 10 cm.

4.3.3.3.2 Sardine

Four coherent post-strata were delimited for the acoustic assessment. The acoustic estimates by stratum and total area are shown in Table 4.3.3.2.2.1 and Figure 4.3.3.2.2.2. Sardine was the most important species in terms of biomass and the second in abundance: 25167 t and 500 millions of fish have been estimated for this species for the whole surveyed area. The estimates provided to this WG are not age structured, although may be assumed that the two first cohorts should correspond to juvenile sardines. According to this, and establishing a size limit for this fraction at the 16.5 cm size class, the abundance and biomass of these juveniles (i.e. smaller than 17 cm) would be estimated at 3382 t and 130 millions, 13% and 26% of the total estimated biomass and abundance.

4.3.3.4 Conclusion

Figure 4.3.3.4.1 shows an attempt of assessing the magnitude of our undersampling of the extension of the distribution area of anchovy juveniles by comparison of our results with the ones obtained during the ARSA 1109 groundfish survey, a survey conducted just after the acoustic one (9– 23 November). This is the only ancillary information available, since the fishery in those dates (the other source of information possible) either showed a very low intensity or even stopped.

Although the bottom-trawl gear used in the groundfish survey (2 m vertical opening) not showed as the most suitable gear to sample anchovy, the distribution of the occurrence of the species in this last survey might give us an approximate picture of the probable general distribution of the species in the area. The size and age composition from bottom-trawl hauls indicate that smaller (age 0) anchovies are mainly concentrated in the same waters previously sampled by the acoustic survey. Taking into account that the acoustic assessment is underestimated, these data seem to suggest that such estimates might well include the bulk of the juvenile fraction of the anchovy population.

The continuation of this survey within an annual series is still not guaranteed for next years and in fact no survey of these characteristics has been carried out in 2010.

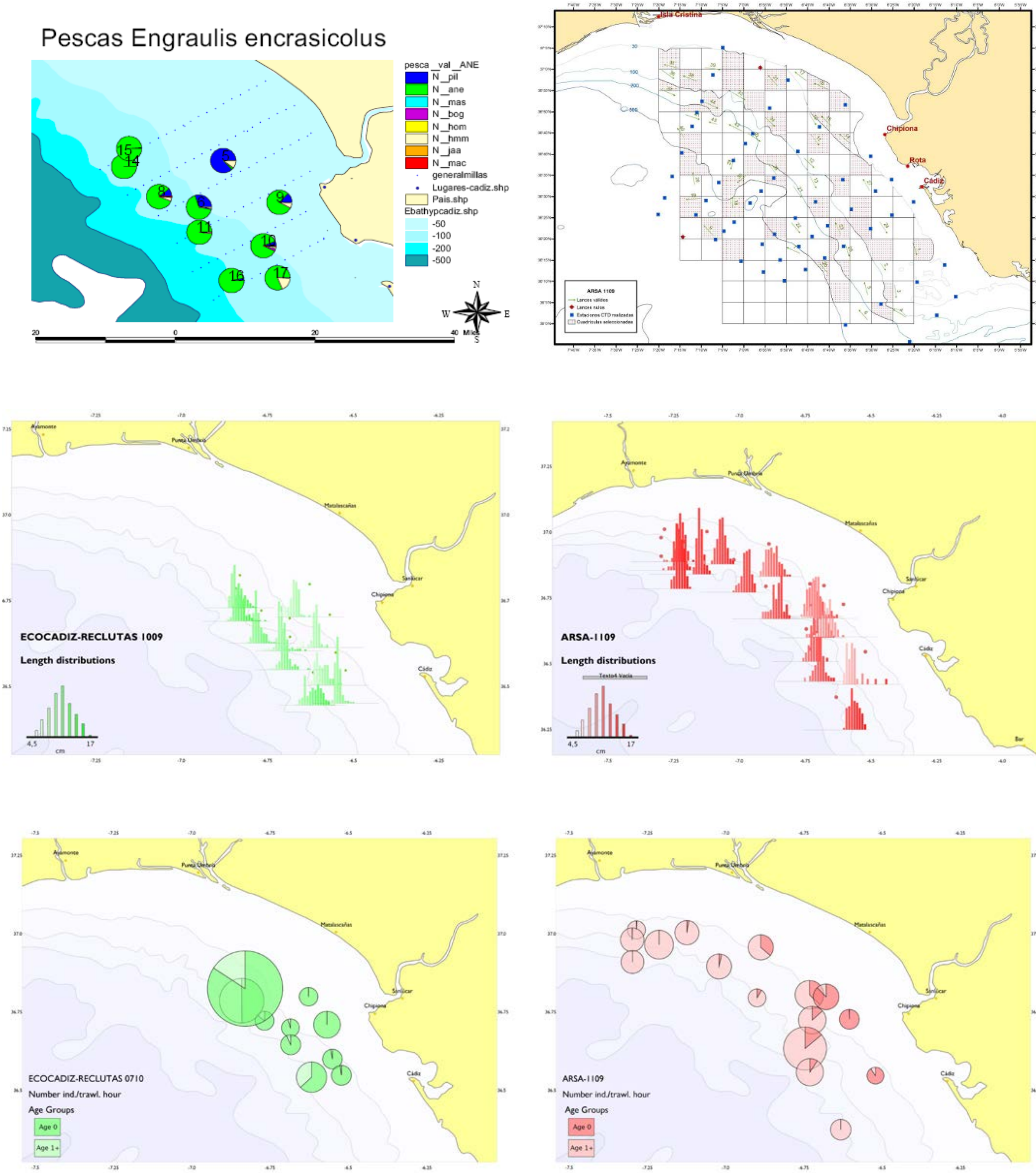


Figure 4.3.3.4.1. ECOCÁDIZ-RECLUTAS 1009 survey. Comparison of results obtained from fishing stations carried out during the present survey (26 October – 5 November, left column) with those ones carried out during the ARSA 1109 groundfish survey (9 – 23 November 2009, right column). Top row: Sampling grids with indication of the trawl hauls. Middle row: anchovy length frequency distributions by fishing station. Bottom row: anchovy age composition (% in

numbers of age 0 fish vs. age 1+ fish by trawling hour) by fishing station. Circle size proportional to the yield in numbers (number per trawling hour).

4.4 Common Data base from Surveys on pelagics in Subareas VIII and IX

Since 2008, WGACEGG produces regional scale maps by combining the data of the international spring coordinated acoustic/CUFES surveys of IPIMAR, IEO and Ifremer. These maps allow for the construction of a common database with a defined spatial resolution. In addition this year, the coordinated acoustic surveys were extended by the Peltic survey of Cefas, which covered the Celtic sea and the western English Channel (approx. 48–50°N, 5–10°W). The Peltic survey did not use CUFES.

Regional scale maps were derived by combining acoustic sA and CUFES survey data and computing the average per block over a defined grid, following the procedure established in 2008 (WGACEGG 2008 report). As in previous years, grid cells were valued when they contained at least 3 samples. As in previous years, to allow robust visualization of the maps on the arithmetic scale, the data values were truncated to the quantile q98. In this procedure, the 2% of the data values greater than q98 were equalled to q98.

Similar grid maps and database are produced also for the DEPM surveys in the region, although for 2010 this only affects to the DEPM in May for anchovy in subarea VIII (BIOMAN).

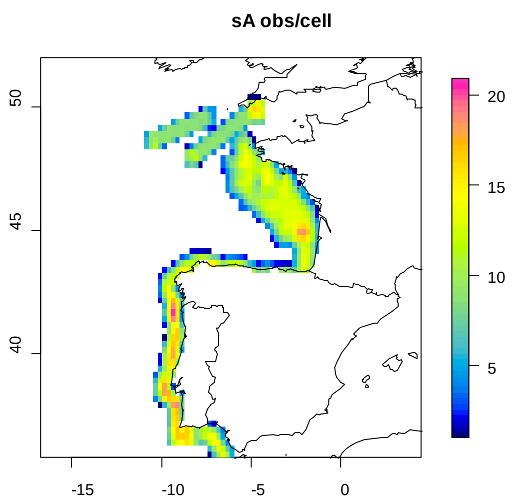


Figure 4.4.1. Map of the number of acoustic sA values in grid cells.

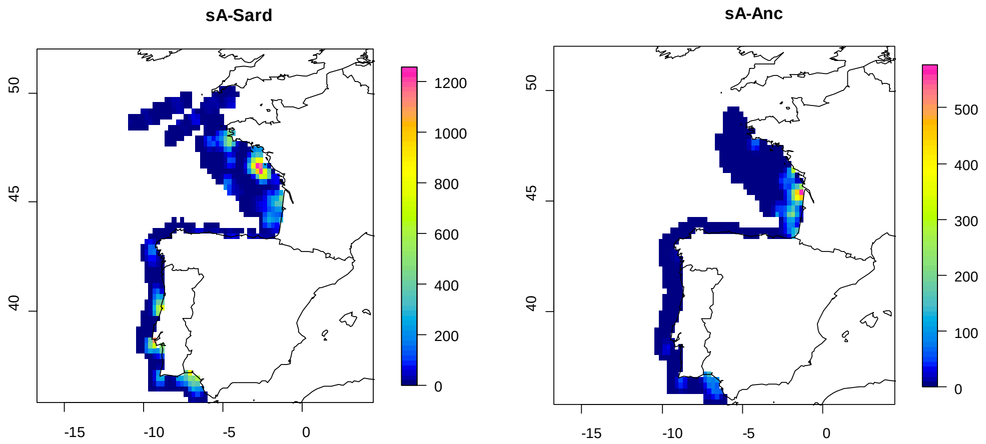


Figure 4.4.2. Map of acoustic sA for sardine (right) and anchovy (left).

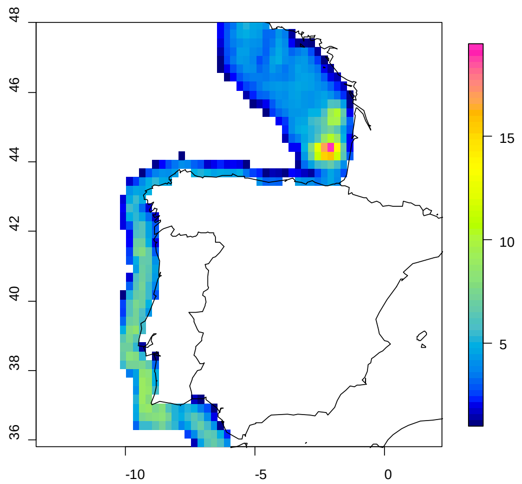


Figure 4.4.3. Map of the number of CUFES samples in grid cells.

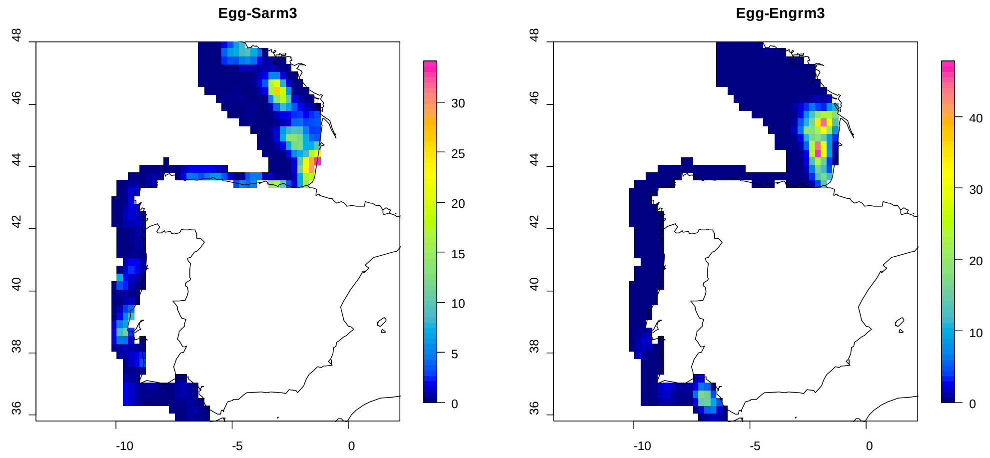


Figure 4.4.4. Map of CUFES egg density (nb/m3) for sardine (left) and anchovy (right).

4.5 French Sentinel Surveys

A 2-years pilot study is in progress since April 2009. This study relies on a partnership with Ifremer (French Institute for the Research and Exploitation of the Sea), CNPMEM (National Committee of Marine Fisheries and Aquaculture), DPMA (Direction of Marine Fisheries and Aquaculture) and is funded by national and European funds.

This project aims at developing an early indicator of the evolution of small pelagic resources (anchovy and sardine) in the Bay of Biscay from observations performed by fishers assisted by scientists. Surveys have been carried out regularly by pelagic pair-trawlers and purse-seiners in collaboration with scientists from the EMH (Ecology and Model for Fishery sciences) department of Ifremer, in 2 key zones: Gironde and South Brittany (Figure 4.5.1.), from April 2009 to September 2010.

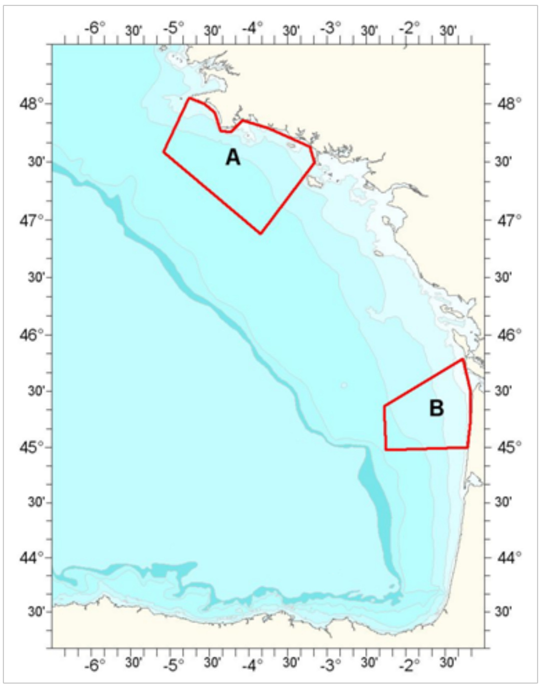


Figure 4.5.1. French Sentinel surveys in 2009 and 2010.

The project is built around the following questions:

- How are each year class progressively built ?
- What is their biological condition at each stage of their life ?
- How to define the reproductive potential by the intra-year history of growth ?
- When do juveniles appear in each area ?
- When does recruitment occur in each area ?
- What is the life-history of the stock ?
- What is the behaviour of the fish according to its abundance and/or its sharing of space with another species ?

Each survey is based on mutual knowledge enrichment between fishers and scientists. Fishermen are volunteers and their involvement in the project is balanced by financial compensations for the time at sea. The two key areas must be visited at each survey (5 days each) by pairtrawlers (for acoustics and fishing) and 1 or 2 days are dedicated to purse-seiners for fishing operations when not fishable by trawling. The Captain is free to go directly to the position he choose. His decision is leaded by his own knowledge and experience and all latest information he collected from the other local fishers who may have noticed the presence of anchovies or sardines during their recent fishing operations. Then, in agreement with the scientist on board, a suitable (opportunistic) sampling strategy is decided in order to measure the spatial extent and characterize the fish considering the time available and weather conditions. Without prior information, a more traditional sampling strategy is applied to survey the area through a regular sampling grid.

Acoustic data are stored from a calibrated split-beam echosounder (Simrad EK60 – 70 kHz) mounted on a towed body as often as possible in order to characterize the aggregation patterns when fish is present and have a measurement of density.

When available, sensors (temperature and salinity) are fixed on the fishing gears to record the physical parameters of the environment. Trawl or seine hauls are done when the "team captain-scientist" consider that it is necessary to identify echotraces and/or to get biological parameters.

As commercial vessels are surveying with the RV “Thalassa” during the PELGAS surveys, these "consort surveys" are considered for the two key areas in May. Therefore, seven surveys have been carried out since May 2009 (Figure 4.5.2.):

- May 2009, consort survey during PELGAS09
- August 2009
- December 2009
- April 2009
- May 2010, consort survey during PELGAS10
- July 2010
- September 2010

A total of 143 fishing operations were realized among 67 days at sea. The totality of acoustic data and biological material is not yet available, but some of the results can be already emphasized.

- First of all the partnership between scientists and fishers is a real success and it increased considerably the dialogue and understanding.

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

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

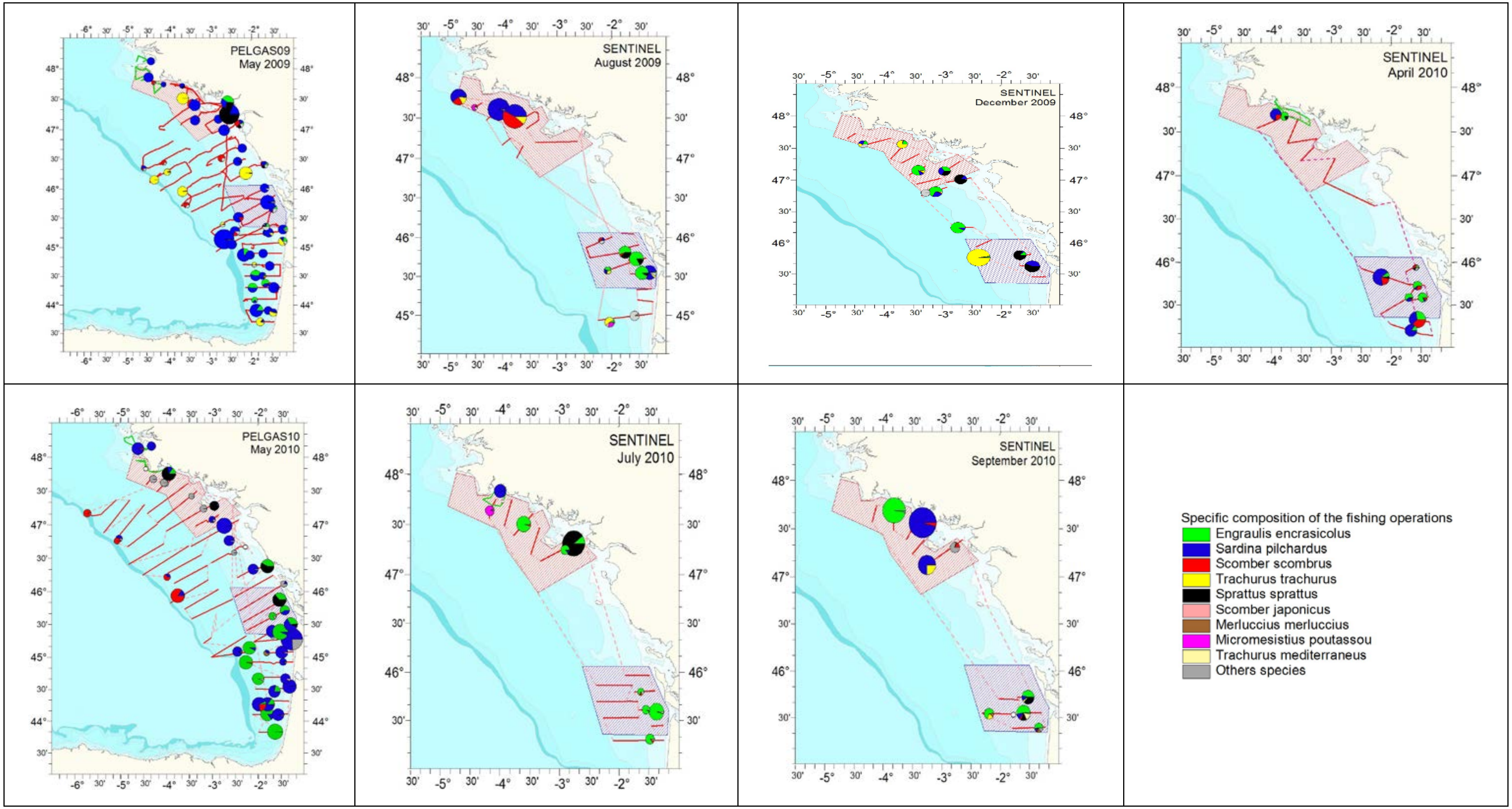


Figure 4.5.2. Transects and fishing operations carried out during sentinel surveys from May 2009 to September 2010 (the May surveys are consort surveys with PELGAS surveys).

5 Planning and coordination of surveys in 2011

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

5.1.1 Spring surveys

The joint planning and coordination of spring acoustic surveys of IPIMAR (PELAGO), IEO (PELACUS) and Ifremer (PELGAS) within this working group (see Section 6.1.2 of ICES 2007), covers the pelagic fish community on the continental shelf extending from Trafalgar to Brest, i.e. from 36º N to 48º N (**Section 4.1** of this report). In addition, the first systematic (non exploratory) survey coverage of the region North of 48° N across Celtic sea and western Channel will be carried out by Cefas (UK) at the beginning of June 2011 (following PELGAS). So in 2011, and by the first time, four acoustic surveys will be carried out subsequently and closely coordinated as to cover the entire areas from Cape Gibraltar to the Celtic sea and western Channel.

The efforts initiated in 2008 in collecting intensive acoustic, trawl, eggs and oceanographic (through CUFES and associated sensors) data will be maintained with the prospect of creating a regional time-series with annual periodicity of fish distribution and of its environment.

The foreseen dates of these surveys are:

IPIMAR acoustic survey (PELAGO) is planned to take place between 30th March and 30th April 2011 and will cover, as usual, the ICES area IXa from the Portuguese/Spanish border, in the north, to Cape Trafalgar, in Cadiz Bay. An intercalibration exercise will be planned between Portuguese and Spanish scientists, to be carried out during the spring surveys.

IEO is planning to carry out the 2011 acoustic survey between 26th march and 22th April 2011, covering the Spanish continental shelf from Portuguese/Spanish border to Spanish/French border.

Ifremer acoustic survey for 2011 will be from 25 April to 5 June, from Bayonne to Brest.

Cefas' first acoustic survey on sardine and other small pelagic fish species will take place between the 20 May and 10 June 2011. It will cover the western English Channel and the Celtic Sea shelf area north of the Bay of Biscay (between 48° and 52°), equivalent to ICEAS areas VIIe-h, j.

5.1.2 Autumn surveys in Subarea VIII in 2011

For the next year 2011, both institutes AZTI and IEO have agreed to conduct a single coordinated autumn survey for anchovy. A protocol detailing the specific objectives and tasks of each team in the common survey is being developed among both groups. However, the level of participation of IEO will depend on several factors still uncertain, as the amount of funding and the availability of a research vessel for the survey. Therefore, the detailed organization of activities in the common survey will be carried out during the first part of year 2011, as long as the situation is clarified.

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

5.2.1 Sardine and Anchovy Surveys

Anchovy DEPM 2011

The next DEPM survey BIOMAN 11 in the Bay of Biscay to estimate the spawning-stock biomass (SSB) of anchovy and the numbers-at-age of the population will be carried out from the 6th to the 30th of May 2011. The survey will be carried out on board the RV "Investigador" were the plankton samples will be obtained concurrently with the adult sampling on board RV "Emma Bardán" were the adult samples will be obtained with this pelagic trawl. Moreover additional adult samples will be obtained opportunistically with the collaboration of the purse-seine commercial fleet. This survey will be in contact with the surveys PELGAS 11 and PELACUS 0411.

The next DEPM survey to estimate the SSB of anchovy in the Gulf of Cadiz (triennial survey) will be carried out from the 13–28 July 2011. The survey will be carried out on-board the RV "Cornide de Saavedra" (IEO). The plankton and adults samples will be obtain in the same vessel, with a PairoVET net (150 μ mesh size) and a pelagic trawl respectively.

Sardine DEPM 2011

A DEPM survey for the Atlantic-Iberian sardine will take place in 2011 covering the area from the Gulf of Cadiz to the Bay of Biscay. The region from the Gulf of Cadiz to the northern Portugal/Spain border (Minho River) will be surveyed by IPIMAR (Instituto de Investigação das Pescas e do Mar, Portugal), while IEO (Instituto Español de Oceanografía, Spain) will cover the northwestern and north Iberian Peninsula and inner part of the Bay of Biscay (to 45°N). The remainder area of the Bay of Biscay from 45ºN to 48ºN latitude will be covered by AZTI (Instituto Tecnológico Pesquero y Alimentario, Spain). Due to differences in the peak spawning period of sardine and logistics within the different institutes, it is not possible for the independent surveys to follow a tighter sequential schedule in time.

Ichthyoplankton surveying will be undertaken following a predefined grid of sampling stations along-transects perpendicular to the coast (Figure 5.2.1.1). The inshore limit of transects will be determined by bottom depth (as close to the shore as possible), while the offshore extension will be decided adaptively. The procedure agreed during the SGSBSA in 2004 (ICES, 2005) for ichthyoplankton sampling will be followed. In Table 5.2.1.1 is presented a summary of the equipment and methods adopted.

Adult fish samples will be obtained from the research vessels or commercial fleets. Sampling protocols for sardine adults and laboratory processing of samples will be performed according to the procedures adopted in previous DEPM surveys (ICES 2007, ICES 2005) and most important information is gathered in Table 5.2.1.2.

The ichthyoplankton survey and the adult sampling for IPIMAR will take place in January/February on-board RV "Noruega", additional adult sampling will be obtained opportunistically with the collaboration of the purse-seine commercial fleet. In the case of IEO, ichthyoplankton survey and the adult sampling will be performed in March/April, on-board RV "Cornide de Saavedra" for ichthyoplankton survey and on-board RV "Thalassa" and "Cornide de Saavedra" for adult sampling. For AZTI the ichthyoplankton sampling will be take place in May on-board the RV "Investigador" concurrently with the adult sampling on-board the RV "Emma Bardan".

The survey methodology and strategy used will follow the general plan agreed for previous surveys (ICES 2005, 2006), and most important information is gathered in Table 2. Considering that the histological processing and analysis is expected to last at least 6 months, it will not be possible to provide the results of the SSB estimate to the ICES assessment WG (WGANSA) which will meet in June 2011. However, it is expected that Egg Productions (P0) and spawning areas could be presented in June 2011, and that some preliminary results on the adult parameters could also be provided during the next meeting of this WG (November 2011). The final estimates of SSB for the Atlantic-Iberian area are intended to be available for the next WGANSA in June 2012.

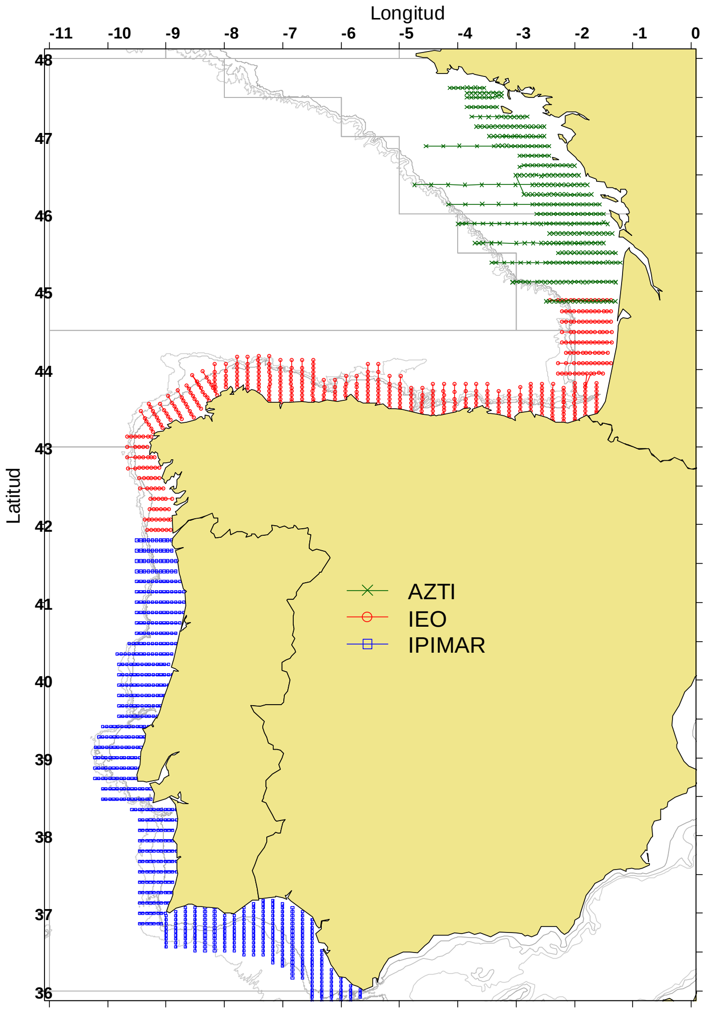


Figure 5.2.1.1. Grid of provisional PAIROVET sampling stations.

Table 5.2.1.1. Planning of survey and egg processing methodology for sardine in 2011.

	SARDINE		
SURVEY:	IPIMAR (PORTUGAL)	IEO (SPAIN)	AZTI (SPAIN)
SURVEY AREA	PORTUGAL AND GULF OF CADIZ 36–42°N	GALICIA AND BAY OF BISCAY 42–45°N	BAY OF BISCAY 45–48°N
RV	"Noruega"	"Cornide de Saavedra"	"Investigador"
Survey period(1)	January 25 /February 28	March 25 / April 18	May 6–30
ICES Division	IXa South, IXa Central	IXa North, VIIIc, VIIIb (to 45ºN)	VIIIb (from 45ºN), VIIIa,b
Sampling grid	8 x 3(2)	8 x 3(2)	7.5x3(2)
Sampler	PAIROVET (1 net for egg processing)	PAIROVET (1 net for egg processing)	PAIROVET (2 nets for egg processing)
Mesh size (µm)	150	150	150
Type of haul	Vertical	Vertical	Vertical
Sampling max. depth (m)	150	100	100
Towing speed (m/s)	1	1	1
Acceptable max. angle	20º	20º	15º
Hydrographical sensor	CTDF (FSI) (3)	CTD (Seabird37)(3)	CTD (RBR) (3)
Flowmeter	Y	Y	Y
Clinometer	Y	Y	N
Eggs staged (Gamulin and Hure, 1955)	all	all	all
CUFES (ø 335µm)	3 nmiles (sample unit)	3 nmiles (sample unit)	1.5 nmiles (sample unit)
Environmental data	fluorescence, temp, salinity	fluorescence (surface only), temp, salinity	fluorescence (surface only), temp, salinity
Processing			
Temperature for egg ageing	Surface and mean top 10 m	10 m	10 m
Egg ageing	Bayesian (Bernal 2007)	Bayesian (Bernal 2007)	Bayesian (Bernal 2007)
Egg Production	GLM (GAMs available)	GLM (GAMs available)	GLM (GAMs available)

(1) Provisional dates

(2) Adaptive, see sampling design (ICES, 2005)

(3) CTD coupled to PAIROVET

Table 5.2.1.2. Planning of survey methodology for sardine adult sampling and processing in 2011.

SARDINE ADULT SAMPLING	IPIMAR (PORTUGAL)	IEO (SPAIN)	AZTI (SPAIN)
RV	"Noruega"	"Thalassa" "Cornide de Saavedra"	"Enma Bardam"
Gears	Pelagic trawl Bottom trawl	Pelagic trawl	Pelagic trawl
Sampling period	During the day hours	During the day hours	During night and day
Complementary samples	Opportunistic commercial purse-seiners samples		
Biological sampling: - Survey - Commercial	- On fresh material, on-board of the RV - On frozen material, at the institute laboratory (gonad preserved on the harbour)	- On fresh material, on board of the RV	- On fresh material on-board of the RV
Preservation	Buffered formaldehyde 4% (distilled water)	Buffered formaldehyde 4% (distilled water)	Buffered formaldehyde 4% (tap water)
Conservation	In formalin	In formalin	In formalin
Processing			
Histology: - Embedding mat. - Stain	 - Paraffin - Haematoxilin-Eosin	 - Resin - Haematoxilin-Eosin	 - Resin - Haematoxilin-Eosin
S estimation	Day 1 and Day 2 POFs (Pérez *et al*., 1992a and Ganias *et al*., 2007)	Day 1 and Day 2 POFs (Pérez *et al*., 1992a and Ganias *et al*., 2007)	Day 1 and Day 2 POFs (Pérez *et al*., 1992a and Ganias *et al*., 2007)
R estimation	The observed weight fraction of the females	The observed weight fraction of the females	The observed weight fraction of the females
F estimation	On hydrated females (without POFs), Pérez *et al*. 1992b, Ganias *et al*. 2010	On hydrated females (without POFs), Pérez *et al*. 1992b	On hydrated females (without POFs), Pérez *et al*. 1992b

6 Revision and update of survey's time-series estimates

6.1 Revision of Anchovy DEPM based SSB estimates in the Bay of Biscay

The procedures for the estimation of the Spawning frequency (S) for the Bay of Biscay anchovy have been revised due to a better understanding of the POF degeneration cycle (Alday *et al.*, 2008) and its application to the estimation of S (Uriarte *et al.* submitted). Such revision of the Spawning Fraction is finished (**Figure 6.1.1**), but pending of final due publication. This will affect the past Spawning Biomass estimates of anchovy by the DEPM leading to a reduction of those estimates by about 40%.

Moreover a revision of the anchovy egg mortality was present last and this year (see Section 7.1.1). However the revision of the series of SSB estimate for the Bay of Biscay anchovy was not ready to this working group because we have to better conclude and publish the mortality anchovy eggs issue.

The working group discussed in previous years the changes in the estimation procedures of the Spawning Frequency and of the Egg Production and endorsed their implementation. So in principle as soon as the revised series is made in full available to ICES it could be adopted. However, given the strong impact those changes will have on the Spawning Biomass estimates, the WG considered the convenience of earlier publication in a peer review Journal before the new estimates are incorporated as input for the management advice.

The use of the new DEPM SSB series and their implications in the assessment should be evaluated at WGANSA. Nevertheless the WG noticed the convenience of a better understanding of the reasons of the discrepancies in absolute terms between the DEPM and acoustic estimates for this anchovy in the Bay of Biscay and several ideas were put forward for evaluation prior to the next WGACEGG meeting in 2011, such as:

- List the changes of parameters throughout time globally and by strata for both methods. Are differences originated in persistent regions or areas?
- Describe common indicators for both surveys and compare (Area, CUFES egg abundance, SSS, SST, nº schools…).

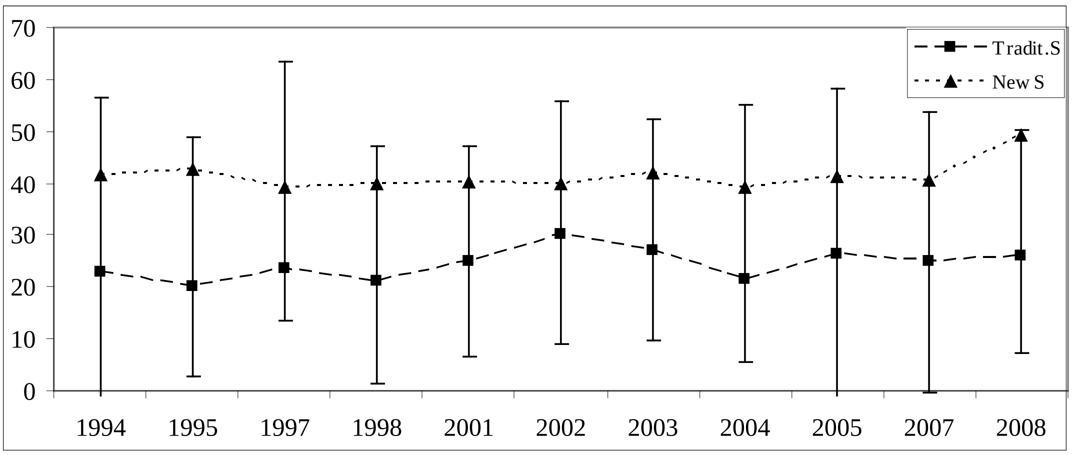


Figure 6.1.1. Past and new spawning fraction estimates for the Bay of Biscay anchovy. New estimates based on the incidence of spawning cohorts Day (0+1)/2 are presented.

6.2 Revision of Sardine DEPM based SSB estimates in the Iberian Peninsula

Since DEPM was first applied for the Iberian sardine several improvements were considered in sampling and laboratorial and data analyses. The methodological developments were discussed and implemented within the WGACEGG over the years; Changes introduced gave rise to modifications in the way the estimates are obtained. Small changes in some parameters may cause considerable modification in SSB.

Partial revisions on the DEPM (for some parameters) have been conducted and the results reported in the WGACEGG. It is now pertinent that a full revision of the estimates, applying the traditional method with the recent developments, are gathered and presented to the group.

At the 2010 WGACEGG meeting, revised estimates for egg production (area definition, egg ageing and egg production and mortality estimates) undertaken using the procedures described in the report of 2009 (ICES CM 2009/LRC:20), were discussed, but were not yet adopted as further justification of the origin of the changes compared with previous estimates were considered necessary. In addition, in order to complete the revisions and estimates of SSB, an update/review of adult parameters needs to be considered.

Therefore, for 2011 a ToR was defined staying that the DEPM series would be revised and the estimates presented should be published prior to the sardine bench mark assessment meeting, which is expected to occur in 2012.

6.3 Revision of ECOCÁDIZ-COSTA 0709 (and ECOCÁDIZ 0609)

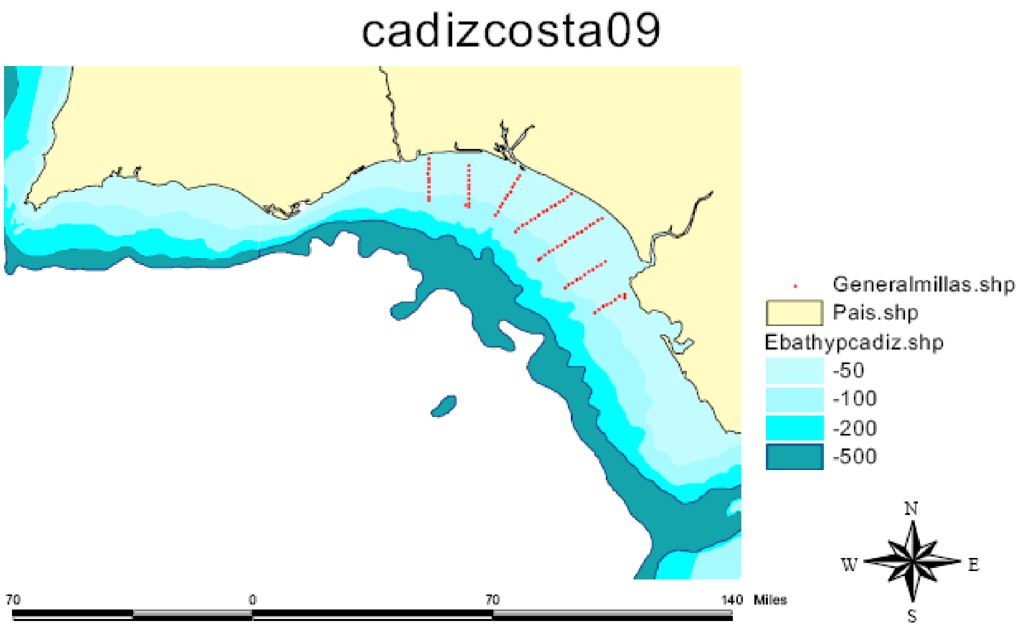
6.3.1 Description of the survey

Aiming at the acoustic surveying of the shallowest waters off the Gulf of Cádiz, the ECOCÁDIZ-COSTA 0709 survey was conducted almost synchronously (from 2 to 9 July 2009) to the conventional ECOCÁDIZ 0609 survey (from 27 June to 6 July; their results were reported last year's WG, ICES, 2009) with the IEO's RV "Francisco de Paula Navarro" (30 m length; 4.3 m draught). Survey design consisted in a systematic grid with 7 transects equally spaced by 8 nm, normal to the shoreline, between 50 m depth and the shallowest depth possible. Actually, ECOCÁDIZ-COSTA's sampling grid was the continuation of the ECOCÁDIZ transects R05 to R11 from 50 m depth inshore (Figure 6.3.1.1). The Navarro's acoustic equipment (a non-scientific echosounder, the Simrad™ ES60 Single-Beam Multi-Purpose Fish-Finder, only working with a Simrad™ Single-Beam 38 kHz GPT and transducer) and its configuration had to be the same one than the previously used in the PACAS 0708 survey (the first of two pilot experiments for acoustic surveying of Gulf of Cádiz shallow waters, <20 m depth, conducted in 2008; ICES, 2008; Ramos *et al.*, 2010). Unfortunately, the characteristics of the acoustic equipment prevented from its proper calibration and therefore the resulting estimates should be only considered as orientative ones of the magnitude of the unsampled fraction of the assessed populations. Furthermore, the Navarro was only equipped for this summer's survey with its standard configuration for bottom-trawl fishing which consists in the great vertical opening GOC 73 bottom-trawl gear (3.5 m standard mean vertical opening, 20 mm mesh size in the inner small-meshed codend) and the Morgére WH-S(8) trawl doors (2.6 m2, 350 kg). Some arrangements in the floating rope (by increasing the number of floats) allowed to achieve a 5 m mean vertical opening but they didn't give any chance for the midwater fishing, with all the fishing operations being therefore performed over or very close to the bottom. Neither CUFES nor CTD sampling, nor census of apical predators were carried out with the RV “Navarro”.

From a total of 7 fishing operations, 4 hauls were considered as valid fishing stations according to a correct gear performance and resulting catches (Figure 6.3.1.2). Such valid hauls were only restricted to the 17–29 m depth range and yielded a total of 424 kg and 6 thousand fish. The more frequently captured species were the sparids Diplodus annularis and D. bellotti, anchovy, sardine, Mediterranean horse-mackerel and hake. Seventy six per cent (76%) and 41% of the total fished biomass and number of fish, respectively, corresponded to fish species other than those (pelagic) species usually assessed in the conventional surveys.

A total of 84 nautical miles (ESDUs) were acoustically sampled by echo-integration for assessment purposes (Figure 6.3.1.3). For the whole “pelagic fish assemblage” was estimated a total backscattered energy of 31336 m^2 nmi^{-2}. The fact of the valid fishing hauls were restricted to the 17–29 m depth range led to the impossibility of interpreting the echograms for those ESDUs included into the bathymetric range comprised between 25–50 m. The estimated NASCs from such ESDUs were coded as NI (i.e. not identified). NI NASCs accounted for 52% of this total backscattering energy. Fortunately, the not identified ESDUs were previously assessed in the conventional survey and, therefore, this loss of information may be considered irrelevant. Acoustic energies were not very high in shallower waters, a fact which is reflected in the contribution to the total energy by the most coastal species. So, sardine only contributed with 12%, followed by anchovy with 11%, bogue with 10%, Mediterranean horse-mackerel with 9%, chub mackerel with 7% (the set of assessed species), and negligible energetic contributions by horse mackerel and blue-jack mackerel, and a null contribution by round sardinella and mackerel.

It should be recalled that all the following information will only refer to the ECOCÁDIZ-COSTA 0709 results although graphical information from the conventional survey is also given for visual inspection and comparative purposes.



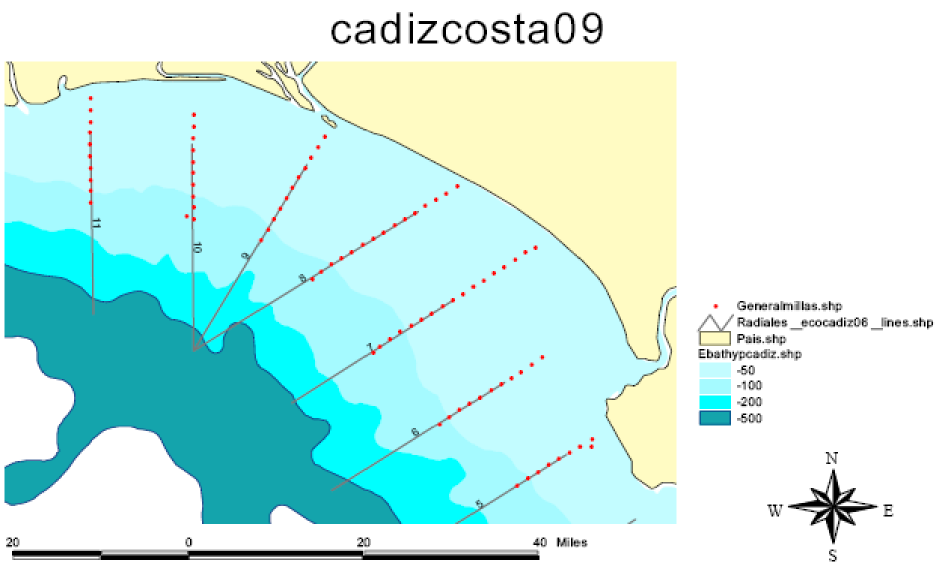


Figure 6.3.1.1. ECOCÁDIZ-COSTA 0709 survey. Top: survey transects. Bottom: the (coastal) survey transects (red dotted lines) are over imposed to the ones of the ECOCÁDIZ 0609 conventional survey (grey lines) for comparison.

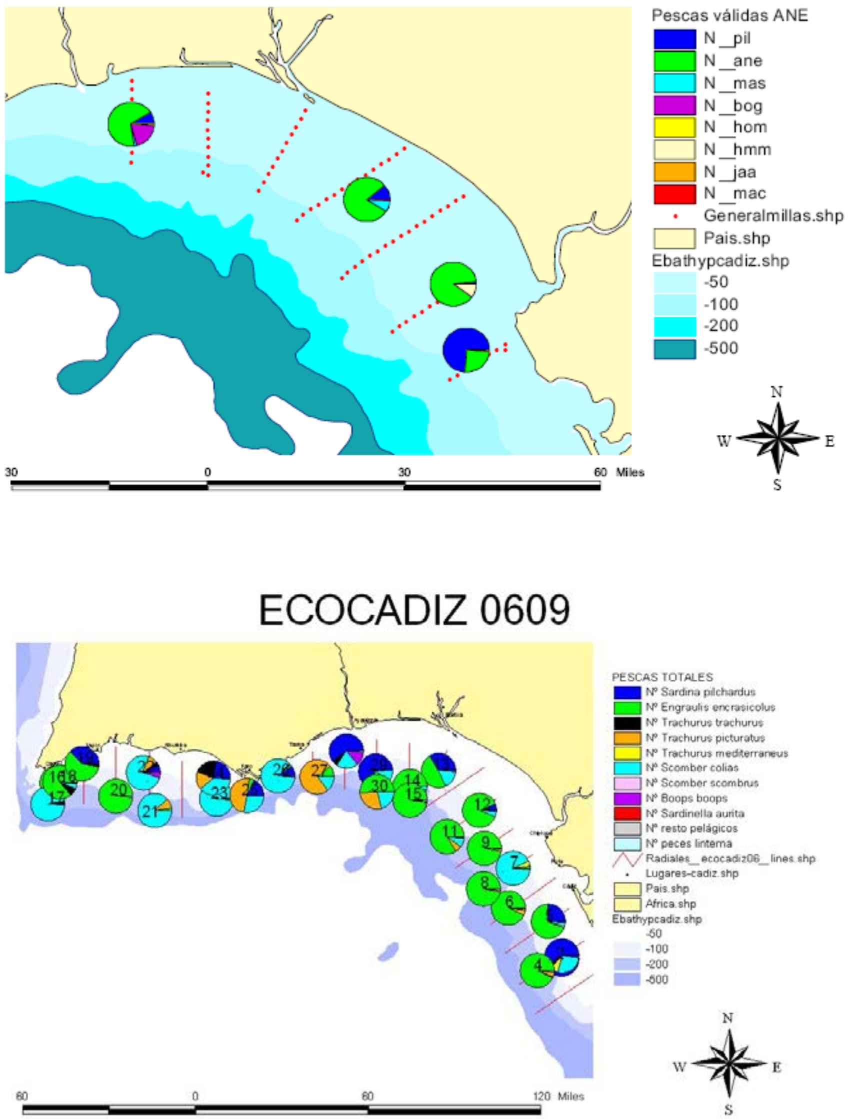


Figure 6.3.1.2. ECOCÁDIZ-COSTA 0709 survey. Top: location of valid fishing stations and their species composition (expressed as percentages in number). Bottom: location of valid fishing stations from the ECOCÁDIZ 0609 conventional survey for comparison.

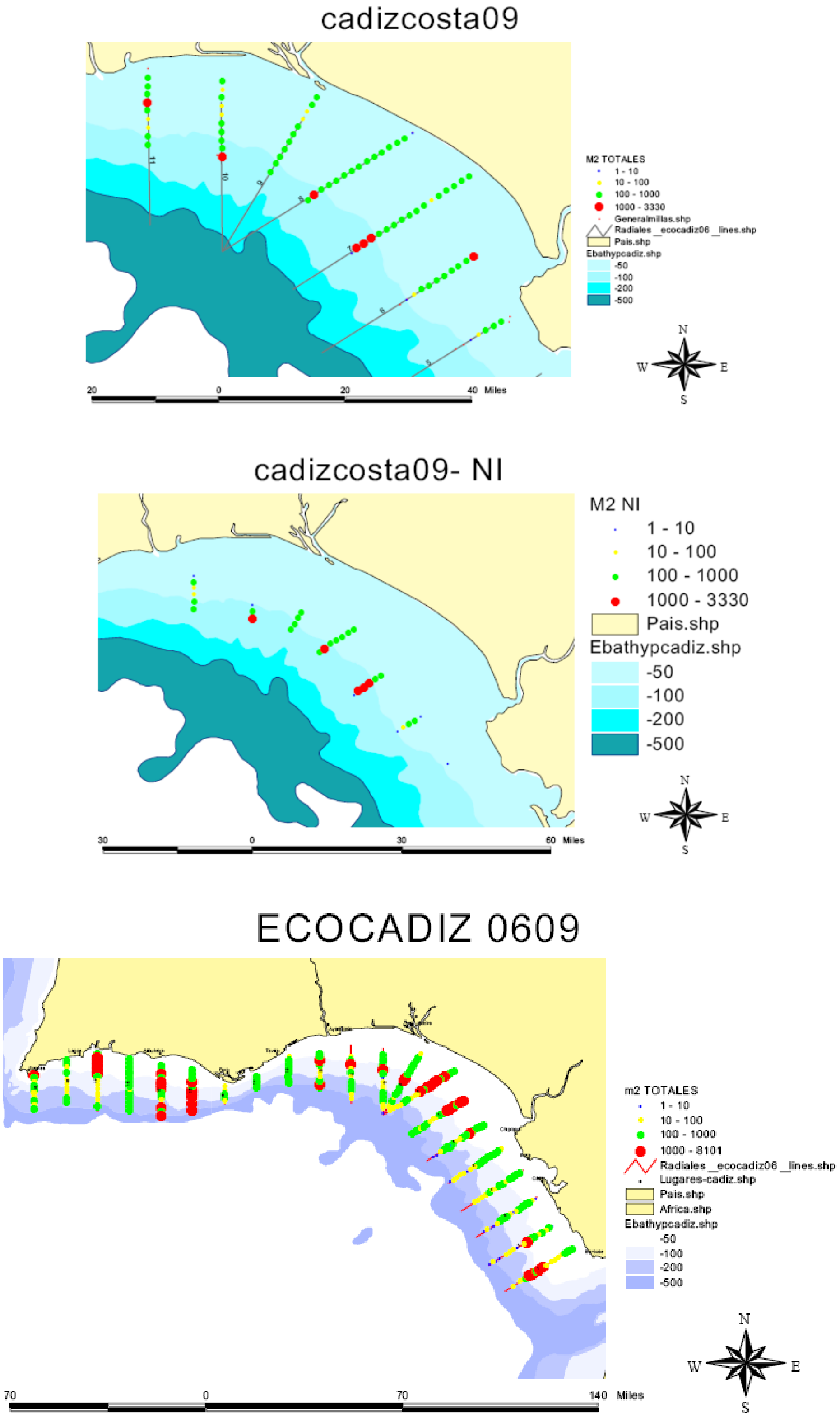


Figure 6.3.1.3. ECOCÁDIZ-COSTA 0709 survey. Top: distribution of the total backscattering energy attributed to the pelagic fish species assemblage. Middle: ESDUs where the total backscattering energy was not possible to be allocated by species (i.e. species not identified, NI) because of the absence of fishing hauls in this depth range. Bottom: distribution of the total backscattering energy attributed to the pelagic fish species assemblage for the ECOCÁDIZ 0609 conventional survey for comparison.

6.3.2 Distribution of anchovy and sardine

6.3.2.1 Anchovy

Anchovy was distributed all over the sampled coastal waters, with the highest densities occurring just in the central part of the sampled area (in front of Guadalquivir river mouth; **Figure 6.3.2.1.1**).

The size class range of the coastal population varied between 9.5 and 16 cm classes, showing bimodality at 11 and 13 cm size classes. As also observed in the conventional survey, size- and age-based estimates suggested an westward increasing size (-age) gradient, with the largest (and oldest) anchovies being more abundant in the westernmost limit of the sampled area, and the smaller and younger first spawners located in shallow waters close to the Guadalquivir river (**Tables 6.3.2.1.1 and 6.3.2.1.2, Figures 6.3.2.1.2 and 6.3.2.1.3**).

Table 6.3.2.1.1. ECOCÁDIZ-COSTA 0709 survey. Anchovy (*Engraulis encrasicolus*). Estimated abundance (top, in numbers) and biomass (bottom, in tons) by size class, homogeneous size-based stratum and total area.

***ECOCÁDIZ-COSTA 0709* . *E. encrasicolus* . ABUNDANCE (in nº of individuals)**

Size (cm)	POL01	POL02	POL03	POL04	Total n	Millions
9	0	0	0	0	**0**	**0**
9.5	0	0	2483647	0	**2483647**	**2**
10	0	0	8445220	0	**8445220**	**8**
10.5	0	0	20367546	148946	**20516492**	**21**
11	0	508157	29807044	297891	**30613092**	**31**
11.5	0	3557887	12916604	1935960	**18410451**	**18**
12	384783	16264963	5961573	3871921	**26483240**	**26**
12.5	769566	20331007	993459	6403664	**28497696**	**28**
13	7692925	17790222	993459	2829468	**29306074**	**29**
13.5	12693052	12707076	0	1042453	**26442581**	**26**
14	17309081	4574201	0	148946	**22032228**	**22**
14.5	15385850	2033416	0	0	**17419266**	**17**
15	8462491	508157	0	0	**8970648**	**9**
15.5	4616029	508157	0	0	**5124186**	**5**
16	1153665	0	0	0	**1153665**	**1**
Total n	**68467442**	**78783243**	**81968552**	**16679249**	**245898486**	**246**
Millions	**68**	**79**	**82**	**17**	**246**	

***ECOCÁDIZ-COSTA 0709* . *E. encrasicolus* . BIOMASS (t)**

Talla (cm)	POL01	POL02	POL03	POL04	Total
9	0	0	0	0	**0**
9.5	0	0	14.863	0	**14.863**
10	0	0	59.108	0	**59.108**
10.5	0	0	165.488	1.210	**166.698**
11	0	4.761	279.249	2.791	**286.801**
11.5	0	38.196	138.669	20.784	**197.649**
12	4.707	198.963	72.926	47.364	**323.960**
12.5	10.671	281.904	13.775	88.791	**395.141**
13	120.327	278.261	15.539	44.256	**458.383**
13.5	222.960	223.206	0	18.311	**464.477**
14	340.036	89.860	0	2.926	**432.822**
14.5	336.734	44.503	0	0	**381.237**
15	205.595	12.346	0	0	**217.941**
15.5	124.071	13.658	0	0	**137.729**
16	34.198	0	0	0	**34.198**
Total	**1399.299**	**1185.658**	**759.617**	**226.433**	**3571.007**

Table 6.3.2.1.2. ECOCÁDIZ-COSTA 0709 survey. Anchovy (*Engraulis encrasicolus*). Estimated abundance (thousands of individuals) and biomass (tons) by age group and homogeneous size-based strata (Polygons, POL01 to POL04, ordered from west to east).

Age class	POL01	POL02	POL03	POL04	TOTAL
	Number	Number	Number	Number	Number
0					
I	47290	73906	81969	16679	219844
II	17985	4877			22862
III	3192				3193
IV					245898
TOTAL	68467	78783	81969	16679	219844

Age class	POL01	POL02	POL03	POL04	TOTAL
	Weight	Weight	Weight	Weight	Weight
0					
I	923	1087	760	226	2995
II	394	99			493
III	83				83
IV					
TOTAL	1399	1186	760	226	3571

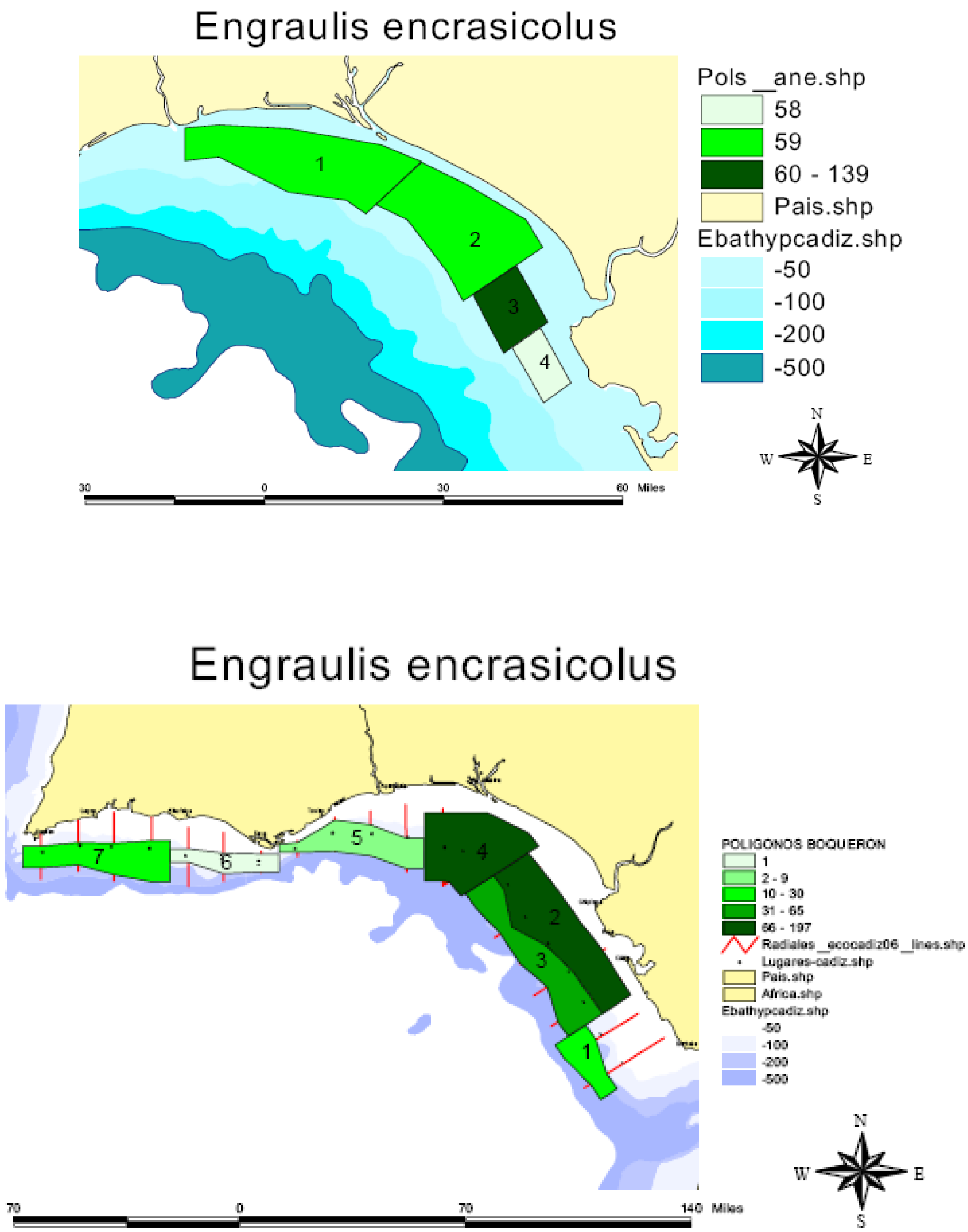


Figure 6.3.2.1.1. ECOCÁDIZ-COSTA 0709 survey. Anchovy (*Engraulis encrasicolus*). Distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each post-stratum. Top: present survey. Bottom: ECOCÁDIZ 0609 conventional survey. Note that colour scales used in both surveys are not completely equivalent.

ECOCÁDIZ-COSTA 0709: **Anchovy (*E. encrasicolus*)**

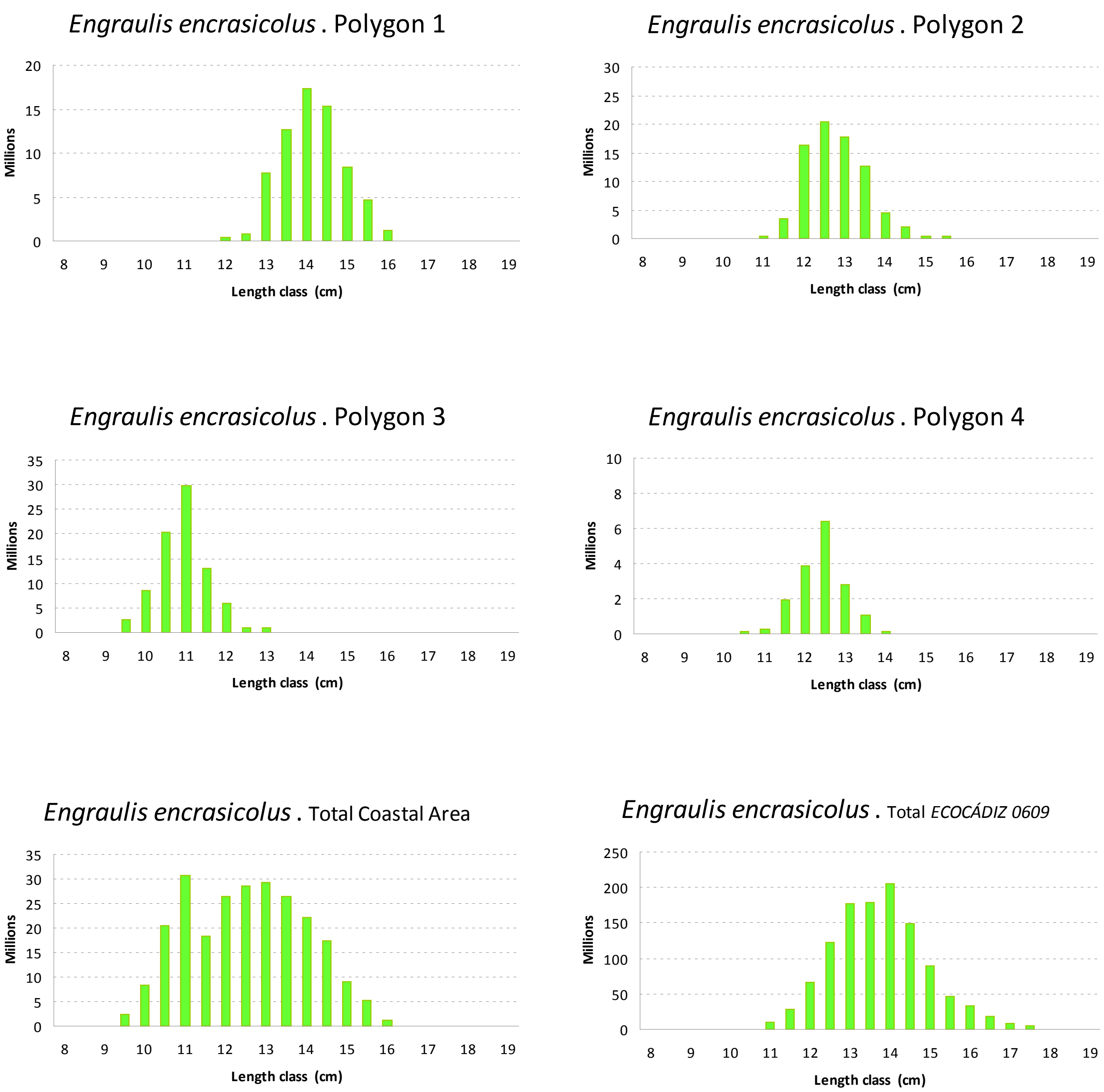


Figure 6.3.2.1.2. ECOCÁDIZ-COSTA 0709 survey. Anchovy (*E. encrasicolus*). Estimated abundances by length class by homogeneous stratum (ordered from west to east, numeration as in Figure 6.3.2.1.1) and total area. The size composition estimated for the population in the ECOCÁDIZ 0609 conventional survey is also shown for comparative purposes. Note the different scales in the y-axis.

ECOCÁDIZ-COSTA 0709: **Anchovy (*E. encrasicolus*)**

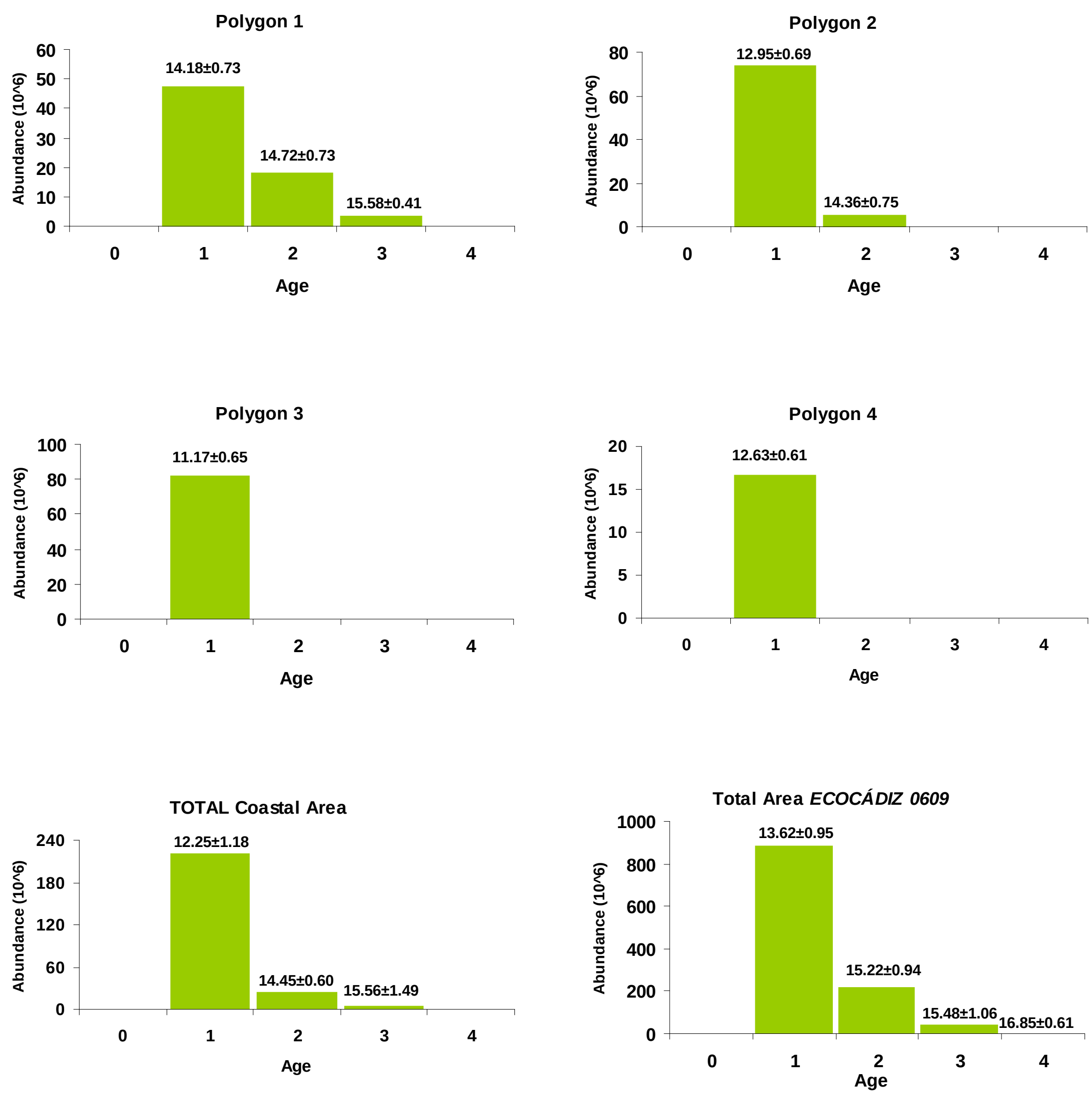


Figure 6.3.2.1.3. ECOCÁDIZ-COSTA 0709 survey. Anchovy (*E. encrasicolus*). Estimated abundance (millions of individuals) by age group for each homogeneous stratum (ordered from west to east, numeration as in Figure 6.3.2.1.1) and total area. The age composition estimated for the population in the ECOCÁDIZ 0609 conventional survey is also shown for comparative purposes. Note the different scales in the y-axis. Mean length (±SD) by age group is also shown.

6.3.2.2 Sardine

Sardine occurred all over the coastal area and, as also described for anchovy, the former species also showed the highest densities close to the Guadalquivir river mouth. Sizes of the assessed population in coastal waters ranged between 16 and 20.5 cm size classes, with a modal class at 18 cm. The size composition of the surveyed population does not evidence any clear geographical cline in size (**Table 6.3.2.2.1, Figure 6.3.2.2.1**).

Table 6.3.2.2.1. ECOCÁDIZ-COSTA 0709 survey. Sardine (*Sardina pilchardus*). Estimated abundance (top, in numbers) and biomass (bottom, in tons) by size class, homogeneous size-based stratum and total area.

ECOCÁDIZ-COSTA 0709 **. *S. pilchardus* . ABUNDANCE (nº of individuals)**				
Size (cm)	**POL01**	**POL02**	**Total n**	**Millions**
15	0	0	**0**	**0**
15.5	0	0	**0**	**0**
16	680844	1133289	**1814133**	**2**
16.5	3402340	1133289	**4535629**	**5**
17	16331796	5666818	**21998614**	**22**
17.5	13610300	9822706	**23433006**	**23**
18	22456572	8311406	**30767978**	**31**
18.5	14290204	5666818	**19957022**	**20**
19	12929456	3777878	**16707334**	**17**
19.5	4763088	1511299	**6274387**	**6**
20	4083184	0	**4083184**	**4**
20.5	1360748	0	**1360748**	**1**
Total n	**93908532**	**37023503**	**130932035**	**131**
Millions	**94**	**37**	**131**	

ECOCÁDIZ-COSTA 0709 **. *S. pilchardus* . BIOMASS (t)**			
Size (cm)	**POL01**	**POL02**	**Total**
15	0	0	**0**
15.5	0	0	**0**
16	26.154	43.534	**69.688**
16.5	142.928	47.608	**190.536**
17	748.303	259.647	**1007.950**
17.5	678.482	489.668	**1168.150**
18	1215.134	449.733	**1664.867**
18.5	837.465	332.099	**1169.564**
19	818.924	239.283	**1058.207**
19.5	325.404	103.249	**428.653**
20	300.318	0	**300.318**
20.5	107.554	0	**107.554**
Total	**5200.666**	**1964.821**	**7165.487**

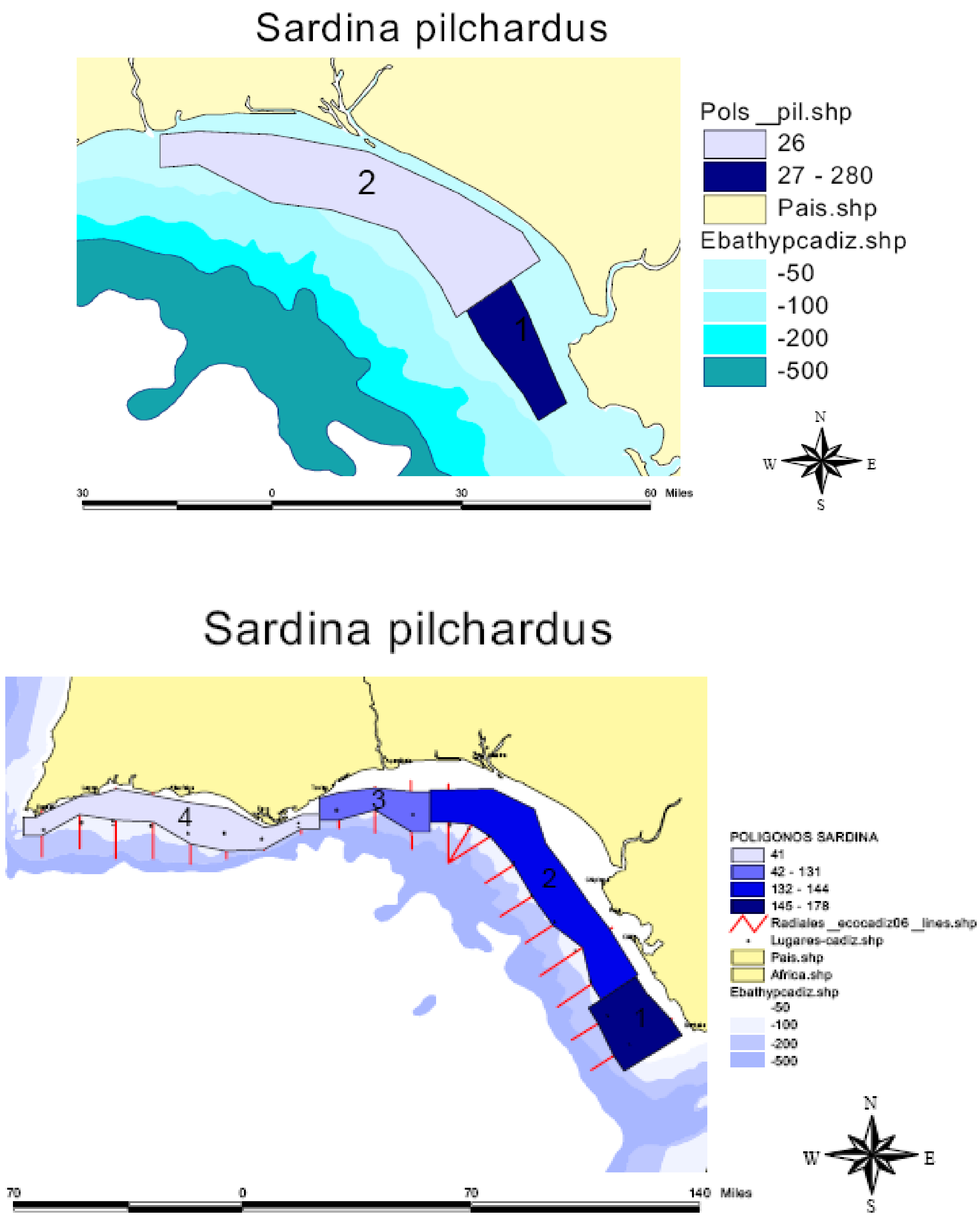


Figure 6.3.2.2.1. ECOCÁDIZ-COSTA 0709 survey. Sardine (*Sardina pilchardus*). Distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each post-stratum. Top: present survey. Bottom: ECOCÁDIZ 0609 conventional survey. Note that colour scales used in both surveys are not completely equivalent.

ECOCÁDIZ-COSTA 0709: **Sardine** *(S. pilchardus)*

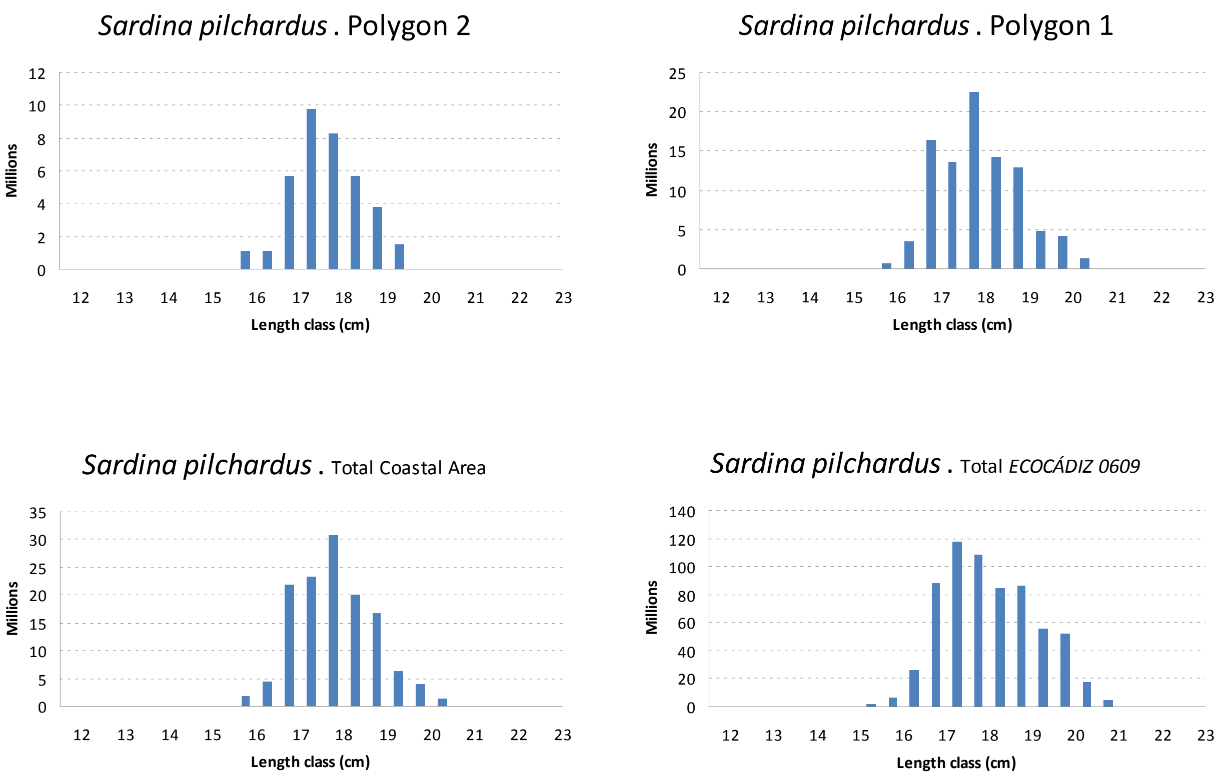


Figure 6.3.2.2.2. ECOCÁDIZ-COSTA 0709 survey. Sardine (*Sardina pilchardus*). Estimated abundances by length class by homogeneous stratum (ordered from west to east, numeration as in Figure 6.3.2.2.1) and total area. The size composition estimated for the population in the ECOCÁDIZ 0609 conventional survey is also shown for comparative purposes. Note the different scales in the y-axis.

6.3.3 Stock estimates

6.3.3.1 Anchovy

Four sectors have been differentiated according to the SA values distribution and the size composition in the fishing stations. The acoustic estimates by homogeneous stratum and total area are shown in Tables 6.3.2.1.1 and 6.3.2.1.2 and Figures 6.3.2.1.2 and 6.3.2.1.3. A total of 3571 t and 246 millions of fish have been estimated for this species for the whole surveyed area.

6.3.3.2 Sardine

Two size-based homogeneous sectors were delimited for the acoustic assessment. The acoustic estimates by homogeneous stratum and total area are shown in Table 6.3.2.2.1 and Figure 6.3.2.2.1. Sardine was the most important species in terms of biomass and the second one in abundance: 7165 t and 131 millions of fish have been estimated for this species for the whole surveyed area.

6.3.4 Conclusion

Table 6.3.4.1 shows tentative merged estimates for those coinciding species in both the standard and coastal surveys (data in red bold italics). For the comments above about the unsuitability of the acoustic equipment used in the coastal survey ECOCÁDIZ-COSTA 0709, the resulting estimates from this survey should be considered for the time being as orientative ones. The Portuguese estimates from its PELAGO 09 survey have also been included in that table for comparison for the same species. By summing up the new coastal estimates to those ones from the conventional survey still yield differences with those estimates from the Portuguese survey, conducted about 2 months before. For the purposes of comparing trends and for the abovementioned reasons we still prefer to maintain the estimates obtained from the standard survey (in bolded black). Nevertheless, our results demonstrate that coastal shallow waters not covered by conventional surveys may hold a relatively important biomass. The continuity of sampling the coastal waters either by a complementary survey like this one or by a vessel capable of sampling the whole study area, including these shallow waters, is not guaranteed for next years.

Table 6.3.4.1. ECOCÁDIZ-COSTA 0709 survey. Species-specific acoustic estimates from both coastal and conventional Summer Spanish acoustic surveys and from the Spring Portuguese PELAGO 09 acoustic survey, conducted 3 months before. A tentative merged estimate (in red) is also given for the Spanish surveys.

Species/Survey	Sardine	Anchovy	Chub mack.	Medit Horse-mack	Bogue
ECOCÁDIZ-COSTA 0709 **Biomass (t)**	7165	3571	1830	2892	1970
ECOCÁDIZ 0609 **Biomass (t)**	**37020**	**21580**	**56276**	**2705**	**3412**
ECOCÁDIZ 2009 **Biomass (t)**	*44185*	*25151*	*58106*	*5597*	*5382*
PELAGO 09 **Biomass (t)**	97700	24800	82000	-	-
ECOCÁDIZ-COSTA 0709 **Abundance (million fish)**	131	246	19	23	24
ECOCÁDIZ 0609 **Abundance (million fish)**	**649**	**1137**	**629**	**28**	**42**
ECOCÁDIZ 2009 **Abundance (million fish)**	*780*	*1383*	*648*	*51*	*66*
PELAGO 09 **Abundance (million fish)**	1845	2069	628	-	-

7 Method improvements of Acoustic and DEPM surveys

7.1 Progress in DEPM-based estimates

7.1.1 Mortality of anchovy eggs

Last year, an analysis was presented showing that the egg mortality (Z) could not be distinguished statistically between years and strata. However further ANOVA analysis reported this year, indicates that the complex models with Z being estimated by survey and strata fit better the whole series of the DEPM egg data since 1990. Temperature has not produced any significant result with biological sense, suggesting increase in Z (in absolute terms) as temperature increases. Therefore, the data are better explained under the null hypothesis of Z being different among spatial strata and years, and therefore it is retained, despite the methods used to estimate it have not statistical power for their individual discrimination. Further studies Bayesian methods assuming a prior restricted distribution of z could be suitable for this type of noisy data.

However New P0 estimates are due according to the new definitions of valid range of cohort-ages per strata to make the estimations of Z and P0. As described last year, the upper limit has to be set at the age for which 99% of the eggs have not yet passed to larvae, this being defined for the incubation temperature corresponding to 95% percentile of incubation temperatures of the eggs in the strata (or survey if no strata is defined within it). The lower limit has been always set at 4 hours, to assure sufficient dispersion of eggs and full recruitment of them to the plankton and to the Pairovet net (no need for its modification is considered so far).

7.1.2 Training and cross checking of sardine histological analysis of POFs.

Between the 18–22 October, a joint training of histological analysis of sardine ovary slides took place in the AZTI infrastructures in Pasaia (San Sebastian) with participants from AZTI and IPIMAR. This exercise was an internal recommendation from the WG last year's meeting, within the frame of the application of the DEPM to Iberian sardine and anticipating the triennial DEPM joint survey in 2011.

This exercise focused mainly on the identification and staging of oocytes, post-ovulatory follicles (POF) and atresia, key histological structures for the estimation of the adult parameters (mature fraction of the female population, batch fecundity and spawning fraction).

The training was carried out informally: the participants observed and analysed together sardine ovary histological slides from samples collected during the AZTI 2008 DEPM survey with the aim of covering all oocytes, POF and atresia stages, and simultaneously the main problems were identified and doubts clarified. Each participant also analysed independently 15 histological slides selected at random, the results were compared and overall the agreement between the participants was good. At the end, pictures were taken from all POF and oocyte stages observed in the collection of slides to produce an identification key for resin embedded sardine ovary samples.

Several aspects related to the methodology used by each institute (collection of the samples, histological processing) as well as diverse issues concerning the estimation of the spawning fraction in sardine were also discussed during this week.

As the colleagues from IEO could unfortunately not be able to participate (physically) to this training, a session was created on the "Dropbox" server (www.dropbox.com), where all relevant documents were placed and will remain available online.

From this training, the following topics were agreed as future actions:

- The colleagues from IEO are invited to place in the "Dropbox" document(s) with the criteria currently used for the classification of the histological structures considered (oocytes, POFs, atresia) and the methodology applied to the estimation of the DEPM adult parameters, for comparison between the institutions.
- Some aspects related to the histological analysis and parameters estimation will likely need to be standardized between the institutions, either during the WGACEGGS meeting in 2011 or informally at distance.
- After the 2011 triennial joint survey and during the analysis of the histological samples, an exchange of photos between the institutions and cross-checking of the classification of the histological structures can take place whenever the participants feel necessary, using the "Dropbox" server as an exchange platform.

7.2 Progress in acoustic based estimates

7.2.1 Intercallibration of Spanish and Portuguese Spring acoustic surveys in 2008 and 2009

The intercalibration between "Noruega" and "Thalassa" research vessels performed in 2008 and 2009 give contradictory signals. In 2008 the values obtain for the "Thalassa" bottom and plankton integration was greater than for "Noruega". On the contrary, during the 2009, the bottom integration values are similar between the two ships (Figure 7.2.1.1), but "Noruega" integrates more fish than "Thalassa" (Figure 7.2.1.2).

It was considered that it is necessary a more complete intercalibration exercise, over several types of fish and plankton distributions, during day and night-time. For that reason, a ToR is included in order to perform another intercalibration exercise during the spring 2011 acoustic surveys.

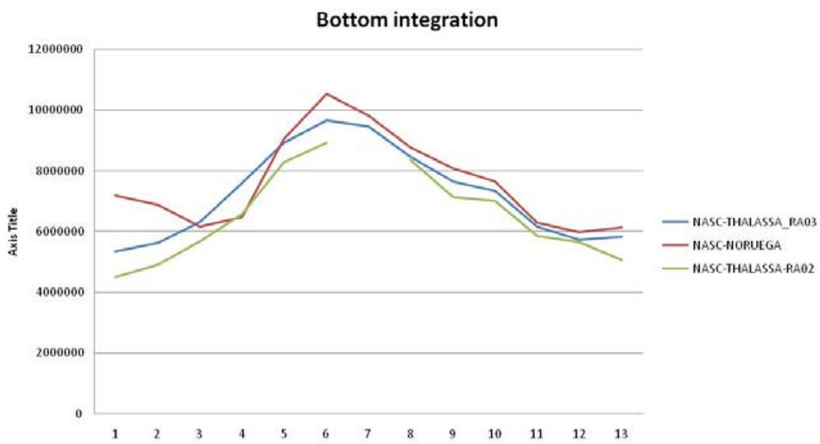


Figure 7.2.1.1. Bottom integration comparison during the intercalibration exercise in 2009.

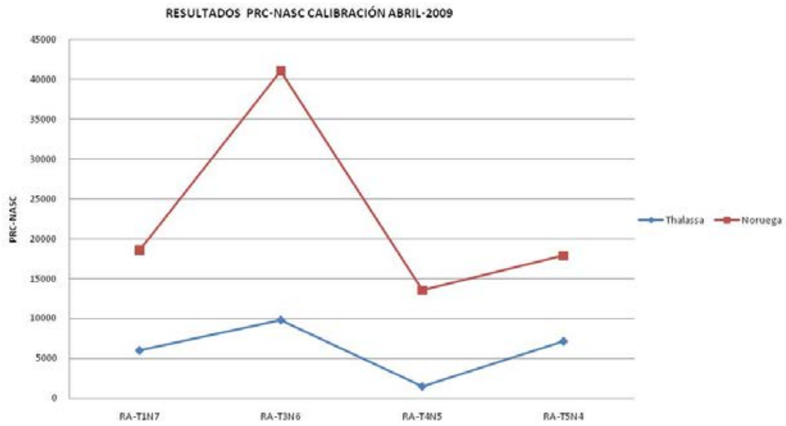


Figure 7.2.1.2. Fish acoustic energy comparison of the accumulated NASC along the 4 radials, during the 2009 intercalibration exercise.

7.2.2 Inner calibration of Portuguese acoustic survey by Echo-integration of the bottom on selected parts of transects along the whole time-series.

An acoustic bottom integration was performed using the data of four recent surveys, along a transect with a stable median grain size sand, and the results are compared (**Figure 7.2.2.1**).

During the sardine echosurveys transects an area with an uniform sand bottom near Arrifana, between 37º 12′ and 37º 15′ parallels is systematically covered. We believe that this bottom sediment is stable because it is not in a river plume. The variability of the bottom integration (**Table 7.2.2.2 and Figure 7.2.2.2)** may reflect the weather conditions during each survey passage.

Table 7.2.2.1. Bottom NASC integrated along five miles in four surveys.

Mile number	PEL09	OUT-08	PEL08	PEL07
1	3123827	3052872	2911764	3425108
2	4189306	4026418	3349291	3321198
3	3759419	2920675	3123710	3089341
4	3188569	3256439	2993705	3005969
5	3324522	3354543	3382377	3175193
average	**3322189**	**3152169**	**3203362**	**3517129**

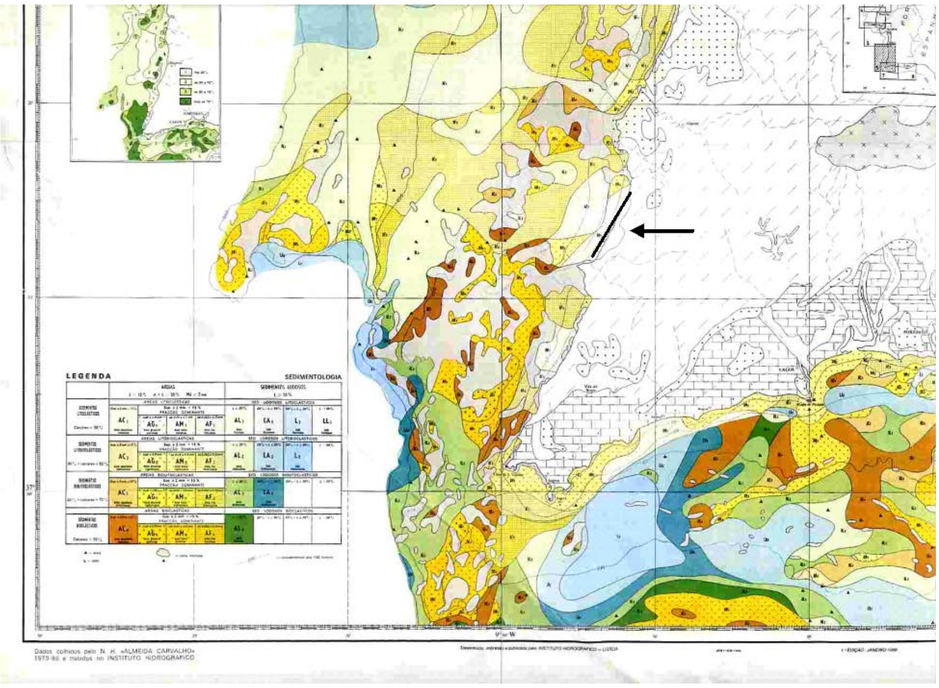


Figure 7.2.2.1. Location of the transect where the bottom integration took place.

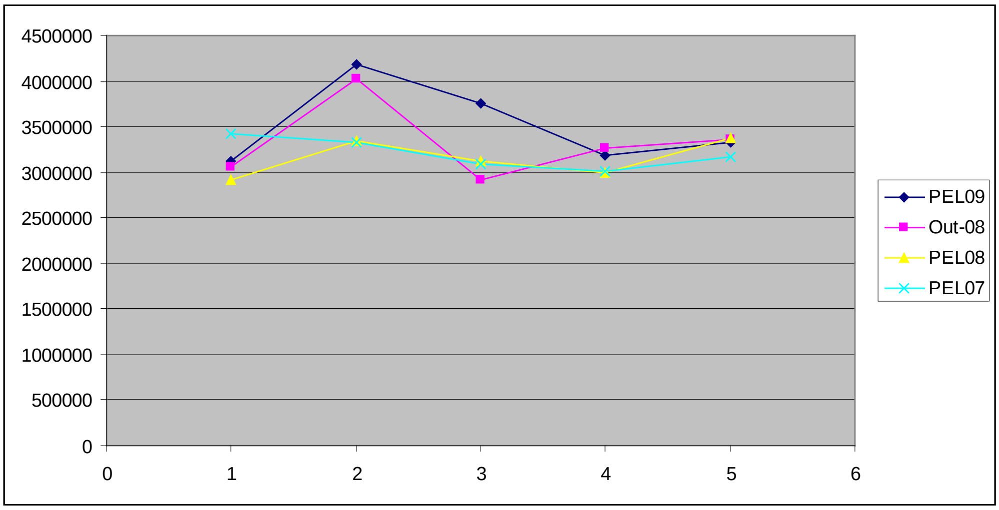


Figure 7.2.2.2. Five miles NASC comparisons of the same transect, covered by four acoustic surveys.

7.2.3 Calibration exercise of vessels in JUVENA2010 surveys and preliminary results of calibration of performance acoustic acquisition

Echosounders calibration

Echosounders calibration was performed at the beginning of the sampling time for both vessels at the Cantabrian coast, profiting of the good weather conditions (absence of swell, wind and currents). The sphere method was followed (Foote *et al.*, 1987).

Ships Intercalibration

The inter-ship calibration between EB and IL was performed along a 30 nautical miles transect. The intercalibration analysis of the data registered by EB and IL have shown a slight negative bias of the EB collected data (about 5%) in the particular weather conditions existing the day of the exercise. Therefore, the acoustic data recorded by the EB is expected to require a correction factor of about 1.05. However, as the correction factor is likely to depend on the weather conditions, the application will be delayed until the analysis of the dependence of the correction factors on the windspeed is completed.

7.2.4 In-depth characterization of Biscay surface pelagic fish communities with ME70 multibeam echosounder

7.2.4.1 Introduction

Small pelagic fish adjust their spatial occupation strategy, and namely their shoaling behaviour, according to intrinsic (species-specific) and extrinsic environmental conditions and/or fishing pressure. Fisheries echosounders are one of the main observation tools of pelagic fish communities, as they provide quantitative acoustic descriptors of pelagic fish shoals that can then used as proxys to infer the specific composition of acoustic schools and/or characterize pelagic habitats. However, echosounders sampling volume is restricted, especially close to the sea surface, due to: i) surface blind-zone, and ii) narrow and conical vertical acoustic beam. Abundance and spatial distribution of near-surface pelagic fish communities are then generally poorly assessed by classical monobeam echosounders.

The ME70 multibeam echosounder is a new acoustic device providing data of unique range and resolution for the description of the three-dimensional (3D: vertical x athwart x alongship) morphology of small pelagics shoals (Figure 1). ME70 multiple beams namely provide a 12-fold greater sampling volume than monobeam echosounders. This feature is particularly prominent near the sea surface, where classical acoustic beams are very narrow. We here assess the improvement conferred by the use of ME70 3D acoustic data instead of classical two-dimensional (2D: vertical x alongship) acoustic backscatters, in terms of abundance estimation and morphological description of surface fish shoals.

Numerous peculiar pelagic fish shoals have been detected in the Bay of Biscay during the PELGAS spring acoustic cruise in May-June 2009. The shoals have been observed at day, close to the sea surface (6–30 m depth), both with monobeam (Simrad ER60) and multibeam (Simrad ME70) echosounders operated on-board RV "Thalassa". A total of 3 identification trawl hauls revealed they were likely comprised of 47% 20 cm sardine and 47% 17 cm, big, anchovies. The large anchovies detected close to the sea surface were termed "freed anchovy" by contrast to smaller, "shy", observed at the same time close to the seabed (Figure 7.2.4.1).

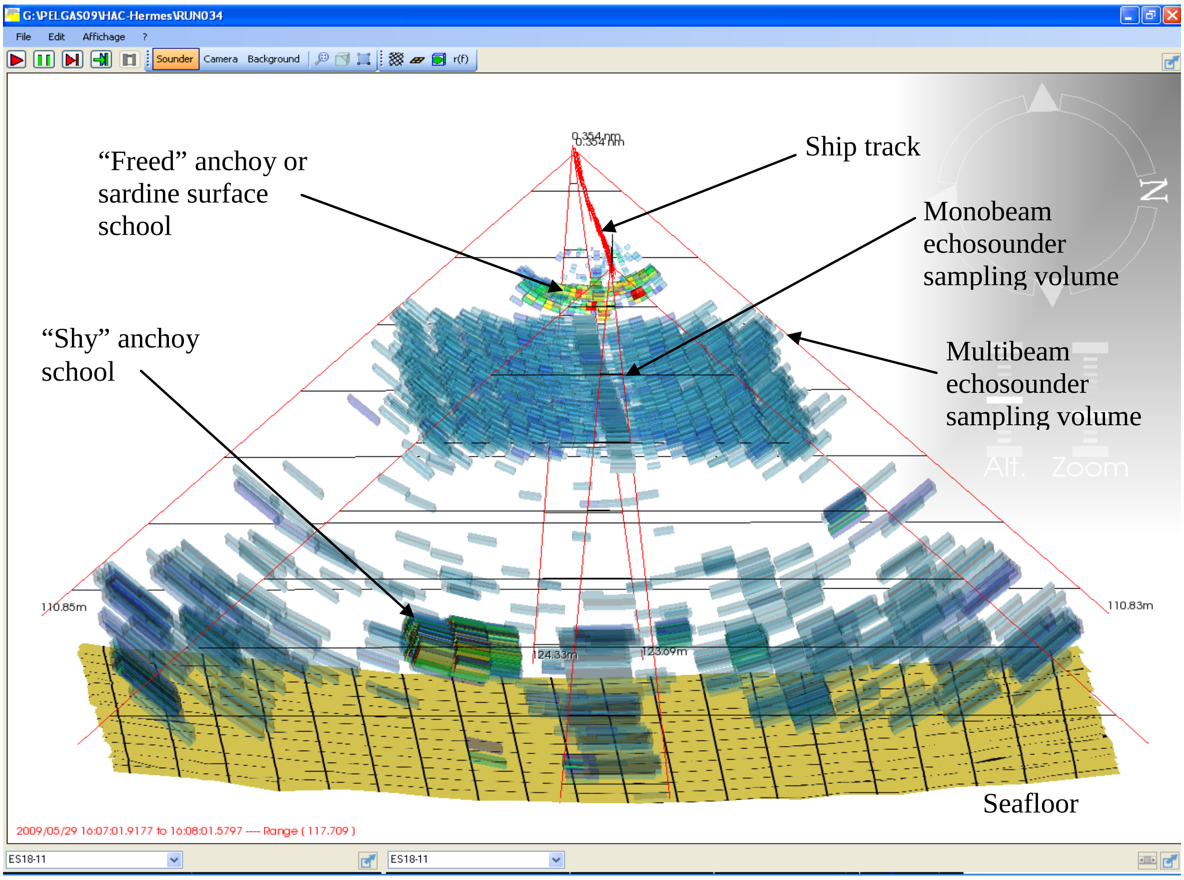


Figure 7.2.4.1. 3D acoustic image of mixed "freed" anchovy-sardine surface shoals and deeper "shy" anchoy shoals in the Bay of Biscay (-60 dB display threshold).

Both 2D and 3D acoustic data provided by mono and multibeam systems were processed to answer 2 questions about surface shoals: i) How many shoals have been detected with mono vs. multibeams echosounders?, and ii) What do we learn from 3D schools descriptors compared to 2D ones?

7.2.4.2 Material and methods

Data. To ease the fish acoustic shoal extraction process, a dataset collected during daytime on 2009/05/29 was selected, in an area where strong sound-scattering layers were absent. We implemented a loosely supervised data processing within the Matlab software, interfaced with Movies3D libraries. Interfacing the two software allowed for completing a string of data analysis in a single environment, from raw acoustic (.hac) files batch processing to statistical analysis.

Acoustic shoal extraction. An image analysis methodology ('shoal extraction by spatial contiguity') was applied using several minimum echo-integration thresholds to 2D and 3D acoustic data simultaneously collected above 30 m depth. A sensitivity analysis was performed on the resulting shoal descriptors to define an optimum threshold: -60 dB, for extracting fish shoal from plankton sound-scattering layers (Figure 7.2.4.2).

Statistics. Shoal counts based on 2D and 3D data were compared. 2D and 3D shoals were further classified by applying a Principal Component Analysis (PCA) on shoals positional, morphological and energetical descriptors, followed by a Hierarchical Clustering on PCA scores.

7.2.4.3 Results

A total of 246 and 39 acoustic shoals were extracted from 3D and 2D acoustic data, respectively. Overall, 6 times more surface shoals were detected with the multibeam echosounder compared to the monobeam system.

The PCA and clustering analysis revealed 2 distinct groups of shoals: the first one comprised of relatively small, numerous shoals and the second comprised of fewer, larger shoals (Figure 7.2.4.3).

The classification procedure led to the definition of clusters of shoals with similar attributes, based on 2D or 3D data. However, the smaller number of shoals detected by the monobeam system prevented from drawing any firm conclusions on shoal classification, as the second cluster identified with 2D data were comprised of only 2 shoals. Moreover, the width and volume attributes were almost constant in the case of 2D shoals, in fact equal to the acoustic beam width and volume at-depth, and were considered non-relevant. Distributions of cluster 1 shoal descriptors relevant in 2D and 3D were comparable (Figure 7.2.4.4).

The 3D descriptor that differed most between clusters 1 and 2 was the shoal volume (Figure 7.2.4.5).

This descriptor synthetizes the complex 3D shoal shape into a single numerical value. This exemplifies the potential extra-discriminative power of 3D shoal descriptors, compared to 2D ones.

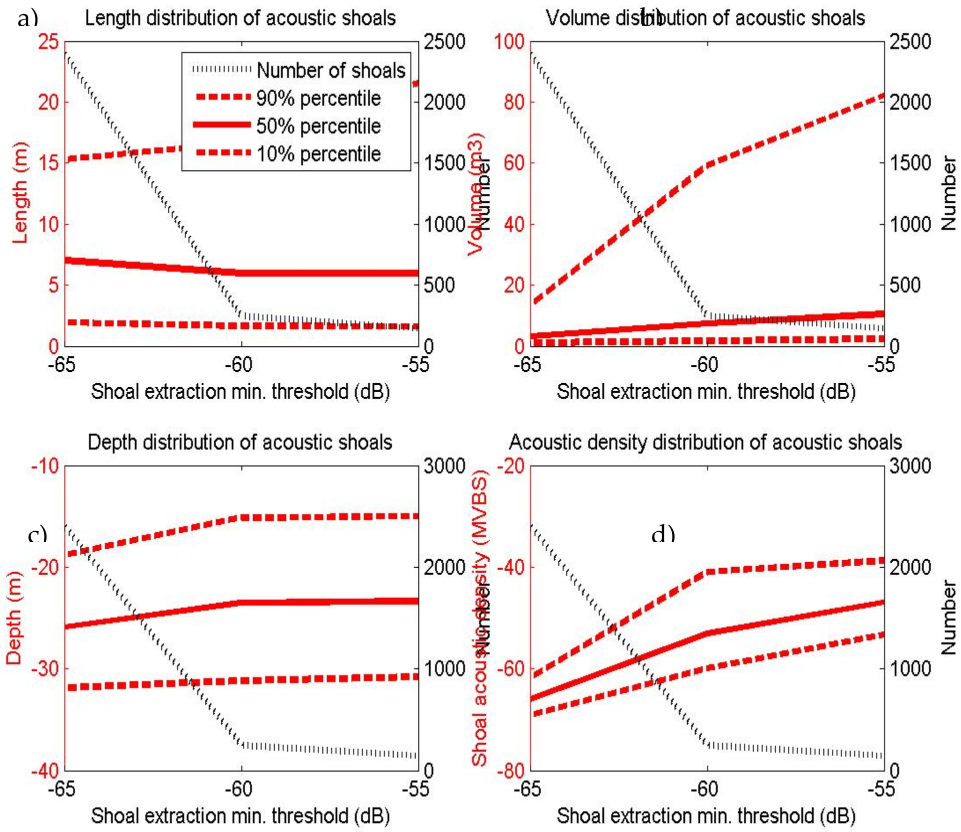


Figure 7.2.4.2. Sensitivity analysis of 4 acoustic shoals descriptors extracted at 3 minimum echo-integration thresholds. Red curves: 10, 50 and 90% percentiles of acoustic shoals descriptors distributions: a) shoal length ; b) shoal volume ; c) shoal depth ; d) shoal density. Black curve: total number of shoals extracted.

A)	B)

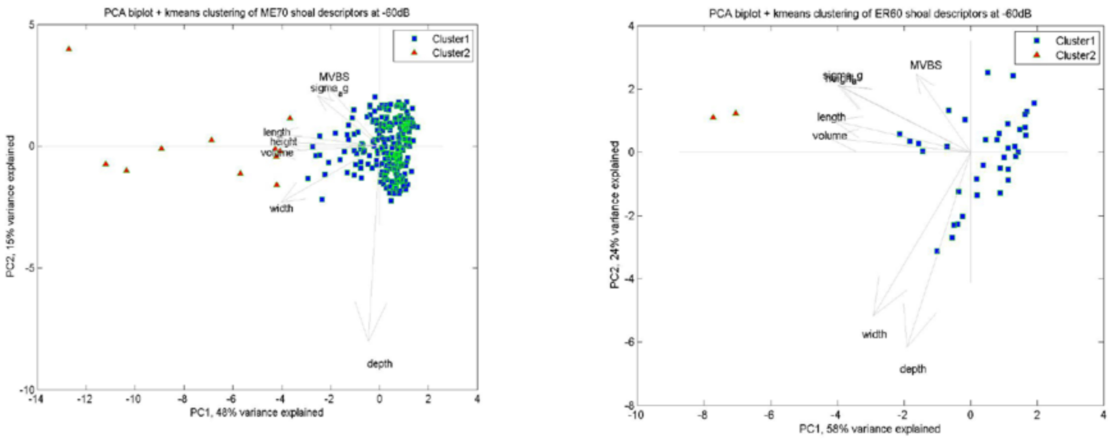


Figure 7.2.4.3. First factorial planes from Principal Component Analysis performed on 3D (a) and 2D (b) acoustic shoal descriptors, with clustering results. Blue squares: shoals classified in Cluster 1; red triangles: shoals classified in Cluster 2.

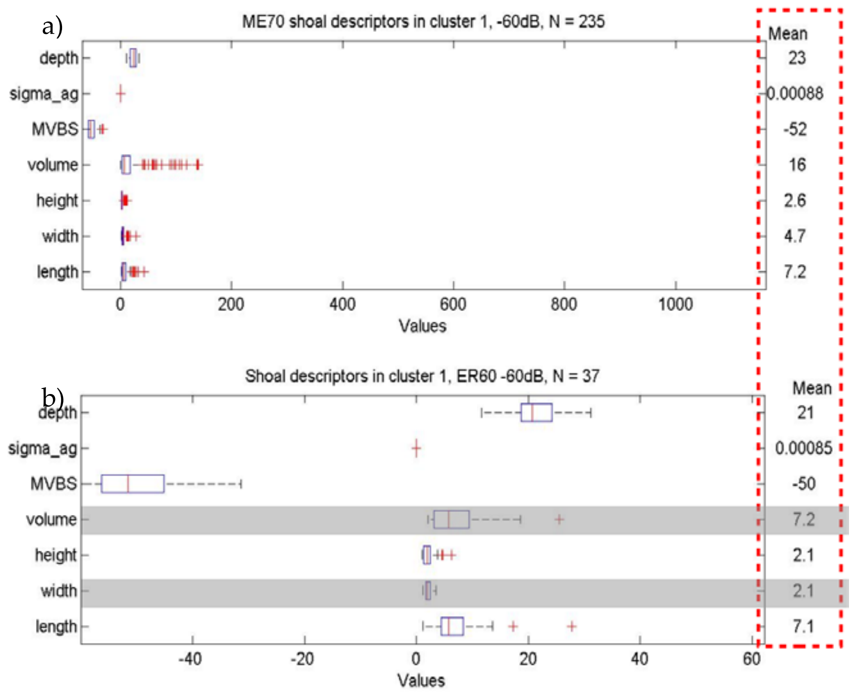


Figure 7.2.4.4. Distributions of acoustic descriptors of 3D (a) and 2D (b) shoals classified in cluster 1, with mean values in the right hand column. Distributions of non-relevant 2D descriptors shaded.

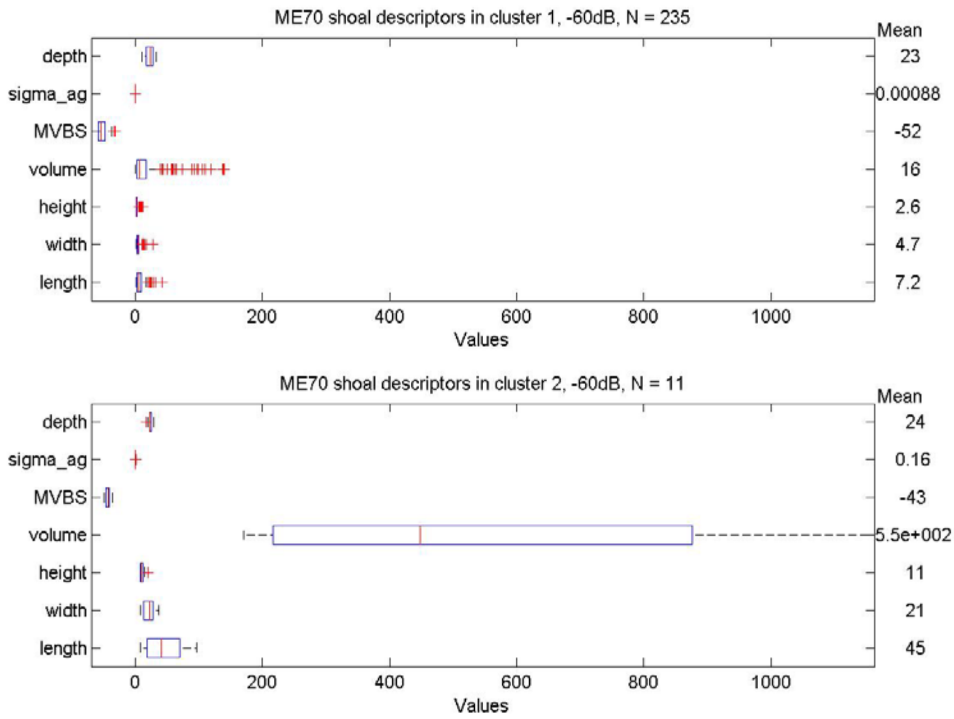


Figure 7.2.4.5. Distributions of 3D acoustic descriptors of cluster 1 (a) and cluster 2 (b), with mean values in the right hand column.

7.2.4.4 Discussion and Conclusions

Abundance and acoustic descriptors of shoals extracted using an optimized threshold were compared for 2D and 3D acoustic data, to quantify the improvement in terms of precision of surface fish stock assessment and shoal classification conferred by the use of ME70 data.

Sampling a 12-fold larger volume, the multibeam echosounder not surprisingly allowed for the detection of more shoals (6 times) than classical monobeam systems. One could argue that the ratios of multibeam/monobeam sampling volumes and number of shoals detected should be similar. This would happen if sampling scales were identical in all directions (isotropic sampling), e.g. as in the case of quadrat sampling. Acoustic sampling is by essence anisotropic, the alongship direction being sampled at larger spatial scales (e.g. the transect length), than the athwartship dimension, which is solely sampled up to the beam, or to the of beam fan, width.

We hypothetise that the mean inter-school distance was in our case still larger than the multibeam fan width, leading to a non proportional increase of the number of schools detected, relatively to the increase of the sampling volume.

Detecting more surface schools with the multibeam system is per se interesting to: i) improve the precision of acoustic fish biomass estimates and shoal classification; ii) provide useful guidance for triggering identification fishing i.e. better answering the question of when to fish the surface layer to identify acoustic marks.

Regarding 3D acoustic shoals classification, the shoal volume was the more discriminant 3D descriptor. Using these new descriptors should ultimately lead to a better knowledge of the surface fish community, including freed anchovies behaviour.

7.2.5 TS-length relationships for European clupeids: recent progress and future work (a joint session with AcousMed)

7.2.5.1 Introduction

Knowledge of the acoustic response of single fish (or Target Strength: TS) is of prime importance for acoustic target classification and abundance estimation. TS-length equations have been established since decades for numerous species and size range using several experimental and/or modelling techniques. They are usually expressed as: TS = a·log10(L) + b, where L is the fish length in cm. The ***a*** coefficient is commonly set to 20, leading to the alternative equation: TS = 20·log10(L) + ***b20*** (L in cm).

A WGACEGG/AcousMed joint session on TS equations estimation for anchovy and sardine was held in Palma de Mallorca on 22 October, 2010. Oral presentations included: i) a literature review of TS~length equations by Mathieu Doray (Ifremer), ii) results of in-situ TS analysis conducted in Spanish Mediterranean waters (Magdalena Iglesias, IEO) and in the Aegean Sea (Maria Myrto Pyrounaki, HCMR), and iii) results of ex-situ experiments conducted in the Sicily Channel (Walter Basilone, CNR-IAMC). Biomass estimates based on several TS equations in use in the Mediterranean were also presented by each partner. The session main outcomes are summarized below.

7.2.5.2 Literature review of TS~length equations (Mathieu Doray, Ifremer)

An exhaustive set of published TS-length equations was collected and gathered into a database called 'TSbase' (examples of database entries can be found in Table 1). The objective is to investigate two questions: i) can we find global statistical patterns in TS-length equation coefficients?, and ii) would this global pattern provide useful guidance when assessing and choosing TS-length coefficients for European small pelagic fish stock acoustic assessment?

Material and methods

In this study, a TS~length equation is characterized by: i) ***a***, ***b*** coefficients; ii) a fish length range over which the equation is defined (here fish length is thought to be proportional to fish TS, or swimbladder volume), and iii) the acoustic frequency used for TS measurements.

We collected a total of 129 TS-length equations from the literature (Figure 7.2.5.1), established for 51 species, using 7 acoustic frequencies (including 90 equations established at the 38 kHz frequency and 25 at the 120 kHz one). The ***a*** coefficient was set to 20 in 83 equations. TS equations were established for 2 fish with oil-filled swimbladder, 23 fish without swimbladder, 44 physostomous fish and 59 physoclistous fish.

A Principal Component Analysis (PCA), followed by a K-mean clustering (KMC) on PCA scores was performed on the equation descriptors (***a***, ***b***, length range, frequency), to classify the equations and to study the correlations between descriptors. The optimal number of clusters was determined by minimizing the simple structure index "ssi" (Dolnicar *et al.*, 1999).

Clusters of equations that differed too much from the average equation were filtered out.

We then selected the equations with a set to 20, to further classify comparable equations, the same procedure was applied to this set of equations. Metadata (location, method, diel period, swimbladder type, belongings to taxonomic groups...) were projected as illustrative variables on the first PCA plane, to study their correlations with the descriptors.

A Redundancy Analysis (RDA) was performed to test for the significance of the relationships between equations descriptors and metadata.

In the same way, PCA and KMC were applied to classify the clupeid equations and identify eventual outliers.

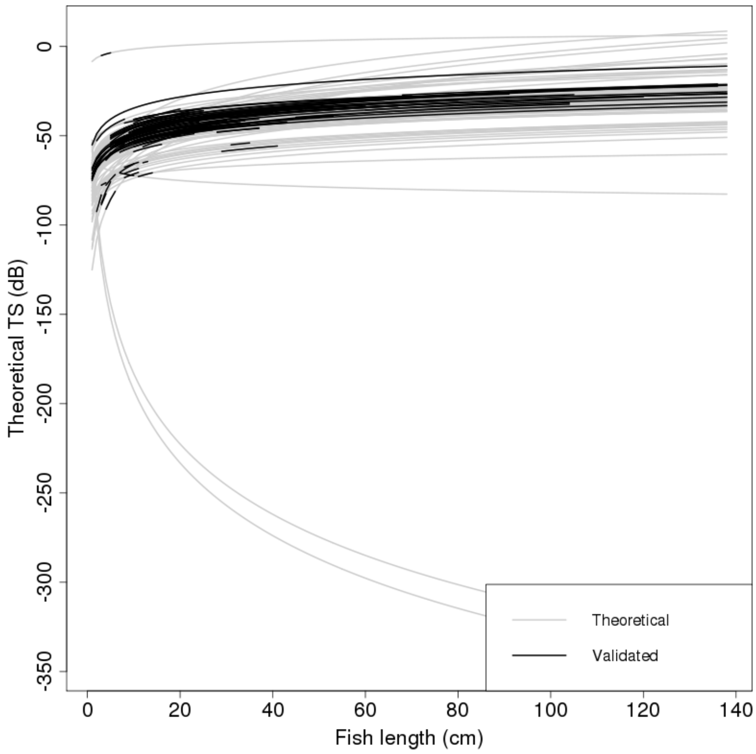


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Figure 7.2.5.1. TS~length equations. Black line: TS~length curve for the studied fish length range; grey lines: TS~length curve outside the studied fish length range.

Results

Positions of individual TS~length equations and correlations between descriptors in the plane formed by the first two eigenvectors of the Principal Component Analysis (PCA) performed on all equations is showed in Figure 7.2.5.2. Length range and mean length descriptors show high positive correlation and contribute to the first eigenvector. They are uncorrelated with the ***a*** and ***b*** coefficients, and to a lesser extent to the acoustic frequency, which essentially contribute to the second eigenvector. The ***a*** and ***b*** coefficients are positively correlated and show negative correlation with the acoustic frequency (Figure 7.2.5.2).

The KCM performed on PCA scores identified 8 groups of equations with similar descriptors in the first PCA plane (Figure 7.2.5.2). One cluster, comprised of myctophids and eel, was clearly separated from the other equations. It was filtered out to restrict the analysis to comparable equations.

Figure 7.2.5.3 shows the results of the same procedure applied on TS equations where the ***a*** coefficient was set to 20. The optimal number of clusters was 11. The correlation structure of equation descriptors in the PCA score plane is similar to these observed for all equations. Large physoclistous fish (essentially cod) equations with low ***b*** coefficient occupy the left hand side of the PCA plane. A medium cod equation with very low coefficient is separated from others. Small (physostomous) fish occupy the right hand side of the PCA plane. Small fish studied with higher frequencies are segregated in the right-bottom corner.

The only significant metadata explaining 31% of TS equations variability in the RDA analysis was their belongings to large taxonomic groups.

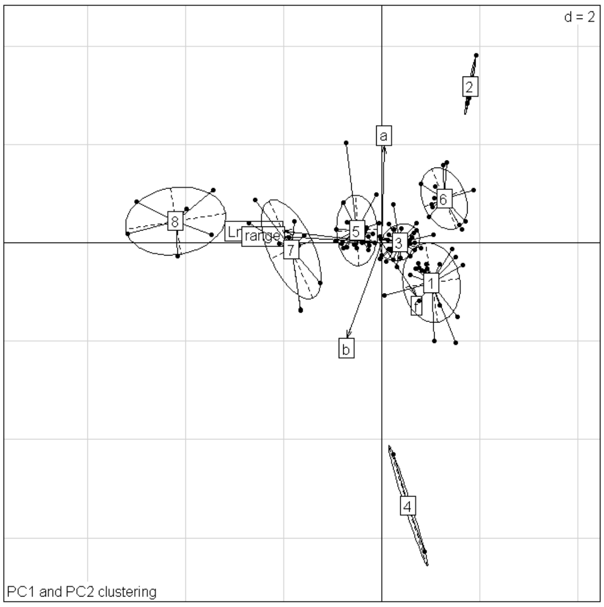

Figure 7.2.5.2. TS~length equations (dots) and their descriptors (arrows) in the Principal Component Analysis (PCA) first eigenvectors plane. Ellipses indicate belongings to equation clusters defined by K-mean clustering on the first two PCA scores.

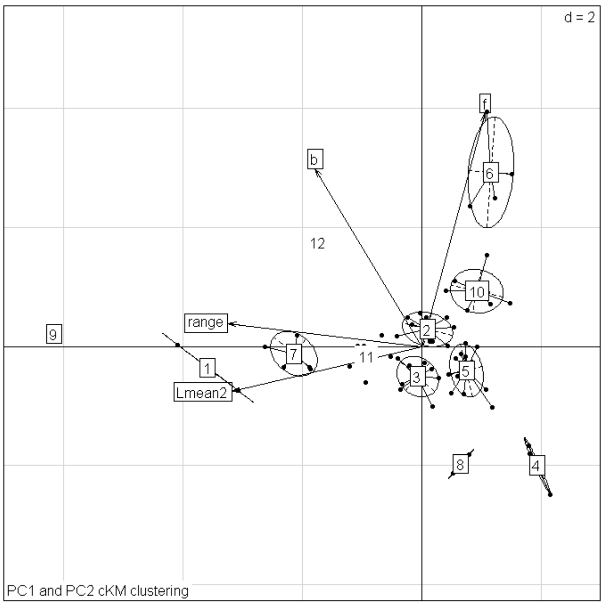

Figure 7.2.5.3. TS~length equations with a set to 20 (dots) and their descriptors (arrows) in the Principal Component Analysis (PCA) first eigenvectors plane. Ellipses indicate belongings to equation clusters defined by K-mean clustering on the first two PCA scores.

Discussion and Conclusions

The TS~length equations database, TSbase, and the associated exploratory analysis procedures proposed here provide an overview of TS variability, on the basis of peer reviewed results established over 30 years. Assuming that some general law may govern the relationship between fish TS and length, these tools can be used to identify equations that strongly differ from the bulk of TS~length relationships, and provide rationale for TS~length equation selection. In this respect, TSbase is a valuable tool to discuss the selection of a TS~length equation, into the context of TS equations in use elsewhere for identical l or related species and size classes. It might then provide some useful guidance to fisheries acousticians facing the dilemma of TS~length equation selection.

However, even if large patterns appear (effect of frequency...), the variability of TS parameters found in TSbase remains high, and largely unexplained from a quantitative point of view. The only available metadata explaining a significant part of the TS equations variability, the belonging to large taxonomic groups, is in fact not really informative. Our unability to find significant differences between clusters of equations derived from PCA results probably comes from the fact that the number of observations are very different from one metadata factor level to another (lots of species have been studied in lots of different locations, with different methods). The unbalanced dataset can not be adequately partitioned by analysis of variance techniques. Exploratory techniques like PCA however provide some qualitative insight into TS variability.

Last but not least, adding new equations and metadata into the database (fish sample size, goodness-of-fit, depth range, season...) could help partitioning the TS equations variance and then improve our ability to select appropriate TS~length equation. It is then suggested to provide a public access to the database to help enriching its content (see recommendation section).

7.2.5.3 TS~length equations for clupeids, with special emphasis on anchovy and sardine

TS~length equations for clupeids

Coefficients and metadata of TS~length equations of clupeid species collected in TSbase are presented in Table 7.2.5.1. TS~length equations established for clupeid fish are shown in Figure 7.2.5.4.

These equations are relatively concentrated close to the origin of the PCA plane defined with the equations whose a coefficient is set to 20 (Figure 7.2.5.5), except for a Japanese anchovy studied at the 200 kHz frequency, that is clearly segregated. Distributions of ***b20*** coefficients per species are shown in Figure 7.2.5.6.

In the case of anchovy, TS~length equations were established for different species in South Africa (*Engraulis capensis*: in situ direct TS measurements by Barange *et al.*, 1996), Peru (*Engraulis rigens*: cage experiments by Guttierez and MacLennan, 1998) and Asia (*Engraulis japonicus*: cage experiments by Kang *et al.*, 2009; in situ direct TS measurements by Zhao *et al.*, 2008 and Sawada *et al.*, 2009). TS~length equations commonly used for the acoustic assessment of European anchovy, Engraulis encrasicolus, stocks include a generic equations for physostomous fish derived using all methods (Foote, 1987) and an equation for clupeids, based on in situ direct TS measurements of a mixture of herring and sprat (ICES, 1982). Generic equations in use for E. encrasicolus provide intermediate values, between higher-TS equations obtained for E. Japonicus (Kang *et al.*, 2009; Sawada *et al.*, 2009; Zhao *et al.*, 2008) and lower-TS equations reported for *E. capensis* (Barange *et al*., 1996) and *E. rigens* (Guttierez and MacLennan, 1998; Figure 7.2.5.7).

In the case of sardine, TS~length equations were solely established for *Sardinops ocellatus*, based on in situ direct TS measurements conducted in South Africa (Barange *et al*., 1996), and for *Sardinops sagax*, based in situ direct TS measurements in Peru (IMARPE unpublished data). TS~length equations commonly used for the acoustic assessment of the European sardine, *Sardina pilchardus*, are the same as those used for European anchovy (Figure 7.2.5.7). TS equations established for southern hemisphere sardine species provide lower TS values than generic ones (Figure 7.2.5.8).

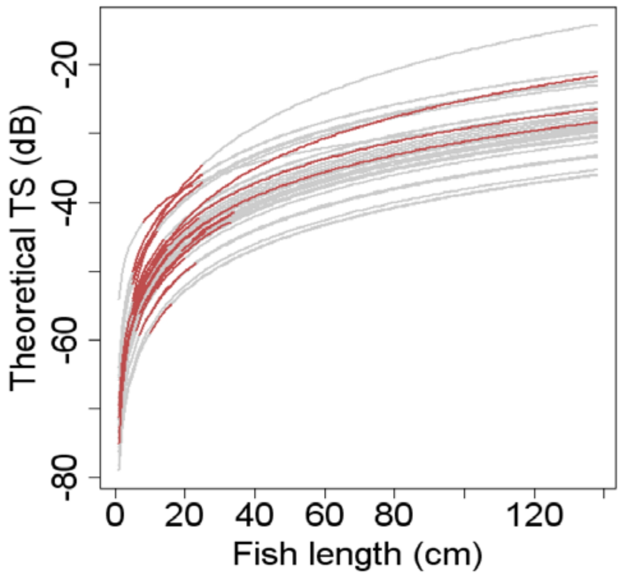

Figure 7.2.5.4. TS~length equations for clupeid fish. Red line: TS~length curve for the studied fish length range; grey lines: TS~length curve outside the studied fish length range.

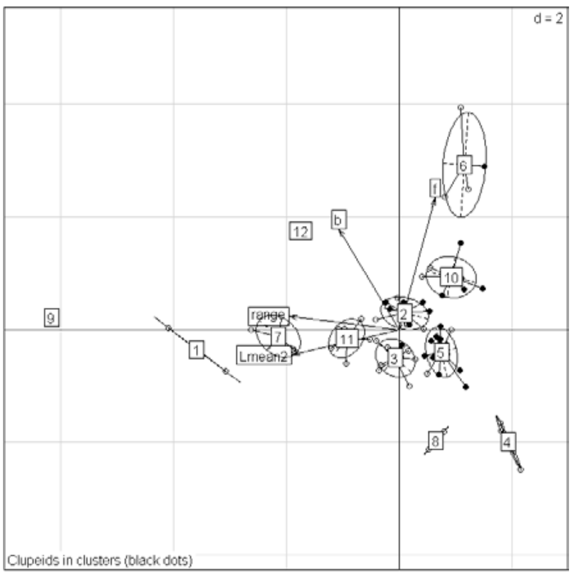

Figure 7.2.5.5. Clupeid fish equations (black dots) in the Principal Component Analysis (PCA) first eigenvectors plane defined for TS~length equations with a set to 20 (dots).

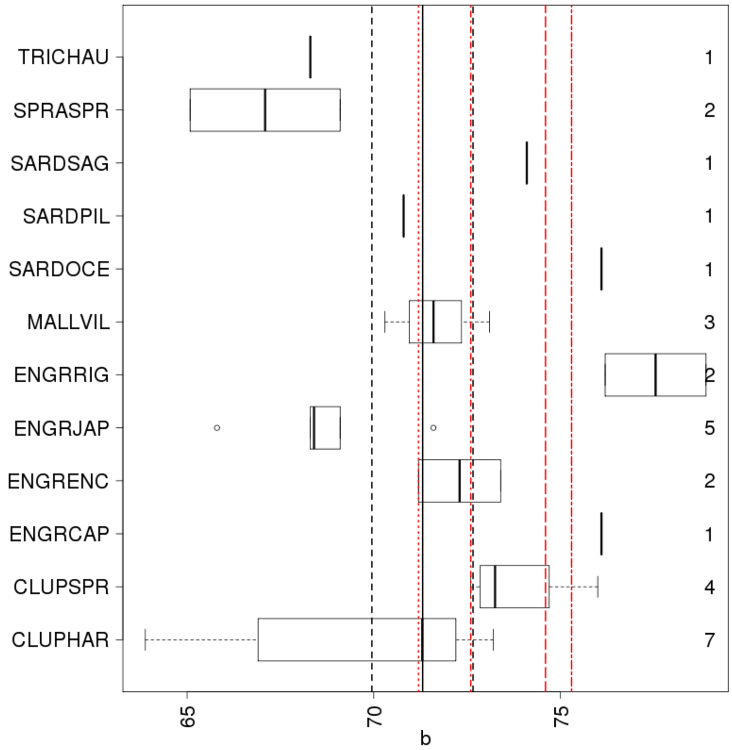

Figure 7.2.5.6. Boxplots of b values established for clupeid species. TRICHAU: *Trichiurus haumela*; SPRASPR: *Sprattus sprattus*; SARDSAG: *Sardinops sagax*; SARDPIL: *Sardina pilchardus*; SARDOCE: *Sardinops ocelattus*; MALLVIL: *Mallotus villosus*; ENGRRIG: *Engraulis rigens*; ENGRJAP: *Engraulis japonicus*; ENGRENC: *Engraulis encrasicolus*; ENGRCAP: *Engraulis capensis*; CLUPSPR: mix of *Clupea harengus* and *Sprattus sprattus*; CLUPHAR: *Clupea harengus*. Straight black line: mean b values with confidence interval (dashed lines); red lines: b values used for anchovy and sardine acoustic biomass assessment in Europe: red dotted line: b = 71.2; red dotted-dashed line: 72.6; red long dashed line: b = 74.6; red double dashed line: b = 75.3. Number of equation established for each species in the right column.

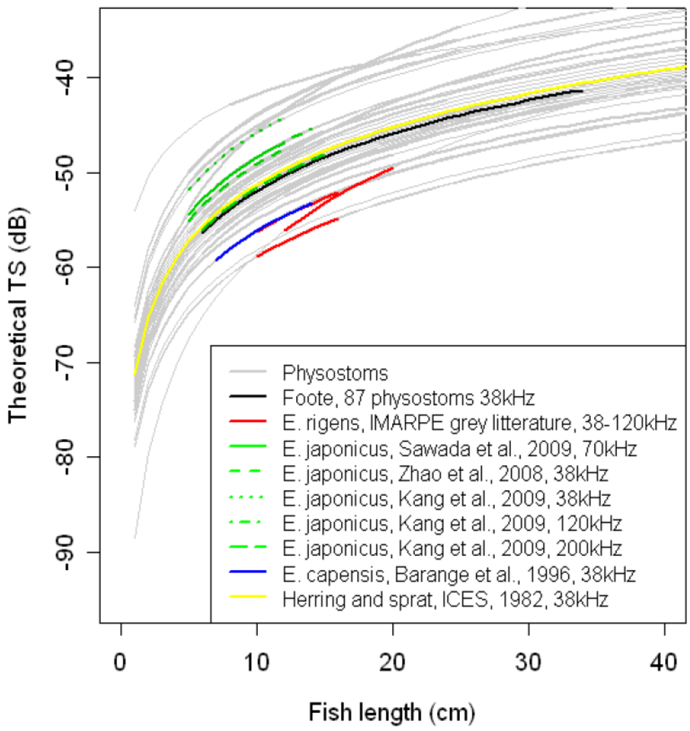

Figure 7.2.5.7. TS~length equations for anchovy. Coloured lines: TS~length curve for the studied anchovy length range; grey lines: TS~length curve of physostomous fish, outside the studied fish length range.

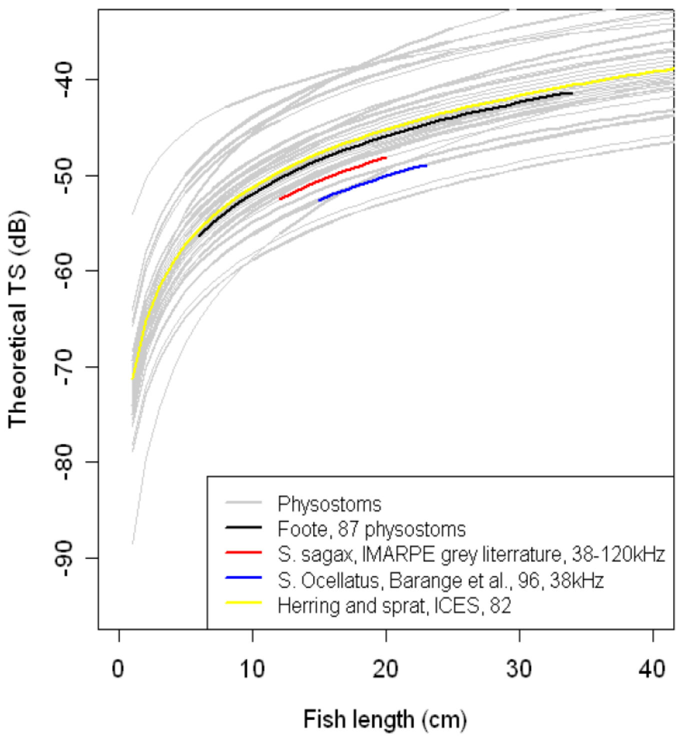

Figure 7.2.5.8. TS~length equations for sardine. Coloured lines: TS~length curve for the studied sardine length range; grey lines: TS~length curve of physostomous fish, outside the studied fish length range.

Table 7.2.5.1. TS~length equations for clupeid species from TSbase.

ref	f	spname	sp	codesp	SBT	Lmin	Lmax	Lmean	location	DN	method	b	a
Edwards et al., 1984	38	Herring	Clupea harengus	CLUPHAR	PHYSSTO	7	27	18.8	N.E. Atlantic	A	exsitu	-71.5	20.1
Faessler et Gorska, 2009	38	Herring	Clupea harengus	CLUPHAR	PHYSSTO	5	25		Baltic Sea		model	-63.88	20
Faessler et Gorska, 2009	38	Herring	Clupea harengus	CLUPHAR	PHYSSTO	5	25		Baltic Sea		model	-64.07	20.08
Peltonen and Balk, 2005	38	Herring	Clupea harengus	CLUPHAR	PHYSSTO	8	22	12	Baltic Sea	N	insitu	-54	12.3
Peltonen and Balk, 2005	38	Herring	Clupea harengus	CLUPHAR	PHYSSTO	8	22	12	Baltic Sea	N	insitu	-63.9	20
Edwards et al., 1984	38	Herring	Clupea harengus	CLUPHAR	PHYSSTO	7	27	18.8	N.E. Atlantic	A	exsitu	-71.3	20
Foote, 1987	38	Herring	Clupea harengus	CLUPHAR	PHYSSTO	24	34	28.5	North Sea	N	insitu	-72.1	20
Halldorsson and Reynisson, 1983	38	Herring	Clupea harengus	CLUPHAR	PHYSSTO	9	33	21.5	Iceland	N	ind	-73.2	20
Misund and Beltestad, 1996	38	Herring	Clupea harengus	CLUPHAR	PHYSSTO			32.8	Norwegian fjords	D	comp	-71.1	20
Rudstam et al., 1988	70	Herring	Clupea harengus	CLUPHAR	PHYSSTO	6	24	13	Baltic Sea	N	ind	-75.5	21.7
Misund and Ovredal, 1988	70	Herring	Clupea harengus	CLUPHAR	PHYSSTO	22	33	28	Norwegian fjords	D	ind	-72.3	20
Rudstam et al., 1988	70	Herring	Clupea harengus	CLUPHAR	PHYSSTO	6	24	13	Baltic Sea	N	ind	-69.9	20
Degnbol et al., 1985	38	Herring/sprat	Clupea sprattus	CLUPSPR	PHYSSTO	19	26	21	Kattegat/Skagerak	A	comp	-72.6	20
Edwards et al., 1984	38	Herring/sprat	Clupea sprattus	CLUPSPR	PHYSSTO	12	21	16.6	N.E. Atlantic	A	insitu	-73.4	20
Degnbol et al., 1985	120	Herring/sprat	Clupea sprattus	CLUPSPR	PHYSSTO	7	19	13.8	S.E. Baltic	N	comp	-73.1	20
Edwards et al., 1984	120	Herring/sprat	Clupea sprattus	CLUPSPR	PHYSSTO	12	21	16.6	N.E. Atlantic	A	insitu	-76	20
ICES, 1982	38	Herring/sprat	Clupea sprattus	CLUPSPR	PHYSSTO				North Atlantic			-71.2	20
Barange et al., 1996	38	South African Anchovy	Engraulis capensis	ENGRCAP	PHYSSTO	7	14		South Africa	N	insitu	-76.1	20
Miquel et al., Ecomed 2009	38	European Anchovy	Engraulis encrasicolus	ENGRENC	PHYSSTO	8.5	12	11.7	Spanish Mediterranean	N	insitu	-71.42	20
Miquel et al., MEDIAS 0710	38	European Anchovy	Engraulis encrasicolus	ENGRENC	PHYSSTO			13.4	Spanish Mediterranean	N	insitu	-78.5	20
Pyrounaki et al., HCMR 2010	38	European Anchovy	Engraulis encrasicolus	ENGRENC	PHYSSTO	4.7	16.5	11.5	Aegean sea	N	insitu	-73.4	20
Sawada et al., 2009	70	Japanese Anchovy	Engraulis japonicus	ENGRJAP	PHYSSTO	9.6	14.8	12.2	Japan	N	insitu	-68.3	20
Zhao et al., 2008	38	Japanese Anchovy	Engraulis japonicus	ENGRJAP	PHYSSTO	6	15	10.6	Yellow Sea	N	insitu	-71.6	20
Kang et al., 2009	38	Japanese Anchovy	Engraulis japonicus	ENGRJAP	PHYSSTO	4.8	12.2		Korea	A	exsitu	-65.8	20
Kang et al., 2009	120	Japanese Anchovy	Engraulis japonicus	ENGRJAP	PHYSSTO	4.8	12.2		Korea	A	exsitu	-68.4	20
Kang et al., 2009	200	Japanese Anchovy	Engraulis japonicus	ENGRJAP	PHYSSTO	4.8	12.2		Korea	A	exsitu	-69.1	20
Gutierrez and MacLennan, 1998	38	Anchoveta	Engraulis rigens	ENGRRIG	PHYSSTO	10	16	12.8	Peru	A	exsitu	-78.9	20
Gutierrez and MacLennan, 1998	120	Anchoveta	Engraulis rigens	ENGRRIG	PHYSSTO	10	16	11.3	Peru	A	exsitu	-76.2	20
Simmonds et al., 2009	38	Anchoveta	Engraulis rigens	ENGRRIG	PHYSSTO	12	20	14	Peru		insitu	-88.57	30.05
Guttormsen and Wilson, 2009	38	Capelin	Mallotus villosus	MALLVIL	PHYSSTO	5	15	10	Alaska	N	insitu	-70.3	20
Guttormsen and Wilson, 2009	38	Capelin	Mallotus villosus	MALLVIL	PHYSSTO	5	15	10	Alaska	N	insitu	-71.6	20
Rose, 1998	38	Capelin	Mallotus villosus	MALLVIL	PHYSSTO	9	15	12.3	Newfoundland	A	insitu	-73.1	20
Dommasnes and Rottingen, 1984	38	Capelin	Mallotus villosus	MALLVIL	PHYSSTO				Barents Sea			-74	19.1
Gauthier and Horne, 2004	38	Capelin	Mallotus villosus	MALLVIL	PHYSSTO				St Lawrence			-69.3	20
Gauthier and Horne, 2004	38	Capelin	Mallotus villosus	MALLVIL	PHYSSTO							-75	24.9
Halldorsson and Reynisson, 1983	38	Capelin	Mallotus villosus	MALLVIL	PHYSSTO			11.5	Iceland	N	ind	-78.1	20
Halldorsson and Reynisson, 1983	38	Capelin	Mallotus villosus	MALLVIL	PHYSSTO			14.5	Iceland	N	ind	-78.8	20
Rose, 1998	38	Capelin	Mallotus villosus	MALLVIL	PHYSSTO	9	15	12.3	Newfoundland	A	insitu	-74.3	21.1
Rose and Legget, 1988	120	Capelin	Mallotus villosus	MALLVIL	PHYSSTO			16.5	St Lawrence	D	insitu	-65.3	20
Pyrounaki et al., HCMR 2010	38	European Sardine	Sardina pilchardus	SARDPIL	PHYSSTO	5.8	16.2	8.5	Aegean sea	N	insitu	-70.8	20
Barange et al., 1996	38	Pilchard	Sardinops ocellatus	SARDOCE	PHYSSTO	15	23		S.E. Atlantic	N	insitu	-76.1	20
Gutierrez and MacLennan, 1998	120	Sardine	Sardinops sagax	SARDSAG	PHYSSTO	12	20		Peru	A	exsitu	-74.1	20
Robinson, 1983	30	Sprat	Sprattus sprattus	SPRASPR	PHYSSTO	9	15	12.6	North Sea	N	ind	-69.1	20
Robinson, 1983	30	Sprat	Sprattus sprattus	SPRASPR	PHYSSTO			7.15	North Sea	N	ind	-70.7	20
Faessler et Gorska, 2009	38	Sprat	Sprattus sprattus	SPRASPR	PHYSSTO	5	25		Baltic Sea		model	-65.08	20
Faessler et Gorska, 2009	38	Sprat	Sprattus sprattus	SPRASPR	PHYSSTO	5	25		Baltic Sea		model	-73.06	27.5
Zhao, 2006	38	Hairtail	Trichiurus haumela	TRICHAU	PHYSSTO	6.2	11.5		Yellow Sea	N	insitu	-68.3	20

Table 7.2.5.2. ***b20*** **values used for anchovy and sardine acoustic biomass assessment in Europe.**

b20	Sardine	Anchovy
IFREMER	-71.2	-71.2
IEO	-72.6	-72.6
IPIMAR	-72.6	-71.2
AZTI	-72.6	-72.6
HCMR	-72.6	-71.2
CNR-ISMAR	-72.5	-74.6
CNR-IAMC	-70.5	-75.3

Recent in-situ/ex-situ experiments in Europe (Magdalena Iglesias *et al.*, IEO; Maria Myrto Pyrounaki *et al.*, HCMR; Walter Basilone, CNR-IAMC)

All ***b20*** values used for anchovy and sardine acoustic biomass assessments in Europe are presented in Table 7.2.5.2. Recent in-situ direct TS recordings targeting European anchovy and sardine have been conducted in the Mediterranean, using a standard protocol defined within the framework of the AcousMed project. Miquel *et al*. (unpublished data) have computed a ***b20*** value equal to -71.42 for 12 cm anchovy at night, during the Ecomed 2009 cruise. During the MEDIAS 2010 survey, they have computed a ***b20*** value equal to -78.5 at night, in an area where they had observed almost pure anchovy schools during daytime. However, as no trawl haul was performed during the night, some doubts remain on the species whose TS were recorded.

Pyrounaki *et al*. (unpublished data) have computed a ***b20*** value of -73.4 in the Aegean Sea for 11.5 cm anchovy, based on extensive (46 hauls) TS recordings at night from 2004 to 2010. They also reported a ***b20*** value of -70.8 for 8.5 cm sardine based on a small (6 hauls) night sample.

These in-situ ***b20*** values have been used to draw ***b20*** distributions for European anchovy and sardine in Figure 7.2.5.6. Miquel *et al*. fully validated ***b20*** value for anchovy fall within the confidence interval around the average ***b20*** value computed for all clupeid species. Pyrounaki *et al*. ***b20*** value for anchovy is outside the confidence interval, but still lesser than ***b20*** values reported in South Africa and Peru for local anchovies.

Basilone *et al*. (unpublished data) have computed ***b20*** values equal to -68,9 and -68,07 for anchovy at the 200kHz frequency, based on cage experiments conducted in the Sicily Channel. However, more measurements should be conducted to improve the R2 values associated to these ***b20***s (0.53 and 0.65, respectively).

7.2.5.4 Influence of TS~length equation selection on fish stock estimates in the Mediterranean (Magdalena Iglesias *et al.*, IEO ; Maria Myrto Pyrounaki *et al.*, HCMR)

In the single species case, the « echo integrator conversion factor » (Simmonds and MacLennan, 2005) used to estimate the fish biomass from the observed echo integrals solely depends on the TS~length equation parameters and on the species length frequency. All other things being held constant, the ratio of biomass estimates obtained with two different ***b20***s is then equal to 10^(db20/10), where db20 is the ***b20*** difference.

European sardine and anchovy are often found in mixed concentrations. In this mixed species case, the echo integrator conversion factor not only depends on TS~length equation parameters, but also on the species proportions in the area. Differences in fish biomass estimates are then not strictly proportional to difference in the ***b20***s.

To assess the actual effects on fish stock acoustic estimates of differences in TS~length equations parameters combined with the observed species proportions, fish stock biomass estimates have been computed using various equations in the Aegean Sea (Table 7.2.5.3) and in the Spanish Mediterranean waters (Table 7.2.5.4). The ratios of biomass estimates obtained with different ***b20***s for the mixed species are compared to the biomass ratios that would have been obtained in the single species case.

In the Aegean Sea, anchovy and sardine acoustic biomass estimates have been compared for 5 different years and two ***b20*** values (-71.2 and -75.3 for anchovy and -70.51 and -72.6 for sardine). The average of the yearly anchovy biomass estimates, computed with the two different ***b20***s, over the time-series was 2.8, close to the ratio that would have been expected in the single species case: 2.6 (for a 4,1 dB ***b20*** difference). Similar results were found for sardine: mean mixed species ratio: 1.8 vs. single species ratio: 1.6.

In the Spanish Mediterranean Sea, anchovy and sardine acoustic biomass estimates have been computed in two different areas, based on the ***b20*** values in use at IEO, CNR and HCMR (Table 7.2.5.4). Ratios of the biomass estimates have in this case been referenced to the IEO estimates.

In both areas, the average multispecies biomass ratio for anchovy (1.1 and 1) and sardine (0.9 and 0.9) are close to the single species biomass ratio for both species (1.4 and 1.2, respectively).

These results confirm that acoustic fish biomass estimates heavily depend on the TS~length equation selection, even in the case of mixed species. Anchovy biomass estimates can for instance vary up to 3 fold, depending the choice of the TS~length equation within those in use in the Mediterranean.

Table 7.2.5.3. Average, standard deviation (sd) and coefficient of variation (CV) of fish stock estimates and ratio, computed over the years 2003–2006 and 2008, with different b20 values for anchovy and sardine in the Aegean Sea.

Aegean Sea	2003	2004	2005	2006	2008	Average	St. dev.	CV
Anchovy biomass, b20=-71.2	47 838	46 508	31 852	62 685	60 601	49 897	12 393	25%
Anchovy biomass, b20=-75.3	111 106	129 414	113 684	182 853	158 184	139 048	26 763	19%
Biomass ratio	2.3	2.8	3.6	2.9	2.6	2.8	0.4	13%
Sardine biomass, b20=-70.51	12 769	9 682	14 209	24 490	13 545	14 939	5 486	37%
Sardine biomass, b20=-72.6	19 281	14 857	20 464	42 856	39 395	27 371	11 996	44%
Biomass ratio	1.5	1.5	1.4	1.7	2.9	1.8	0.6	32%

Table 7.2.5.4. Ratios of the sardine and anchovy biomass estimates computed in two area of the Spanish Mediterranean with the b20s values used by various institutes. Biomass ratios are computed referenced to the IEO biomass estimate: biomass ratio ref. IEO = institute Y biomass estimate / IEO biomass estimate.

Spanish Mediterranean	AN area		SA area	
	SA	AN	SA	AN
	IEO *b20s*: AN=SA=-72.6			
CNR-SICILY *b20s:* AN=-75.3 SA=-70.5	1.4	0.7	1.0	0.7
CNR-ANCONA *b20s:* AN=-74.6 SA=-72.5	1.0	0.7	0.9	0.7
HCMR *b20s*: AN=-71.2 SA=-72.6	1.0	1.4	1.1	1.2
Average ref. IEO *b20*	1.1	0.9	1.0	0.9
sd ref. IEO *b20*	0.2	0.4	0.1	0.3

7.2.5.5 Discussion and Conclusions

Except from ***b20*** values used by CNR, ***b20*** values used for anchovy and sardine acoustic biomass assessment in Europe (-71.2 or -72.6) lay within the confidence interval around the average ***b20*** value computed based on all clupeid equations (Figure 7.2.5.6). Assuming that some general law may govern the relationship between clupeids TS and length, the choice of one of these ***b20*** values hence appear reasonable, in the context of all TS studies conducted on clupeids. Selecting either one or the other ***b20*** values may lead to differences in absolute biomass estimates of about 40% (single species case).

However, the studies presented here on the impact of TS equation selection on biomass estimates suggest that TS values act more or less as a scaling factor in the acoustic fish biomass estimation process. Even if there is a bias in the estimate, the acoustic biomass estimate can still be used as a relative index, which provides insights into the trends of the true (unknown) fish stock biomass.

TS being by essence highly variable, it is advisable to conduct more TS measurements of European anchovy and sardine, in various environmental conditions, to further investigate the range of variations of their TS. Assessing the range of TS variability is in fact crucial to the accurate computation of the estimation error around the fish biomass estimates, and then to adequately interpret the fish acoustic index fluctuations (either in an absolute or relative way).

The new TS experiments should ideally be conducted in more controlled experimental conditions: either in cage (e.g. Kang *et al*., 2009), or using remotely operated vehicles equipped with both video and acoustics devices (e.g. Sawada *et al*., 2009). The new TS studies results should be included in TSbase, to improve our understanding of the impact of European anchovy and sardine TS variability on survey strategies and fish stock biomass estimates.

7.3 Addressing descriptor indicators for determining GES of exploited populations

WGACEGG was required for methods for delivery of the following information to assessment working groups in 2012:

- i) Proportion of fish larger than the mean size of first sexual maturation
- ii) Mean maximum length of fish found in research vessel surveys.
- iii) 95th % percentile of the fish length distribution observed

Background:

The Marine Strategy Framework Directive (MSFD) adopted in July 2008 aims at achieving or maintaining a good environmental status by 2020 at the latest.

The Commission Decision of 1 September 2010 on criteria and methodological standards on good environmental status (GES) of marine waters in the framework of Article 9 (3) of the MSFD contains a number of criteria and associated indicators for assessing good environmental status, in relation to the 11 descriptors of good environmental status laid down in Annex I of the Directive. For the implementation of the MSFD Science must provide the knowledge upon which integrated management can build the tools for assessing progress towards good environmental status.

The above ToR was inserted into all ICES survey groups in response to the MSFD requirements of GES (Good environmental status) descriptor 3.3.

Among the qualitative descriptors for determining GES (Annex I of the Commission Decision1) Descriptor 3 stays that "Populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock".

And descriptor 3.3 is:

Descriptor 3.3. Population age and size distribution

Primary indicators. *Healthy stocks are characterized by large proportion of old, large individuals. Indicators based on the relative abundance of large fish include:*

- *Proportion of fish larger than the mean size of first sexual maturation (3.3.1)*
- *Mean maximum length across all species found in research vessel surveys (3.3.2)*
- *95 % percentile of the fish length distribution observed in research vessel surveys (3.3.3).*

Secondary indicator:

[1] COMMISSION DECISION of 1 September 2010 on criteria and methodological standards on good environmental status of marine waters (notified under document C(2010) 5956) (Text with EEA relevance) (2010/477/EU)

— *Size at first sexual maturation, which may reflect the extent of undesirable genetic effects of exploitation (3.3.4).*

For the two sets of indicators (proportion of old fish and size at first sexual maturation), expert judgement is required for determining whether there is a high probability that the intrinsic genetic diversity of the stock will not be undermined. The expert judgement needs to be made following an analysis of the time-series available for the indicator, together with any other information on the biology of the species.

The group was informed that: ICES wants to allow assessment groups to comment on the GES descriptors for 2012, so the Group has a year and a half to think of ways to address these descriptors, and think of the a way to feed this information to the appropriate assessment groups. At this stage priority should be given to general methods to address them.

Provisional ANSWER:

WGACEGG addressed briefly this ToR and came out with the following comments:

a) Definitive answer will be given in the WGACEGG report of 2011.
b) Indicators related to the descriptors of 3.3, others than the one currently listed in the Commission Decision will also be considered by the Group according to the work carried out in FISBOAT (FP contract 502572; Petitgas *et al*., 2009, Cotter *et al*., 2009 and Petitgas and Poulard, 2009).
c) Concerning the concrete procedures to elaborate the above 3 indicators an advanced answer is proposed:

— *Proportion of fish larger than the mean size of first sexual maturation (3.3.1)*

Answer: Acoustic Pelagic surveys provide estimate of both total abundance and corresponding length distribution which results from suitable weighted mean of the individual length distribution of the fishing hauls. As such they can provide the proportion of fish larger than the means size of first sexual maturation corresponding to the total length distribution. However notice that size at first maturation has only a biological meaning when maturity is not fully achieved since the first years of life. As such anchovy in the Bay of Biscay, which attains full maturity since the first year of life cannot report on this value other than the 100%. Icthyoplankton surveys often do not obtain length composition of the population and therefore will not contribute to that indicator. In case the Icthyoplankton survey would produce a weighted length composition of the total population then it could contribute to i.

— *Mean maximum length across all species found in research vessel surveys (3.3.2)*

Answer: Mean Maximum length can be a vague or confusing term with unknown statistical properties or not clear biological meaning, as there can always be seen abnormal big fish but of little representativeness of the typical population size distribution. A weighted (or unweighted) mean of the biggest fish in each haul can always be made parallel with the population length distribution estimation, but the properties of that estimator are not clear right now for pelagic species (at least). Length corresponding to different percentiles has statistical properties which make them better indicators (as the following one).

— *95 % percentile of the fish length distribution observed in research vessel surveys (3.3.3). The surveys providing length distribution of the assessed population can directly supply such percentile.*

7.4 Requirements for the Benchmarck of Sardine in 2012 concerning Egg and Acoustic surveys

A sardine benchmark workshop has been proposed for 2012 (WD, WGACEGG, Silva *et al*., 2010). From a list of candidate topics to be discussed in the benchmark, (1) the intercalibration of Portuguese and Spanish acoustic surveys, (2) the revision of sardine DEPM data, (3) maturity ogives and weights-at-age for use in stock assessment (4) the revision of the catchability pattern of acoustic surveys, are of interest to WGACEGG. Topic (1) is already a ToR and additional emphasis on its completion has been put by the benchmark (see Annex 4). Topic 2 is being addressed by IPIMAR and IEO and WGACEGG agreed to propose it for a short ToR (see Annex 4).

Regarding topic (3), stock maturity ogives and weights-at-age are currently derived from spring acoustic data (end of spawning season and minimum of condition off Portugal) while the DEPM (peak spawning time) is used to tune SSB in the assessment model. Maturity and weights-at-age decline from the peak to the end of the spawning season and this is expected to enlarge the discrepancy between observed and predicted SSB in the assessment. Given maturity and weight data are also available from the DEPM survey, with the advantage that maturity are microscopic stages observed at peak spawning time, their use in stock assessment in alternative to acoustic survey data should be evaluated. Therefore, a recommendation to evaluate estimates of maturity and weights-at-age from DEPM and spring acoustic surveys for stock assessment is included for 2011.

Topic (4) is related with survey catchability that may have changed due to fishing gear changes during the early 1990s. There are indications of a shift in the depth distribution of hauls with sardine, mainly in the Portuguese surveys. This may have modified catchability- at-age given the differential depth distribution of smaller and larger fish. However, the change in hauls depth distribution may alternatively reflect a real shift in the spatial distribution of the fish. Uncertainty regarding changes in catchability was one of the reasons that led to the exclusion of 1980s surveys from the assessment. A re-evaluation of this issue was considered relevant to the benchmark and has been included in the recommendations for 2011.

The integration of results that are proposed for revision will allow a well-informed evaluation of the uncertainties in the input data for the assessment and will assist on the interpretation of the apparent divergent tendencies for the SSB estimates, in some years, from the DEPM and acoustics surveys.

8 Progress in Cross-validation and integration of acoustic and egg production surveys

No further progress has been reported to this WG.

The contribution of Petitgas *et al*. (2009) for a quantitative combination of acoustic and CUFES data for the quality control of acoustic survey estimates is so far the most complete approach to get this integration.

9 Conclusions and interim Plan of actions for 2010

a) Surveys at sea, coordination and results:

In 2010 WGACEGG has continued making a big effort to review and produce joint presentations of the large amount of surveys, their biomass estimates on sardine and anchovy (by acoustic and DEPM methods) and of the remaining ecosystem fish components (in the case of the Spring acoustic surveys). These surveys are being made in a coordinated fashion as have been designed in previous WGACEGG meetings. For the coordinated acoustic Spring acoustic Surveys (of IPIMAR, IEO and Ifremer) the WG is providing since 2008 a synoptic vision of most pelagic species from Cadiz to French Brittany (subareas VIII and IX), being a product of the effort made in ICES WGACEGG group towards achieving those ecosystem surveys. In addition from this year onwards a new survey over the Celtic Sea and English Channel has been added to this coordinated acoustic survey (PELTIC10, carried out by Cefas). The acoustic survey made in Cadiz in June-July 2009 (by IEO) is not integrated in this synoptic review, but their results are compared with the PELAGO survey which cover the same area some 2 months earlier.

As in previous years, the surveys reveal that sardine abundance is about an order of magnitude higher than that of anchovy across the whole subareas IX and VIII. Sardine abundance is similar in subarea VIII as in last year 2009, but shows a decreasing trend in Portuguese waters form 294,000 t in 2009 to 179,000 t in 2010 (particularly due to the drop in IXa CS and South). For anchovy, a raise of biomass levels was detected in subarea VIII, whereas in IXa South (Algarve and Cadiz) a noticeable drop was recorded both in the Portuguese acoustic survey, as in the Spanish ECOCADIZ survey in July. This is the third year for anchovy of consecutive drop in biomass in this region.

As in 2009 there was a single DEPM survey for anchovy which covered only subarea VIII. As the acoustic survey, this DEPM survey points to a recovery of biomass levels compared with previous years in the Bay of Biscay. Although, in relative terms the upwards tendency of anchovy was rather similar for the acoustic and DEPM surveys in subarea VIII, in absolute terms the acoustic estimate doubled that of DEPM and this was cause of discussion and warning for this discrepancy. A ToR has been added for next year meeting to address Long Tor 3 , to cross-validate and integrate egg production and acoustic methods, in which methods to properly make the comparison of results in absolute terms should be dealt with.

In autumn 2010, the acoustic survey for juveniles in the Bay of Biscay (JUVENA, being carried out since 2003), recorded the highest abundance of anchovy juveniles since the beginning of their series (Section 4.4). In addition results of the ECOCÁDIZ-RECLUTAS 1009 survey were reported. This is the first attempt by the IEO of acoustically assessing the abundance of anchovy and sardine juveniles in their main recruitment areas off the Gulf of Cádiz. The survey was carried out between 26 October and 5 November 2009 on-board the Spanish RV "Emma Bardán" and despite some limitations in covered area, it showed (also by comparison with a subsequent bottom-trawl survey) its capability to a successful assessment of the juveniles of these two species in the Gulf of Cadiz. Unfortunately the survey is not guaranteed for next years and in fact no survey of these characteristics has been carried out in 2010.

The WG considered the convenience for the presentation during the meeting of survey results of emphasizing the specific problems encountered during the surveys and discussing the ways suggested to solve them.

The WG endorsed the continuity of the coordination of the surveys: The coordination of the acoustic surveys in spring was considered satisfactory and it was set again. Coordination for the 2011 acoustic and DEPM surveys was made (Section 5), including now the Triennial egg survey for Sardine in 2011, which will be this time expanded to the whole area VIII thanks to a concerted action of AZTI and IEO. The spring acoustic surveys will include the new survey made by Cefas, PELTIC11, in Subdivisions VIIe-j, h. In autumn, JUVENA survey will be the sole survey on the assessment of anchovy juveniles.

The standard procedures for the implementation of the acoustic and DEPM surveys have been summarized respectively in two annexes to this report (Annex 6 and 7). In relation to this and SGSIPS, The working group discuss and agree to cooperate with SGSIPS in the elaboration of a synthesis paper about the "Standardizing ichthyoplankton surveys: review of methods" for which due coordination was established with the Chair of that group (Cindy van Damme). In addition the WG endorses the recommendation of SGSIPS numbers 3 and 4 about the Manuals of the different ichthyoplankton surveys to update them regularly and place them in an ICES public folder (see recommendations).

b) Progress on methodologies and inner and crossed validation of surveys:

Assuring the quality of the surveys is usually made in the WG by endorsing and discussing inter-calibration between and within surveys, by discussing revisions of past series estimates according to past inter-calibration, or new methods or works, and by Updating the group on advances and improvements of acoustic and DEPM methods.

Concerning the revision of past series estimates:

- For the DEPM: Updates on the revision of the series of Biomass from the DEPM surveys for anchovy in the Bay of Biscay and for sardine around the Iberian Peninsula were reported, but the work is to be finished for the next WG. Revisions included new of estimates of spawning fraction (anchovy), which implies a decrease in the spawning-stock biomass levels of about 38%, and revisions of the egg mortality estimates for both sardine and anchovy, etc Given the strong impact that some of these changes may have on the DEPM Spawning Biomass estimates, the WG considered the convenience of earlier publication in a peer review Journal before the new estimates are incorporated as input for the management advice.

IN order to improve the estimates of spawning fraction estimates for sardine, now that a new Triennial egg survey in foreseen for 2011, with the inclusion of a new team (AZTI) in the application of the DEPM method to this species, a training and cross checking of sardine histological analysis of POFs was carried out between IPIMAR and AZTI was carried out between the 18–22 October 2010. In general in order to improve the estimation of the spawning fraction a workshop will be carried out in

2011 on the spawning fraction estimation during our next WGACEGG meeting (ToR g).

According to these reviews, for 2011 a recommendation was set staying that the sardine DEPM series would be revised and the estimates presented should be published prior to the sardine bench mark assessment meeting, which is expected to occur in 2012.

Concerning the evaluation of the precision and robustness of surveys' estimates through inner calibration and cross comparison of survey results (either among concurrent or consecutive acoustic surveys or by comparison between the acoustic and concurrent DEPM estimates), the WG dealt with:

- Effects of too coastal distribution of pelagic resources on the ordinary acoustic estimates of these resources in Cadiz by comparison between the ECOCADIZ0609 acoustic estimates and ECOCADIZ-COSTA0709 (Section 6.3):

ECOCÁDIZ-COSTA 0709 survey was conducted almost synchronously (from 2– 9 July 2009) to the conventional ECOCÁDIZ 0609 survey (from 27 June to 6 July) Actually, ECOCÁDIZ-COSTA's sampling grid was the continuation of the ECOCÁDIZ0609 transects R05 to R11 from 50 m depth inshore (Figure 6.3.1.1). The Navarro's acoustic equipment (a non-scientific echosounder, the Simrad™ ES60 Single-Beam Multi-Purpose Fish-Finder, only working with a Simrad™ Single-Beam 38 kHz GPT and transducer) prevented from its proper calibration and therefore the resulting estimates should be only considered as orientative ones of the magnitude of the unsampled fraction of the assessed populations. Furthermore, the Navarro was only equipped for this summer's survey with its standard configuration for bottom-trawl fishing with some arrangements in the floating rope which allowed to achieve a 5 m mean vertical opening, but it hadn't any chance for the midwater fishing.

Results demonstrate that coastal shallow waters not covered by conventional surveys may hold a relatively important biomass (of about 20% or 15% of biomass of that evaluated in not coastal waters Table 6.3.4.1), in some cases with some smaller sizes (as for anchovy). The continuity of sampling the coastal waters is probably recommendable either by a complementary survey like this one or by a vessel capable of sampling the whole study area. Alternatively some other experimental surveys could be done in order to obtain an average percentage correction factor for the usual losses during the non-coastal surveys. IN this case, however, further surveying of these shallow waters is not guaranteed for next years.

- Comparison between ECOCADIZ2009 and the Portuguese acoustic survey PELAGO09 (which took place about 2 months before) reveal discrepancies in the sardine and chub mackerel estimates (PELAGO exceeding by about 150% and 50% the ECOCADIZ estimates) but with agreement in the anchovy estimates (in absolute terms; Section 6, Table 6.3.4.1).
- The intercalibration between "Noruega" and "Thalassa" research vessels (Section 7.2.1) performed in 2008 and 2009 give contradictory signals. In 2008 the values obtain for the "Thalassa" bottom and plankton integration was greater than for "Noruega". On the contrary, during the 2009, the bottom integration values are similar between the two ships (Figure 7.2.1.1), but "Noruega" integrates more fish than "Thalassa" (Figure 7.2.1.2).

It was considered that it is necessary a more complete intercalibration exercise, over several types of fish and plankton distributions, during day and night-time. For that reason, a recommendation is included in order to perform another joint intercalibration exercise during spring 2011 acoustic surveys and to discuss this during a dedicated workshop during the 2011 WGACEGGG meeting (ToR f).

- Inner calibration of Portuguese acoustic survey by Echo-integration of the bottom on selected parts of transects along the whole time-series (Section 7.2.2) Four survey's exercises are shown, along a transect with a stable median grain size sand (Figure 7.2.2.1). Some variability of the bottom integration (Table 7.2.2.2 and Figure 7.2.2.2) was found (in some cases relevant) which may reflect the weather conditions during each survey passage.
- Calibration exercise between the two vessels operating in JUVENA2010 survey (Section 7.2.3). The inter-ship calibration between EB and IL was performed along a 30 nautical miles transect. The intercalibration analysis of the data registered by EB and IL have shown a slight negative bias of the EB collected data (about 5%) in the particular weather conditions existing on the day of the exercise.

This survey JUVENA made in past years several intercalibration exercises with PELACUS10 survey, over some coincident areas covered concurrently, with some discrepancies which were ultimately understood on the basis of different fishing system and identification of echoes and natural variability of observations.

- Advances in abundance estimation and morphological description of surface fish shoals achieved by using the ME70 multibeam echosounder were described. This is a new acoustic device providing data of unique range and resolution for the description of the three-dimensional (3D: vertical x athwart x alongship) morphology of small pelagics shoals. ME70 multiple beams namely provide a 12-fold greater sampling volume than monobeam echosounders. This feature is particularly prominent near the sea surface, where classical acoustic beams are very narrow. Results showed a non proportional increase of the number of schools detected, relatively to the increase of the sampling volume of the multibeam vs. the monobeam trasducers. Detecting more surface schools with the multibeam system is per se interesting to: i) improve the precision of acoustic fish biomass estimates and shoal classification; ii) provide useful guidance for triggering identification fishing i.e. better answering the question of when to fish the surface layer to identify acoustic marks.
- Finally in cooperation with AcousMed the joint session on Target strength allowed to review the cumulated knowledge of target strength on sardine and anchovy and share ideas to keep on advancing in a better knowledge of this parameter, including the potential for a future joint research or project. Target Strength~length equations used for anchovy and sardine acoustic biomass assessment in Atlantic European waters appear reasonable, in the context of all TS studies conducted on clupeids. More controlled TS experiments are however needed to further assess the variability of European sardine and anchovy TS.

The WG discussed the former results concluding some general ideas to keep on moving in future to solve some of the detected problems:

a) To demand that inter-calibration exercises are made simultaneously over several types of fish and plankton distributions during day and night-time, being of interest also the inclusion of a bottom seabed, in order to detect different performance of the acoustic systems and to explore their causes. Inclusion of these exercises in coordinated surveys seems to be very convenient given the differences (too often) found.

b) Variability among surveys estimates differing in their coverage some weeks or months may be high, due either to different behaviour of fish or to migrations or changes in spatial distributions.

c) Comparison between methods (Acoustic and DEPM) should require therefore a close simultaneity among them to avoid any disturbance or differences in the observed pelagic community.

d) Given the discrepancies in absolute terms between the DEPM and acoustic estimates for anchovy in the Bay of Biscay, which are expected to increase after the revision of the series outlined above, and for sardine in 2008 (see last year report), several ideas were put forward for further examination and understanding of these differences during WGACEGG meeting in 2011, such as:

- List the changes of parameters throughout time globally and by strata for both methods. Are differences originated in persistent regions or areas?
- Describe common indicators for both surveys and compare (Area, CUFES egg abundance, SSS, SST, nº schools…). The use of common observation methods in both types of surveys can help to compare the observations of the pelagic community being achieved during the coverage produced by each survey, as for instance CUFES set at the same depth (aside the vessel or haul mounted) and/or acoustic recording (at one or several frequencies, 38, 120 kHz, with similar settings) or even using multibeam echosounders for school echo counting and characterization, etc.

e) To keep on making measurements of Target strength of fish and developing of common protocols for carrying out such measurements experiments.

Finally the working had a very positive view of the experience of having common workshops with AcousMed, for the share of knowledge it has supposed. As such, the WG decided to enhance the cooperation between WGAGEGG and ACOUSMED teams to share experiences in the acoustic surveys and to promote common actions and workshops, at least every two years.

c) Future challenges and Contributing to ecosystem monitoring.

The Group suffers from duality in its conception and in the way of being perceived within the ICES community: On the one hand it is responsible for providing direct monitoring for two major small pelagic stocks (sardine and anchovy) in these south-easter regions (VIII and IXa) in direct connection to the assessment working group WGANSA. As such a relevant part of its work is to standardize, plan and analyse all the relevant surveys and to integrate these together to give the best possible advice to the WGANSA for integrated assessment purposes. This is something the WG has been doing since its origin, in spite that some of the most methodological issues are already being partly covered by WGFAST for acoustics and (might be) by the new starting Standards in Ichthyoplankton Surveys (SIPS) for egg surveys. On the other hand the group is set within the SCICOM Steering Group on Ecosystem Surveys Science and Technology (SSGESST) of ICES. The SSGESST, in relation to the ICES Science Plan 2009–20013 is expected to contribute particularly in the first thematic area entitled Understanding Ecosystem Functioning. The Acoustic and DEPM surveys being coordinated in WGACEGG and the synoptic overview of the pelagic community over the Mid Southern European waters which is being produced by the WG (along with its database) should provide useful insights not only for the direct monitoring and assessment of anchovy and sardine, but also about the spatial distribution patterns of adults and juveniles of these and connected pelagic species and their habitats. Monitoring the status of this population (with the best standard methods and practices – Long ToRs 1 to 3- and the occupation of the potential habitats (Long ToRs 4 and 5) are very relevant to the topic about Fish life-history information in support of Ecosystem Approach to Management.

In order to improve the contribution of the group to the objectives of the Steering Group on Ecosystem Surveys Science and Technology (SSGESST), within which WGACEGG is included, the Working Group decided to restructure a bit the way of working during the WGACEGG meeting, by Spending more time in joint presentation and analysis of results from the coordinated and concurrent surveys, rather on the survey results on isolation. To this purpose more time will be dedicated to the joint analysis and cross validation of results.

IN addition the WG has designed and will work during 2011 to Produce a joint publication on the pelagic ecosystem of the southwestern waters (Subareas VIII and IXa), in the period 2005–2010. The idea was to prepare such publication during the year (2011) and use WGACEGG meeting to comment and discuss advanced versions of the different chapters of the contribution and devise and workout the bulk of the joint analysis of results concerning the last chapter of the contribution. The work will be proposed to the ICES publication committee in the form of a Cooperative Research Report on Acoustic and Egg Surveys in ICES Areas VIII and IX 2005–2010.

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Annex 1: List of participants

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		TOTAL	24	21

Annex 2: Agenda

Initial agenda

WGACEGG took place in parallel for the first three days with the meeting of AcousMed (Project Coordinator: Marianna Giannoulaki HCMR), which is a project that aims at the "Harmonisation of the acoustic data in the Mediterranean 2002–2006". For this reason, members of WGACEGG working mainly on acoustic past most of their times in Monday and Tuesday attending AcousMed meeting, as their objective are common to those of WGACEGG. These two days were used by the rest of the members of WGACEGG to go over the DEPM issues of WGACEGG.

Agreed Initial agenda:

			WGACEGG GENERAL AGENDA	In parallel
day	**Week day**	**time**	**Subjects only for WGACEGGs**	**Shared sessions with AcousMed**
October 22	Monday	Morning	Joint session with AcousMed 2nd Meeting: WP3.1Target Strength estimation	WP3.1 TS equations estimation for anchovy and sardine (WP Leader: Magdalena Iglesias, IEO)
October 22	Monday	Afternoon	Official Opening and Consolidations of the database for DEPM and Coordination 2011. Sardine Maturity	
October 23	Tuesday	Morning	DEPM surveys and methods (ToRs 1 and 2; 5–6 presentations)	WP3.2 Day-Night differences in biological sampling within acoustic surveys (WP Leader: Athanasios Machias, HCMR)
October 23	Tuesday	Afternoon	Coordination 2011 and drafting sections of DEPM for the report	WP3.3 Day-Night differences in acoustic sampling within acoustic surveys (WP Leader: Angelo Bonanno, CNR- IAMC)
October 24	Wednesday	Morning	Acoustic surveys (ToRs 1 and 2) (About 7 presentations) and consolidation of databases	
October 24	Wednesday	Afternoon	Consolidations of the database for Acoustics and Coordination 2011: Joint Paper Acoustic and DEPM	
October 25	Thursday	Morning	Autumn Acoustic surveys and Methodological Acoustic issues (ToRs 2) and Anchovy DEPM review in VIII (About 4–3 presentations)	
October 25	Thursday	Afternoon	Drafting the Report, Joint Paper, Standard Manuals and General Issues	
October 26	Friday	Morning	Drafting the Report, Joint Paper and General Issues	
October 26	Friday	Afternoon	Closing of the meeting at 14:00	

Annex 2 (cont..): Actual Agenda of the meeting

AGENDA OF WORK by day

Long TOR	Justification	Country	Survey or Subject reported	Who	When	When
	Opening		review of the Agenda for DEPM issues	A. Uriarte & All	Monday 22	15:00
			Consolidate the database for 2008-2010 and to prepare the synoptic maps for 2010. Including 2005 DEPM survey data??	Data Coordinators: IPIMAR IFREMER, IEO & AZTI		
4	Short TOR b	All			Monday 22	16:15
1	Coordination 2011	Internatior	Sardine 2011 DEPM Survey	G. Costas et al.	Tuesday 23	17:00
	End of the working session					18:30
					DAY 2	
			Preparison of works of DEPM issues		Tuesday 23	9:00
1	surveys 2010 (Short TOR c)	Spain	Anchovy DEPM BIOMAN2010	M. Santos	Tuesday 23	11:00
2	Methodology TOR 2	Spain	Advances in estimates of Egg Mortality Z	M. Santos	Tuesday 23	12:30
			To make a training and cross checking of sardine histological analysis of POFs at an ad hoc workshop in IPIMAR before next WGACEGG.	C. Nuñes & M. Santos		
2	Short TOR b	Spain-Port			Tuesday 23	13:30
	Luch				Tuesday 23	13:45
1	Review of Series mentioned in the Plan of Actions (##1)	Spain	Review2005 DEPM estimate of Cadiz according the same procedures applied in 2008	M. Paz Jimenez	Tuesday 23	15:00
1	Review of Series	Spain	PRELIMINARY ESTIMATES OF SARDINE DAILY EGG PRODUCTION IN SPANISH WATERS (1990-2008)	Paz Díaz	Tuesday 23	15:00
1	Coordination 2011	All	Consolidate the Annexes of standard Manuals for the DEPM surveys	M. Angelico et al.	Tuesday 23	17:15
	Reporting	All	Drafting DEPM sections for the report and collaborating with WGSIPS and discuss CV of Fecundity in DCRF	All	Tuesday 23	17:30
	End of the working session					18:30
					DAY 3	
	General Introduction to WGACEGG meeting			A. Uriarte	Wednesday 2	9:00
1	surveys 2010	Spain	ECOCÁDIZ 0710	F. Ramos	Thursday 25	10:00
1	surveys 2010 (Short TOR c)	Porgual	PELAGO 10	V. Marques	Wednesday 2	10:25
1	surveys 2010 (Short TOR c)	Spain	PELACUS0410	M. Iglesias	Wednesday 2	10:55
1	surveys 2010 (Short TOR c)	France	PELGAS 10	J. Massé	Wednesday 2	11:55
1	surveys 2010 (Short TOR c)	UK	PELTIC 2010 Experimental Acoustic survey	Van Der Kooij	Wednesday 2	13:30
2	Methodology TOR 2	France	In-depth characterisation of Biscay surface pelagic fish communities with ME70 multibeam echosounder' on the comparison of mono and multi-beam acoustic school descriptors.	M. Doray	Wednesday 2	13:45
4	General	All	Discussions on future of WGACEGG and its relationships with AcousMed	all	Wednesday 2	14:00
	Luch					
4	General	All	Discussions on future of WGACEGG and election of new Chairman	all	Wednesday 2	16:00
1	General	Internatior	Topis related to next sardine benchmark	All	Wednesday 2	17:00
	End of the working session					18:30
					DAY 4	
1 & 2	surveys 2009	Spain	ECOCÁDIZ-COSTA 0709	F. Ramos	Thursday 25	9:30
1	surveys 2009	Spain	ECOCÁDIZ-RECLUTAS 1009	F. Ramos	Thursday 25	10:10
1	surveys 2010 (Short TOR c)	Spain	JUVENA 2010	G. Boyra	Thursday 25	10:20
1	Review of Series, Pending from past years	Spain	Revision of Anchovy DEPM based SSB estimates in VIII	M. Santos	Thursday 25	10:40
2	Pending from past years	Spain-Port	intercalibration between "Thalassa" and "Noruega" in 2008 and 2009	M. Iglesias & V. Marques	Thursday 25	11:40
2	Short TOR a	Spain-Port	Intra and Inter survey variations in bottom integration	M. Iglesias & V. Marques	Thursday 25	12:50
1	surveys 2010 (Short TOR c)	France	Experimental SENTINEL surveys	J. Massé	Thursday 25	13:00
	Luch				Thursday 25	13:45
5	Extra TORs from SICOM	All	Prepare methods for delivery of the following information to assessment working groups in 2012	Proposals from Acoustic and DEPM leaders of surveys	Thursday 25	15:00
1	Coordination 2011	All	Consolidate the Annexes of standard Manuals for the Acoustic and DEPM surveys	Massé et al.	Thursday 25	15:30
	reporting		Drafting the report and Maps	All	Thursday 25	16:00
	General Issues		General Issues and Extra TORs and RECOMENDATIONS & PLAN OF ACTIONS		Thursday 25	17:00
	End of the working session					18:30
					DAY 5	
	General	All	General Issues and TORs 2011, recommendations, New Chair,		Friday 26	9:00
5	Short TOR b	All	to prepare a joint publication on the spatial distribution of the small pelagics in the South East of Europe based on the common data base and auxiliary information	A. Uriarte,and all	Friday 26	11:30
	End of the Meeting					13:30

Annex 3: WGACEGG terms of reference for the next meeting in 2011

The **Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VIII and IX (WGACEGG),** chaired by Jacques Massé*, France will meet by correspondence in 2011 to:

a) Update the common regional database from the surveys made of egg densities, acoustic energies and fishing operations for anchovy and sardine

b) Produce resulting maps of anchovy and sardine distributions (adults and their eggs) at regional scale

c) Define the data for the common database at a regional scale

d) Write the chapters of the Cooperative Research Report on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VIII and IX (WGACEGG) 2005–2010

and will meet in Barcelona (at ICM head quarters), from 21–25 November 2011, to:

e) Report the spring and autumn surveys of the year (presentation of events, observations and first results) and emphasizing the specific problems encountered and discussing the ways suggested to solve them.

f) Run a dedicated session on acoustic surveys for :

- i) analyse the inter-calibration experiments performed in 2010 and 2011
- ii) produce a WD on inter-calibration results for WGANSA for 2012.
- iii) scrutinize echotraces for a common interpretation

g) Run a dedicated session on egg surveys to :

- i) revise the estimation of the spawning fraction in sardine and anchovy according to the histological examination of gonads
- ii) review the estimates of the sardine DEPM historical series in Divisions IXa and VIIIc.
- iii) Compare macroscopic and microscopic maturity ogives of sardine using DEPM data.

h) Develop ways to integrate all data collected during the pelagic surveys to contribute to ecosystem assessment at regional scale

i) Continue data analyses linking fish and egg distributions with environmental, prey and predator fields and prepare for a joint publication

j) Conclude the CRR by discussing the draft chapter on crossed analysis of surveys results and the contribution of egg and acoustic survey series to ecosystem assessment.

k) Update the Methodology Manuals

l) Answer to the request made by SSG-SUE on preparing methods for delivering the following information to assessment working groups in 2012:

- i) Proportion of fish larger than the mean size of first sexual maturation
- ii) Mean maximum length of fish found in research vessel surveys
- iii) 95th % percentile of the fish length distribution observed

m) Prepare a work programme to address Long Tor 3: "Develop a framework to cross-validate and integrate egg production and acoustic methods for the estimation of Spawning stock biomass and its distribution".

WGACEGG will report by 20 December 2011 (via SSGESST) for the attention of SCICOM and ACOM.

Supporting Information

Priority	The Group has high priority as it will be responsible for providing direct monitoring for two major small pelagic stocks (sardine and anchovy) in this area. These stocks are distributed across national boundaries. The most important part of its work will be to standardize, plan and analyse all the relevant surveys and to integrate these together to give the best possible advice to the WGANSA for integrated assessment purposes.
Scientific Justification and relation to Science Plan 2009–2013	Long ToRs of this WG remain unchanged since their formulation in 2007: **Long-term Terms of Reference of WGACEGG:** 1) Plan, coordinate and review acoustic and egg surveys in ICES Areas VIII and IX and standardize analysis procedures; 2) Update on innovations on sampling and estimation methods for DEPM and acoustics; 3) Develop a framework to cross-validate and integrate egg production and acoustic methods for the estimation of Spawning stock biomass and its distribution; 4) Produce an annual synoptic overview of distribution, abundance and population structure of sardine and anchovy in relation to the pelagic ecosystem for ICES areas VIII and IXa; 5) Integrate biological/environmental information from surveys and additional sources to improve the understanding of the spatial distribution and dynamics of sardine and anchovy in relation to the pelagic ecosystem in ICES Areas VIII and IXa. Concerning the adopted ICES Science Plan 2009–20013 WGACEGG is expected to contribute particularly in the first thematic area entitled Understanding Ecosystem Functioning. The Acoustic and DEPM surveys being coordinated in this group and the synoptic overview of the pelagic community of Mid Southern European waters will provide useful insights not only for the direct monitoring and assessment of anchovy and sardine, but also about the spatial distribution patterns of adults and juveniles of these and connected pelagic species and their habitats. Monitoring the status of this population (with the best standard methods and practices – Long ToRs 1) to 3), and 2011 ToR d) e) and f) and j) -, the occupation of their potential habitats (Long ToRs 4) and 5) and 2011 ToRs a-b and g-h are very relevant to the topic about Fish life-history information in support of Ecosystem Approach to Management. Habitat mapping should also contribute to the topic of the role of coastal-zone habitat in population dynamics of commercially exploited Species. The aims of Long Term 5 to integrate biological/environmental information from surveys and additional sources to improve the understanding of the spatial distribution and dynamics of sardine and anchovy in relation to the pelagic ecosystem in ICES Areas VIII and IXa should also contribute to the topic of Integration of surveys and observational technologies into operational ecosystem surveys (2011 Tor g-i)..
Resource Requirements	None
Participants	20–25

Secretariat Facilities	None
Financial	None
Linkages to Advisory Committees	ACOM
Linkages to other Committees Groups	WGANSA, WGLESP, WGFE, WGEGGS, WGFAST/WGFTFB, WGISUR
Linkages to other Organizations	Other countries/institutions applying the DEPM, or carrying out integrated acoustic-egg surveys worldwide. Linkages with mediterranean small pelagic acoustic committees (MEDIAS) are also seek. Participation in FRESH COST actions are also seek

Annex 4: Recommendations

WGACEGG 2010 Recommendations	Action
Workshop on the estimation of the spawning fraction in sardine and anchovy according to the histological examination of gonads (chaired by A. Uriarte) for two days at the beginning of WGACEGG meeting.	Contact DEPM applyiers in the Mediterranean area to attend this workshop.
Workshop on inter-calibrations of vessels (and scrutinisation of echoes; chaired by V. Marques and M. Iglesias) for two days at the beginning of WGACEGG meeting.	Contact Medias to invite interested people to attend this workshop.
Recommendation to ICES to place the manuals of standards application of DEPM and acoustic surveys in subareas VIIIc and IXa in the ICES web (publicly available; A. Uriarte). This endorses SGSIPS recommendation 3 and 4: Manuals of the different ichthyoplankton surveys should be standardized and regularly updated. These manuals should be produced as stand-alone reports accesible to anyone rather than an annex in the coordination group reports SGSIPS recommended to create a folder on the ICES website to store (ichthyoplankton) survey manuals in order to have easy access to all (ichthyoplankton) survey manuals.	PUBCOM, ICES secretariat
Investigate the influence of different vessel (acoustic inter-calibration) and fishing gears in the catchability of sardine along the survey historical series. Assess possible behaviour and/or depth distribution changes.	IPIMAR and IEO to analyse the historical data
Compare macroscopic and microscopic maturity ogives usingDEPM data. Compare maturity ogives obtained during spring acoustic surveys between IEO and IPIMAR. IPIMAR to compare maturity ogives calculated with samples from the beginning, mid and end of the spawning season.	IEO and IPIMAR to analyse the existing data
To strengthen the collaboration between WGACEGG and MEDIAS working group (DCF of the UE) in order to continue striving for a standardization and planning of acoustic surveys from Celtic sea to Aegean sea and have a global approach of the pelagic ecosystem in southeast of Europe in Atlantic and Mediterranean seas. This would include joint workshops or thematic sessions at least every two years, and promoting coordinatet studies on European sardine and anchovy Target Strengths (TS)	ICES secretariat to communicate this recommendation to SSGESST / And WGACEGG and MEDIAS Chairs to keep in contact to organize the collaboration.
To suggest to WGFAST maintaining and enriching the Target Strength ~length equation database, TSbase, within an open access framework.	Ifremer to present the Target Strength~length equation database TSbase to WGFAST ICES secretariat to pass the recommendation to WGAFAST
Next meeting and venue of WGACEGG in Barcelona from 21 to 25 November (contact I. Palomera (ICM)) Proposed New Chair for WGACEGG in 2011: Jacques Massé	ICES secretariat

Annex 5: List of Working Documents and Presentations

List of Working Documents submitted to this Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VIII and IX [WGACEGG, Palma de Mallorca, Spain, 22–26 November 2010]. Including a small abstract per WD:

Maria Manuel Angélico, Cristina Nunes, Alexandra Silva (WD 2009). Planning the 2011 Portuguese DEPM survey for sardine

The triennial DEPM for the Atlanto-Iberian sardine will take place in 2011, conducted jointly by IPIMAR, IEO and AZTI, aiming to cover the continental shelf waters from the Strait of Gibraltar to the French part of the Bay of Biscay. The plankton and adult surveying is anticipated to follow the sampling design, and the laboratory processing of the samples according to the procedures, agreed between the institutions for the previous triennial DEPM survey (WGACEGG 2007, 2009). This WD describes the planning for the Portuguese campaign that will be carried out in January/February.

Alexandra Silva, Maria Manuel Angélico, Gersom Costas, Paz Díaz, Concha Franco, Magdalena Iglesias, Ana Lago de Lanzós, Vítor Marques, Cristina Nunes, José Ramón Pérez, Isabel Riveiro, Maria Begoña Santos Eduardo Soares (WD 2009). Topics to address for the next sardine benchmark

A sardine benchmark workshop has been proposed for 2012 as a recommendation of the WGANSA, the latter being responsible to assess the progress on the benchmark preparation made up to the next assessment meeting in June 2011. A list of topics to be considered in the benchmark was elaborated (WGANSA 2010), and several ones are part of the work developed within WGACEGG. This WD aims thus to present these topics, to explain the uncertainty and problems existing for each one (including the implications for the assessment) and to make some suggestions for future work to deal with each issue, promoting the discussion within the WG.

Ramos, F., M. Iglesias, J. Miquel, D. Oñate, J. Tornero, and A. Ventero, WD2010a. Acoustic assessment and distribution of the main pelagic fish species in the ICES Subdivision IXa South during the *ECOCÁDIZ 0710* Spanish survey (July 2010).

Abstract: The present working document summarizes the main results from the Spanish acoustic (pelagic ecosystem-) survey conducted by IEO between 25 July and 1 August 2010 in the Portuguese (but with an incomplete coverage) and Spanish shelf waters (20–200 m isobaths) off the Gulf of Cadiz on-board the RV "*Cornide de Saavedra*". The survey season was coincident with the anchovy (*Engraulis encrasicolus*) peak spawning to achieve an acoustic estimate of its SSB in the study area as well. This year the surveyed area was reduced to an area limited by the waters placed between Cape Trafalgar and Cape Santa Maria. Abundance and biomass estimates are given for all the mid-sized and small pelagic fish species susceptible of being acoustically assessed according to their occurrence and abundance levels in the study area. The distribution of these species is also shown from the mapping of their backscattering energies. In the sampled area, anchovy was distributed all over the shelf of the study area with the densest concentrations being recorded over the middle-outer shelf in the westernmost area. The total biomass estimated for anchovy was 12.3

thousand tonnes (954 million fish) and sustained, as an average, by smaller anchovies than those observed the last year. Sardine (*Sardina pilchardus*) occurred all over the inner-middle shelf, in shallower waters than anchovy, and also showing the highest densities in the westernmost coastal waters of the sampled area. The species was the most important one in terms of both biomass (67 thousand tonnes) and abundance (2 thousand million fish) and showed evidences of a relatively good recruitment. Chub mackerel (*Scomber colias*) was almost absent in the shallower waters and in the whole central part of the sampled area. This species was among the species which less contributed to the total biomass and abundance of the pelagic species assemblage, with almost 3 thousand tonnes and 43 million fish only. Acoustic estimates for jack and horse-mackerel species (*Trachurus spp*.), and bogue (*Boops boops*) are also given in the WD. No acoustic estimates either for mackerel *S. scombrus* or round sardinella (*Sardinella aurita*) were computed because their incidental occurrence or even absence in the study area during the survey. Because of the problems with the acoustic sampling coverage, results from this survey are not directly comparable with those provided by IPIMAR from its *PELAGO10* spring survey, although some inferences on the most recent trends in the population levels of the main species may still be raised.

Ramos, F., M. Iglesias, J. Miquel, D. Oñate, J. Tornero, M.A. Peña, and A. Ventero, WD2010b. Acoustic assessment and distribution of anchovy and sardine juveniles in the ICES Subdivision IXa South during the *ECOCÁDIZ-RECLUTAS 1009* Spanish survey (October-November 2009).

Abstract: *ECOCÁDIZ-RECLUTAS 1009* survey is the first attempt by the IEO of acoustically assessing the abundance of anchovy and sardine juveniles in their main recruitment areas off the Gulf of Cádiz. The survey was conducted between 26 October and 5 November 2009 on-board the Spanish RV *Emma Bardán.* In order to achieve a better sampling coverage of juveniles, the acoustic sampling grid was more intensive (4 nm-spaced transects) than the adopted one in conventional surveys. Unfortunately, the initially planned survey area limits and the ship-time available (17 transects over waters shallower than 50 m depth between Tavira and Chipiona, and 11 days) showed both insufficient due to a deeper bathymetric distribution of anchovy juveniles than expected and the succession of a series of unforeseen problems which led to drastically reduce the actual sampled area to only 6 transects from the easternmost zone. Acoustic estimates from this last area are available for anchovy (2771 t, 524 million fish), sardine (25167 t, 500 millions), chub mackerel (17627 t, 152 millions) and Mediterranean horse-mackerel (17005 t, 159 millions). The abundance and biomass of age 0 anchovies in the surveyed area were estimated at 2588 t and 510 million fish, respectively, i.e. 93% and 97% of the total estimated anchovy biomass and abundance. Sardine estimates were not age-structured but the abundance and biomass of juveniles smaller than 17 cm were estimated at 3382 t and 130 millions, 13% and 26% of the total estimated species’ biomass and abundance. An approximate evaluation of the impact of the incomplete coverage of the anchovy juvenile distribution during the survey was carried out by comparison of our data with the resulting yields and location of positive fishing stations from a groundfish survey carried out just after the present survey.

Santos, M., A. Uriarte and L. Ibaibarriaga, WD2010: Spawning Stock Biomass estimates of the Bay of Biscay anchovy (*Engraulis encrasicolus, L.*) in 2010 applying the DEPM.

Abstract: The research survey BIOMAN10 for the application of the Daily Egg Production Method (DEPM) for the Bay of Biscay anchovy was conducted in May 2010 from the 5th to the 20th covering the whole spawning area of the species. Total egg production (P_{tot}) was calculated as the product of the spawning area and the daily egg production rate (P_0), which was obtained from the exponential decay mortality model fitted as a Generalized Linear Model (GLM) to the egg daily cohorts. The adult parameters, Sex Ratio, Batch Fecundity and Weight of mature females, were estimated based on the adult samples obtained during the survey and the Spawning frequency estimate was obtained as the mean from the historical series. The spawning biomass estimate resulted in **42,979 t** with a **coefficient of variation** of **15%.**

Magdalena Iglesias, Begoña Santos, Miguel Bernal, Joan Miquel, Dolores Oñate, Carmela Porteiro and Isabel Riveiro. (WD 2010). Sardine and anchovy in Galicia and Cantabrian waters: results from the Spanish spring acoustic survey Pelacus0410.

Results of the Spanish spring acoustic survey PELACUS0410 carried out from the 27 March to the 20 April gave values of 39,669 tons of sardine (539 million fish) in the northwest and northern Spanish waters. Most fish was found in south Galician waters (ICES Subareas IXa-N) and consisted of age 2 fish (fish born in 2008). Age 2 sardine also predominated in ICES Subarea VIIIcW but not in the Cantabrian Sea where older fish (age 3) were more abundant (ICES Subareas VIIIcE-w y VIIIcE-e). There has been a decrease in the abundance and biomass of sardine estimated in PELACUS0410 compared to the values obtained in previous surveys. These figures seem to indicate that the last strong sardine recruitment (2004) probably halted the stock's downward trend apparent since 2001 in Spanish waters. But there is also evidence that the effect of the 2004 recruitment in the surveyed area was not at the level of the previous strong recruitment (2000) since both biomass and abundance values are now at their lowest since 2001. Few anchovy (225 tons corresponding to 8 million fish) were detected during the survey, and occupied two separate areas: south Galicia (ICES Subareas IXa-N) and the Basque country/ French border (ICES Subarea VIIIcE-e and ICES Division VIIIb).

PELACUS0410 also obtained data on the distribution of sardine and anchovy eggs and their number in the surveyed area. Sardine eggs were found in larger quantities and over a wider area than in 2009 being closer to the coast in Galicia and more widespread over the shelf in the Cantabrian Sea. In the case of anchovy, eggs were found in very small numbers (a total of 150 eggs were found over the whole surveyed area) and mainly in the same area were the adults were detected (the border between the Basque country and French waters).

List of Presentations made to this Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VIII and IX [WGACEGG, 22 – 26 November 2010, Palma de Mallorca (Spain)].

Maria Manuel Angélico, Cristina Nunes, Alexandra Silva (WD 2009). Planning the 2011 Portuguese DEPM survey for sardine

Díaz, P., A. Lago de Lanzós, C. Franco and G. Costas. Preliminary estimates of sardine daily egg production in Spanish waters (1988–2008).

Alexandra Silva, Maria Manuel Angélico, Gersom Costas, Paz Díaz, Concha Franco, Magdalena Iglesias, Ana Lago de Lanzós, Vítor Marques, Cristina Nunes, José Ramón Pérez, Isabel Riveiro, Maria Begoña Santos Eduardo Soares (WD 2009). Topics to address for the next sardine benchmark

Ramos, F., M. Iglesias, J. Miquel, D. Oñate, and M. Millán. A first attempt of acoustically assessing the shallow waters (<20 m depth) off the Gulf of Cádiz (ICES Subdivision IXa South): results from the *ECOCÁDIZ-COSTA 0709* Spanish survey (July 2009).

Ramos, F., M. Iglesias, J. Miquel, D. Oñate, J. Tornero, M.A. Peña, and A. Ventero. Acoustic assessment and distribution of anchovy and sardine juveniles in the ICES Subdivision IXa South during the *ECOCÁDIZ-RECLUTAS 1009* Spanish survey (October-November 2009).

Ramos, F., M. Iglesias, J. Miquel, D. Oñate, J. Tornero, and A. Ventero. Acoustic assessment and distribution of the main pelagic fish species in the ICES Subdivision IXa South during the *ECOCÁDIZ 0710* Spanish survey (July 2010).

Magdalena Iglesias, Begoña Santos, Miguel Bernal, Joan Miquel, Dolores Oñate, Carmela Porteiro and Isabel Riveiro. (WD 2010). Sardine and anchovy in Galicia and Cantabrian waters: results from the Spanish spring acoustic survey Pelacus0410.

Annex 6: Protocols of acoustic surveys in spring and autumn

The acoustic methodology is used to estimate the population biomass of sardine and anchovy in the southwestern European waters (ICES Divisions VIII and IXa) both in spring and autumn surveys by the Spanish (IEO, AZTI), French (Ifremer) and the Portuguese (IPIMAR) fisheries institutions. In order to facilitate the comparability of the estimation procedures in every season-area, detailed protocols explaining the particularities of the applied methodology in each case are presented in this Annex, as well as a comparison table summarizing the main differences in the methodologies.

A.6.1 Ifremer acoustic protocol

Objectives

The main objective of PELGAS sea surveys is to assess the biomass of anchovy (*Engraulis encrasicolus*) and sardine (*Sardina pilchardus*) populations in the Bay of Biscay, based on fisheries acoustic data.

Complementary data on the whole pelagic ecosystem (hydrology, plankton, fish eggs and larvae, other fish species, seabirds and marine mammals) are also collected during the cruise.

Pelagic ecosystem overview

The Bay of Biscay is a mixed-species ecosystem where gregarious pelagic fish species form numerous small schools [Petitgas 2003]. Main pelagic species include: sardine, anchovy, sprat (*Sprattus sprattus*), Atlantic mackerel (*Scomber scombrus),* chub mackerel *(Scomber japonicus*), Atlantic horse mackerel (*Trachurus trachurus*), Mediterranean horse mackerel (*Trachurus mediterraneus*), hake (*Merluccius merluccius*) and blue whiting (*Micromesistius poutassou*).

Acoustic instrument and platform

The acoustic data are collected on-board RV "Thalassa" equipped with a Simrad ER60 echosounder operating at five frequencies: 18, 38, 70, 120 and 200 kHz (beam angles at -3 dB: 7°). The vessel is also equipped with a Simrad ME70 multibeam echosounder operated in fisheries research mode. The echosounder transducers are mounted in the vessel keel, at 6 m below the sea surface.

The ME70 multibeam echosounder is configured with 21 acoustic beams spanning 84° in the athwardship direction. The spread of steering angles through the fan was optimized for side-lobe reduction (mean two way side lobes: -83 dB). Each beam has a unique frequency in the range 70–120 kHz, the highest frequencies being in the centre, and the lowest frequencies in the outer beams to maximize the angular resolution ("Λ" configuration, [Trenkel2008#2]. Width and frequency of each beam are detailed in Table 1. Beam emission was in groups of 4 beams, yielding a blind zone extent of

Table A.6.1.1. Characteristics of ME70 acoustic beams. Steering angles are given from port (negative values) to starboard (positive values).

Beam number	Steering angle (°)	Frequency (kHz)	Beam width (°)	Side lobe level (dB)
1	-39	79	9.4	-82
2	-30	85	7.9	-82
3	-23	91	6.9	-83
4	-16	97	6.2	-83
5	-10	104	5.7	-84
6	-4	110	5.4	-84
7	1	117	5	-85
8	6	113	5.2	-84
9	11	107	5.6	-84
10	17	100	6.1	-83
11	24	94	6.7	-83
12	30	88	7.7	-82
13	39	82	9.2	-81

Acoustic measurements

The pulse length is set to 1.024 ms for all frequencies and echosounders. *In situ* on-axis calibration of the echosounders is performed before each cruise using a standard methodology [Foote1987#1479][Trenkel2008#2].

Acoustic data are acquired with the Movies+ [Weill1993] and Hermes software and archived in the international hydroacoustic data format (HAC) [ICES2005] at a -100 dB threshold.

Species identification by trawling

The identification of species and size classes comprising fish echotraces [ICES2000] heavily depends on identification via trawl hauls performed by RV "Thalassa" using a 2 doors, headline: 57 m, footrope: 52 m pelagic trawl. Echograms are scrutinized in real time and trawl hauls are performed as often as possible. Rationale for performing an identification haul includes:

- observation of numerous fish echotraces over several elementary sampling units (ESUs) or of very dense fish echotraces in one ESU;
- changes in the echotrace characteristics (morphology, density or position in the water column);
- observation of an echotrace type fished on previous transects, but never fished on the current transect.

Acoustic transects are adaptively interrupted to perform the trawl hauls and subsequently resumed. During Pelgas, the trawl stations are then conditioned on the positions of particular acoustic images that are considered to be representative of communities of echotraces during the survey [Petitgas, 2003].

Trawl catches do not allow for the identification of single schools but an ensemble of schools over several nautical miles, resulting in identifying groups of schools to species assemblages.

Since 2007 commercial pairtrawler has accompanied RV "Thalassa" during the Pelgas cruise to increase the effort devoted to echotrace identification.

Survey design

Acoustic data are collected along systematic parallel transects perpendicular to the French coast (Figure 1), from the Northern French coast to Spain. The transects are uniformly spaced every 12 nautical miles (22 km). The mean size of clusters of pelagic fish schools in the Bay of Biscay has been estimated to 8 km [Petitgas2003#299]. The inter-transect distance results from a compromise between ship time and cluster mean size.

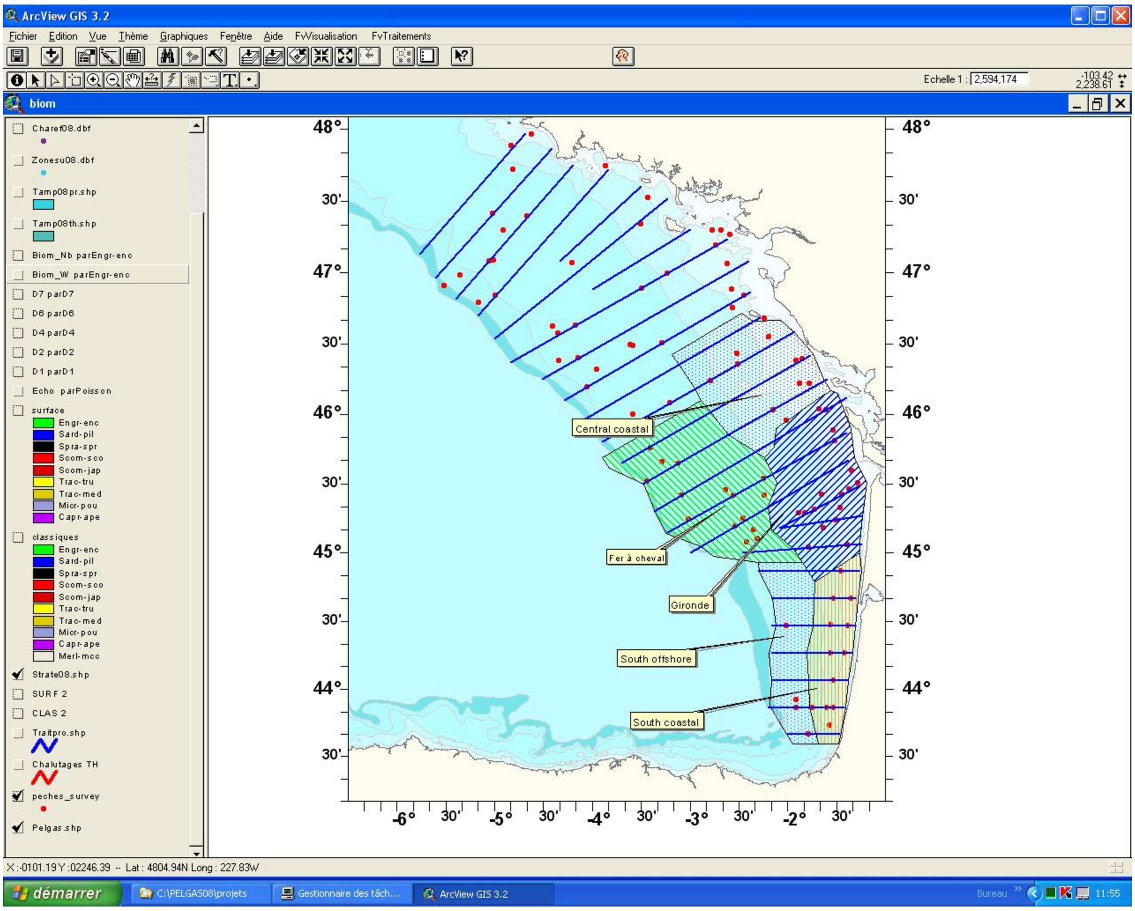

Figure A.6.1.1. Bay of Biscay map and PELGAS survey design. Blue lines: acoustic transects; red dots: trawl haul station; coloured areas: post-stratification regions.

The survey design allows for the coverage of the whole Biscay continental shelf, from 25 m depth to the shelf break (200 m depth). The nominal sailing speed is 10 knots (1 knot = 1852 $m.s^{-1}$), the speed being reduced to 2 knots on average during fishing operations. This speed allows sampling the whole Biscay shelf in about 30 days.

Acoustic fish stock biomass assessment

General framework

Acoustic biomass estimation requires the combination of data from various origins collected along the cruise track [Woillez2009#1482]. This can be viewed as the combination of three data fields: total acoustic backscatter, proportions by species and/or size class and mean length (Figure 2).

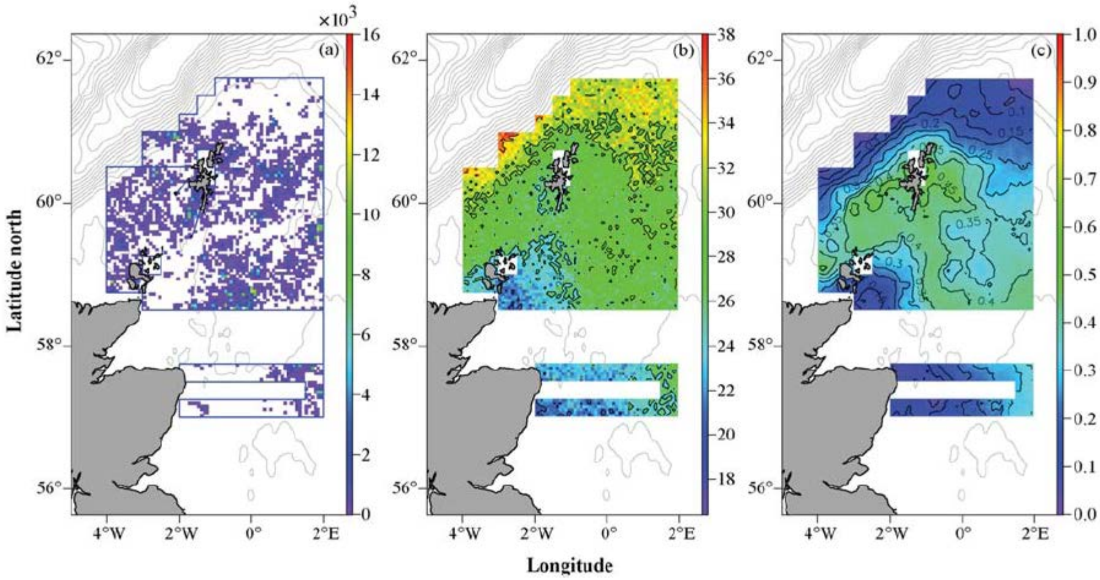

Figure A.6.1.2. Data fields required for acoustic biomass assessment of a given species: a) total fish acoustic backscatter; b) species mean length; c) proportion by species and/or size class. Red dotted line: ship track; black lines: homogeneous regions boundaries. (Adapted from Woillez *et al.* (2009)).

First, the mean density of insonified fish is usually computed for each ESU of the cruise track, and for each species and depth channel considered. This involves five main steps: [Simmonds2005]:

- <u>definition of the proportions by species from fishing data.</u>

  This can be done by: i) allocating to each ESU the proportions by species recorded in a specific "reference haul"; ii) defining regions where species/size compositions are homogeneous. Mean species/size compositions computed for each region are then applied to the ESUs comprised in the regions [Simmonds2005]; iii) computing estimates of species proportions at the nodes of a grid overlain on the survey area, using a geostatistical model (kriging, geostatistical simulation) [Gimona2003][Walline2007][Woillez2009#1482]. Modelled species proportions are then allocated to the closest ESUs.

- Partitioning of the total echo integrals between species.

  When acoustic marks can be visually allocated with good confidence to a single species, no further echo integrals partitioning is needed after the scrutinizing process.

  Conversely, when two or more species are found in mixed concentrations and their marks cannot be distinguished on the echogram, further partitioning to species level is possible by including the composition of trawl catches [Nakken1977]. Echo-integrals E_i allocated to species i then writes [Simmonds2005]:

$$E_i = \frac{w_i \langle \sigma_i \rangle}{\sum_{j=1}^{N} w_j \langle \sigma_j \rangle} E_m \qquad (1)$$

where:

w_i are expressed as the proportional number or weight of each species in the trawl catches (eventually weighted by total haul catches or mean acoustic backscatter in the vicinity of the haul(s)).

$<\sigma_i>$ is the mean backscattering cross section of the species *i*.

The mean backscattering cross section is derived from the mean target strength of one fish TS_1, as a function of its length *L*:

$$TS_1 = b_i + m_i \log(L) \qquad (2)$$

where b_i and m_i are species-specific coefficients, assumed to be known from experimental evidence. A formula for the mean backscattering cross section is:

$$\langle \sigma_i \rangle = 10^{(b_i + m_i \log(\langle L \rangle))/10} \qquad (3)$$

where $<L>$ is species *i* mean length.

b_i et m_i coefficients used for Pelgas surveys are presented in Table A.6.1.2.

Table A.6.1.2. TS coefficients used for acoustic fish biomass assessment.

Species	**Frequency (kHz)**	m_i	b_i
Engraulis encrasicolus	38	20	71.2
Sardina pilchardus	38	20	71.2
Scomber japonicus	38	20	70
Scomber scombrus	38	20	86
Sprattus sprattus	38	20	71.2
Trachurus mediterraneus	38	20	68.7
Trachurus trachurus	38	20	68.7
Micromesistius poutassou	38	20	67

- Estimation of the density of targets of species *i*, using the generic formula:

$$F_i = \frac{C_E}{\langle \sigma_i \rangle} E_i \qquad (4)$$

where:

F_i is the areal density of target of species *i*

C_E is the equipment calibration factor which is the same for all species

$<\sigma_i>$ is the mean backscattering cross section of the species *i*

- Number-weight relationships

F_i can be expressed in weight of fish per surface unit by multiplying F_i by some estimate of the overall mean weight of species *i*.

Alternatively, one can use a weight-based TS function i.e. the target strength of 1 kg of fish to compute F_i. If the mean relationship between the length *L* of a fish and its weight *W* is expressed as:

$$W = a_f L^{b_f} \qquad (5)$$

Because the number of individuals per unit weight of fish is *1/W*, the weight-based TS function writes [Simmonds2005]:

$$TS_w = \frac{TS_1}{W} = b_w + m_w \log(L) \qquad (6)$$

where:

$$b_w = b_i - 10\log(a_f) \text{ and } m_w = m_i - 10\log(b_f) \qquad (7)$$

- Abundance estimation

Areal densities of target of species i per ESU must then be raised to the total surface of the surveyed area. This implies to make some assumptions on the density of fish in areas that have not been sampled. The abundance is calculated independently for each species or category of target defined during echo-partitioning.

If geostatistical interpolation procedures (kriging, conditional simulations) have been used to estimate the total fish abundance in the surveyed area from fish densities per ESU [Rivoirard2000][Gimona2003][Walline2007][Woillez2009#1482], total abundance estimates in previously defined homogeneous regions (Figure 2) are most of the time computed by multiplying the mean fish density per ESU by the total surface of the region.

From (1) and (4), the total abundance in number Q_i of species i in an homogeneous region of surface A then writes:

$$Q_i = F_i \times A = \frac{C_E}{\sigma_i} \frac{z_i \sigma_i}{\sum_j z_j \sigma_j} E_m \times A = C_E \frac{z_i}{\sum_j z_j \sigma_j} E_m \times A = Z_i \times E_m \times A \tag{8}$$

Z_i is a region-specific weighting factor depending only on trawl catches and TS equations [Diner1983].

In the same way, the total abundance in weight Q_{w-i} of species i in an homogeneous region of surface A then writes:

$$Q_{w-i} = \langle W_i \rangle \times F_i \times A = \langle W_i \rangle \times C_E \frac{z_i}{\sum_j z_j \sigma_j} E_m \times A = X_i \times E_m \times A \tag{9}$$

Where:

$<W_i>$ is the mean weight of species i in the region

X_i is a region-specific weighting factor depending only on trawl catches and TS equations [Diner1983].

Using the weight-based TS equation (6), X_i is expressed as:

$$X_i = C_E z_i / \left(\sum_j z_j 10^{TS_{w-j}/10} \right) \tag{10}$$

Where TS_{k-j} is the weight-based mean TS of species j in the region.

<u>Ifremer's procedure for acoustic fish stock biomass assessment</u>

Biscay fish population biomass is assessed during Pelgas cruise using an "expert" methodology to combine acoustic and fishing data. This methodology is summarized in Figure 3.

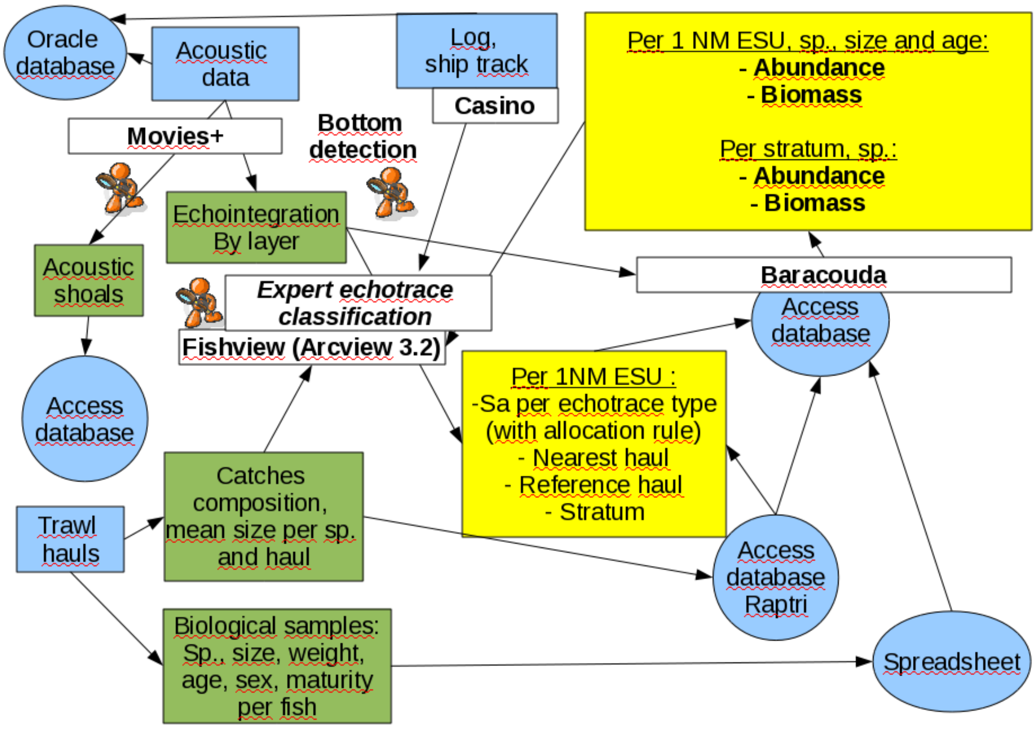

Figure A.6.1.3. Flow diagram summarizing the expert methodology used to assess fish population biomass during Pelgas. Blue rectangles: raw data; blue circles: data storage; green rectangles: preprocessed data, white rectangles: softwares; yellow rectangles: assessment results.

Acoustic data preprocessing

Only 38 kHz backscatters are used for biomass assessment. However, echograms recorded at other frequencies are often scrutinized to help isolating fish echotraces from sound-scattering layers (SSLs).

Pelagic fish are frequently scattered close to the sea surface and within the surface acoustic blind zone (0–10 m depth) at night. SSLs are also denser during night-time than at day, making fish echotrace partitioning less reliable. Only daytime acoustic data are then used for stock assessment purposes.

Echograms are first scrutinized and bottom detection errors are manually corrected. Daytime 38 kHz volume backscattering coefficients (S_v) higher than -60 dB [Petitgas1998] and recorded from 10 m depth to 150 m depth along acoustic transects are then echo-integrated in each beam over standard depth channel of 10 m thickness and averaged over 1 NM long Elementary Sampling Units (ESUs). Resulting values of Nautical area backscattering coefficients (S_A) are used in subsequent analysis.

Classification of echo integrals

Expert echogram scrutinizing is then performed to allocate echo integrals (S_A) thought to correspond to fish targets to several echotrace categories in each ESU, based on echotraces shape, density and position. Echotrace categories correspond to species or group of species found in midwater identification trawls. At least 4 categories are generally considered during a survey:

- D1: diffuse shoals or layers close to the bottom or small "drops" extending up to 10 m above the seabed. These echotypes are allocated to horse mackerel and gadoids;
- D2: schools displaying sharp edges and often high density, generally distributed up to 50 m above seabed in coastal areas and sometimes offshore. These echotypes are allocated to anchovy, sprat, sardine and mackerel;
- D3: diffuse echotraces often observed offshore all along the shelf break, allocated to a mixture of blue whiting and myctophids;
- D4: small, dense and very superficial (0–30 m depth) schools attributed to sardine, mackerel or anchovy.

Other echotype categories are adaptively defined every year (Dn) to accommodate new temporary aggregation patterns or species mixtures (e.g. when sardine forms large schools very close to the coast, or dense small superficial schools offshore).

When fish echotraces cannot be visually allocated to species, especially for diffuse, multispecies layers, echo integrals are partitioned according to the catch composition in the area.

Association of acoustic and fishing data

Selection of homogeneous regions

At large-scale, acoustic ESUs are allocated to homogeneous regions visually defined based on trawl haul composition (species and size; Figure 1). Regions are further partitioned in two depth layers for depths higher than 50 m. Fish backscatter classified into the D4 category are then allocated to the surface layer, whereas other categories are pooled in the bottom layer.

Region-averages of the trawl haul compositions are computed, by weighing the species/size compositions of the hauls performed in a region by the mean fish backscatter recorded in a 10 NM square centred on the haul position [Massé1995].

Reference hauls

A "reference haul" is manually allocated to each ESU, according to:

- Haul depth: surface hauls are exclusively applied to D4 (surface echotraces) and bottom hauls to other echotraces categories (D1, D2, Dn...) ;
- In the case of bottom hauls, the resemblance between echotraces observed in the ESU and echotraces of nearby ESUs where a trawl haul was performed.
- Size composition distributions derived from reference haul catches are generally used to compute biomass at length in the associated ESU. Catches from another haul are alternatively used if the reference haul sample size is too small.

Acoustic biomass estimates

Abundance and biomass at size per species and ESU

Fish densities per species and size class are computed for each echotype category and ESU based on:

- fish backscatters allocated to the echotype category in ESU *x*;
- the species composition and the size distribution in the reference haul associated with the ESU.

Acoustic backscatter $E_{ild}(x)$ of species *i* of mean length *l* in echotype category *d* and ESU *x*, associated with reference haul *r* writes [Diner1983]:

$$E_{ild}(x)=\frac{q_{ild}(r)\sigma_{il}(r)}{\sum_{j-1}^{N} q_{jld}(r)\sigma_{jl}(r)}E_d(x) \tag{11}$$

where:

- $q_{ild}(r)$ is the ratio of the catches of species *i* of size *l* over the total catches of the *N* species of echotype *d* in reference haul *r*;
- $E_d(x)$ is the average fish backscatter allocated to echotype category *d* in ESU *x*.
- $\sigma_{il}(r)$ is the backscattering cross section of species *i* of size *l* in the reference haul *r*.

Replacing $E_{ild}(x)$ in (4) by its expression in (11), the density of fish of size *l* and species *i* in echotype category *d* and ESU *x* associated with reference haul *r* writes:

$$F_{ild}(x)=\frac{C_E}{\sigma_{il}(r)}\frac{q_{ild}(r)\sigma_{il}(r)}{\sum_j q_{jld}(r)\sigma_{jl}(r)}E_d(x)=C_E\frac{q_{ild}(r)}{\sum_j q_{jld}(r)\sigma_{jl}(r)}E_d(x) \tag{12}$$

The total density of targets of species *i* and size *l* for each ESU is then computed as the sum of the fish densities at size *l* over all echotype categories comprising species *i:*

$$F_{il}(x)=\sum_d F_{ild}(x) \tag{13}$$

Total abundance in number and weight of fish of species *i* and class size *l* per square nautical mile are actually computed for each ESU using (8) and (9), with *A* equal to 1:

$$Q_{il}(x)=F_{il}(x) \text{ and } Q_{w\ il}(x)=F_{il}(x)\times\langle W_{il}\rangle(r) \tag{14}$$

Where $<W_{il}>(r)$ is the mean weight of species *i* of size *l* in haul *r*.

Abundance and biomass at-age per species and ESU

Size-age keys are derived from biological samples by otolith reading.

The density of fish of age *a* and species *i,* in echotype category *d* and ESU *x,* associated with reference haul *r,* then writes:

$$F_{ila}(x)=q_{ila}F_{il}(x) \tag{15}$$

where:

- q_{ila} is the proportion of fish of species *i* and age *a* in the size class *l*, according to the size-age key;
- $F_{il}(x)$ is the density of fish of species *i* and size *l* in ESU *x*.

The total density of fish of age *a* and species *i* in ESU *x* is computed as the sum of $F_{ila}(x)$ over *l*.

Total abundance and biomass estimates per square nautical miles are actually computed in each ESU for each species and age class using (8) and (9), with *A* equal to 1.

Biomass estimates per species and region

Echo-integrals allocated to each echotype category in each ESU are averaged for each homogeneous region and partitioned to species level relative to the species composition in the region's mean haul.

In each region, the estimated areal fish density $F_{i,d}$ of species *i* in echotype category *d* comprising *N* species is computed as (1)(4)[Diner1983]:

$$F_{id}=C_E \frac{w_{id}}{\sum_{j=1}^{N} w_{jd}\langle\sigma_j\rangle} E_d \tag{16}$$

where:

- C_E is an equipment calibration factor;
- E_d is the mean fish backscatter per ESU for echotype category *d* in the region;
- $\langle\sigma_i\rangle=10^{(b_i+m_i\log(\bar{L}_i))/10}$ is the mean backscattering cross section of species *i*, derived from the species mean length, in the region's mean haul and from coefficients b_i et m_i (Table 2);
- w_{id} is the weight of species *i* in the computation of the mean species composition of echotype category *d* in the region [Diner1983]:

$$w_{id}=\frac{\sum_{k=1}^{M} E_k q_{ik}/q_{dk}}{\sum_{k=1}^{M} E_k} \tag{17}$$

where:

- q_{ik} are the catches of species *i* recorded in the *M* hauls *k* performed in the region;
- q_{dk} are the total catches of the species comprised in the echotype category *d* in a haul *k* ;
- E_k is the average fish backscatter recorded in a 10 NM square centred on the position of haul *k* [Massé1995].

For each region, abundance Q_{id} and biomass $Q_{w\text{-}id}$ of species *i* in echotype category *d* are computed as:

$$Q_{id} = F_{id} \times A \text{ and } Q_{w\ id} = Q_{id} \times \bar{w}_i \quad (18)$$

where:

- *A* is the region area;
- $\bar{w}_i$ is the mean weight of species *i*, derived from biological samples.

Total density estimates for species *i* in the region is actually computed as the average of density estimates of species *i* in all echotype categories. In the same way, total abundance and biomass estimates for species *i* are computed as the sum of abundance/biomass estimates of species *i* in all echotype categories in the region.

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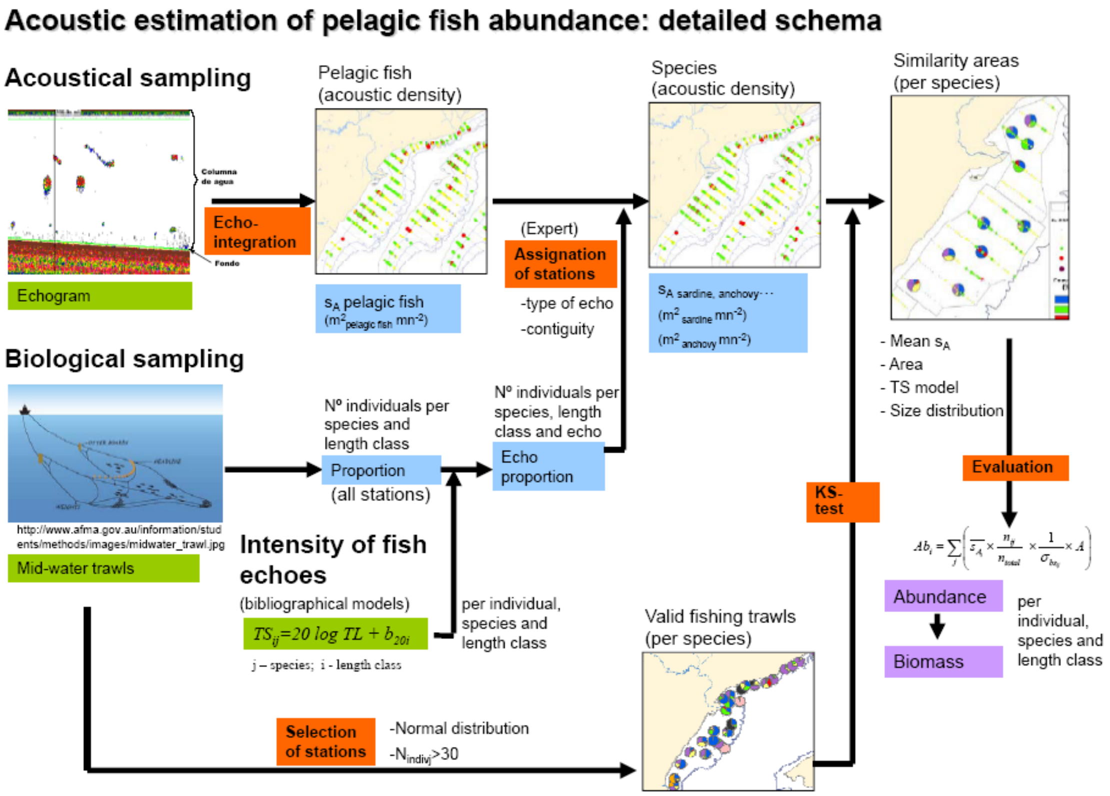
A.6.2 IEO acoustic protocol



A.6.3 IPIMAR acoustic protocol

Equipment

Simrad EK 500 de 38 KHz, split-beam transducer 8º x 7º (equivalent beam angle: 10logψ =-20.2 dB; pulse duration =1 ms), calibrated prior to the survey. With 120KHz the echosounder does not have the capacity of processing all the pings ("ping error" warning). For this reason this frequency is no longer acquired during the surveyed radials.

Data storage and pos-processing: Movies+

Netsounder: SCANMAR trawl-eye and depth sensor.

Pelagic trawl (10 m vertical opening) and bottom trawl (NTC) to identify echoes split acoustic energy and gather biological data. Opportunistic fishing.

Sample design:

Parallel systematic grid, 8 nautical miles apart (west coast), 6 nautical miles in Algarve; in Cadiz, not parallel, around 8 nm in the middle of the radials. Only day coverage.

EDSU: 1 nautical mile

Vessel speed: 9–10 knots

Vessel draft: 4 meter

Abundance estimates:

Integration EDSU: 1nmi.

Surface threshold (from transducer): 3 to 10 m, according to the weather.

Bottom threshold: 0.2 m.

Survey area divided in 4 zones: OCN (Caminha to Nazaré), OCS (Nazaré to Cape S. Vicente), ALG (S. Vicente to V. Real Sto António) and CAD (V. Real to Cape Trafalgar)

Acoustic energy splitted by trawl proportion (in number) taking into account the species TS's, if direct energy extraction is not possible

Stratification in coherent (length composition, density) areas for each species

Area density calculated by arithmetic mean.

Estimation in number of individuals, by length class, in each coherent area. The hauls are combined in this area, usually without weighting.

Biomass estimation using weight/length relationship

Estimated abundance by age groups using age/length key

The fish number (N) is obtained dividing the total acoustic fish energy in the area by the scattering energy of a single fish, which is a function of the length (L) for each species.

$$N = \frac{S_A}{<\sigma>}$$

<σ> being the mean backscattered acoustic energy of a fish with length (L)

The conversion constant (C) between acoustic energy S_A and the number of fish is:

$$C = \frac{1}{<\sigma>}$$

<σ> is obtained by back transforming the TS "Target Strength" of the species:

$$<\sigma> = \frac{10^{TS/10}}{4\pi}$$

The number of fish of length class (L) in each sector is:

$$N_L = C_i\, C_L <S_A> A$$

Being:

C_i – calibration constant (unity for the calibrated EK500)

C_L – The conversion constant from acoustic energy to number of fish of length (L)

$<S_A>$ - acoustic density in the sector (total acoustic integration divided by the number of miles surveyed in the sector.

A – Area of the sector

For sardine the conversion constant is:

C_L= 1448072 L^{-2} m^{-2} mn^{-2}

Energy splitting between species and between length classes

If S_A is the total energy of the species mixture and N_i the proportion in number of the species *i* in the fishing sample, than the acoustic energy of the species *i* (S_{Ai}) is:

$$S_{Ai} = S_A \times \frac{N_i < \sigma_i >}{\sum_i N_i < \sigma_i >}$$

$<\sigma_i>$ is the mean acoustic section (TS in linear units) of the species *i* in the sample.

For the split of acoustic energy between length classes the methodology is similar:

$$S_{Aj} = S_A \times \frac{P_j \sigma_j}{\sum_j P_j \sigma_j}$$

S_{Aj} is the acoustic energy attributed to class *j*

P_j is proportion of the length class *j* in the sample.

σ_j is the backscattering acoustic equivalent section (TS in linear units) for a fish of class *j*

Target Strength's b_{20} used (20logL - b_{20})

Sardina pilchardus (PIL): 72.6 dB

Scomber Japonicus (MAS): 68.7 dB

Scomber scombrus (MAC): 82 dB

Trachurus trachurus (HOM): 68.7 dB

Trachurus picturatus (JAA): 68.7 dB

Boops boops (BOG): 67.0 dB

Engraulis encrasicholus (ANE): 72.6 dB

Micromesistius poutassou (WHB): 80 dB

Macroramphosus spp (SNS): 80 dB

Capros aper (BOC): 80dB

Main problems:

- Old equipment (15 years old). Constraint to use only one frequency.
- Trawl net: only small pelagic trawl (8–10 m vertical opening) not able to fish efficiently pelagic targets in large depth water column (although efficient at low depth).
- Ship without enough power to drive a bigger net.
- Transducers not mounted in a stabilized platform: the echo strength fluctuates with the ship movement (mainly roll)

A.6.4 AZTI acoustic protocol

Platform

In the period from 2003 to 2004, the survey was conducted on-board single commercial fishing vessels equipped with scientific echosounders. In 2005, an additional fishing vessel was added to the survey to provide extra fishing operations. Since 2006 an oceanographic vessel, the RV "Emma Bardán", was additionally incorporated to the survey. The commercial vessels are selected by competition each year, taking into account various parameters concerning fishing efficiency, habitability and security. The commercial vessels use purse-seines and the RV "Emma Bardan" uses a pelagic trawl. The characteristics of the vessels are presented in Table A.6.4.1:

Table A.6.4.1. Characteristics of the vessels involved in the surveys, including scientific equipment and installation.

			PURSE SEINER	PELAGIC TRAWLER
Vessel	name		variable	Emma Bardán
	length		33	27
	side		8	7
	draft		3.5	4
	Acoustic instalation		pole with housing aside of the vessel	hull mounted
Equipment	Split-beam transducers (kHz)		38,120,200	38,120,200
	Multibeam		no	no
	Single beam		for visualization only	no
Fishing gear	Pelagic trawl	nº of doors		2
		vert opening		15
		Mesh size (mm)		4
	Purse seine	Depth	75	
		Perimeter	400	
		Mesh size	4	

Acoustic equipment includes split-beam echosounders Simrad EK60 (Kongsberg Simrad AS, Kongsberg, Norway). The transducers are installed looking vertically downwards, about 3 m deep, mounted at the end of a pole attached to the side of the vessel in the case of commercial fishing vessels and at the vessel hull in the case of the oceanographic vessel. Fishing operations were based only on purse seining up to 2005 but since then onwards both pelagic trawling and purse-seines are combined for species identification and biological sampling.

Data acquisition

JUVENA surveys take place annually between September and October. The sampling area includes the waters of the Bay of Biscay (being 5º W and 47º45′ N the limits). The acoustic sampling is performed during daytime, when juveniles are aggregated in schools and can be distinguished from plankton structures. The coverage is done following parallel transects spaced 17.5 (from 2003 to 2005) or 15 nautical mile (since 2006) perpendicular to the coast, taking into account the expected spatial distribution of anchovy juveniles for these dates, that is, crossing the continental shelf in their way to the coast from offshore waters (Uriarte *et al.,* 2001). Sampling starts in the Cantabrian Sea, covering it from West to East, then continues towards the North to cover the waters in front of the French Coast.

A threshold of -100 dB is applied for data collection. The water column is sampled acoustically to depths of 200 m. Acquisition quality control is established by means of several calibrations. Transducers are calibrated using the sphere method at the beginning of each survey. The SNR is estimated every three years, reading the noise levels measured by ER60 with the echosounders in passive mode at different vessel speeds. Inter-ship calibrations are conducted between the vessels in every survey since 2006. Here, the vessels sample simultaneously several nautical miles and the echointegration of the bottom and the water column echoes are compared. Also, a new calibration is being developed, to deal with the motion-induced attenuation produced by peach and roll and the boundary bubble layer below the hull, by measuring and modelling the losses at different speeds of the vessel and weather conditions.

Fish identity and population size structure is obtained from fishing hauls and echotrace characteristics.

Table A.6.4.2. Sampling strategy and acoustic configuration of the equipment.

	Inter transect distance (n.mi.)	15 – 17.5
Sampling design	vessel speed (knutt)	7 - 9
	fixed/adaptive coverage	Adaptive length of transects
Acoustic configuration	Main frequency (kHz)	38
	Puse length (ms)	1.024
	Power 18 kHz (W)	-
	Power 38 kHz (W)	1200
	Power 70 kHz (W)	-
	Power 120 kHz (W)	250
	Power 200 kHz (W)	210
	Threshold (dB)	default
	Ping rate (s)	0.25–0.5
	Range (m)	200
Calibrations	Sphere	at the beginning of the survey
	SNR at different speeds	every 3 years
	Intership comparison	every survey
	Motion induced attenuation	in test phase

Abundance estimations

During the survey, each fishing haul is classified to species and a random sample of each species is measured to produce length frequencies (in classes of 0.5 cm for anchovy and sardine, and 1 cm for the rest of the species) of the communities. A complete biological sampling is performed of the anchovy samples in order to analyse biological parameters of the population, as the age, size or size-weight ratio.

The hauls are grouped by strata of homogeneous species and size composition. The spatial limits of the strata are determined by visual inspection of the echograms. The composition by size and species of each homogeneous stratum is represented by a virtual haul obtained averaging the composition (percentage of individuals) of the hauls contained in the stratum, weighted to the acoustic energy in the vicinity (2 nautical mile diameter) of each haul.

Thus, given a homogeneous stratum with M hauls, if E_k is the mean acoustic energy in the vicinity of the haul k, w_i, the proportion of individuals each species i in the total capture of the stratum, is calculated as follows:

$$w_i = \sum_j w_{ij} = \sum_j \left(\frac{\sum_{k=1}^{M} \left(q_{ijk} \cdot E_k / Q_k \right)}{\sum_{k=1}^{M} E_k} \right).$$

Being q_{ijk} the quantity (in numbers) of species i and length j in the haul k; and Q_k, the total quantity of any species and size in the haul k.

The visual scrutiny is used also to clean the echograms, that is, inspect the proper detection of the bottom echo and remove noise from bubbles, double echoes and plankton. Then, acoustic data processing is performed by layer echo-integration by 0.1 nautical mile (185.6 m) using Movies+ software (Ifremer, France). Echointegration is done only on the strata positive of anchovy. The water column echoes, thresholded to -60 dB, are integrated into six depth channels: 5–15 m, 15–25 m, 25–35 m, 35–45 m, 45–70 m, 70–120 m and 120–200 m.

Inside each homogeneous stratum, the echo integrals, or NASC, are converted to biomass, using the echointegration conversion factor for mixture of species. Thus, let s_A be echo integral, the mean value in each homogeneous stratum, $E_m = \langle s_A \rangle$, is converted to total numbers of the mixture of species by:

$$N_T = \frac{E_m \cdot A}{4\pi \left(\sum_i w_i \langle \sigma_i \rangle \right)}$$

The conversion factor is based in the scattering cross section of each species. Each fish species has a different acoustic response, defined by its scattering cross section, which measures the amount of the acoustic energy incident to the target that is scattered backwards in the incident direction. This scattering cross section depends upon the species i and the size of the target j, according to:

$$\sigma_{ij} = 10^{TS_j/10} = 10^{\{(b_i + a_i \log L_j)/10\}}$$

Here, L_j represents the size class, and the constants a_i and b_i are determined empirically for each species. In fisheries acoustics it is a common assumption to use a value of 20 for a_i for all the species. For anchovy, we use b_{20} vale of -72.6 dB leaving to the following TS-length relationship:

$$TS_j = -72.6 + 20 \log L_j$$

In order to distinguish their own contribution, anchovy juveniles and adults are separated and treated as different species. Thus, the proportion of anchovy in the hauls of each stratum (w_{ij}) is multiplied by a age–length key to separate the proportion of adults and juveniles. Then, separated w_i are obtained for each group.

The b_{20} values for the rest of the species are presented in the following table:

Table A.6.4.3. b_{20} values of the main species considered in the data processing.

ANE	*Engraulis encrasicholus*	Clupeidae	-72.6
PIL	*Sardina pilchardus*	Clupeidae	-72.6
SPR	*Sprattus spratus*	Clupeidae	-72.6
HOM	*Trachurus trachurus*	carangidae	-68.7
HMM	*Trachurus mediterraneus*	carangidae	-68.7
MAC	*Scomber scombrus*	scombridae	-88
MAS	*Scomber Japonicus*	scombridae	-68.7
BON	*sarda sarda*	scombridae	-68.7
SAU	*scomberesox saurus*	belonidae	-67
GAR	*Belone belone*	belonidae	-67
BOG	*Boops boops*	sparidae	-67
BRB	*Spondyliosoma cantharus*	sparidae	-67
WHB	*micromesistus pautassous*	gadidae	-67
BIB	*Trisopterus luscus*	gadidae	-67
HKE	*Merluccius merluccius*	gadidae	-67
Others	*Others*		-67

Inside each homogeneous stratum, the mean scattering cross section is defined for each species, by means of the size distribution of such species obtained in the hauls of the stratum:

$$\langle \sigma_i \rangle = \frac{\sum_j w_{ij} \sigma_{ij}}{w_i} .$$

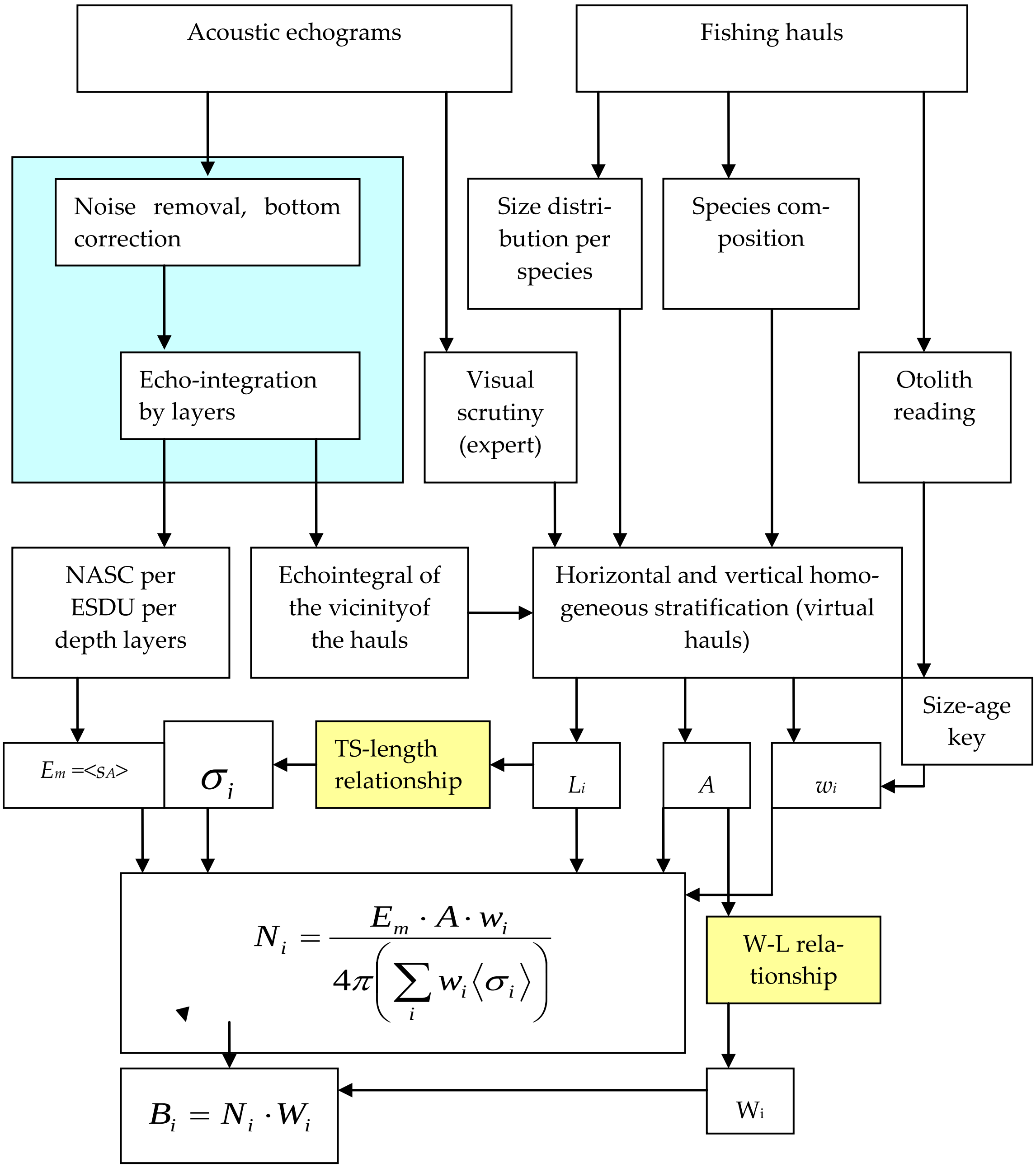
Given the total number of fish in the stratum, the numbers of each species are obtained multiplying by the proportion in numbers of each species in the virtual haul w_i:

$$N_i = N_T \cdot w_i$$

The biomass is obtained by multiplying Ni times the mean weight $< W_i >$, which is calculated using a global size-length ratio:

$$< W_i >= a \cdot < L_i >^b$$

Table A.6.4.4. Synoptic scheme of the whole data processing procedure.



A.6.5 Comparison tables

Table A.6.5.1. TS species.

	SPECIES	FAM	AZTI	IEO	IFREMER	IPIMAR
ANE	*Engraulis encrasicholus*	Clupeidae	-72.6	-72.6	-71.2	-72.6
PIL	*Sardina pilchardus*	Clupeidae	-72.6	-72.6	-71.2	-72.6
SPR	*Sprattus spratus*	Clupeidae	-72.6	-72.6	-71.2	-72.6
HOM	*Trachurus trachurus*	carangidae	-68.7	-68.7	-68.5	-68.7
HMM	*Trachurus mediterraneus*	carangidae	-68.7	-68.7	-68.5	-68.7
MAC	*Scomber scombrus*	scombridae	-88	-84.9	-82	-82
MAS	*Scomber Japonicus*	scombridae	-68.7	-68.7	-68.7	-68.7
BON	*sarda sarda*	scombridae	-68.7		-68.7	-
SAU	*scomberesox saurus*	belonidae	-67		-67	-
GAR	*Belone belone*	belonidae	-67		-67	-
BOG	*Boops boops*	sparidae	-67	-67	-67	-67
BRB	*Spondyliosoma cantharus*	sparidae	-67		-67	-
WHB	*micromesistus pautassous*	gadidae	-67	-67.5	-67	-80
BIB	*Trisopterus luscus*	gadidae	-67		-67	-
HKE	*Merluccius merluccius*	gadidae	-67	-67	-67	-
	Macroramphosus spp			-84.9		
BOC	*Capros aper*	caproidae	-	-84.9	NA	-80
WEG	*Trachinus draco*	trachinidae	-		NA	-
BSS	*Dicentrarchus labrax*	serranidae	-		NA	-
SQR	*Loligo vulgaris*	Cephalopoda	-		NA	-
LXX	*Benthosema gladidae*	myctophidae	-		NA	-
JEL	*Rhopilema spp*	SCYPHOZOA	-		NA	-
SPX	*Salpidae*	THALIACEA	-		NA	-
Others	*Others*		-		-67	

Table A.6.5.2. Platform.

			AZTI_PURSE	AZTI_PEL	IEO_N	IEO_S	IFREMER	IPIMAR
VESSEL	name		variable	Emma Bardán	Thalassa	Cornide Saavedra	Thalassa	Noruega
	length		33	27	73.65	66.7	73.65	47.5
	side		8	7	14.9	11.3	14.9	10
	draft		3.5	4	6.15	5	6.15	4.5
	Acoustic installation		side perch	hull	hull	hull	hull	hull
EQUIPMENT	Split-beam transducers (kHz)		38,120,200	38,120,200	18, 38, 70, 120, 200	18,38,70, 120,200	12, 18, 38, 70, 120, 200	38
	Multi-beam		no	no	X	no	X	no
	Single beam		visualization	no	49		49	120
FISHING GEAR	Pelagic trawl	nº of doors		2	2	2	2	2
		vert opening		15	10 - 15 (57/52)	10	10 - 15 (57/52)	10
					20 - 25 (76/70)	14–15	20 - 25 (76/70)	20
					-	18–20	-	NCT
		Mesh size (mm)		4	12	20	12	NCT
	Bottom trawl	Head-line	-		57		57	20
		Foot-rope	-		52		52	-
		Mesh size (mm)	-		4		4	-
	Purse seine	Depth	75					-
		Perimeter	400					
		Mesh size	4					

Table A.6.5.3. Data acquisition procedure.

		AZTI	IEO_N	IEO_S	IFREMER	IPIMAR
SAMPLING DESIGN	inter transect distance (n.mi.)	15	8	8	12	8
	vessel speed (knutt)	7 - 9	10	10	10	9–10
	fixed/adaptive coverage	adaptive	fixed	fixed	fixed	fixed
ACOUSTIC CONFIGURATION	Main frequency (kHz)	38	38	38	38	38
	Puse length (ms)	1.024	1.024	1.024	1	1
	Power 18 kHz (W)	-	2000	2000	2000 / 11	
	Power 38 kHz (W)	1200	2000	2000	2000 / 7	2000
	Power 70 kHz (W)	-	600	600	600 / 7	
	Power 120 kHz (W)	250	200	200	200 / 7	1000
	Power 200 kHz (W)	210	90	90	90 / 7	
	Threshold (dB)	default	no	no	-120	-70
	Ping rate (s)	0.25–0.5	0.2–1	max	0.2–1	1
	Range (m)	200	250	250	400	
CALIBRATIONS	Sphere	at the beginning of the survey	at the beggining if possible	at the beggining if possible	at the beginning or end of the survey	at the beginning of the survey
	SNR at different speeds	every 3 years	no	yes	no	
	Intership comparison	every survey	yes	no	no	
	Motion induced attenuation	in test phase			noise measurements	

Table A.6.5.4. Data processing.

		AZTI	IEO_N	IEO_S	IFREMER	IPIMAR
PRE-PROCESSING	software	Movies+	SonarDataEchoview	SonarDataEchoview	Movies+	Movies+
	correct bottom detection	autom. inspection / manual correction	autom. inspection / manual correction	autom. inspection / manual correction	autom. inspection / manual correction	autom. inspection / manual correction
	remove noise	manually	manually	manually	manually	manually
	remove plankton	manually	manually	manually	manually	manually
	multyfrequency based group classification	not yet	not systematically	not systematically	not systematically	not yet
ECHO INTEGRATION	by schools	not yet	yes	yes	yes (-60 to -50 dB threshold)	not yet
	by layers	yes	yes	yes	yes	yes
	ESDU length (n.mi.)	0.1	1	1	1	1
	Threshold (dB)	-60 to -55	-60	-60	-60	-60 to -55
SPECIES ASIGNATION	expert (echogram interpretation and species composition)	yes	yes	yes	yes	yes
	reference haul	occasionall y			for distribution along-transect	usually
	strata (virtual-combined haul)	mainly			yes	occasionall y
	averaging hauls	weighted to acoustic energy			weighted to acoustic energy	usually non weighted
	nearest haul	no			for length distribution	
SPECIES ASIGNATION	strata - virtual hauls	mainly	mainly	mainly	when pure species visual identification	mainly
	nearest haul	no			no	

Annex 7: DEPM general common methods: sampling and processing

The Daily Egg Production Method is used to estimate the population spawning biomass of both sardine and anchovy in the Iberian Peninsula (ICES Divisions VIIIc and IXa) by the Spanish (IEO, AZTI) and the Portuguese (IPIMAR) fisheries institutions. The sardine DEPM was started in 1988 by IEO and IPIMAR, then was repeated in 1990 only by the IEO and jointly again in 1997 and subsequently triennially since 1999, covering by IEO and IPIMAR all the Iberian Peninsula. The current Bay of Biscay anchovy DEPM surveys have been carried out annually since 1988 by AZTI (Santiago and Sanz, 1992, Motos *et al*., 2005, Somarakis *et al*., 2004), while the Gulf of Cadiz anchovy DEPM surveys have been carried out triennially since 2005 (ICES 2009). Sampling design and methodology was further standardized in 2002 to coordinate both the sampling methodology and the common analyses of the data collected.

The DEPM survey targeting the Atlantic Iberian sardine covers the area from the Gulf of Cadiz to the inner part of the Bay of Biscay (sardine Atlantic-Iberian stock). The region on the Gulf of Cadiz to the Northern Portugal/Spain border (River Minho) is surveyed by IPIMAR in January-February, while IEO covers the North-western and North Iberian Peninsula and part of the Bay of Biscay (from 42°N to 45°N) in April. For 2008 an extra sampling was considered by inclusion of information for sardine collected during AZTI´s Anchovy DEPM survey in the northern part of subarea VIII. Since 2011, the sardine triennial DEPM survey of all subarea VIII is being covered by the collaboration between IEO (up to 45ºN) and AZTI (up to 48ºN).

The DEPM surveys targeting anchovy for the Bay of Biscay (ICES Divisions VIIIa,b,c) and the Gulf of Cadiz (ICES Division IXa) cover both the Spanish eastern Cantabrian Sea and the Atlantic French coast (from 43ºN to 48ºN and from the French coast to 5ºW) surveyed by AZTI in May and the Gulf of Cadiz continental shelf (from Cape Trafalgar to Cape São Vicente) surveyed by IEO in July. These surveys cover the main spawning grounds of the Bay of Biscay and Gulf of Cadiz anchovy stocks.

Egg sampling and processing

The main ichthyoplankton sampler is the PAIROVET (double CalVET - Smith *et al*., 1985) net, with the auxiliary use of the Continuous Underway Fish Egg Sampler (CUFES, Checkley *et al*., 1997) for adaptive decisions in order to delimit the spawning area and to modify adaptively the intensity of the PAIROVET sampling. The DEPM surveys perform ichthyoplankton sampling on fixed stations with a PAIROVET, using a net with 150 µm mesh size and fitted with flowmeters, operating vertically (1 m/s) to the surface from 5 m above the bottom to a maximum sampling depth of 100 m, or 150 m, in the IPIMAR survey. The CUFES is equipped with a 335 µm mesh size net, operating horizontally at 3 or 5 m depth. Both samplers are used on a sampling grid consisting of fixed transects perpendicular to the coast and spaced 8 nm (in the case of the AZTI surveys transects are spaced 15 nm or 7nm in areas of high abundances of egg). The inshore limit of the transects is determined by bottom depth (as close to shore as possible) while the offshore extension is decided adaptively (based on the presence of eggs) but always covering the extension of the platform to the 200 m isobath. The sampling protocol agreed by the ICES Working Group on Acoustic and Eggs (WGACEGG) can be summarized as follows:

- CUFES samples (ongoing) are taken every 3 nm throughout a transect (AZTI, splitting them in two, for every 1.5 nm).

- PAIROVET samples are always taken every 3 nm in the inner shelf (~100m depth; down to 100 m towing depth - IEO and AZTI- or to 150 m , IPIMAR).
- PAIROVET samples are taken every 3 nm or 6 nm beyond the inner shelf, depending on the results of the most recent CUFES sample, collected every 3 nm (1.5 nm in the case of the AZTI survey) to allow for time to look at the sample before reaching the next grid position. When an ongoing CUFES is negative for sardine or anchovy egg presence, the following PAIROVET, at 3 nm, is skipped.
- The outer limit of a transect is reached when two consecutive CUFES samples (of 3 nm spaced; for AZTI when three consecutive samples of 1.5 nm) are negative beyond the 200 m depth isobath, (or at the 200 m isobath in the case of IEO).
- When finishing a transect offshore the vessel should proceed to the next transect and carries out CUFES sampling on the inter-transect distance to check for egg presence. When eggs are found sampling should be extended offshore in the next transect. If no eggs are found, sampling starts (always) with a PAIROVET at a point at the same latitude or longitude or equal distance from the isobath, depending on transect orientation, and then continue from there towards the shore using the sampling criteria defined above.
- Whenever a towing angle deviates from the vertical more than 30º the sample should be discarded and the haul repeated.

In order to obtain temperature, salinity and depth profiles at every station, the PAIROVET sampler include a CTD (+ fluorometer, when available). Also, the CUFES has a coupled CT (thermosalinometer) and fluorometer sensors that continuously register surface temperature, salinity and fluorescence (at 3 or 5 m depth depending on vessel used) on the transects.

After hauling, nets are washed from the outside with seawater under pressure and plankton samples from the two codend are preserved in buffered formaldehyde at 4% (Sodium Tetra borate or Sodium Acetate). Samples are then sorted, and sardine and anchovy eggs are identified and counted (in some cases at sea as for IEO and AZTI). Once at the laboratory anchovy eggs are staged following the 11-stage development scale of Moser and Alshtrom (1985) while sardine eggs are staged following the 11-stage scale of Gamulin and Hure (1955). In the case of the IEO surveys, only samples from one codend are sorted, samples from the second codend are used for plankton biomass quantification.

Date, time, position (GPS), flowmeter readings, cable released and its angle and sampling and bottom depth data are registered.

Table 1 summarizes the main characteristics of the sardine and anchovy DEPM surveys. The methodology adopted for the sardine and anchovy egg data follows the general plan agreed for previous surveys (cf. ICES, 2005, 2006 and 2007).

Estimation of the Total Egg Production (P_{tot}) and area calculation (A)

The total area (A) is calculated as the sum of the area represented by each station. The spawning area (A+) is delimited with the outer zero sardine/anchovy egg stations. It may sometimes contain a few inner zero egg stations embedded on it (Picquelle and

Stauffer, 1985). The spawning area is calculated as the sum of the area represented by those stations.

The eggs staged in the laboratory are transformed into daily cohort abundances using a multinomial egg ages model (Bayesian ageing method, Bernal 2007). The Bayesian ageing method requires a probability function of spawning time. Distribution has been assumed with peak of spawning activity at 21:00 GMT for sardine and at 23:00 GMT for anchovy. Daily egg production (P0) and mortality (z) rates are estimated by fitting an exponential mortality model to the egg abundance by cohorts and corresponding mean age:

$$E[P] = P_0 \, e^{-Z \, age}$$

The model is fitted as a generalized linear model (GLM) with negative binomial distribution and log link.

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

$$P_{tot} = P_0 \cdot A+$$

All calculations are undertaken using packages and routines developed in R and freely available at project *ichthyoanalysis* (http://sourceforge.net/projects/ichthyoanalysis). For anchovy in the Bay of Biscay another specific script with some differences is used.

Table 2 summarizes the methodology adopted for the sardine and anchovy egg data follows the general plan agreed for previous Working Groups (ICES, 2005, 2006 and 2007).

Table 1 Common General Sampling.

	SARDINE		ANCHOVY	
DEPM	PORTUGAL (IPIMAR)	SPAIN (IEO)	SPAIN (AZTI)	SPAIN (IEO)
SURVEY AREA	Portugal and Gulf of Cadiz (36º-42ºN, 6º-10ºW)	NW and N Spain and Bay of Biscay (42º-45ºN,1º-10ºW)	Eastern Cantabrian Sea and Bay of Biscay (43º- 48ºN, 5º-1ºW)	Gulf of Cadiz (36º-37ºN, 6º-9ºW)
Sampling grid (nm)	8x3	8x3	15x3	8x3
PairoVET nets	2	1	2	1
Sampling maximum depth (m)	150	100	100	100
Hydrographic sensor	CTDF (FSI)	CTD (Seabird37) CTD SBE25	CTD (RBR)	CTD SBE25 CTD SBE37
Flowmeter	Y	Y	Y	Y
Clinometers	Y	Y	N	N
CUFES, mesh 335µm	3 nm (sample unit)	3 nm (sample unit)	1.5 nm (sample unit)	3 nm (sample unit)
Environmental data	Fluorescence, Temp, Salinity	Fluorescence (surface only), Temp, Salinity	Fluorescence, Temp, Salinity	Fluorescence (surface only), Temp, Salinity

Table 2. Processing and analyses for eggs.

DEPM	SARDINE Portugal (IPIMAR)	 Spain (IEO)	 Spain (AZTI)	ANCHOVY Spain (AZTI)	 Spain (IEO)
EGGS					
Number of Eggs staged	All	All	Subsampling up to a max. of 75 eggs if necessay	Subsampling up to a max. of 75 eggs if necessay	all
Classification of stages according to	Gamulin and Hure, (1955)	Gamulin and Hure, (1955)	Gamulin and Hure, (1955)	Moser and Alshtrom (1985)	Moser and Alshtrom (1985)
Depth of reference for egg incubation Temperature	Surface (continuous underway CTF)	10 m	10 m	10 m	5 m
Peak spawning hour	21:00	21:00	21:00	23:00	23:00
Egg ageing procedure	Bayesian (Bernal 2007)	Bayesian (Bernal 2007)	Bayesian (Bernal 2007)	Bayesian (Bernal 2007)	Bayesian (Bernal 2007)
Egg Production estimation	GLM (and GAMs available)	GLM (and GAMs available)	GLM (and GAMs available)	GLM (and GAMs available)	GLM (and GAMs available)

Adults sampling and processing

During the DEPM survey, fishing hauls are undertaken for the estimation of the adult parameters (sex ratio, female weight, batch fecundity and spawning fraction) within the mature component of the population. Hereafter follows a brief description of the sampling, laboratory analysis and estimation procedures used for adults, also summarized in Table 3, following the methodology agreed in previous WG meetings (e.g. ICES 2008).

Fishing hauls are conducted by pelagic or bottom-trawling following the species schools detection by the echosounder. The number of samples and its spatial distribution is organized to ensure a good and homogeneous coverage of the survey area. In the Portuguese survey, the samples collected by the RV are complemented with samples obtained from the commercial purse-seine fleet at the main landing harbours, ideally within a week of the surveying by the RV in each area.

On-board the RV, and for each haul, a minimum of 60 sardines or anchovy are randomly selected and biologically sampled (length, total weight, gutted weight, sex, macroscopic maturity stage). The objective is to obtain 25–30 mature females. These can also be complemented by additional fish (maximum 160) from the same haul in order to achieve that minimum of 25–30 mature females for histology. Moreover, otoliths are extracted to obtain the age composition per sample (only from females in the case of IPIMAR). From the same haul extra hydrated females for the fecundity estimations can also be obtained. For the first 25–30 females (of all macroscopic maturity stages) of the sample, the gonads are immediately collected and preserved in formaldehyde solution (4% in distilled or tap water, buffered with Sodium phosphate salts) for posterior weighting and histological processing at the laboratory. The biological sampling and ovaries fixation are always carried out in fresh material, with the exception of some of the commercial samples obtained from the Portuguese purse-seines in case the biological sampling is impractical to perform on the fresh material immediately or within a few hours after fishing: in this case, immediately after the fish landing, the abdomen of each fish sampled is slightly opened, the two lobes of the gonad are removed and immediately preserved in formaldehyde solution for histology; the remaining body of the fish is frozen for posterior complete biological sampling in laboratory, the correct total body weight of the fish taking into account the weight of the removed lobes of the gonad.

The preserved ovaries are weighted in laboratory (before being transferred to ethanol 70º, in case they are) and the obtained weights corrected by a conversion factor (between fresh and formaldehyde fixed material) established previously. These ovaries are then processed for histology: they are embedded in either resin (IEO, AZTI) or paraffin (IPIMAR), the histological sections (3–5 µm) are stained with haematoxylin and eosin, and the slides examined and scored for their maturity stage (based in the most advanced batch of oocytes and atresia intensity: Hunter and Macewicz 1985, WD Alday *et al*., 2010, Ganias *et al*., 2004), POF presence and POF age assignment to daily cohorts (Hunter and Macewicz 1985, Pérez *et al*., 1992a, Ganias *et al*., 2007, Alday *et al*., 2008). Prior to fecundity estimation, hydrated ovaries are also processed histologically in order to check for POF presence and thus avoid underestimating fecundity (Hunter *et al*., 1985, Pérez *et al*., 1992b). The individual batch fecundity is then measured, by means of the gravimetric method applied to the hydrated oocytes, on 1–3 whole mount subsamples per ovary, weighting on average 50–150 mg (Hunter *et al*., 1985).

The adult parameters estimated for each fishing haul considers only the mature fraction of the population (determined by the fish macroscopic maturity data). The estimation of the sex ratio, the mean female weight and the mean female expected batch fecundity is based on the biological data collected from both survey and commercial samples, whereas the preserved gonads are used to measure the individual batch fecundity, to assess the mature/immature condition of females and to estimate the daily spawning fraction.

Before the estimation of the mean female weight per haul (**W**), the individual total weight of the hydrated females is corrected by a linear regression between the total weight of non-hydrated females and their corresponding gonad-free weight (Wnov).

The **sex ratio (R)** in weight per haul is obtained as the quotient between the total weight of females on the total weight of males and females, but for anchovy in the Bay of Biscay given the constancy of this parameter, since 1994 the proportion of mature females per sample is being assumed to be equal to 1:1 in numbers. This implies to adopt as R the mean value of the ratio between the average female weight and the sum of the average female and male weights of the anchovies by samples.

The expected individual **batch fecundity (F)** for all mature females (hydrated and non-hydrated) is estimated by the hydrated egg method (Hunter *et al*., 1985), i.e. by modelling the individual batch fecundity observed (Fobs) in the sample of hydrated females and their gonad-free weight (Wnov) by a GLM and applying this subsequently to all mature females. For anchovy subsampling of the hydrated ovary is made by selecting three pieces of approximately 50 mg from different parts of each ovary, (Sanz and Uriarte (1989).

For sardine (as for anchovy in the past), the **spawning fraction (S)**, the fraction of females spawning per day is determined, for each haul, as the average number of females with Day-1 or Day-2 POF (divided by the total number of mature females. The hydrated females are not included due to possible over-sampling of active spawning females close to the peak spawning time. (Santiago and Sanz 1992, Bernal 2007). In this case, the number of females with Day-0 POF (of the mature females) is corrected by the average number of females with Day-1 or Day-2 POF (Picquelle and Stauffer 1985, Pérez *et al*., 1992a, Motos 1994, Ganias *et al*., 2007). For anchovy, however this procedure is being totally revised nowadays and current practice estimates S as the average fraction of Day-0 (in prespawning condition or just after spawning) and Day-1 POF among the mature females (without any correction; Uriarte *et al*., in press). Nevertheless this change has not yet been incorporated in the estimates and recent estimates of spawning fraction for anchovy were taken just as the average of the past historical series produced with the old procedure described before. Once the change is fully incorporated the whole historical series of S and Biomass will change and this methodological annex will be accordingly changed.

The mean and variance of the adult parameters for all the samples collected is then obtained using the methodology from Picquelle and Stauffer (1985) for cluster sampling (weighted means and variances). In the case of IEO and IPIMAR, all estimations and statistical analysis are performed using the R software (http://www.R-project.org); in the case of AZTI the calculations are made using an Excel workbook.

In addition, **population in numbers at-age** are produced for anchovy in the Bay of Biscay (see Uriarte 2001), making use of the age readings available from otoliths from the adult samples collected during the survey. Estimates of anchovy mean weights and proportions at-age in the adult population are computed as a weighted average of the mean weight and age composition per samples, where the weighting factors are proportional to the population (in numbers) in different sub-stratums. These weighting factors are calculated according to the relative egg abundance and to the amount of samples in the sub-stratums defined for the proposed of the estimation of the numbers at-age. These strata are defined each year depending on the distribution of the adult samples i.e. size, weight, age and the distribution of the anchovy eggs.

Mean and variance of the adult parameters for the Population in numbers at-age and the Population length distribution (total weight, proportion by ages and length distribution) are estimated following equations 4 and 5 for cluster sampling from Picquelle and Stauffer (1985).

Table 3. General sampling, samples processing and data analyses for adults.

DEPM Survey Adults	Sardine		Anchovy	
	Portugal (IPIMAR)	Spain (IEO)	Spain (AZTI)	Spain (IEO)
Survey area	Portugal and Gulf of Cadiz (~36–42ºN)	NW and N Spain and Bay of Biscay (9.5ºW - 42–45ºN)	Eastern Cantabrian Sea and Bay of Biscay (5ºW 43- 48ºN)	Gulf of Cádiz (36º18′-36º75′N –6º22′–8º92′W)
Common General Sampling				
Gears	Pelagic and Bottom trawl, purse-seiner	Pelagic trawl	Pelagic trawl purse-seiner	Pelagic trawl
Trawls time	During the whole day	During the whole day	During the whole day	During the day hours
Biological sampling:	On fresh material, on-board of the RV and on frozen for commercial; gonads fresh	On fresh material, on-board of the RV	On fresh material, on-board the RV and in formalin for commercials	On fresh material, on-board of the RV
Sample size	60 indiv. randomly (30 female minimum); extra if needed and if hydrated found	60 indiv. randomly minimum (30 mature female); extra if needed and if hydrated found	60 indiv. randomly minimum (25 mature female); extra if needed and if hydrated found	60 indiv. randomly minimum (30 mature female); extra if needed and if hydrated found
Fixation	Buffered formaldehyde 4% (distilled water)	Buffered formaldehyde 4% (distilled water)	Buffered formaldehyde 4% (tap water)	Buffered formaldehyde 4% (distilled water)
Preservation	Formalin	Formalin	Formalin	No
Samples Processing and Data Analyses				
Histology: Embedding material and Staining	- Paraffin - Haematoxilin-Eosin	- Resin - Haematoxilin-Eosin	- Resin - Haematoxilin-Eosin	- Resin - Haematoxilin-Eosin
W estimation	Weight of hydrated females corrected previous to estimation	Weight of hydrated females corrected previous to estimation	Weight of hydrated females corrected previous to estimation	Weight of hydrated females corrected previous to estimation
R estimation	The observed weight fraction of the females	The observed weight fraction of the females	Theoretical expected values assumed to be equal to 1:1 in numbers checked with observed	The observed weight fraction of the females

DEPM SURVEY ADULTS	SARDINE		ANCHOVY	
	PORTUGAL (IPIMAR)	SPAIN (IEO)	SPAIN (AZTI)	SPAIN (IEO)
S estimation	Day 1 and Day 2 POFs (according to Pérez *et al*., 1992a and Ganias *et al*., 2007)	Day 1 and Day 2 POFs (according to Pérez *et al*., 1992a and Ganias *et al*., 2007)	A model based on the historical series between S and SST (and since 2010 the historical mean; Parameter being revised)	Day 1 and Day 2 POFs
F estimation	On hydrated females (without POFs), according to Pérez *et al*. 1992b and Ganias *et al*. 2010	On hydrated females (without POFs), according to Pérez *et al*. 1992b	On hydrated females (without POFs), according to Hunter *et al*. (1985)	On hydrated females (without POFs), according to Hunter *et al*. 1985

References to Annex 7

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