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

17-21 November 2014

Vigo, Spain

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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 VII, VIII and IX (previously ICES Areas VIII and IX), met in Vigo, Spain, from 17–21 November 2014. As every two years, in 2014 also MEDIAS members were invited to participate at the WGACEGG meeting; this practice, which was framed in order to promote exchange of experiences and ideas for development and collaborative work, has become regular event every second year. The meeting was attended by 27 participants from seven countries (representing nine institutes). Prior to the meeting, – on 16 November, – an informal workshop, with WGACEGG and MEDIAS members, was organized to get potential users acquainted with the EchoR software under development by Ifremer for acoustic biomass estimation data processing. Thirteen participants attended this training session. Days 1 and 2 were spend on presentations by both WGACEGG and MEDIAS participants and the remainder of the week used for general WGACEGG business and specific DEPM or acoustics issues either in plenary or parallel sessions.

Fourteen surveys (four from 2013 and 10 from 2014) were reported to the Group. The highlights from 2014 surveying showed:

- A reduced biomass of sardine in Iberian waters, in particular Cantabrian Sea, which has been corroborated by both acoustic and DEPM surveys, without sign of good incoming year class, and almost stable trend in VIIIab;
- A marked declining trend, since 2012, in both mean weight and mean age for sardine in VIIIab due to the strength of the last incoming year classes;
- Oppositely, a weak declining trend in both mean weight and mean age of sardine in VIIIc due to the lack of strong incoming year classes in the last years in Iberian waters;
- An increasing trend in anchovy biomass indices from both acoustic and DEPM in Bay of Biscay surveys;
- The highest record in the JUVENA anchovy prerecruit index almost occupying the whole Bay of Biscay, being as well the highest distribution area ever reported, but with a relatively small mean length size in the westernmost area;
- An increase in clupeid fish (sardine, anchovy and sprat) in southern VII Divisions the name and the date of the meeting (the latter is very important in terms of meetings held regularly);

During the session dedicated to DEPM aspects a revision on the major pending issues was conducted and a plan of actions was delineated (Annex 8.6).

During the session addressing acoustic issues results of the intercalibration between the French RV Thalassa and the Spanish RV Miguel Oliver were reported. No significant changes were found between the performance of both vessels either in terms of acoustic records or at the fishing stations. On the other hand progress on in situ TS measurements conducted during the PELGAS cruise were also presented together with the multifrequency approach echogram post-analysis used during the PELTIC survey.

The Group endorsed the newly collected results on anchovy recruitment from the 2014 autumn acoustic survey in the BoB (JUVENA), which were subsequently made available for assessment modelling by WGHANSA.

In preparation for the 2016 sardine benchmark some members of the WGHANSA, who are simultaneously members of WGACEGG, raised the discussion on some issues related to DEPM and acoustic data available for assessment. It was decided that extra plankton samples from surveys which took place in the intermediate years between DEPM surveys will be explored in order to assess its value for egg abundance index estimation. The results on acoustic inter-calibration experiments undertaken in the past by IPMA and IEO are to be revisited and conclusions and eventual pending issues on catchability differences or other related aspects presented to the Group.

The Group planned the coordinated 2015 surveys and agreed on the timing for having the results available for assessment purposes.

1 Administrative details

Working Group name

Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VII, VIII and IX

Year of Appointment

2005 (with the current designation since 2013)

Reporting year within current cycle (1, 2 or 3)

1

Chair(s)

Maria Manuel Angélico, Portugal

Pablo Carrera, Spain

Meeting venue

Vigo, Spain

Meeting dates

17–21 November 2014

2 Terms of Reference

a) Provide echo-integration and DEPM estimates for sardine and anchovy in ICES sub-Areas VII, VIII and IX

b) Analyse sardine and anchovy distribution (adults and eggs), aggregation patterns and their habitats in European waters (Atlantic and Mediterranean waters)

c) Provide information on hydrographical and ecosystem indicators such as temperature, salinity, plankton characteristics, top predators abundances, egg densities for sardine and anchovy and backscattering acoustic energy from pelagic fish

d) Asses developments in the technologies and data analysis for the application of the Daily Egg production method (on Egg Production or adult parameters)

e) Asses developments in technologies and data analysis for providing MSFD indicators and survey-base operational products for stakeholders

f) Coordination and standardization of the surveys

3 Summary of Work plan

Year 1	General meeting, including joint session with MEDIAS (Mediterranean acoustic survey on small pelagic)
	Session for acoustic data analysis and post-processing techniques
	Session to improve egg production estimations, including new approaches for egg mortality, and the acoustic survey design aiming at to estimate sardine and anchovy egg production from CUFES and from Pairovets.
	Session to analyse the proposed list of MSFD indicators by country (France, Ireland, Portugal, Spain and UK), aiming at to choose a list of potential candidates to be measured during the WGACEGG surveys
Year 2	General meeting
	Session to analyse progress on acoustic data analysis and post-processing techniques
	Session on the analysis of discrepancies between egg and acoustic survey indices (in collaboration with WGISDAA)
	Session to analyse progress on MSFD indicator measurements
	Session to analyse possible survey-base operational products for stakeholders
	Session to analyse progress on sardine and anchovy egg production estimates from CUFES and Pairovet
	Work by correspondence with MEDIAS (Mediterranean acoustic survey on small pelagic)
Year 3	General meeting, including joint session with MEDIAS (Mediterranean acoustic survey on small pelagic).
	Session to analyse progress on acoustic data analysis and post-processing techniques
	Session to analyse progress on MSFD indicator measurements
	Session to analyse possible survey-base operational products for stakeholders
	Session on the analysis of discrepancies between egg and acoustic survey indices (in collaboration with WGISDAA)
	Session to analyse progress on sardine and anchovy egg production estimates from CUFES and Pairovet

4 List of Outcomes and Achievements of the WG in this delivery period

The following outcomes and achievements were obtained during this delivery period:

- Sardine and anchovy indices derived from acoustic-trawl and DEPM used as input fishery-independent data for analytical assessment purposes in ICES WGHANSA.
    - Structured numbers at age for sardine in VIIIc and IXa from PELAGO and PELACUS acoustic-trawl surveys
    - Anchovy total biomass estimated by PELGAS acoustic-trawl survey in VIIIab.
    - Anchovy proportion of the biomass at age 1 estimated by PELGAS acoustic trawl survey.
    - Anchovy juvenile abundance index estimated by JUVENA acoustic-trawl survey in VIIIabc.
    - Sardine total biomass estimated by PELGAS acoustic-trawl survey in VIIIab.
    - Sardine abundance at age 1 estimated by PELGAS acoustic trawl survey in VIIIab
    - Anchovy proportion of the biomass at age 1 estimated by BIOMAN DEPM survey in VIIIab
    - Sardine egg counts from BIOMAN DEPM survey in VIIIab
    - Anchovy total biomass estimated by BIOMAN DEPM survey in VIIIab.
    - Spawning-stock biomass index for sardine in VIIIc and IXa from PT-DEPM14-PIL and SAREVA DEPM surveys
    - Anchovy total biomass estimated by PELAGO and ECOCADIZ acoustic-trawl surveys in IXa.
    - Anchovy total biomass estimated by ECOCADIZ-Recruit acoustic-trawl survey in IXa.
    - Anchovy total biomass estimated by BOCADEVA DEPM survey in IXa.
- Other acoustic-trawl indices used as biological information at the WGHANSA:
    - Horse mackerel distribution and numbers-at-age estimated by PELAGO and PELACUS acoustic-trawl surveys in IXa.
- Other acoustic-trawl indices used as biological information at the WGWIDE:
- Horse mackerel, boarfish, mackerel and blue whiting distribution and numbers-at-age estimated by PELACUS acoustic trawl surveys in IXa and VIIIc.
- Other survey-derived operational products.
    - Sardine, anchovy and sprat distribution and numbers-at-age estimated by PELTIC acoustic trawl survey in VII.
    - Seabirds and marine mammals distribution and counts obtained by PELAGO, PELACUS, PELGAS, JUVENA and PELTIC.
    - Sea surface microplastic distribution obtained during PELACUS and PELGAS surveys.

All these products are also available in standard survey grid maps.

In addition, a number of works will be presented at the ICES SOMEACOUSTICS, to be held in Nantes from 25th and 28th May. Namely, progress has been done on the following issues:

- TS measurements on board RV Thalassa using the remotely underwater vehicule EROC with a 70 kHz transducer coupled with an "ENROL" device located in the codend of the trawl gear.
- X-ray sardine analysis by tomography for TS modelling
- Multifrequency processing for fish species discrimination

5 Progress report on ToRs and workplan

ToR's were done as scheduled, with the following highlights:

- Two days were devoted for sharing experiences on acoustic-trawl and ichthyoplankton surveys targeted on sardine and anchovy with the Working Group on Mediterranean Acoustic Surveys (MEDIAS).
- A survey protocol on DEPM surveys for sardine and anchovy was drafted
- Some progress on TS measurements have been done, although no updated values for sardine or anchovy have been proposed, nor a common TS (b_{20}) values for the main species has been established

Echo-integration and DEPM estimates for sardine and anchovy in ICES sub-Areas, VIII and IX were provided (*ToR a*). Besides, during the survey presentation, changes in the distribution pattern of sardine have been described although, at present, any analysis of the survey time-series was implemented (*ToR b*). The Group continued the compilation of the survey data in the gridding format described and shown in Annex 8.4. The effort undertaken by all institutes has allowed the standardization of the information and the creation of common file. The following table summarizes the data fed into the WGACEGG grid scheme in 2014. Some variables such as marine birds and mammals were not yet available for gridding since this information for most cases is gathered by other institutions other than the ones running the surveys (*ToR c*). Main developments and pending issues related to surveying (*ToR d*, Annex 8.6) discussed during the meeting included

With respect to MSFD indicators from surveys and survey-base operational products for stakeholders (*ToR e*) it came across from the discussions during the meeting that some clarification is necessary in relation to MSFD requirements and national decisions, also a thoughtful discussions is felt needed by the national MSFD coordinators and surveying coordination in order to explore allocation of resources for extra sampling and processing directed at MSFD objectives that are not currently covered by the regular surveying considered within WGACEGG. The Group acknowledged that substantial progress has been made by all institutes in order to carry out progressively more multidisciplinary surveying which will allow a more comprehensive ecosystem characterization. However, survey coordinators also pointed out that the main objectives of the surveys cannot be disrupted, and that extra sampling is sometimes restricted by vessel size and number of researcher onboard. The variables which could be used for MSFD requirements are listed in Annex 8.7.

For 2015, seven surveys are planned (*ToR f*, Annex 8.9) in divisions VIII and IX and two in division VII.

On the other hand, no changes in ToR have been proposed.

6 Revisions to the work plan and justification

No changes in the work plan were addressed.

7 Next meetings (Interim reports only)

Next meeting of WGACEGG will be held in Lowestoft, UK, from 16–20 November 2015.

Annex 8.1: List of participants

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Annex 8.2: Recommendations

Recommendation	Adressed to
1.Following the intercalibration exercise done between RV Thalassa and Miguel Oliver, a new exercise among the later vessel and the RV Noruega together with the new Portuguese one, which will soon substitute the RV Noruega, is recommended. This should be done once the new Portuguese research vessel is available.	Spanish and Portuguese DCF
2.In order to improve accuracy and precision in sardine and anchovy biomass estimation from egg surveys (both direct DEPM and EPM targeted on horse mackerel and mackerel), intercalibration workhsops for staging eggs (from both CUFES and PAIROVET) and gonads slides are recommended. These would first be done by correspondence followed by a presential meeting.	Azti, IEO, IPMA
3. The Working Group recommends to explore the feasibility of presenting a survey-based operational monitoring research project within the specific Atlantic Arc callings in order to address most of the descriptors related with ToR C, D and F .	Azti, Cefas, IEO, Ifremer, IMR, IPMA
4.The Working Group recommends to develop further investigations on adult parameters(POF's) and egg mortality estimates, including new statistical approaches, in order to improve SSB estimations from DEPM applied to sardine and anchovy stocks.	Azti, IEO, IPMA

Annex 8.3: Agenda

DAY	TIME	ITEM
17/11	**09:30**	**Welcome. Presentation...** **ToR revision and work plan** **CCR**
	10:00	WGACEGG business. Report Grid maps Next meeting Acoustic congress Nantes Larvae Conference
	11:00	DEPM Survey reports (15 minutes each): Anchovy (BIOMAN) Anchovy (BOCADEVA Sardine (SAREVA) and Sardine (DEPM-PIL-Portugal) Isabel Riveiro – short presentation the assessment results on sardine Andres short presentation the assessment results on anchovy Request for giving advice for anchovy in December based on these data, and to forecast possible catches for 2015.
	13:30	lunch break
	15:00	Acoustic survey reports (15 minutes each) ECOCADIZ PELAGO JUVESAR PELACUS PELGAS JUVENA OTHERS :PELTIC; HERRING SURVEY; BOAR FISH SURVEY, IBTS
	18:30	Discussion
	18:30	End session
18/11	**9:00**	**Acoustic survey reports (cont'd):** **Medias**
	11:00	Coffee break
	11.30	Sardine stuff: analysis of the Iberian sardine dynamic and behaviour in relation to adjacent areas (VII and VIIIab; Mediterranean), distribution, density, schooling and other issues. Identify those issues and, if needed propose workshops
	13:30	Lunch break
	15:00	Anchovy stuff: id
	16:30	Coffee break
	17:00	MSDF descriptors and indicators. Present state and feasibility of measuring

	18:30	End session
19/11	**09:00**	**Summarizing**
	10:00	Parallel Sessions. Acoustic: towards a common acoustic data exploration and analysis using multifrequency (proposed co-chairs: Jeroen and Matthieu). Background noise remove; detecting and removed pitfalls...); echogram vertical overlapping (i.e. averaging, shifting pings...). Bubbles swept-down removal Species multifrequency ID: analysis of frequency response: mackerel, anchovy, boar fish, lanternfish (M. muelleri)... Intercalibration between Thalassa and Miguel Oliver TS measurements Echo R Manual Egg surveys: - mortality issues and discussion on work for WGALES - issues with fecundity and spawning fraction estimation (interannual variability and sampling artfacts) - discussion the way forward from traditional estimation to application of developments (e.g. external mortality model using environmental parameters, Bayesian approach to estimation of P0 and z, etc.
	11:00	Coffee break
	11:30	Parallel sessions cont'd
	13:30	Lunch Time
	15:00	Parallel sessions cont'd
	16:30	Coffee break
	17:00	Finishing parallel sessions
	17:30	Plenary. Summary of major results and recommendations for each parallel session
	18:30	End session
20/11	**9:00**	**Plenary. Summary of major results and recommendations for each parallel session (if required)**
	11:00	Coffee break
	11:30	WGACEGG business. List of possible common contributions to acoustic symposium WGALES CUFES data for egg index estimation, (quantitative estimator of egg production)
	13:30	Lunch time
	15:00	MSDF descriptors. Acoustic estimation for WIDE (mackerel, horse mackerel, boar fish and blue whiting)
	16:30	Coffee break
	17:00	Report
	18:30	End session
21/11	**09:30**	**Summary. Hotspots for discussion**

11:00	Coffee break
11:30	Surveys for 2015; coordination and specific recommendations on account meeting results
12:30	WGACEGG business. Finishing report dead lines Grid maps Next meeting
13:30	End meeting

Annex8.4: General overview on sardine and anchovy abundance distributions from the DEPM and acoustic surveys in ICES Areas VIII and IX

General overview comprises Areas VIII and IX but in Section 8.7, a summary on VII surveys is also provided.

Tables 8.4.1 and 8.4.2 summarizes DEPM and acoustic surveys targeted on sardine and anchovy carried out in ICES Areas VIII and IX.

Table 8.4.1. Main characteristics of the acoustic surveys carried out in ICES Areas VIII and IX.

SURVEY	INSTI-TUTION	VESSEL	DATE	AREA	Transect distance	Nmi surveyed	Acoustic frequencies	Fishing station	CUFES	SSS/SST	CTD/ Plankton	Apical predators
ECOCADIZ	IEO	Cornide de Saavedra	02/08-13/08[1]	IXa-S	8	320	18, 38, 70, 120, 200	16	117	Y	117	N
JUVENA	AZTI	R. Margalef/ E. Bardán	01/09-30/09[3]	VIII	16	2250	18, 38, 70, 120, 200[3]	69	N	Y	Y	Y
JUVESAR	IPMA	Noruega	05/11-15/11	IXa-CN	8/4	Na	38	17	N	Y	40	Y
PELACUS	IEO	Miguel Oliver	13/03-16/04	IXaN-VIIIc	8	1075	18, 38, 120, 200	52	358	Y	105	114.95 hours
PELAGO	IPMA	Noruega	3/04-12/05	IXa	8	989	38	35	Y[4]	Y	Y[4]	y[4]
PELGAS	Ifremer	Thalassa	24/04-05/06	VIIIab	12	2011	18, 38, 70, 120, 200, 333	116[2]	788	Y	110	260 hours
ECOCADIZ	IEO	Miguel Oliver	24/07-06/08	IXa-S	8	320	18, 38, 120, 200	21	153	Y	176	na
JUVENA	AZTI	R. Margalef/ E. Bardán	01/09-30/09[3]	VIII	16	3000	18, 38, 70, 120, 200[3]	79	N	Y	???	144.6 hours
ECOCADIZ reclutas	IEO	Ramón Margalef	13/10-31/10	IXa-S	8	300	18, 38, 120, 200	17	N	Y	184	N

Remarks:

[1] Carried out in 2013, but nor reported previously.

[2] 54 performed by commercial fishing vessels.

[3] Two configurations for R. Magalef in survey transects: on shelf, drop keel (R. Margalef); on outside shelf, side perch with 38 120 kHz facing down and 200 kHz lateral).

[4] See DEPM14-PIL survey.

Table 8.4.2. General information on the DEPM surveys undertaken in ICES Areas VIII and IX. Temperature in ºC (including min/mean/max values), Pairovet tows (total number, positives and total number of egg), CUFES samples (total number, positives and total number of egg) and Fishing hauls (RV hauls, positive hauls and + commercial).

Survey Institute	Area	Dates	Vessel	Temp	PairoVET	CUFES	Fishing hauls	Total fish sampled	Females for histology – Hydrated females
PT-DEPM14-PIL IPMA	IXa-S	15-26/04	Noruega	14.5/16.3/19.1	134 (62) 2019	146 (60) 2695	17 (16) + 4[1]	938	444 70
	IXa-W	15-21/03; 4-15/04	Noruega	12.8/14.9/18.5	265 (101) 2164	313 (116) 12709	47 (33) + 16[1]	1635	705 21
SAREVA IEO	IXa- N, VIIIc	29/03-09/04 16/04-21/04	Vizconde de Eza	12.3/13.0/14.9	394 (66) 313	339 (112) 2186	57[2](15)	755	262 119
	VIIIb	09/04-16/04	Vizconde de Eza	12.3/13.2/14.5	128(77) 1449	122(98) 12067	13(3)	324	148 51
BIOMAN – ANE AZTI	VIIIabc	5-23/05	Ramón Margalef	12.3/14.8/16.6	767 (348) 22,310	1745 (730) 88,707	51(42) + 6[1]	2762	1263 278
BIOMAN – PIL AZTI	VIIIab	11-23/05	Ramón Margalef	12.4/14.4/16.8	521 (311) 8,266	1183 (642) 14,661	30(8)	623	220 36
BOCADEVA IEO	IXa-S	24-31/07	Ramón Margalef	15.1/20.6/23.9	151 (70) 3087	153 (90) 41941	25[2](19)	1351	849 170

Remarks:

[1] Samples obtained from commercial vessels.

[2] Samples obtained during the acoustic survey carried out by RV Miquel Oliver.

Acoustic surveys carried out in spring and summer are targeted on adults whereas those performed in fall are focusing on anchovy juveniles. Material and methods of each survey are detailed in Annex 11 (8.11 Survey reports).

Following the methodology described in ICES (2015), grid maps were created for the main oceanographic (SSS and SST), acoustic (NASC), egg (CUFES and PairoVET hauls); and top predators raw variables. For each variable, the grid is constructed as follows: (i) 200 grids are generated each with a different origin; (ii) block averaging is performed for each; (iii) all grids are then superposed; (iv) the mean in each cell is calculated by averaging the cell means of all grids. The grid mesh is 0.25°x0.25°, the lower left corner of the grid is positioned at 10.2°W and 35.8°N.

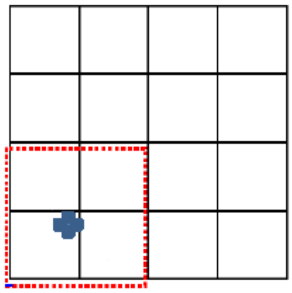

Figure 8.4.1. Schematic of the standard grid (black: 0.25°x0.25°), the large block (dashed red line) in which the grid origin is randomized. The cross (blue) shows the position at which the origin is randomized. The cross (blue) shows the position at which the origin of the grid is positioned to present mesh is 0.25°x0.25°, the lower left corner of the grid is positioned at 10.2°W and 35.8°N.

This methodology mitigates either the effect of empty/high values, typical from very skewed data as acoustics, when averaging over too small blocks as well as the effect of the position of the origin on the block averaging.

8.4.1.1 Summer acoustic surveys in 2013. ECOCADIZ 0813

8.4.1.1.1 Oceanographic conditions

The survey area was characterized by cold waters in the western area derived from a relatively intense upwelling-favourable westerly winds, but without inference in the eastern part where SST reached up to 24ºC. Besides, SSS followed the same pattern with more salty waters in the eastern part than in the western one (Figure 8.4.1.1.1.1).

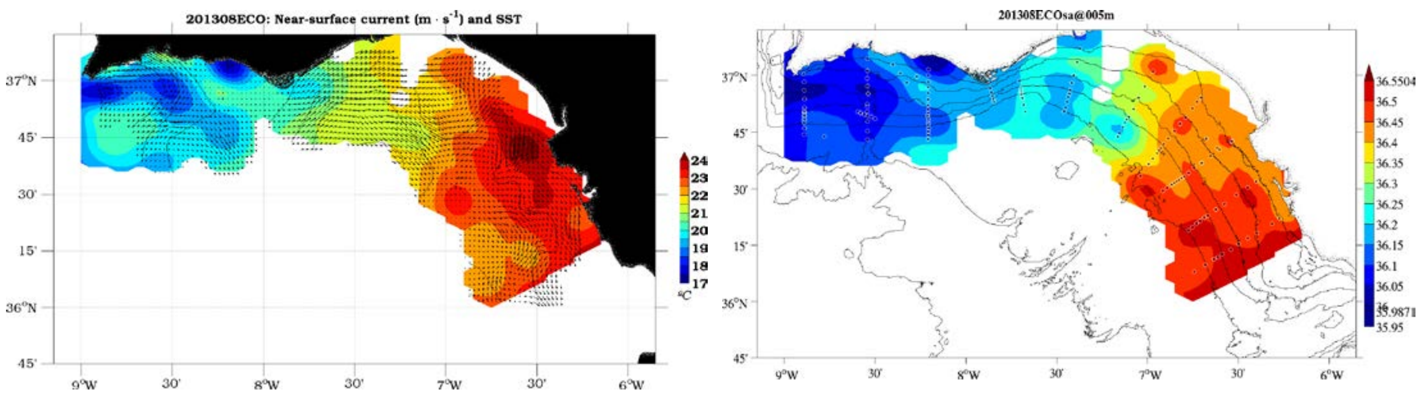

Figure 8.4.1.1.1.1. Oceanographic conditions during the *ECOCADIZ 0813* survey. Bottom row: (left) near sea-surface (5 m depth) temperature and ADCP velocity vectors and (right) salinity.

8.4.1.1.2 Sardine and anchovy distribution derived from NASC

8.4.1.1.2.1 Sardine

During the ECOCADIZ 0813 survey sardine mainly occurred over the inner-middle shelf of both extremes of the surveyed area, in shallower waters than anchovy (see next section), and curiously in those waters where anchovy was absent, resulting in a distribution pattern almost complementary to the one deployed by this last species (Figure 8.4.1.1.2.1.1). In any case, higher sardine densities were more constantly recorded in the waters west to Cape Santa Maria.

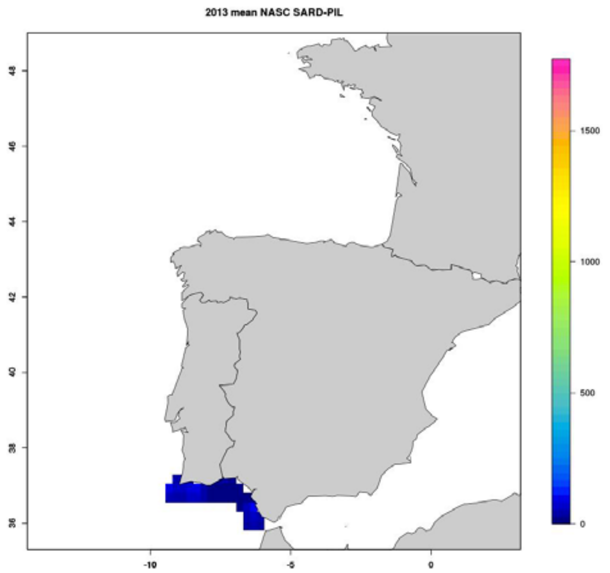

Figure 8.4.1.1.2.1.1. Spatial distribution of acoustic energy (NASC) attributed to Gulf of Cadiz sardine in summer 2013 during the *ECOCADIZ 0813* survey (IEO).

8.4.1.1.2.2 Anchovy

The bulk of the anchovy population was concentrated, as usual, in the central part of the surveyed area, which corresponds to the Spanish shelf. In this area, the species distributed all over the shelf showing spots of high density at different depths. A residual nucleus was also recorded to the west of Cape Santa Maria, in waters with a bathymetry between 75 and 108 m depth (Figure 8.4.1.1.2.2.1).

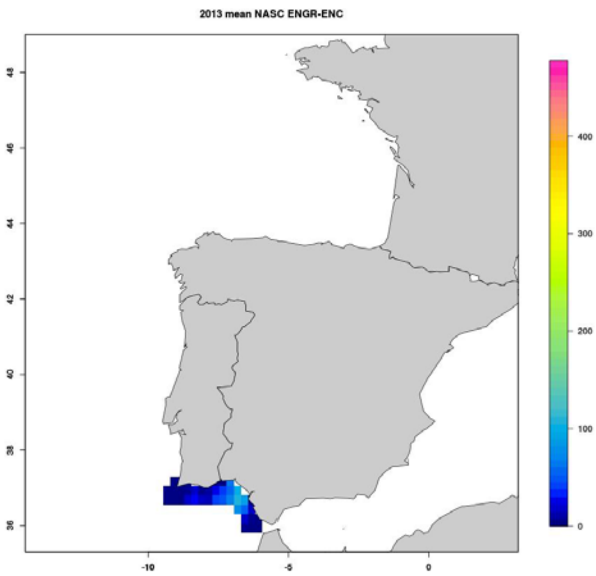

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Figure 8.4.1.1.2.2.1. Spatial distribution of acoustic energy (NASC) attributed to Gulf of Cadiz anchovy in summer 2013 during the *ECOCADIZ 0813* survey.

8.4.1.1.3 CUFES

Anchovy egg distribution in summer 2013, as sampled by CUFES, resembled the abovementioned distribution for adult fish, with higher egg densities being mainly recorded in the inner-middle shelf waters located between Cadiz Bay and Tinto-Odiel rivers mouths, although the highest egg density (130 eggs m^{-3}) was recorded in one station at 87.6 m depth located in the transect closer to the Portuguese-Spanish border (Figure 8.4.1.1.3.1).

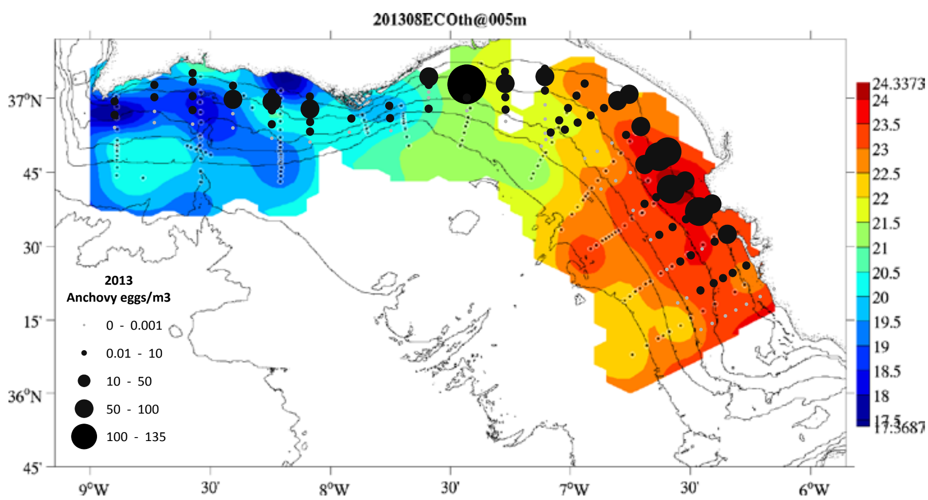

Figure 8.4.1.1.3.1. Spatial distribution of Gulf of Cadiz anchovy egg densities (eggs m^{-3}) as sampled by CUFES in summer 2013 during the *ECOCADIZ 0813* survey (IEO). Egg distribution superimposed to the distribution of sea temperature at 5 m depth (CTD casts).

8.4.1.1.4 Sardine and anchovy mean weight and length

8.4.1.1.4.1 Sardine

Sardine mean weight and length-at-age in the assessed population are not available to this WG. Alternatively, Figure 8.4.1.1.4.1.1 shows the mean length and weight along the time-series. The 2013 summer estimates (167 mm, 24.0 g) are within the observed range for this population through the historical series.

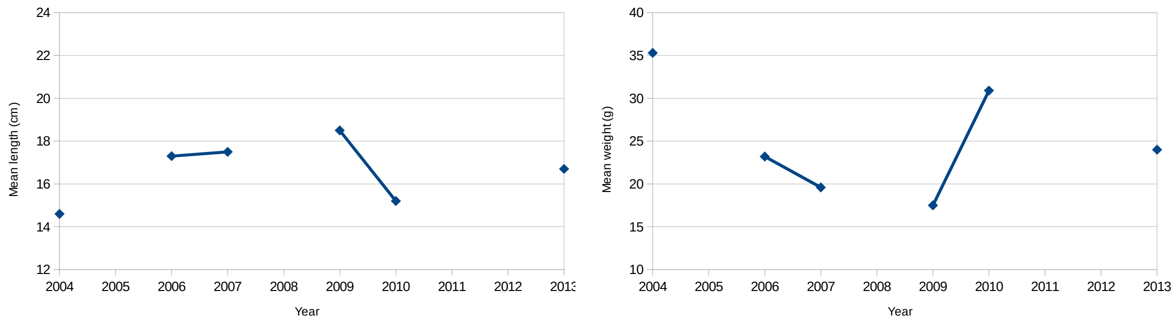

Figure 8.4.1.1.4.1.1. Sardine mean length and weight along the time-series (gaps mean no survey).

8.4.1.1.4.2 Anchovy

As in 2010, the 2013 recruitment was found during the survey as shown in Figure 8.4.1.1.4.2.1. Possible cause would be the delayed survey dates. However, no trends were observed in mean length nor in mean weight for the population as shown in figure Figure 8.4.1.1.4.2.2.

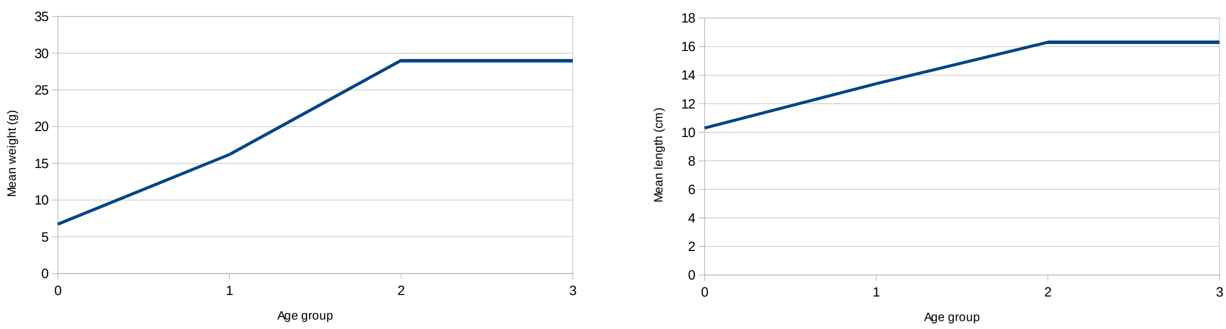

Figure 8.4.1.1.4.2.1. Anchovy mean length and mean weight-at-age estimated during ECOCADIZ.

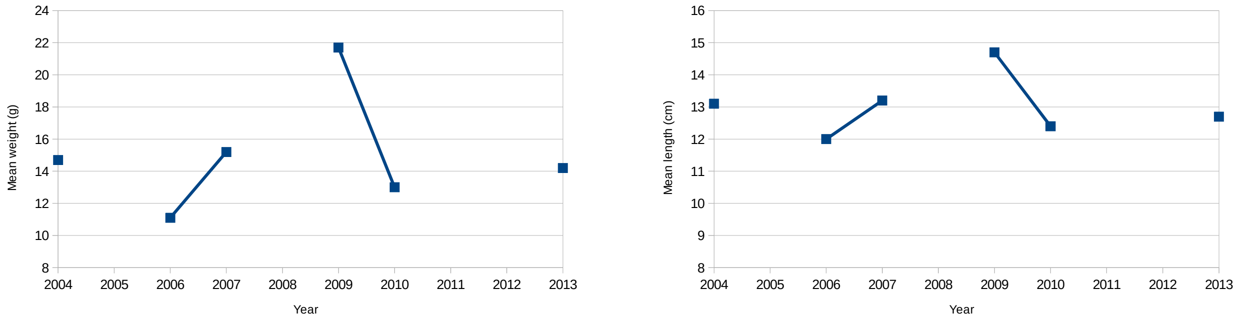

Figure 8.4.1.1.4.2.2. Anchovy mean length and weight along the time-series (gaps mean no survey).

8.4.1.1.5 Biomass estimations

8.4.1.1.5.1 Sardine

The acoustic estimates by post-strata are given in Ramos *et al.* (2014a, WD 11 in Annex 8.10). Overall estimates along the time-series is shown in Figure 8.4.1.1.5.1.1. Sardine was the third most important species in terms of both biomass and abundance: 9 670 t and 232 millions of fish were estimated for this species for the whole surveyed area, which is the lowest value in the time-series.

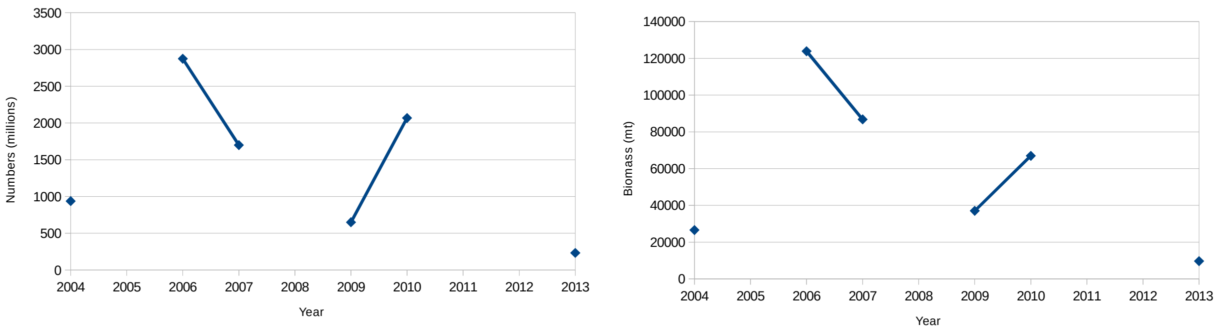

Figure 8.4.1.1.5.1.1. Sardine abundance (million fish) and biomass (tonnes) for *ECOCADIZ* time-series. (gaps mean no survey).

8.4.1.1.5.2 Anchovy

The acoustic estimates by post-strata are given in Ramos *et al.* (2014a, WD 11 in Annex 8.10). As seen for sardine, 2013 estimates is the lowest value in the time-series with only 8.5 thousand tonnes corresponding to 609 million fish (Figure 8.4.1.1.5.2.1).

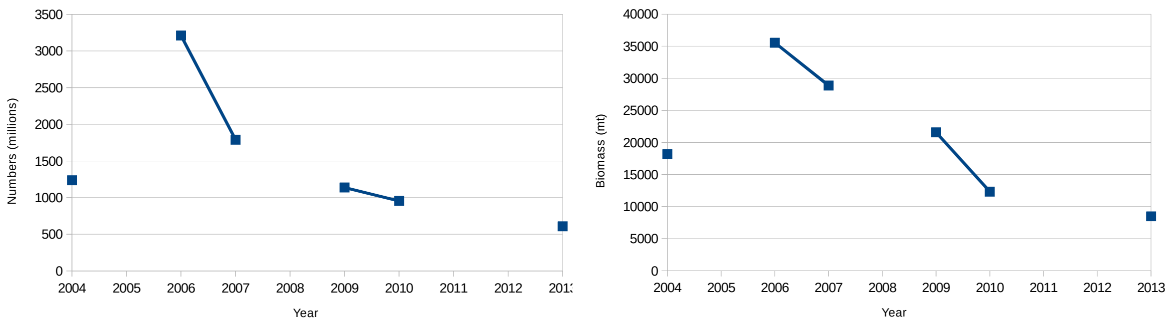

Figure 8.4.1.1.5.1.2. Anchovy abundance (million fish) and biomass (tonnes) for *ECOCADIZ* time-series. (gaps mean no survey).

<u>8.4.1.1.6 Other fish species</u>

Information on the spatial distribution and acoustic estimates for other fish species is detailed in Ramos *et al.* (2014a; WD 11 in Annex 8.10).

8.4.1.2 Autumn acoustic surveys in 2013. JUVESAR13 and JUVENA 2013

Information on these surveys are detailed in Silva *et al.* (2014) and Boyra (2014; WD08 and WD07 respectively in Annex 8.10).

<u>8.4.1.2.1 Sardine and anchovy distribution derived from NASC</u>

Figure 8.4.1.2.1.1 shows the sampling intensity by grid block.

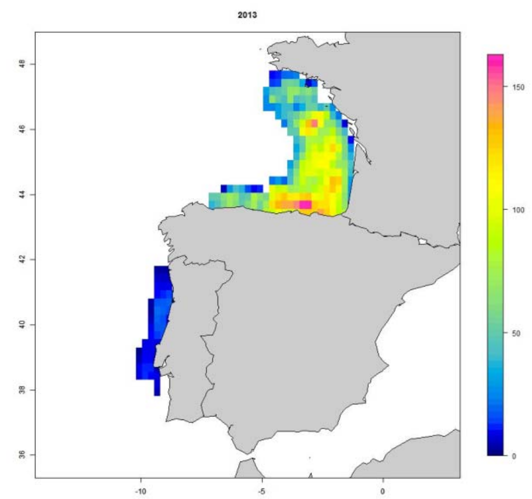

Figure 8.4.1.2.1.1. Number of data points within each grid of 0.25°x0.25°.

8.4.1.2.1.1 Sardine

Sardine mainly occurred around Lisbon area and in the coastal waters of France (south Garonne mouth). No sardine or scarce density was found in the Cantabrian and close to the Spanish Portuguese border, as shown in Figure 8.4.1.2.1.1.1.

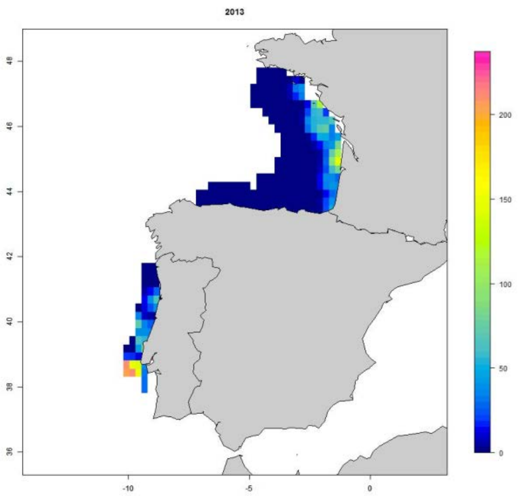

Figure 8.4.1.2.1.1.1. Average sardine abundance and distribution derived from NASC raw values

8.4.1.2.1.2 Anchovy

Almost no anchovy has been detected in Portuguese waters. In the Bay of Biscay, main spots were located close to cape Peñas in the Cantabrian Sea, and in French waters, in the southern part of Brittany, as shown in Figure 8.4.1.2.1.1.2.

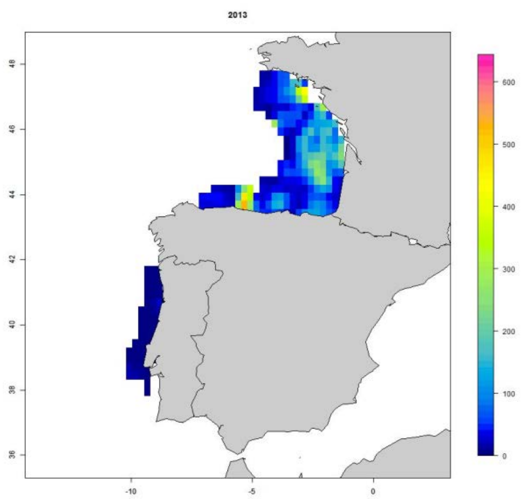

Figure 8.4.1.2.1.2.1. Average anchovy abundance and distribution derived from NASC raw values.

Almost no anchovy has been detected in Portuguese waters. In the Bay of Biscay, main spots were located close to cape Peñas in the Cantabrian Sea, and in French waters, in the southern part of Brittany, as shown in Figure 8.4.1.2.1.1.2.

8.4.2 Spring surveys 2014

8.4.2.1 Oceanographic conditions

Despite winter was characterized by a successive waves of storms, weather condition became more stable at the beginning of spring and only few storms occurred during the survey period. Therefore, waters were less salty than expected except those of the Iberian Northwestern corner (Figure 8.4.2.2a), which area also colder than the surrounding ones. Besides, river Douro and Adour/Garonne plumes were clearly established.

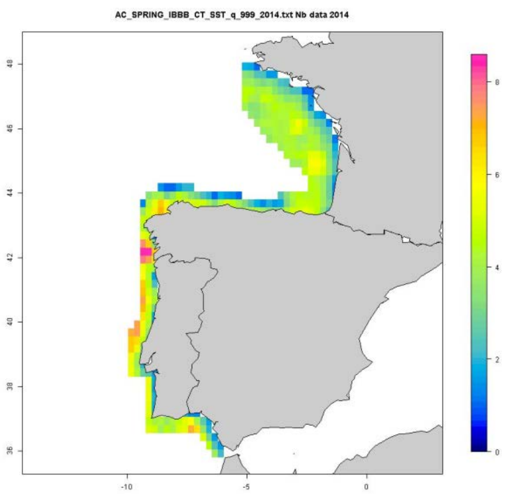

Figure 8.4.2.1. Number of data points within each grid of 0.25ºx0.25º.

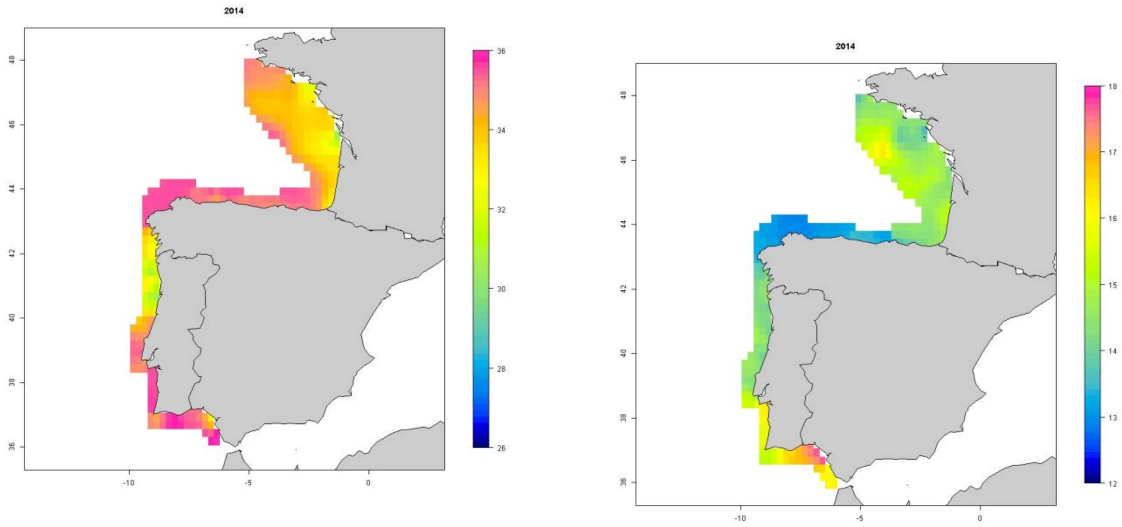

Figure 8.4.2.1. Average sea surface salinity (left panel) and temperature (right panel).

In the case of the Bay of Biscay, these conditions led to impressive abundance of gelatinous organisms, particularly salps, covering the whole platform in the northern part of the Bay Biscay. No water stratification was found in Cantabrian Sea whereas it was light in the Bay of Biscay. Summarized the oceanographic conditions in spring were characterized by:

- Mixed water column with only light temperature stratification in the Bay of Biscay.
- Important presence of the Douro and Adour/Garonne river plumes
- Colder and saltier waters in the south western part of the Cantabrian Sea and more warmer and less saltier waters in the rest of the surveyed area.

8.4.2.2 Sardine and anchovy distribution derived from NASC

Sampling intensity by grid block is show in Figure 8.4.2.2.1.

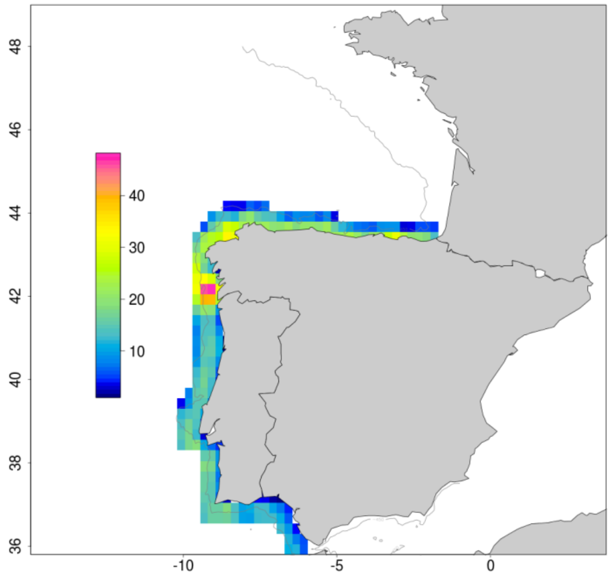

Figure 8.4.2.2.1. Number of data points within each grid of 0.25ºx0.25º.

Sardine mainly occurred in French coastal waters with two smaller spots located in the Atlantic waters of the Iberian peninsula, south Porto (around 40º) and in the Gulf of Cadiz (Figure 8.4.2.2.2). As in previous years, density off north Spanish coast was very scarce.

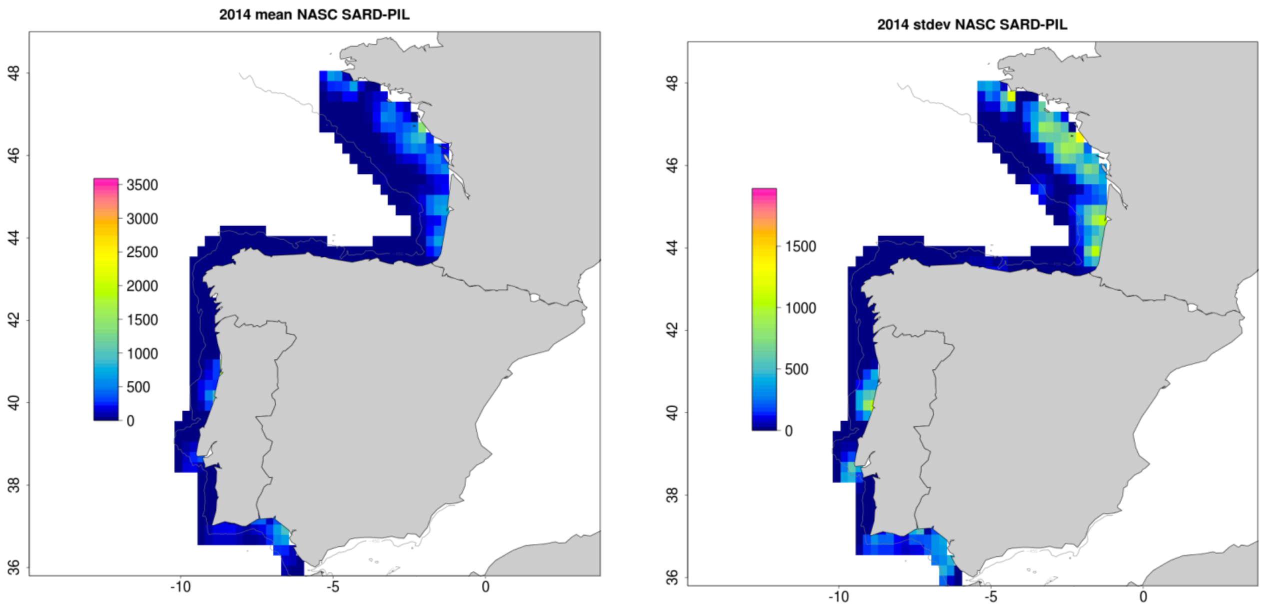

Figure 8.4.2.2.2. Average (left panel) and standard deviation (right panel) sardine abundance and distribution derived from NASC raw values.

For anchovy, the distribution pattern was similar, although more concentrated, with the highest concentrations located in French waters, south of the Garonne mouth, and in the Gulf of Cadiz close to the Guadalquivir mouth. (Figure 8.4.2.2.3).

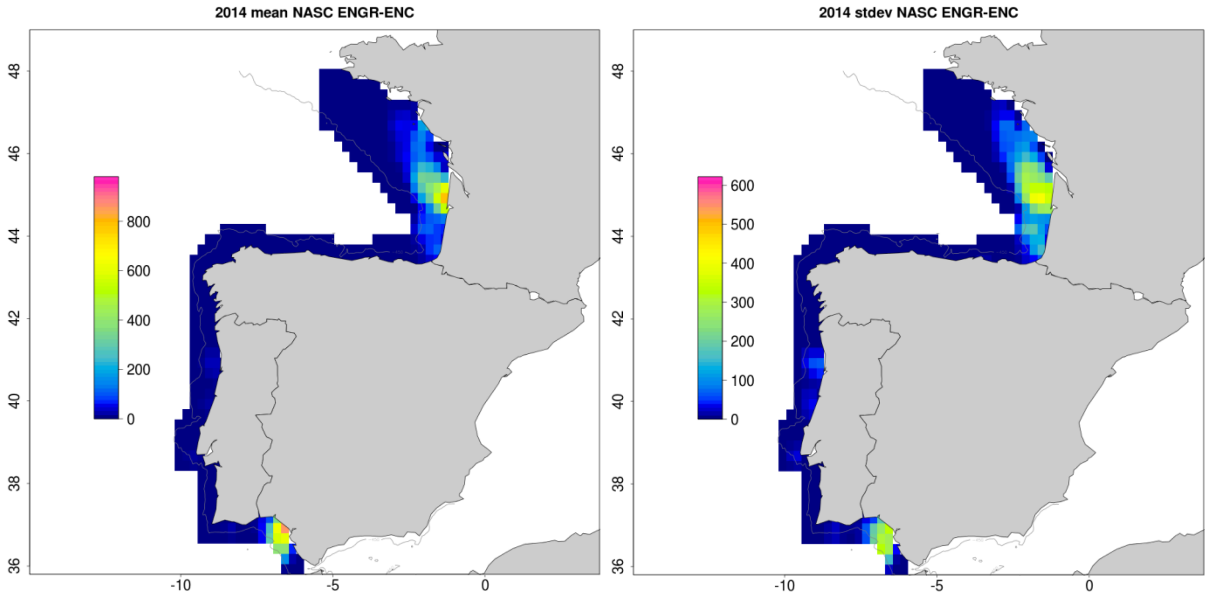

Figure 8.4.2.2.3. Average (left panel) and standard deviation (right panel) anchovy abundance and distribution derived from NASC raw values.

8.4.2.3 Sardine and anchovy mean weight and length-at-age

Mean weight and length-at-age were calculated from the length and age abundance and biomass matrices estimated for each ICES Subdivision. Besides, for each age, a mean weight or length anomaly was calculated as the difference between the mean weight or length at-age calculated in each ICES Subdivision and the weighted average weight or length calculated for the whole area. During spring of 2014, the biggest sardines at any age occurred in north Spanish and in south Atlantic Portuguese waters, as shown in Figures 8.4.2.3.1 and 8.4.2.3.2. On the contrary, the smallest were located off north Portugal.

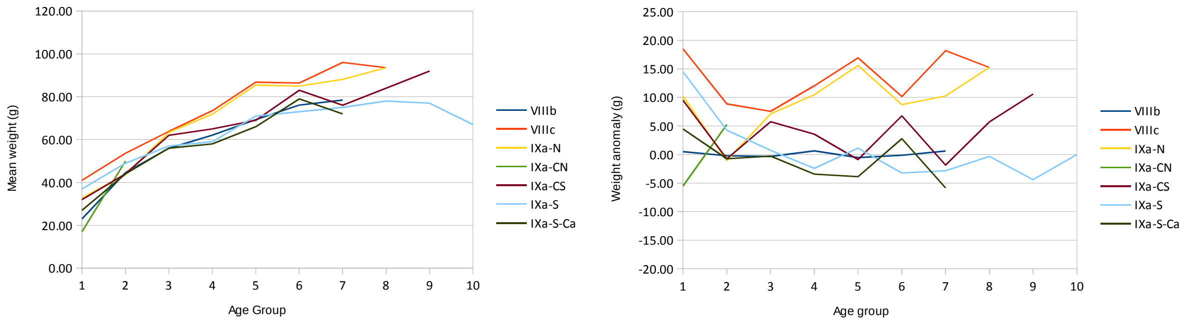

Figure 8.4.2.3.1. Mean weight-at-age by ICES Subdivision and mean weight-at-age anomaly (difference between mean weight-at-age in each ICES Subdivision and the weighted mean weight or length-at-age calculated for the whole surveyed area)

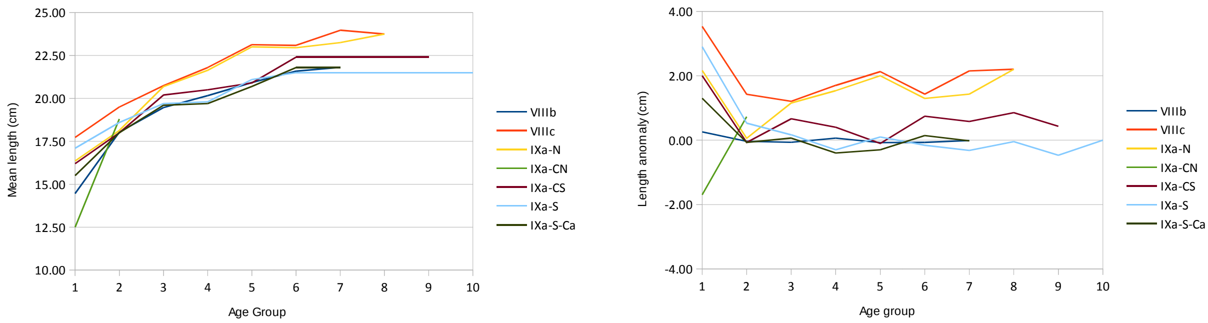

Figure 8.4.2.3.2. Mean length-at-age by ICES Subdivision and mean length-at-age anomaly (difference between each mean length-at-age by ICES Subdivision and the weighted mean length for each age).

While this calculation is based on both trawl results and acoustics backscattered energy attributed to sardine or anchovy, those provided by the DEPM surveys are only based on those fishing stations (and strata) used to apply the method and hence, nor the strata or the fishing station neither mean weights and lengths are directly comparable, but every time-series is itself coherent.

In the same way, an annual mean weight and length has been calculated as the difference between each mean weight or length by year and ICES Division and the weighted mean weight or length for the time-series 2003–14. Results are shown in Figures 8.4.2.3.3 and 8.4.2.3.4.

Figure 8.4.2.3.3. Mean weight by year and ICES Subdivision and mean weight anomaly (difference between each mean weight by ICES Subdivision and the weighted mean weight for the 2003–2014 time-series). In 2012, no acoustic survey was undertaken by Portugal.

Figure 8.4.2.3.4. Sardine mean length by year and ICES Subdivision and mean length anomaly (difference between each mean length by ICES Subdivision and then weighted mean length for the 2003–2014 time-series). In 2012, no acoustic survey was undertaken by Portugal.

Table 8.4.2.3.1. Sardine mean weight by age group and ICES Subdivision estimated from 2014 spring surveys.

	1	2	3	4	5	6	7	8	9	10	Mean
VIIIb	23.02	44.53	55.93	62.07	69.35	76.11	78.46		86.50		37.55
VIIIc	41.01	53.60	63.83	73.47	86.80	86.38	96.02	93.55			61.12
IXa-N	32.69	43.67	63.37	71.91	85.46	84.96	88.10	93.55			37.24
IXa-CN	17.00	50.00									17.19
IXa-CS	32.00	44.00	62.00	65.00	69.00	83.00	76.00	84.00	92.00		33.54
IXa-S	37.00	49.00	57.00	59.00	71.00	73.00	75.00	78.00	77.00	67.00	56.39
IXa-S-Ca	27.00	44.00	56.00	58.00	66.00	79.00	72.00				34.67
Mean	22.52	44.74	56.27	61.44	69.88	76.23	77.85	78.31	81.40	67.00	35.22

Table 8.4.2.3.2. Sardine mean length by age group and ICES Subdivision estimated from 2014 spring surveys.

	1	2	3	4	5	6	7	8	9	10	Mean
VIIIb	14.46	18.04	19.47	20.16	20.92	21.59	21.81		22.53		16.74
VIIIc	17.73	19.50	20.74	21.80	23.13	23.09	23.97	23.75			20.31
IXa-N	16.36	18.13	20.69	21.64	23.00	22.95	23.25	23.75			17.03
IXa-CN	12.50	18.80									12.54
IXa-CS	16.20	18.00	20.20	20.50	20.90	22.40	22.40	22.40	22.40		16.42
IXa-S	17.10	18.60	19.70	19.80	21.10	21.50	21.50	21.50	21.50	21.50	19.44
IXa-S-Ca	15.50	18.00	19.60	19.70	20.70	21.80	21.80				16.58
Mean	14.20	18.07	19.53	20.10	21.00	21.66	21.82	21.55	21.97	21.50	16.26

Table 8.4.2.3.3. Sardine mean weight by year and ICES Subdivision. In 2012, no acoustic survey was undertaken by Portugal.

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Sp-IX a	54.13	60.88	23.71	44.25	60.93	68.35	47.62	67.80	50.17	74.84	51.01	37.30
Pt-IX a	32.35	46.84	23.92	38.86	50.94	34.86	30.75	23.15	46.97		44.89	28.45
IX a	32.95	47.54	23.91	39.10	51.84	37.66	30.83	24.04	47.00	74.84	44.94	28.45
VIIIc	70.22	73.21	82.52	82.27	70.79	83.01	74.41	76.51	83.90	93.20	65.85	61.55
VIIIab	70.13	61.97	61.00	57.65	62.67	56.67	47.51	51.47	52.04	42.28	32.08	37.50
Mean	40.84	57.20	32.99	43.85	54.53	49.73	40.88	38.40	50.99	43.43	34.03	35.19

Table 8.4.2.3.4. Sardine mean length by year and ices Subdivision. In 2012, no acoustic survey was undertaken by Portugal.

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Sp-IX a	19.48	20.25	14.43	17.61	19.78	20.48	18.33	20.30	18.80	21.15	18.98	17.05
Pt-IX a	16.42	16.30	14.50	17.16	18.47	15.34	15.34	14.00	16.30		16.00	14.66
IX a	16.50	16.50	14.50	17.18	18.59	15.77	15.35	14.12	16.32	21.15	16.02	14.66
VIIIc	21.17	21.66	21.71	21.91	20.72	21.83	21.50	21.32	22.30	22.70	20.88	20.31
VIIIab	20.97	19.85	19.74	19.60	20.01	19.21	18.06	18.80	18.80	17.26	15.70	16.74
Mean	17.48	18.66	15.76	17.77	18.92	17.81	16.96	16.54	18.12	17.39	15.76	16.26

While in the Iberian Peninsula, mean weight or length remained more or less stable until 2012, when a decreasing trend was also observed reaching the lowest value of the time-series in 2014, in VIIIab the decreasing trend is much significant with a net decrease between 2003 and 2014 of 32.63 g and 4.25 cm per sardine. However, this decrease in mean length is consequence of the strength of the incoming recruitments since 2011.

For anchovy, mean length and weight in VIIIab are shown in the following table:

	Age groups				
	1	2	3	4	mean
Mean length	16.04	17.43	18.22	19.81	15.76
Mean weight	14.52	18.92	21.82	28.53	16.42

8.4.2.4 Sardine and anchovy biomass and abundance estimation

Figure 8.4.2.4.1 show the numbers-at-age by ICES Subdivision estimated during the 2014 spring acoustic surveys. Age group 1 was the most abundant and mainly occurred in French waters, North Portugal and the Gulf of Cadiz. The bulk of the sardines were found in French waters. Up to seven 7 years old, more than the 50% of the sardines (more than 80% for ages 2 and 3) are located in this area. The oldest ones, although negligible in number, occurred in the Algarve Area.

Table 8.4.2.4.1. Sardine abundance at age by ICES Subdivision estimated during the 2014 spring acoustic surveys. Numbers in millions.

	VIIIab	VIIIc	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S-Ca
1	3987.60	15.84	2.43	1688.00	219.00	83.00	839.00
2	3240.91	63.85	0.69	10.00	22.00	66.00	267.00
3	863.76	35.37	0.11	0.00	0.80	48.00	66.00
4	269.98	12.02	0.04	0.00	1.00	51.00	57.00
5	183.56	7.16	0.02	0.00	0.20	27.00	14.00
6	132.25	8.36	0.03	0.00	0.40	34.00	14.00
7	39.78	4.34	0.01	0.00	0.10	28.00	4.00
8+	4.77	0.23	0.00	0.00	0.40	21.60	0.00
Total	8722.60	147.18	3.32	1698.00	243.90	358.60	1261.00

Figure 8.4.2.4.1. Sardine abundance at age by ICES Subdivision estimated during the 2014 spring acoustic surveys. Left panel in absolute numbers (million fish); right panel, relative numbers-at-age.

Table 8.4.2.4.2.Sardine biomass at age (thousand tonnes) by ICES Subdivision estimated during the 2014 spring acoustic surveys.

	VIIIab	VIIIc	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S-Ca
1	92.81	0.66	0.08	28.22	6.95	3.10	23.03
2	148.12	3.46	0.03	0.49	0.96	3.19	11.85
3	49.04	2.27	0.01	0.00	0.05	2.73	3.72
4	16.91	0.89	0.00	0.00	0.07	2.99	3.31
5	12.88	0.62	0.00	0.00	0.02	1.88	0.90
6	10.21	0.73	0.00	0.00	0.04	2.46	1.11
7	3.24	0.42	0.00	0.00	0.01	2.06	0.29
8+	0.43	0.02	0.00	0.00	0.03	1.62	0.00
Total	333.64	9.08	0.12	28.70	8.12	20.03	44.20

In biomass (Figure 8.4.2.4.2) age group 2 was the most abundant, mainly concentrated in French waters, and only a small portion has been found in the Gulf of Cadiz (<10%).

Table 8.4.2.4.1. Sardine abundance at age by ICES Subdivision estimated during the 2014 spring acoustic surveys. Numbers in millions.

	VIIIab	VIIIc	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S-Ca
1	3987.60	15.84	2.43	1688.00	219.00	83.00	839.00
2	3240.91	63.85	0.69	10.00	22.00	66.00	267.00
3	863.76	35.37	0.11	0.00	0.80	48.00	66.00
4	269.98	12.02	0.04	0.00	1.00	51.00	57.00
5	183.56	7.16	0.02	0.00	0.20	27.00	14.00
6	132.25	8.36	0.03	0.00	0.40	34.00	14.00
7	39.78	4.34	0.01	0.00	0.10	28.00	4.00
8+	4.77	0.23	0.00	0.00	0.40	21.60	0.00
Total	8722.60	147.18	3.32	1698.00	243.90	358.60	1261.00

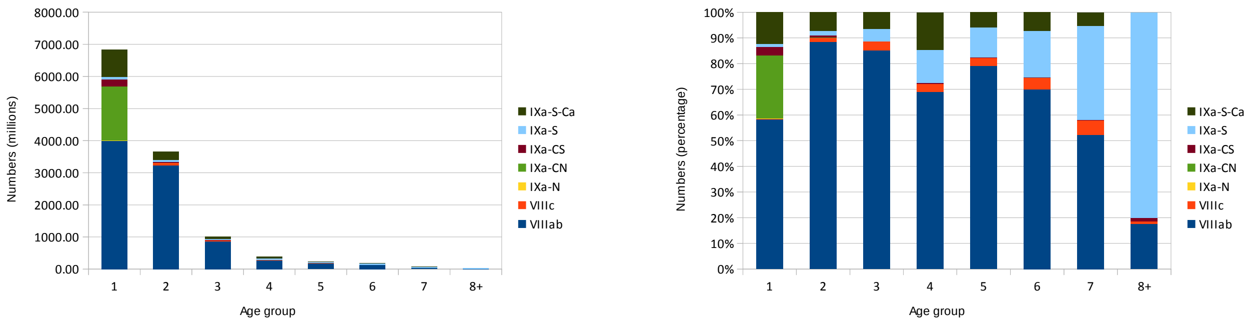

Figure 8.4.2.4.1. Sardine abundance at age by ICES Subdivision estimated during the 2014 spring acoustic surveys. Left panel in absolute numbers (million fish); right panel, relative numbers-at-age.

Table 8.4.2.4.2.Sardine biomass at age (thousand tonnes) by ICES Subdivision estimated during the 2014 spring acoustic surveys.

	VIIIab	VIIIc	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S-Ca
1	92.81	0.66	0.08	28.22	6.95	3.10	23.03
2	148.12	3.46	0.03	0.49	0.96	3.19	11.85
3	49.04	2.27	0.01	0.00	0.05	2.73	3.72
4	16.91	0.89	0.00	0.00	0.07	2.99	3.31
5	12.88	0.62	0.00	0.00	0.02	1.88	0.90
6	10.21	0.73	0.00	0.00	0.04	2.46	1.11
7	3.24	0.42	0.00	0.00	0.01	2.06	0.29
8+	0.43	0.02	0.00	0.00	0.03	1.62	0.00
Total	333.64	9.08	0.12	28.70	8.12	20.03	44.20

In biomass (Figure 8.4.2.4.2) age group 2 was the most abundant, mainly concentrated in French waters, and only a small portion has been found in the Gulf of Cadiz (<10%).

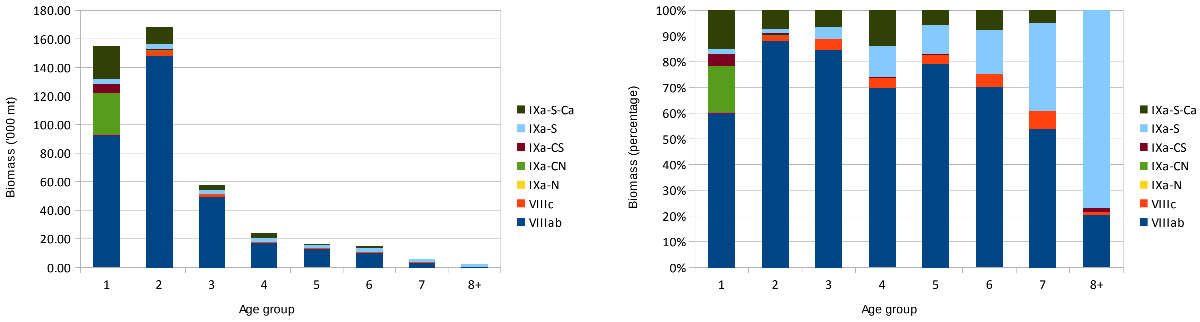

Figure 8.4.2.4.2. Sardine abundance at age by ICES Subdivision estimated during the 2014 spring acoustic surveys. Left panel in absolute biomass (thousand tonnes); right panel, relative biomass at age.

Since 2003 both biomass and abundance show a declining trend in the Iberian Peninsula whereas in French waters, although total biomass is fluctuating around the mean (341 thousand tonnes), the abundance in number has an increasing trend due to the strength of the last recruitments (Figure 8.4.2.4.3).

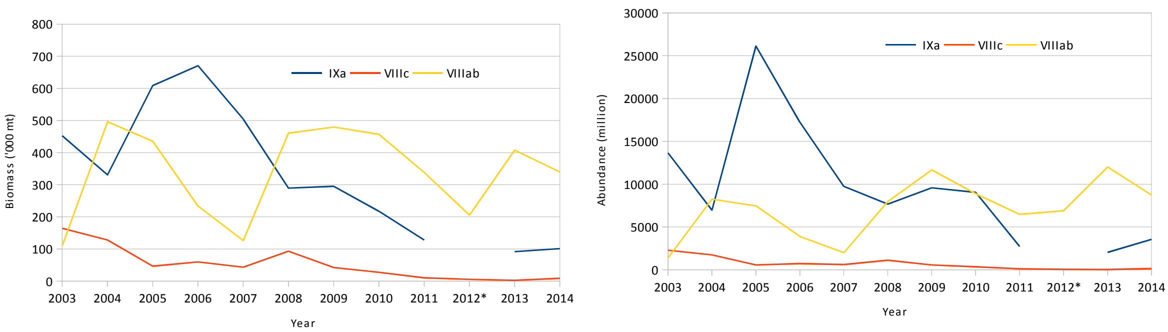

Figure 8.4.2.4.3. Sardine abundance at age by ICES Subdivision estimated during the spring acoustic surveys 2003–14. Left panel biomass (thousand tonnes); right panel, numbers (millions). In 2012, no acoustic survey was undertaken by Portugal.

Figure 8.4.2.4.2. Sardine abundance at age by ICES Subdivision estimated during the 2014 spring acoustic surveys. Left panel in absolute biomass (thousand tonnes); right panel, relative biomass at age.

Since 2003 both biomass and abundance show a declining trend in the Iberian Peninsula whereas in French waters, although total biomass is fluctuating around the mean (341 thousand tonnes), the abundance in number has an increasing trend due to the strength of the last recruitments (Figure 8.4.2.4.3).

Figure 8.4.2.4.3. Sardine abundance at age by ICES Subdivision estimated during the spring acoustic surveys 2003–14. Left panel biomass (thousand tonnes); right panel, numbers (millions). In 2012, no acoustic survey was undertaken by Portugal.

Table 8.4.2.4.3. Sardine abundance (million fish) by ICES Subdivision estimated during the spring acoustic surveys for the period 2003–14. In 2012, no acoustic survey was undertaken by Portugal.

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Sp-IX a	372.32	347.51	905.61	753.10	868.56	643.29	45.15	179.07	26.06	156.20	15.93	1.34
Pt-IX a	13290.32	6623.65	25223.37	16485.11	8872.62	7031.10	9529.80	8861.69	2697.55		2026.22	3561.50
IX a	13662.64	6971.16	26128.98	17238.21	9741.17	7674.39	9574.96	9040.75	2723.61	156.20	2042.15	3562.84
VIIIc	2290.31	1749.31	565.11	730.56	613.82	1118.70	567.52	359.75	123.65	61.02	38.42	145.80
VIIIab	1382.42	8247.98	7465.71	3901.39	2005.77	7983.51	11666.87	8883.33	6479.40	6896.23	12012.27	8722.60
Total	17335.37	16968.45	34159.79	21870.16	12360.77	16776.59	21809.35	18283.83	9326.66	7113.45	14092.84	12431.24

Table 8.4.2.4.4. Sardine biomass (thousand tonnes) by ICES Subdivision estimated during the spring acoustic surveys for the period 2003–14. In 2012, no acoustic survey was undertaken by Portugal.

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Sp-IX a	20.43	21.16	21.51	33.33	52.94	44.23	2.17	12.14	1.31	11.69	0.81	0.05
Pt-IX a	432.12	309.54	587.41	637.39	451.57	245.18	293.00	205.16	126.71		90.95	101.05
IX a	452.55	330.71	608.92	670.72	504.51	289.42	295.17	217.30	128.01	11.69	91.77	101.10
VIIIc	164.47	128.08	46.63	60.10	43.45	93.27	42.43	27.53	10.37	5.69	2.53	8.97
VIIIab	111.23	496.37	435.29	234.13	126.24	460.73	479.68	457.08	338.47	205.63	407.74	339.61
Total	728.26	955.16	1090.84	964.95	674.20	843.41	817.28	701.91	476.85	223.01	502.04	449.68

For anchovy, abundance and biomass by age group in VIIIab are shown in the following table:

	Age groups				
	1	2	3	4	Total
Abundance (million fish)	5955.72	1711.87	262.75	31.85	7962.20
Biomass (thousand tonnes)	86.67	32.23	5.64	0.88	125.43

8.4.2.5 Other fish species

Spring surveys also provide abundance estimates and distribution for other pelagic fish species such as mackerel, horse mackerel, boarfish, bogue, chub mackerel or sprat. Table 8.4.2.5.1 shows the data available (biomass estimation and/or NASC distribution) for the main species. For those species and areas where NASC values were available, a grid map has been produced.

Table 8.4.2.5.1. Available information (NASC distribution and biomass estimation -thousand tonnes when available-) by ICES Divisions (IXa split in northern Spain, Portugal and Gulf of Cadiz) for mackerel (MAC), horse mackerel (HOM), Blue whiting (BWH), sprat (SPR), boar fish (BOC), chub mackerel (MAS), lanternfish (MAV), hake (HKE) and bogue (BOG).

	MAC		HOM		BWH		SPR		BOC		MAS	MAV	HKE	BOG
Area	NASC	Biom.	NASC	Biom.	NASC	Biom.	NASC	Biom.	NASC	Biom.	NASC	NASC	NASC	NASC
VIIIab	Y	410	Y	53	Y	25	Y	34	-	-	-	-	-	-
VIIIc	Y	806	Y	31	Y	22	-	-	Y	25	Y	Y	Y	Y
IXa-Sp	Y	2	Y	13	Y	2	-	-	-	-	Y	Y	Y	Y
IXa-Pt	-	-	Y	na	-	-	-	-	-	-	Y	-	-	Y
IXa-GoC	-	-	Y	na	-	-	-	-	-	-	Y	-	-	Y

8.4.2.5.1 Mackerel

Data for mackerel were provided by PELACUS and PELGAS. 410 and 808 thousand tonnes were respectively estimated in VIIIab and in VIIIc. In IXa, only 2 thousand tonnes were assessed, most of them belonging to age group 1. Age group 5 was dominant in VIII Divisions.

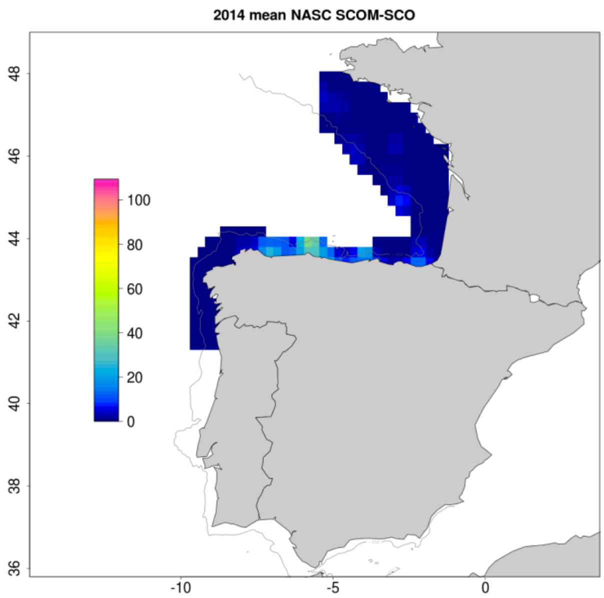

Figure 8.4.2.5.1.1. Average mackerel abundance and distribution derived from NASC raw values (only for those areas where data were available).

The bulk of the distribution was located in the middle of the Cantabrian Sea. Besides, in this area, mackerel either occurred in thick and dense schools near the seabed or in a continuous layer locate d at around 50 m depth, sometimes rising to the sea surface, being visible by the observers.

8.4.2.5.2 Horse mackerel

Horse mackerel was evenly distributed from Gulf of Cadiz to Brittany. 53 thousand tonnes were estimated in VIIIab, 31 thousand tonnes in VIIIc, and 13 thousand tonnes in IXa-N. Length distribution ranged between 10 to 37 cm with the main mode estimated at 20–21 cm.

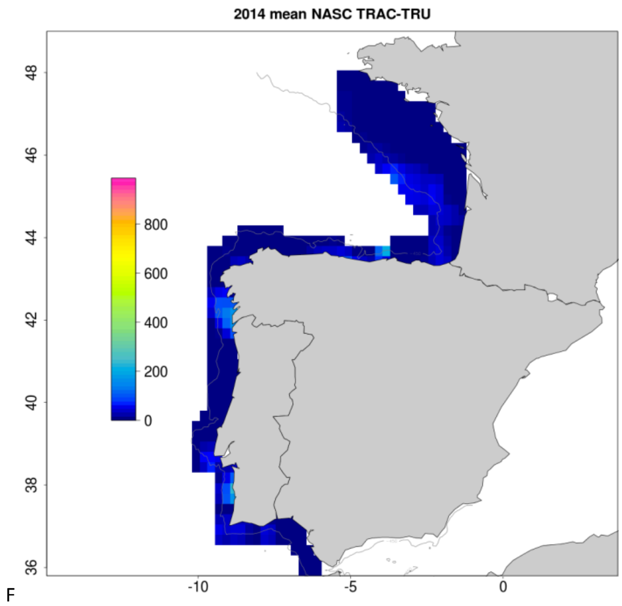

Figure 8.4.2.5.2.1. Average horse mackerel abundance and distribution derived from NASC raw values (only for those areas where data were available).

8.4.2.5.3 Blue whiting

Blue whiting occurred close to the slope, mainly in the Cantabrian Sea and offshore Brittany. However the abundance, although probably its distribution area wouldn't be entirely covered by the surveys (i.e. offshore extension in pelagic layers), is relatively low with only 25 thousand tonnes in French waters and more or less the same quantity in Northern Spanish waters.

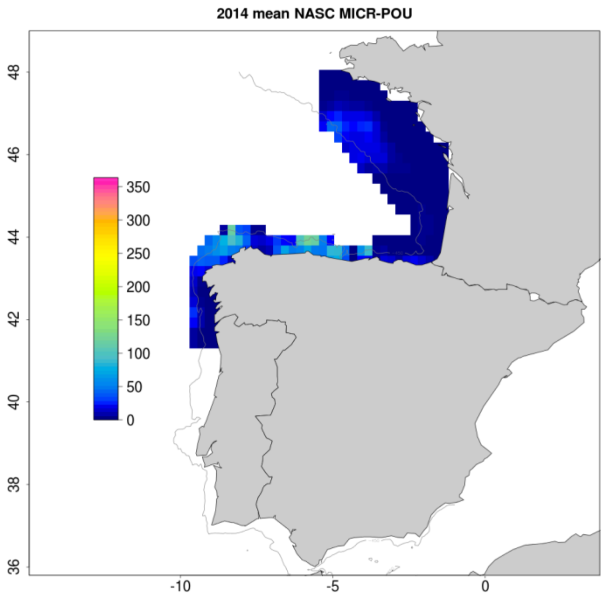

Figure 8.4.2.5.2.1. Average blue whiting abundance and distribution derived from NASC raw values (only for those areas where data were available).

8.4.2.5.4 Sprat

NASC data from sprat are only provided by PELGAS where this fish species occurred around the main river plume areas (Garonne and coastal waters of Brittany). Total abundance was estimated to be 34 thousand tonnes. Along the time-series, this abundance index exhibits wide year-to-year variation.

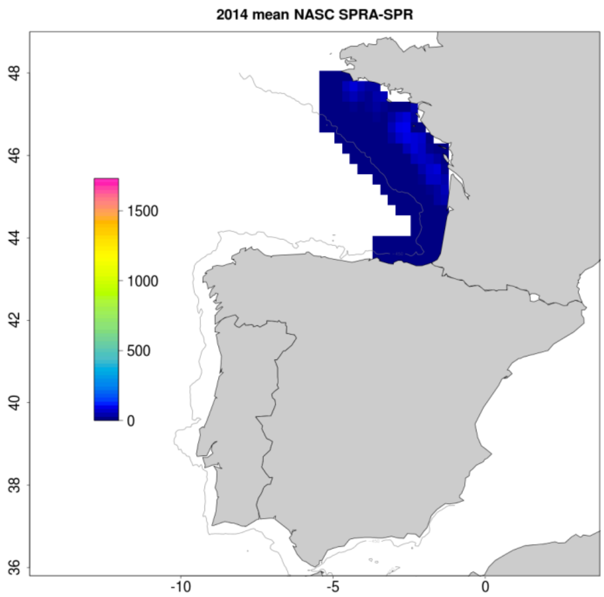

Figure 8.4.2.5.2.1. Average sprat abundance and distribution derived from NASC raw values (only for those areas where data were available).

8.4.2.5.5 Boarfish

For boarfish, only PELACUS, together with the specific survey BFAS conducted in VII, is providing abundance and fish distribution. With the new TS/length relationship, boarfish biomass was estimated to be 25 thousand tonnes, with a bimodal length distribution, with the first mode located at 8 cm and the second at 14 cm. The bulk of the distribution is located in the western part of the Cantabrian Sea with an additional spot close to Santander.

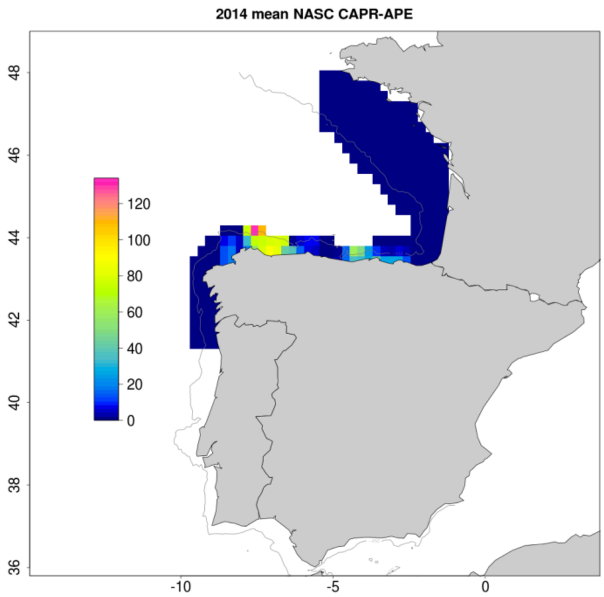

Figure 8.4.2.5.5.1. Average boarfish abundance and distribution derived from NASC raw values (only for those areas where data were available).

8.4.2.5.6 Chub mackerel

Although chub mackerel is distributed throughout the surveyed area, the most important concentrations are located in southern areas (Gulf of Cadiz, Algarve).

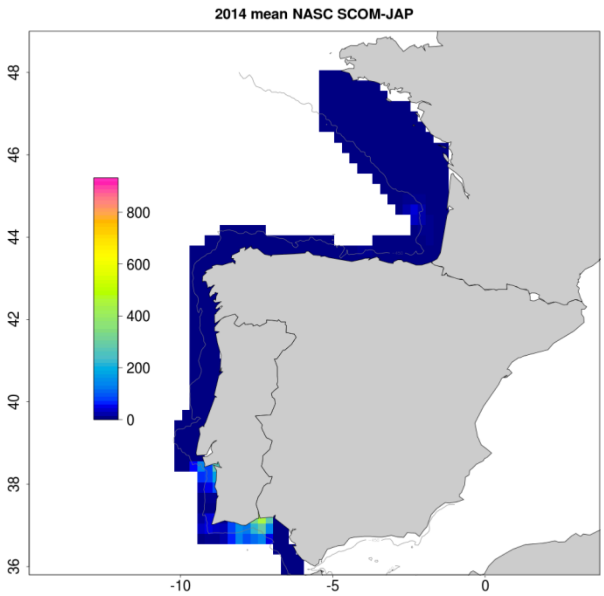

Figure 8.4.2.5.6.1. Average chub mackerel abundance and distribution derived from NASC raw values.

8.4.2.5.7 Mediterranean horse mackerel

Mediterranean horse mackerel is mainly located at the inner part of the Bay of Biscay, as show in Figure 8.4.2.5.7.1.

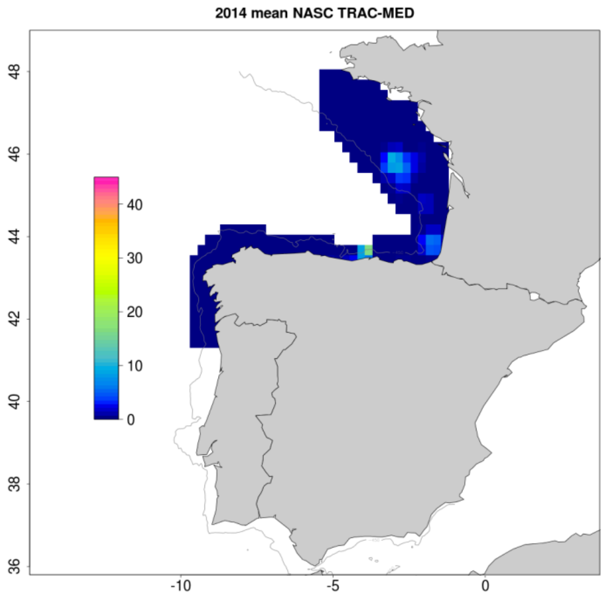

Figure 8.4.2.5.7.1. Average Mediterranean horse mackerel abundance and distribution derived from NASC raw values (only for those areas where data were available).

8.4.2.5.8 Bogue

NASC values for bogue are provided by PELAGO and PELACUS survey. Together with a patch located within the Rias Baixas area (NW Spanish IXa), the bulk of the distribution is located around Cape San Vicente area, as show in Figure 8.4.2.5.8.1

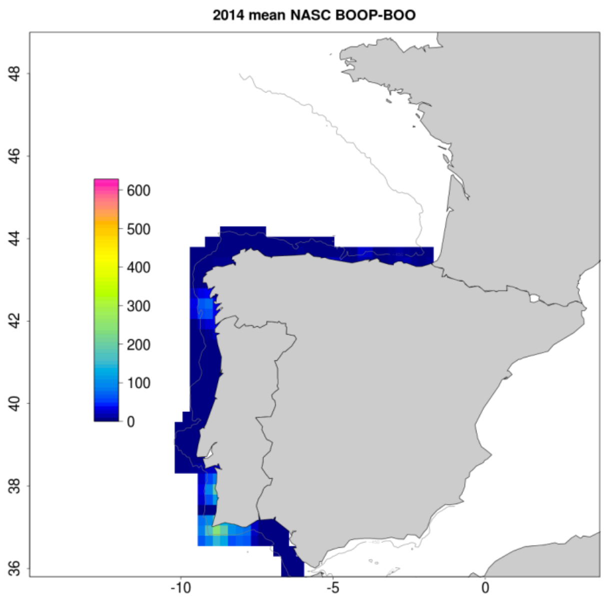

Figure 8.4.2.5.8.1. Average bogue abundance and distribution derived from NASC raw values (only for those areas where data were available).

8.4.2.5.9 Hake

NASC values for hake are derived from the fish proportion found at the ground-truthed fishing stations in PELACUS. These were mainly composed by small size (<25cm) specimen and thus reflecting areas of higher juvenile concentration. These mainly occurred in the western part (Atlantic waters), with two additional areas, one locate at the inner part of the Bay of Biscay and around Cape Peñas.

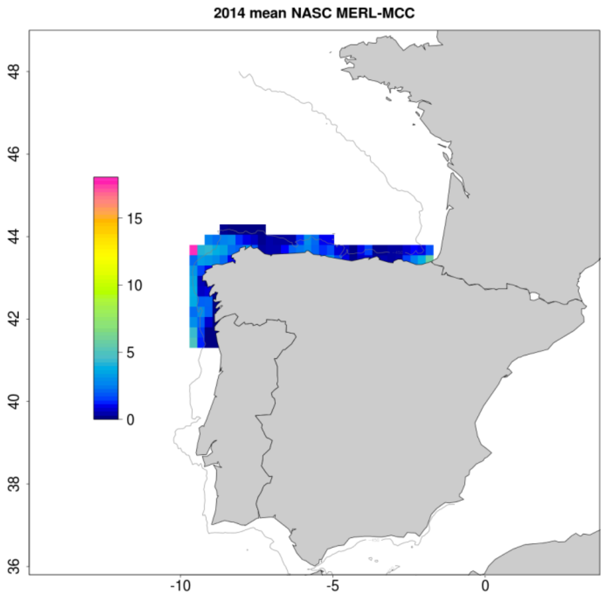

Figure 8.4.2.5.9.1. Average hake abundance and distribution derived from NASC raw values (only for those areas where data were available).

8.4.2.5.10 Silver Lightfish

Normally *M. muelleri* occurred offshore, from the slope to deep-seawaters. However, last year was found over the continental self, in the northwestern area of the Spanish waters.

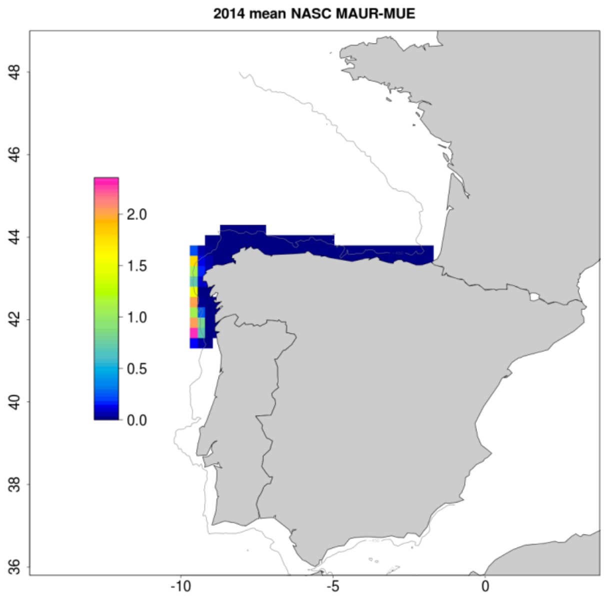

Figure 8.4.2.5.10.1. Average silver light fish abundance and distribution derived from NASC raw values (only for those areas where data were available).

8.4.2.5 Other observations

Marine mammals and birds were also recorded, but neither distribution nor abundance are available for the time being.

8.4.2.6 Sardine and anchovy egg distributions from CUFES sampling

The egg distribution from CUFES sampling is presented in Figure 8.4.2.6.1. It can be observed that sardine eggs during the period surveyed had a wider distribution than anchovy eggs; however, the maximum densities were found for anchovy. Anchovy egg occurrence in more localized regions is nonetheless consistent with the species distribution which are scarcely represented in the western Iberian shores (except in the vicinity of some relevant rivers) and western Cantabrian Sea. It is also important to note that the Portuguese survey, which covers southern and western Iberia, and the Spanish survey, which starts at the northern border between Portugal and Spain and reaches the French border, are conducted in early spring and therefore off peak for anchovy spawning. Even so, the egg distribution observed matched fairly the adult fish distribution for both sardine and anchovy. In 2014, egg abundances in Cantabrian waters were very low but taken as a whole the number of eggs were within the range observed during the surveys time-series for the period 2003–-2012 for the area covered by the three surveys. Maximum densities for sardine eggs were lower than the ones observed in the period 2003–2012 while maximum abundances for anchovy eggs were higher in 2014 than for the historic period mentioned above.

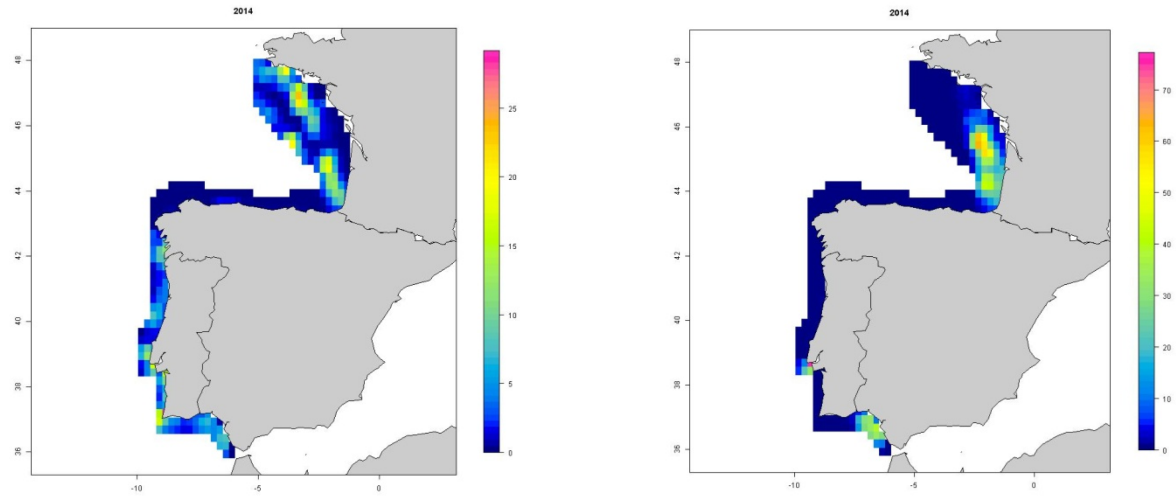

Figure 8.4.2.6.1. Sardine (left panel) and anchovy (right panel) egg distributions from CUFES (eggs/m3) sampling during the spring acoustics surveys (IPMA, IEO, Ifremer). For dates of coverage in each region see Table 8.4.1. Note that due to the data range in the observations the colour scales do not match between left and right panels.

8.4.3. DEPM surveys

8.4.3.1. Oceanographic conditions (SST, SSS)

The distribution patterns of sea surface temperature (SST) and sea surface salinity (SSS) observed during the 2014 surveys were the typical for the region with temperature and salinity decreasing from south to north along the Iberian shores and then showing an increase over the wider platform of the Bay of Biscay by the time spring conditions were already in place (Figure 8.4.3.1). Despite the fact that the Portuguese survey started later than usual the river plumes in NW Portugal, and also in W Galicia, were very clear as a consequence of rainy and stormy periods which occurred towards the end of the winter period. The signatures of the Adour and Garonne River off the French coast were also evident. By the time the Gulf of Cadiz DEPM survey for anchovy was conducted in summer, the maximum temperature (not shown) had raised by about 3 ºC compared to the maps presented.

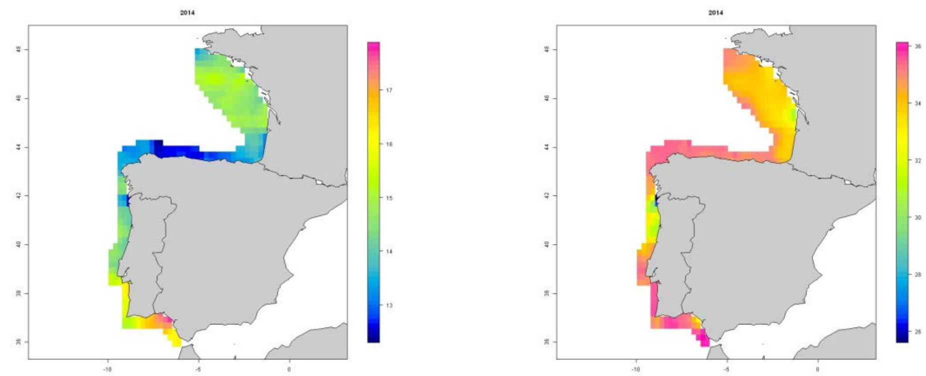

Figure 8.4.3.1. Sea surface temperature (left panel) and salinity (right panel) during the period March-May 2014 during the DEPM surveys for sardine (IPMA, IEO) and anchovy in the Bay of Biscay north of 45ºN (AZTI). For dates of coverage in each region, see Table 8.4.2.

8.4.3.2. Sardine

8.4.3.2.1. Egg distributions from CUFES and PairoVET observations

Sardine egg distributions patterns derived from CUFES and PairoVET observations during the winter/spring 2014 DEPM surveys looked alike with higher abundances in the southern and southwestern Iberian coasts and in the mid shelf of the Bay of Biscay. Sardine egg abundances were very low in the Cantabrian Sea where the numbers observed were the lowest of the time-series (Figure 8.4.3.2.1). As it has been noted in recent years the sardine egg abundances in western Iberia and Bay of Biscay are similar or even higher in the more northern region where an increase in the sardine population has been observed. Figure 8.4.3.2.2 shows the distribution of eggs during the anchovy DEPM surveys that took place in late spring in the Bay of Biscay (in part repeated with Figure 8.4.3.2.1) and during summer in the Gulf of Cadiz. Accordingly, because the DEPM survey for the Gulf of Cadiz anchovy is conducted in summer, off spawning season for sardine, the observations of sardine eggs are residual as expected. The gridded egg density maximum in 2014 derived from CUFES sampling was considerably higher than the average of the historic series (2003–2011) while it was within the average for the PairoVET observations. For higher spatial resolution in the egg distributions see the detailed maps in the survey reports in Annex 8.10.

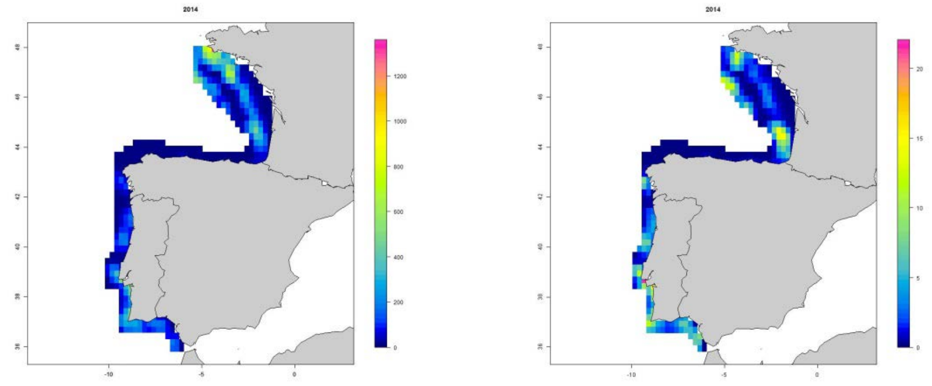

Figure 8.4.3.2.1. Sardine egg distributions from PairoVET (left panel; eggs/m^2) and CUFES (right panel; eggs/m^3) observations collected during the DEPM surveys for sardine (IPMA, IEO) and anchovy in the Bay of Biscay north of 45ºN (AZTI). For dates of coverage in each region see Table 8.4.2. Note that due to the data range in the observations the colour scales do not match between figures.

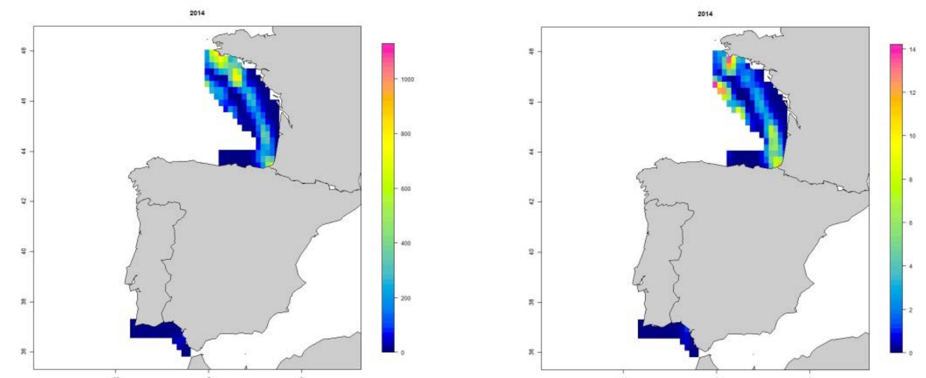

Figure 8.4.3.2.2. Sardine Egg distributions from PairoVET (left panel; eggs/m^2) and CUFES (right panel; eggs/m^3) observations collected during the DEPM surveys for anchovy in the Bay of Biscay (AZTI) and Gulf of Cadiz (IEO). For dates of coverage in each region see Table 8.4.2. Note that due to the data range in the observations the colour scales do not match between figures.

8.4.3.2.2. Mean weight and length-at-age and reproductive parameters

During the 2014 survey the availability of adult sardine for trawling was limited in the whole area; nevertheless, 55 samples were obtained, 12 in the south, 17 in the west and 15 in the north, 3 in the VIIIb area up to 45ºN and 8 in the VIIIab area (45–48ºN). Extra samples (20) from purse-seiners were collected in Portugal (Table 8.4.2). Despite the fact that sardine schools were less available than during other surveys the number of hydrated females (indicating spawning activity) collected was higher than in 2011 for all the areas sampled.

Table 8.4.3.2.1. Sardine mean weight (g) at age and mean length (mm) at age for individual randomly sampled by areas covered for sardine DEPM surveys (IPMA, IEO, AZTI).

	IPMA	IPMA	IEO	IEO	AZTI
Mean weight (g)	IXa South	IXa West	IXa N & VIIIc	VIIIb (up to 45ºN)	VIIIab (45–48ºN)
Age 1	35.2	27.0	32.7	43.8	28.8
Age 2	50.9	50.2	52.6	46.3	46.9
Age 3	58.5	62.0	65.2	60.5	58.7
Age 4	58.9	73.6	72.7	79.0	70.1
Age 5	68.6	76.3	87.9	85.2	74.7
Age 6	69.2	80.2	86.4	91.1	92.4
Age 7	69.9	81.5	94.6	97.6	103.8
Age 8	71.1	82.5		97.3	103.8
Age 9	71.4	88.3			
Age 10	62.0	98.0			

	IPMA	IPMA	IEO	IEO	AZTI
Mean length (mm)	IXa South	IXa West	IXa N & VIIIc	VIIIb (up to 45ºN)	VIIIab (45–48ºN)
Age 1	164	152	160	181	155
Age 2	188	183	194	186	181
Age 3	198	194	209	203	194
Age 4	200	215	216	221	206
Age 5	211	215	231	228	209
Age 6	213	224	231	233	224
Age 7	215	215	236	241	233
Age 8	216	221		243	233
Age 9	218	233			
Age 10	208	232			

One not anticipated result was that for the first time, mean female weight and batch fecundity were lower for the northern than for the western and southern strata, and were the lowest observed off the Spanish coast in the whole series, indicating a structure of the population unusual for that area. In fact, the mode of individual's age distribution off the northern Spanish coast was 1 year-old, these fish representing about half of the individuals for which otoliths were sampled. On the western coast, the majority of individuals for which age data are available were also aged as 1 year-old. On the contrary, sardine age distribution off the southern coasts was widespread with fish aged from 1 to 7, with no clear modal ages. Mean female weight obtained for the Spanish coast was much lower (48.7) than values reported from the whole historical series, which ranged between 70.1 g in 1997 and 85.8 g in 2011, whereas in the South coast mean weight estimate was the highest (60.7 g) observed since 1997 (values ranging between 38.8 g in 2002 and 56.3 g in 2008).

Batch fecundity doubled in the western area and increased slightly in the south compared with 2011; for the north, the lowest values were observed which were similar to the estimates for west and south in previous years. Spawning fraction for the north strata in 2014 was lower than for the 2011 survey but similar to estimations of other years. For southern and western strata average values were used since the information was not fully available by the time the estimations were presented.

For the VIIIb (up to 45ºN) area, the estimates obtained for the adult parameters are close to those obtained for the whole time-series. Values of mean female weight and batch fecundity are higher for the southern French area than those obtained in the adjacent areas (northern Iberian Peninsula and French shores surveyed during the AZTI campaign).

For the VIIIab (from 45ºN to 48ºN) all the adult parameters are in the range of the adult parameters from the other areas surveyed but the weight is more similar to that in the west Cantabrian Sea. The area passed the shelf break at 47ºN could not be sampled by this survey but the survey PELGAS (Ifremer) covered it (pers.com.) and the weight of the sardines at this oceanic area was similar to that in VIIIb up to 45ºN, so it is possible that these individuals moved from the corner of the Bay of Biscay to the northwest in the oceanic part, outside the platform. For similar female mean weights, batch fecundity was nevertheless higher for the VIIIab (northern to 45ºN) than in the Cantabrian Sea (IXa N and VIIIc). The spawning fraction estimates obtained were relatively homogeneous in the whole area covered by the different DEPM surveys, which in 2014 were more coincident in time in relation to sardine spawning season (March-May) due to the delayed realization of IPMA's survey (for the IXa S and W, the S estimates are still preliminary).

Table 8.4.3.2.2. Reproductive parameters derived from sardine DEPM surveys (IPMA, IEO, AZTI) with corresponding CV (%) in brackets by institution and area. Females mean weight (g), Batch fecundity (number of eggs spawned per mature females per batch), Sex ratio (fraction of population that are mature females by weight), Spawning fraction (fraction of mature females spawning), Daily specific fecundity (nº of egg per g of biomass) and Spawning-stock biomass (tons).

Reproductive parameters Sardine DEPM	IPMA	IPMA	IEO	IEO	AZTI
	IXa South	IXa West	IXa N & VIIIc	VIIIb (up to 45ºN)	VIIIab (45–48ºN)
Female Weight	60.7 (5)	52.6 (14)	48.7 (11)	65.51 (22)	48.46 (5)
Batch Fecundity	22673 (7)	22585 (14)	17118 (12)	25545 (24)	21056 (12)
Sex Ratio	0.602 (8)	0.505 (6)	0.40 (15)	0.59 (12)	0.482 (18)
Spawning Fraction	0.081 (9)*	0.066 (8)*	0.093 (34)	0.084 (25)	0.089 (23)
Daily Specific Fecundity	18.2 (15)	14.3 (22)	13.1 (41)	19.3 (43)	18.6 (32)
Spawning Biomass (tons)	38994 (31)	67819 (32)	23882 (49)	86624 (51)	322974 (35)

*** Values estimated by bootstrap (WGACEGG 2012).**

8.4.3.2.3. Egg parameters

The spawning area in 2014 as a whole for area IXa and VIIIc was slightly reduced compared to 2011 and the smallest of the historic series; this was particularly evident for the Cantabrian Sea where less than half of the area was positive for eggs compared to the previous survey. The egg distribution was patchy and very low sardine eggs were observed off the Spanish shores. In western Portugal, the spawning area increased to more than double. Daily egg production per m2 (eggs/m2/day) was higher for the southern stratum, intermediate in the west coast and lower in the north; for all strata daily egg production per m2 was much lower than in recent surveys

The sum of total egg production for the 3 strata of Divisions IXa and VIIIc in 2014 were much lower than in 2011, in particular in the northern and southern regions, and similar in the west. The mortality value (single mortality for whole area) was one of the lowest of the series but with high CV.

Further north in French waters the egg densities were higher than in the more southern regions however not as high as previously observed and the spawning area was reduced compared to past surveys. The daily egg production per m2 and total egg production (eggs/day) in area VIIIb up to 45ºN was much higher than in the adjacent stratum, in Cantabrian waters and also higher than further north, north of 45ºN. This was possibly related to the structure of the sardine population observed in the inner corner of the Bay of Biscay where the larger (more fecund) individuals of all of the 2014 surveys were collected.

Table 8.4.3.2.3. Eggs parameters derived from sardine DEPM surveys with their CV (%) in brackets. Final egg production model for the Iberian Peninsula include individual egg production estimates for each strata (IXa South, IXa West and IXa North-VIIIc) and a common mortality for the whole area. Significant mortality values ($hour^{-1}$) are shown. ** Significance at p<0.01 and * Significance at p<0.001.**

	IPMA	IPMA	IEO	IEO	AZTI
Eggs parameters Sardine DEPM	IXa South	IXa West	IXa N and VIIIc	VIIIb (up to 45ºN)	VIIIab (45–48ºN)
Survey area (km2)	14559	27357	38914	13480	69944
Positive area (km2)	6825	11001	7494	7914	46512
Z (hour -1)	-0.017 ** (36)			-0.021*** (29)	-0.013***(30)
Z (daily -1)	-0.41**(36)			-0.50***(29)	-0.31***(30)
P0 (eggs/m2/day)	104 (27)	89 (23)	40 (26)	214 (28)	129 (15)
P0 tot (eggs/day; x1012)	0.71 (27)	0.97 (23)	0.31 (26)	1.70 (28)	6.02 (15)

8.4.3.2.4. Biomass estimates

SSB estimation for the northern strata in 2014 was the lowest of the whole series (23882 tons). For the western and south coasts, SSB estimates are still preliminary (because spawning fraction estimations from the 2014 observations were not used yet), but the results suggest also a substantial decrease of the biomass in these two strata, compared to 2011. Despite the fact that the Portuguese survey was conducted later than usual the population was actively spawning and the results obtained for all parameters estimated were consistent.

The SSB estimate for the area VIIIB covered by IEO was around 40% lower than in 2011. This reduction is mostly a consequence of the decrease in total egg production, from 2.7 (eggs/day) in 2011 to 1.7 (eggs/day) in 2014. The biomass estimate in the VIIIab this year was the highest, compared with the rest of the areas surveyed.

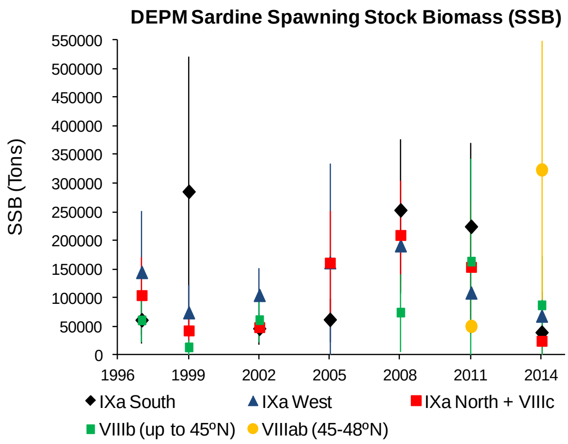

Figure 8.4.3.2.3. Time-series of the sardine DEPM based SSB estimates by areas. Vertical lines indicate SSB approximate 95% confidence intervals (i.e. ± 2 standard-deviations). Sardine DEPM in area VIIIab (45–48ºN) was first considered in 2011.

8.4.3.3. Anchovy

8.4.3.3.1. Egg distributions from CUFES and PairoVET observations

Anchovy egg distribution patterns derived from CUFES and PairoVET observations during the 2014 DEPM surveys are similar, highlighting the usual higher densities in the Bay of Biscay and inner Gulf of Cadiz where the anchovy populations are relevant. The maps in Figure 8.4.3.3.1. gives a better representation of the anchovy egg densities since the observations correspond to the DEPM surveys directed at the species. In the maps representing the peak season for anchovy the densities in the Gulf of Cadiz are higher and more widely spread than earlier in the season. In this area, anchovy eggs were caught mainly in the coastal area located in Spanish waters, and the higher abundances were found in areas located close to Huelva, inside the isobaths of the 130 m. Temperature (SST) ranged between 17.9 and 23.6 ºC (mean 21.6 ºC). As usual, and related to the population's dimension, the anchovy egg density is higher in the Bay of Biscay than in the Gulf of Cadiz. In the Bay of Biscay this year, no anchovy eggs were found in the Cantabrian coast. The spawning area started at 43º37'N in the French platform and the northern limit was found at 47º N. The eggs in the French platform were encountered in the historical common places: between Adour River and Arcachon passed the 200m depth from the coast and in the area of influence of Garonne River, from the coast to the 100m depth line.

The data used to obtain the maps in Figure 8.4.3.3.2 are partly derived from observations undertaken during the sardine DEPM in the Iberian waters (until 45ºN) and only at the beginning of the spawning season for anchovy. From 45ºN to the North are from DEPM survey for anchovy in the Bay of Biscay (May; AZTI) data repeated in Figure 8.4.3.3.1 For higher spatial resolution in the egg distributions see the detailed maps in Annex 8.10.

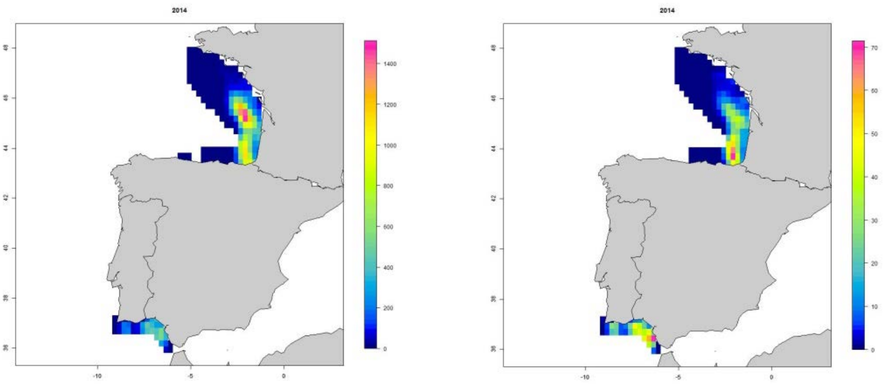

Figure 8.4.3.3.1. Anchovy egg distributions from PairoVET (left panel; eggs/m²) and CUFES (right panel; eggs/m³) collected during the DEPM surveys for anchovy in the Bay of Biscay (May; AZTI) and Gulf of Cadiz (July; IEO). For dates of coverage in each region see Table 8.4.2. Note that due to the data range in the observations the colour scales do not match between figures.

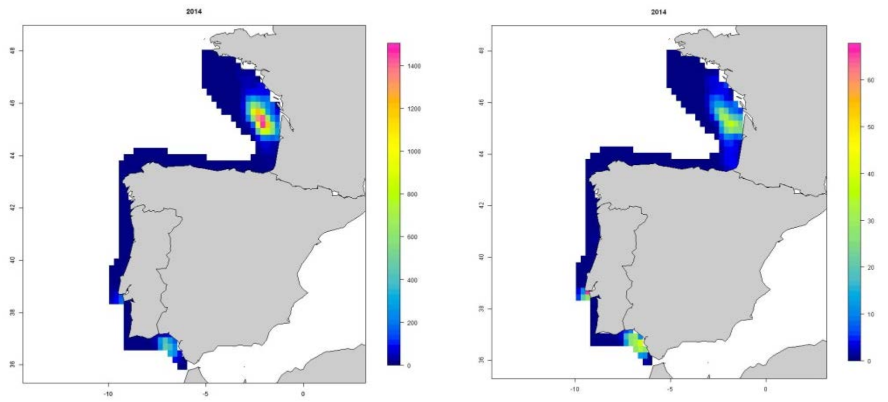

Figure 8.4.3.3.2. Anchovy egg distributions from PairoVET (left panel; eggs/m²) and CUFES (right panel; eggs/m³) observations collected during the DEPM surveys for sardine (IPMA, IEO) until 45ºN and DEPM anchovy in the Bay of Biscay in May from 45ºN to the North (AZTI; data repeated in Figure 8.4.3.3.1). For dates of coverage in each region see Table 8.4.2. Note that due to the data range in the observations the colour scales do not match between figures.

8.4.3.3.2. Mean weight at age; mean length-at-age; SSB at age

For the purpose of producing population at age estimates, the age readings based on 2405 otoliths from 47 samples were available. Estimates of anchovy mean weights and proportions at age in the population were the average of proportions at age in the samples, weighted by the population each sample represents. 73% of the population in numbers and 65% in mass correspond to age 1 (see Table 8.4.3.3.1). This is a year with a good recruitment after several years in the past with failure recruitments.

Table 8.4.3.3.1. Percentage at age, numbers-at-age, weight at age, Spawning-stock biomass at age and percentage at age in mass estimates for the Bay of Biscay anchovy in 2014, survey BIOMAN (AZTI). With their standard error (S.e.) and CV. There is no information on these estimates for the Gulf of Cadiz (IEO).

Anchovy DEPM VIIIabc BIOMAN (AZTI survey in May)			
Parameter	estimate	S.e.	CV
Percentage at age 1	0.73	0.03	0.0464
Percentage at age 2	0.21	0.03	0.1286
Percentage at age 3	0.06	0.01	0.1819
Numbers-at-age 1	3,863	658	0.1704
Numbers-at-age 2	1,109	169	0.1524
Numbers-at-age 3	294	67	0.2264
Weight at age 1 (g)	15.3		
Weight at age 2 (g)	22.3		
Weight at age 3 (g)	22.7		
SSB at age 1 (Tons)	58,079		
SSB at age 2 (Tons)	24,358		
SSB at age 3 (Tons)	6,574		
Percentage at age 1 in mass	65.2		
Percentage at age 2 in mass	27.4		
Percentage at age 3 in mass	7.4		

8.4.3.3.3. Reproductive parameters

The reproductive parameters for the DEPM in 2014 estimated for anchovy in the Gulf of Cadiz are very similar to the previous survey (2011), and very similar to anchovy in area VIIIabc, to (Table 8.4.3.3.2). The estimation of the spawning fraction (S) in 2014 is not available yet. In order to obtain a preliminary estimate of the SSB for 2014, the S value derived from the 2011 has been used. For anchovy in the Bay of Biscay in May 2014, comparing the adult parameters with the corresponding mean historical series (1987–2014), total mean weight and female weight are at the level of the historical mean (19g and 24.8g, respectively). For the batch fecundity, this year's estimate is lower than the historical mean (11,377 eggs per mature female per batch), the sex ratio is the same as the historical mean. The spawning fraction is as well at the same level as the historical mean (0.39) and the SSB is the second highest of the historical series.

Table 8.4.3.3.2. Reproductive parameters in 2014, derived from anchovy DEPM surveys: BOCADEVA, in the Gulf of Cadiz in July (IEO, Cadiz) and BIOMAN in the Bay of Biscay (AZTI) in May, with corresponding CV in brackets. Total mean weight (g) from males and females, Females mean weight (g), Batch fecundity (number of eggs spawned per mature females per batch), Sex ratio (fraction of population that are mature females by weight), Spawning fraction (fraction of mature females spawning per day), Daily fecundity (nº of egg per g of biomass per day) and Spawning-stock biomass (tons).

Reproductive parameters	IEO Cádiz (BOCADEVA)	AZTI (BIOMAN)
Anchovy DEPM	IXa South (July)	VIIIabc (May)
Total Weight	NA	17.07 (0.07)
Female Weight	18.22 (0.08)	21.09 (0.04)
Batch Fecundity	7,502 (0.08)	7,972 (0.06)
Sex Ratio	0.54 (0.008)	0.54 (0.02)
Spawning Fraction	0.28 (0.04)[1]	0.37 (0.03)
Daily fecundity (tons)	NA	76.14 (0.05)
Spawning Biomass	31,569 (0.30)[2]	89,011 (0.12)

[1] 2011 survey's value

[2] Estimated using the spawning fraction value from the 2011 survey'.

8.4.3.3.4. Egg parameters

As is shown in Table 8.4.3.3.3, the spawning area and P_{tot} values are smaller in the Gulf of Cadiz than the Bay of Biscay, accordingly to the area they inhabit.

The P_{tot} estimations in the Gulf of Cadiz are very similar to the last surveys (2008, 2011 and 2014), but a positive trend in the P_0 values is observed, obtaining for this year the highest value (313.5 eggs/m²/day). Regarding this parameter, the value estimated for the anchovy in the Gulf of Cadiz is higher than the one estimated in the Bay of Biscay. In relation to the egg daily mortality rate, the value obtained in the Gulf of Cadiz presents a very high CV with no statistical significance.

In the Bay of Biscay the spawning area is at the same level of the mean historical series (1987–2014) that is 39000km² and the total daily egg production is double when compared to the mean historical series. The high biomass of this year is due to the high total egg production.

Table 8.4.3.3.3. Eggs parameters 2014 from anchovy DEPM surveys: In Gulf of Cadiz in July (IEO Cadiz) survey called BOCADEVA and in Bay of Biscay (AZTI) in May survey called BIOMAN, with their CV in brackets by survey. Daily egg production (P_0), daily mortality rate (z) and total daily egg production are estimate for the whole area in each survey.

Eggs parameters	IEO Cádiz (BOCADEVA)	AZTI (BIOMAN)
Anchovy DEPM	IXa South (July)	VIIIabc (May)
Survey area (km²)	14,595	104,015
Positive area (km²)	6,214	35,317
Z (egg daily mortality rate)	-0.33 (1.19)	-0.17 (0.34)
P0 (eggs/m²/day)	313.5 (0.34)	191.37 (0.11)
P tot (eggs/day; x10^{12})	1.95 (0.34)	6.76 (0.11)

8.4.3.3.5. Biomass estimates

The DEPM for spawning-stock biomass estimation for the Gulf of Cadiz anchovy (ICES, Subdivision IXa South) is conducted every three years (IEO, Spain) and the first survey of this series was carried out in 2005; this year´s survey, BOCADEVA 0714, was the fourth anchovy survey of the series (Figure 8.4.3.3.3). In 2005, the SSB was the lowest value of the series (14,700 tons), in 2008 this value doubled and it has remained stable at very similar values (ranged between 31,500–32,800 tons) since then.

The same method is applied every year by AZTI since 1987 in the Bay of Biscay (ICES VIIabc) to estimate the anchovy spawning-stock biomass. In this period the anchovy population passed from a period of very low biomasses (2005–2009), associated to a fishery closure for 5 years, to a recovery up to its historical maximum in 2011. The 2014 SSB estimate is the second highest of the series (Figure 8.4.3.3.3).

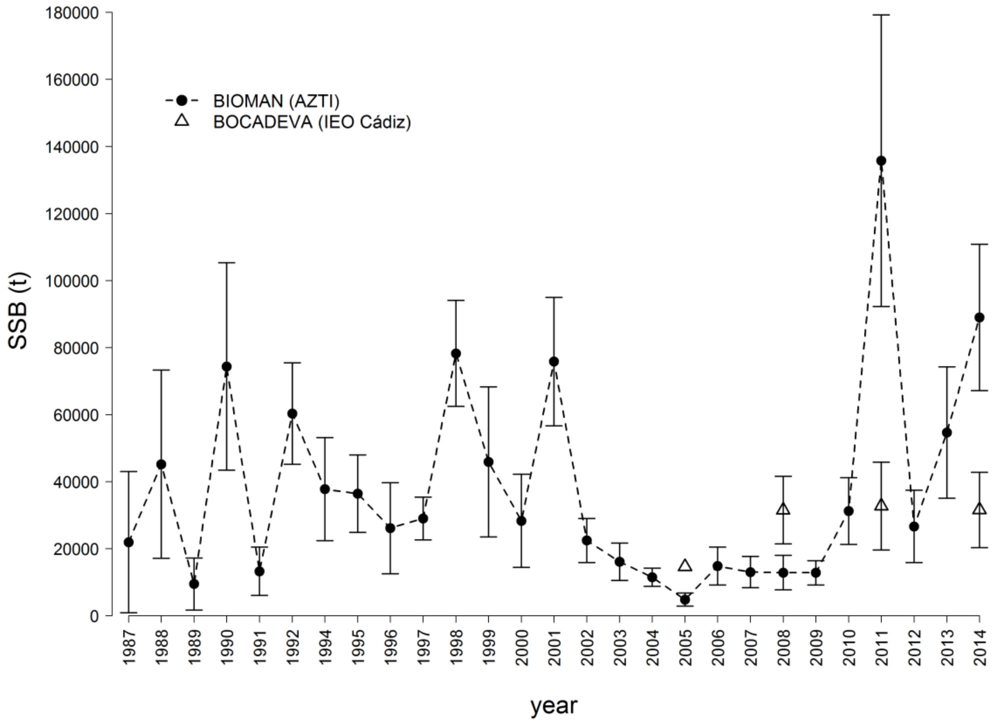

Figure 8.4.3.3.3. Time-series for anchovy DEPM based SSB estimates by survey: the Gulf of Cadiz survey in July (IEO Cadiz), called BOCADEVA, and the Bay of Biscay (AZTI) survey in May, called BIOMAN. Vertical lines indicate SSB 95% confidence intervals (i.e. ± 1 standard-deviations).

8.4.4 Summer acoustic surveys (2014)

8.4.4.1. Oceanographic conditions

As in 2013, *ECOCADIZ 2014–07* was characterized by an upwelling area located at the western part, with colder and less saltier waters as compared with the most stable eastern area (see Sánchez-Leal *et al*. (2014, WD 15 in **Annex 8.10**) for further details.

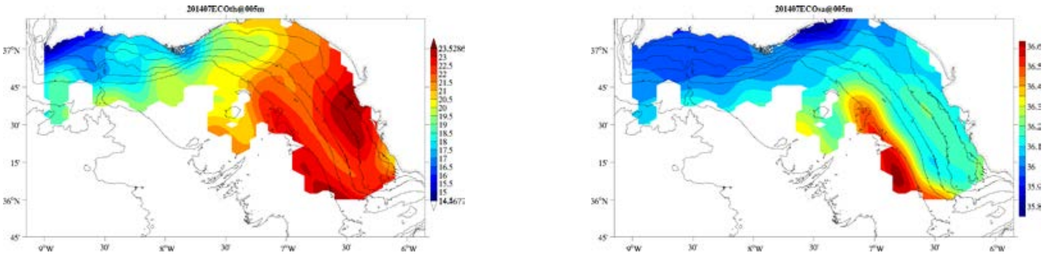

Figure 8.4.4.1.1. Oceanographic conditions during the *ECOCADIZ 2014–07* survey. Temperature (left) and salinity (right) as measured by CTD at 5 m depth.

8.4.4.2. Sardine and anchovy distribution derived from NASC

8.4.4.2.1. Sardine

Sardine was mainly restricted to the inner-middle shelf of two well delimitated areas: the area comprised between Capes San Vicente and Santa Maria, in the Portuguese western Algarve, and the densest one, comprised between the Guadiana and Tinto-Odiel rivers mouths, over the Spanish shelf. A residual area with sardine occurrence was recorded in the easternmost waters, between Cadiz Bay and Cape Trafalgar. Unlike the widely distributed anchovy (see below), sardine showed during the survey relatively important areas with very low or even null occurrence (**Figure 8.4.4.2.1.1**).

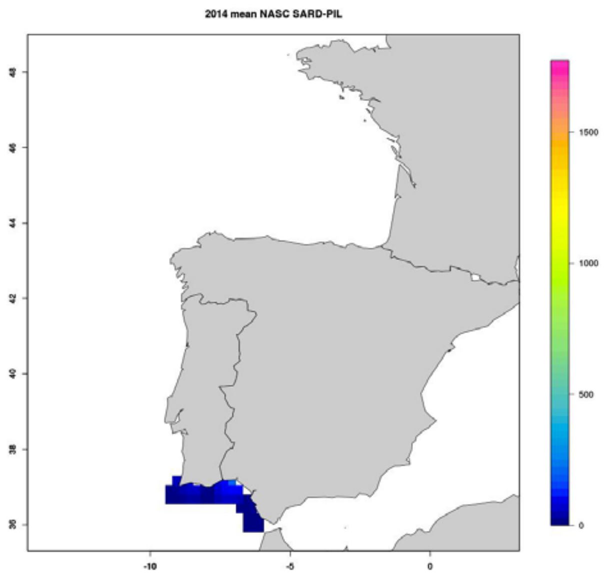

Figure 8.4.4.2.1.1. Spatial distribution of acoustic energy (NASC) attributed to Gulf of Cadiz sardine in summer 2014 during the *ECOCADIZ 2014–07* survey (IEO).

8.4.4.2.2. Anchovy

Although widely distributed over the surveyed area, the bulk of the anchovy population was concentrated, as usual, in the central part of the surveyed area which corresponds to the Spanish western shelf. In this area, the species distributed all over the shelf showing spots of high density at different depths. A residual nucleus, although also showing local spots of a very high density, was recorded to the west of Cape Santa Maria, in inner-mid shelf waters (**Figure 8.4.4.2.2.1**).

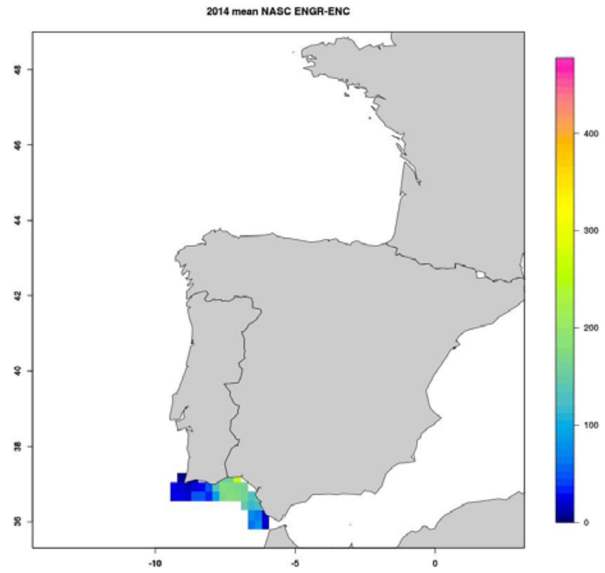

Figure 8.4.4.2.2.1. Spatial distribution of acoustic energy (NASC) attributed to Gulf of Cadiz anchovy in summer 2014 during the *ECOCADIZ 2014–07* survey (IEO).

8.4.4.3. CUFES

CUFES sampling was not carried out during the *ECOCADIZ 2014–07* survey but in the *BOCADEVA 0714* egg survey (see **Section 8.4.4.3** and figures therein). Egg distribution (as sampled either by CUFES or PairoVET samplers) resembled in a great extent the abovementioned adults' distribution pattern, both in the extension of the adults' distribution area and the location of fish density peaks. The total egg number sampled by CUFES (41 941 eggs) was the largest number ever recorded in the series of both acoustic and egg surveys carried out in the area (**Figure 8.4.4.2.3.1**). The mean egg density was estimated at 23.9 eggs m^{-3}. The majority of anchovy eggs were collected inshore the 100 m isobath, with the highest densities occurring in the coastal waters in front the Tinto-Odiel River mouth, between 58 and 98 m depth.

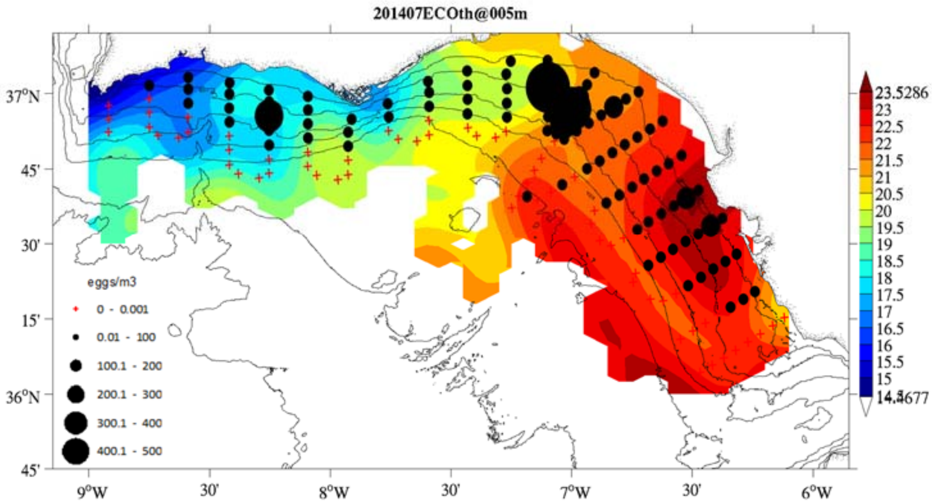

Figure 8.4.4.2.3.1. Spatial distribution of Gulf of Cadiz anchovy egg densities (eggs m⁻³) as sampled by CUFES in summer 2014 during the *BOCADEVA 0714* survey (IEO). The egg survey was synchronous to the *ECOCADIZ 2014–07* acoustic survey. Egg distribution superimposed to the distribution of sea temperature at 5 m depth (CTD casts).

8.4.4.4 Sardine and anchovy mean weight and length

8.4.4.4.1 Sardine

Sardine mean weight and length-at-age in the assessed population are not available to this WG. Figure 8.4.4.4.1.1 describes the estimates of the above variables for the whole estimated population through the ECOCADIZ series. The 2014 summer estimates (164 mm, 25.9 g), is similar to that observed in the previous year.

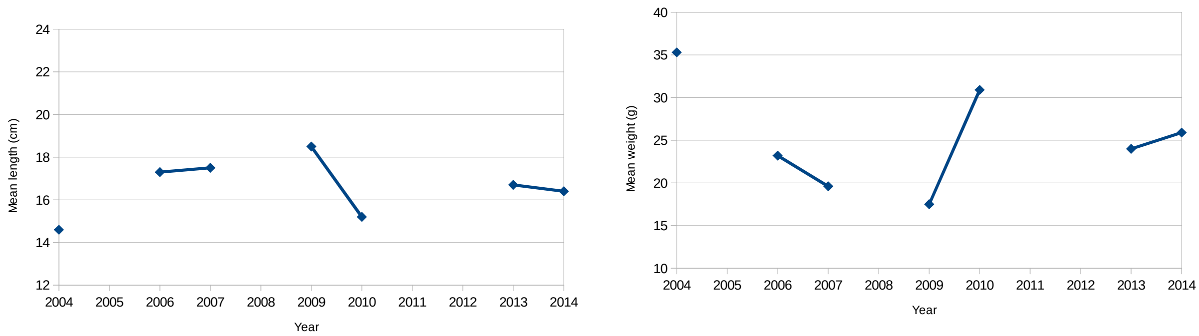

Figure 8.4.4.4.1.1. Sardine mean length and weight along the time-series (gaps mean no survey).

8.4.4.4.2 Anchovy

As in the previous year, the 2014 recruitment was found during the survey as shown in Figure 8.4.4.4.2.1. Possible cause would be the delayed survey dates. However, no trends were observed in mean length nor in mean weight for the population as shown in Figure 8.4.1.4.2.2.

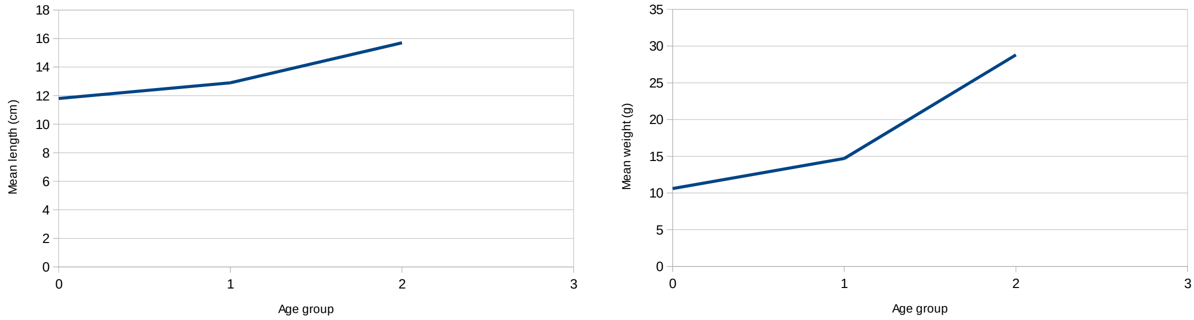

Figure 8.4.4.4.2.1. Anchovy mean length and mean weight-at-age estimated during ECOCADIZ Gulf of Cadiz.

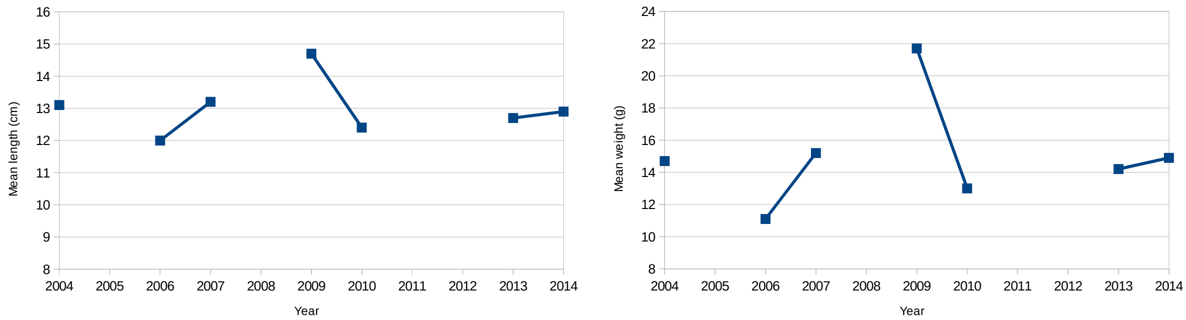

Figure 8.4.4.4.2.2. Anchovy mean length and weight along the time-series (gaps mean no survey).

8.4.4.5 Biomass estimations

8.4.4.5.1 Sardine

The acoustic estimates by post-strata are given in Ramos *et al*. (2014b, WD 12 in **Annex 8.10**). Overall estimates along the time-series is shown in **Figure 8.4.4.5.1.1**. Again, both biomass and abundance shows a decreasing trends being 2014 estimation the lowest value in the time-series.

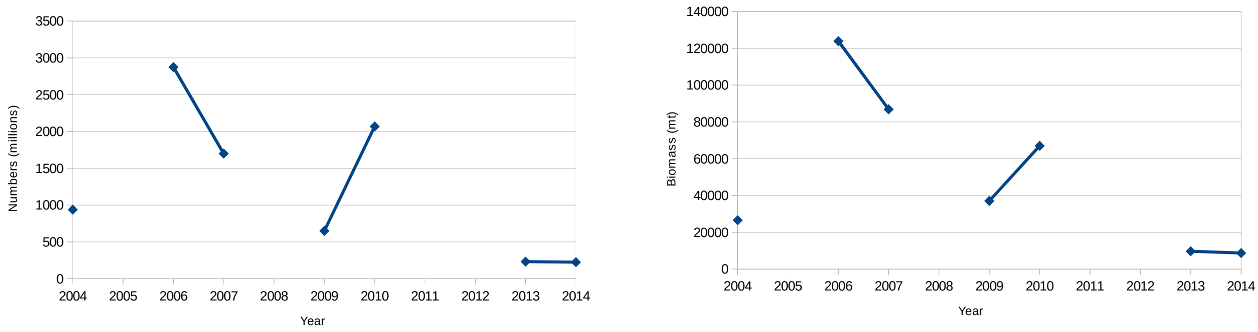

Figure 8.4.4.5.1.1. Sardine abundance (million fish) and biomass (tonnes) for *ECOCADIZ* time-series. (gaps mean no survey).

8.4.4.5.2 Anchovy

The acoustic estimates by coherent post-stratum are shown in Ramos *et al*. (2014b, WD 12 in **Annex 8.10**). Overall estimates are shown in **Figure 8.4.4.5.2.1**. A total of 29 219 t and 1 962 million fish have been estimated, being the most abundant fish species. Besides, this estimation was well above of the historical mean. As usual, largest anchovies occurred in the westernmost waters whereas the smallest ones were observed in the central coastal part of the sampled area, coinciding with the location of the main recruitment area for the species, in the surroundings of the Guadalquivir river mouth (see Ramos *et al*., 2014b, WD 12 in **Annex 8.10**).

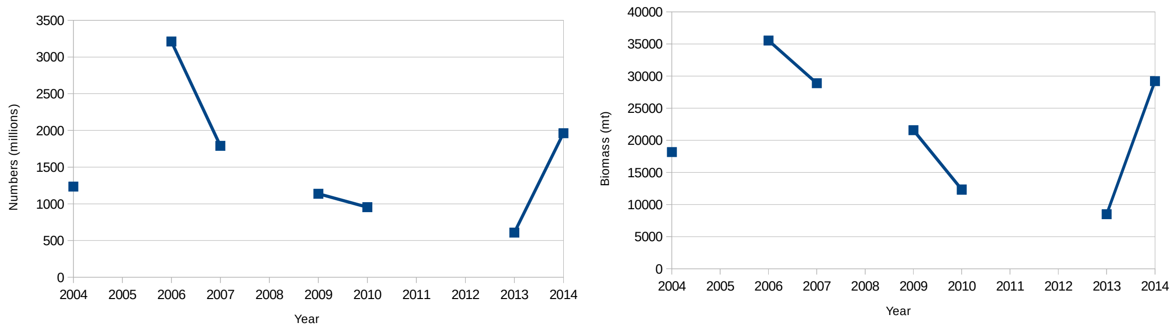

Figure 8.4.4.5.1.2. Anchovy abundance (million fish) and biomass (tonnes) for *ECOCADIZ* time-series. (gaps mean no survey).

8.4.1.6 Other fish species

Information on the spatial distribution and acoustic estimates for other fish species is detailed in Ramos *et al*. (2014b, WD 12 in **Annex 8.10**).

8.4.5 Autumn surveys 2014– autumn acoustic survey of juvenile anchovy in the Bay of Biscay

8.4.5.1 Oceanographic conditions

Data from continuous SSS, SST and SSF were recorded together with CTD casts. However, this information is still not available

8.4.5.2 Sardine and anchovy distribution derived from NASC

Sampling intensity by grid block is shown in Figure 8.4.5.2.1.

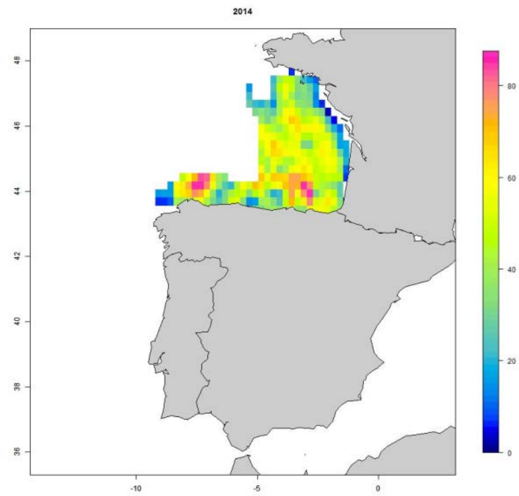

Figure 8.4.5.2.1. Number of data points within each grid of 0.25°x0.25°.

8.4.5.2.1 Sardine

Most of the sardine occurred in coastal waters, mainly in south Brittany and around the mouth of the Garonne River. On the contrary, the occurrence in Spanish waters was scarce as shown in **Figure 8.4.5.2.1.1.**

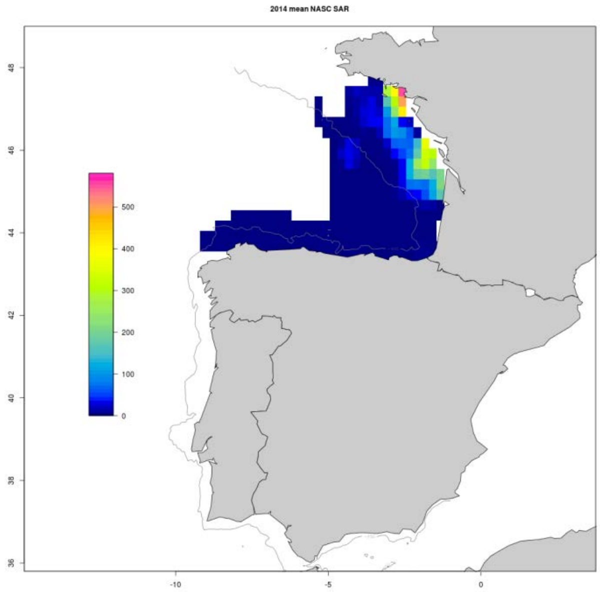

Figure 8.4.5.2.1.1. Average sardine abundance and distribution derived from NASC raw values.

8.4.5.2.2 Anchovy

Anchovy population was divided in juveniles (age group 0) and adults (age group +1). In 2014 juvenile were widely distributed off Bay of Biscay and in the uppermost part of the water column forming the typical superficial aggregations of pure juvenile anchovy mixed in occasions with smaller proportions of juvenile horse mackerel, gelatinous species and krill. In the Cantabrian Sea, (Spanish area) mean size was less than 6 cm and the vertical distribution extended from 5 to 150 m depth, deeper than usual, while in southern French waters mean size ranged from 5 to 8 cm. Besides some juveniles occurred as well with adults in schools close to the seabed, mixed also with superior proportions of other species, mainly small sardine in the coastal area, and horse mackerel and blue whiting on the mid continental shelf. Figure 8.4.5.2.2.1 shows both the juvenile and adult distribution.

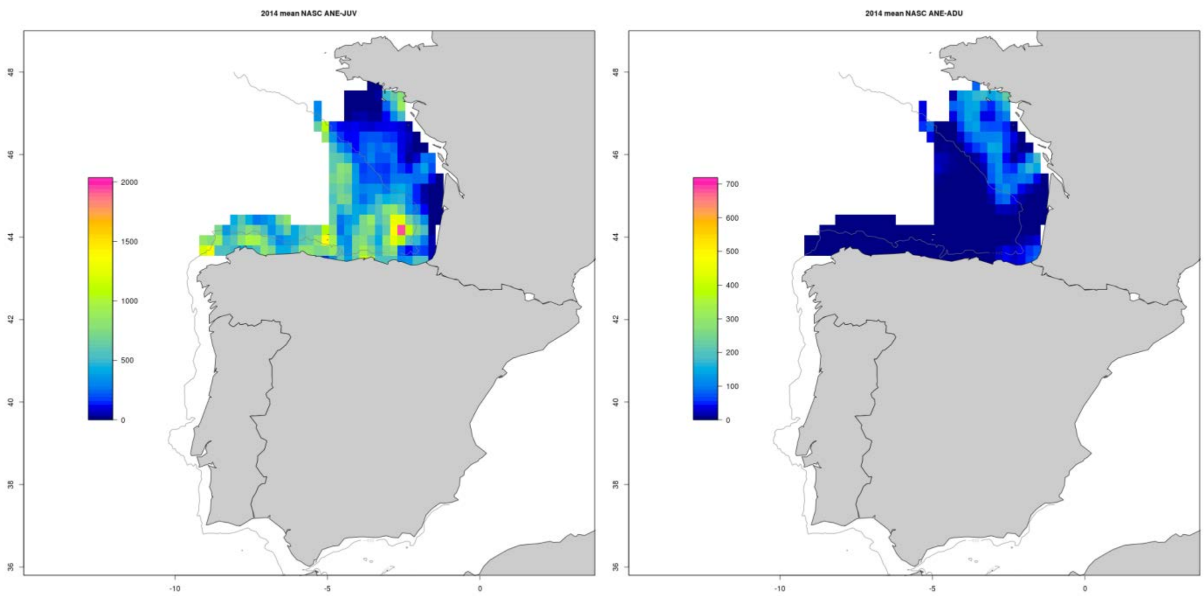

Figure 8.4.5.2.2.1. Average anchovy abundance and distribution derived from NASC raw values. Left panel, juveniles (age group 0); right panel, adults (age group +1).

8.4.5.3 CUFES

No information on egg distribution is available since this survey takes place outside the main spawning period.

8.4.5.4 Sardine and Anchovy mean length

Mena length for sardine was 14.3 cm. Anchovy mean length for recruits (age group 0) was 5.9 cm, below the historical mean and second smallest along the time-series as shown in Figure 8.4.5.4.1.

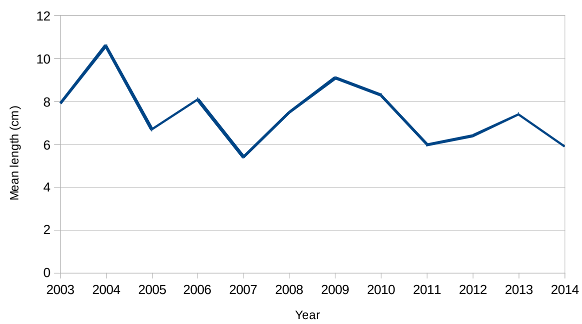

Figure 8.4.5.4.1. Anchovy mean length for recruits (age group 0) along JUVENA time-series.

8.4.5.5 Sardine and anchovy biomass estimation

Sardine biomass e was estimated to be 144042.61 mt, mainly located, and as previously stated, in French waters.

On the other hand, anchovy adult (age group +1) biomass was estimated to be 114898.50 tonnes, and juveniles (age group 0) biomass achieved the highest estimation along the time-series with 723945.83 mt (Figure 8.4.5.5.1). Besides, the occupied (positive) area was also the highest, as shown in Figure 8.4.5.5.2.

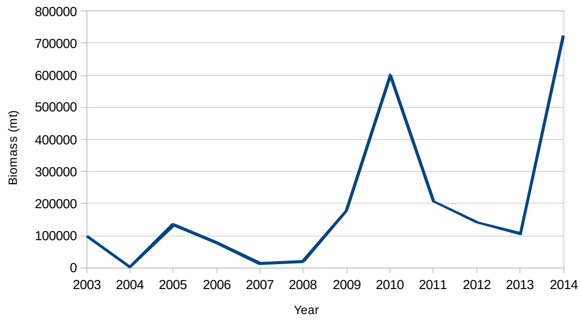

Figure 8.4.5.5.1. Anchovy recruits (age group 0) biomass estimates in JUVENA time-series.

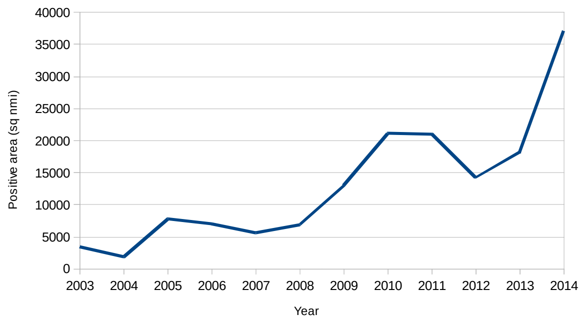

Figure 8.4.5.5.2. Positive area of anchovy recruits (nmi²) in JUVENA time-series.

8.4.5.6 Other fish species

Horse mackerel was the second highest abundant fish species with 146 thousand tones with mean length of 7.1 cm. Mackerel was also abundant (57 thousand tones), with mean length of 24.7 cm, followed by hake (35 thousand tones) and mean length of 17.8 cm. Only 6.4 thousand tons of blue whiting were estimated with mean length of 17.5 cm.

8.4.6. ***ECOCADIZ-RECLUTAS 2014–10*** survey (IEO)

The *ECOCADIZ-RECLUTAS 2014–10* survey was carried out between 13th and 31st October 2014 onboard the Spanish RV *Ramón Margalef* covering a survey area comprising the waters of the Gulf of Cadiz, both Spanish and Portuguese, between the 20 m and 200 m isobaths. A detailed description of the survey, the methods employed and the results from the echotrace ground-truthing hauls (species composition, frequency of occurrence of the main species, anchovy and sardine size compositions) is given in Ramos and Tornero (2014; WD 13 in **Annex 8.10**). The survey's main objective is the acoustic assessment of anchovy and sardine juveniles (age 0 fish) in the recruitment areas of the Gulf of Cadiz. The acoustic assessment of both these population fractions as well as the population levels of other pelagic species was not available to the WG.

The anchovy size composition from ground-truthing hauls indicated that smallest recruits were concentrated in the surroundings of the Guadalquivir river mouth and adjacent shallow waters, the typical recruitment area for the species. For sardine is more difficult to advance some spatial pattern regarding its body size because the small number of positive hauls, although the smallest sardines seemed to be more frequent in the central waters of the Gulf.

8.4.7 Acoustic surveys in VII

8.4.7.1 Summer survey. Boarfish acoustic survey, BFAS

A detailed description of the survey methodology and results are provided in the survey cruise report (O'Donnell *et al.,* 2014, WD1, also available at: http://hdl.handle.net/10793/981).

8.4.7.1.1 Sardine and anchovy records

Neither sardine nor anchovy were found during this survey.

8.4.7.1.2 Distribution of other small pelagics

Biomass and abundance was determined from integrated acoustic data for boarfish only during the survey at this time. Other small pelagics are reported only from distribution observed from trawl catches.

Boarfish

Eighteen hauls were carried out by the *Felucca* during the survey, nine of which contained boarfish. An additional three carried out by the *Explorer* were used in the analysis. In total, 3,160 lengths and 1,102 length/weight measurements were taken in addition to 397 individual boarfish otoliths collected for aging. Boarfish distribution is shown in Figure. 8.4.7.1.2.1

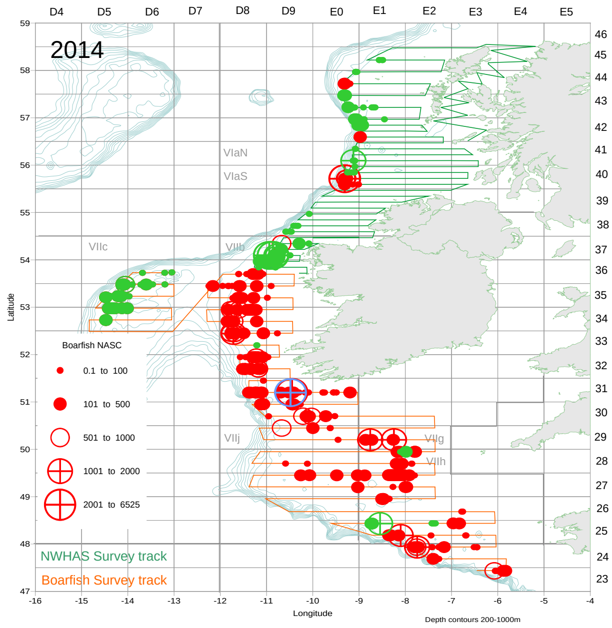

Figure 8.4.7.1.2.1. NASC plot of boarfish distribution 2014 results. Note: Red circles represent 'definitely' boarfish category, green 'probably boarfish' and blue 'boarfish with mix species.

Overall, the total-stock biomass was 57% lower than at the same time in 2013 while survey effort, geographical coverage and timing remained unchanged. Observed biomass was lower in all areas with the exception of the northern area and this was due to the more northward distribution of the stock than in previous years. The most pronounced change in biomass was noted in the southern area (down by c. 200,000 t from 2013) which is the largest geographically and has previously contained upwards of 60% of the stock.

The stock was considered to be well contained within the survey area, the northward distribution was bounded by the surveys northern limits and a relatively small amount of biomass was observed along the southern most transect. Information from the Ifremer PELGAS acoustic survey in the Bay of Biscay (May-June) confirms that low abundances of boarfish were observed overall and particularly in northern Biscay (Pierre Petitgas *pers comm.*).

Herring

In total 47 herring (*Clupea harengus*) echotraces were observed during the survey but no trawl samples were taken. The distribution of herring was divided into two areas; northwest of the Aran Islands and southwest of Ireland in the Mizen area. The largest single herring echotrace was observed southwest of Mizen Head and would likely form part of the autumn spawning component of the Celtic Sea stock.

Horse mackerel

Horse mackerel (*Trachurus trachurus*) were encountered in 28% of survey hauls and were most frequently encountered in deeper waters (>80m) and often occurred in catches with boarfish. A total of 247 echotraces were assigned to horse mackerel and 155 were measured and 284 length and weights were recorded. The modal length of horse mackerel was 30.3 cm (range 21–37cm) and mean weight was 241g. Horse mackerel were widely distributed throughout the survey area from the Porcupine Bank to the southern Celtic Sea occurring mainly as low and medium density echotraces spaced over a wide area.

As in previous years stomach contents analysis revealed horse mackerel to be actively feeding on boarfish eggs where the two species were encountered together.

Blue whiting

Blue whiting (*Mircomesistius poutassou*) were widespread throughout the survey occurring in 28% of trawl catches. Acoustically, blue whiting were the most abundant species observed this year and were of the highest density observed so far. The appearance of large numbers of 0-group blue whiting is in line with the recent period of strong recruitment within this stock. High density clusters of echotraces dominated the west coast and shelf edge contours in the Celtic Sea appearing as juvenile 0-group fish and to a lesser extent as mature fish. High densities were also reported further north during the *Explorer* survey. A total of 1,144 blue whiting were measured and 574 length and weights were recorded. The modal length occurred at 16.3cm (range 8–29cm) and mean weight was 28g.

8.4.7.2 Autumn surveys

8.4.7.2.1 Herring acoustic survey: CSHAS 2014

A detailed description of the survey methodology and results are provided in the survey cruise report (O'Donnell *et al.*, 2014, WD2).

8.4.7.2.1.1 Sardine and anchovy records

Neither sardine nor anchovy were found during this survey.

8.4.7.1.1.2 Distribution of other small pelagics

Herring

Total herring biomass shown above was determined from 18 survey strata of which 3 contained herring. Survey biomass and abundance was derived from 167 echotraces identified as herring with the aid of 19 directed trawls. Of the 167 herring echotraces over 98% were identified as 'definitely herring', less than 1% as 'probably herring' and less than 0.5% as 'mixed herring' (Figure 8.4.7.1.1.2.1).

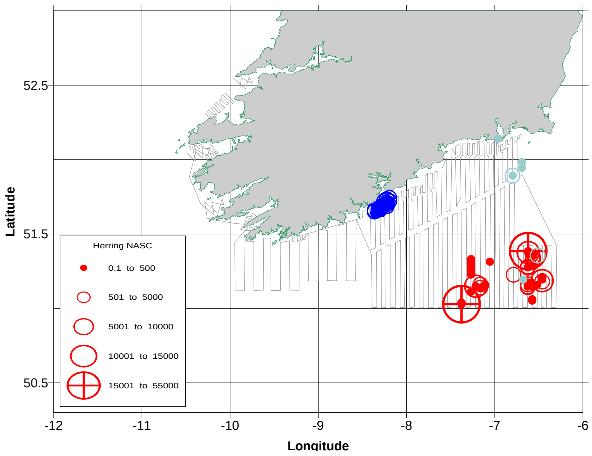

Figure 8.4.7.1.1.2.1. NASC plot of herring distribution 2014.

Sprat

Sprat were found in 13 of 18 survey strata during the survey and sampled in 14 of 19 hauls. In total 2,226 individual length measurements and 501 length/weight measurements were recorded. Mean length was 8.2cm and mean weight was 4g. Individuals ranged from 5 to 14.5cm in length and 1 to 29g in weight. The highest concentration of biomass was observed offshore and accounted for c. 41% of total biomass. (Figure 8.4.7.1.1.2.2).

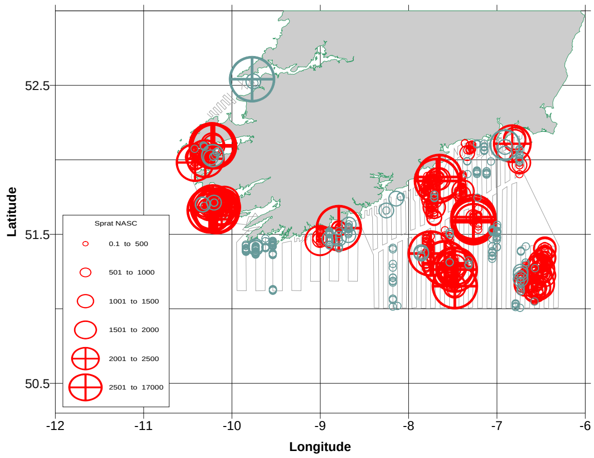

Figure 8.4.7.1.1.2.2. NASC plot of sprat distribution 2014.

8.4.7.2.2 Pelagic ecosystem survey in western Channel and eastern Celtic Sea. PELTIC 14

Survey details were given as power-point presentation. It was carried out from 30th September to 19th October on board RV Cefas Endeavour. Survey design and strategies are those of the VIII and IX surveys, with acoustic, trawls and observed done during daytime and CTD/(Ichthyo)plankton during night-time.

8.4.7.2.2.1 Oceanographic conditions

Sea surface water temperature was warm, higher than 18°C) in Lyme Bay (western Channel). Patches of high primary production more offshore in cool water off Western Channel, but the autumn bloom was small.

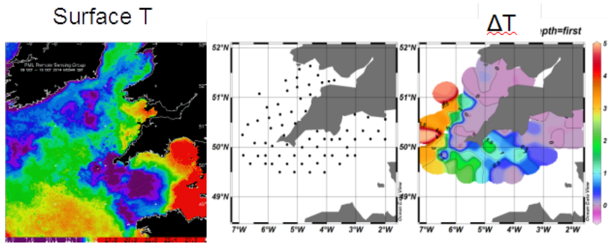

Figure 8.4.7.2.2.1. Sea surface temperature.

8.4.7.2.2.2 Main results

Figure 8.4.7.2.2.2.1 shows the species composition found at the fishing stations.

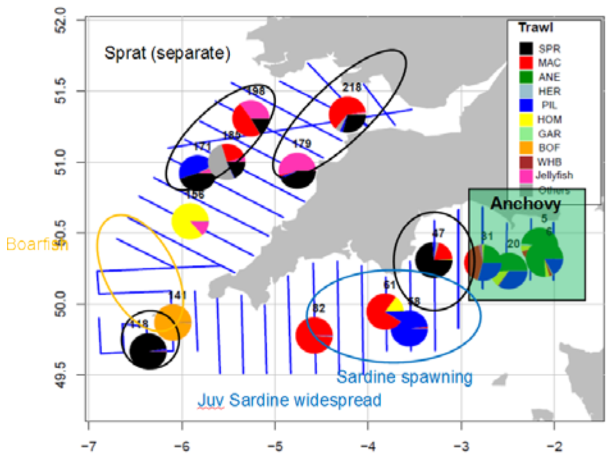

Figure 8.4.7.2.2.2.1. Fish proportion obtained in the different fishing stations and distribution area of the main species. (SPR=sprat, MAC=mackerel, ANE=anchovy, HER=herring, PIL=sardine, HOM= horse mackerel, GAR=garfish, BOF=Boarfish, WHB=Blue whiting).

Anchovy was only observed in (eastern part) western Channel, none found elsewhere. Juveniles were mixed with adult fish and the perception is that the occurrence has an increasing trend. Figure 8.4.7.2.2.2.2 shows the length distribution and Table 8.4.7.2.2.2.1 shows the mean length-at-age and the proportion in number.

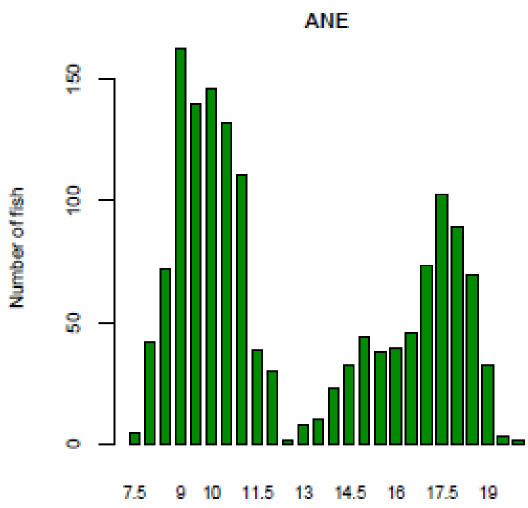

Figure 8.4.7.2.2.2.2. Anchovy length distribution found in PELTIC14.

Table 8.4.7.2.2.2.1. Anchovy mean length-at-age and proportion by age group in PELTIC14.

Age	*L*mean	% fish
0	10.33	40.1
1	15.19	12.6
2	17.33	45.4
3	16.33	1.9

On the other hand, juvenile sardine were widespread distributed and mixed with sprat while the adults, which were in spawning were only located at Western Channel, which confirmed the egg distribution found between 2012 and 2014. As in the case of anchovy, it seems that the biomass index has an increasing trends. Figure 8.4.7.2.2.2.3 shows the sardine length distribution found in the different areas whereas Table 8.4.7.2.2.2.2 shows the mean length-at-age and the proportion.

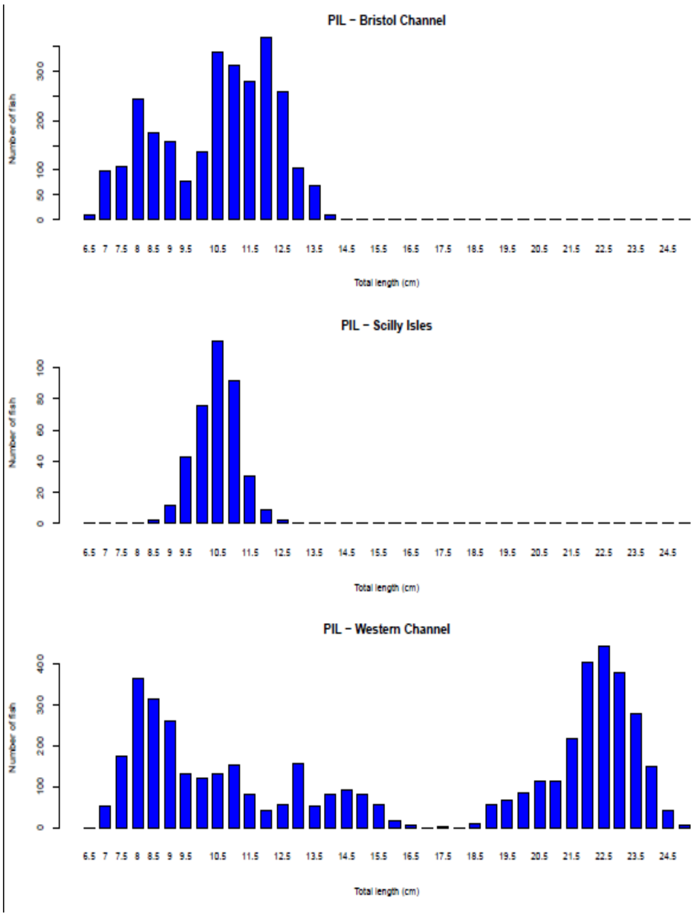

Figure 8.4.7.2.2.2.3. Sardine length distribution found in PELTIC14.

Table 8.4.7.2.2.2.2. Sardine mean length-at-age and proportion by age group in PELTIC14.

Age	*L*mean	% fish
0	10.66	67.6
1	16.77	7.7
2	20.10	9.2
3	21.89	6.5
4	23.29	7.1
5	23.58	0.9
6	23.75	0.9

In observed for anchovy and sardine, sprat abundance shows also an increase in trend, with juveniles more widespread than before and even, they were found for first time in Isles of Scilly. Besides, it occurred in huge concentrations off Bristol Channel, never seen before. On the other hand, juveniles were found in high concentration in shallower waters as seen in previous years. Figure 8.4.7.2.2.2.4 shows the sardine length distribution found in the different areas whereas Table 8.4.7.2.2.2.3 shows the mean length-at-age and the proportion.

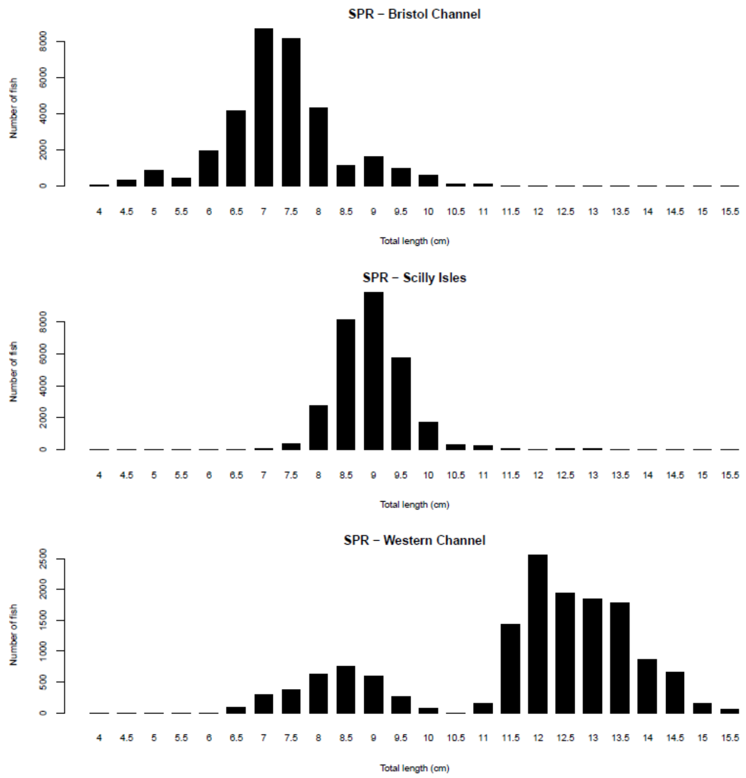

Figure 8.4.7.2.2.2.4. Sprat length distribution found in PELTIC14.

Table 8.4.7.2.2.2.3. Sprat mean length-at-age and proportion by age group in PELTIC14.

Age	*L*mean	% fish
0	7.09	9.5
1	8.80	25.9
2	10.86	17.0
3	12.94	10.1
4	13.50	1.8
5	15.00	0.6

Annex 8.5: Development of acoustics

8.5.1. TS experiments

Ifremer has conducted in 2014 in situ TS measurement and modelling studies aiming at characterizing the specific target strength values of Bay of Biscay anchovy and sardine.

8.5.1.1. In-situ TS measurement with EROC/ENROL

Mathieu Doray, Laurent Berger, Jean Yves Coail, Jean Philippe Vacherot, Gérard Bavouzet, Pierre Petitgas

The first study was performed during the PELGAS2014 survey onboard RV Thalassa. The Remotely Operated underwater Vehicule EROC was used to record in-situ targets of small pelagic fish funnelled through a pelagic trawl, fitted with the 'ENROL' device to keep the codend opened. The EROC was fitted with a 70 kHz Simrad EK60 echosounder and a high definition; low light level, camera, as well as magnus effect rotors that allow moving it around the fishing trawl.

The open trawl was set at about 40 m depth in front of the Gironde mouth, in dense fish aggregations, mostly comprised of 12.5 cm mean length european anchovy (*Engrails encrasicolus*; N=4 trawl hauls, mean anchovy proportion in the catch: 88%). Contrary to the previous attempts where the EROC was deployed above the codend to measure the TS of escaping, heavily tilted fish, the EROC was this time positioned at ~2m above the central part of the fishing trawl, where fish actively swim against the current to try escaping through the trawl mouth. EROC was kept stationary for 1 hour above a mark made in the central part of the trawl to record TS of fish passing in the trawl (Figure 1). The EROC was brought near the codend every hour to visually check that the fish in trawl were anchovies. TS of 19 small groups of anchovy swimming in the trawl were recorded with the acoustic parameters listed in Table 1. The ping rate (btw. 5 and 6 pings per seconds) and the vertical resolution (10 cm with a pulse length 128µs) were set at maximum to increase the odds of detecting TS of individual fish inside the small groups of anchovies. TS were detected by the Simrad algorithm: i) in the trawl head and footropes, ii) inside groups of anchovies. TS echograms were scrutinized to separate trawl TS from fish TS. Fish TS were tracked to get information on anchovies swimming behaviour in the trawl.

A total of 178 fish tracks were recorded on 01/06/2014 between 10:00 and 15:00 GMT, comprising 2188 TS. The mean number of TS per track was 12, ranging from 2 to 66. TS were averaged over tracks to filter out the intra-track variability (tail beat effect…). The mean TS per track distribution was symmetrical, centred on a median value of -48dB, with a low standard deviation (2.6dB; Figure 3). The mean TS summary statistics were:

Min.	1st Qu	Median	Mean	3rd Qu	Max.	SD
55.94	-47.19	-46.22	-46.48	-45.34	-38.29	2.6

The fish TS track angles in the vertical direction was unimodal and symmetrical, centred on a mean value of 2.9°, and narrowly spread (SD=20°; Figure 4). Assuming that the fish track vertical TS angles are representative of the fish tilt angles, this result led us to assume that the vast majority of fish was swimming in the trawl with a tilt angle close to horizontal.

The fish TS track angles in the vertical horizontal was unimodal and symmetrical, centred on a mean value of 0° (Figure 5), meaning that most of the fish were swimming toward the trawl mouth. No relationship was found between the mean track TS and the track parameters (no. of pings, angles, depth variation…).

This new application of the EROC/ENROL methodology allowed for the recording of TS of anchovy that were consistently swimming horizontally toward the trawl mouth. We assume that this fish tilt angle distribution is closer to the (largely unknown) mean natural tilt angle distribution of wild anchovies. The species composition of the fish in the trawl was regularly visually checked during the experiments with the EROC camera. The method thus allows for the control of both the species composition and the fish tilt angle. It seems appropriate to collect in-situ TS of nearly horizontal small gregarious fish species that are normally too mobile and densely packed to allow for TS recording at day.

The mean in situ TS derived from these results would correspond to a b20 parameter of -68.2dB according to the classical TS~length equation: TS = 20log10(Lcm)+b20, where Lcm is the fish mean length in cm.

This preliminary b20 value for Biscay anchovy has to be compared with b20 values used so far for the acoustic biomass assessment of anchovy in Europe: b20=-71.2 at Ifremer, and b20=-72.6 at IPMA and IEO, and to the classical b20 value proposed by Foote (1987) for physostoms: b=-71.9.

The in-situ (at depth) calibration of the echosounder was impossible to complete, due to connections problems with the EROC. This essential step to validate the in-situ TS values will hopefully be conducted next year.

The EROC/ENROL TS measurements could then be multiplied to provide reliable in-situ TS for several anchovy size classes (adult and juvenile) and depths, but also on other species and during different season, to investigate the effects of seasonal physiological changes on TS.

The comparison of these controlled in-situ TS values to ex-situ and modelling results should actually provide a robust TS~length relationship for European sardine and anchovy.

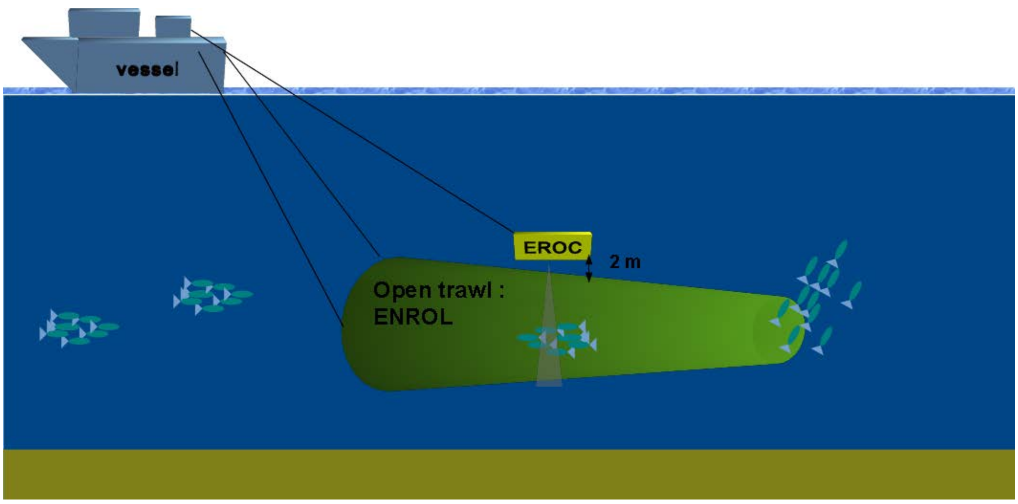

Figure 8.5.1.1.1. EROC/ENROL sampling configuration.

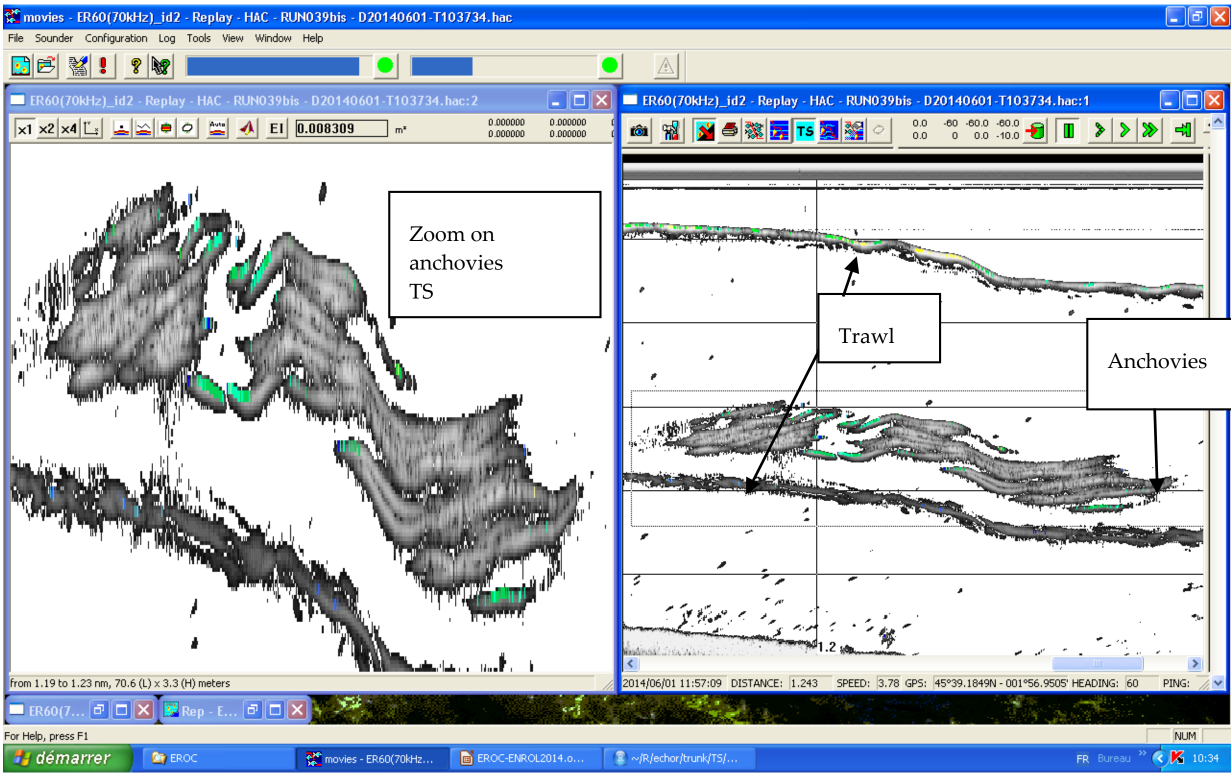

Figure 8.5.1.1.2. Example of in-situ TS tracking of anchovy swimming in the trawl with the Movies+ software. TS are represented as colour dots.

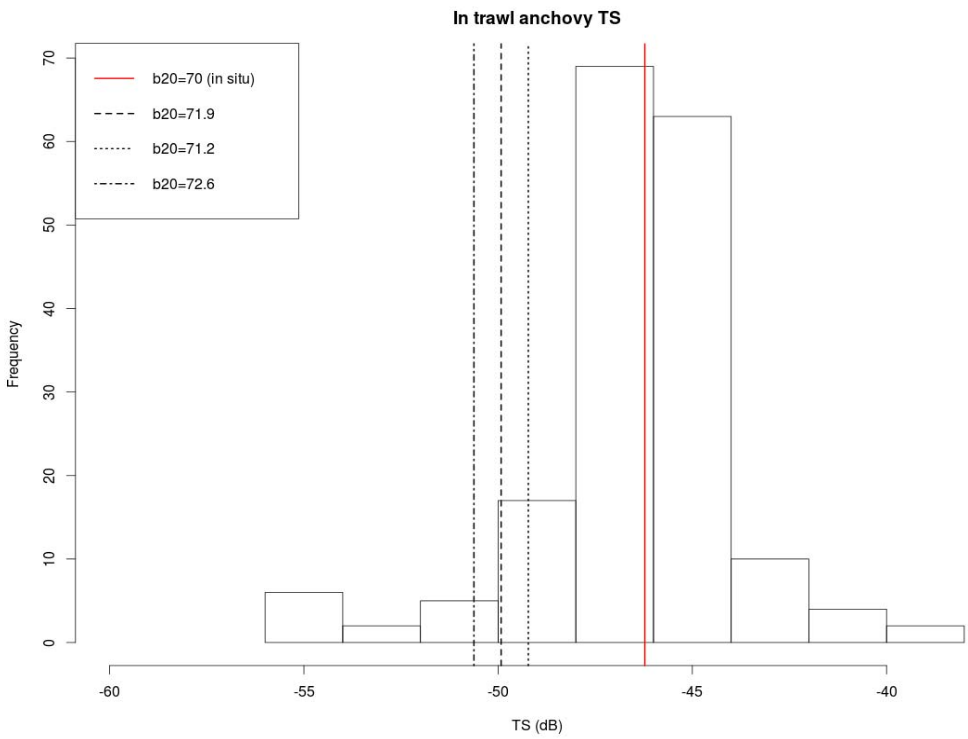

Figure 8.5.1.1.3. In-situ mean anchovy TS distribution. Red line: in-situ TS median, dotted line: theoretical TS of a 12.5cm anchovy with b20=-71.2, dashed line: theoretical TS of a 12.5cm anchovy with b20=-71.9, dotted-dashed line: theoretical TS of a 12.5cm anchovy with b20=-72.6.

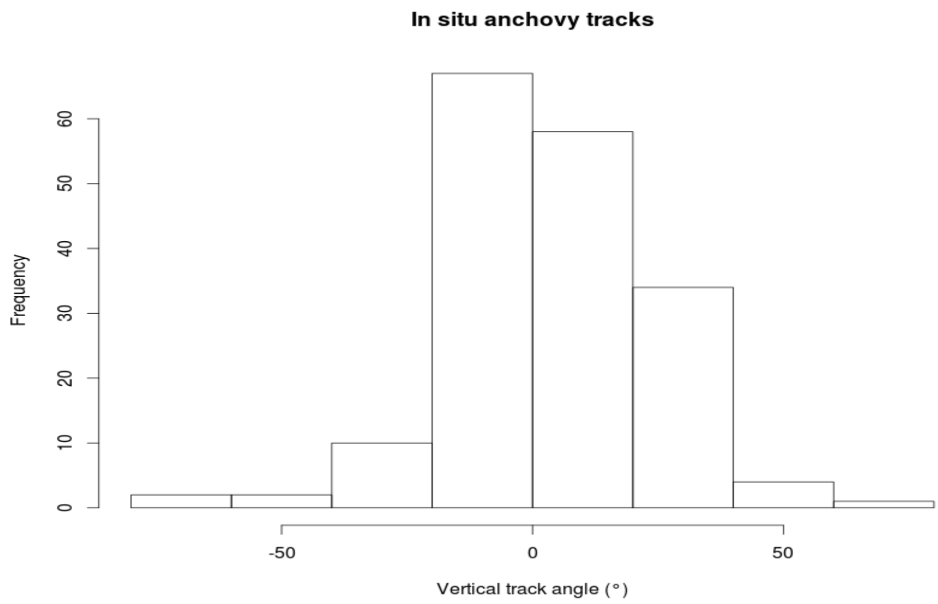

Figure 8.5.1.4. Vertical track angle distribution of the in situ anchovy TS.

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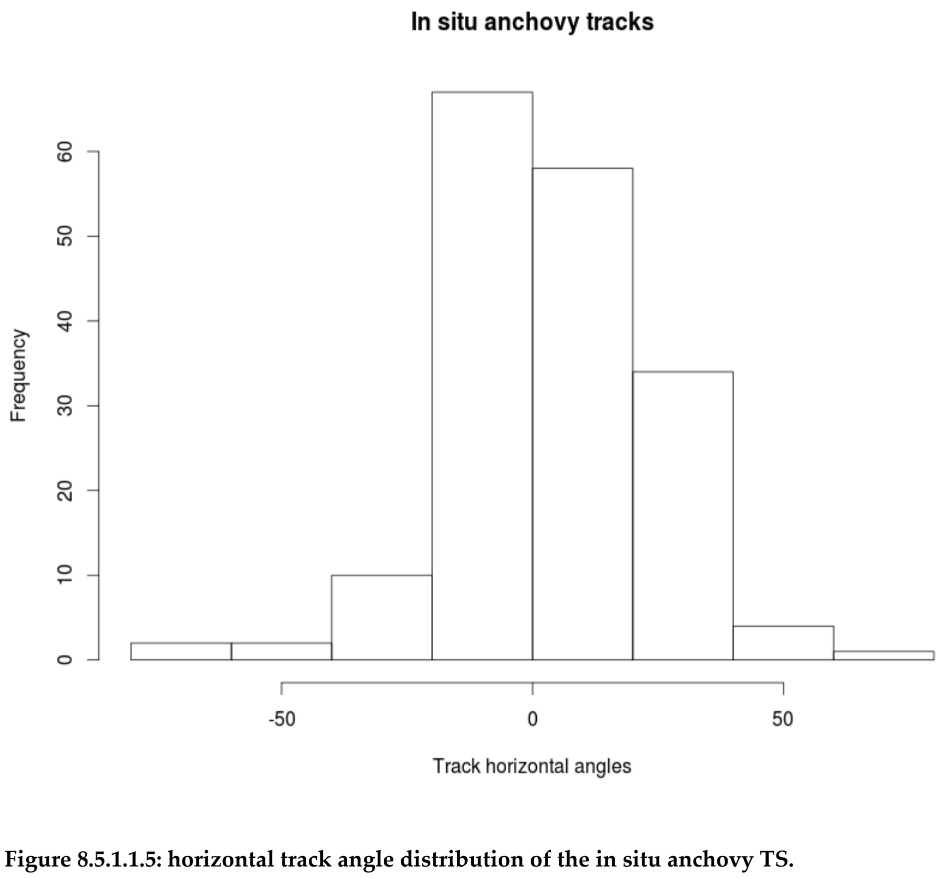

Figure 8.5.1.1.5: horizontal track angle distribution of the in situ anchovy TS.

8.5.1.2 The TOMOFISH project: X-ray microTomography for Fish Target Strength Modelling

Mathieu Doray, Xavier de la Bernardie, Laurent Berger, Elisabeth Lys, Pierre Morinière, Pierre Petitgas, Paul Bourriau, Manuella Rabiller

The Ifremer project « TOMOFISH » aims at modelling the Target Strength of small pelagic fish based on 3D X-ray scans realized with a RX-microtomograph by the Ecole des Mines de Nantes laboratory Subatech. The fish swimbladder contributing for about 90% of the target strength, the role of this organ will be specifically investigated (Figure 1).

The project involved the collection of samples:

- of anchovy and sardine during the PELGAS2014 survey. These samples were collected near the sea surface by pelagic trawling and frozen. They were scanned after defrosting.
- of sardine onboard a 16 m purse-seiner on 01/10/2014 near Quiberon. A total of 400 hundred of these sardines were kept alive and stocked in a tank at the La Rochelle aquarium. Another sample of 148 sardines were scanned fresh the day following the catch.

About 50% of the stocked sardine survived after the first month at the aquarium. Sub-samples of 20 and 22 sardines were taken from the aquarium tank, 1 week (06/10/2014) and 1.5 months (13/11/2014) after the catch, respectively. These sardines were sacrificed in a eugenol bath with control of their pre and post death behaviour, to detect any gas release that could have modified the volume of their swimbladder.

Trawling appeared to induce a physical or nervous stress too intense to allow for the collection of sardine and anchovy with well-inflated swimbladders. Only 22 sardine larger than 20 cm had inflated swimbladder in the trawl samples and were scanned. A third of the sardine caught onboard the purse-seiner and scanned right after the catch had inflated swimbladders.

Finally, 5 out of 20 and 15 out of 22 sardines had inflated swimbladders during the 06/10/2014 and 13/11/2014 sampling at the aquarium, respectively.

The behavioural observations realized at the aquarium revealed that 12 out of 20 and 8 out of 22 sardines released gas bubbles after they died during the 2 samplings at the aquarium, respectively.

As the sardines which had released bubbles had a swimbladder significantly less inflated than those which did not, we concluded that the gas bubbles they released should have been expulsed from the swimbladder after their death (due to post-mortem muscle relaxation?)

The fact that the sardine that had been acclimated in the aquarium for 1.5 months had more inflated swimbladder on average than the sardine analysed just after the catch, or after 1 week in the tank led us to postulate that:

- significant gas release from the swimbladder must occur, due to the stress of the catch, even with a purse-seine;
- the swimbladder of unstressed sardines swimming near the surface must be normally well inflated, as most of the swimbladders of the sardine were inflated during the last experiment at the aquarium.

The next step of the project involve:

- The derivation of acoustic models based on the swimbladder morphologies. These models will relate the TS to the acoustic frequency and the fish tilt angle. The Kirschoff Ray Mode, prolate sheroid, and finite elements approaches should be tested.
- The assessment of the effect of freezing on the swimbladder inflation rate.

- The purse seining of adult anchovy to conduct the same type of experiment next year.
- The development of a methodology to realize RX-scans of juvenile or larvae of anchovy and sardine.

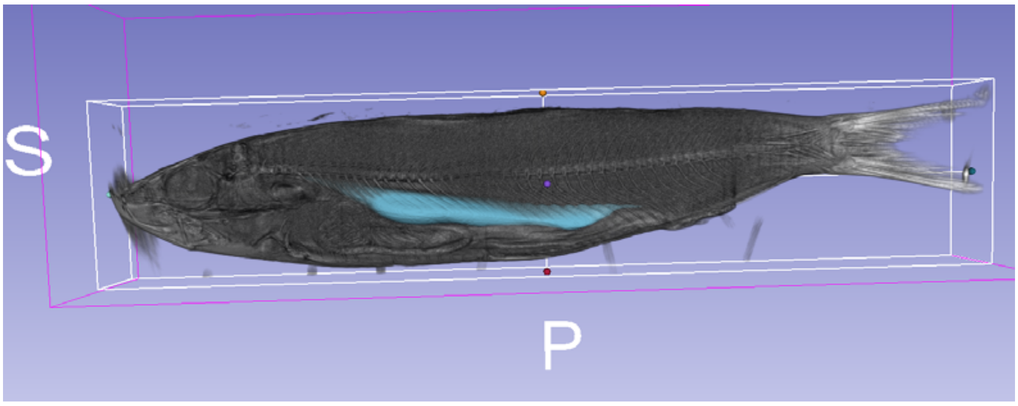

Figure 8.5.1.2.1. Sardine 3D morphology characterized by RX-microtomography. The swimbladder is the blue shape presenting the highest density contrast with the other organs.

8.5.2 INTERCALIBRATION BETWEEN RV THALASSA AND MIGUEL OLIVER

An intercalibration survey aiming at to verify if the PELACUS survey time-series could have been affected by the change from RV Thalassa to RV Miguel Oliver has been carried out off the Garonne mouth from 11–17 April 2014. To do that, the inter-ship variability of some sampler devices (mainly acoustics, CUFES and fishing gears) have been compared with the intra-ship variability of order to give coherence to the time-series (i.e. small vessel effect). Accordingly, the null hypothesis the characterization of the pelagic ecosystem by means of an acoustic-trawl survey would give significant differences on account the vessel effects was tested. Survey report is provided in Annex 8.10.

Acoustic sampling consisted in two tracks 2.5 spaced and divided in two areas, shallower, with 22 nmi from 40 to 60 m, and deeper , with 10 nmi, from 110 m to the slope. These four track were surveyed three times for each vessel, first in parallel and the others with one of the vessels leading. In the same way 15 parallel fishing station were also performed. However, the intercalibration has been made in a small area and only during the light hours of four days and a half of effective work. It is; therefore, complicate to extract conclusions for a large-scale survey such as PELACUS time-series.

In spite no significant differences in mean backscattering energy were found, it seems that RV Miguel Oliver, although showed worse noise spectra than RV Thalassa specially at higher frequencies (200 kHz), consistently accounted higher cumulated backscattering energy values than Thalassa. In addition. Contradictory, the high level of cavitation showed by RV Miguel Oliver would not result in a higher fish avoidance and the low cumulated backscattering energy values achieved by RV Thalassa could be related with a higher fish avoidance or more presumably with a higher diving response to RV Thalassa. This kind of response changes the tilt angle and TS becomes lower than expected, which in turn results in an underestimation of the fish abundance. This contradictory response has been already observed in other ship comparisons. Fish reactions cannot be explained only by considering noise spectra but also sound pressure fields and particle acceleration. This later feature would explain the results obtained.

In the same way, the different fishing gear used for both vessels would not result in significant differences between catch composition and length structure as the intra-ship variability was similar to the inter-ship one. However, it should be mention that RV Miguel Oliver has had higher accessibility to horse mackerel and hake than RV Thalassa.

Finally CUFES performance was similar for both vessels as the intra-ship variability is of the same order as the inter-ship one.

Given these results, it seems that the PELACUS time-series would not be affected by the change from RV Thalassa to RV Miguel Oliver.

8.5.3. WGACEGG2014 EchoR training course

8.5.3.1 Introduction

EchoR is a suite of R codes aiming at:

- handling preprocessed fisheries acoustics data collected during sea surveys;
- computing standard ec(h)osystemic indicators based on those fisheries acoustics data. These indicators include:
  - biomass estimates per fish species and elementary sampling distance units (ESDU) ;
  - biomass-at-length estimates per fish species and ESDU ;
  - biomass-at-age estimates per fish species and ESDU;
  - biomass estimates per fish species and post-stratification regions;
  - synthetic spatial (Woillez *et al.*, 2007) and population dynamics indicators can also be computed based on per ESDU data;
  - Actually, EchoR comprises plotting routines that allow to produce the standard grid maps used to exchange data within the WGACEGG working group.

Methods for acoustic fish biomass assessment implemented in EchoR are described in Simmonds and MacLennan (2005) and Doray *et al.* (2010).

Package sources and support can be found at: https://forge.ifremer.fr/plugins/mediawiki/wiki/echor/index.php/Accueil

The objectives of the WGACEGG2014 EchoR training were:

- To provide an overview of the methods implemented in the package to all users, and discuss everyone practice, based on the EchoR framework;
- to present the new package new features to more experienced users. The new features are essentially related to biomass estimation per age and post-stratification region;
- to demonstrate the package capabilities with a demo dataset included in the package, and eventually with users data.

8.5.3.2. Training highlights

A total of 14 people from France, Spain, Portugal, Italy, Greece, Croatia and Turkey took the training, from 09:00 to 19:00 on 16/11/2014. Some trainees from Portugal, Basque Country and Greece already use EchoR in their institution. The other have discovered the software.

In IPMA in Portugal, the anchovy and sardine biomass estimations per ESDU computed with EchoR were almost identical with those computed with previous home-made dedicated software.

The presentation of EchoR built-in methods raised interesting issues on how fisheries acoustic data should be processed to derive fish biomass estimates. The main questions (and answers) are summarized below.

8.5.3.2.1. Why bothering with echotypes?

Echotype is like prose, all fisheries acoustician use it, sometimes unconsciously.

An echotype can be defined as a recurrent pattern that can be observed on the echograms of a given survey, and be associated with a species, or a group of species. An echotype can be as general as “all the echoes that are supposed to be produced by fish in my survey” or as specific as “the typical school shape of a given species and/or size or age class”, which I am sure to be able to separate from other echoes. Echotypes must hence be defined prior to scrutinizing. They simply represent the different categories to which fish (or other species of interest) NASC will be classified into during the scrutinizing process. The echotype definition in EchoR is quite flexible: an echotype is defined as the combination of:

- the name(s) of the species it refers to,
- an optional size categories (one or several),
- a depth stratum, where the echotype is supposed to always appear.

The depth strata classically corresponds to the depth layers that are well sampled by the survey fishing gears (Figure 1). In Figure 1, the surface echotype will be exclusively associated to surface trawl hauls, if it is associated to the “surface” depth stratum. The other echotypes will be exclusively associated to near-bottom-trawl hauls, which can possibly sample the species they comprise. They will be defined as belonging to the “near bottom” depth stratum.

If one can just extract fish NASC from other NASC (plankton etc...) while scrutinizing a survey, one can simply define an echotype that comprises all fish species in the area. If trawl hauls are only performed efficiently near the bottom, this global fish echotype will be defined only in the area near the bottom that is well sampled. Fish NASC (and biomass) will in this case be split between species solely based on the trawl catches composition.

On the other hand, if some fish species form schools that have so specific features that allows separating them from other echotraces while scrutinizing, it is advisable to create a specific, single species echotype to treat the specific school of the species independently. This is especially true if the schools of the recognizable species are dense (such as sardine for example). Creating a specific echotype for the species will reduce the risk of allocating some NASC of the dense, well recognizable species schools to other species, which form less dense and less recognizable schools (cf. echotype 4 in Figure 1). This bias for instance happens when the trawl catch composition does not perfectly represent the real species composition in the schools, whereas all species belong to a single ehcotype.

In EchoR, fish biomass estimates are first computed by echotype, and therefore split between the species comprising the echotypes. All the target species must then appear in the echotypes. If they do not, they will not be assessed.

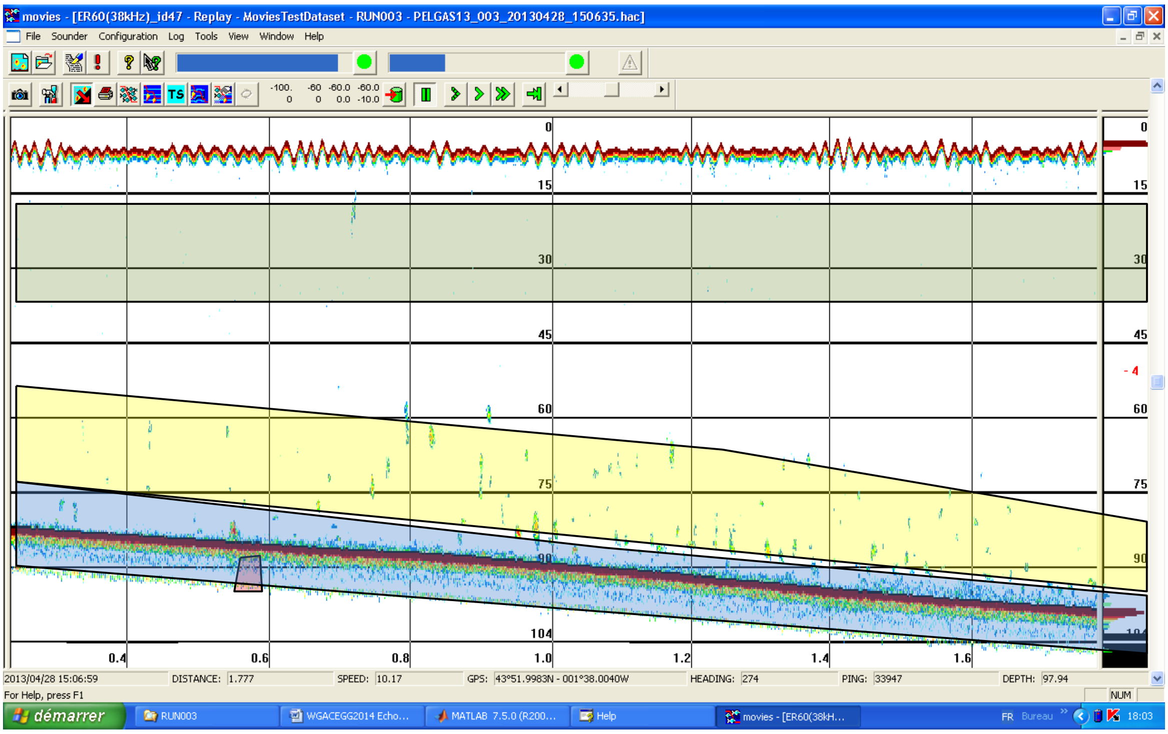

Figure 1. Echotypes and depth stratum examples. A total of 4 different echotypes have been used to scrutinize this echogram: i) a surface echogram (green polygon) that comprises all the school echotraces and species observed between 10 and 30 m on the echogram; ii) an echotype comprising all the schools at least than 10 m above the bottom (blue polygon), iii) an echotype comprising the schools located at more than 10 m above the bottom (yellow polygon), and iv) an echotype comprising only the species that produces the dense school that has been isolated from the rest in the red polygon.

8.5.3.2.2.How to handle rare species in EchoR?

A subject related to the definition of echotypes is the handling of rare species. Echotypes must comprise the species of interest, but what to do with the rare species that appear from time to time in the catches?

One cannot simply remove them from the catches, as they were present in the sea and hence have contributed to the fish NASC that was recorded.

One option consists in including all the species found in the catches in the echotype definition, even the rare ones. Every species will in this case be assessed. This method has the merit of simplicity, except perhaps during the echotype definition process, if the species list is very long. It has however several drawbacks:

- the processing time might increase significantly, as all species will be processed;
- the results files and plots are more complicated to interpret, as all species are included;
- the procedures that produces results per size and age class will probably not work, as length and/or age distributions will be missing for rare species;
- the absence of specific TS for the rare species might bias some results, especially if some rare individuals are very big.

A procedure is available in EchoR to mitigate some of these drawbacks: the “complementation”.

The idea is to pool all rare (or non-target species) into a fake species called "complement" (species code: "COMP-LEM"). This fake species will be given constant mean length, weight and TS parameter to ensure that the TS values used to compute its fake biomass will not be extreme. Only the rare species total weight and number per haul will be retained and summed over each haul to compute the "complement" proportion in the hauls, which will be further used to derive the X_E scaling factor for each haul and species.

8.5.3.2.3. But why the heck should I define size categories?

Several size categories have eventually to be defined for a given species, if its size distribution displays several modes. In fact, the TS per species and trawl haul used for biomass assessment are computed based on the mean length provided in the "Total-Sample" fishing data. If the species length distribution is plurimodal in a haul, the mean length value, and therefore the TS, will not be representative of the real fish size distribution, and the biomass results will be biased. This is why it is advised to define several unimodal size categories in the case of species with plurimodal size distribution, to ensure that the mean length per species, size category and haul will be accurately computed. This can be done automatically using the "sizecat" function on at-length data (subsample input date). The function checks if the global size distributions of the species are unimodal. If not, it defines 2 size modes and a break value, which is used to update the belongings to size categories in the "CATEG" columns of the total and sub samples datasets. By default, the two size categories defined by the "sizecat" functions are: "small" (or "no size category"): size code"0") or "big" (size code"G").

8.5.3.2.4. How to compute standard "grid maps" with EchoR?

The functions for producing standard WGACEGG grid maps have been included in EchoR. Grid maps can be computed and plotted using the "gridNmap" front-end function. See the help page.

Annex 8.6: Developments in DEPM

8.6.1. DEPM session summary

During half-day of the 2014 WGACEGG meeting the participants were divided in two subgroups in order to hold dedicated sessions on "DEPM" and "Acoustics" issues respectively; the following text gives a summary of the topics discussed and an overview of the work planned for the coming year(s) relating to DEPM subjects.

The Group started by revising the current shortcomings for each DEPM survey pointing out ideas for development. After, some requests raised by WGHANSA were considered and finally, a detailed discussion was undertaken concerning the exploration of all the information collected over the years, which has not yet been fully investigated from a more ecological perspective.

It was a consensual idea that considerable progress has been made in many aspects relating to DEPM methodological issues in surveying, laboratorial processing and analyses, since the Group started. While realizing that there are still methodological questions to be addressed or further explored (in particular for the surveys which started more recently) the Group agreed on the scientific benefit that could come from thoroughly exploring the data compiled during the DEPM surveys in conjunction with other contributions from fields such as regional oceanography and its spatial and temporal variability and fish physiological/biological factors both at the individual and population levels.

Adult fish issues

I. Concerning <u>sampling</u> it was agreed:

1) to make an effort for obtaining more sardine samples during future surveys in particular in the main spawning loci
2) to carry out statistical testing (e.g. test used by Picquelle, 1985) for defining the appropriate sample size for sardine (number and size of fish samples) for spawning fraction and batch fecundity accurate estimation
3) to compile previous analyses regarding the differences in length and other parameters in relation to fishing gear used for sardine (pelagic and bottom trawl and purse-seining)
4) to gather biological data on sardine from regular national sampling programmes directed at commercial vessels from several ports (Basque Country, Santander, A Coruna, Vigo, Matosinhos, FFoz, Peniche, Sesimbra, Olhão, Cadiz) in order to contextualize the DEPM results in relation to the annual reproductive cycle. Start the data compilation for the period September 2013 – June 2014 in order to relate the information to the 2014 DEPM result. After, recover the information also for the other years of the DEPM series.

II. Concerning <u>laboratorial analyses</u> it was agreed:

1) the need to organize a new workshop (on-site or via web facilities) for intercalibration of sardine and anchovy POFs ageing among slide readers and produce support documentation to be used by all laboratories.
2) to explore the possibility of carrying out, during future surveys (possibly within the Galician Rias together with acoustics experiments with encaged fish) an *in situ* experiment to investigate sardine POFs degeneration

III. Concerning mathematical analyses and estimation it was agreed:

1) to compile the results on sardine and Gulf of Cadiz anchovy on POFs analyses already done to create the basis for revisiting the subject of degeneration of POFs and ageing (use exploratory approaches mentioned in the literature (e.g. Alday *et al.*, 2008; Uriarte *et al.*, 2012)

2) to evaluate the utilization of mean historic values of sardine spawning fraction per strata (taking into account population structure)vs. estimates from each surveys and to explore S according to population age structure, daily time of fishing, gear, number and size of samples, in order to check potential biases. Conclude on best estimation procedure.

Egg issues

I. Concerning sampling it was agreed:

1) to assess possible inclusion of stratified vertical sampling during the next sardine DEPM surveys and assess the need to repeat egg density experiments (at sea) to support the work on egg abundance indices estimation from CUFES data

II. Concerning laboratorial analyses it was agreed:

1) the need to organize a new workshop (on-site or via web facilities) for inter-calibration of sardine and anchovy egg staging given that it has not been done since 2001; explore the option of doing it together with the WKFATHOM organized by WGMEGS and under the umbrella of WGALES.

III. Concerning mathematical analyses and estimation it was agreed:

1. to explore the information available on within season variability of P0 estimation (and if possible SSB) resulting from consecutive coverage of the same area (e.g. NW Portugal in 2014, area VIIIc surveyed by IEO and AZTI with a time-lag of few weeks); analyse egg estimation in conjunction to population structure and reproductive parameters variability within the period considered
2. to pursue new mathematical ways for mortality and egg production estimation (e.g. update on Bayesian approach for mortality and P0 estimation)
3. to present developments on mortality estimation for sardine and GoC anchovy during the Annual Fish Larvae Conference, in July 2015

SSB estimation issues

it was agreed:

1) to test the application of DEPM to estimate biomasses per age for sardine and GoC anchovy 2014; areas IXa, VIIIabc

2) to conduct analyses on historic series fluctuations of SSB and all DEPM parameters considering population structure and environmental variability.

General issues

The Group felt that some statistical support (from experienced statistician in these specific subjects), is needed to help in pursuing some of the above mentioned analyses and developments. To this end dedicated workshops and short-term grants for statistical advice should be considered within the programmes which fund the DEPM surveys.

Addressing WGHANSA issues/requests

During the meeting in plenary session, a presentation was conducted by WGHANSA members who are simultaneously members of WGACEGG (see Annex 8.8).

The issues raised from the sardine assessment perspective led to the following decisions by WGACEGG:

1) In order to clarify the possible conflicting signals between DEPM and acoustic surveys biomass results in some years it was decided that the Group (DEPM and acoustics researchers) will look again at all the information and produce a WD for the next meeting (already set as a ToR for 2015). The analyses are also to be supported by the development of abundance egg indices from CUFES sampling.

2) Since the sardine DEPM results are obtained in a triennial basis, the assessment model shows some difficulty in coping simultaneously with the tendencies from a non-continuous DEPM dataseries and from an annual acoustics dataset. To try to fill in the gaps in the DEPM series it was discussed the possibility of obtaining egg data for the years during which no DEPM takes place but for which information may exist coming from either AEPM or DEPM for mackerel and horse-mackerel and from acoustics surveying.

The Group agreed on exploring the following additional egg data (or samples) for the years without sardine DEPM surveys:

Extra CalVET and Bongo samples

IPMA will stage sardine eggs, already sorted (CalVET samples), from the horse-mackerel DEPM surveys in 2007, 2010 and 2013; and for the same years IEO will stage the sardine eggs collected, and already sorted, in the samples from the AEPM for mackerel and horse-mackerel (Bongo samples).

After the egg data are available its value for egg production estimation will be assessed (questions may arise with the spatial resolution since the survey designs for the alternative datasets may not be adequate for sardine abundance distribution) and eventually SSB estimations will be attempted using adult parameters from historic means. Should the results from this exercise, of using extra information to fill in the gaps for the years without sardine DEPM surveys, look adequate for producing estimations for sardine, the utilization of data from other years prior to 2007 may also be assessed.

CUFES samples

At the same time, CalVET and Bongo samples from the surveys listed above are processed the possible utilization of indices of abundance derived from CUFES surveying will be explored (Boyra *et al.*, 2003; Petitgas *et al.*, 2006, Petitgas *et al.*, 2009; Gati, 2012).

IPMA and IEO have agreed on further exploring the data and samples obtained by CUFES during DEPM and acoustics surveying. Therefore, the following plan of actions was appointed:

i) identify the surveys to be used for the analyses

ii) compare vertical (CalVET) and surface (CUFES) abundance data

iii) analyse available vertical distribution data on staged eggs

iv) select available vertical distribution models (e.g. Ifremer, AZTI) v) compile and/or obtain data on staged egg from CUFES samples

vi) compile TS vertical data during the surveys

vii) in collaboration between Ifremer; AZTI, IEO, IPMA develop egg abundance indices from CUFES egg data

This objective of obtaining abundance indices from CUFES data will also apply to anchovy egg data (AZTI).

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Gati, P 2012 Validation d'un modèle de distribution verticale des oeufs de poisson et mise en oeuvre opérationnelle dans le cadre de l'évaluation du stock d'anchois européen du golfe de Gascogne. *Master de l'Institut Supérieur des Sciences Agronomiques, Agroalimentaires, Horticoles et du Paysage*, 31 pp

Petitgas, P., Goarant, A., Massé, J., and Bourriau, P. 2009. "Combining Acoustic and CUFES Data for the Quality Control of Fish-stock Survey Estimates." *ICES Journal of Marine Science* 66 (6): 1384–1390.

Petitgas, P., Magri, S., and Lazure, P. 2006. "One-dimensional Biophysical Modelling of Fish Egg Vertical Distributions in Shelf Seas." *Fisheries Oceanography* 15 (5): 413–428.

Picquelle, S. 1985. Sampling requirements for the adult fish survey. In: R. Lasker (ed.). An Egg Production Method for Estimating Spawning Biomass of Pelagic Fish: Application to the Northern Anchovy, *Engraulis mordax*. NOAA Technical Rep NMFS 36: 55–57.

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8.6.2. Intercalibration of CUFES systems between Miguel Oliver and Thalassa vessels, during INTERPELACUS 0314

Since 1996, Spanish acoustic surveys PELACUS were carried out on board RV Thalassa (GENAVIR, Ifremer), but from 2011, this vessel was substituted by the RV Miguel Oliver (Spanish Fisheries Authorities) in the PELACUS spring surveys.

In order to test the consistency of the dataseries used in the assessment, an Intercalibration between Thalassa and Miguel Oliver was performed in April 2014. Although CUFES data in PELACUS surveys are not used directly in the assessment, they are used as a tool to support the correct allocation of schools, and it is important to know whether the egg sampling by both vessels is comparable.

All samples were collected during the INTERPELACUS survey conducted between in April 2014 using "Thalassa" and "Miguel Oliver" research vessels.

In both vessels, CUFES samples are pumping from an internal installation, with the water intake at a depth of 5 meters and with a mesh size of 500 μm in the concentrator sieve and collector.

CUFES sampling takes place during the day, every 3 nautical miles, over a total of four transects in the French shelf, near to the mouth of the Garonne River, during the acoustic coverage. Although both vessels have an internal pumping system with the intake located at more less the same depth, in TH the seawater goes directly to the CUFES while in MO there is a previous tank of about 1m3.

A total of 89 CUFES valid stations (47 in RV Thalassa and 42 in RV Miguel Oliver) were used for intercalibration purposes (Figure 8.6.2.1). Samples were taken during the first and second passages to each transect.

Sardine and anchovy egg concentrations obtained during the intercalibration are shown in Figures 8.6.2.2ab. Sardine egg concentrations during INTERPELACUS were much higher than anchovy ones.

The former were mainly located near the self-break while the second in shallower waters. As it was already mentioned, the first passage to each transect was done in parallel while during the second MO has leaded. The elapsed time between passages was higher than 2 hours (see Table 5 for further details).

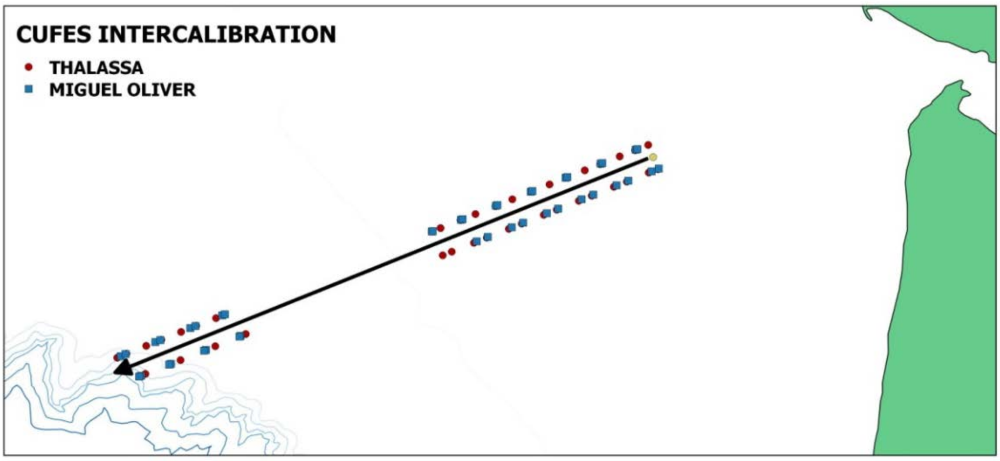

Figure 8.6.2.1. Location of the CUFES stations for each vessel.

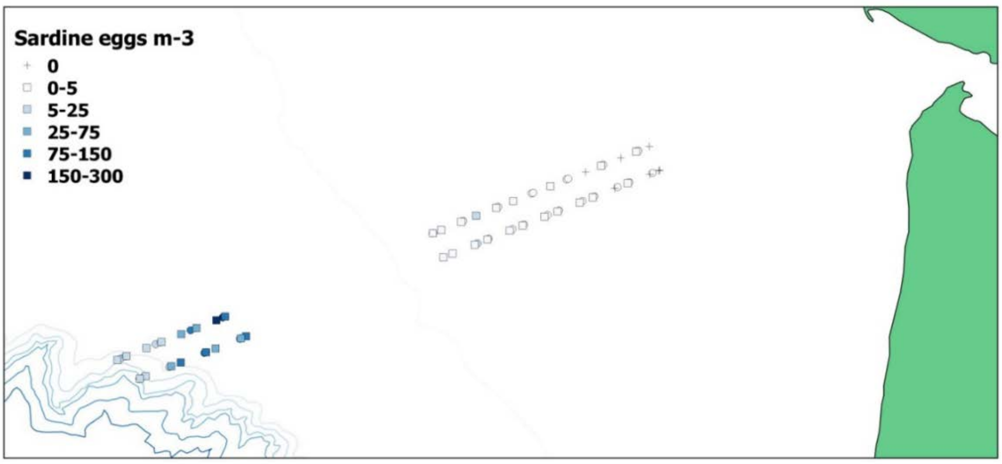

Figure 8.6.2.2.a. Sardine egg concentration (no of egg m-3) obtained from the CUFES stations (all passages) by MO (circles) and TH (square). Colours grade is proportional to concentration.

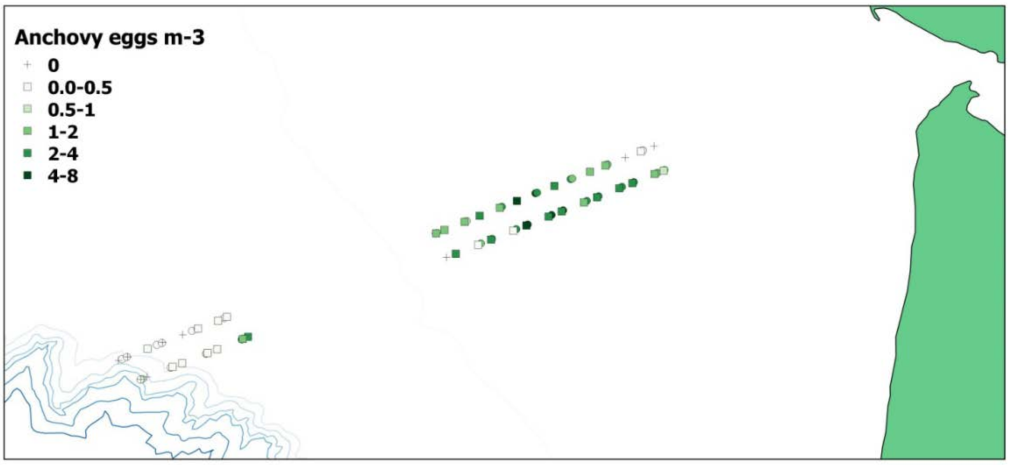

Figure 8.6.2.2.b. Anchovy egg concentration (no of egg m-3) obtained from the CUFES stations (all passages) by MO (circles) and TH (square). Colours grade is proportional to concentration.

Inter-ship analysis

Although the samples were not taken exactly at the same position, for sardine there was a high correlation for sardine egg concentration between pair of stations located at roughly the same position, (Figure 8.6.2.3). On the contrary, for anchovy the correlation was too low.

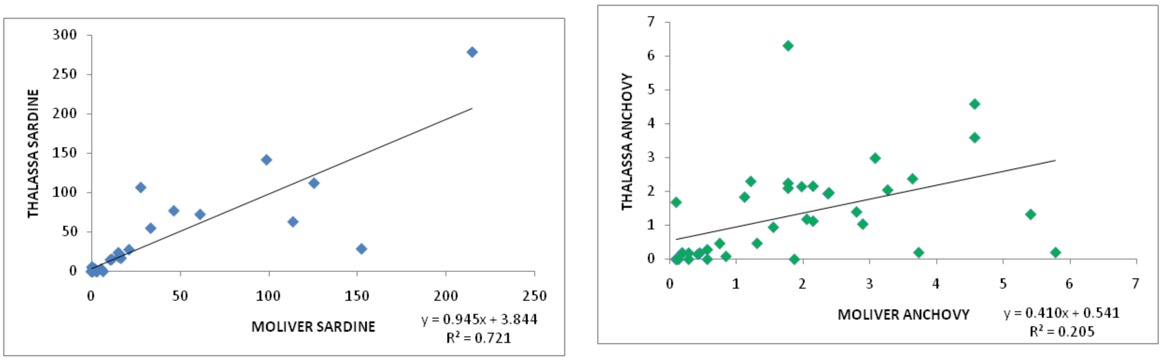

Figure 8.6.2.3. Egg concentration relationship between pairs of samples obtained at roughly the same position for both vessels. Left panel, sardine; right panel, anchovy.

As in the case of the backscattering energy, egg concentration was cumulated from a common starting point, but in this case, the origin was the same for both transects, thus giving a single probability density function for each species. Besides, due to the skewness of the data, these were transformed in logarithmic scale (ln(x+1)). As it was already said, there was a depth trend for both species; for sardine the trend was positive while for anchovy this was negative. For both species, cumulated egg concentration could be adjusted to a simple regression model, linear for sardine and exponential for anchovy. In both cases models were significant, explaining most of the variability (R2 >0.983). Besides, comparison between the models obtained for each species and vessel did not shown differences as shown in Figure 8.6.2.4.

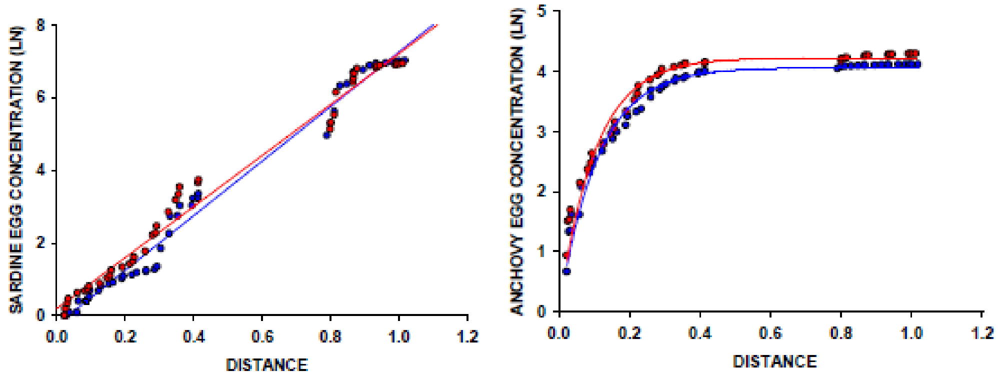

Figure 8.6.2.4. Fitted models and cumulated egg concentration for each species and vessel. Left panel, sardine; right panel anchovy. In red data from MO; in blue data from TH.

Intra-ship analysis

For each vessel, although sardine and anchovy egg abundance was correlated, differences between passages were noticeable. For TH, only in transects R09 and R10 for anchovy and R10 for sardine, differences were lower than a 15%; for MO, only R01 for both species such differences were lower than 15%. Moreover, in TH and for sardine, only in transect R10 these differences were lower than a 50%; in the case of MO most of the differences between passages were lower than 50% except for transect R02. In the case of anchovy, due the small number of eggs, which would be also related, with the lack of spawning activity, all differences for both vessels were below 50% except in R01 for TH (Figure 8.6.2.5).

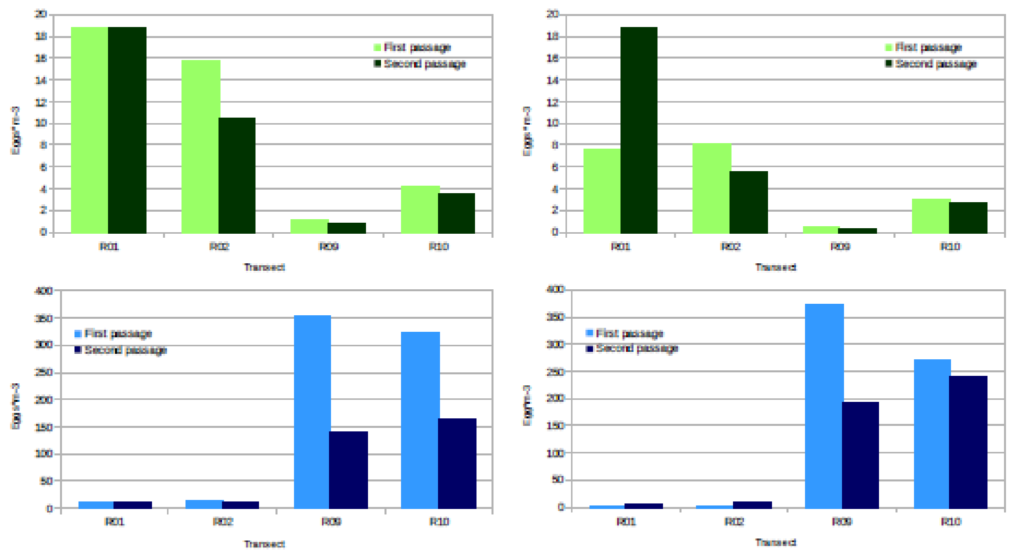

Figure 8.6.2.5. Egg abundance (no egg/m3) for anchovy (green colours) and sardine (blue colours) from the CUFES stations. Lefts panels samples from MO; right panel samples from TH.

On the other hand, the magnitude of the change in sardine egg abundance from the first to the second passage in the slope area occurred in both vessels suggests a high hydrodynamic activity.

8.6.3. Consistency of relative changes in Biomass and Proportions at age 1 in Anchovy Surveys. Preliminary results

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Introduction

For short living population which can easily summarized in a population structured in two age groups (age 1 or recruits and age 2+ or all older fish), if age determination are precise and accurate, there must be a high consistency between the spawning biomass fluctuations and the fluctuations in the one year old recruits, as usually they constitute the major part of the population.

This relies on the fact that if survey's observations are rather precise, any sharp increase in the spawning biomass has to be due to a major increase in the 1 year old recruits (and vice versa, any drop in biomass has to be due to a failure of recruitment). Verification of this principle from the series validates both that surveys are rather precise in terms of monitoring the fluctuations in fish abundance and that age determination are correctly done.

The model

This principle can be checked by fitting of the following model, which relates the ratio of biomasses in two consecutive years of a survey series with the ratio of age, 1 proportions over older fish in the second year:

$$\frac{P_{1,y+1}}{(1-P_{1,y+1})} = e^{-g_{1+}} \cdot \frac{B_{1+,y+1}}{B_{1+,y}} - 1 \qquad \text{Equation 1}$$

Or the other way around:

$$e^{g_{1+}} \cdot \left[\frac{P_{1,y+1}}{(1-P_{1,y+1})} + 1\right] = \frac{B_{1+,y+1}}{B_{1+,y}} \qquad \text{Equation 2}$$

As such equation 1 is a linear model with an intercept of -1 and a slope equal to the inverse of the average survival in biomass of a population from year-to-year (1/exp(g1+)), where g1+ is the instantaneous rate of biomass decay/increase of all ages pooled together ($g1+= G_{1+}- M_{1+} - F_{1+}$, with G, F and M corresponding to the rates of individual growth in mass, natural mortality and fishing mortality respectively). Since G, M and F usually vary across ages and may change along the time-series, the slope cannot properly be considered a constant but subject to structural and process error. However, as far as such variability result to be of little magnitude, finding a significant fitting to such relationship should be indicative of an overall satisfactory performance of the age determination as well as that of the biomass estimation of the surveys. This is suitable model for anchovy-like populations as they are constituted of two age groups the 1 and 2+ year old (Ibaibarriaga, 2008).

Finally, it is worth reminding that both the related variables are subject to observation errors. So that outliers can be due either to errors in the observation process of the ratios of successive biomass from surveys or in the P1 estimates of the second year.

Model derivation:

By calling:

P1 and P2+ to the ratio in biomass of the age 1 (or recruits) and older fish over the spawning biomass respectively

B1+, B1 and B2+ the spawning biomass corresponding to the total, age 1 older fish respectively. Notice that

And g1+, g1 and g2+ to the annual survival rates of biomass affecting the total population or to ages 1 and 2 respectively. Any of these rates equal to the individual increase in mass due to growth minus the natural and fishing mortalities (g = G-M-F)

Then $B_{2+,y+1} = B_{1+,y} \cdot e^{g_{1+}}$

Then

$$\frac{P_{1,y+1}}{(1-P_{1,y+1})} = \frac{P_{1,y+1}}{P_{2+,y+1}} = \frac{\frac{B_{1,y+1}}{B_{1+,y+1}}}{\frac{B_{2+,y+1}}{B_{1+,y+1}}} = \frac{B_{1,y+1}}{B_{2+,y+1}}$$

And

$$\frac{B_{1,y+1}}{B_{2+,y+1}} = \frac{B_{1,y+1} + B_{2+,y+1} - B_{2+,y+1}}{B_{2+,y+1}} = \frac{B_{1+,y+1}}{B_{2+,y+1}} - 1 = \frac{B_{1+,y+1}}{B_{1+,y} \cdot e^{g_{1+}}} - \mathbf{1}$$

Joining these two expressions, we have equation 1.

$$\frac{P_{1,y+1}}{(1-P_{1,y+1})} = e^{-g_{1+}} \cdot \frac{B_{1+,y+1}}{B_{1+,y}} - \mathbf{1}$$

Notice however that the slope is not a constant, but as far as ***g*** changes by ages then different annual age structures will result in different relative survivals in mass every year. IN fact, even assuming that g1 and g2+ are constant values (invariant throughout the time-series) the slope (exp(g1+)) will change yearly, because:

$$B_{1+,y} \cdot e^{g_{1+,y}} = B_{1,y} \cdot e^{g_{1,y}} + B_{2+,y} \cdot e^{g_{2+,y}}$$

$$e^{g_{1+,y}} = \frac{B_{1,y}}{B_{1+,y}} \cdot e^{g_{1,y}} + \frac{B_{2+,y}}{B_{1+,y}} \cdot e^{g_{2+,y}} = P_{1,y} \cdot e^{g_{1,y}} + P_{2+,y} \cdot e^{g_{2+,y}}$$

The actual slope of equation 1 is a weighted average of the survival in mass of the two age groups weighted to their relative frequency in the first of the two successive years (in year y).The changes in that weighted mean is the minimum it should be expected to vary yearly. This is structural error of the model.

In addition, there can be changes in Fishing mortality randomly from year to year or some tendencies throughout the time-series, while the same may happen with growth rate or with the natural mortality. These can be considered as process errors (probably, but not necessarily, random). Therefore the degree of successful fitting of the model will depend on the degree of structural and process error in the survival in mass of the population (in the inverse of the slope) and in the observation errors. If these errors are big then the fitting will become not significant. However, we can expect that for a stable fishery with rather constant fishing mortalities at age and growth and natural mortalities at age constant g1 and g2+ will be rather constant as well and variability will be small.

Preliminary Application to the Spring Surveys on the Bay of Biscay anchovy.

A direct fitting of the series of data available in the input data to the assessment in ICES (2014; table …) results is significant fitting of the complete series of data to the model in equation 1 (Figure 8.6.3.1).

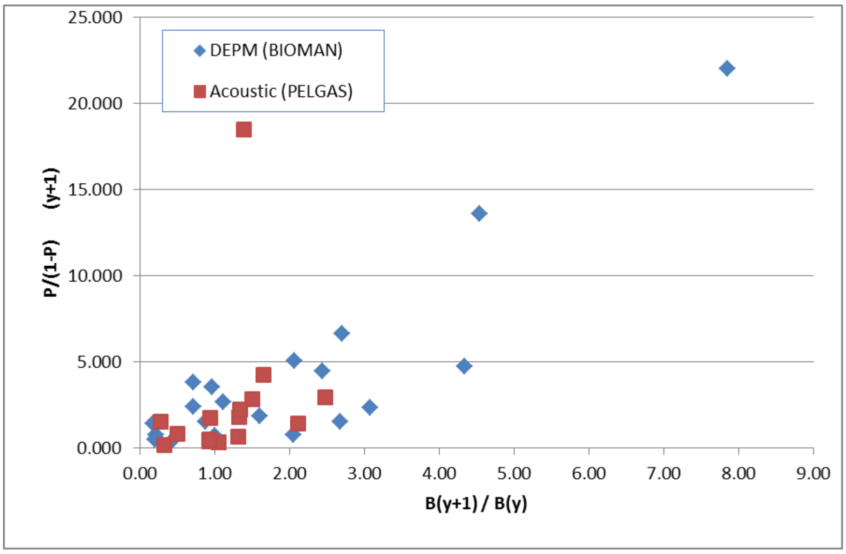


Figure 8.6.3.1. Relationship for the acoustic and DEPM surveys on the Bay of Biscay between the ratios of biomasses in two consecutive years of a survey series with the ratio of age 1 proportions over older fish in the second year (N=37, R= 0.729, P= 7*E-7).

Obviously, this means that the structural variability of the survival in mass (1/slope) is little compared with the driving force of recruitment and it implies that age readings are globally correct. There is an acoustic survey output, which does not align with the rest of observations: This the 1992/1991 point, for which the increase of high rate of P1 over P2+ demands a far higher increase in biomass from 1991 to 1992. The DEPM pointed out to a sharp increase in biomass between these two years, and particularly disagreed with acoustics in the 1991 estimate. Therefore, the most likely potential explanation was some overestimate in the 1991 acoustic estimate.

Despite the apparent moderate structural variability of the survival in mass (1/slope) from Figure 8.6.3.1, we have made some checking of this by trying to estimate the variability of the g1+ parameter from the output of WGHANSA assessment. In the table below, we show a preliminary assessment of g parameters and the slope over the assessment of this population to test how much structural variability of the slope can be affecting the model as applied to anchovy in the Bay of Biscay. Certainly variability is rather high across the series and so it will be the structural variability around the fitted model of equation 1 (Figure 8.6.3.1), in addition to all types of observation errors.

Table 8.6.3.1. Preliminary assessment of g1 and g2+ and the slope (or its inverse) by blocks of periods from the historical assessment carried out in ICES, for which exploitation seems to have been rather stable, which may allow some constant g1+ be presumed:

	Median Values Between Surveys (According to WGHANSA)									
Periods	F Age 1	F Age 2	G1	G2	M1	M2	**g1**	**g2+**	P1	**exp(g1+) (Y+1)**
1987-95	1.335	1.530	0.447	0.229	**0.9333**	**1.2000**	-1.821	-2.502	0.75	0.14
1996-2004	1.083	1.130	0.447	0.229	0.933	1.200	-1.570	-2.101	0.75	0.19
2005-2009	0.061	0.081	0.447	0.229	0.933	1.200	-0.547	-1.053	0.75	0.52
2010-2013	0.423	0.488	0.447	0.229	0.933	1.200	-0.909	-1.459	0.75	0.36
Total	0.860	0.953	0.447	0.229	0.933	1.200	-1.346	-1.924	0.75	0.23
1987-2004	1.191	1.315	0.447	0.229	0.933	1.200	-1.677	-2.286	0.75	0.17

The slope of the linear model of equation 1 fitted to the Figure 8.6.3.1 (forced to pass through -1) is about 2.52; this suggests an average survival in mass of about 40%. A rough estimate from the available data of the historical mean value corresponding to 1/exp(g1+) according to the latest assessment of ICES results in a value about 3.63, higher than the fitted slope, this suggests an average survival in mass of about 28%. This matter deserves further research.

Preliminary Conclusions and perspectives

The model can be applied to any time-series of surveys if they provide both total biomass and relative abundance of recruits within it. However, in order to work it recruitment has to be a substantial part of the biomass (so suitable for short living species) and variability of recruitment is to be high, so the contrast (signal) in the observations overcomes the potential observation errors. In other words, the structural and process errors of the model (affecting the slope) are to be small enough as to not mask the relationship between the variables produced by the series.

The model can be used to:

- Assess the slope or (inverse of) survival rate of biomass and instantaneous rate g1+
- Assess consistency of biomass fluctuations in a survey series with the changes in the relative strength of recruits (P1; and thus to Identify potential outliers in biomass observations), provided errors in age determination are small and key population rates do not change much
- Assess the consistency of proportion at age estimates (and of age readings too) with the biomass estimates of a series of surveys, provided errors in biomass observations are small and key population rates do not change much in time.

These checking can be made for a single survey series or for twin survey series provided the most reliable and consistent information of the two surveys is identified (and averaged over the two surveys) so that it can be used as predictor of the other source of information, i.e. if survey agree on the percentages at age, then this information can be averaged for the two surveys and used as indicator of expected relative changes in biomasses between successive years.

More work is to be done on the statistical properties of this relationship as to determine an objective manner to flag as outliers points surpassing threshold deviations from expectations.

Annex 8.7: Ecosystem indicators

During the last meetings, the WGACEGG participants explored a list of potential indicators of the (good) environmental status of the pelagic ecosystem in ICES areas VIIe,f,g,h; VIII and IX that could be provided by the group in the mid-term (ICES 2011), within the framework of the Marine Strategy Framework Directive (MSFD). These indicators could be provided, at both the survey and regional scale, for time periods including spring, summer, autumn and winter/spring, depending on surveys. The regional scale was defined as the area encompassing areas VIIe,f,g,h ; VIII and IX. The survey scale was defined as the areas covered by each survey.

WGACEGG list of potential indicators describe changes in both the biodiversity and the commercial species of the regional pelagic ecosystem. Indicators also describe marine litter.

Biodiversity indicators are defined at the species and community of species taxonomic levels. Species for which indicators are available at the regional scale are European anchovy (*Engraulis encrasicolus*) and sardine (*Sardina pilchardus*), at the adult and egg stages, as well as adult mammals and seabirds. Indicators of anchovy and sardine larvae are available for certain surveys. Indicators of juvenile anchovy are also available in the Bay of Biscay in autumn (JUVENA survey). Species community indicators describe the pelagic fish community at the adult and egg stages, as well as the zooplankton community. Commercial fish indicators describe variations in anchovy and sardine stocks.

According with the EU Commission Decision of 1st September 2010 (2010/477/EU), and accounting the list of different sampling techniques and results achieved by a standard acoustic trawl- survey (i.e. PELGAS), the potential list of indicators (Criteria for good environmental status relevant to the descriptors of Annex I to Directive 2008/56/EC) is the following:

- Species distribution (range; 1.1)
  - Distributional range (1.1.1)
  - Distributional pattern within the latter, where appropriate (1.1.2)
- Population size (abundance and biomass; 1.2)
  - Abundance and biomass; 1.2.1)
- Population condition (1.3)
  - Population demographic characteristics (e.g. body size or age class structure, sex ratio, fecundity rates, survival/mortality rates; 1.3.1).
  - Population genetic structure, where appropriate (1.3.2)
- Habitat distribution. (1.4)
  - Distributional range (1.4.1)
  - Distributional pattern (1.4.2)
- Habitat extent. (1.5)
  - Habitat area (1.5.1)
- Habitat condition (1.6):
  - Condition of the typical species and communities (1.6.1)
  - Relative abundance and/or biomass, as appropriate (1.6.2)
  - Physical, hydrological and chemical conditions (1.6.3)

- Ecosystem structure (1.7)
  - Composition and relative proportions of ecosystem components (habitats and species; 1.7.1)
- Level of pressure of the fishing activity (3.1).
  - Primary indicator F (3.1.1)
  - Secondary Indicator ratio between catch and biomass index (hereinafter 'catch/biomass ratio'; 3.1.1)
- Reproductive capacity of the stock (3.2)
  - Spawning-stock biomass (3.2.1)
  - Biomass indices (3.2.2)
- Population age and size distribution (3.3)
  - 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)
  - Size at first sexual maturation, which may reflect the extent of undesirable genetic effects of exploitation (3.3.4)
- Proportion of selected species at the top of foodwebs. (4.2)
  - Large fish (by weight; 4.2.1).
- Abundance/distribution of key trophic groups/species (4.3)
  - Abundance trends of functionally important selected groups/species (4.3.1)
  - groups with fast turnover rates (e.g. phytoplankton, zooplankton, jellyfish, bivalve molluscs, short-living pelagic fish) that will respond quickly to ecosystem change and are useful as early warning indicators,
  - groups/species that are targeted by human activities or that are indirectly affected by them (in particular, bycatch and discards),
  - habitat-defining groups/species,
  - groups/species at the top of the foodweb,
  - long-distance anadromous and catadromous migrating species,
  - groups/species that are tightly linked to specific groups/species at another trophic level.
- Nutrients levels (5.1)
  - Nutrients concentration in the water column (5.1.1)
  - Nutrient ratios (silica, nitrogen and phosphorus), where appropriate (5.1.2)
- Direct effects of nutrient enrichment (5.2)
  - Chlorophyll concentration in the water column (5.2.1)
  - Water transparency related to increase in suspended algae, where relevant (5.2.2)
- Impact of permanent hydrographical changes (7.2)
  - Spatial extent of habitats affected by the permanent alteration (7.2.1)

  - Changes in habitats, in particular the functions provided (e.g. spawning, breeding and feeding areas and migration routes of fish, birds and mammals), due to altered hydrographical conditions (7.2.2)
- Characteristics of litter in the marine and coastal environment (10.1)
  - Trends in the amount of litter in the water column (including floating at the surface) and deposited on the sea- floor, including analysis of its composition, spatial distribution and, where possible, source (10.1.2)
  - Trends in the amount, distribution and, where possible, composition of micro-particles (in particular micro- plastics; 10.1.3)

In addition, the following indicators would be provided:

Descriptor	Attribute	Criteria		Indicators
Biodiversity	Species	*Population size*		**DEPM and acoustic total biomass&abundance estimates, along with estimation error**
		Population condition		**Acoustic biomass&abundance estimates per size/age**
				DEPM biomass&abundance estimate per size/age (Biscay anchovy)
		Species distribution	*Distributional range*	Surface area
			Distributional pattern (survey scale)	Centre of gravity
				Spatial patches
				Inertia
				Isotropy
				Positive area
				Spreading area
				Equivalent area
				Gini index
				Coefficient of variation of strictly positive densities
				Microstructure
				Global index of collocation
				Mean biomass
				Percentage of total area occupied
			Distributional pattern (regional scale)	Regional synthesis of spatial indicators at the survey scale
	Community	*Community condition*		**Total pelagic fish NASC**
				LOPC zooplankton abundance at lengths (PELGAS, PELACUS)
				Species composition
				Relative population abundance
		Habitats	*Habitat condition*	**Surface temperature**
				Surface salinity
				Nutrients (PELGAS, PELTIC)
Commercial fish	Reproductive capacity			**DEPM Spawning Stock Biomass (SSB) estimate**
				Acoustic SSB estimate
				DEPM fecundity
				DEPM spawning frequency
	Age and size distribution			95% percentile of the population length distribution
				Proportion of fish larger than L50 (only relevant for sardine, as all age 1 anchovies are mature)
Marine litter in the marine environment	Amount, composition and source of litter floating at sea, in the water column and on the sea floor			Floating litter (PELGAS, PELACUS)
				Litter in trawl catches (PELGAS, PELTIC)
				Microlitter in zooplancton samples (PELTIC)

The indicators describing the species distributional patterns are described in (Woillez *et al.*, 2007). Indicators in bold are already provided by WGACEGG. Indicators not in bold could be provided every year in a near future.

Annex 8.8: Issues raised by WGHANSA

Results of the 2014 sardine assessment from WGHANSA were presented in the first session of the WGACEGG.

Since 2012, sardine is assessed with Stock Synthesis (SS3), by means of data from commercial landings (1978–2013) and from surveys (acoustic and DEPM).

Results of the last assessment showed the bad situation of the Iberian sardine population. B1+ at the beginning of 2013, 149 thousand t is 69% below the historical mean biomass B1+(1978–2013)= 480 thousand t. Fsq=0.44 is 42% above the historical mean. The assessment indicates a 14% increase in B1+ and a 15% decrease of F from 2012 to 2013 which reflect a slight increase in recruitment and a drop in catches (16%). B1+ in 2014= 188 thousand t.

F has increased since 2008, shows values above the historical range in 2010 and 2011 and has decreased 36% from 2011 to 2013. If F2014 does not exceed F2013=0.44, corresponding to catches in 2014of 51 thousand t and the 2014 recruitment continues to be at a low level (RGM(09–13) = 4384 million individuals) B1+ in 2015 is estimated to be 169 thousand t, i.e. at a level similar to 2014. The 2013 recruitment, estimated to be 6247 million individuals (CV=22%), is 43% above the RGM(09–13) and is expected to contribute to reverse the decrease of the stock.

Management alternatives:

1) Precautionary considerations (ICES recommendation, June 2014):

The stock biomass is at a historically low level and fishing mortality has increased to historically high levels in recent years. F should be brought back to where it was before the start of this increase, i.e. the 2002–2007 average. However, taking into account the low biomass, below previous Bloss and the below-average recruitment, fishing mortality F should be reduced further. For F to be reduced to zero at zero biomass the reduction should be the ratio between the current biomass (B1+(2014) = 188 kt) and the average biomass in this period (460 kt, ratio of 41%) to F = 0.11.This results in catches of no more than 16 000 t.

2) EC Management Plan (nowadays implemented for both Portugal and Spain):

In order to ensure recovery of the sardine stock, Portugal and Spain developed a multiannual management plan. This management plan consists in a rule where the TAC is set at a fixed level, but reduced if the biomass (B1+) is below a trigger B1 (368.4 kt), and the fishery is stopped at B1+ below another reference point B0 (135 kt).

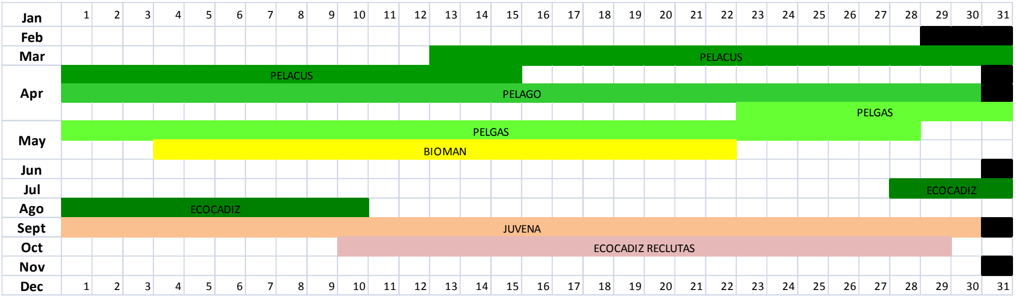
This plan was evaluated by ICES (at the request of the European Commission) in a workshop in June 2013 (WKSardineMP, 2013; ICES, 2013) with scientists and stakeholders, and given the data available, ICES therefore concludes that the plan is provisionally precautionary. Following the proposed EC management plan implies that the TAC is set by the formula 0.36 × (B1+ (2014) − lower trigger level) = (0.36 × (188 − 135))) because the biomass is currently between the two trigger points in the harvest rule, resulting in catches of no more than 19 095 t in 2015.

In addition, some unresolved issues related to the acoustic and egg surveys, relevant to the next sardine benchmark (proposed for 2017), and pending the advice of the WGACEGG, were raised. One of these issues, the retrospective in the assessment (tendency to overestimate biomass and underestimate fishing mortality), is partly caused by conflicting signals of the DEPM and the acoustic surveys in some years and is accentuated by the triennial mode of the DEPM survey. The group discussed possible ways to reduce this problem, namely the possibility to use samples from CUFES and/or samples from the mackerel and horse mackerel egg surveys (P0 seems to be a good proxy of SSB) to provide additional estimates of SSB for interim years of the DEPM (see Annex 8.6.).

Another issue is the possible difference in catchability of Portuguese and Spanish acoustic surveys (i.e. different acoustic and fish sampling performance due to different vessel-effect on fish behaviour). On this subject, the working group recommends to revisit the data from previous intercalibration exercises. On the other hand, in short term the RV Noruega will be substituted by a new vessel. Although there is not a precise schedule on when this new platform will be available, the working group considers that it should be preferable to plan a dedicated intercalibration experiment once this new vessel be available and to prepare a single experiment using the three vessels (Miguel Oliver, Noruega and the Portuguese new vessel). This exercise should be conducted at the same period and in one of the areas covered by the large-scale surveys PELACUS or PELAGO (i.e. excluding possible time and space effect in the data variability). In the same way, this should be conducted in one area with high expected fish abundance; otherwise the results would be inconclusive due the expected large variability associated to low abundance (i.e. lower school occurrence probability than desirable, affecting both acoustic and fishing results). Moreover, this exercise should be also used to test the CUFES performance.

Annex 8.9: Planning and coordination of surveys for 2015

Survey planning for 2015 is summarized in the table below.



Spring and summer acoustic surveys

The spring acoustic surveys will be carried out following the standard methodologies defined by the Group and as usual with coordination between IPMA, IEO and Ifremer. IPMA will survey the southern region from Cadiz to the northern border between Portugal and Galicia (PELAGO); IEO will operate off western Galicia and the Cantabrian Sea (PELACUS) and Ifremer (PELGAS) will cover the French shelf of the Bay of Biscay.

In summer, IEO will carry out the ECOCADIZ survey in the southern Spanish and Portuguese waters of the Gulf of Cadiz.

Autumn recruitment surveys

As a result of the compromise of collaboration between AZTI and IEO, this year 2014, as happened in the previous years, the JUVENA survey was coordinated between both institutes, AZTI leading the assessment studies of the JUVENA series, and IEO the ecological studies, substantially increasing the planktonic sampling effort and adding new ecological-environmental objectives to the project. For the next year (2015), it is planned to continue this collaboration in similar terms than those carried out in the past years.

In the Gulf of Cadiz, it is planned by IEO a recruitment survey – ECOCADIZ_RECLUTAS.

DEPM surveys in regions VIII and IX

In 2015 the annual anchovy DEPM survey in the Bay of Biscay (BIOMAN) will take place in May conducted by AZTI, covering the usual spawning grounds ranging from 5ºW to the French coast for Cantabrian sea and from there to 48ºN for the French area. This survey will be carried out as usual, following the standards defined in the manual for the DEPM survey (Annex 7 of WGACEGG 2010 report (ICES 2010: ICES CM 2010/SSGESST:24).

The next anchovy DEPM in the Gulf of Cadiz will take place in 2017 by IEO.

The next triennial sardine DEPM survey will take place in 2017 covering the area from the Gulf of Cadiz to the North of the Bay of Biscay (48ºN). The region from the Gulf of Cadiz to the northern border between Portugal and Spain will be surveyed by IPMA; IEO will cover the northwestern Iberian Peninsula and the inner part of the Bay of Biscay until 45ºN and AZTI will survey the North of the Bay of Biscay from 45ºN to 48ºN. The coordination of the sardine survey will be planned in detail in the 2016 WGACEGG meeting.

Annex 8.10: Survey reports – Working Documents

Annex 8.10 - Survey Reports

The following list of WDs with the respective survey reports is included in this annex 8.10

1.
Boarfish Acoustic Survey - Cruise Report (10 July – 31 July, 2014)
Ciaran O’Donnell and Cormac Nolan

2.
Celtic Sea Herring Acoustic Survey Cruise Report 2014 (06 - 26 October, 2014)
Cormac Nolan, Ciaran O’Donnell, Deirdre Lynch, Kieran Lyons, Niall Keogh, Stephen McAvoy, Ciaran Cronin and William Hunt

3.
Direct assessment of small pelagic fish by the PELGAS14 acoustic survey
Erwan Duhamel, Mathieu Doray, Martin Huret, Matthieu Authier, and Thomas Gestin
Special thanks to Jacques Massé, Florence Sanchez, Pierre Petitgas, Lionel Pawlowski

4.
Index of biomass of Bay of Biscay anchovy (*Engraulis encrasicolus*, L.) and sardine (*Sardina pilchardus*) in 2014 applying the DEPM
M. Santos, L. Ibaibarriaga, and A. Uriarte

5.
Preliminary sardine spawning stock biomass estimates at ICES divisions VIIIab applying the DEPM in 2014
Paz Díaz, Maria Santos, Ana Lago de Lanzós, Concha Franco, Jose Ramón Pérez, and Andrés Uriarte

6.
Cruise Report PELACUS 0314 - Pelagic ecosystem acoustic-trawl survey
Pablo Carrera, Isabel Riveiro, M. Begoña Santos, Maite Louzao, José Luís Murcia, Xulio Valeiras, Salvador García Barcelona, José Antonio Vázquez, and Izaskun Preciado

7.
Acoustic surveying of anchovy Juveniles in the Bay of Biscay: JUVENA 2014 Survey Report
Guillermo Boyra

8.
JUVESAR13 Survey Report
A. Silva, Marques V. , Santos A.M., Santos A., Barra J., Bento T., Guerreiro M., Malta T., Matos A., Pereira A., Rodríguez-Climent S., Santos C., Silva A.V.

9.
Sardine spawning biomass estimation (ICES areas IXa and VIIIc) through the application of DEPM in 2014
Maria Manuel Angélico, Paz Díaz, Ana Lago de Lanzós, Cristina Nunes, Elisabete Henriques and Jose Ramón Pérez

10.
Acoustic survey carried out from 3 April to 12 May 2014 off the Portuguese Continental Waters and

Gulf of Cadiz, onboard RV “Noruega”
Vítor Marques, Maria Manuel Angélico, Alexandra Silva, Eduardo Soares, and Cristina Nunes

11.
Acoustic assessment and distribution of the main pelagic fish species in the ICES Subdivision IXa South during the ECOCADIZ 0813 Spanish survey (August 2013)
Fernando Ramos, Magdalena Iglesias, Paz Jiménez, Joan Miquel, Dolors Oñate,
Jorge Tornero, Ana Ventero, and Nuria Díaz

12.
Acoustic assessment and distribution of the main pelagic fish species in the ICES Subdivision IXa South during the *ECOCADIZ 2014 07* Spanish survey (July August 2014). Fernando Ramos, Magdalena Iglesias, Paz Jiménez, Joan Miquel, Dolors Oñate,
Jorge Tornero, Ana Ventero and Nuria Díaz(2)

13.
The ECOCADIZ RECLUTAS 2014-10 Spanish acoustic survey (October-November 2014, ICES Subdivision IXa South): sampling methods and main results from echo-trace ground-truthing fishin g hauls
Fernando Ramos and Jorge Tornero

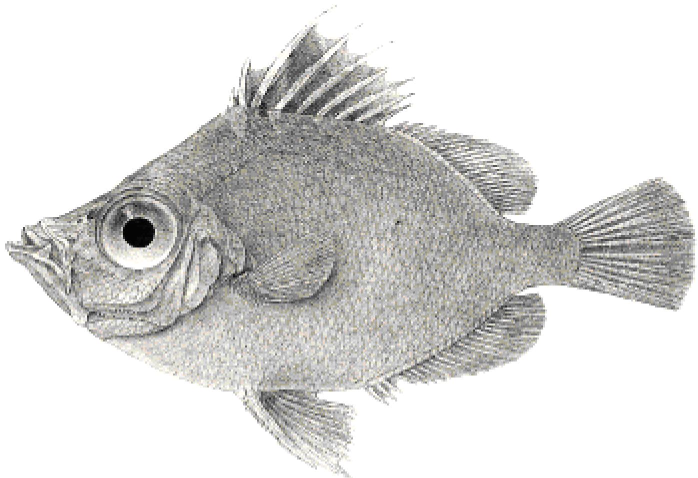
14.
BOCADEVA 0714 **-** Gulf of Cadiz Anchovy Egg Survey and 2014 SSB preliminary estimates.
M.P. Jiménez, J. Tornero, C. González, F. Ramos and R. Sánchez-Leal

15.
Physical oceanography conditions in the Gulf of Cadiz during ECOCADIZ **-** BOCADEVA 201407 cruises
Ricardo F. Sánchez Leal, C. González, V. Pita, J. Barrado, F. Ramos, M. Paz Jiménez, and M.J. Bellanco

FEAS Survey Series: 2014/03

Boarfish Acoustic Survey
Cruise Report

10 July – 31 July, 2014



Day (1966)

MFV Felucca

Ciaran O'Donnell and Cormac Nolan

The Marine Institute, Fisheries Ecosystems Advisory Services

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1 Introduction

From the early 1970s the abundance of boarfish (*Capros aper*) was seen to increase exponentially and distribution spread increasingly northwards along the western seaboard and Bay of Biscay (Blanchard and Vandermeirsch, 2005). At the same time, boarfish were caught in increasing quantities in both pelagic and demersal fisheries. This in turn resulted in damage to more commercially valuable target species. Exploratory fishing for boarfish by Irish vessels began in the later 1980s when commercial quantities were encountered during the spring horse mackerel (*Trachurus* trachurus) and mackerel (*Scrombrus scomber*) fisheries in northern Biscay. Several landings were made into Ireland for fishmeal during this time but due to logistical problems related to handling (prominent dorsal spines) this species was not favoured by processors. Interest increased again temporarily in the mid 1990s when Dutch pelagic vessels landed frozen samples to determine if a market could be developed for human consumption.

During the early 2000s Irish landings were relatively small (<700t per yr) and it was not until 2006 that a directed fishery developed. Fishing was undertaken primarily by vessels from the Castletownbere and Killybegs RSW fleets (refrigerated seawater vessels), which targeted boarfish from northern Biscay to the southern Celtic Sea. In 2007-08 vessels from Scotland and Denmark also began targeting boarfish in quantity. Irish landings are primarily landed into fishmeal plants in Denmark and the Faroe Islands with increasing amounts being landed in Killybegs in recent years. The boarfish fishery bridged an important gap between the short season fisheries for horse mackerel, mackerel and blue whiting (*Micromesistius poutassou*).

A precautionary interim management plan was adopted in November 2010 covering ICES Divisions VI, VII and VIII and an EU TAC of 33,000t was set. Of this the Irish allocation for 2011 was 22,000t. This precautionary TAC was based on 50-75% of total landings from the period 2007-2009 which peaked at over 83,400t (2009). Landings in 2010 reached over 137,000t prior to the introduction of TAC control. In addition to the TAC, seasonal closures were implemented; from September 1- October 31 (Division VIIg) to protect herring feeding and pre spawning aggregations and from March 15–August 31 where mackerel are frequently encountered as a large bycatch. A catch rule ceiling of 5% bycatch was also implemented within the fishery where boarfish are taken with other TAC controlled species. In 2014 the EU TAC was set at 127,509t a 55% increase from 2013 with an Irish allocation of 88,115t.

This survey represents the fourth dedicated research survey for boarfish in the time series. The commercial fishing vessel MFV *Felucca* was used for the third time and was equipped with a calibrated scientific echosounder (Simrad EK 60) and transducer within a towed body.

Data from this survey will be presented to the ICES assessment Working Group for Widely Distributed Stocks (WGWIDE) meeting in August 2014 and as part of the ICES Planning Group meeting for International Pelagic Surveys (WGIPS) meeting in January 2015 (WGIPS).

2 Materials and Methods

2.1 Scientific Personnel

Organisation	Name	Capacity
FEAS	Ciaran O'Donnell	Acoustics (SIC)
FEAS	Turloch Smith	Analyst
FEAS	Michael McAuliffe	Analyst
Contractor	Martin Oliver	Analyst

2.2 Survey Plan

2.2.1 Survey objectives

The primary survey objectives of the survey are listed below:

- Collect integrated and calibrated acoustic data on boarfish (*Capros aper*) aggregations within the pre-determined survey area
- Determine the biomass and abundance of boarfish within the survey area
- Collect biological samples from directed trawling on insonified echotraces to determine age structure and maturity state of survey stock as well as to identify echotrace to species.
- Determine the extent and behaviour of boarfish aggregations within the survey area to aid the design of future surveys
- Dovetail with the RV Celtic Explorer in the northern area to ensure close spatio-temporal alignment and synoptic coverage

2.2.2 Area of operation and survey design

The survey started on the Porcupine Bank before moving to survey the shelf sea between 53°40'N and 47°30'N from north to south (Figure 1). Area coverage was based on the distribution of catches from the previous surveys (O'Donnell *et al.* 2011).Timing was planned to coincide with the arrival of the RV *Celtic Explorer* in the northern survey area to ensure a continuous, quasi-synoptic coverage of the combined area.

In total 3,552nmi (nautical miles) of cruise track was undertaken by both vessels over 130 transects relating to a total area coverage of 56,202nmi^2. Transect spacing was set at 15nmi for the *Felucca* and 15 and 7.5nmi for the *Explorer* component. For the area covered by the *Explorer* only strata bordering the shelf edge were considered during the analysis.

Coverage extended in coastal areas from the c.50m contour to the shelf slope (250m). An elementary distance sampling unit (EDSU) of 1nmi was used during the analysis of combined survey data.

The survey was carried out from 04:00–00:00 each day for both surveys to coincide with the hours of daylight when boarfish are most often observed in homogenous schools. During the hours of darkness boarfish schools tend to disperse into mixed species scattering layers.

2.3 Sampling protocols and equipment specifications

2.3.1 Acoustic equipment

Equipment settings were determined before the start of the survey and are based on established settings employed on previous surveys (O'Donnell *et al.,* 2004 & 2011).

Acoustic data were collected using a Simrad EK 60 scientific echosounder topside unit. A Simrad ES-38B (38 KHz) split-beam transducer was mounted within a towbody frame and deployed on the port side via a towing boom to a working depth of 3-3.5m (Appendix 1).

Cruising speed was largely determined by the weather and the affects on the quality of acoustic data. Where possible cruising speed was maintained at 10kts.

2.3.2 Calibration of acoustic equipment

The EK 60 was calibrated in Donegal Bay prior to the start of the survey in calm conditions. The calibration was carried out using standard methodology as described by Foote *et al.* (1987). Results of the calibration are presented in Table 1.

2.3.4 Acoustic data acquisition

Acoustic data were recorded onto the hard-drive of the processing unit. The "RAW files" were logged via a continuous Ethernet connection as "EK5" files to a laptop and a HDD hard drive as a backup. Sonar Data's Myriax Echoview® Live viewer (V5.3) was used to display echograms in real time and to allow the scientists to scroll through noting the locations and depths of target schools to a log file. A member of the scientific crew monitored the equipment continually. Time and location were recorded for each transect start/end position within each stratum. This log was also used to monitor "off track events" such as fishing operations.

2.3.5 Echogram scrutinisation

Acoustic data was backed up every 24 hrs and scrutinised using Echoview® post processing software (V5.3). The scrutiny process involved the allocation of echotraces (schools) to particular species or species mix categories, based on the information from the directed trawl hauls.

The NASC (Nautical Area Scattering Coefficient) values from each boarfish echotrace were allocated to one of 4 categories after scrutiny of the echograms. Categories identified on the basis of echotrace scrutiny were as follows:

1. "Definitely boarfish" echotraces were identified on the basis of captures of boarfish from the fishing trawls which were sampled directly. Based on the directly sampled schools we also characterised echotrace as definitely boarfish which appeared very similar on the echogram i.e. , large marks which showed as very high intensity (red), located high in the water column (day) and as strong circular schools.

2. "Probably boarfish" were attributed to smaller echotraces that had not been fished but which had similar characteristics to "definite" boarfish traces.

3. "Boarfish in a mixture" were attributed to NASC values arising from all fish traces in which boarfish were contained, based on the presence of a proportion of boarfish in the catch or within the nearest trawl haul. Boarfish were often taken during trawling in mixed species layers during the hours of darkness.

4. "Possibly boarfish" were attributed to small echotraces outside areas where fishing was carried out, but which had the characteristics of definite boarfish traces.

This set of categories allowed us to present the biomass estimates in terms of the best estimate (Cats 1-3), the minimum estimate (Cat 1 + 3), and the maximum estimate (Cats 1-4).

Echograms were divided into transects. Off track events, such as trawl hauls and hydrographic stations were excluded from further analysis. Echo integration was performed on regions which were defined by enclosing selected parts of the echogram that corresponded to one of the four categories above. The echograms were generally analysed and echo-integrals calculated, at a threshold of -70 dB, where necessary heavy backscatter from plankton was filtered out by thresholding at –65 dB.

2.3.6 Biological sampling

A single pelagic midwater trawl with the dimensions of 296m in total length with a 78m brailer (codend) was used during the survey. The horizontal net spread averaged 90m from wing to wing Mesh size in the wings was 12.8m through to 2cm in the cod-end liner. The net was fished with a vertical mouth opening averaging 50m observed using a cable linked Simrad FS 900 netsonde (200 kHz). The net was fitted with Marport catch and tunnel sensors to monitor the amount catch entering the trawl.

An independent light and video/stills camera system was located in the end section of the net and positioned close to the brailer to record fish behaviour in the trawl and to verify trawl catches composition with echotrace identification. Details of camera rig and positioning within the trawl are provided in Appendix 2.

All components of the catch were sorted to species level and weight by species was recorded. For species other than boarfish, length and weight measurements were taken for 100 individuals per trawl in addition to a c.300 fish length frequency sample. Length, weight, sex and maturity data were recorded for individual boarfish in a random 50 fish sample from each trawl haul. In addition a further 100 length/weight and 300 fish length frequency measurements were taken from each haul. Due to the complexity of aging boarfish, no aging was carried out onboard and samples were analysed back in the lab. The appropriate raising factors were calculated and applied to provide length frequency compositions for the bulk of each haul.

The decision to fish on particular echotraces was based on both the distance from other fishing operations on similar schools, and on the difference between recently observed echotraces and others previously sampled.

2.4 Analysis methods

2.4.1 Abundance estimates

The recordings of area back scattering strength (NASC) per nautical mile were averaged over a one nautical mile EDSU (Elementary sampling distance unit), and the allocation of NASC value to boarfish and other acoustic targets was based on the composition of the trawl catches and the appearance of the echotraces.

To estimate the abundance, the allocated NASC values were averaged for ICES statistical rectangles (1° latitude by 2° longitude). For each statistical area, the unit area density of fish (S_A) in number per square nautical mile ($N*nmi^{-2}$) was calculated using standard equations (Foote et al. 1987, Toresen *et al*. 1998).

NASC values assigned according to scrutinisation methods (section 2.3.5) were used to estimate the boarfish numbers according to the method of Dalen and Nakken (1983).

The following TS-length relationships used were those recommended by the acoustic survey planning group (ICES, 1994):

Herring	TS =	$20\log_{10}L - 71.2$ dB per individual (L = length in cm)
Sprat	TS =	$20\log_{10}L - 71.2$ dB per individual (L = length in cm)
Mackerel	TS =	$20\log_{10}L - 84.9$ dB per individual (L = length in cm)
Horse mackerel	TS =	$20\log_{10}L - 67.5$ dB per individual (L = length in cm)

The TS length relationship used for gadoids was a general physoclist relationship (Foote, 1987):

Gadoids	TS =	$20\log_{10}L - 67.4$ dB per individual (L = length in cm)

For boarfish (*Capros aper*) a species specific TS length relationship was applied based on theoretical swimbladder modelling (Fässler *et al.* 2013).

Boarfish TS = $20\log_{10}L - 66.2$ dB per individual (L = length in cm)

To estimate the total abundance of fish, the unit area abundance for each statistical rectangle was multiplied by the number of square nautical miles in each statistical rectangle and then summed for all statistical rectangles for the total area. Biomass estimation was calculated by multiplying abundance in numbers by the average weight of the fish in each statistical rectangle and then sum of all squares by rectangle and summed for the total area.

3 Results

3.1 Boarfish abundance and distribution

The results presented here are a composite of data collected during this survey and on the northwest herring acoustic survey (RV *Celtic Explorer*). Surveys were timed to ensure a continuous quasi-synoptic coverage over 45 days without interruption from north (58°30'N) to south (47°30'N).

Eighteen hauls were carried out by the *Felucca* during the survey, 9 of which contained boarfish (Figure 1, Table 2). An additional 3 carried out by the *Explorer* were used in the analysis. In total, 3,160 lengths and 1,102 length/weight measurements were taken in addition to 397 individual boarfish otiliths collected for aging.

3.1.2 Boarfish biomass and abundance

A full breakdown of the stock estimate is presented by strata, age, length, maturity, biomass, and abundance in Tables 4-8 and Figures 3 & 4.

Boarfish	Abund (mils)	Biomass (t)	% contribution
Total estimate			
Definitely	2,227	133,713	71.2
Probably	830	51,461	27.4
Mixture	41	2,605	1.4
Total estimate	**3,098**	**187,779**	**100**
Possibly	-	-	
SSB Estimate			
Definelty	2,223	133,600	71.2
Probably	829	51,449	27.4
Mixture	41	2,605	1.4
SSB estimate	**3,093**	**187,654**	**100**
Possibly	-	-	

3.1.3 Boarfish distribution

Overall, total observed stock biomass was 57% lower than during the same time period in 2013. All survey areas showed a decrease in biomass with the exception of the northern area where more was observed than in previous years. Geographical occurrence of boarfish followed a similar pattern to previous years with core spawning areas containing the largest abundance. However, in 2014 the distribution of biomass followed a more northward trend than in previous years. This was most apparent in the northern area (54-59ºN) and western areas (54-51º30'N) which combined contained more biomass in 2014 than the southern area which is the largest geographically and historically the most productive.

A total of 611 boarfish echotraces were identified during the survey. Of this 71% were categorised as 'definitely' boarfish (403 echotraces), 27% as 'probably' (207) and a single echotrace represented 1% of 'boarfish in a mixture'. A full breakdown of school categorisation, abundance and biomass by ICES statistical rectangle is provided in Table 9. A total of 66 ICES rectangles were covered by the survey representing combined area coverage of 56,202nmi^2, a decrease of 1% from 2013.

Of the biomass observed in 2014 the southern area contained the largest proportion of stock biomass (over 39%), ranking second was the western area where 36% of biomass was recorded. The northern area and Porcupine Bank contributed 17% and 8% respectively.

On the Porcupine Bank, boarfish were observed in a cluster of medium to high density echotraces located close to the shelf edge (Figure 2 & Figure 5a). Echotraces here were categorised as 'Probably' boarfish as it was not possible to trawl due to technical difficulties onboard (Figure 1, Table 2). However, the likelihood is that these echotraces were indeed 'def' boarfish based on previous observations. The number (n=70) and acoustic density of echotraces observed was lower than in 2013 and similar to that observed in 2012 which was considered as high (54,200t). Biomass for this region was 14,600t representing c.8% of the total. Biological information from nearby hauls (western area) were applied during the analysis.

The northern area contributed 17% (32,000t) to the total biomass and 15.8% (488.7 million) to total abundance. This is markedly higher than previous years (13,900t in 2013; 9,800t in 2012) in what was historically regarded as a peripheral area. Echotraces were greater in number and acoustic density, and more widespread than previous years (Figures 2 & 5b). Boarfish samples were composed of mature, ripe and spawning fish (4-15+yrs yrs). Area coverage and survey effort were comparable to previous years.

The western area contributed c.36% (67,400t) to total biomass and 35% (1087.7 million) to total abundance. This area was characterised by clusters of medium and high density echotraces predominantly located west of 11ºW (Figures 2 & 5c). Overall the number and acoustic density of echotraces was lower resulting in a biomass 27% less than 2013. However, the single highest density cluster of echotraces for the entire survey was observed in the western area relating to 22,700t of biomass within a single ICES rectangle (Table 9). Area coverage and survey effort were comparable to previous years.

The southern area contributed 39% (73,700t) to total biomass and 41% (1279.5 million) to total abundance. Distribution was comparable to previous years, however, the number and acoustic density of boarfish echotraces was much reduced. A difference in biomass of almost 200,000t as compared to 2013 was observed. Off the southwest coast, spawning fish were observed close to the shelf edge and further to the east around a number of offshore banks (Figure 5d). A second area was located in the east around a complex of offshore banks along 08ºW line of longitude and contained spawning aggregations (Figure 5e). A third area, in the south of the survey contained spawning aggregations of boarfish close to the bottom along the shelf edge.

3.1.4 Boarfish stock structure

An age length key compiled primarily from commercial samples collected during 2012/2013 fishery was applied during the analysis of survey data. This ALK was used in place of a survey derived ALK due to the unavailability of aged samples during the analysis.

Age distribution as determined from survey samples indicate that the stock is dominated by the following age classes in terms of biomass: 15+, 7, 10 and 9 year old fish representing over 66% of the total biomass and 15+, 7, 8 and 9 years in terms of abundance (Figure 3, Tables 3, 5 & 6).

Immature fish were observed in all survey regions albeit in small numbers (Tables 7&8). Immature boarfish (< 9.7 cm TL) were observed in the highest abundance in the southern (0.1% of biomass and 0.16% of abundance) in line with previous observations. Some of the largest fish were again observed in the northern and western survey areas with more mixed length cohorts further south (Figure 4).

3.2 Other pelagics

3.2.1 Herring

In total 47 herring (*Clupea harengus*) echotraces were observed during the survey but no trawl samples were taken. The distribution of herring was divided into two areas; northwest of the Aran Islands and southwest of Ireland in the Mizen area. The largest single herring echotrace was observed southwest of Mizen Head and would likely form part of the autumn spawning component of the Celtic Sea stock.

3.2.2 Horse mackerel

Horse mackerel (*Trachurus trachurus*) were encountered in 28% of survey hauls and were most frequently encountered in deeper waters (>80m) and often occurred in catches with boarfish (Table 2).

A total of 247 echotraces were assigned to horse mackerel and 155 were measured and 284 length and weights were recorded. The modal length of horse mackerel was 30.3cm (range 21-37cm) and mean weight was 241g.

Horse mackerel were widely distributed throughout the survey area from the Porcupine Bank to the southern Celtic Sea occurring mainly as low and medium density echotraces spaced over a wide area.

As in previous years stomach contents analysis revealed horse mackerel to be actively feeding on boarfish eggs where the two species were encountered together.

3.2.3 Blue whiting

Blue whiting (*Mircomesistius poutassou*) were widespread throughout the survey occurring in 28% of trawl catches. Acoustically, blue whiting were the most abundant species observed this year and were of the highest density observed so far. The appearance of large numbers of 0-group blue whiting is in line with the recent period of strong recruitment within this stock. High density clusters of echotraces dominated the west coast and shelf edge contours in the Celtic Sea appearing as juvenile 0-group fish and to a lesser extent as mature fish (Figure 5h). High densities were also reported further north during the *Explorer* survey.

A total of 1,144 blue whiting were measured and 574 length and weights were recorded. The modal length occurred at 16.3cm (range 8-29cm) and mean weight was 28g.

3.3 Trawl mounted camera

A camera system was installed in the trawl close to the joining section with the brailer (codend). The system was used as a means to help groundtruth acoustic observations using optics and catch composition against the corresponding trawled echotrace. Camera and lighting specification are detailed in Appendix 2. As this system was being trailed for the first time during the survey it was not deployed until weather conditions were ideal.

Positioning within the trawl was determined and marked out prior to the survey. The camera was installed in the top section of the net on the 120mm mesh line (full mesh) along the central line. The lights (x2) were positioned 50cm behind the camera and 50cm to the side to prevent glare. The camera and lights were positioned looking backwards at the mouth of the brailer. In this position the diameter of the net was in the region of 4.5m tapering to a brailer diameter of 3.7m.

The system was deployed in a total of 6 hauls (Table 2, Figures 7-10) and proved very useful not only for groundtruthing but also as a means of recording behaviour of target species and gear performance. The positioning of the system close to the coded was used as a visual means of determining the composition of the catch that was committed to the brailer and thus would appear in the end sample. The net employed during this survey is a standard commercial trawl and brailer (section 2.3.6) fitted with a 20mm brailer liner for the purposes of the survey.

4 Discussion and conclusions

4.1 Discussion

Overall, the survey can be considered a success with all components of the work program completed as planned with little downtime. Survey design, timing, transect spacing and geographical coverage were maintained in 2014 from 2012 baselines. Area coverage was comparable with 2013 (1% difference) as was transect mileage. The number of survey hauls was lower as a consequence of the lower abundance observed.

The total number of echotraces and acoustic density of those echotraces was lower in 2014 than previous years. Unquantified sonar observations during routine surveying as well as off track investigations in areas targeted during the fishery (specific Banks in the Celtic Sea) indicated that echosounder observations were indeed representative of aggregations present in the wider area. The single highest value echotrace observed in 2014 was in fact larger than the equivalent in 2013, however, echotrace count was down overall. Echotrace identification was considered accurate with over 71% of the total biomass attributed to the 'definitely' category. The higher proportion of 'probably' boarfish this year (c.27%) can be attributed to firstly, the inability to trawl on the Porcupine Bank due to technical issues onboard resulting in all echotraces (n=70) being categorised as 'probably' and secondly the higher proportion of boarfish observed in the northern area (Celtic Explorer) in close proximity to higher density blue whiting echotraces.

Overall, the total stock biomass was 57% lower than at the same time in 2013 while survey effort, geographical coverage and timing remained unchanged. Observed biomass was lower in all areas with the exception of the northern area and this was due to the more northward distribution of the stock than in previous years. The most pronounced change in biomass was noted in the southern area (down by c.200,000t from 2013) which is the largest geographically and has previously contained upwards of 60% of the stock.

The stock was considered to be well contained within the survey area, the northward distribution was bounded by the surveys northern limits and a relatively small amount of biomass was observed along the southern most transect. Information from the IFREMER PELGAS acoustic survey in the Bay of Biscay (May-June) confirms that low abundances of boarfish were observed overall and particularly in northern Biscay (Pierre Pettitgas *pers comm.*).

4.2 Conclusions

Acoustically derived estimates of abundance are used as a relative index of abundance of the stock present within the survey area at the time of surveying. The survey therefore acts as a 'snapshot' of the stock and should not be considered as a measure of absolute stock abundance. The use of an abundance index allows for the percentage change between successive estimates to be tracked over time to reveal trends in stock abundance as the time series develops.

Geographical coverage can now be considered as established for core spawning areas covered during the survey. The more northern distribution of the stock in 2014 was contained within the survey area and information from other acoustic survey (IFREMER Bay of Biscay) supports our observations that no significant amounts of biomass were missed to the south of our survey limit. Real time information from demersal fishermen working in the mid Celtic Sea support our observations of lower numbers of boarfish overall and eastern distribution was considered contained within the survey area as no boarfish were observed on eastern transect legs.

The identification of boarfish echotraces is considered accurate and aided by targeted directed trawling. The high abundance of juvenile blue whiting this year within core boarfish areas, most notably in the west and south, made analysis more difficult due to the large numbers of non boarfish echotraces encountered. However, the acoustic characteristics of the 2 species are distinctly different enough to aid separation using a single acoustic frequency.

The age profile of the stock as determined from trawl samples is comparable to previous years with the bulk of the stock dominated by the oldest fish (15+ years). The 7-10 year old fish remain the next dominate cohort group within the time series thus validating the ability of the survey to capture the age structure of the spawning population.

Overall the 2014 estimate is considered as an accurate reflection of the biomass on the ground during the time of the survey for equal and comparable survey effort. The 2014 estimate is the third point in the current comparable time series and is the third successive survey to record a decrease in boarfish biomass.

4.3 Recommendations

The following recommendations are based on observations made during the survey and are provided as a means of improving future surveys.

- The timing of the survey should continue to be aligned with the northwest herring survey to extend the area coverage in the northern area and ensure northern containment of the stock.
- All efforts should be made to ensure good containment of the stock in the southern region of the survey.
- Continued participation in the annual ICES WGACEGG meeting to facilitate acoustic data and knowledge exchange between participant countries surveying in the Celtic Sea and Bay of Biscay. Namely, Ireland, UK and France.
- It is recommended that the use of optics within the trawl for groundtruthing of echotrace composition be continued and developed where possible for future use.
- To increase the precision of the survey it is recommended that this survey be conducted onboard dedicated research platform with the capacity to collect multi frequency acoustic data.
- It is recommended that supporting hydrographic data is collected to compliment acoustic observations for future surveys. This can best be carried out using a dedicated research platform.

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Table 1. Survey settings and calibration report (38 kHz) for the tow body system (Simrad ER60 echosounder).

Echo Sounder System Calibration

Vessel : F/V Felucca		Date : 11.07.14	
Echo sounder : EK60 Tow Body		Locality : Donegal Bay	
Type of Sphere : CU 64	TS Sphere: -33.50 dB (Corrected for soundvelocity o	Depth(Sea floor) 16 m	

Calibration Version 2.1.0.12

Comments:
Offshore drift calibration. Weather conditions good

Reference Target:

TS	-33.52 dB	Min. Distance	10.0m
TS Deviation	5 dB	Max. Distance	12.5m

Transducer: ES38B Serial No.

Frequency	38000 Hz	Beamtype	Split
Gain	26.03 dB	Two Way Beam Angle	-20.6 dB
Athw. Angle Sens.	21.90	Along. Angle Sens.	21.90
Athw. Beam Angle	7.00 deg	Along. Beam Angle	7.03 deg
Athw. Offset Angle	0.26 deg	Along. Offset Angl	-0.10 deg
SaCorrection	-0.67 dB	Depth	5.00 m

Transceiver: GPT 38 kHz 009072033933 1 ES38B

Pulse Duration	1.024 ms	Sample Interval	0.192 m
Power	2000 W	Receiver Bandwidth	2.43 kHz

Sounder Type:
ER60 Version 2.2.1

TS Detection:

Min. Value	-50.0 dB	Min. Spacing	100 %
Max. Beam Comp.	6.0 dB	Min. Echolength	80 %
Max. Phase Dev.	8.0	Max. Echolength	180 %

Environment:

Absorption Coeff.	9.1 dB/km	Sound Velocity	1506.5 m/s

Beam Model results:

Transducer Gain =	26.28 dB	SaCorrection =	-0.69 dB
Athw. Beam Angle =	6.99 deg	Along. Beam Angle =	7.03 deg
Athw. Offset Angle =	0.10 deg	Along. Offset Angle=	-0.06 deg

Data deviation from beam model:
RMS = 0.15 dB
Max = 0.38 dB No. = 252 Athw. = -3.7 deg Along = 3.1 deg
Min = -0.59 dB No. = 259 Athw. = 4.9 deg Along = -0.9 deg

Data deviation from polynomial model:
RMS = 0.08 dB
Max = 0.24 dB No. = 255 Athw. = 3.5 deg Along = -0.3 deg
Min = -0.21 dB No. = 49 Athw. = 1.0 deg Along = 1.8 deg

Comments :
Flat calm conditions
Wind Force : 2-5 kn. **Wind Direction :** S
Raw Data File: C:\Program files\Simrad\Scientific\EK60\Data\Calibration\BFAS 2014\Tow body
Calibration File: C:\Program files\Simrad\Scientific\EK60\Data\Calibration\BFAS 2014\Tow body

Calibration : Ciaran O'Donnell

Table 2. Catch composition and position of hauls undertaken by the MFV *Felucca* and for the Celtic Explorer.

Felucca

No.	Date	Lat. N	Lon. W	Time	Bottom (m)	Target btm (m)	Bulk Catch (Kg)	Boarfish %	Mackerel %	Herring %	H Mack %	Others^ %
1	13.07.14	52.98	-14.38	09:33	220	120	Foul					
2	15.07.14	53.45	-11.40	15:19	136	60-80	2,000	95.0	1.0		4.0	
3	16.07.14	53.19	-10.43	10:28	100	0-40	2,500	1.0				99.0
4	16.07.14	52.11	-11.66	18:00	162	65	1,500	86.8	3.1		10.1	
5	17.07.14	52.69	-10.74	10:18	130	30-70	4,000					100.0
6	17.07.14	52.45	-10.69	15:22	119	20-70	500					100.0
7	18.07.14	51.95	-11.41	01:54	217	60-80	1,500	49.2	29.8		21.0	
8	18.07.14	51.70	-10.78	17:50	156	15-80	2,500					100.0
9	19.07.14	51.21	-10.43	11:46	159	100	3,500	48.1	4.4		47.5	
10	20.07.14	50.95	-11.14	08:22	190	120	0					
11*	21.07.14	50.45	-8.75	10:08	125	0-15	2,000		12.8		4.0	83.2
12*	22.07.14	49.84	-7.96	18:55	85	15-35	4,500	100.0				
13*	23.07.14	49.95	-10.44	10:29	134	0-40	5,000					100.0
14	24.07.14	49.47	-8.14	11:24	120	0-40	3,000	98.6	1.4			
15*	24.07.14	49.45	-10.55	23:08	144	0-18	7				100.0	
16*	25.07.14	49.21	-10.26	13:28	158	40-60	4,000					100.0
17*	28.07.14	47.93	-7.31	18:28	182	0-30	1,500	100.0				
18	29.07.14	47.42	-6.00	11:37	155	40-70	1,000	100.0				

^ Includes non target pelagic/demersal species and other taxa
*Camera installed in trawl

Table 2. Continued

Celtic Explorer

No.	Date	Lat. N	Lon. W	Time	Bottom (m)	Target btm (m)	Bulk Catch (Kg)	Boarfish %	Mackerel %	Herring %	H Mack %	Others^ %
7	28.06.14	57.71	-9.28	07:19	150	135	88	92.7	4.7	2.3		0.4
11	30.06.14	56.53	-8.94	15:22	148	143	500	95.1	2.9			2.0
19	05.07.14	55.71	-9.24	12:22	137	127	49	99.4				0.6

^ Includes non target pelagic/demersal species and other taxa

Table 3. Age length key compiled from commercial catch and survey samples collected during 2011-2013.

Length (cm)	Age (years) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
7	1														
7.5	1	1													
8		1													
8.5		1	1												
9		1	1												
9.5			1												
10			1												
10.5			2	10	3										
11			1	29	14	2	2								
11.5				9	21	21	18	2	2	1					1
12				4	17	22	38	12	8					1	1
12.5					5	9	42	37	14	6	2		1	1	5
13					2	4	31	28	24	12	6	2	3	2	11
13.5					1	3	26	22	21	14	6	5	4	1	20
14							6	8	18	22	8	3	7	6	30
14.5						1	1	2	3	8	1	6	6	2	19
15							1	1		2	2	2	5	2	19
15.5										2					8
16															1
16.5															1
17															1
17.5															1
18															1
18.5															
19															

Table 4. Boarfish length at age (years) as abundance (millions) and biomass (000's tonnes).

Length (cm)	Age (years) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Abundance (millions)	Biomass (000s t)	Mn wt (g)
4.5																		
5																		
5.5																		
6																		
6.5																		
7																		
7.5																		
8																		
8.5																		
9																		
9.5																		
10			8.8													8.8	0.2	23.9
10.5			4.11	20.6	6.2											30.9	0.9	27.4
11			2.14	62	29.9	4.3	4.3									102.7	3.2	31.3
11.5				10.1	23.5	23.5	20.2	2.2	2.2	1.1						82.9	2.9	35.5
12				5.53	23.5	30.4	52.6	16.6	11.1						1.4	141.1	5.7	40.1
12.5					7.58	13.6	63.7	56.1	21.2	9.1	3.0		1.5	1.5	1.5	178.9	8.1	45.0
13					7.53	15.1	117	105	90.3	45.2	22.6	7.5	11.3	3.8	18.8	444.0	22.4	50.4
13.5					4.07	12.2	102	89.6	85.5	57.0	24.4	20.4	16.3	8.1	44.8	464.2	26.1	56.1
14							38.1	50.8	114	140	50.8	19.0	44.4	6.4	127	590.3	36.8	62.3
14.5						5.78	5.78	11.6	17.3	46.2	5.78	34.7	34.7	34.7	173	369.9	25.5	68.8
15							11.7	11.7		23.3	23.3	23.3	58.3	23.3	221	396.3	30.1	75.8
15.5										10.8				10.8	103	124.1	10.3	83.3
16															109	109.2	10.0	91.2
16.5															19.8	19.8	2.0	99.7
17															30.9	30.9	3.4	108.6
17.5															2.46	2.5	0.3	118.0
18															1.99	1.99	0.25	127.9
18.5																		
19																		
19.5																		
20																		
SSN			12.87	96.1	102	105	415	344	342	332	130	105	166	88.6	855	3,093.5		
SSB			0.336	3.03	3.82	4.65	21.1	18.4	19.1	20.5	7.97	6.86	11.1	6.16	64.6		187.7	
Mn wt (g)			25.9	31.4	37.5	44.3	50.8	53.6	56	61.6	61.4	65.4	66.8	69.6	75.5			
Mn L (cm)			10.5	11.3	11.9	12.6	13.2	13.5	13.7	14.2	14.1	14.5	14.6	14.8	15.2			

Table 5. Boarfish total biomass (000's tonnes) at age (years) by ICES statistical rectangle.

Region	Strata	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
North	37D9	0	0	0	0.1	0.2	0.2	1.4	1.3	1.4	1.5	0.6	0.5	0.9	0.4	4.1	12.4
	38D9	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0.2	0.5
	39E0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	40E0	0	0	0	0	0	0.1	0.5	0.5	0.6	0.8	0.3	0.3	0.5	0.3	3.1	6.9
	41E0	0	0	0	0	0	0	0.2	0.2	0.2	0.3	0.1	0.1	0.2	0.1	1.1	2.5
	42E1	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0.3	0.6
	42E0	0	0	0	0	0	0	0.3	0.3	0.4	0.5	0.2	0.2	0.3	0.2	2.1	4.7
	43E1	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0.2	0.5
	43E0	0	0	0	0	0	0	0.1	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.9	2
	44E0	0	0	0	0	0	0	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.7	1.7
	45E1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0.2
Porc	36D6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0.2
	35D5	0	0	0	0.1	0.1	0.2	1.1	1	0.9	0.9	0.4	0.3	0.5	0.3	2.6	8.4
	35D6	0	0	0	0	0	0	0.1	0.1	0.1	0.1	0	0	0	0	0.3	0.9
	34D5	0	0	0	0	0.1	0.1	0.7	0.6	0.6	0.6	0.2	0.2	0.3	0.2	1.6	5.1
	34D6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	33D5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	33D6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
West	36D8	0	0	0	0.1	0.1	0.1	1	1	1	1.1	0.4	0.4	0.7	0.3	2.9	9
	36D9	0	0	0	0	0	0.1	0.4	0.4	0.4	0.4	0.2	0.2	0.3	0.1	1.2	3.8
	35D7	0	0	0	0	0	0	0.1	0.1	0.1	0.1	0	0	0	0	0.2	0.6
	35D8	0	0	0	0	0.1	0.1	0.5	0.5	0.5	0.5	0.2	0.2	0.3	0.1	1.4	4.4
	35D9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1
	34D7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	34D8	0	0	0	0.2	0.4	0.6	2.9	2.6	2.6	2.6	1	0.9	1.3	0.8	7	22.7
	34D9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	33D8	0	0	0	0.1	0.2	0.3	1.4	1.3	1.3	1.3	0.5	0.4	0.7	0.4	3.8	11.5
	33D9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1
	32D8	0	0	0	0	0.1	0.2	1.3	1.3	1.4	1.6	0.7	0.6	1	0.5	6.5	15.1
	32D9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1
South	31D8	0	0	0	0	0.1	0.1	0.3	0.3	0.3	0.3	0.1	0.1	0.2	0.1	1.3	3.3
	31D9	0	0	0	0.1	0.2	0.2	0.8	0.7	0.7	0.8	0.3	0.3	0.5	0.3	3.3	8.2
	31E0	0	0	0	0	0	0	0.2	0.1	0.1	0.2	0.1	0.1	0.1	0	0.6	1.5
	30D8	0	0	0	0	0.1	0.1	0.4	0.3	0.3	0.4	0.2	0.1	0.2	0.1	1.6	3.9
	30D9	0	0	0	0.1	0.1	0.2	0.6	0.6	0.6	0.7	0.3	0.2	0.4	0.2	2.6	6.5
	30E0	0	0	0	0	0	0	0.1	0.1	0.1	0.1	0	0	0.1	0	0.4	0.9
	30E1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	30E2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	29D8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	29D9	0	0	0	0	0	0	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0	0.6	1.5
	29E0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0.5
	29E1	0	0	0	0.1	0.1	0.1	0.4	0.4	0.4	0.5	0.2	0.1	0.3	0.2	2.1	4.8
	29E2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	28D8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	28D9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0.2
	28E0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	28E1	0	0	0	0.1	0	0.1	0.3	0.2	0.3	0.3	0.1	0.1	0.2	0.1	1.3	3
	28E2	0	0	0	0.1	0.1	0.1	0.6	0.6	0.6	0.7	0.3	0.2	0.4	0.2	3.1	7.1
	27D8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	27D9	0	0	0	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0	0	0	0	0.1	1
	27E0	0	0	0	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0	0	0	0	0.1	0.9
	27E1	0	0	0.1	0.4	0.4	0.3	1	0.7	0.7	0.5	0.2	0.1	0.2	0.1	0.8	5.5
	27E2	0	0	0	0.3	0.3	0.2	0.7	0.5	0.5	0.4	0.2	0.1	0.1	0.1	0.6	3.9
	26D9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	26E0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	26E1	0	0	0	0.2	0.1	0.1	0.4	0.3	0.3	0.2	0.1	0.1	0.1	0	0.3	2.1
	26E2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	26E3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0.2
	25E0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	25E1	0	0	0.1	0.5	0.5	0.4	1.4	1.1	1	1	0.4	0.3	0.5	0.3	2.8	10.4
	25E2	0	0	0	0	0	0	0.1	0	0	0	0	0	0	0	0.1	0.5
	25E3	0	0	0	0	0	0	0.1	0.1	0.1	0.1	0	0	0	0	0.2	0.7
	24E2	0	0	0	0.2	0.2	0.2	0.6	0.4	0.4	0.4	0.2	0.1	0.2	0.1	1.2	4.4
	24E3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0.3
	23E3	0	0	0	0	0	0	0.1	0.1	0.1	0.1	0	0	0	0	0.1	0.6
	23E4	0	0	0	0	0	0.1	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.4	1.8
	Total	0	0	0.4	3.1	3.8	4.6	21.1	18.4	19.1	20.5	8	6.9	11.1	6.2	64.6	187.8
	%	0	0	0.2	1.6	2	2.5	11.2	9.8	10.2	10.9	4.2	3.7	5.9	3.3	34.4	100

Table 6. Boarfish total abundance (millions) at age (years) by ICES statistical rectangle.

Region	Strata	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
North	37D9	0	0	0.2	3.3	3.8	4.6	25.6	23.3	24.1	23.8	10.1	7.6	13.1	5.8	55.2	200.4
	38D9	0	0	0.0	0.1	0.1	0.2	0.9	0.8	0.9	0.9	0.4	0.3	0.5	0.3	2.5	7.7
	39E0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	40E0	0	0	0	0.1	0.7	1.6	8.9	8.7	10.0	12.2	4.4	4.5	6.8	4.2	40.3	102.4
	41E0	0	0	0	0.1	0.3	0.6	3.2	3.1	3.6	4.4	1.6	1.7	2.5	1.5	14.7	37.3
	42E1	0	0	0	0	0.0	0.1	0.6	0.6	0.8	1.1	0.4	0.4	0.6	0.4	3.5	8.5
	42E0	0	0	0	0	0.2	0.7	4.9	5.1	6.4	8.5	3.0	3.3	4.9	3.1	28.1	68.3
	43E1	0	0	0	0	0.0	0.1	0.5	0.6	0.7	0.9	0.3	0.4	0.5	0.3	2.9	7.3
	43E0	0	0	0	0	0.1	0.3	2.2	2.3	2.8	3.7	1.3	1.4	2.1	1.4	11.8	29.4
	44E0	0	0	0	0	0.1	0.3	1.8	1.9	2.4	3.1	1.1	1.2	1.7	1.1	9.8	24.4
	45E1	0	0	0	0	0.0	0.0	0.2	0.2	0.3	0.4	0.1	0.1	0.2	0.1	1.2	2.9
Porc	36D6	0	0	0.002	0.1	0.1	0.1	0.5	0.4	0.4	0.4	0.2	0.1	0.2	0.1	0.9	3.4
	35D5	0	0	0.1	2.2	3.3	4.5	21.1	18.2	17.0	15.5	5.9	5.1	7.2	4.3	35.2	139.6
	35D6	0	0	0.0	0.2	0.3	0.5	2.2	1.9	1.8	1.6	0.6	0.5	0.8	0.4	3.7	14.5
	34D5	0	0	0.0	1.3	2.0	2.7	12.9	11.1	10.3	9.4	3.6	3.1	4.4	2.6	21.4	84.8
	34D6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	33D5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	33D6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
West	36D8	0	0	0.1	2.4	2.8	3.4	18.5	16.8	17.5	17.2	7.3	5.5	9.5	4.2	39.9	145.0
	36D9	0	0	0.1	1.0	1.2	1.4	7.9	7.2	7.4	7.3	3.1	2.3	4.0	1.8	17.0	61.6
	35D7	0	0	0.0	0.2	0.2	0.2	1.3	1.1	1.1	1.1	0.5	0.4	0.6	0.3	2.6	9.5
	35D8	0	0	0.0	1.1	1.6	2.0	10.2	9.0	8.8	8.3	3.3	2.7	4.2	2.2	18.9	72.3
	35D9	0	0	0.0	0.0	0.0	0.0	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.5	1.7
	34D7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	34D8	0	0	0.2	5.8	9.0	12.2	57.2	49.3	46.1	42.0	15.9	13.7	19.6	11.6	95.3	377.8
	34D9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	33D8	0	0	0.1	2.6	4.1	5.7	27.3	23.7	22.6	21.1	8.1	6.9	10.1	5.8	50.9	188.9
	33D9	0	0	0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.0	0.4	1.2
	32D8	0	0	0.0	1.3	2.5	4.1	24.6	22.6	24.6	26.1	10.6	8.4	14.1	7.1	82.4	228.5
	32D9	0	0	0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.0	0.4	1.2
South	31D8	0	0	0.1	1.2	1.7	1.9	6.6	5.2	5.2	5.5	2.1	1.7	2.9	1.5	16.8	52.5
	31D9	0	0	0.2	2.9	4.2	4.8	16.4	13.0	13.0	13.6	5.3	4.3	7.3	3.8	41.9	130.7
	31E0	0	0	0.0	0.5	0.8	0.9	3.0	2.4	2.4	2.5	1.0	0.8	1.4	0.7	7.7	24.2
	30D8	0	0	0.1	1.4	2.0	2.3	7.8	6.2	6.2	6.5	2.5	2.1	3.5	1.8	20.0	62.5
	30D9	0	0	0.1	2.3	3.3	3.8	12.9	10.3	10.3	10.7	4.2	3.4	5.8	3.0	33.2	103.4
	30E0	0	0	0.0	0.3	0.5	0.5	1.8	1.5	1.5	1.5	0.6	0.5	0.8	0.4	4.7	14.6
	30E1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	30E2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	29D8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	29D9	0	0	0.0	0.5	0.8	0.9	2.9	2.3	2.3	2.4	1.0	0.8	1.3	0.7	7.5	23.5
	29E0	0	0	0.0	0.2	0.2	0.3	0.9	0.8	0.8	0.8	0.3	0.2	0.4	0.2	2.5	7.6
	29E1	0	0	1.1	2.9	2.1	1.8	7.9	6.8	7.3	7.8	3.0	2.2	3.8	2.2	26.3	75.2
	29E2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	28D8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	28D9	0	0	0.1	0.3	0.3	0.2	0.6	0.4	0.4	0.4	0.1	0.1	0.2	0.1	0.7	3.9
	28E0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	28E1	0	0	0.7	1.9	1.3	1.2	5.0	4.3	4.6	5.0	1.9	1.4	2.4	1.4	16.7	47.9
	28E2	0	0	1.7	4.4	3.2	2.7	11.7	10.1	10.8	11.7	4.4	3.3	5.7	3.4	39.3	112.4
	27D8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	27D9	0	0	0.5	2.2	1.9	1.4	3.6	2.4	2.2	1.6	0.6	0.4	0.6	0.2	2.1	19.7
	27E0	0	0	0.5	2.2	1.9	1.4	3.5	2.4	2.2	1.6	0.6	0.4	0.6	0.2	2.1	19.5
	27E1	0	0	2.6	12.4	10.8	8.3	20.5	13.6	12.6	9.5	3.7	2.3	3.3	1.4	11.9	112.8
	27E2	0	0	1.9	8.9	7.8	5.9	14.7	9.8	9.1	6.8	2.7	1.6	2.4	1.0	8.5	80.9
	26D9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	26E0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	26E1	0	0	1.0	4.8	4.2	3.2	7.9	5.3	4.9	3.7	1.4	0.9	1.3	0.5	4.6	43.8
	26E2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	26E3	0	0	0.0	0.3	0.2	0.2	0.5	0.4	0.4	0.3	0.1	0.1	0.2	0.1	0.7	3.6
	25E0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	25E1	0	0	2.3	16.5	13.5	10.2	29.4	20.9	19.3	16.7	6.9	4.7	8.1	3.9	38.2	190.4
	25E2	0	0	0.1	0.7	0.6	0.4	1.3	0.9	0.9	0.7	0.3	0.2	0.4	0.2	1.7	8.5
	25E3	0	0	0.2	1.1	0.9	0.7	2.0	1.4	1.3	1.2	0.5	0.3	0.6	0.3	2.7	13.2
	24E2	0	0	0.9	6.8	5.5	4.2	12.2	8.7	8.0	7.0	2.9	2.0	3.4	1.7	16.3	79.6
	24E3	0	0	0.1	0.5	0.4	0.3	1.0	0.7	0.6	0.6	0.2	0.2	0.3	0.1	1.3	6.4
	23E3	0	0	0.0	0.3	0.4	0.5	1.9	1.5	1.4	1.2	0.5	0.3	0.5	0.3	2.1	10.9
	23E4	0	0	0.1	1.0	1.3	1.4	5.5	4.4	4.1	3.6	1.3	1.0	1.5	0.8	6.2	32.1
	Total	0	0	15.0	98.2	102.3	104.9	414.6	343.9	341.9	332.3	129.9	104.9	166.5	88.6	855.2	3098.3
	%	0	0	0.5	3.2	3.3	3.4	13.4	11.1	11.0	10.7	4.2	3.4	5.4	2.9	27.6	100
	Cv (%)	NA	NA	25.7	22.4	18.8	16.9	16.1	16.0	15.5	15.3	15.5	15.2	14.8	14.8	14.4	NA

Table 7. Boarfish biomass (000's tonnes) by maturity by ICES statistical rectangle.

Region	Strata	Imm	Mature	Spent	Total
North	37D9	0	12.4	0	12.4
	38D9	0	0.5	0	0.5
	39E0	0	0	0	0
	40E0	0	6.9	0	6.9
	41E0	0	2.5	0	2.5
	42E1	0	0.6	0	0.6
	42E0	0	4.7	0	4.7
	43E1	0	0.5	0	0.5
	43E0	0	2	0	2
	44E0	0	1.7	0	1.7
	45E1	0	0.2	0	0.2
Porc	36D6	0	0.2	0	0.2
	35D5	0	8.4	0	8.4
	35D6	0	0.9	0	0.9
	34D5	0	5.1	0	5.1
	34D6	0	0	0	0
	33D5	0	0	0	0
	33D6	0	0	0	0
West	36D8	0	9	0	9
	36D9	0	3.8	0	3.8
	35D7	0	0.6	0	0.6
	35D8	0	4.4	0	4.4
	35D9	0	0.1	0	0.1
	34D7	0	0	0	0
	34D8	0	22.7	0	22.7
	34D9	0	0	0	0
	33D8	0	11.5	0	11.5
	33D9	0	0.1	0	0.1
	32D8	0	15.1	0	15.1
	32D9	0	0.1	0	0.1
South	31D8	0	3.3	0	3.3
	31D9	0	8.2	0	8.2
	31E0	0	1.5	0	1.5
	30D8	0	3.9	0	3.9
	30D9	0	6.5	0	6.5
	30E0	0	0.9	0	0.9
	30E1	0	0	0	0
	30E2	0	0	0	0
	29D8	0	0	0	0
	29D9	0	1.5	0	1.5
	29E0	0	0.5	0	0.5
	29E1	0	4.8	0	4.8
	29E2	0	0	0	0
	28D8	0	0	0	0
	28D9	0	0.2	0	0.2
	28E0	0	0	0	0
	28E1	0	3	0	3
	28E2	0	7.1	0	7.1
	27D8	0	0	0	0
	27D9	0	1	0	1
	27E0	0	0.9	0	0.9
	27E1	0	5.5	0	5.5
	27E2	0	3.9	0	3.9
	26D9	0	0	0	0
	26E0	0	0	0	0
	26E1	0	2.1	0	2.1
	26E2	0	0	0	0
	26E3	0	0.2	0	0.2
	25E0	0	0	0	0
	25E1	0	10.4	0	10.4
	25E2	0	0.5	0	0.5
	25E3	0	0.7	0	0.7
	24E2	0.1	4.3	0	4.4
	24E3	0	0.3	0	0.3
	23E3	0	0.6	0	0.6
	23E4	0	1.8	0	1.8
	Total	0.1	187.7	0	187.8
	%	0.1	99.9	0	100

Table 8. Boarfish abundance (millions) by maturity by ICES statistical rectangle.

Region	Strata	Imm	Mature	Spent	Total
North	37D9	0.08	200.36	0	200.44
	38D9	0	7.72	0	7.72
	39E0	0	0	0	0
	40E0	0	102.44	0	102.44
	41E0	0	37.30	0	37.30
	42E1	0	8.47	0	8.47
	42E0	0	68.27	0	68.27
	43E1	0	7.30	0	7.30
	43E0	0	29.44	0	29.44
	44E0	0	24.45	0	24.45
	45E1	0	2.91	0	2.91
Porc	36D6	0	3.42	0	3.42
	35D5	0	139.57	0	139.57
	35D6	0	14.49	0	14.49
	34D5	0	84.81	0	84.81
	34D6	0	0	0	0
	33D5	0	0	0	0
	33D6	0	0	0	0
West	36D8	0.06	144.95	0	145.01
	36D9	0.02	61.61	0	61.63
	35D7	0	9.52	0	9.52
	35D8	0.01	72.27	0	72.29
	35D9	0.00	1.71	0	1.71
	34D7	0	0	0	0
	34D8	0	377.79	0	377.79
	34D9	0	0	0	0
	33D8	0	188.86	0	188.86
	33D9	0	1.22	0	1.22
	32D8	0	228.53	0	228.53
	32D9	0	1.17	0	1.17
South	31D8	0.04	52.46	0	52.50
	31D9	0.09	130.59	0	130.68
	31E0	0.02	24.14	0	24.16
	30D8	0.04	62.43	0	62.47
	30D9	0.07	103.35	0	103.42
	30E0	0.01	14.61	0	14.62
	30E1	0	0	0	0
	30E2	0	0	0	0
	29D8	0	0	0	0
	29D9	0.02	23.52	0	23.54
	29E0	0.01	7.61	0	7.61
	29E1	0.39	74.81	0	75.21
	29E2	0	0	0	0
	28D8	0	0	0	0
	28D9	0.02	3.85	0	3.87
	28E0	0	0	0	0
	28E1	0.25	47.61	0	47.86
	28E2	0.59	111.81	0	112.40
	27D8	0	0	0	0
	27D9	0.13	19.53	0	19.66
	27E0	0.13	19.38	0	19.51
	27E1	0.74	112.07	0	112.81
	27E2	0.53	80.38	0	80.92
	26D9	0	0	0	0
	26E0	0	0	0	0
	26E1	0.29	43.50	0	43.79
	26E2	0	0	0	0
	26E3	0.02	3.57	0	3.58
	25E0	0	0	0	0
	25E1	0.81	189.57	0	190.38
	25E2	0.04	8.42	0	8.45
	25E3	0.06	13.14	0	13.20
	24E2	0.33	79.24	0	79.57
	24E3	0.03	6.36	0	6.39
	23E3	0.01	10.90	0	10.91
	23E4	0.03	32.02	0	32.06
	Total	4.84	3093.45	0.00	3098.30
	%	0.16	99.84	0.00	100.00

Table 9. Boarfish biomass and abundance by ICES statistical rectangle.

Region	Strata	No. transects	No. schools	Def schools	Prob schools	Mix schools	% zeros	Def Biomass	Prob Biomass	Mix Biomass	Biomass (000't)	SSB (000't)	Abundance millions
North	37D9	4	21	1	20	0	25	1	11.4	0	12.4	12.4	200.4
	38D9	4	10	0	10	0	25	0	0.5	0	0.5	0.5	7.7
	39E0	3	0	0	0	0	100	0	0	0	0	0	0
	40E0	4	22	15	7	0	0	6.8	0.2	0	6.9	6.9	102.4
	41E0	3	4	0	4	0	33	0	2.5	0	2.5	2.5	37.3
	42E1	4	14	4	10	0	25	0.2	0.4	0	0.6	0.6	8.5
	42E0	2	14	0	14	0	0	0	4.7	0	4.7	4.7	68.3
	43E1	1	5	0	5	0	0	0	0.5	0	0.5	0.5	7.3
	43E0	2	15	0	15	0	0	0	2	0	2	2	29.4
	44E0	2	15	11	4	0	0	1.5	0.2	0	1.7	1.7	24.4
	45E1	1	4	0	4	0	0	0	0.2	0	0.2	0.2	2.9
Porc	36D6	1	3	0	3	0	0	0	0.2	0	0.2	0.2	3.4
	35D5	2	39	0	39	0	0	0	8.4	0	8.4	8.4	139.6
	35D6	2	8	0	8	0	0	0	0.9	0	0.9	0.9	14.5
	34D5	2	20	0	20	0	0	0	5.1	0	5.1	5.1	84.8
	34D6	2	0	0	0	0	100	0	0	0	0	0	0
	33D5	1	0	0	0	0	100	0	0	0	0	0	0
	33D6	1	0	0	0	0	100	0	0	0	0	0	0
West	36D8	3	31	18	13	0	0	2.5	6.5	0	9	9	145.0
	36D9	3	16	0	16	0	33	0	3.8	0	3.8	3.8	61.6
	35D7	2	4	4	0	0	50	0.6	0	0	0.6	0.6	9.5
	35D8	2	26	26	0	0	0	4.4	0	0	4.4	4.4	72.3
	35D9	2	2	2	0	0	0	0.1	0	0	0.1	0.1	1.7
	34D7	2	0	0	0	0	100	0	0	0	0	0	0
	34D8	2	41	41	0	0	0	22.7	0	0	22.7	22.7	377.8
	34D9	2	0	0	0	0	100	0	0	0	0	0	0
	33D8	2	21	19	2	0	0	11.4	0.1	0	11.5	11.5	188.9
	33D9	2	1	1	0	0	50	0.1	0	0	0.1	0.1	1.2
	32D8	2	36	36	0	0	0	15.1	0	0	15.1	15.1	228.5
	32D9	2	3	3	0	0	50	0.1	0	0	0.1	0.1	1.2
South	31D8	2	15	15	0	0	0	3.3	0	0	3.3	3.3	52.5
	31D9	2	15	14	0	1	50	5.6	0	2.6	8.2	8.2	130.7
	31E0	1	13	13	0	0	0	1.5	0	0	1.5	1.5	24.2
	30D8	1	9	9	0	0	0	3.9	0	0	3.9	3.9	62.5
	30D9	2	21	21	0	0	0	6.5	0	0	6.5	6.5	103.4
	30E0	2	5	5	0	0	50	0.9	0	0	0.9	0.9	14.6
	30E1	1	0	0	0	0	100	0	0	0	0	0	0
	30E2	1	0	0	0	0	100	0	0	0	0	0	0
	29D8	2	0	0	0	0	100	0	0	0	0	0	0
	29D9	2	1	1	0	0	50	1.5	0	0	1.5	1.5	23.5
	29E0	2	4	4	0	0	0	0.5	0	0	0.5	0.5	7.6
	29E1	2	11	11	0	0	50	4.8	0	0	4.8	4.8	75.2
	29E2	2	0	0	0	0	100	0	0	0	0	0	0
	28D8	1	0	0	0	0	100	0	0	0	0	0	0
	28D9	2	2	2	0	0	50	0.2	0	0	0.2	0.2	3.9
	28E0	2	0	0	0	0	100	0	0	0	0	0	0
	28E1	2	16	15	1	0	0	2.9	0.1	0	3	3	47.9
	28E2	2	9	8	1	0	0	6.5	0.7	0	7.1	7.1	112.4
	27D8	2	0	0	0	0	100	0	0	0	0	0	0
	27D9	2	2	2	0	0	50	1	0	0	1	1	19.7
	27E0	2	6	6	0	0	0	1	0	0	1	0.9	19.5
	27E1	2	27	27	0	0	0	5.5	0	0	5.5	5.5	112.8
	27E2	2	10	10	0	0	0	3.9	0	0	3.9	3.9	80.9
	26D9	2	0	0	0	0	100	0	0	0	0	0	0
	26E0	2	0	0	0	0	100	0	0	0	0	0	0
	26E1	2	14	14	0	0	50	2.1	0	0	2.1	2.1	43.8
	26E2	2	0	0	0	0	100	0	0	0	0	0	0
	26E3	1	2	2	0	0	0	0.2	0	0	0.2	0.2	3.6
	25E0	1	0	0	0	0	100	0	0	0	0	0	0
	25E1	2	14	8	6	0	0	7.7	2.7	0	10.4	10.4	190.4
	25E2	2	6	1	5	0	0	0	0.4	0	0.5	0.5	8.5
	25E3	2	4	4	0	0	0	0.7	0	0	0.7	0.7	13.2
	24E2	2	15	15	0	0	0	4.4	0	0	4.4	4.3	79.6
	24E3	2	4	4	0	0	0	0.4	0	0	0.4	0.3	6.4
	23E3	1	6	6	0	0	0	0.6	0	0	0.6	0.6	10.9
	23E4	1	5	5	0	0	0	1.8	0	0	1.8	1.8	32.1
	Total	130	611	403	207	1	34	133.7	51.5	2.6	187.8	187.7	3098.3
	CV (%)	-	-	-	-	-	-	-	-	-	15.1	NA	15.1

Table 10. Boarfish survey time series, updated with new TS-Length relationship.

Age (Yrs)	2011	2012	2013	2014
0	-	-	-	-
1	4.9	21.5	-	-
2	11.3	10.8	78.0	-
3	54.2	174.1	1,842.9	15.0
4	176.0	64.8	696.4	98.2
5	404.7	95.0	381.6	102.3
6	1,068.0	736.1	253.8	104.9
7	1,052.0	973.8	1,056.6	414.6
8	632.5	758.9	879.4	343.8
9	946.1	848.6	800.9	341.9
10	831.8	955.9	703.8	332.3
11	259.7	650.9	263.7	129.9
12	457.2	1,099.7	202.9	104.9
13	281.7	857.2	296.6	166.4
14	257.2	655.8	169.8	88.5
15+	1,746.0	6,353.7	1,464.3	855.1
TSN (mil)	8,183	14,257	9,091	3,098
TSB ('000t)	456,115	863,446	439,890	187,779
SSB ('000t)	455,375	861,544	423,158	187,654
CV	17.5	10.6	17.5	15.1

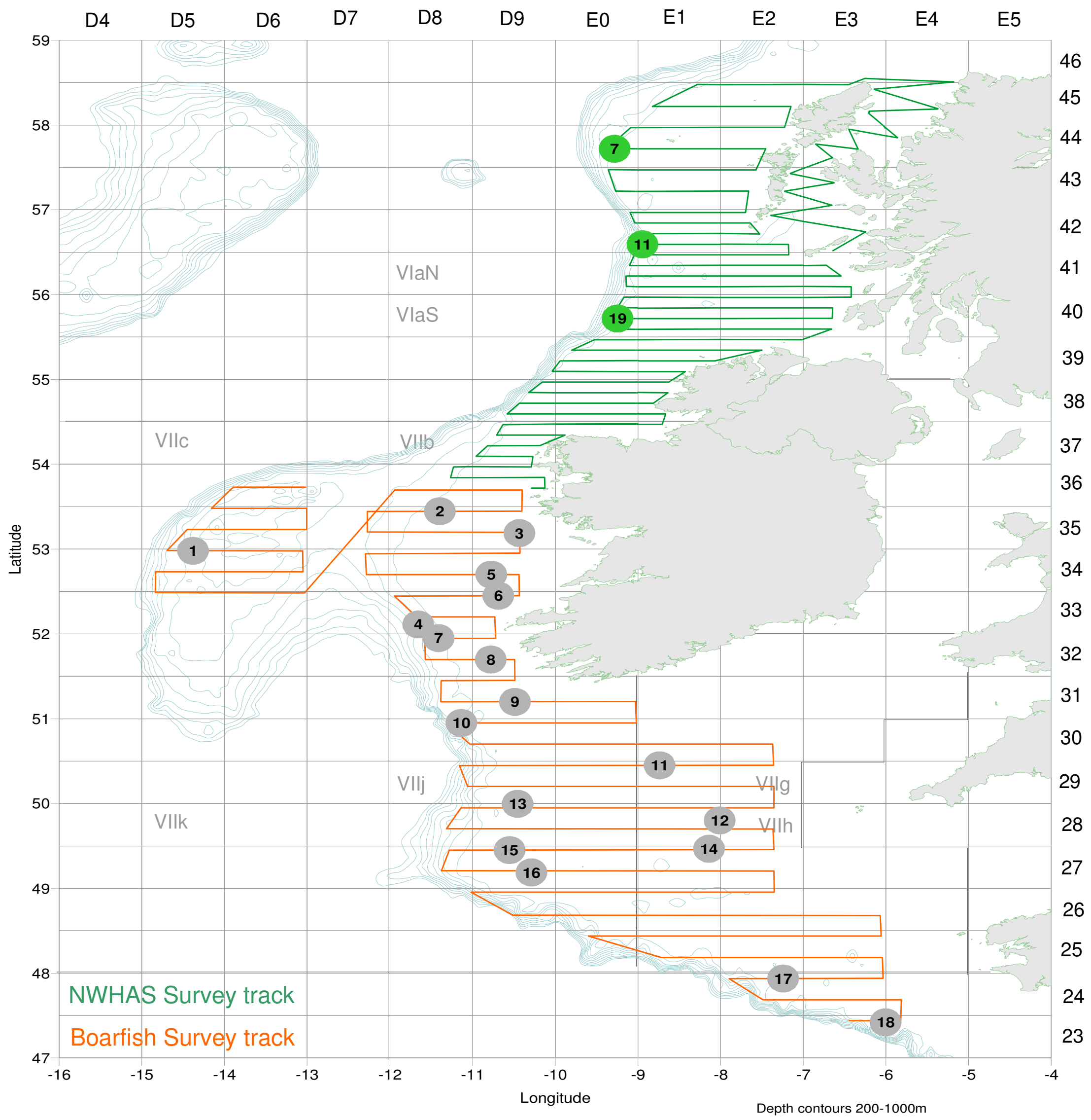


Figure 1. Cruise tracks and haul positions for the FV *Felucca* (orange) and RV *Celtic Explorer* (green) that contained boarfish.

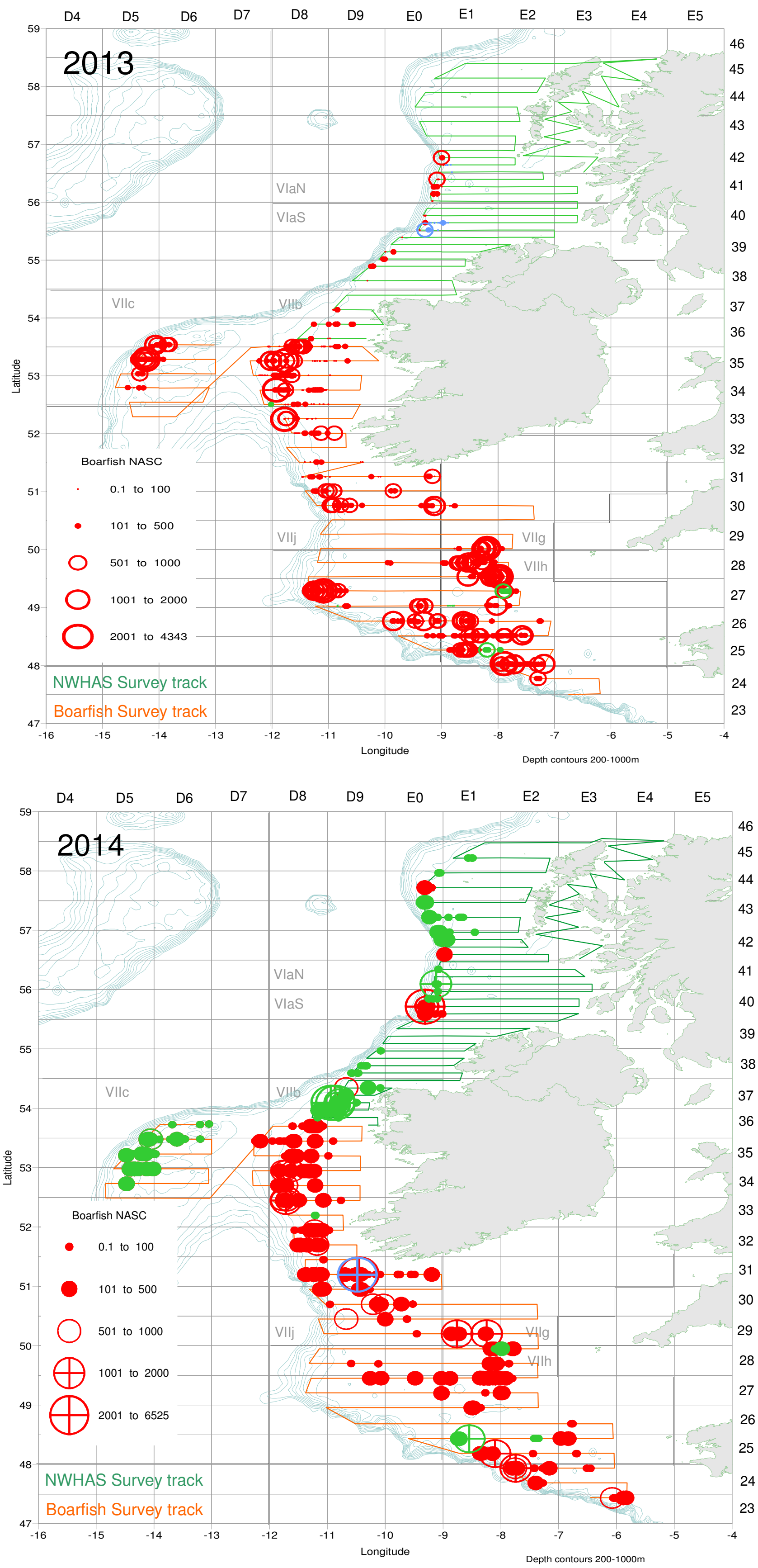


Figure 2. NASC plot of boarfish distribution. Circle size proportional to NASC value. Red circles represent 'definitely' boarfish, green; 'probably boarfish' and blue; 'boarfish mix'.

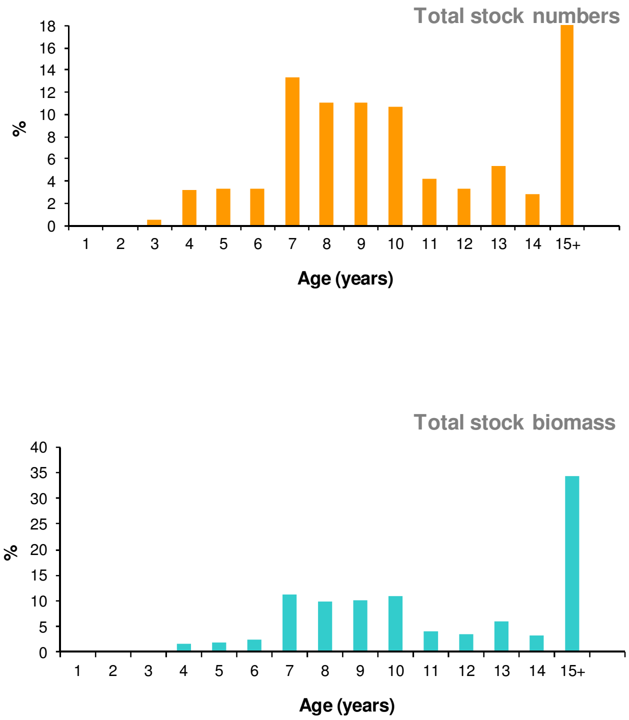
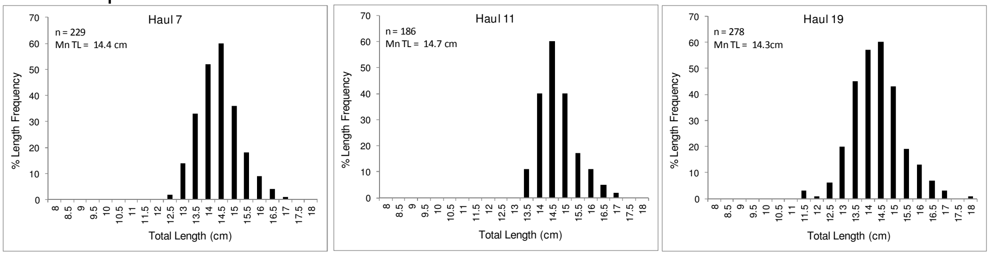


Figure 3. Percentage breakdown of total stock numbers (top) and total stock biomass (bottom) of survey stock.

Celtic Explorer Hauls



Felucca Hauls

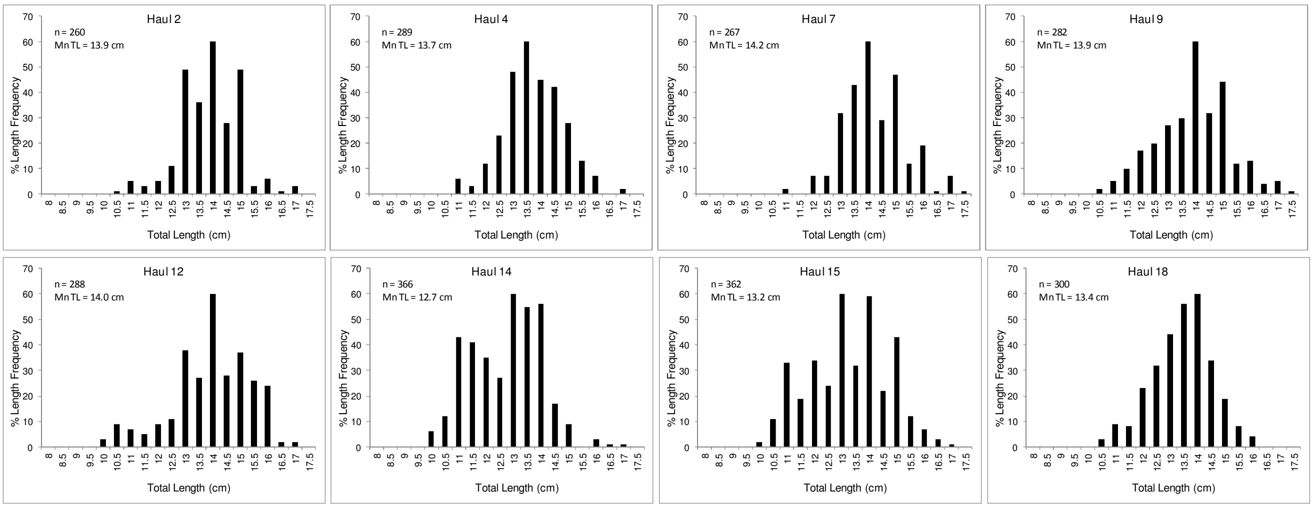
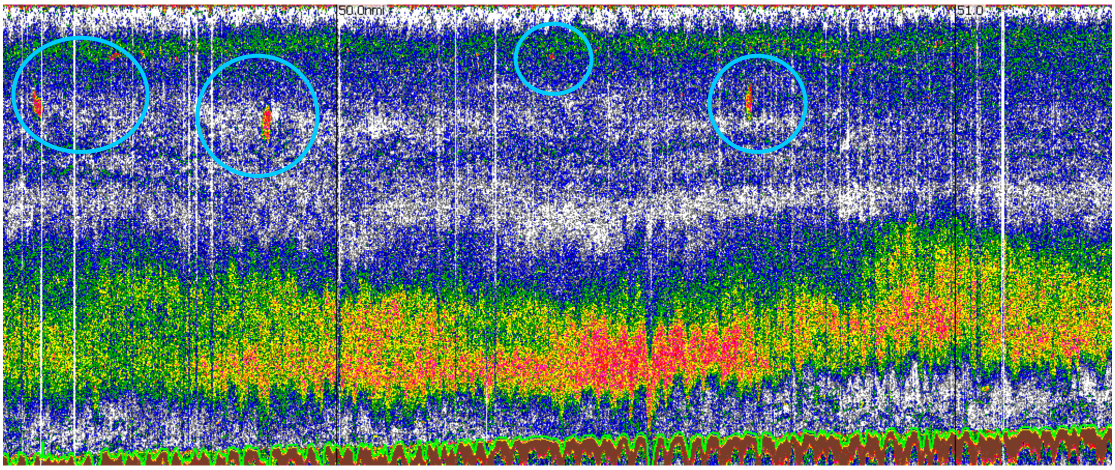
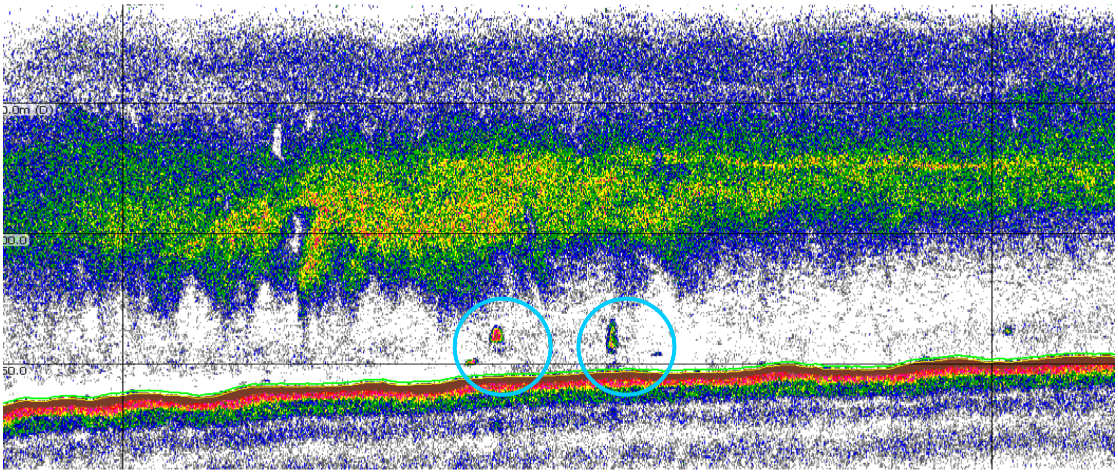


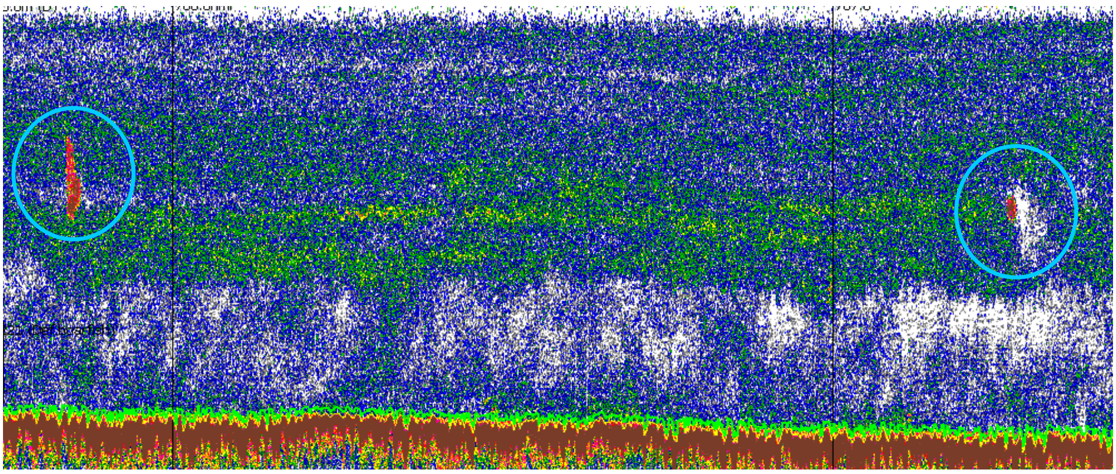
Figure 4. Mean length and length distribution of boarfish by haul.



a). Highest density boarfish echotraces (circled) observed to the west of the **Porcupine Bank**. Bottom depth is 220m with boarfish at 40-60m below the surface.

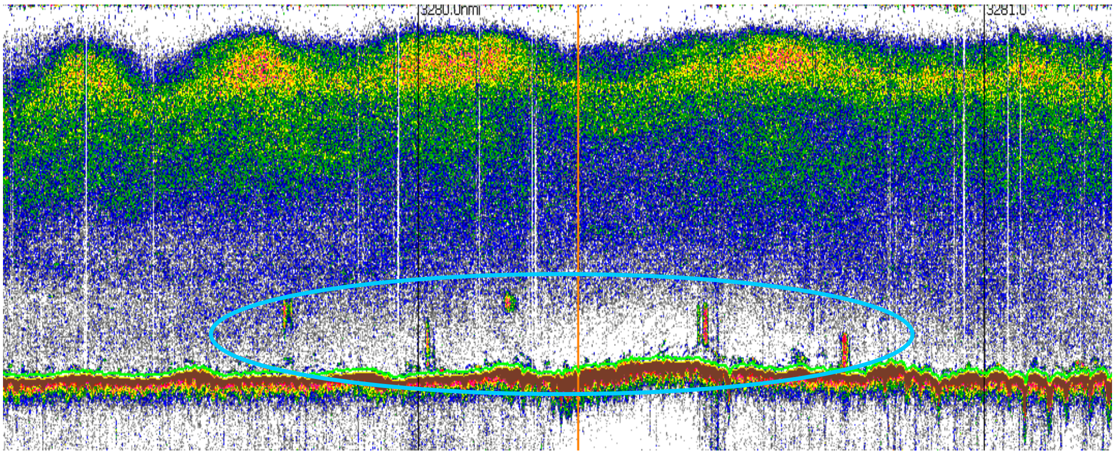


b). Boarfish echotraces from **northern area** at 57°30N recorded prior to Haul 07 by the *Celtic Explorer.* Bottom depth is 150m with targets at 0-20m.

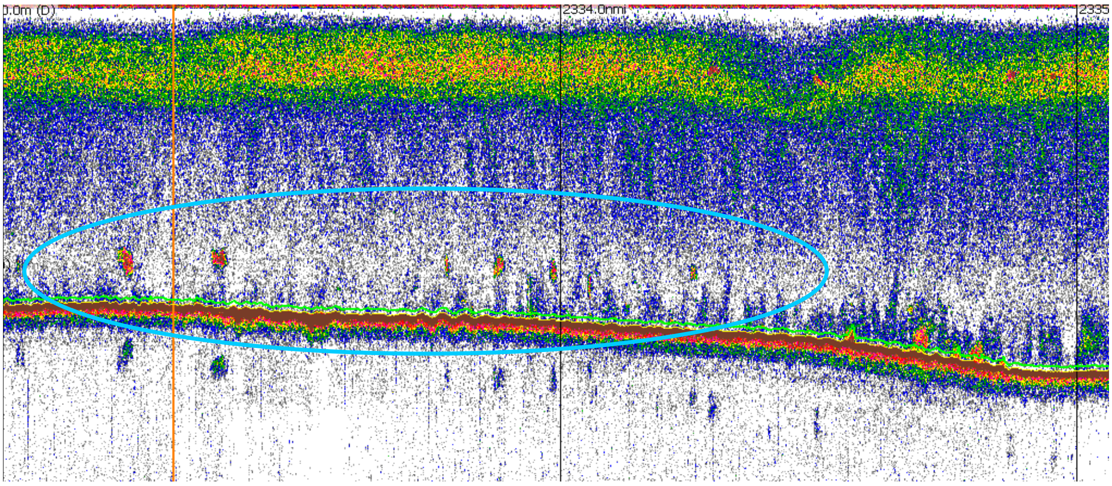


c). High density midwater boarfish schools (circled) typical of those encountered in the **western area** (51°-54°N). Recorded prior to Haul 03. Bottom depth is 150m with target schools at 40-60m.

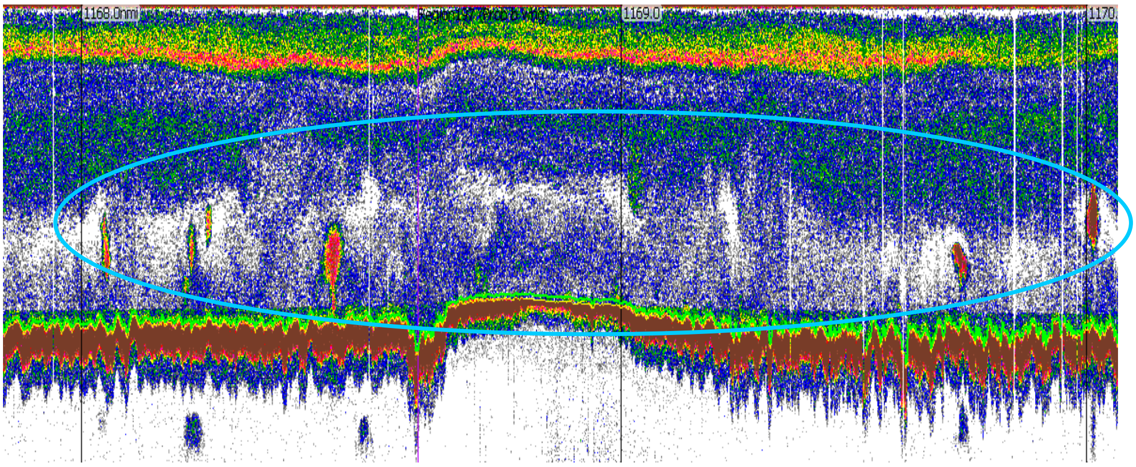
Figures 5a-h. Echotraces recorded at 38 kHz. Note: vertical bands on echograms represent 1nmi (nautical mile) sampling intervals.



d). Medium density boarfish echotraces recorded prior to Haul 16 located close to the shelf edge in the **southern area**. Bottom depth is 182m with targets extending from 0-30m off the bottom.

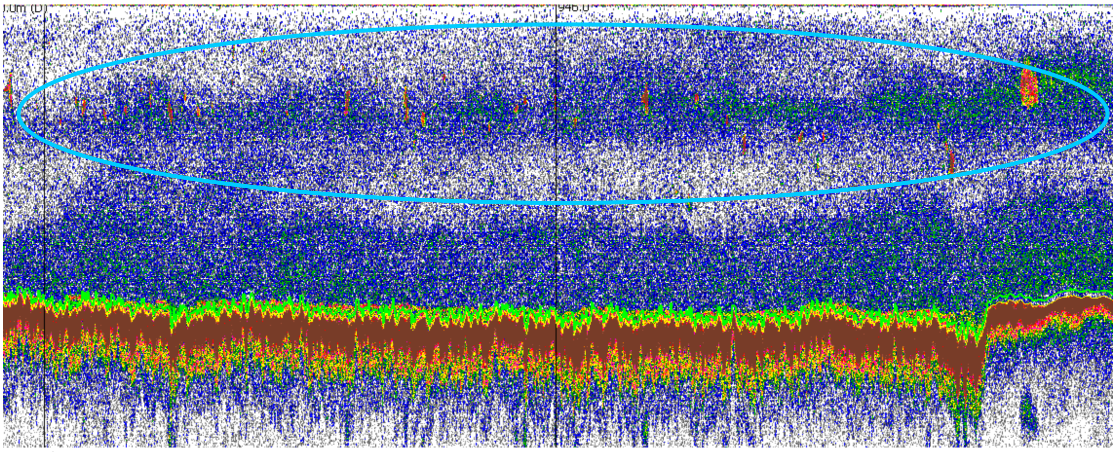


e). High density **off** bottom echotraces of boarfish typical of those encountered on the Banks in the east of the **southern area** (south of 50°N and east of 09ºW). Echogram recorded prior to Haul 13. Bottom depth is 120m with targets extending from 15-25m off the bottom.

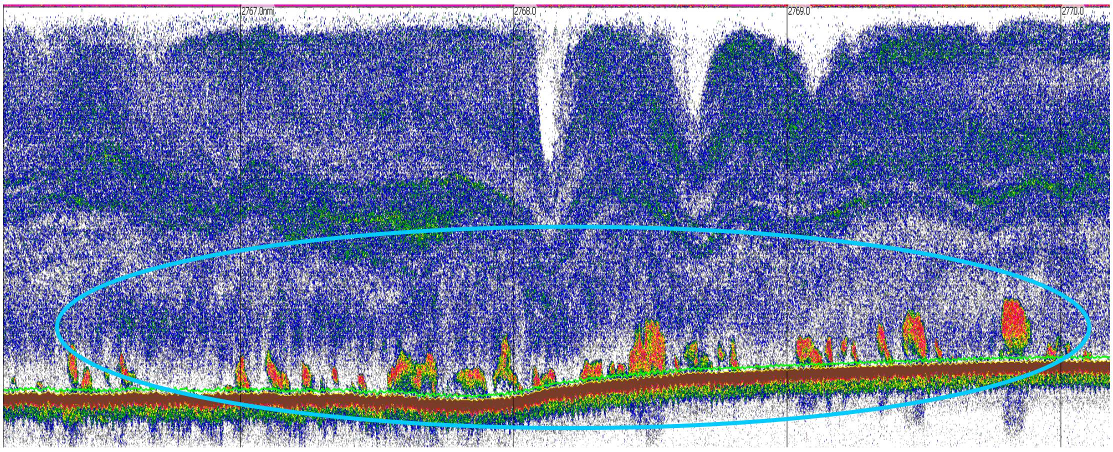


f). High density aggregations of juvenile 0-group blue whiting, recorded in the western area prior to Haul 07. Bottom depth is 70m with targets extending from 0-35m off the bottom.

Figures 5a-h. continued.



g). Surface aggregations of juvenile sprat recorded in the western area prior to Haul 05. Bottom depth is 115m with sprat occurring between 20-40m below the surface.



h). High-density aggregations of 0-group juvenile blue whiting as commonly observed in the southern region within a range of 20nmi from the shelf edge. Mark intensity and size typical of those encountered from 50º-48ºN.

Figures 5a-h. continued.

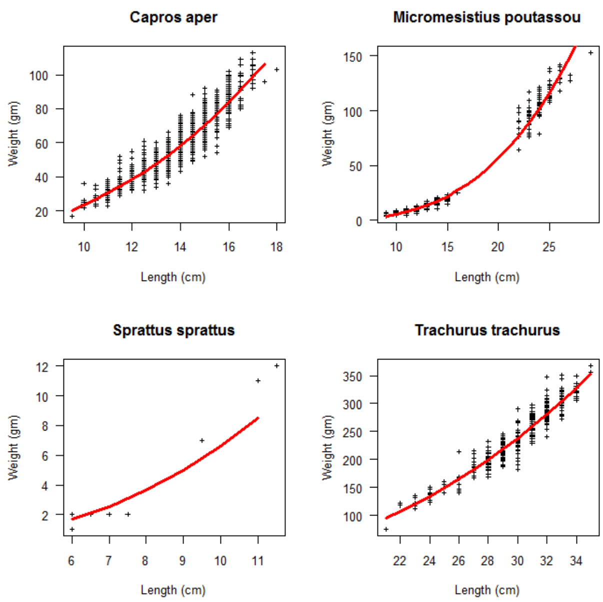


Figure 6. Length weight plots of major trawl component species.

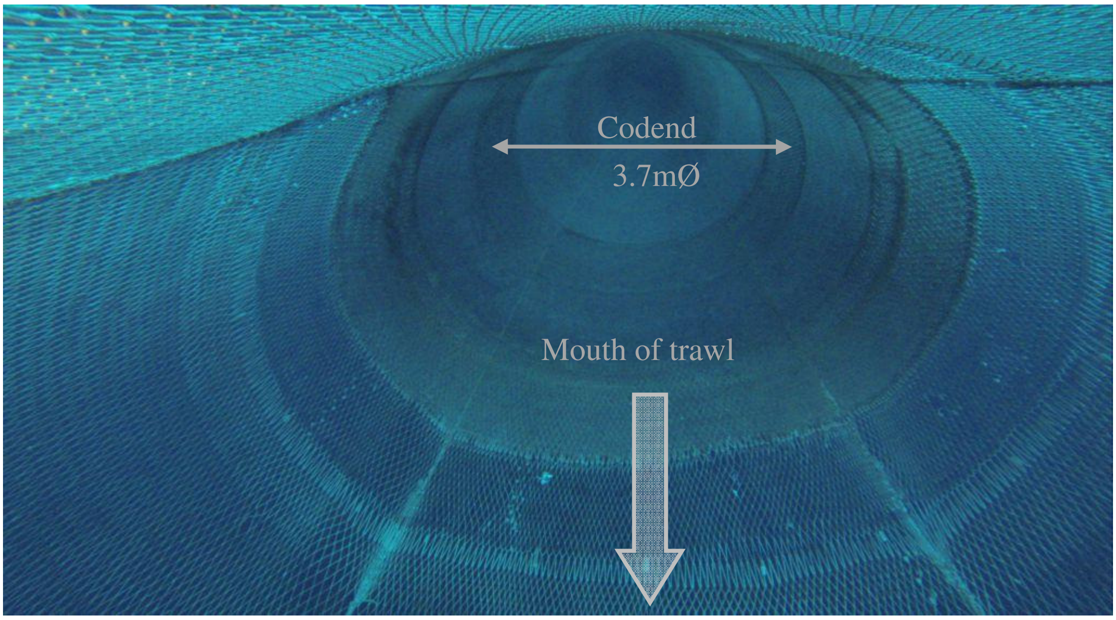


Figure 7. Unobstructed view of 4 panel single midwater trawl with standardised camera positioning.

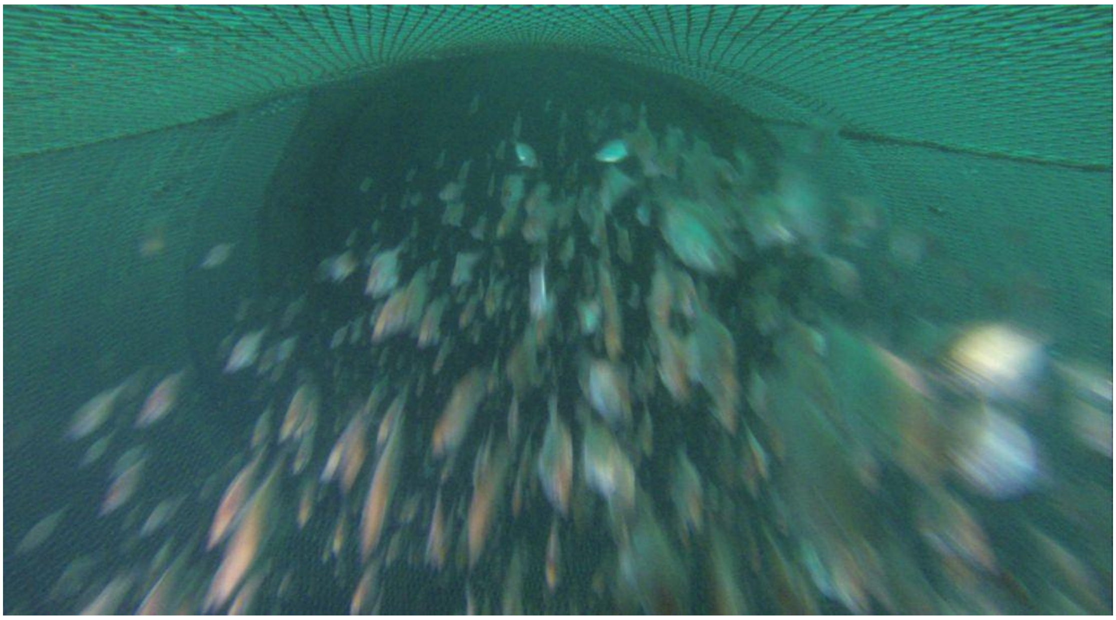


Figure 8. Haul 11. Catch 4.5t of 100% boarfish sampled within 45m of the bottom with a water depth of 85m. High plankton density in localised area resulted in a green hue to images.

Figure 9. Haul 12. Catch 5t of 100% juvenile blue whiting sampled within 45m of the bottom with a water depth of 134m.

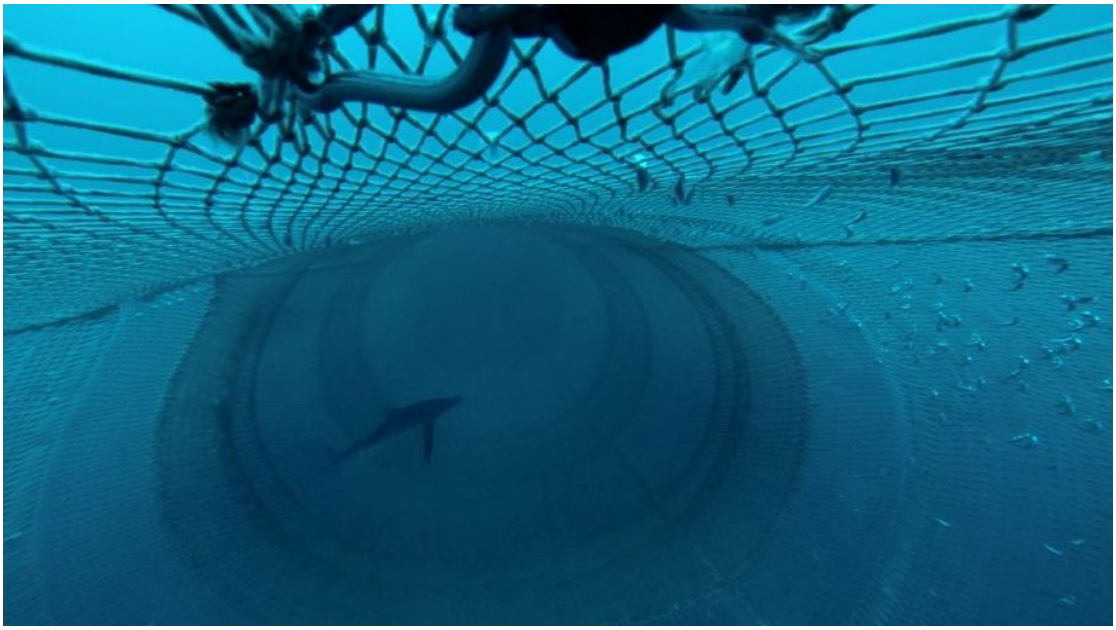


Figure 10. Haul 16. Blue shark (*Prionace glauca)* bycatch from catch of 4t of juvenile blue whiting (99%) and mackerel (1%) sampled within 45m of the bottom, water depth of 120m.

Appendix 1

Details of the charter vessel and tow body set up used during the survey.

Figure 1. FV *Felucca* (SO 108). 54m LOA

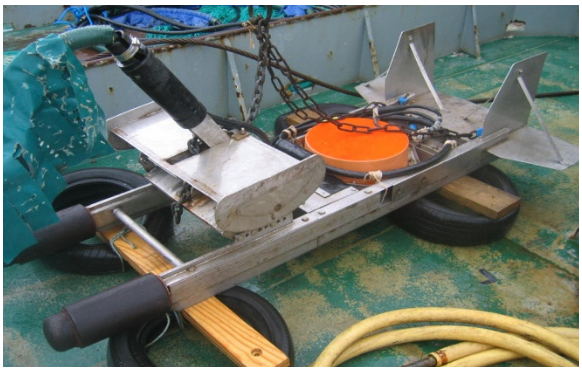


Figure 2. Tow sled with 38 kHz split beam transducer (orange centre screen).

Figure 3. Towing boom c.3m long, with support stays.

Figure 4. Top side monitoring station located on the bridge. Laptop (left) running Echoview and EK60 topside PC unit (right).

Appendix 2

Details of the in-trawl camera rig and positioning within the trawl.

The camera is a GoPro Hero 3+ black edition (www.gopro.com)
The camera allows a wide range of settings for stills and video capture. Details of settings are provided in the GoPro user manual (GoPro User Manual).

The camera housing
The camera housing is certified to a depth of 2,750m and is milled from a single block of anodised 6061 aircraft grade aluminium. The housing weighs 497 gr. The dimensions are: Length 8.3cm, Width 6.5cm, Height 5.4cm.

Light source
Light is provided by two modified Nautilux dive torches with an output of 2000 lumens. Modification increased the beam width to 120º from a narrow original spec. The torches have 3 constant light settings: High (2000 lumens), Medium (1400 Lumens), Low (600 Lumens). The high setting was used during the survey and provided c.2.5 hours of light more than enough for our needs. The light colour is neutral white at 4000K and provided by 3 x Cree XML LEDS.

Light housing
Lights were housed within two aluminium canisters depth rated to 1,250m.The outside dimensions of the cylindrical canister are 18cm long 18cm with a diameter of 7.6cm.

Mounting plates
Mounting plates were fabricated using polyethylene backing plates and strengthened using 316 grade stainless steel flat bar supports. A protective roll cage was constructed to protect the units during shooting and hauling. Both the camera and lights were attached to the mounting plates using adjustable angle mounts to fine tun field of view and illumination.

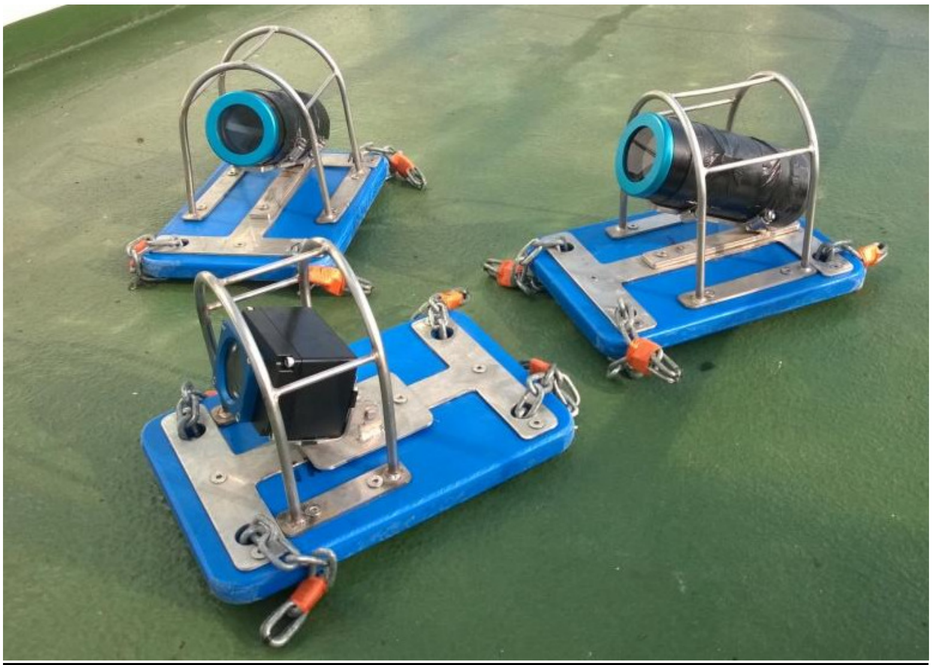


Figure 1 Camera (bottom) and lights on mounting plates.

Mounting within the trawl
Positioning of the camera was determined prior to the survey and marked out to allow ease of installation at sea. The rig was installed in the top of the net with the camera positioned along the mid line at a distance of 6m from the entrance to the brailer. The lights were positioned at 0.5m behind the camera and 0.5m to either side. This positioning allowed the entire net circle

within the field of view. Camera and lights were positioned facing backwards towards the brailer.

Mounting plates were installed upside down within the trawl through pre-cut holes and secured using screw lock clips to fixed mounting points. The rig was installed and removed for each trawl haul.

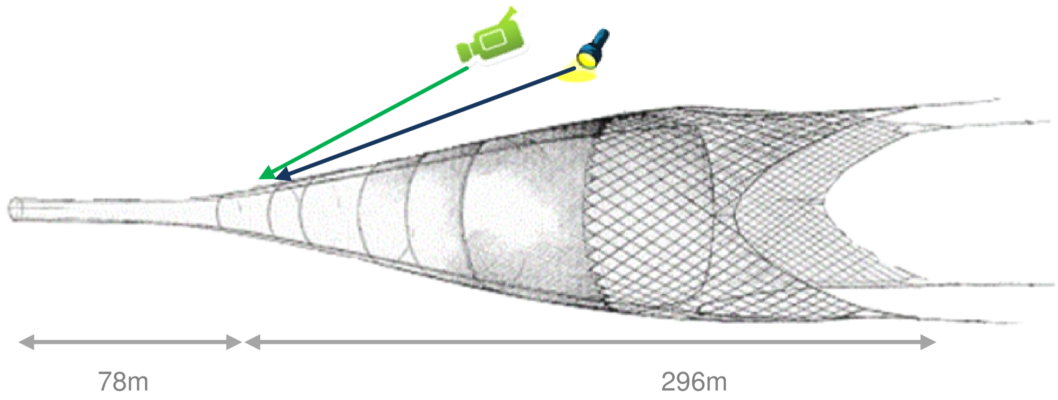


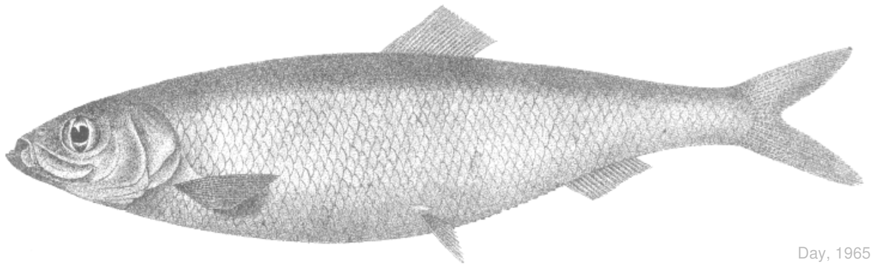
Figure 2 Schematic of pelagic trawl and positioning of camera and light rig. Rig was positioned on the top sheet (60mm half mesh) facing the mouth of the brailer. Net has a fishing circle of 1,050m with a vertical opening of c.50m.

<u>Data collection</u>
Continuous video and still shots (5 sec intervals) were recorded for each for the duration of each haul and recorded onto a MicroSD card within the camera. Viewing was carried out post trawl using Microsoft office software.

FSS Survey Series: 2014/04

Celtic Sea Herring Acoustic Survey Cruise Report 2014

06 - 26 October, 2014


Day, 1965

Cormac Nolan[1], Ciaran O'Donnell[1], Deirdre Lynch[1], Kieran Lyons[2], Niall Keogh[3], Stephen McAvoy[3], Ciaran Cronin[4] and William Hunt[5]

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Fisheries Ecosystems Advisory Services

Table of Contents

1 Introduction

In the southwest of Ireland and the Celtic Sea (ICES Divisions VIIaS, g & j), herring are an important commercial species to the pelagic and polyvalent fleet. The local fleet is composed of dry hold polyvalent vessels and a smaller number of large purpose built refrigerated seawater vessels (RSW). The stock is composed of both autumn and winter spawning components with the latter dominating. The fishery targets pre-spawning and spawning aggregations in Q3-4. The Irish commercial fishery has historically taken place within 1-20nmi (nautical miles) of the coast. Since the mid 2000s RSW fleet have actively targeted offshore aggregations migrating from summer feeding in the south Celtic Sea. In VIIj, the fishery traditionally begins in mid September and is concentrated within several miles of the coast. The VIIaS fishery peaks towards the year end in December, but may be active from mid October depending on location. In VIIg, along the south coast herring are targeted from October to January at a number of known spawning sites and surrounding areas. Overall, the protracted spawning period of the two components extends from October through to January, with annual variation of up to 3 weeks. Spawning occurs in successive waves in a number of well known locations including large scale grounds and small discreet spawning beds. Since 2008 ICES division VIIaS (spawning box C) has been closed to fishing for vessels over 15m to protect first time spawners. For those vessels less than 15m a small allocation of the quota is given to this ‘sentinel’ fishery operating within the closed area.

The stock structure and discrimination of herring in this area has been investigated recently. Hatfield et al. (2007) has shown the Celtic Sea stock to be fairly discrete. However, it is known that fish in the eastern Celtic Sea recruit from nursery areas in the Irish Sea, returning to the Celtic Sea as young adults (Brophy et al. 2002; Molloy et al., 1993). The stock identity of VIIj herring is less clear, though there is evidence that they have linkages with VIIb and VIaS (ICES, 1994; Grainger, 1978). Molloy (1968) identified possible linkages between young fish in VIIj and those of the Celtic Sea herring. For the purpose of stock assessment and management divisions VIIaS, VIIg and VIIj have been combined since 1982.

For a period in the 1970s and1980s, larval surveys were conducted for herring in this area. However, since 1989, acoustic surveys have been carried out, and currently are the only tuning indices available for this stock. In the Celtic Sea and VIIj, herring acoustic surveys have been carried out since 1989, and this survey is the 21st in the overall acoustic series or the eighth in the modified time series conducted exclusively in October.

The geographical confines of the annual 21 day survey have been modified in recent years to include areas to the south of the main winter spawning grounds in an effort to identify the whereabouts of winter spawning fish before the annual inshore spawning migration. Spatial resolution of acoustic transects has been increased over the entire south coast survey area. The acoustic component of the survey has been further complemented since 2004 by detailed hydrographic, marine mammal and seabird surveys.

2 Materials and Methods

2.1 Scientific Personnel

Organisation	Name	Capacity	Leg
FEAS	Cormac Nolan	Aco (SIC)	All
FEAS	Graham Johnston	Aco	All
FEAS	Andrew Campbell	Aco	1
FEAS	Meadhbh Moriarty	Aco	2
FEAS	Turloch Smith	Aco	All
FEAS	Macdara O'Cuaig	Bio	All
FEAS	Robert Bunn	Bio	All
FEAS	Mairead Sullivan	Bio	1
FEAS	Tobi Rapp	Bio	1
FEAS	John Enright	Bio	2
FEAS	Grainne Ni Choncuir	Bio	2
BWI	Niall Keogh	SBO	All
BWI	Stephen McAvoy	SBO	All
BWI	Katherine Keogan	SBO	1
NPWS	Ciaran Cronin	MMO	All
IWDG	William Hunt	MMO	All
IS&W FPO	John Regan	Industry Rep	All

*SBO- Seabird observer, MMO- marine mammal observer

2.2 Survey Plan

2.2.1 Survey objectives

The primary survey objectives are listed below:

- Carry out a pre-determined survey cruise track
- Determine an age stratified estimate of relative abundance of herring within the survey area (ICES Divisions VIIj, VIIg and VIIaS)
- Collect biological samples from directed trawling on insonified fish echotraces to determine age structure and maturity state of the herring stock
- Determine estimates of biomass and abundance for other small pelagic species within the survey area
- Collect physical oceanography data from vertical profiles from a deployed sensor array.
- Survey by visual observations marine mammal and seabird abundance and distribution (ESAS-European Seabirds At Sea methodology) during the survey
- Sighting survey for marine surface litter

2.2.2 Area of operation

The autumn 2014 survey covered the area from Loop Head in ICES Division VIIb (Figure 1) in Co. Clare and extended south along the western seaboard covering the main bays and inlets in Divisions VIIj & VIIg. The survey started in the southwest and worked in an easterly direction covering offshore strata and then working east to west along the coast.

The survey was broken into 2 main components (Table 1). The first, a broad scale survey, was carried out to contain the stock within the survey confines and was based on the distribution of herring from previous years. A broad scale survey composed of 9 strata formed the boundary component of the survey. Broad scale outer lying areas are important transit areas for herring migrating to inshore spawning areas and from offshore summer feeding grounds. The second component focused exclusively on known spawning areas and was made up of 8 strata.

2.2.3 Survey design

A parallel transect design was used with transects running perpendicular to the coastline and lines of bathymetry where possible. Offshore extension reached up to 70nmi (nautical miles). Transect resolution was set at between 2-4nmi for the broad scale survey and increased to 1nmi for the spawning ground surveys. Bay areas were surveyed using a zigzag transect approach to maximise area coverage. Transect start points within each stratum are randomised each year within established baseline stratum bounds.

In total the combined survey accounted for 3,108nmi; with approximately 2, 623nmi of integrateable acoustic transect available (Table 1).

2.3 Equipment and system details and specifications

2.3.1 Acoustic array

Equipment settings for the acoustic equipment were determined before the start of the survey program and were based on established settings employed by FEAS on previous surveys (O'Donnell *et al.,* 2004). The acoustic settings for the EK60 38 kHz transducer are shown in Table 2.

Acoustic data were collected using the Simrad EK60 scientific echosounder. The Simrad split-beam transducers are mounted within the vessel's drop keel and lowered to the working depth of 3.3m below the vessel's hull or 8.8m sub surface. Four operating frequencies were used during the survey (18, 38, 120 and 200 kHz) for trace recognition purposes, with the 38 kHz data used to generate the abundance estimate.

While on survey track the vessel is normally propelled using DC twin electric motor propulsion system with power supplied from 1 main diesel engine, so in effect providing "silent cruising" as compared to normal operations (Anon, 2002). During fishing operations normal two-engine operations were employed to provide sufficient power to tow the net.

2.3.2 Calibration of acoustic equipment

Calibration of the EK60 was carried out in Galway Bay on the 7th of October during hours of daylight. Only 2 frequencies (18 & 38 kHz) were calibrated.

2.4 Survey protocols

2.4.1 Acoustic data acquisition

Acoustic data were observed and recorded onto the hard-drive of the processing unit using the equipment settings from previous surveys (Table 2). The “RAW files” were logged via a continuous Ethernet connection to the vessels server and the ER60 hard drive as a backup in the event of data loss. In addition, as a further back up a hard copy was stored on an external hard drive. Myriax Echoview® Echolog (Version 5) live viewer was used to display the echogram during data collection to allow the scientists to scroll through echograms noting the locations and depths of fish shoals. A member of the scientific crew monitored the equipment continually. Time and location (GPS position) data was recorded for each transect within each strata. This log was used to monitor the time spent off track during fishing operations and hydrographic stations plus any other important observations.

2.4.2 Echogram scrutinisation

Acoustic data was backed up every 24 hrs and scrutinised using Echoview® (V 5) post processing software. Partitioning of data into the categories shown below was largely subjective and was viewed by a scientist experienced in viewing echograms.

The NASC (Nautical Area Scattering Coefficient) values from each herring region were allocated to one of 4 categories after inspection of the echograms. Categories identified on the basis of trace recognition were as follows:

1. “Definitely herring” echo-traces or traces were identified on the basis of captures of herring from the fishing trawls which had sampled the echo-traces directly, and on large marks which had the characteristics of “definite” herring traces (i.e. very high intensity (red), narrow inverted tear-shaped marks either directly on the bottom or in mid-water and in the case of spawning shoals very dense aggregations in close proximity to the seabed).

2. “Probably herring” were attributed to smaller echo-traces that had not been fished but which had the characteristic of “definite” herring traces.

3. “Herring in a mixture” were attributed to NASC values arising from all fish traces in which herring were thought to be contained, owing to the presence of a proportion of herring within the nearest trawl haul or within a haul that had been carried out on similar echo-traces in similar water depths.

4. “Possibly herring” were attributed to small echo-traces outside areas where fishing was carried out, but which had the characteristics of definite herring traces.

The RAW files were imported into Echoview for post-processing. The echograms were divided into transects. Echotraces belonging to one of the four categories above were identified visually and echo integration was performed on the enclosed regions. The echograms were analysed at a threshold of -70 dB and where necessary plankton was filtered out by thresholding at –65 dB.

The allocated echo integrator counts (NASC values) from these categories were used to estimate the herring numbers according to the method of Dalen and Nakken (1983).

The TS/length relationships used predominantly for the Celtic Sea Herring Survey are those recommended by the acoustic survey planning group based at 38 kHz (Anon, 1994):

Herring	TS = 20logL – 71.2 dB per individual (L = length in cm)
Sprat	TS = 20logL – 71.2 dB per individual (L = length in cm)
Mackerel	TS = 20logL – 84.9 dB per individual (L = length in cm)
Horse mackerel	TS = 20logL – 67.5 dB per individual (L = length in cm)
Anchovy	TS = 20logL – 71.2 dB per individual (L = length in cm)

The TS length relationship used for gadoids was a general physoclist relationship (Foote, 1987):

Gadoids	TS = 20logL – 67.5 dB per individual (L = length in cm)

2.4.3 Biological sampling

A single pelagic midwater trawl with the dimensions of 19m in length (LOA) and 6m at the wing ends and a fishing circle of 330m was employed during the survey (Figure 12). Mesh size in the wings was 3.3m through to 5cm in the cod-end. The net was fished with a vertical mouth opening of approximately 9m, which was observed using a cable linked “BEL Reeson” netsonde (50 kHz). The net was also fitted with a Scanmar depth sensor. Spread between the trawl doors was monitored using Scanmar distance sensors, all sensors being configured and viewed through a Scanmar Scanbas system.

All components of the catch from the trawl hauls were sorted and weighed; fish and other taxa were identified to species level. Fish samples were divided into species composition by weight. Species other than the herring were weighed as a component of the catch. Length frequency and length weight data were collected for each component of the catch. Length measurements of herring, sprat and pilchard were taken to the nearest 0.5cm below. Age, length, weight, sex and maturity data were recorded for individual herring within a random 50 fish sample from each trawl haul, where possible. All herring were aged onboard. The appropriate raising factors were calculated and applied to provide length frequency compositions for the bulk of each haul.

Decisions to fish on particular echo-traces were largely subjective and an attempt was made to target marks in all areas of concentration not just high density shoals. No bottom trawl gear was used during this survey. However, the small size of the midwater gear used and its manoeuvrability in relation to the vessel power allowed samples at or below 1m from the bottom to be taken in areas of clean ground.

2.4.4 Oceanographic data collection

Oceanographic stations were carried out during the survey at predetermined locations along the track. Data on temperature, depth and salinity were collected using a calibrated Seabird 911 sampler at 1m subsurface and 3m above the seabed.

2.4.5 Marine mammal and seabird observations

2.4.5.1 Marine Mammal sighting survey

During the survey an observer kept a daylight watch on marine mammals from the crow's nest (18m above sea level) when weather allowed or from the bridge (11m).

During cetacean observations, watch effort was focused on an area dead ahead of the vessel and 45° to either side using a transect approach. Sightings in an area up to 90° either side of the vessel were recorded. The area was constantly scanned during these hours by eye and with binoculars. Ship's position, course and speed were recorded, environmental conditions were recorded every 15 minutes and included, sea state, visibility, cloud cover, swell height, precipitation, wind speed and wind direction. For each sighting the following data were recorded: time, location, species, distance, bearing and number of animals (adults, juveniles and calves) and behaviour. Relative abundance (RA) of cetaceans was calculated in terms of number of animals sighted per hour surveyed (aph). RA calculations for porpoise, dolphin species and minke whales were made using data collected in Beaufort sea state ≤ 3. RA calculations for large whale species were made using data collected in Beaufort sea state ≤ 5.

2.4.5.2 Seabird sighting survey and surface litter

A standardized line transect method with sub-bands to allow correction for species detection bias and 'snapshots' to account for flying birds was used (following recommendations of Tasker *et al.* 1984; Komdeur *et al.*1992; Camphuysen *et al.* 2004), as outlined below.

Two observers (a primary observer and a primary recorder, who also acted as a secondary observer), in rotation from a pool of three surveyors, were allocated to survey shifts of two hours, surveying from 08.00 (or first light) to 18.00 hours (dusk) each day. Environmental conditions, including wind force and direction, sea state, swell height, visibility and cloud cover, and the ship's speed and heading were recorded at 2-hourly intervals during surveys. In the intervening time, any changes to environmental conditions were also noted, so that a discreet set of environmental conditions was obtained for each 5-minute interval. No surveys were conducted in conditions greater than sea state 5, when high swell made working on deck unsafe or when visibility was reduced to less than 300m.

The seabird observation platform was the wheelhouse deck, which is 10.5m above the waterline and provided a good view of the survey area. The survey area was defined as a 300m wide band operated on one side (in a 90° arc from bow to beam) and ahead of the ship. This survey band was sub-divided (A = 0-50m from the ship, B = 50-100m, C = 100-200m, D = 200-300m, E > 300m) to subsequently allow correction of differences in detection probability with distance from the observer. A fixed-interval range finder (Heinemann 1981) was used to periodically check distance estimates. The area was scanned by eye, with binoculars used only to confirm species identification.

All birds seen on the water within the survey area were counted, and those recorded within the 300m band, were noted as 'in transect'. All flying birds within the survey area were also noted, but only those recorded during a 'snapshot' were regarded as 'in transect'. This method avoids overestimating bird numbers in flight (Tasker *et al.* 1984). The frequency of the snapshot scan was ship-speed dependent, such that they were timed to occur at the moment the ship passed from one survey block (300m x

300m) to the next. Survey time intervals were set at 5 minutes. Additional bird species observed outside the survey area were also recorded and added to the species list for the research cruise, but these will not be included in maps of seabird abundance or density.

On acoustic survey transects the vessel had an average speed of 10 knots, while speed was reduced to 4 knots for trawling effort. Tows lasted around 45 minutes and were mostly separated by extended sessions of steaming at 10 knots, so that few birds were attracted to the ship. CTD stations were conducted on some transects, during which the vessel remained stationary for, on average, 18 minutes. Seabird surveying was interrupted while the ship was stationary at CTD stations and while towing since this can attract large numbers of birds. Where fish sampling operations were prolonged or at close intervals, seabird surveying was only recommenced after a period (45min – 1hr) of prolonged steaming at 10 knots, allowing the associating birds to disperse. Any bird recorded in the survey area that stayed with the ship for more than 2 minutes was regarded as being associated with the survey vessel (Camphuysen *et al.* 2004) and was coded as such (to be excluded from abundance and density calculations).

The daily total count data per day for each species is presented along with the daily survey effort. It is envisaged that this data will be analysed in the future and the seabird abundance (birds per km traveled), and seabird density (birds per km^2) will be mapped per 1⁄4 ICES rectangle (15' latitude x 30' longitude), allowing comparison to the results of previous seabird surveys in Irish waters (e.g. Hall *et al.* in press, Mackey *et al.* 2004, Pollock *et al.* 1997). Through further analysis, species-specific correction factors will be applied to birds observed on the water. It is also hoped to combine this analysis with the results of the cetacean observation and acoustic survey. The binomial species names for the birds recorded are presented in the species accounts.

All visible marine litter was also recorded during bird observations. The litter was identified or described as accurately as possible; quantity, size and distance from the boat was noted. When possible, pictures of the objects were taken.

2.5 Analysis methods

2.5.1 Echogram partitioning

The analysis produced density values of abundance and biomass per nautical mile squared for each transect and mark category for each target species. These were then averaged over each stratum (weighted by transect length) and a biomass and abundance estimated by applying the stratum area and summing the strata estimates. Note that interconnecting inshore and offshore inter-transects were not included in the analysis. Total estimates and age and maturity breakdowns were calculated. Coefficient of variation (cv, standard error divided by the estimate) was estimated in the usual way after assuming that transects were equally spatially distributed within a stratum and that they were statistically independent.

Biomass was calculated from numbers using length-weight relationships determined from the trawl samples taken during the survey for each of the analysis areas.

Herring weight (grams) $= 0.0265 * L^{3.3511}$ (L = length in cm)

Mackerel weight (grams) $= 0.0096 * L^{2.9073}$ (L = length in cm)

Sprat weight (grams) $= 0.0037 * L^{3.3063}$ (L = length in cm)

2.5.2 Abundance estimate

The recordings of area back scattering strength (NASC) per nautical mile were averaged over a one nautical mile EDSU (elementary distance sampling unit), and the allocation of NASC values to herring and other acoustic targets was based on the composition of the trawl catches and the appearance of the echotraces.

To estimate the abundance, the allocated NASC values were averaged by survey strata. For each stratum, the unit area density of fish (S_A) in number per square nautical mile ($N*nmi^{-2}$) was calculated using standard equations (Foote et al. 1987, Toresen *et al*. 1998).

NASC values assigned according to scrutinisation methods (section 2.3.5) were used to estimate the target species numbers according to the method of Dalen and Nakken (1983).

To estimate the total abundance of fish, the unit area abundance for each stratum was multiplied by the number of square nautical miles within the strata and then summed for all strata to provide the total survey area. Biomass estimation was calculated by multiplying abundance in numbers by the average weight of the fish in each strata and then sum of all squares by strata and summed for the total area.

3 Results

3.1 Celtic Sea herring stock

3.1.1 Herring biomass and abundance

Herring	Millions	Biomass (t)	% contribution
Total estimate			
Definitely	402	49,310	98.7
Mixture	2	194	0.4
Probably	4	448	0.9
Possibly	27	3,318	
Total estimate	408	49,952	100
SSB Estimate			
Definitely	367	46,901	98.7
Mixture	2	184	0.4
Probably	3	411	0.9
SSB estimate	372	47,496	100

Total herring biomass shown above was determined from 18 survey strata of which 3 contained herring (Table 10). Survey biomass and abundance was derived from 167 echotraces identified as herring with the aid of 19 directed trawls (Figure 2, Table 3). Of the 167 herring echotraces over 98% were identified as 'definitely herring', less than 1% as 'probably herring' and less than 0.5% as 'mixed herring' echotraces (Table 10).

Herring TSB (total stock biomass) and abundance (TSN) estimates were 49,952t (CV 60.2%) and 408 million individuals (CV 59.1%) respectively. The overall SSB (spawning stock biomass) observed during the survey was 47,496t (CV 60.2%), composed of a spawning abundance (SSN) of 372 million individuals.

A breakdown of herring stock abundance and biomass by age, maturity, size and stratum is shown in Tables 5-10.

3.1.2 Herring distribution

A total of 19 trawl hauls were carried out during the survey (Figure 2), with 5 hauls containing herring and 3 contained >50% herring by weight of catch (Table 3).

Herring distribution was limited exclusively to 3 of 18 survey strata. Two offshore broadscale strata (#7 & 8) contained almost the entire observed herring biomass (99.6% of TSB) and was made up of 144 medium and high density herring echotraces (Figures 6a-d). A small amount of inshore herring were taken as a component of a mixed species echotraces within a localised area (spawning box strata #14) accounting for c.200t of the total stock estimate (Figure 3, Table 10). However, due to the local bathymetry it was not possible to trawl on each of the 115 low density echotraces attributed to the mixed species category in this strata and as a result the c.200t may in fact be an over estimate of the actual abundance.

3.1.3 Herring stock composition

A total of 206 herring were aged from survey samples in addition to 1,455 length measurements and 310 length-weights recorded (Table 4). Herring age samples ranged from 1-9 winter-rings (Tables 5 & 6, Figure 5).

3 winter-ring herring dominated the 2014 estimate representing over 28% of TSB and 27% of TSN (Table 5 and 6). The 2 winter-ring age group were ranked second representing 23% of TSB and 29% of TSN. The third most dominate age group was 4 winter-ring group contributing 21% to the TSB and 17% to TSN.

Maturity analysis indicated over 95% of the TSB as sexually mature (Tables 7 & 8, Figure 5). Mature herring (stages 3 to 8) sampled during the survey were in a pre-spawning state and comprised predominantly of stages 3-4. No spent fish were observed during the survey and this is consistent with the dominant winter spawning stock component.

3.2 Other pelagic species

3.2.1 Sprat

Sprat	Millions	Biomass (t)	% contribution
Total estimate			
Definitely	7,329	43,259	78.9
Mixture	543	3,162	5.8
Probably	1,280	8,405	15.3
Total estimate	9,152	54,826	100

Sprat were found in 13 of 18 survey strata during the survey and sampled in 14 of 19 hauls (Figure 4, Table 3). In total 2,226 individual length measurements and 501 length/weight measurements were recorded. Mean length was 8.2cm and mean weight was 4g. Individuals ranged from 5 to 14.5cm in length and 1 to 29g in weight.

In total 956 individual sprat echotraces were identified during the survey (Table 12). The highest concentration of biomass was observed offshore in strata 7 and accounted for c.29% of total biomass and over 25% of the total abundance (Table 12). Very high density echotraces of sprat dominated (Figure 6e, f). The 'Smalls' strata (#8), contributed a further 12% to the TSB.

Inshore coastal waters accounted for the remaining 59% of stock biomass. The Mizen strata (#6), contributing c.17% to TSB has consistently contained a high portion of sprat biomass year-on-year. Dingle and Kenmare Bays contributed 7% and 11% to the TSB respectively.

The occurrence of high density aggregations of sprat extended further to the east approaching the Bristol Channel and western approaches to the English Channel (Van Der Hooj *pers. comm.).*

The mean length of sprat observed from this year's survey is comparable to previous years and this can be attributed to the widespread occurrence of 0-group fish throughout the survey area. Catches showed the presence of 2 distinct cohorts of 0-group and 1-groups.

3.3 Oceanography

A total of 51 CTD stations were carried out. Surface plots of temperature and salinity are presented for the 5, 20, 40 and the >60 m depth profiles in Figures 7-10.

Sea surface temperature, as measured at 5m, is relatively warm with temperatures above 14ºC for the larger area, the colder plumes of river water are evident around Cork Harbour. Surface salinity follows a similar pattern and is relatively stable throughout the area with the exception of river plumes, note also the plume south of Waterford Harbour (Figure 7). Temperature and salinity profiles at 20m depth (Figure 8) follow a similar stable pattern indicating both profiles are above the thermocline. The influence of the cooler, less saline water along the south coast in the form of the Irish Sea Front is not visible in surface waters as compared to previous years (O'Donnell *et al.,* 2013).

Profiles of 40m and 60m (Figures 9 & 10) are overlaid with herring acoustic density (NASC) data and it is evident that a depth of 40m is below the thermocline ceiling. It is evident from overlay plots that herring are distributed along the convergence region of warmer and cooler waters occurring in the northeastern survey area and is comparable to previous years.

3.4 Marine mammal and seabird observations

3.4.1 Marine mammal sightings

A total of 214 hours and 31 minutes of dedicated surveying was conducted between 06th- 24th October 2014, with 11 hrs of effort on most days covering daylight hours. Shorter survey days occurred on 6 days due to unsuitable weather and/or earlier nightfall (range 1.5 hr to 11 hrs). Some effort occurred on each of the 19 active survey days, although none occurred on the last day (25th) whilst the vessel waited in Galway Bay for her berth. A total of 197 hours and 10 minutes of observation were conducted from the Crow's Nest and a further 17 hours and 21 minutes conducted from the Bridge. Figure 11 gives a good approximation of actual transect area covered by observation effort. Gaps are a result of transect being conducted either during nightfall or when sea conditions were too poor to maintain effort.

A total of 152 specifically identified sighting events occurred, along with 17 sightings of unidentified animals. Seven different cetacean species were recorded, with sightings of three other marine species also logged i.e. Bluefin Tuna (*Thunnus thynnus*), Leatherback Turtle (*Dermochelys coriacaea*) and Grey Seal (*Halichoerus grypus*). By far the most frequent species sighted were Common Dolphins (*Delphinus delphis*) with 99 sighting events recorded. Fin Whales (*Balaenoptera physalus*) were the most frequently encountered of the large whales with 20 sighting events recorded, including one large aggregation of up to 16 animals off Ram Head in Co. Waterford on 22nd October. Table 13 summarises the sightings and estimates of number of individuals and groups size. Further species specific counts are presented in Annex 1.

3.4.2 Seabird sightings and marine litter

A total of 60.53 hours (3632 minutes) of seabird surveys was conducted across thirteen days between 8th and 24th October 2014.

A cumulative total of 9701 individual seabirds of 31 species were recorded, of which 2646 were noted as ‘off survey’, outside of dedicated survey time or associating with the vessel and as such will be excluded from future analysis of abundance and density. A synopsis of daily totals for all seabird species recorded is presented in Table 14. In addition, daily totals for 10 species of migrant terrestrial birds recorded on or around the vessel are also presented in Table 15.

The seabird team recorded presence of marine litter or debris observed in transect areas. Details of distance from the survey vessel, estimated size, material involved, colour and any branding were noted. Recording of marine litter using this format has been ongoing during CSHAS surveys since 2013, data of which is being compiled for future analysis.

4 Discussion and Conclusions

4.1 Discussion

The objectives of the survey were carried out successfully despite two periods of bad weather that required the suspension of acoustic operations in the later third of the cruise. Weather conditions were generally favourable during the first half of the survey but deteriorated after the mid-cruise crew change. On the two occasions mentioned, data drops outs in the echogram caused by the large waves meant the vessel had to heave-to for 8 hours in the Smalls region (stratum 8) and a further 8 hours inshore (stratum 9). Two CTD stations had to be skipped due to rough seas and vessel speed was considerably reduce on southerly transects. This did not affect survey coverage as contingency is built into the survey design. It did however mean that time was not available to extend the survey area (*e.g.* to the east as in 2013). Due to the very strong southerly and south-westerly winds in the last week of the survey, many of the inshore transects in shallow water had to be cut short for safety reasons. Fortunately no herring schools were observed anywhere near the shortened ends of the transects and no reports of herring hauls closer to shore were received from smaller fishing vessels at the time.

The 2014 survey estimate of SSB (47 kt) is considerably lower (42%) than that observed in 2013 (71 kt) and a fraction of that seen in 2012 (246 kt). The large 2012 SSB is likely an over-estimate, being over double the value of the next highest in the time series, but no definite reason for this has been identified to date. Similarly the low 2014 estimate, the lowest in seven years, is most certainly an underestimate but, unlike 2012, there is an apparent reason. As the vast majority of the herring biomass was encountered in the south-eastern corner of the surveyed area it is apparent that the fish were still in transit to inshore spawning grounds. As a result it is likely that the whole spawning stock was not contained by the southern boundary of the survey grid and some portion of it remained unquantified and outside of the survey area. Unfortunately due to the weather delays it was not possible to extend the offshore transects to the south without jeopardising the coverage in the core inshore spawning areas (although it should be noted that only one herring school was recorded in proximity to the southern boundary and three full transects were void of herring before the eastern extent was reached). The view that the stock was still making its way north towards shore is supported by the fact that a very large school of herring was reported by a fishing vessel at roughly 8.25°W, 51.25°N, a number of days after the Celtic Explorer surveyed that area and recorded absolutely no herring echotraces.

Some extremely large, dense sprat schools were present this year and were comprehensively sampled using directed trawling providing a high degree of confidence in the sprat estimate. Indeed, 10 of the 19 hauls contained a large proportion of sprat and 80% of the estimated sprat biomass was attributed to ‘definitely sprat’ echotraces as a result.

Almost exclusively, herring were encountered in single species aggregations during the survey. The one exception to this can be seen south of Cork where a number of ‘herring in a mix’ NASC values are plotted in Figure 3. These marks are ‘herring in a mix’ due to one haul in that vicinity, which contained five herring. Ordinarily a five fish sample would not qualify for use during the analysis (n=50 threshold) however, due to the number and type of echotraces in this known herring area it was decided to include this mixed herring category. The 200 t of herring biomass that these NASC values equate to is probably therefore an overestimate but it does confirm that there were some herring in that area at that time. Unsafe fishing areas caused by varied bathymetry limited the amount of fishing that could be carried out to groundtruth these particular echotraces.

The low number of very high density herring echotraces (within just 2 survey strata) that make up the 2014 estimate has increased the coefficient of variation (CV) of the survey estimate more so than a more homogenous population distribution of smaller less dense echotraces. The CV on the biomass and abundance estimates in 2014 were 60.2% and 59.1% respectively, more than double the values in the recent time series.

The herring schools observed, although of few in number were of high density and this may have been as a result of no actively targeting fishing vessels to disturb them due to the late opening of the fishery. No pair trawlers were seen (via AIS) in the Smalls or surrounding area before the bulk of the stock was surveyed there. The one exception to this was a very large Dutch freezer trawler seen shooting and hauling a pelagic trawl and towing along the southern edge of the ‘Trench’ three or four times, undoubtedly - targeting herring. (After two days it left the area, trawled south west of Kerry, then steamed to VIa.) Early in the survey there were reports of a number of pair trawlers catching herring outside of the survey grid, to the north east. Fishing effort in this area was short lived and by the time the Explorer reached the furthest east planned transect fishing activity had ceased. Due to the adverse weather at the time the decision was made not to place additional survey effort outside of the planned grid.

Completely at odds to all recent Celtic Sea herring acoustic surveys, the distribution of the stock in 2014 was almost entirely outside the coastal strata (*e.g.* Tramore and CS Inshore accounted for 87% of biomass in 2013). The spawning stock had clearly not yet reached the inshore spawning grounds at the time of surveying and an unknown proportion of it may even have lain outside the strata bounds. The reason for the late migration could be higher ambient water temperature which has been ascribed to the later arrival of mackerel and horse mackerel in traditional northern fishing areas (C O'Donnell *pers. comms*). Either way, the fact remains that the reported biomass and abundance are more than likely underestimated and, coupled with the large CVs, may not be suitable for stock assessment purposes.

4.2 Conclusions

- Herring TSB (total stock biomass) and abundance (TSN) estimates were 49,952t (CV 60.2%) and 408 million individuals (CV 59.1%) respectively. Spawning stock biomass (SSB) was 47,496t (CV 60.2%), relating to a spawning abundance (SSN) of 372 million individuals.
- The 2014 survey SSB estimate is 42% lower than that observed in 2013.
- Herring distribution was completely different to previous years with the vast majority of the surveyed stock located in offshore waters in, and to the west of, the Smalls area.
- No herring schools were recorded on the inshore spawning grounds. A very small quantity of herring was observed in mixed species assemblages on inshore transects south of Cork.
- The age profile as determined from survey samples was dominated by 2, 3 and 4 winter ring fish (29%, 28% and 17% of total abundance respectively). This tallies well with the 2013 survey were 1, 2 and 3 ringers dominated and 1-group fish represented almost 40% of the total biomass. Older fish (5-9 winter-rings) were again poorly represented.
- The spawning stock had clearly not yet reached the inshore spawning grounds at the time of surveying and an unknown proportion of it may even have lain outside the strata bounds.
- Therefore the reported biomass and abundance are more than likely underestimated and, coupled with the large CVs, may not be suitable for stock assessment purposes.

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5 Tables and Figures

Table 1. Survey Strata detail.

Strata no.	Strata name	Survey type	Transect type	Active transects	Transect spacing	Transect mileage (nmi)	Strata area (nmi2)
1	Inside Shannon	Broad scale	Zigzag	5	na	23.7	43.8
2	Dingle	Broad scale	Zigzag	9	na	53.6	59.8
3	Kenmare	Broad scale	Zigzag	7	na	39.5	56.9
4	Bantry	Broad scale	Zigzag	6	na	22.5	25.5
5	Dunmanus	Broad scale	Zigzag	5	na	20.2	10.1
6	Mizen	Broad scale	Parallel	14	4	290.0	1196.3
7	Offshore CS	Broad scale	Parallel	31	2	879.0	1893.8
8	Smalls	Broad scale	Parallel	19	2	454.7	959.2
9 (a,b,c,d,e)	CS Inshore	Broad scale	Parallel	33	2	488.2	1057.2
10	Baginbun	Spawning grd	Parallel	9	1	27.3	33.6
11	Tramore	Spawning grd	Parallel	19	1	94.2	113.8
12	Waterford	Spawning grd	Zigzag	3	na	6.4	2.6
13	Ballycotton	Spawning grd	Parallel	16	1	92.2	91.6
14	Daunt	Spawning grd	Parallel	12	1	53.4	60.3
15	Stags	Spawning grd	Parallel	6	1	10.1	13.0
16	Dingle_S	Spawning grd	Parallel	6	1	10.5	11.7
17	Dingle_N	Spawning grd	Parallel	6	1	9.8	10.7
18	Kerry Head	Spawning grd	Parallel	12	1	49.6	58.5
			Total	218		2,624.9	5,699

Table 2. Calibration report: Simrad EK60 echosounder at 38 kHz.

Echo Sounder System Calibration

Vessel :	R/V Celtic Explorer	Date :	06/10/2014
Echo sounder :	ER60 PC	Locality :	Galway Bay
Type of Sphere :	CU-38,1	TS Sphere: -33.50 dB (Corrected for soundvelocity o	Depth(Sea floor) 24 m

Calibration Version 2.1.0.11

Comments:
Black Head

Reference Target:

TS	-33.52 dB	Min. Distance	15.00 m
TS Deviation	5.0 dB	Max. Distance	20.00 m

Transducer: ES38B Serial No. 30227

Frequency	38000 Hz	Beamtype	Split
Gain	25.92 dB	Two Way Beam Angle	-20.6 dB
Athw. Angle Sens.	21.90	Along. Angle Sens.	21.90
Athw. Beam Angle	6.98 deg	Along. Beam Angle	6.94 deg
Athw. Offset Angle	-0.05 deg	Along. Offset Angl	-0.05 deg
SaCorrection	-0.66 dB	Depth	8.8 m

Transceiver: GPT 38 kHz 009072033933 1 ES38B

Pulse Duration	1.024 ms	Sample Interval	0.193 m
Power	2000 W	Receiver Bandwidth	2.43 kHz

Sounder Type:
ER60 Version 2.2.1

TS Detection:

Min. Value	-50.0 dB	Min. Spacing	100 %
Max. Beam Comp.	6.0 dB	Min. Echolength	80 %
Max. Phase Dev.	8.0	Max. Echolength	180 %

Environment:

Absorption Coeff.	8.7 dB/km	Sound Velocity	1509.1 m/s

Beam Model results:

Transducer Gain =	25.89 dB	SaCorrection =	-0.80 dB
Athw. Beam Angle =	6.98 deg	Along. Beam Angle =	6.95deg
Athw. Offset Angle =	-0.05 deg	Along. Offset Angle=	-0.06 deg

Data deviation from beam model:
RMS = 0.12 dB
Max = 0.26 dB No. = 240 Athw. = -3.7 deg Along = -3.4 deg
Min = -0.95 dB No. = 330 Athw. = -1.2 deg Along = 4.4 deg

Data deviation from polynomial model:
RMS = 0.07 dB
Max = 0.23 dB No. = 184 Athw. = 4.6 deg Along = 1.0 deg
Min = -0.81 dB No. = 330 Athw. = -1.2 deg Along = 4.4 deg

Comments :

Wind Force : 4 **Wind Directioi** SW
Raw Data File: \\Expfileclstr\ER-60_Data\CSHAS_2014\RAW ER60 Files\Calibration\CSHAS_2014
Calibration File: \\Expfileclstr\ER-60_Data\ER-60\Calibrations_2014\CSHAS2014\38 KHZ

Calibration : Cormac Nolan

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Table 3. Catch table from directed trawl hauls.

No.	Date	Lat. N	Lon. W	Time	Bottom (m)	Target (m)	Bulk Catch (Kg)	Herring %	Mackerel %	Scad %	Sprat %	Pilchard %	Others* %
1	08.10.14	52 01.22	10 19.81	06:25	52	0-10	34.3		86.2		13.1	0.0	0.7
2	08.10.14	51 42.32	10 07.68	15:19	70	15	8.5		4.1	11.9	83.8		0.2
3	09.10.14	51 06.71	09 44.13	10:02	115	5	47.6						100.0
4	10.10.14	51 15.25	08 54.11	10:30	98	1	4.7				0.1		99.9
5	10.10.14	51 29.16	08 40.89	16:05	80	20	1.1	1.1		19.3	69.3		10.3
6	12.10.14	51 19.84	07 48.24	12:33	86	20	3.5		22.9	2.4	72.4		2.4
7	12.10.14	51 19.57	07 45.02	17:57	86	25	14.4				76.5		23.5
8	13.10.14	51 19.09	07 35.34	07:50	88	0	11.6			0.3	98.7		1.0
9	14.10.14	51 02.33	07 22.71	00:26	95	5	1000.0	100.0					
10	14.10.14	51 35.71	07 16.05	14:08	73	15	150.0		0.2		99.8		
11	14.10.14	51 08.55	07 13.07	19:47	100	20	1000.0	100.0					
12	17.10.14	51 12.55	06 47.24	04:25	84	0	70.9	12.1		3.0			84.8
13	17.10.14	51 15.17	06 40.61	12:00	86	16	29.1		87.1	0.4	11.9		0.6
14	18.10.14	51 18.75	06 34.16	06:35	83	0	500.0	99.2					0.8
15	18.10.14	51 19.80	06 27.68	16:02	120	90	26.7			0.1	1.2		98.7
16	19.10.14	51 57.96	06 44.68	15:00	60	15	2.5			96.1	1.2		2.7
17	22.10.14	52 04.11	07 16.95	10:50	38	0	0.8		33.0	0.5	66.4		
18	22.10.14	51 53.66	07 39.09	06:58	35	5	250.0		0.9	0..96	99.0		0.1
19	23.10.14	51 43.04	08 10.92	10:11	36	5	34.6	1.4	65.9	1.2	22.3		9.2

* Including pelagic, demersal fish and invertebrates

Table 4. Length-frequency of herring hauls used in the analysis.

Haul	**9**	**11**	**12**	**14**	**19***	
length (cm)						Total
11						
11.5						
12						
12.5						0
13						0
13.5						0
14						0
14.5						0
15						0
15.5						0
16						0
16.5						0
17						0
17.5						0
18						0
18.5		3				3
19		12				12
19.5	2	20		4		26
20	3	25		13		41
20.5	5	23		17		45
21	3	32		12		47
21.5	7	27		20	3	57
22	6	60	2	16		84
22.5	16	45		32		93
23	24	58	5	28		115
23.5	29	54	4	39		126
24	31	38	3	26		98
24.5	24	27	6	42	1	100
25	44	25	10	51		130
25.5	47	19	7	60	1	134
26	60	21	6	34		121
26.5	38	9	10	35		92
27	30	6	9	24		69
27.5	19	3	7	8		37
28	9	2	2	3		16
28.5	3			2		5
29	4					4
29.5						0
30						0
30.5						0
31						0
31.5						0
32						0
32.5						0
33						0
Total	**404**	**509**	**71**	**466**	**5**	**1,455**

* Mixed species haul

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Table 5. Total biomass (000's tonnes) of herring at age (winter rings) by strata.

Strata	0	1	2	3	4	5	6	7	8	9	10	Total
1	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0.2	1.5	2.2	1.6	0.5	0.6	0.2	0.4	0	0	7.3
8	0	2.7	9.9	11.9	8.6	2.6	3.2	0.9	2.5	0.2	0	42.5
9	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0.1	0	0	0	0	0	0	0	0.2
15	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	3	11.4	14.2	10.2	3.1	3.8	1.1	2.9	0.2	0	50.0
%	0	6	22.9	28.4	20.5	6.2	7.6	2.3	5.8	0.5	0	100

Table 6. Herring abundance (millions) at age (winter rings) by strata.

Strata	0	1	2	3	4	5	6	7	8	9	10	Total
1	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0
7	0	3.4	14.7	17.5	11.0	3.2	3.5	1.2	2.3	0	0	57.1
8	0	37.5	102.1	94.0	58.2	16.6	20.0	5.5	14.2	1.1	0	349.1
9	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0.6	0.5	0.6	0	0	0	0	0	0	0	1.9
15	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	41.4	117.3	112.1	69.4	19.8	23.6	6.8	16.5	1.3	0	408.1
%	0	10.2	28.7	27.5	17.0	4.8	5.8	1.7	4.0	0	0	100
Cv (%)	NA	57.3	58.1	60.2	62.4	61.5	62.4	61.6	61.3	59.1	NA	NA

Table 7. Herring biomass (000's tonnes) at maturity by strata.

Strata	Imm	Mature	Spent	Total
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
4	0	0	0	0
5	0	0	0	0
6	0	0	0	0
7	0.2	7.1	0	7.3
8	2.3	40.2	0	42.5
9	0	0	0	0
10	0	0	0	0
11	0	0	0	0
12	0	0	0	0
13	0	0	0	0
14	0	0.2	0	0.2
15	0	0	0	0
16	0	0	0	0
17	0	0	0	0
18	0	0	0	0
Total	2.5	47.5	0	50
%	4.9	95.1	0	100

Table 8. Herring abundance (millions) at maturity by strata.

Strata	Imm	Mature	Spent	Total
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
4	0	0	0	0
5	0	0	0	0
6	0	0	0	0
7	2.8	54.3	0.0	57.11
8	33.0	316.1	0.0	349.1
9	0	0	0	0
10	0	0	0	0
11	0	0	0	0
12	0	0	0	0
13	0	0	0	0
14	0.1	1.8	0	1.9
15	0	0	0	0
16	0	0	0	0
17	0	0	0	0
18	0	0	0	0
Total	35.9	372.2	0	408.1
%	8.8	91.2	0	100

Table 9. Herring length at age (winter rings) as abundance (millions) and biomass (000's tonnes).

Length	Age (Rings)											Abund	Biomass	Mn wt
(cm)	0	1	2	3	4	5	6	7	8	9	10	(mils)	000's t	(g)
11														
11.5														
12														
12.5														
13														
13.5														
14														
14.5														
15														
15.5														
16														
16.5														
17														
17.5														
18														
18.5		0.2										0.2	0.0	49.0
19		1.1										1.1	0.1	53.5
19.5		4.29										4.3	0.3	58.3
20		10.5										10.5	0.7	63.4
20.5		4.2	8.42									12.6	0.9	68.8
21		7.12	3.55									10.7	0.8	74.5
21.5		8.17	6.53	1.63								16.3	1.3	80.5
22		3.93	13.1									17.0	1.5	86.9
22.5		1.88	22.7	1.88								26.5	2.5	93.6
23			25.1	2.09								27.2	2.7	100.7
23.5			21.5	12.3								33.7	3.7	108.2
24			11.6	11.6								23.2	2.7	116.0
24.5			4.87	29.3	2.46							36.7	4.6	124.2
25				27.7	13.8			1.96				43.5	5.8	132.8
25.5				19.6	23.9	2.15	2.15		2.15			50.0	7.1	141.8
26				6	10.5	9	4.5					30.0	4.5	151.3
26.5					11.4	7.14	11.4					30.0	4.8	161.1
27					6.01	1.49	3.01	3.01	7.51			21.0	3.6	171.5
27.5					1.25		2.5		3.75	1.25		8.8	1.6	182.2
28									3.09			3.1	0.6	193.5
28.5								1.82				1.8	0.4	205.2
29														
29.5														
30														
30.5														
31														
31.5														
32														
32.5														
33														
33.5														
SSN (mil)		16.3	107	112	69.4	19.8	23.6	6.78	16.5	1.3		372.2		
SSB ('000s t)		1.3	10.6	14.2	10.2	3.1	3.8	1.1	2.9	0.2			47.5	
Mn Wt (g)		72	97.4	127	147	155	161	169	174	182				
Mn length (cm)		21	23	24.9	26	26.5	26.7	27.1	27.4	27.8				

Table 10. Herring biomass and abundance by survey strata.

Category Stratum	No. transects	No. schools	Def schools	Mix schools	Prob schools	% zeros	Def Biomass	Mix Biomass	Prob Biomass	Biomass ('000t)	SSB ('000t)	Abundance millions
1	5	0	0	0	0	100	0	0	0	0	0	0.0
2	9	0	0	0	0	100	0	0	0	0	0	0.0
3	7	0	0	0	0	100	0	0	0	0	0	0.0
4	6	0	0	0	0	100	0	0	0	0	0	0.0
5	5	0	0	0	0	100	0	0	0	0	0	0.0
6	14	0	0	0	0	100	0	0	0	0	0	0.0
7	31	4	4	0	0	97	7.3	0	0	7.3	7.1	57.1
8	19	48	29	0	19	47	42	0	0.4	42.5	40.2	349.1
9	33	0	0	0	0	100	0	0	0	0	0	0.0
10	9	0	0	0	0	100	0	0	0	0	0	0.0
11	19	0	0	0	0	100	0	0	0	0	0	0.0
12	3	0	0	0	0	100	0	0	0	0	0	0.0
13	16	0	0	0	0	100	0	0	0	0	0	0.0
14	12	115	0	115	0	42	0	0.2	0	0.2	0.2	1.9
15	6	0	0	0	0	100	0	0	0	0	0	0.0
16	6	0	0	0	0	100	0	0	0	0	0	0.0
17	6	0	0	0	0	100	0	0	0	0	0	0.0
18	12	0	0	0	0	100	0	0	0	0	0	0.0
Total	218	167	33	115	19	92	49.3	0.2	0.4	50.0	47.5	408.1
Cv (%)	-	-	-	-	-	-	-	-	-	60.2	60.2	59.1

Table 11. Survey time series. Abundance in millions, biomass in 000's tonnes). Age in winter rings. Estimate includes 'Smalls' strata from 2011 onwards.

Season Age (Rings)	1995 1996	1996 1997	1997 1998	1998 1999	1999 2000	2000 2001	2001 2002	2002 2003	2003 2004	2004 2005	2005 2006	2006 2007	2007 2008	2008 2009	2009 2010	2010 2011	2011 2012	2012 2013	2013 2014	2014 2015
0	202	3	-	0	-	25	40	0	24	-	2	-	1	2	239	5	0.1	31	3.8	0
1	25	164	-	30	-	102	28	42	13	-	65	21	106	63	381	346	342	270	698	41
2	157	795	-	186	-	112	187	185	62	-	137	211	70	295	112	549	479	856	291	117
3	38	262	-	133	-	13	213	151	60	-	28	48	220	111	210	156	299	615	197	112
4	34	53	-	165	-	2	42	30	17	-	54	14	31	162	57	193	47	330	43.7	69
5	5	43	-	87	-	1	47	7	5	-	22	11	9	27	125	65	71	49	37.9	20
6	3	1	-	25	-	0	33	7	1	-	5	1	13	6	12	91	24	121	9.8	24
7	1	15	-	24	-	0	24	3	0	-	1	-	4	5	4	7	33	25	4.7	7
8	2	0	-	4	-	0	15	0	0	-	0	-	1	-	6	3	4	23	0	17
9	2	2	-	2	-	0	52	0	0	-	0	-	0	-	1	-	2	3	0.2	1
Abundance	469	1338	-	656	-	256	681	423	183	-	312	305	454	671	1,147	1,414	1,300	2,322	1,286	408
SSB	36	151	-	100	-	20	95	41	20	-	33	36	46	93	91	122	122	246	71	48
CV	53	26	-	36	-	100	88	49	34	-	48	35	25	20	24	20	28	25	28	59.1

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Table 12. Sprat biomass and abundance by survey strata.

Category Stratum	No. transects	No. schools	Def schools	Mix schools	Prob schools	% zeros	Def Biomass	Mix Biomass	Prob Biomass	Biomass ('000t)	Abundance millions
1	5	14	0	11	3	20	0	3.1	0.5	3.6	615.8
2	9	56	53	3	0	11	3.7	0	0	3.8	650.5
3	7	114	106	0	8	0	5.7	0	0.2	5.9	1338.8
4	6	0	0	0	0	100	0	0	0	0.0	0.0
5	5	0	0	0	0	100	0	0	0	0.0	0.0
6	14	119	21	0	98	43	4.4	0	4.7	9.1	1027.3
7	31	232	177	0	55	58	15.5	0	0.6	16.0	2272.6
8	19	214	185	0	29	63	6	0	0.6	6.6	2636.9
9	33	104	72	0	32	61	4	0	1	5.0	308.4
10	9	5	3	0	2	67	1	0	0.5	1.5	86.2
11	19	23	15	0	8	68	0.3	0	0.1	0.3	19.8
12	3	0	0	0	0	100	0	0	0	0.0	0.0
13	16	63	63	0	0	50	2.6	0	0	2.6	146.3
14	12	1	0	0	1	92	0	0	0.1	0.1	8.2
15	6	0	0	0	0	100	0	0	0	0.0	0.0
16	6	7	0	0	7	33	0	0	0.2	0.2	35.7
17	6	4	0	0	4	67	0	0	0	0.0	6.0
18	12	0	0	0	0	100	0	0	0	0.0	0.0
Total	218	956	695	14	247	61	43.3	3.2	8.4	54.8	9,152
Cv (%)	-	-	-	-	-	-	-	-	-	16.7	17

Table 13. Summary of cetacean species sightings (number of sightings followed by best estimate of number of animals in parentheses).

Species	No. of sightings	No. of individuals	Group size range
Fin Whale (Balaenoptera physalus)	20	32	1-4
Humpback Whale (Megaptera novaeangliae)	9	13	1-3
Minke Whale (Balaenoptera acutorostrata)	5	5	1
Risso's dolphin (Grampus griseus)	1	2	2
Bottlenose Dolphin (Tursiops truncatus)	1	1	1
Common Dolphin (Delphinus delphis)	99	2459	1-600
Harbour Porpoise (Phocoena phocoena)	3	5	1-2
Unidentified Large Whale	3	3	1
Unidentified Whale	7	7	1
Unidentified Dolphin	3	60	5-30
Unidentified Cetacean	3	3	1
Leatherback Turtle (Dermochelys coriacaea)	4	4	1
Bluefin Tuna (Thunnus thynnus)	9	222	2-100
Unidentified Tuna	1	1	1
Grey Seal (Halichoerus grypus)	1	1	1
Total	169	2804	n/a

Table 14. Total number of sea bird species recorded.

Vernacular Name	Scientific Name	On Survey	Off Survey	Total
Common Scoter	*Melanitta nigra*	1	2	3
Great Northern Diver	*Gavia immer*	3	1	4
Fulmar	*Fulmarus glacialis*	568	18	586
Fea's / Zino's Petrel	*Pterodroma feae / maderia*		1	1
Great Shearwater	*Puffinus gravis*	7		7
Sooty Shearwater	*Puffinus griseus*	289	516	805
Manx Shearwater	*Puffinus puffinus*	156	68	224
Balearic Shearwater	*Puffinus mauretanicus*	28	3	31
Macaronesian Shearwater	*Puffinus baroli*		1	1
Wilson's Storm-petrel	*Oceanites oceanicus*	1		1
European Storm-petrel	*Hydrobates pelagicus*	119	1096	1215
Leach's Storm-petrel	*Oceanodroma leucorhoa*		4	4
Gannet	*Morus bassanus*	3015	158	3173
Shag	*Phalacrocorax aristotelis*	5		5
Grey Phalarope	*Phalaropus fulicarius*		4	4
Pomarine Skua	*Stercorarius pomarinus*	5	22	27
Arctic Skua	*Stercorarius parasiticus*	5	9	14
Long-tailed Skua	*Stercorarius longicaudus*		1	1
Great Skua	*Stercorarius skua*	55	167	222
Puffin	*Fratercula arctica*	7	6	13
Razorbill	*Alca torda*	177		177
Guillemot	*Uria aalge*	1177		1177
Razorbill / Guillemot		191		191
Arctic Tern	*Sterna paradisaea*	1	5	6
Sabine's Gull	*Xema sabini*		1	1
Kittiwake	*Rissa tridactyla*	124	4	128
Black-headed Gull	*Chroicocephalus ridibundus*		1	1
Mediterranean Gull	*Larus melanocephalus*		1	1
Common Gull	*Larus canus*		2	2
Lesser Black-backed Gull	*Larus fuscus*	60	25	85
Herring Gull	*Larus argentatus*	6	34	40
Great Black-backed Gull	*Larus marinus*	423	40	463
Unidentified Large Gull sp.	*Larus sp.*	632	456	1088
Total		7055	2646	9701

Table 15. Totals of migrant terrestrial bird species recorded.

Vernacular Name	Scientific Name	Total
Grey Goose	*Anser sp.*	5
Common Snipe	*Gallinago gallinago*	4
Merlin	*Falco columbarius*	5
Goldcrest	*Regulus regulus*	1
Swallow	*Hirundo rustica*	4
Starling	*Sturnus vulgaris*	15
Redwing	*Turdus iliacus*	1
Black Redstart	*Phoenicurus ochruros*	1
Pied Wagtail	*Motacilla alba yarellii*	3
Meadow Pipit	*Anthus pratensis*	23
Total		62

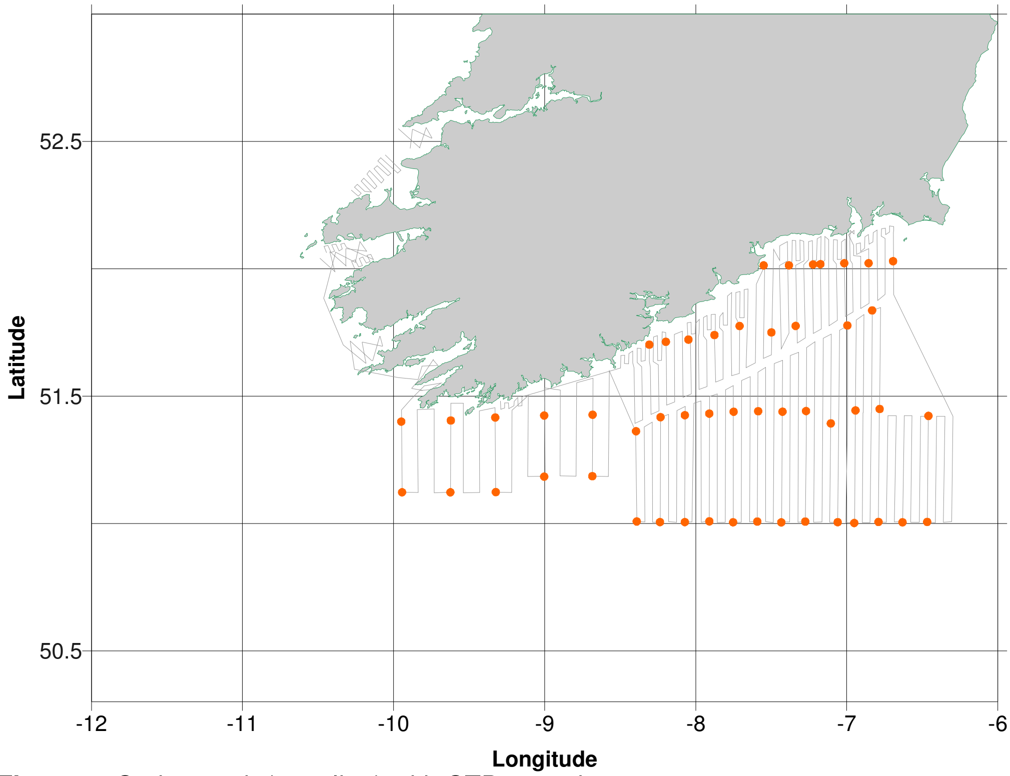

Figure 1. Cruise track (grey line) with CTD casts in orange.

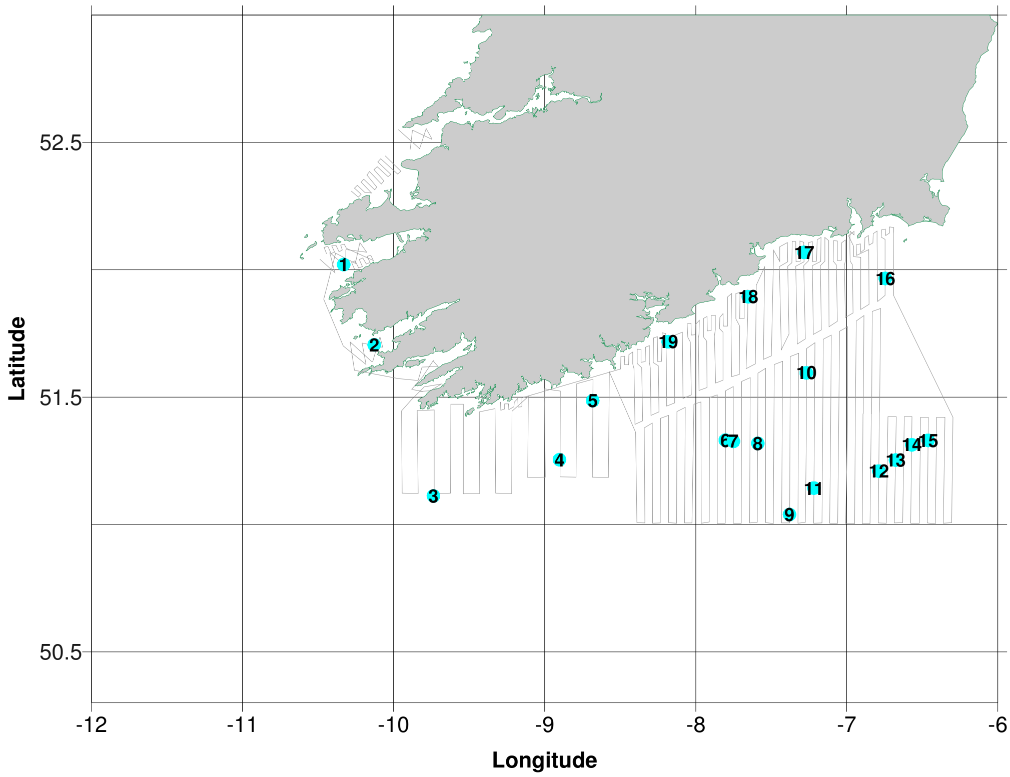

Figure 2. Directed midwater trawl positions.

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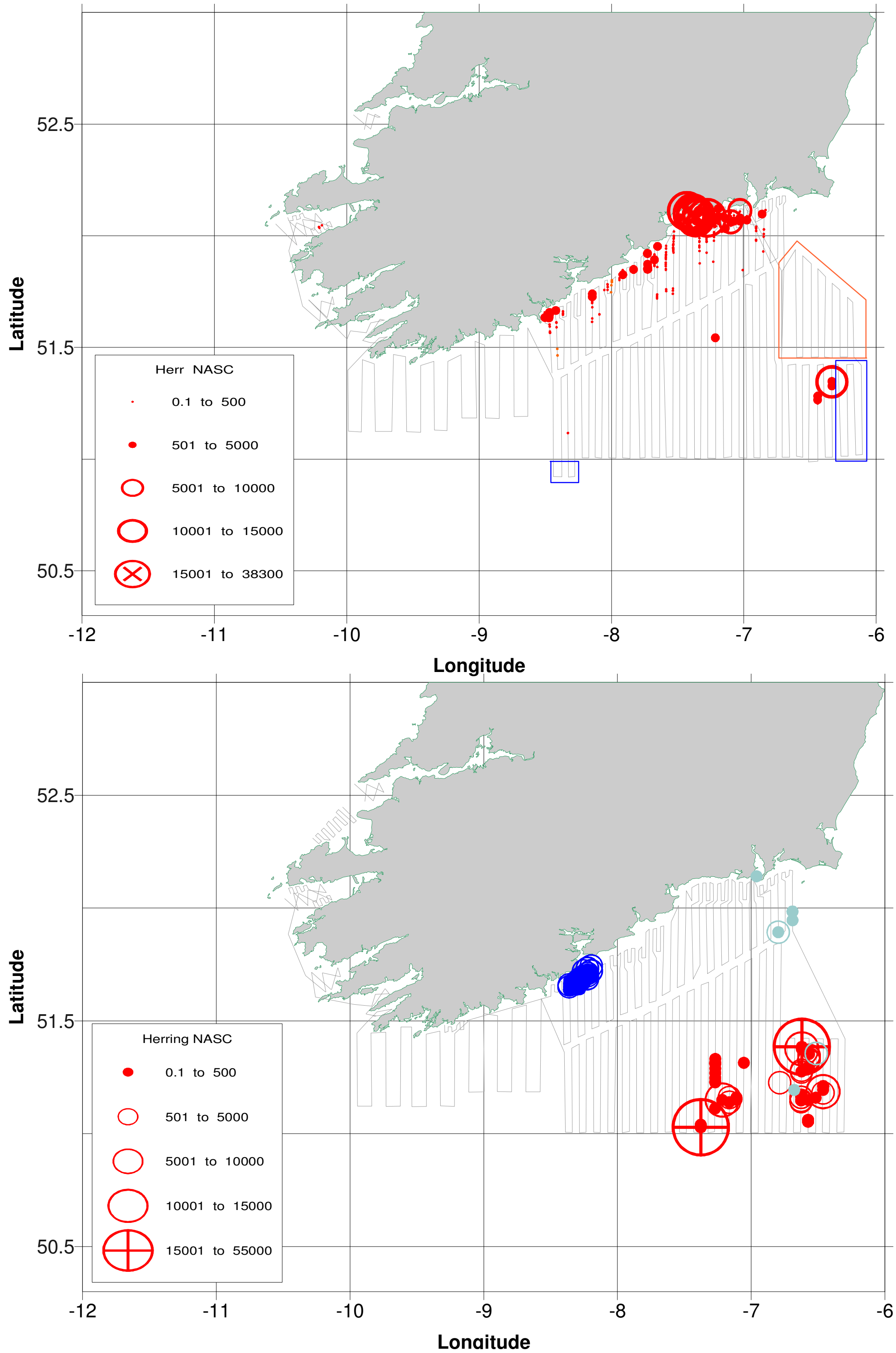


Figure 3. Weighted herring NASC (Nautical area scattering coefficient) plot of the distribution of "definitely" and "probably" categories (red circles), "mixed herring" (blue) and "possibly herring" (teal). Top Panel 2013, bottom panel 2014.

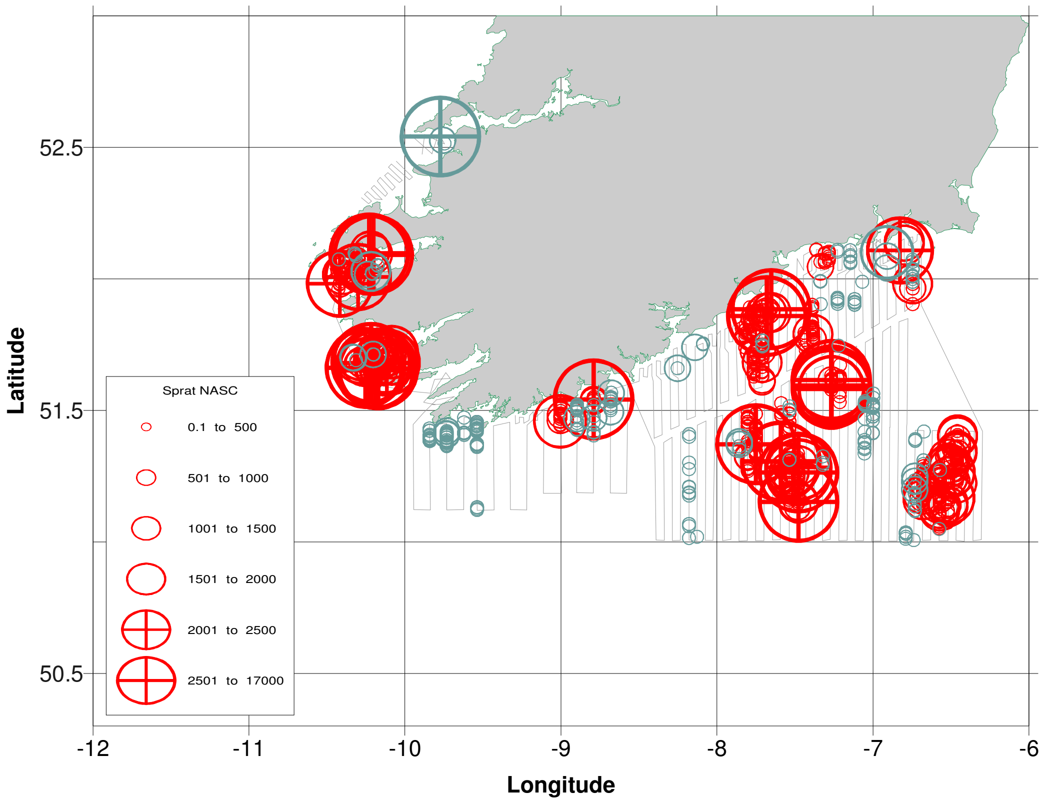
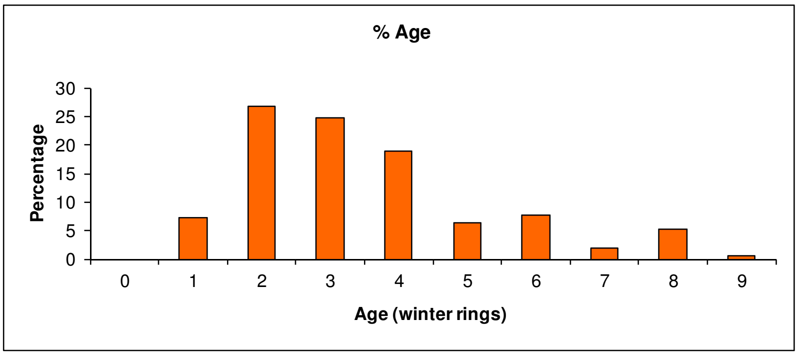


Figure 4. Weighted Sprat NASC (Nautical area scattering coefficient) distribution of "definitely" (red) and "probably" (green) categories.



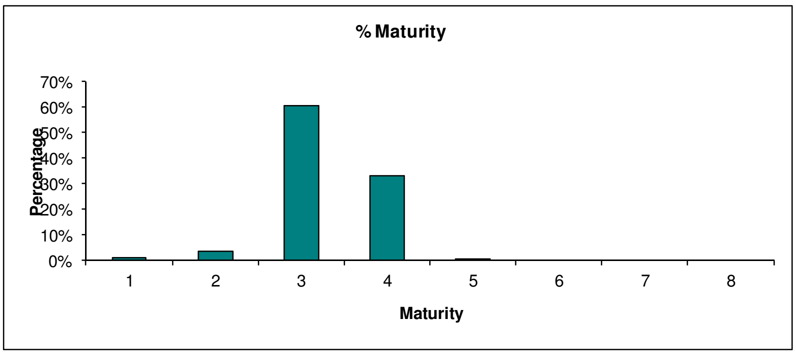
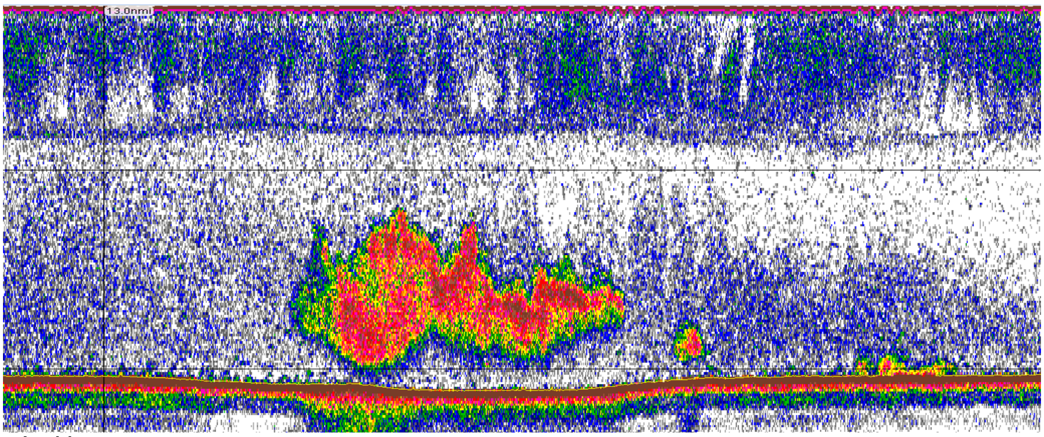
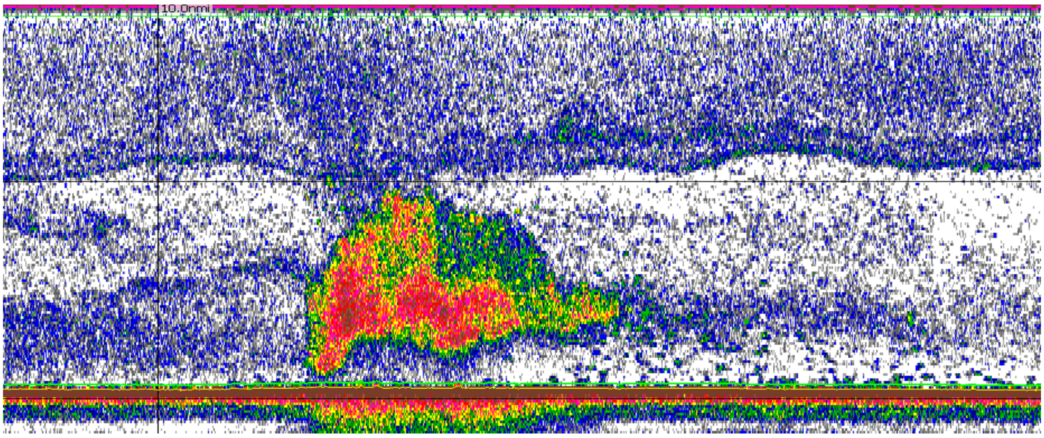


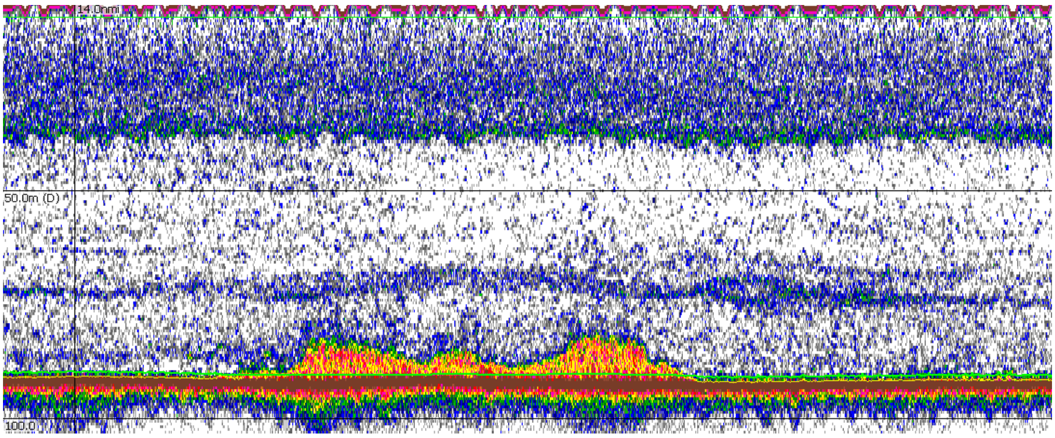
Figure 5. Percentage age and maturity of aged herring samples used in the analysis (n=206).



a). *High density herring echotrace, recorded offshore in the Celtic Sea prior to Haul 09. Observed at night in a water depth 95m.*

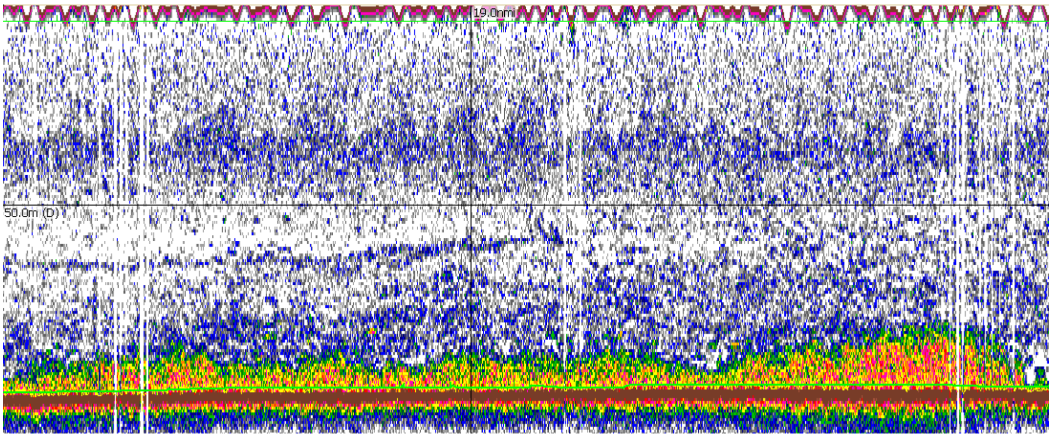


b). *High density echotrace of herring (Haul 11) recorded offshore in the Celtic Sea. Water depth 100m.*

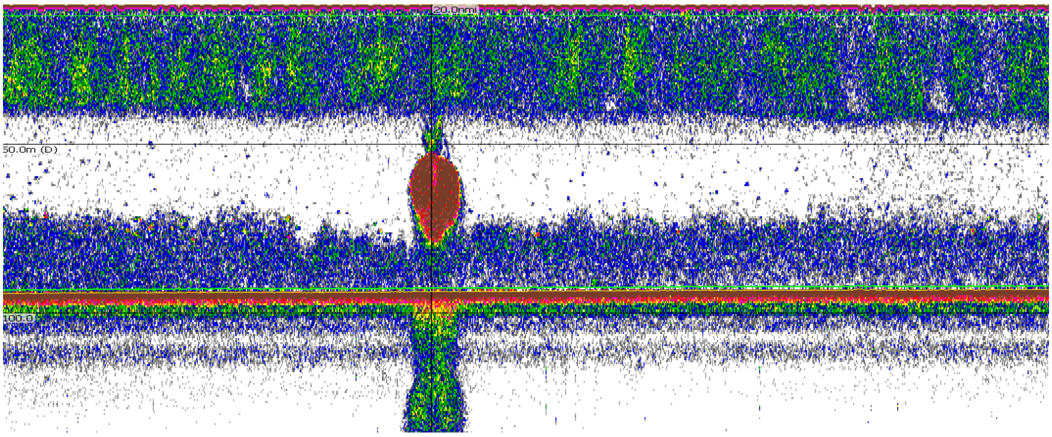


c). *High density herring bottom echotrace (Haul 12) recorded offshore in the 'Smalls' strata at night. Water depth 84m.*

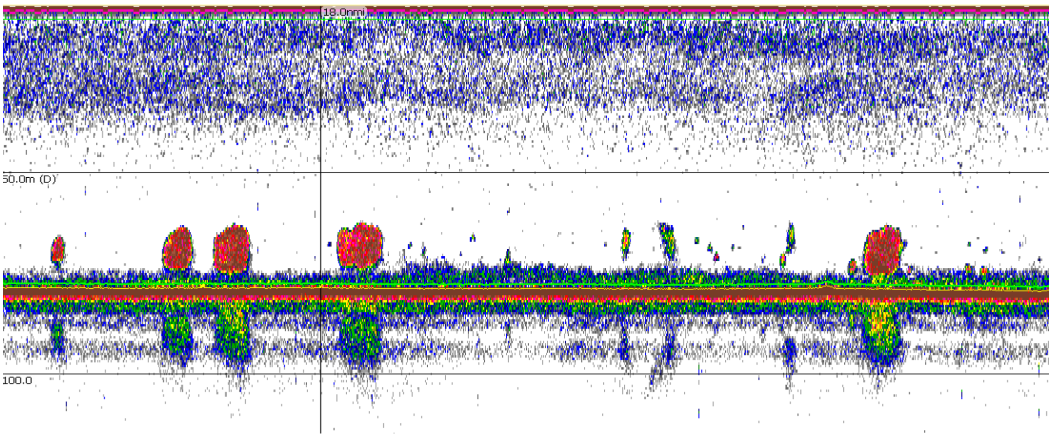
Figure 6a-f. Echograms of trawled biological samples, recorded prior to trawling (EK60, 38 kHz).



d). *High density herring bottom echotrace (Haul 14) recorded offshore in the 'Smalls' strata early morning, pre-dawn. Water depth 83m.*



e). *Very high density single echotrace of sprat recorded offshore in the Celtic Sea prior to Haul 08. Water depth 88m.*



f). *High density cluster of sprat echotraces recorded offshore in the Celtic Sea prior to Haul 10. Water depth 73m.*

Figure 6a-f. Continued.

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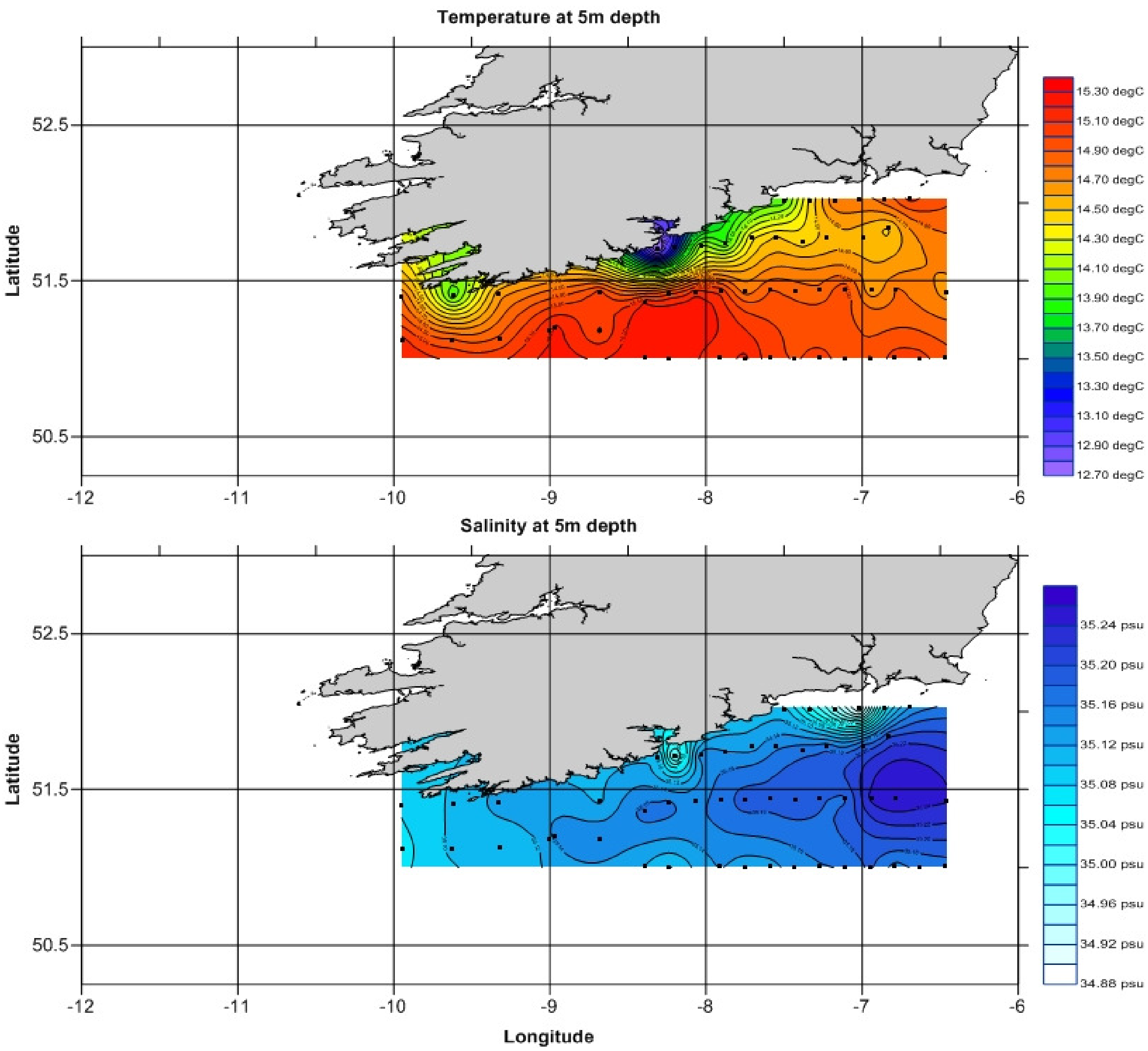

Figure 7. Surface (5m) plots of temperature and salinity compiled from CTD cast data. Station positions shown as block dots (n=51).

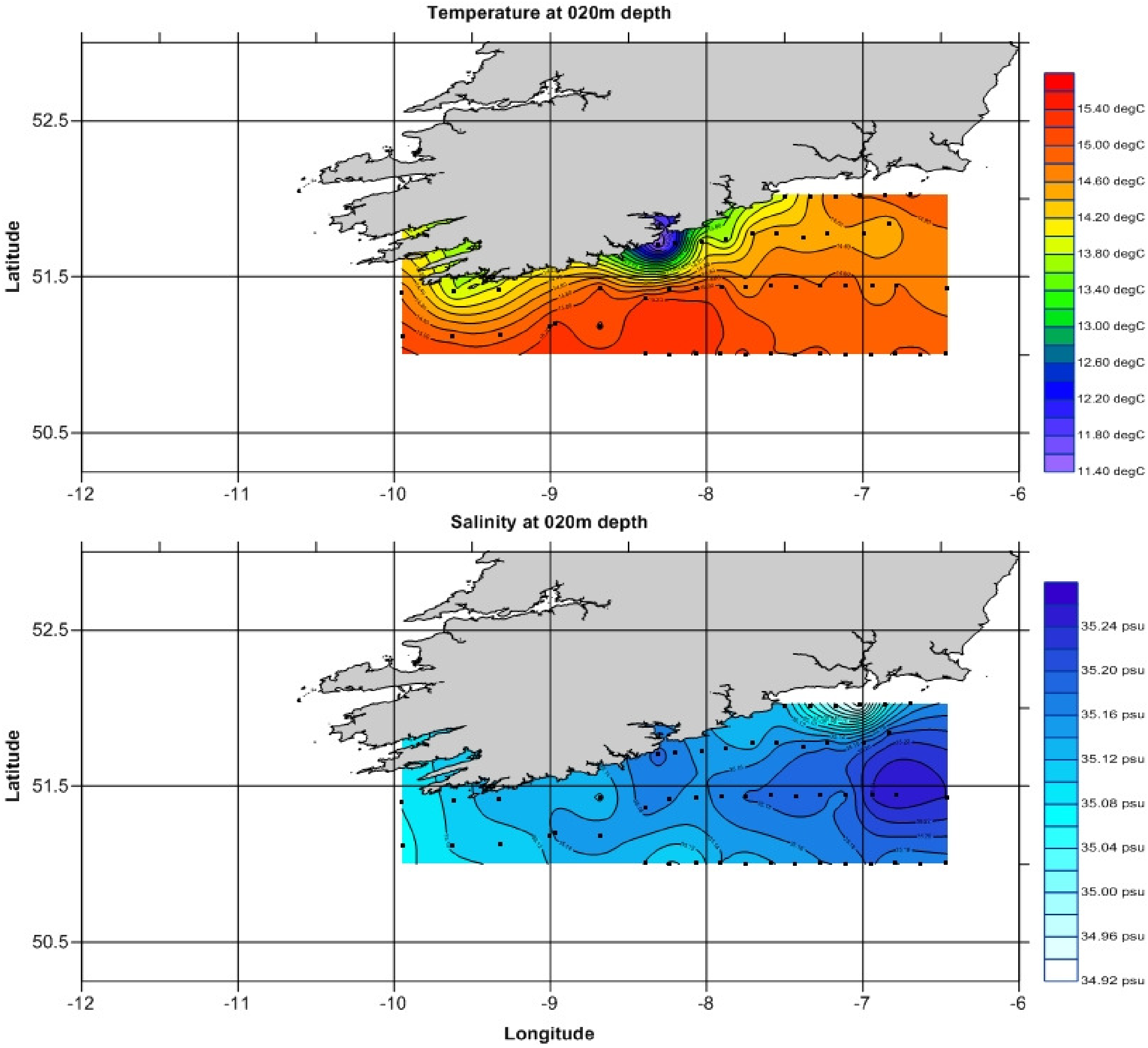

Figure 8. Temperature and salinity at 20m compiled from CTD cast data (n=51). Station positions shown as block dots.

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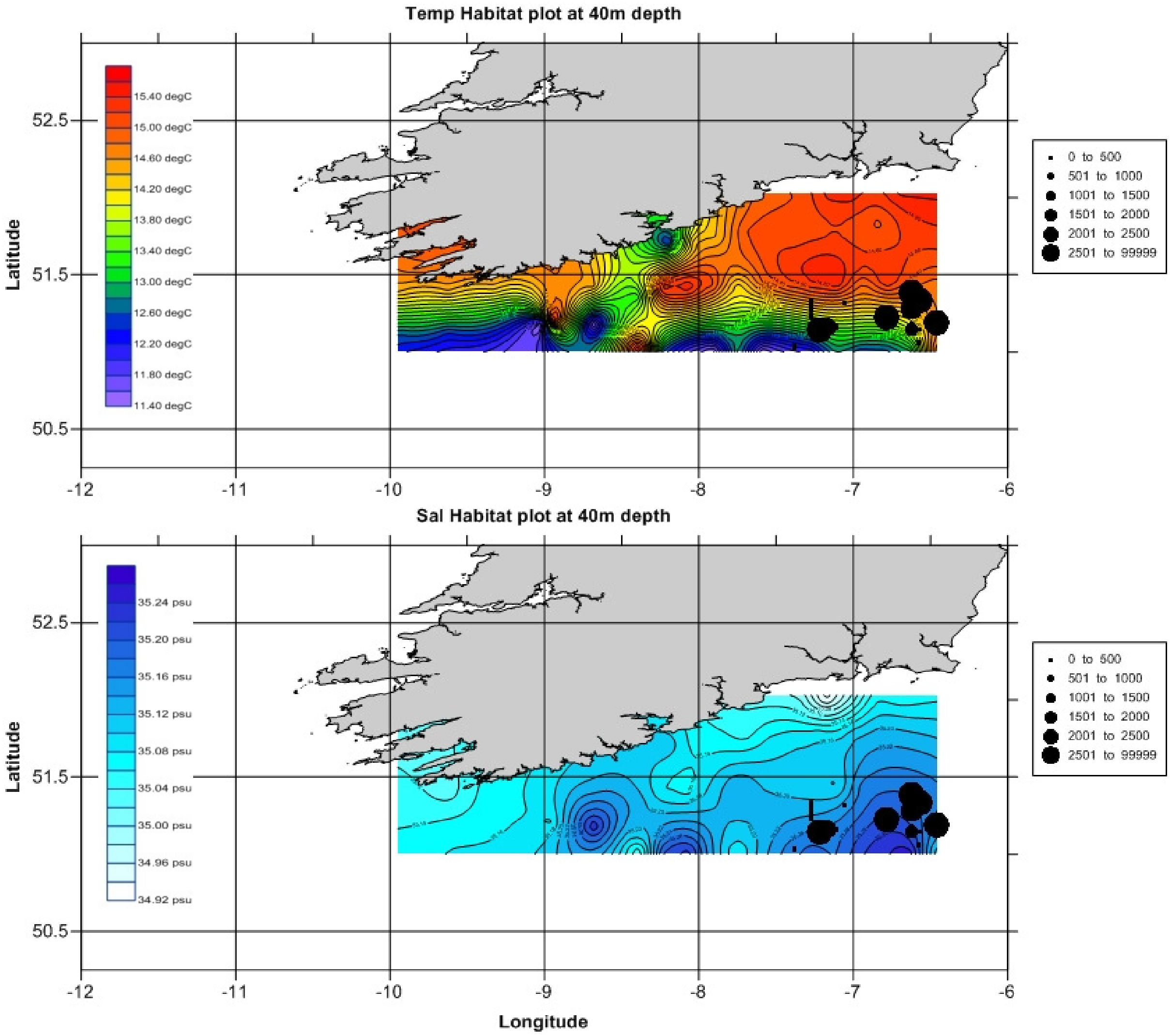

Figure 9. Habitat plots of temperature and salinity at 40m overlaid with herring NASC values (acoustic density) shown as weighted black circles.

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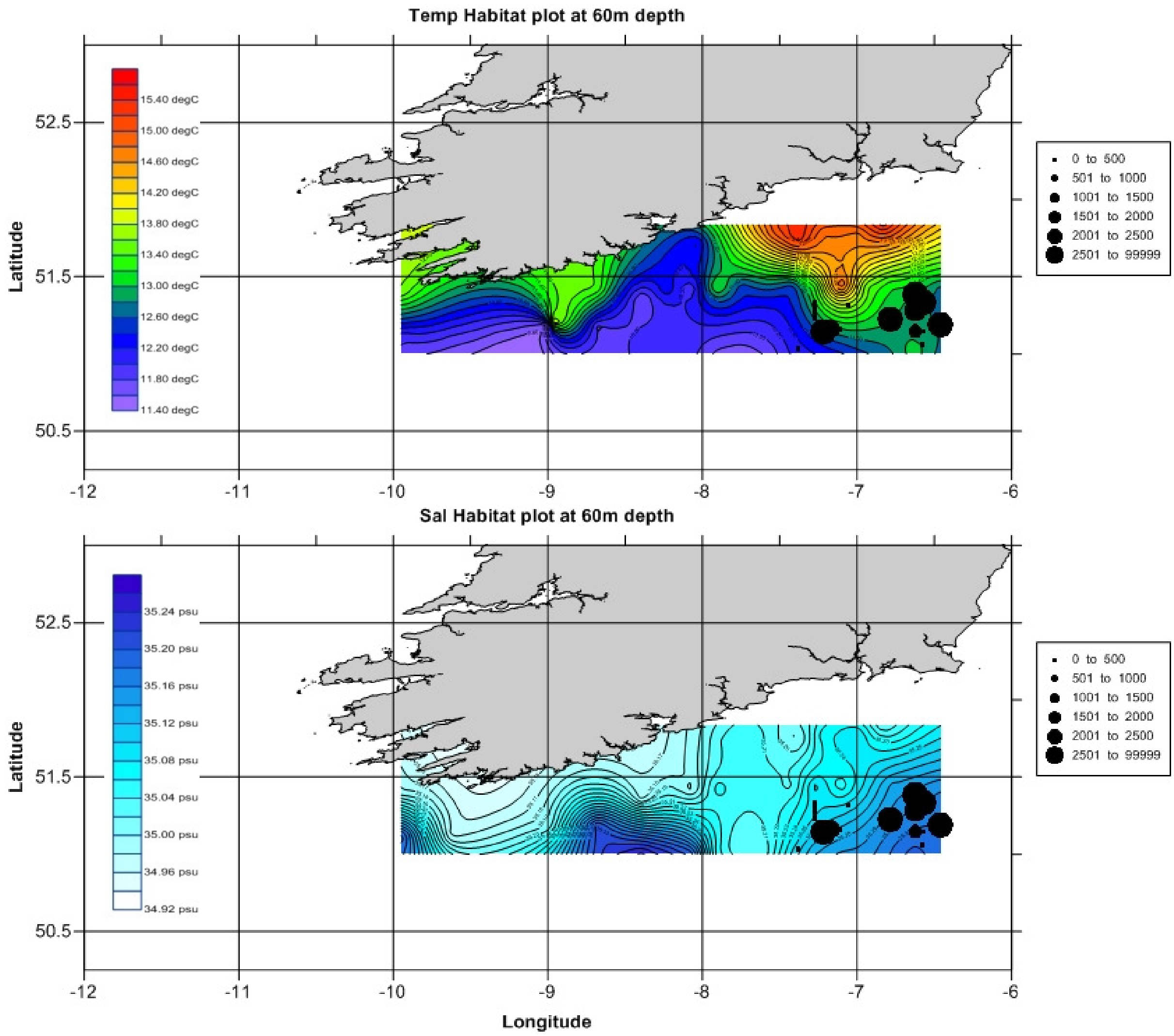

Figure 10. Habitat plots of temperature and salinity at 60m overlaid with herring NASC values (acoustic density) shown as black circles.

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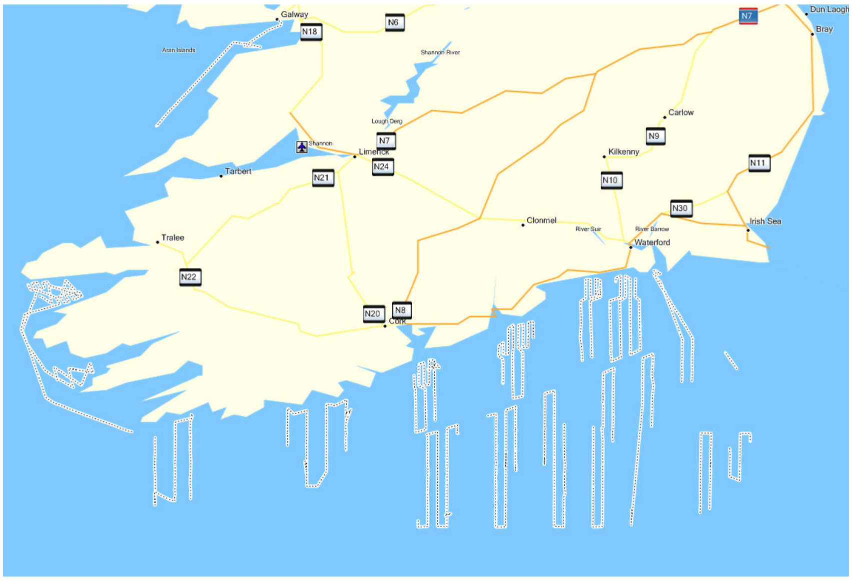


Figure 11. Marine mammal and seabird survey effort showing portion of the acoustic survey track where watch effort was attained.

HERRING MIDWATER TRAWL

40 x 20m

Herring Midwater Trawl

Fishing Circle 330m

1.1.1.2 Mesh Twine

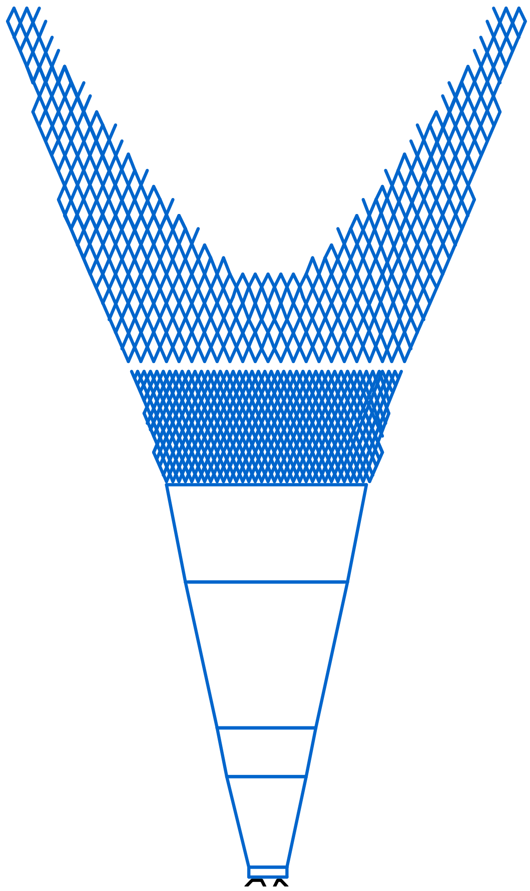
(mm) (No.)

Belly:

1600 210/624

1600 210/624

800 210/312



1.1.1.1 Mes h Twine

(mm) (No.)

Figure 12. Single herring midwater trawl net plan and layout. Celtic Sea herring acoustic survey, October 2012.

Note: All mesh sizes given in half meshes; schematic does not include 32m brailer.

Fisheries Ecosystems Advisory Services

6 Annex 1

Species Accounts: CETACEANS

Fin Whale (Balaenoptera physalus)

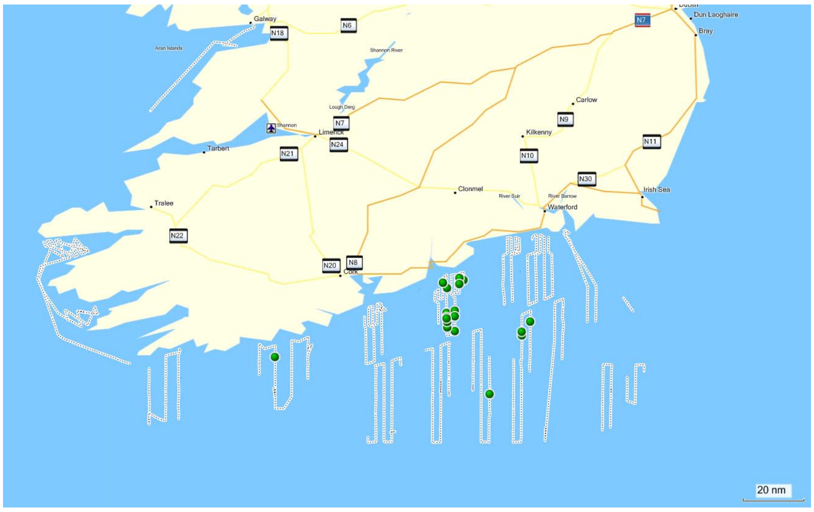


Figure 1. Fin Whale sighting events marked as green circles.

A total of 20 sighting events of Fin Whales occurred with 32 individual animals recorded. There were two significant aggregations noted, with 4 sightings (8 animals) on the 14th, and 10 sightings (16 animals) on the 22nd. The first group were approximately 27 miles SE of Ram Head, Co. Waterford, with the second group between 2 and 10 miles south of there. Photographs later indicated that at least one individually identifiable animal (likely FWIRL50 in IWDG catalogue) was seen in both groups, and as such it seems likely that at least some of the animals seen on the 14th were the same as those seen on the 22nd, approximately 20 miles apart. Feeding activity was noted in some individuals and many sightings seemed to correlate with the presence of Sprat (Sprattus sprattus) rather than Herring (Clupea harengus).

Humpback Whale (Megaptera novaeangliae)

Humpback Whales were encountered on 9 occasions in groups of 1-3, totalling an estimated 13 individuals. The easily identifiable individual HBIRL3 (aka 'Boomerang', see Fig. 5) was encountered twice on the 22nd October, south of Ram Head Co. Waterford. The first sighting of the species occurred on the 13th October when three separate groupings of 1, 2 & 3 animals were sighted at distance, identified by low, bushy blows with 8-10 blows in each sequence. Other sightings were mostly in association with Fin Whales with the last sighting on October 22nd. All sightings were in the seas south of Co. Waterford, and as with Fin Whales most sightings were correlated with the presence of Sprat in the area.

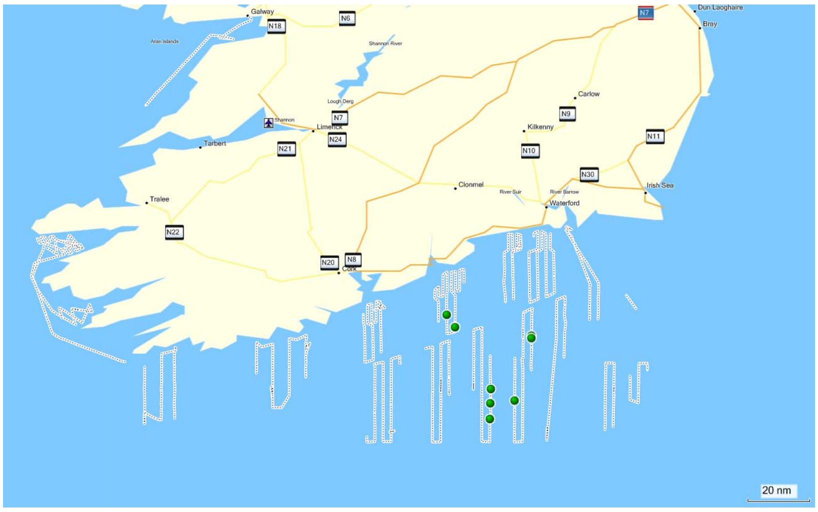


Figure 2. Humpback Whale sighting events marked as green circles.

Figure 3. Humpback Whale surfacing near Ram Head, Co. Waterford. (HBIRL3 aka 'Boomerang') © William Hunt

Minke Whale (Balaenoptera acutorostrata)

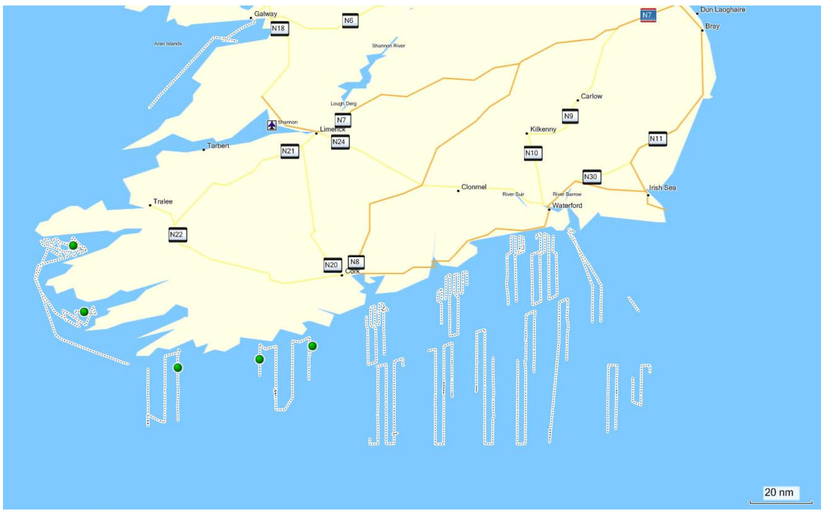


Figure 4. Minke Whale sighting events marked as green circles.

Minke Whales were encountered on 5 different occasions, each event comprising a single animal usually amidst feeding gannets and common dolphins. All occurred in the more inshore waters off the Cork and Kerry coasts, and it is somewhat surprising that none were seen south of Waterford where almost all the other baleen whales were noted amongst large concentrations of Sprat and Herring.

Figure 5. Minke Whale surfacing in Dingle Bay. © William Hunt

Risso's Dolphin (Grampus griseus)

Figure 6. Risso's Dolphin sighting events marked as green circles.

One sighting of Risso's Dolphins occurred, comprising 2 adults, with at least 1 heavily scarred male, 8 miles south of Roche's Point Co. Cork on 23rd October.

Figure 7. Risso's Dolphin ©NPWS.

Bottlenose Dolphin (Tursiops truncatus)

Figure 8. Bottlenose Dolphin sighting events marked as green circles.

A single animal briefly investigated the vessel whilst at anchor off Black Head, Co. Clare on the 7th October.

Common Dolphin (Delphinus delphis)

Numerous sightings of Common Dolphins occurred throughout the trip with sightings occurring on 15 of the 19 survey days. A total of 99 individual sightings were registered, with 2,459 animals recorded. Mean group size was 25 and ranged from individual animals to a group estimated to consist of 600 animals, sighted early on the 14th Oct approximately 50 miles south of Co. Waterford. A number of calf/adult pairs were sighted including one group of 3 adults with a calf each on the 20th October, south of Tramore, Co. Waterford. On the same day the melanistic animal captured in Fig. 12 below was also sighted.

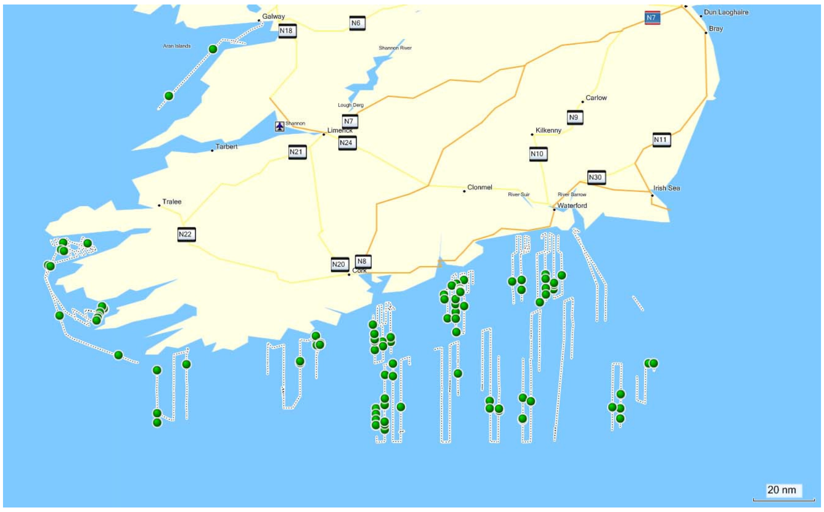


Figure 9. Common Dolphin sighting events marked as green circles.

Figure 10. Common Dolphins leaping. Melanistic individual present. © William Hunt

Harbour Porpoise (Phocoena phocoena)

Figure 11. Harbour Porpoise sighting events marked as green circles.

Three sightings of this species occurred in groups of 1-2 animals with a total of 5 individuals observed. Sightings occurred on the 6th, 10th & 13th October. Weather conditions for the first few days of the survey were very conducive to recording this species so it is somewhat surprising that no more were recorded off the Cork and Kerry coasts. Weather conditions for the rest of the survey were mostly too severe to reliably record this very unobtrusive species.

Unidentified Whale/Large Whale

Ten sightings of unidentifiable whales occurred during the survey. Each event involved a single animal, with the first sighting occurring on 13th Oct and the last on the 23rd October. Distance, poor lighting and brevity of encounters made positive ID of animals difficult. The large whales were noted to have conspicuous blows and were most likely to have been Fin or Humpback whales.

Unidentified Dolphin

Three dolphin sightings occurred, which could not be reliably identified to species level.

Unidentified Cetacean

There were 3 sightings of individual cetaceans which were extremely brief in nature or consisted of brief views of very inconspicuous blows, and it could not be determined with certainty if the sightings referred to whales or dolphins

Species Accounts: Other marine mega fauna

Grey Seal (Halichoerus grypus)

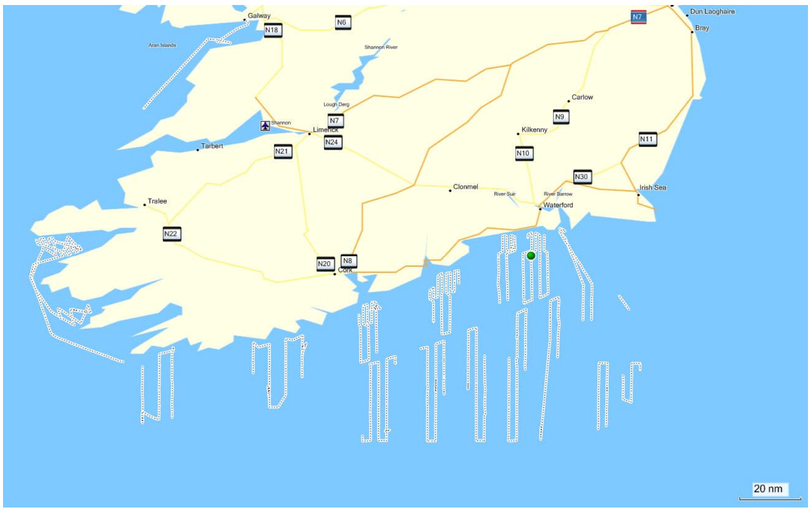


Figure 12. Grey Seal sighting event marked as green circle.

A single sighting of a Grey Seal occurred on the 20th October approximately 8 miles south of Tramore, Co. Waterford.

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Bluefin Tuna (Thunnus thynnus)

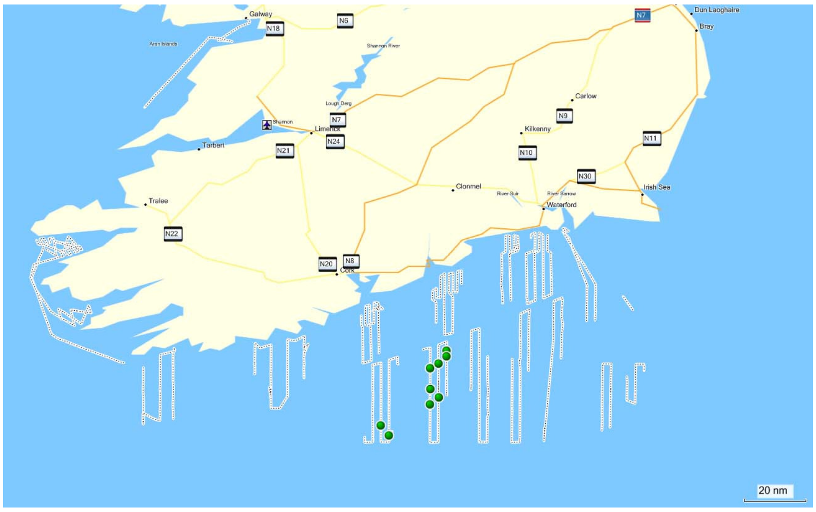

Figure 13. Bluefin Tuna sighting events marked as green circles.

Bluefin tuna were a regular sighting on the 11th & 12th October, with a large feeding frenzy estimated to be in excess of 100 individuals occurring on the 11th (Fig. 7). The sightings occurred generally in the region of 35 miles south of Ballycotton, Co. Cork. Tuna were identified by splashes at the surface, with spray directed almost horizontally in energetic bursts while feeding. A total of 9 sighting events were recorded, with an estimated 222 animals present. A single unidentified Tuna species was recorded on the 13th October. Although views were too poor to enable specific identification it was considered most likely to be another Bluefin Tuna.

Figure 14. Bluefin Tuna feeding, probably on sprat, near the surface approximately 45' S of Roche's Point. © William Hunt

Leatherback Turtle (Dermochelys coriacaea)

Four sightings of individual Leatherback turtles occurred. The first one was sighted off of Deenish Island, Co Kerry on the 8th October while a further 3 were sighted in the space of 30 minutes on the 11th October. These latter were seen over a distance of ~4 nautical miles.

Figure 15. Leatherback Turtle sighting events marked as green circles.

Figure 16. Leatherback turtle sighted near Deenish Island, Co. Kerry. © William Hunt

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Direct assessment of small pelagic fish by the PELGAS14 acoustic survey

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1. MATERIAL AND METHOD

1.1. PELGAS survey on board Thalassa

Acoustic surveys are carried out every year in the Bay of Biscay in spring onboard the French research vessel Thalassa. The objective of PELGAS surveys is to study the abundance and distribution of pelagic fish in the Bay of Biscay. The main target species are anchovy and sardine but they are considered in a multi-specific context and within an ecosystemic approach as they are located in the centre of pelagic ecosystem.

These surveys are connected with IFREMER programs on data collection for monitoring and management of fisheries and ecosystemic approach for fisheries. This task is formally included in the first priorities defined by the Commission regulation EU N° 199/2008 of 06 November 2008 establishing the minimum and extended Community programmes for the collection of data in the fisheries sector and laying down detailed rules for the application of Council Regulation (EC) No 1543/2000. These surveys must be considered in the frame of the Ifremer fisheries ecology action "resources variability" which is the French contribution to the international Globec programme. It is planned with Spain and Portugal in order to have most of the potential area covered from Gibraltar to Brest with the same protocol regarding sampling strategy. Data are available for the ICES working groups WGHANSA, WGWIDE and WGACEGG.

In the spirit of the ecosystemic approach, the pelagic ecosystem is characterised at each trophic level. To achieve this and to assess an optimum horizontal and vertical description of the area, two types of actions are combined :

1) Continuous acquisition of acoustic data from six different frequencies and pumping sea-water under the surface in order to evaluate the number of fish eggs using a CUFES system (Continuous Under-water Fish Eggs Sampler)
2) discrete sampling at stations (by pelagic trawls, plankton nets, CTD). Satellite imagery (temperature and sea colour) and modelling have been also used before and during the survey to recognise the main physical and biological structures and to improve the sampling strategy. Concurrently, a visual counting and identification of cetaceans and birds (from board) carried out in order to characterise the higher level predators of the pelagic ecosystem.

The strategy this year was the identical to previous surveys (2000 to 2013). The protocol for acoustics has been described during WGACEGG in 2009 (*Doray et. Al,2009*):

- acoustic data were collected along systematic parallel transects perpendicular to the French coast (figure 1.1.1). The length of the ESDU (Elementary Sampling Distance Unit) was 1 mile and the transects were uniformly spaced by 12 nautical miles and cover the continental shelf from 20 m depth to the shelf break (or sometimes more offshore – see figure below).
- acoustic data were only collected during the day because of pelagic fishes behaviour in this area. These species are usually dispersed very close to the surface during the night and so "disappear" in the blind layer of the echo-sounders between the surface and 8 m depth.

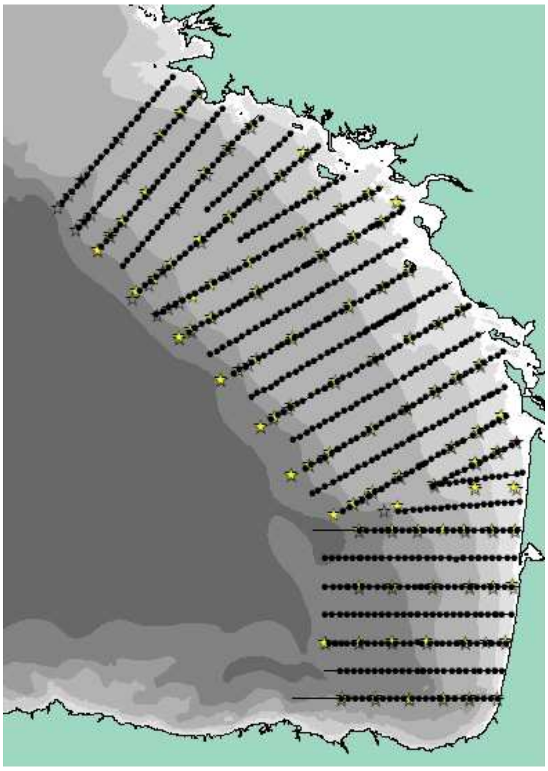


Fig. 1.1.1 - Transects prospected during PELGAS14 by Thalassa.

Three different echo-sounders were used during the survey :

In 2014, as in previous surveys (since 2009), three modes of acoustic observations were used :

- 6 split beam vertical echo-sounders (EK60), 6 frequencies, 18, 38, 70, 120, 200 and 333 kHz
- 1 horizontal echo-sounder on the starboard side for surface echo-traces
- 1 SIMRAD ME70 multi-beam echo-sounder (32 x 2°beams, from 70 to 120 kHz) used essentially for visualisation to observe the behaviour and shapes of fish schools during the whole survey. Nevertheless, only echoes stored on the vertical echo-sounder were used for abundance index calculation.

Energies and samples provided by all sounders were simultaneously visualised and stored using the MOVIES+ and MOVIES3D software and stored at the same standard HAC format.

The calibration method was the same that the one described for the previous years (see WD 2001) and was performed at anchorage in the Douarnenez bay, in the West of Brittany, in good meteorological conditions at the end of the survey.

Acoustic data were collected by R/V Thalassa along a total amount of 6230 nautical miles from which 2011 nautical miles on one way transect were used for assessment. A total of 28 352 fishes were measured (including 9038 anchovies and 8129 sardines) and 2458 otoliths were collected for age determination (1197 of anchovy and 1261 of sardine).

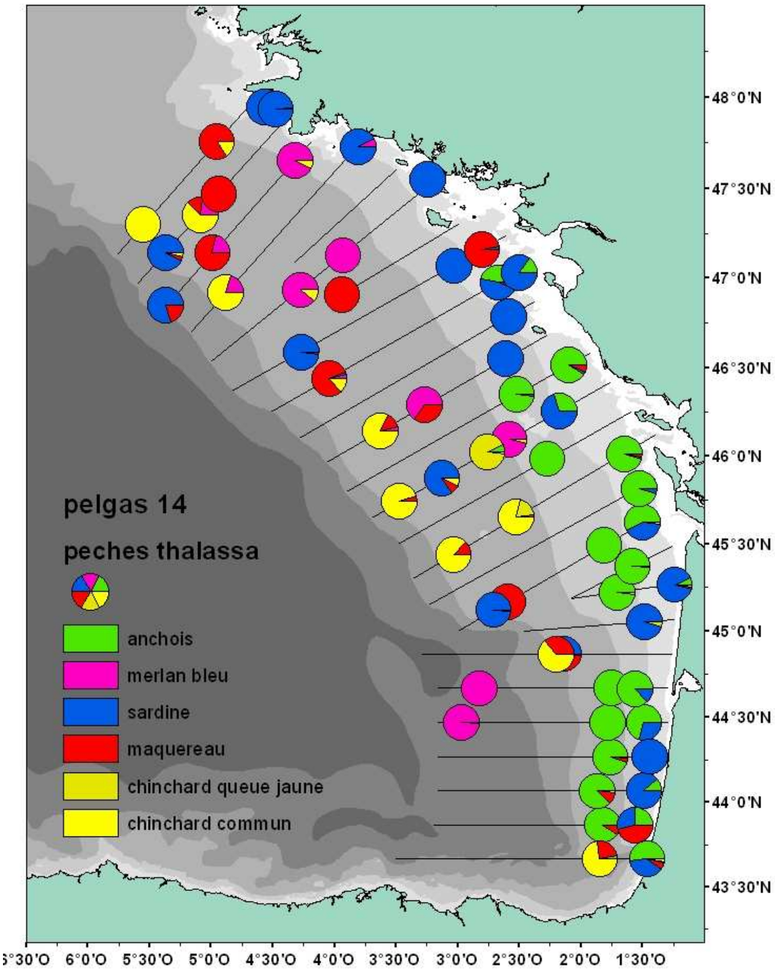


Fig. 1.1.2: Species distribution according to Thalassa identification hauls.

1.2. The consort survey

A consort survey is routinely organised since 2007 with French commercial vessels during 18 days. This approach, in the continuity of last year survey, and their trawl hauls were used for echoes identification and biological parameters at the same level than Thalassa ones.

Five commercial vessels (two pairs of pelagic trawlers during the two first weeks and a single pelagic trawler for the 4 last days) participated to PELGAS14 survey:

Vessel	gear	Period	Days at sea
Le Natif / La Roumasse	Pelagic pair trawl	30/04 to 05/05/2014	7
Le Joker / Ar Raok II	Pelagic pair trawl	06/05 to 12/05/2014	7
Bara Pemdez II	Pelagic single trawl	20/05 to 24/05/2014	4

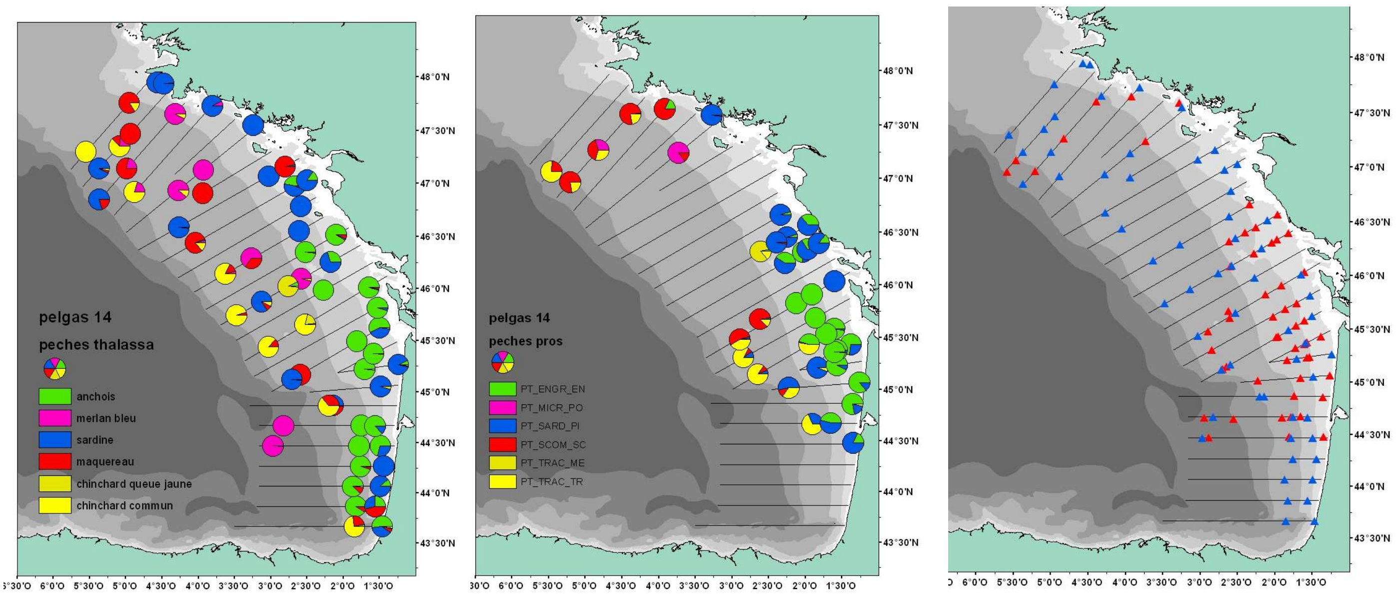
The regular transects network agreed for several years for Thalassa is 12 miles separated parallel transects. Commercial vessels worked between standard transects and 2 NM northern.

Sometimes, they carried out fishing operations on request (complementary to Thalassa, particularly for surface hauls or in very coastal areas) Their pelagic trawl was until 25 m vertical opening and the mesh of their codend was similar to Thalassa (12 mm).

A scientific observer was onboard to control every operation, and to collect biological data. The fishing operations were systematically agreed after a radio contact with Thalassa in order to confirm their usefulness. In some occasions, the use was to check the spatial extension of species already observed and identified by Thalassa (and therefore the spatial distribution), in others the objective was to enlarge the vertical distribution description by stratified catches. Globally, a great attention was given on a good distribution of samples to avoid over-sampling on some situations. Regularly a biological sample was provided by commercial vessels to Thalassa to improve otoliths collection and sexual maturity (351 otoliths of anchovy, 304 of sardine). A total of 14 648 fishes were measured onboard commercial vessels, including 5599 anchovies and 4044 sardines.

The catches and biological data have been directly used with the same consideration than Thalassa ones for identification and biological characterisation.

A total of 116 hauls were carried out during the assessment coverage including 62 hauls by Thalassa and 54 hauls by commercial vessels.



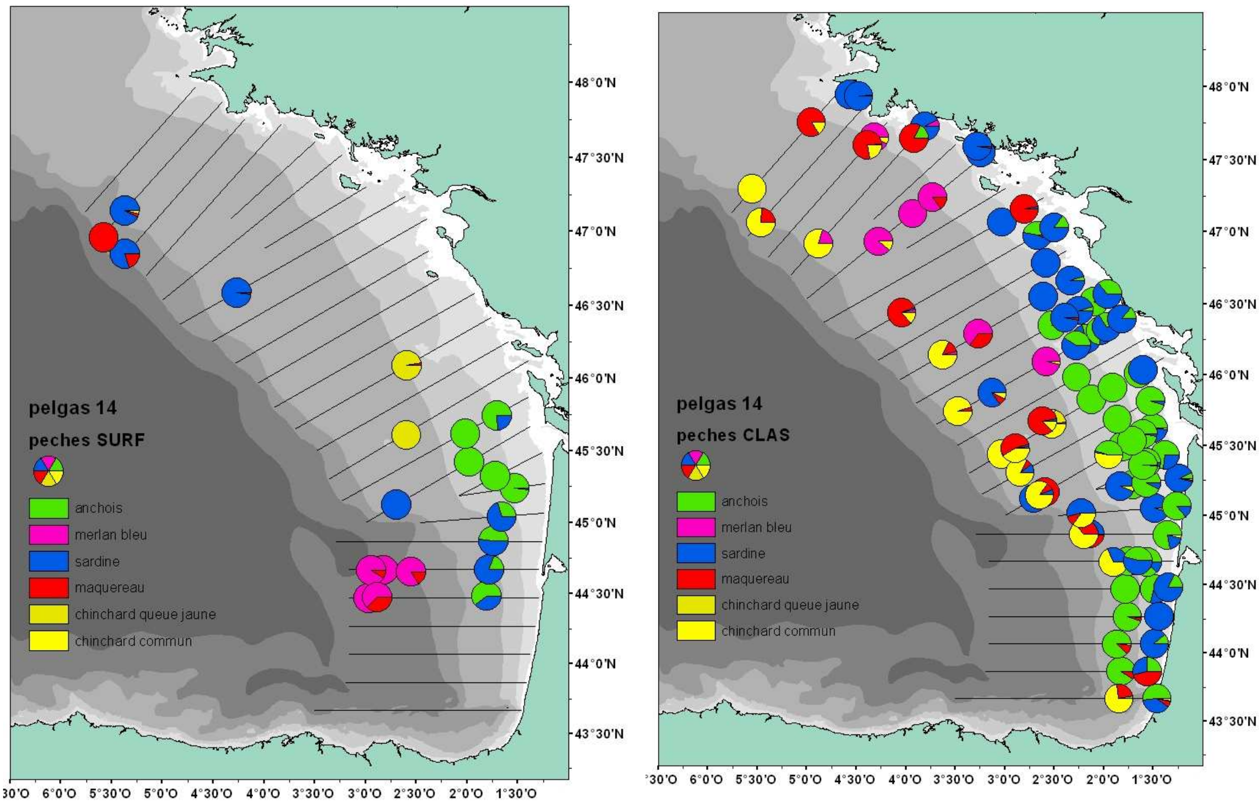
a) Thalassa (nb :62) *b) Commercial vessels (nb : 54)* *c) all fishing hauls (nb :116) thalassa n Blue and commercial in red*

Figure 1.2.2 : fishing operations carried out by Thalassa and commercial vessels during consort survey PELGAS14

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

	R/V Thalassa	Commercial vessels	Total
Surface Hauls	**5**	**16**	**21**
Classic Hauls	**52**	**35**	**87**
Valid	**57**	**51**	**108**
Null	5	3	8
Total	62	54	116

Table 1.2.3. : number of fishing operations carried out by Thalassa and commercial vessels during consort survey PELGAS14



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

b) classic Hauls carried out near the bottom and 50m upper (Thalassa + commercial vessels)

Figure 1.2.4 : Vertical localisation of fishing operations carried out by Thalassa and commercial vessels during survey PELGAS14

2. ACOUSTICS DATA PROCESSING

2.1. Echo-traces classification

All the acoustic data along the transects were processed and scrutinised by the date of the meeting. Acoustic energies (Sa) have been cleaned by sorting only fish energies (excluding bottom echoes, parasites, plankton, etc.) and classified into 5 categories of echo-traces this year :

D1 – energies attributed to mackerel, chub mackerel, horse mackerel, blue whiting, hake, whiting, corresponding to cloudy schools or layers (sometimes small dispersed points) close to the bottom or of small drops in a 10m height layer close to the bottom.

D2 –energies attributed to anchovy, sardine, and sprat corresponding to the usual echo-traces observed in this area since more than 15 years, constituted by schools well defined, mainly situated between the bottom and 50 meters above. These echoes are typical of clupeids in coastal areas and sometimes more offshore.

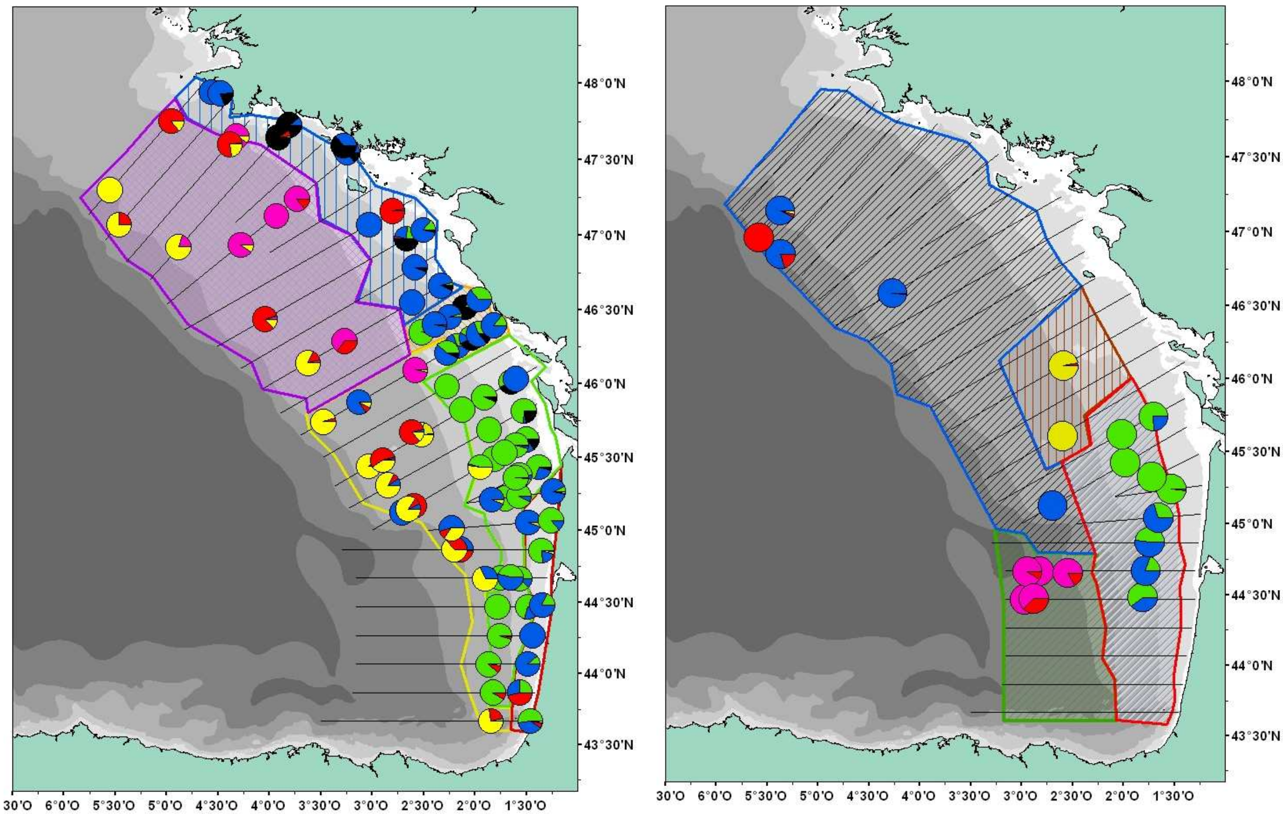
D3 – energies attributed to scattered detection corresponding to blue whiting, myctophids, boarfish and mackerel.

D4 – energies attributed to sardine, mackerel and anchovy corresponding to small and (mainly) dense echoes, very close to the surface.

D8 – energies attributed exclusively to sardine (big and very dense schools).

2.2. Splitting of energies into species

As for previous years (except in 2003, see WD-2003), the global area has been split into several strata where coherent communities were observed (species associations) in order to minimise the variability due to the variable mixing of species. Figure 2.2. shows the strata considered to evaluate biomass of each species. For each strata, energies where converted into biomass by applying catch ratio, length distributions and weighted by abundance of fish in the haul surrounded area.



Coherent classic strata Coherent surface strata

Fig. 2.2. – Coherent strata (classic and surface), in terms of echoes and species distribution, taken into consideration for multi-species biomass estimate from acoustic and catches data during PELGAS14 survey.

2.3. Biomass estimates

The fishing strategy has been followed all along the survey in order to profit of the best efficiency of each vessel and maximise the number of samples (in term of identification and biological parameters as well). Therefore, the commercial vessels carried out mostly surface hauls when Thalassa fish preferably in the bottom layer. According to previous strata, using both Thalassa and consort fishing operations, biomass estimates have been calculated for each main pelagic species in the surveyed area.

Biomass indices are gathered in tables 2.3.1. and 2.3.2., and in figure 2.3.1. No estimate has been provided for mackerel according to the low level of TS and particular behaviour in the Bay of Biscay where it is scattered and mixed with plankton echoes.

Anchovy was present this year as a relatively high abundance index (above the average of the serie), with a bit more than 125 000 tonnes, exclusively from the coast to the depth of 100m.

Sardine was still well present this year, mostly in coastal waters from the South until the North of the bay of Biscay. It was also spotted offshore (mainly in the Northern part), in lower quantity, near the surface.

About other species, an other characteristic of this year is that horse mackerel shows a small increase of the biomass, but keep a low level at this period in the bay of Biscay.

Mackerel appears very dispersed all over the area, and mainly close to the surface. It was the most abundant specie close to the surface, all clupeids appearing this year in coastal waters.

	Classic	Surface	Total
Anchovy	110 343	15 084	**125 427**
Sardine	308 759	30 848	**339 607**
Sprat	33 894		**33 894**
Mackerel	110 174	300 006	**410 181**
Horse Mackerel	53 154		**53 154**
Blue whiting	25 015		**25 015**

Table 2.3.1. Acoustic biomass index for the main species by strata during PELGAS14

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
anchovy	**113 120**	**105 801**	**110 566**	**30 632**	**45 965**	**14 643**	**30 877**	**40 876**	**37 574**	**34 855**	**86 354**	**142 601**	**186 865**	**93 854**	**125 427**
CV anchovy	*0.064*	*0.141*	*0.113*	*0.132*	*0.167*	*0.171*	*0.136*	*0.100*	*0.162*	*0.112*	*0.147*	*0.07741*	*0.04665*	*0.12821*	*0.062928*
Sardine	**376 442**	**383 515**	**563 880**	**111 234**	**496 371**	**435 287**	**234 128**	**126 237**	**460 727**	**479 684**	**457 081**	**338 468**	**205 627**	**407 740**	**339 607**
CV sardine	*0.083*	*0.117*	*0.088*	*0.241*	*0.121*	*0.135*	*0.117*	*0.159*	*0.139*	*0.098*	*0.091*	*0.06991*	*0.07668*	*0.07382*	*0.065212*
Sprat	**30 034**	**137 908**	**77 812**	**23 994**	**15 807**	**72 684**	**30 009**	**17 312**	**50 092**	**112 497**	**67 046**	**34 726**	**6 417**	**44 651**	**33 894**
CV sprat	*0.098*	*0.155*	*0.120*	*0.198*	*0.178*	*0.228*	*0.162*	*0.132*	*0.268*	*0.108*	*0.108*			*0.19922*	*0.241009*
Horse mackerel	**230 530**	**149 053**	**191 258**	**198 528**	**186 046**	**181 448**	**156 300**	**45 098**	**100 406**	**56 593**	**11 662**	**61 237**	**7 435**	**33 471**	**53 154**
CV HM	*0.079*	*0.204*	*0.156*	*0.137*	*0.287*	*0.160*	*0.316*	*0.065*	*0.455*	*0.09*	*0.188*			*0.30067*	*0.227089*
Blue Whiting	-	-	**35 518**	**1 953**	**12 267**	**26 099**	**1 766**	**3 545**	**576**	**4 333**	**48 141**	**11 823**	**68 533**	**25 715**	**25 015**
CV BW	-	-	*0.386*	*0.131*	*0.202*	*0.593*	*0.210*	*0.147*	*0.253*	*0.219*	*0.074*			*0.15422*	*0.337606*

Table 2.3.2. Acoustic biomass index for the five main pelagic species since the beginning of PELGAS surveys (2000)

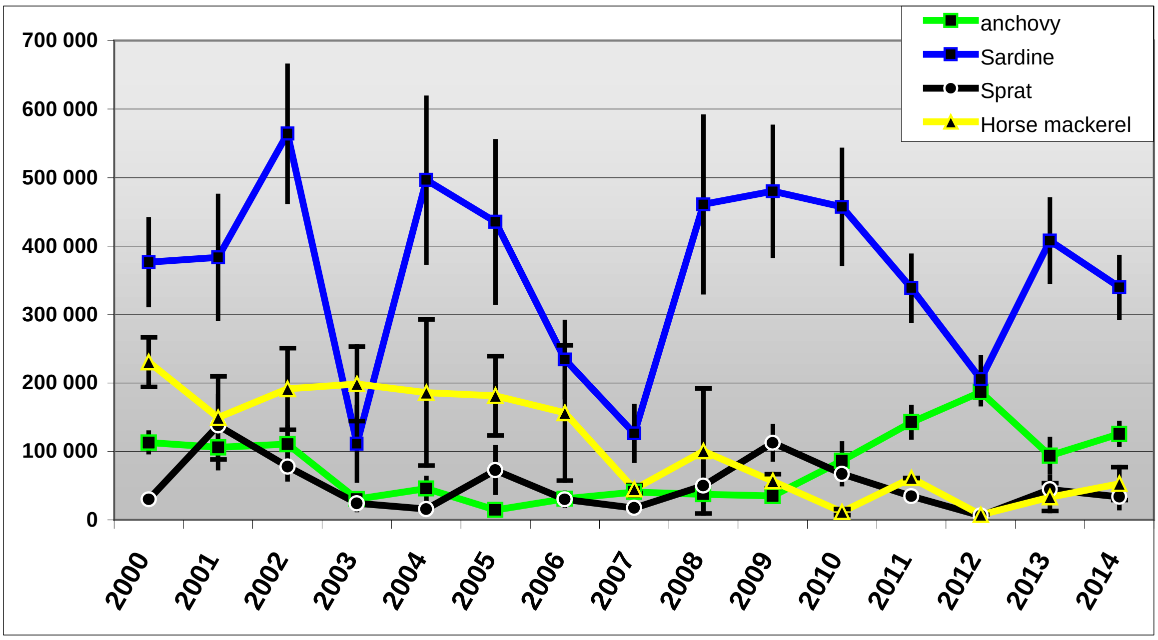


figure 2.3.1. – biomass estimate using Thalassa acoustic data along transects and all the consort identification fishing operations (Thalassa + commercial vessels) and coefficients of variation associated.

2.4. Validation of the echotraces srutinizing

This year, a study was done on the impact of the person operating the srutinization of the echotraces. As last year, 4 people were able to do it (including a new one). Some transects analyses were done in parallel by each "srutinizer" to assess the impact on the biomass calculation. This impact is low for the two most important species targeted by the PELGAS survey (sardine and anchovy, less than 10% of difference for these two species in terms of final biomass estimate).

Nevertheless, this bias seems to be more important on mackerel and horse mackerel : for 3 "scrutinizers", the result is good with differences of less than 10 percent for each biomass calculation for the same species. But for one person (the new one), the difference in the final index seems to be significant with an increase of 30 % compared to the other ones.

This exercise will be carried on again next years, with a real intercalibration, and probably a workshop before the next survey to teach everybody the scrutinizing of the echoes in the same manner.

3. ANCHOVY DATA

3.1. anchovy biomass

The biomass estimate of anchovy observed during PELGAS13 is **125 427** tons. (table 2.3.), which is at a high level on the PELGAS series, and constituting a new increase of this biomass in the bay o Biscay.

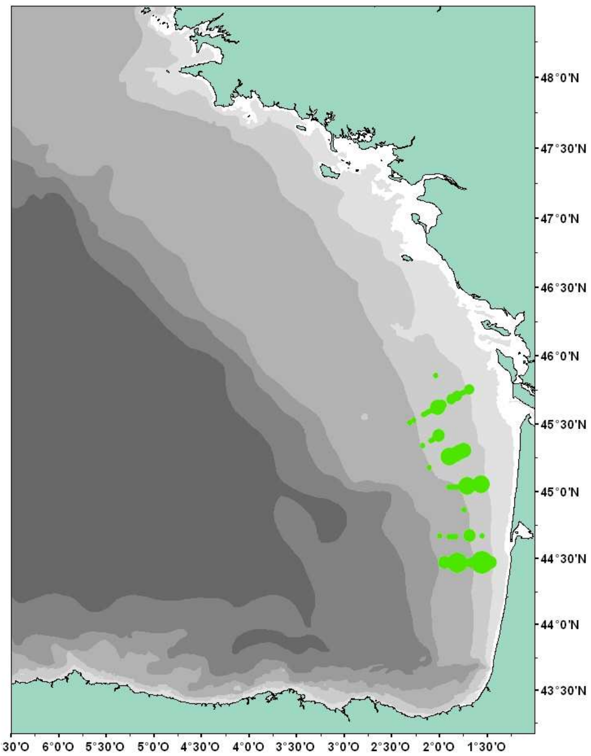
The main observation in 2013 is that sardine, anchovy and sprat were well present in important densities in coastal waters. These echoes were systematically identified on each transect and revealed almost pure anchovy in the Gironde area (mainly one year old in front of the river plume).

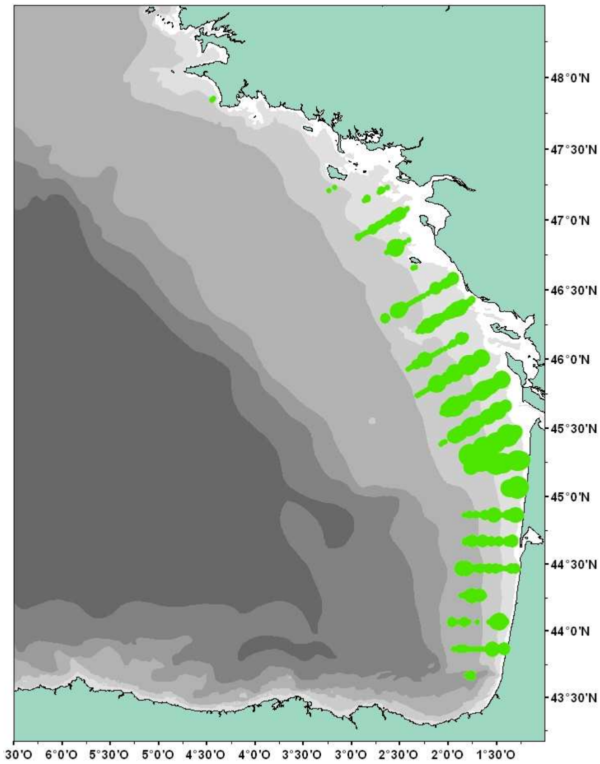
In the Gironde area, we found a configuration more classic (in size and in Sa), with an acoustic energy attributed to anchovy about the average, and far away from the very high energies from 2012. Nevertheless, anchovy was predominant in this area. The most part of the age 1 of anchovy was there, in size class comparable with a "normal" year (all, except 2012 where the fish was much smaller).

In the South part of the bay of Biscay, anchovy was also well present in the middle of the platform, in the whole water column (close to the bottom until the surface).

On the South coast of Brittany, sightings of anchovy occurred around the Loire river and in much lower quantities in the south west of Brittany, still along the coast.

One thing must be noticed this year, the absence of anchovy along the shelf break, neither at the surface, nor at the bottom.





Surface distribution

Classic distribution, between the bottom and 40m above

Figure 3.1. – Anchovy distribution according to PELGAS14 survey.

3.2. Anchovy length structure

Length distribution in the trawl hauls were estimated from random samples. The population length distributions (figures 3.2.1 and 3.2.2) has been estimated by a weighted average of the length distribution in the hauls. Weights used are acoustic coefficients (Dev*Xe Moule in thousands of individuals per n.m.^{2}) which correspond to the abundance in the area sampled by each trawl haul.

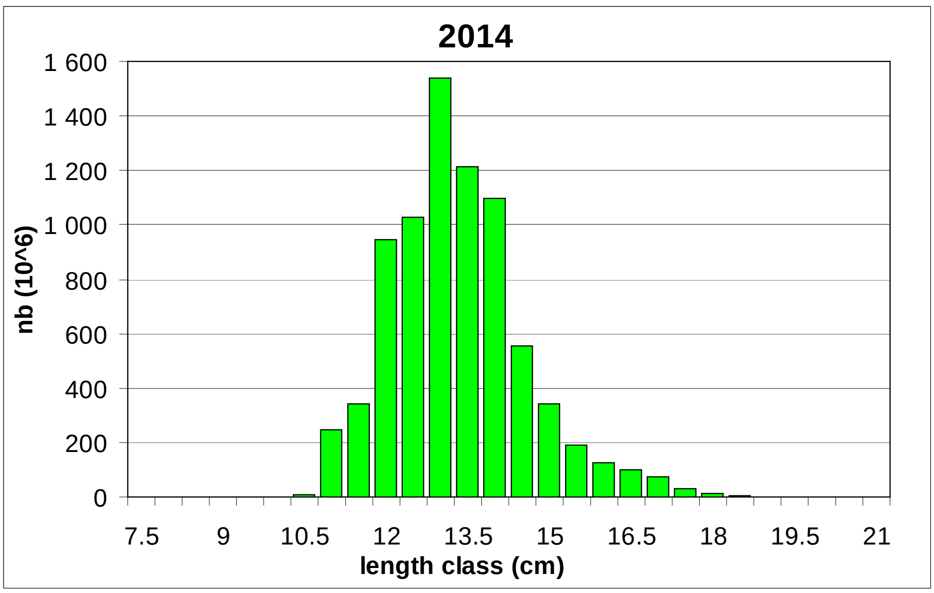


Figure 3.2.1: length distribution of global anchovy as observed during PELGAS14 survey

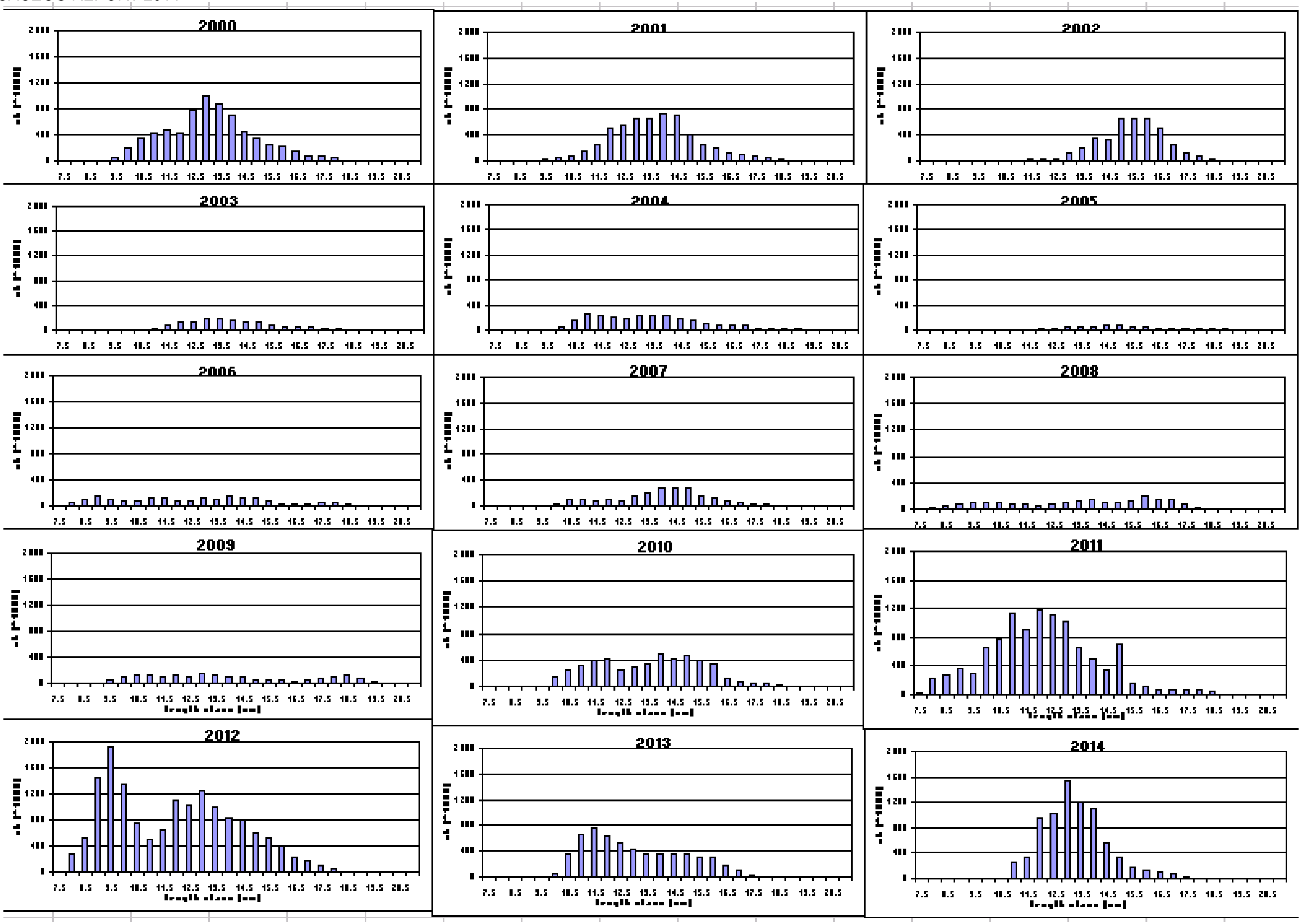


Figure 3.2.2. – length composition of anchovy as estimated by acoustics since 2000

. 3.3. Demographic structure

An age length key was built for anchovy from the trawl catches (Thalassa hauls) and samples from commercial vessels. We took the otoliths from a set number of fishes per length class (4 to 6 / half-cm), for a total amount of around 50 fish per haul. As there was a lot of fishing operations where anchovy was present, the number of otoliths we took during the survey was more or less the same as the 3 last years (1197 otoliths read on board), The population length distributions were estimated by a weighted use of length distributions in the hauls, weighted as described in section 3.2.

NB age	age				
length (mm)	1	2	3	4	Total
85	100.00%	0.00%	0.00%	0.00%	100.00%
90	100.00%	0.00%	0.00%	0.00%	100.00%
95	100.00%	0.00%	0.00%	0.00%	100.00%
100	100.00%	0.00%	0.00%	0.00%	100.00%
105	100.00%	0.00%	0.00%	0.00%	100.00%
110	88.89%	3.70%	7.41%	0.00%	100.00%
115	77.42%	19.35%	3.23%	0.00%	100.00%
120	92.00%	6.67%	1.33%	0.00%	100.00%
125	89.36%	10.64%	0.00%	0.00%	100.00%
130	85.93%	14.07%	0.00%	0.00%	100.00%
135	84.72%	13.19%	2.08%	0.00%	100.00%
140	66.42%	31.39%	2.19%	0.00%	100.00%
145	57.63%	38.14%	3.39%	0.85%	100.00%
150	46.15%	43.27%	9.62%	0.96%	100.00%
155	27.27%	61.36%	9.09%	2.27%	100.00%
160	13.85%	64.62%	18.46%	3.08%	100.00%
165	2.13%	74.47%	17.02%	6.38%	100.00%
170	0.00%	61.11%	33.33%	5.56%	100.00%
175	0.00%	51.85%	37.04%	11.11%	100.00%
180	0.00%	30.77%	61.54%	7.69%	100.00%
185	0.00%	66.67%	33.33%	0.00%	100.00%
190	0.00%	0.00%	100.00%	0.00%	100.00%

Table 3.3.1. PELGAS14 anchovy Age/Length key.

Applying the age distribution to the abundance in biomass and numbers, the distribution in age of the biomass has been calculated. The total biomass used here has been updated with the value obtained from the previous method based on strata.

Age distribution is shown in figures 3.3.2. The age distributions compared from 2000 to 2014 are shown in figure 3.3.3.

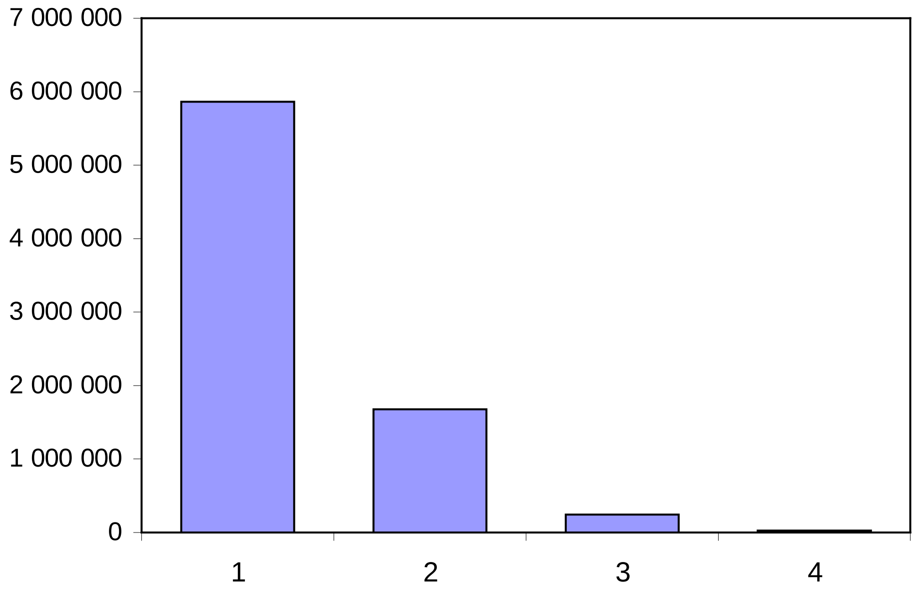


Figure 3.3.2– global age composition (numbers) of anchovy as observed during PELGAS14.

Looking at the numbers at age since 2000 (fig 3.3.3.), the number of 1 year old anchovies this year seems to be around the average of the serie, but far away from the 2011 and 2012 levels of recruitment.

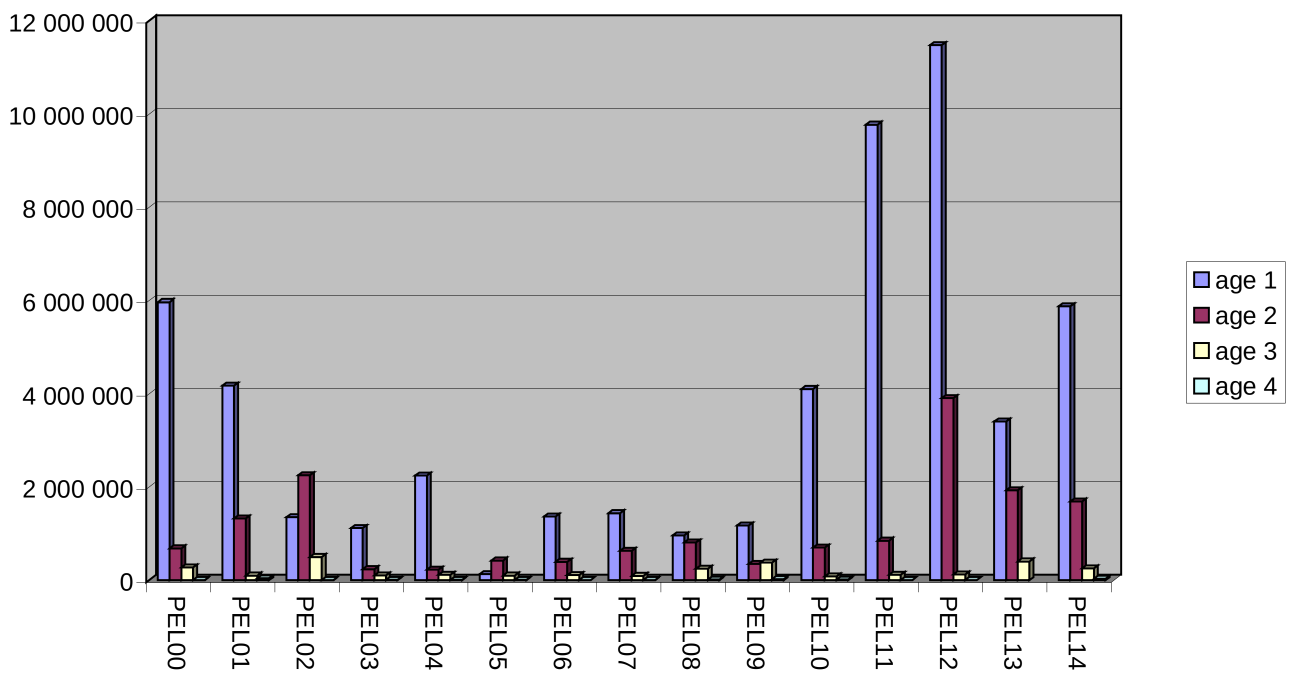


Figure 3.3.3 Anchovy numbers at age as observed during PELGAS surveys since 2000

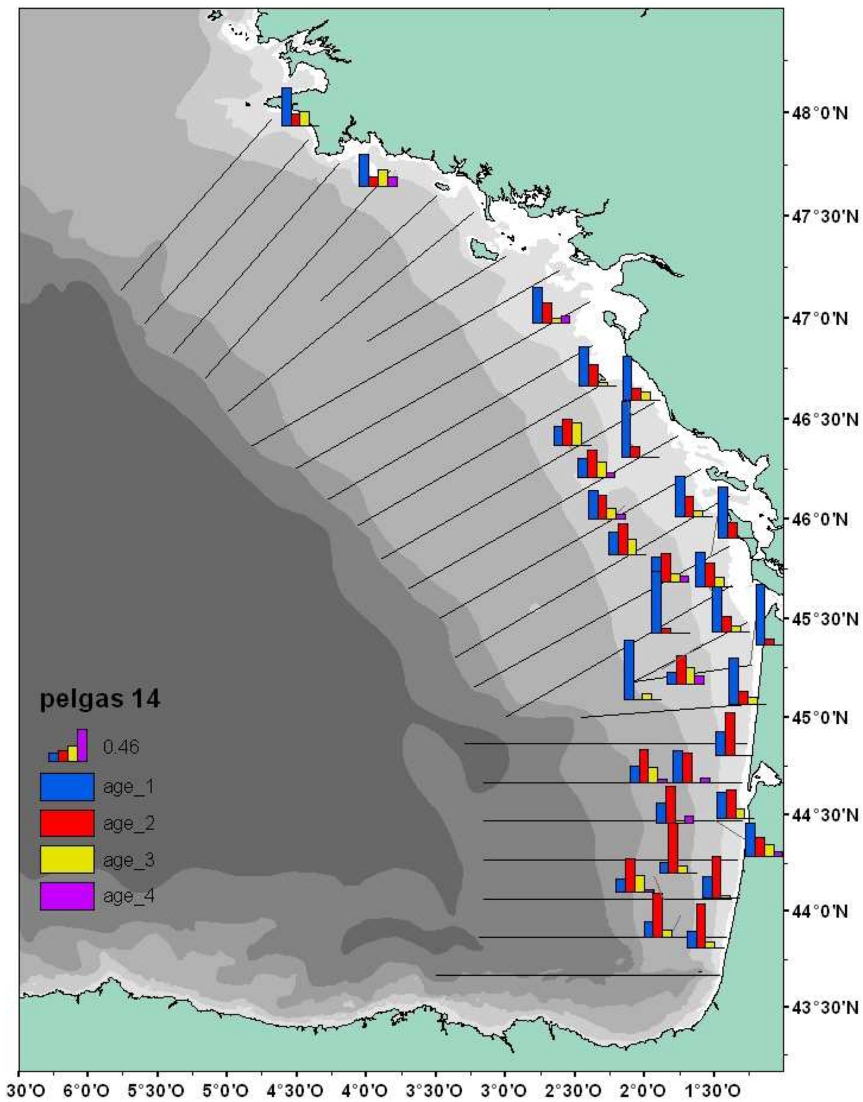


Figure 3.3.4 Anchovy proportion at age in each haul as observed during PELGAS14 survey.

During previous surveys, anchovy was well geographically stratified depending on the age (*see WD 2010, Direct assessment of small pelagic fish by the PELGAS10 acoustic survey, Masse J and Duhamel E.*). It is less true this year as age1 were as usual predominant in the Gironde area, but also dispersed on the platform, mixed with age 2..

age	PEL14 % - nb
1	74.8
2	21.5
3	3.3
4	0.4

age	PEL14 - % W
1	69.1
2	25.7
3	4.5
4	0.7

Figure 3.3.5 percentage by age of the Anchovy population observed during PELGAS14 in numbers (left) and biomass (right).

3.4. Weight/Length key

Based on 1197 weights of individual fishes, the following weight/length key was established (figure 4.5.) :

W= 2E-06L$^{3.2032}$ with R2 = 0.9537 *(with W in grams and L in mm)*

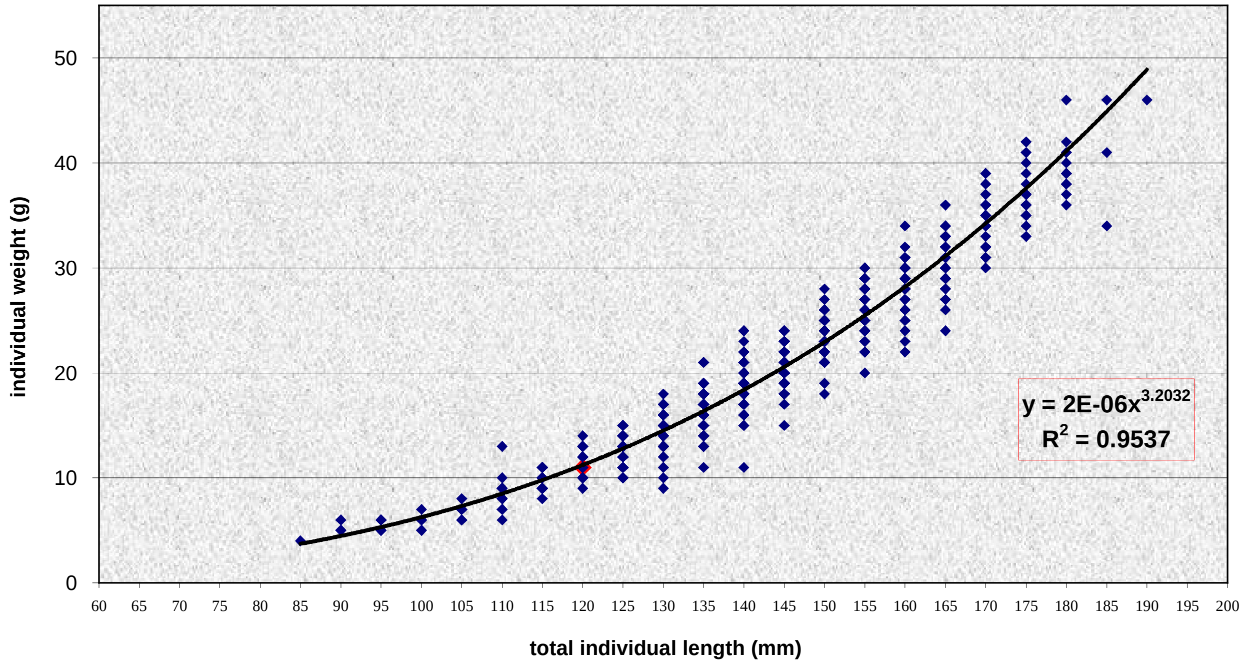


Fig. 3.4. – Weight/length key of anchovy established during PELGAS14

3.5. Mean Weight at age

mean weigth at age (g)	AGE			
survey	1	2	3	4
PEL00	14.78	25.98	30.62	36.06
PEL01	16.09	25.91	21.28	36.39
PEL02	20.41	27.17	28.49	36.85
PEL03	16.73	25.63	32.79	28.79
PEL04	15.12	32.83	36.98	52.32
PEL05	18.80	26.29	32.75	30.74
PEL06	13.39	25.47	31.87	46.12
PEL07	17.80	24.28	20.66	
PEL08	11.57	26.94	27.34	27.37
PEL09	15.26	31.04	40.24	41.59
PEL10	15.74	25.94	34.78	48.11
PEL11	11.33	27.13	26.02	60.54
PEL12	7.72	19.70	20.85	35.36
PEL13	12.61	21.34	26.46	
PEL14	14.52	18.92	21.82	28.53

Fig. 3.5. – mean weight at age (g) of anchovy for each PELGAS survey

3.6. Eggs

During this survey, in addition of acoustic transects and pelagic trawl hauls, 788 CUFES samples were collected and counted, 67 vertical plankton hauls and 110 vertical profiles with CTD were carried out. Eggs were sorted and counted during the survey.

This year was classical in terms of eggs spatial distribution, according to the adults, with maximum for anchovy in the middle of the shelf, a few along the coast North of the Gironde, and a very low abundance along the shelf break (fig 3.6.1).

Looking at the time series from 2000 to 2014 (Figure 3.6.2. and 3.6.3.), anchovy eggs abundance is above the average of the time series since 2000, but far away from the 2011 strong peak.

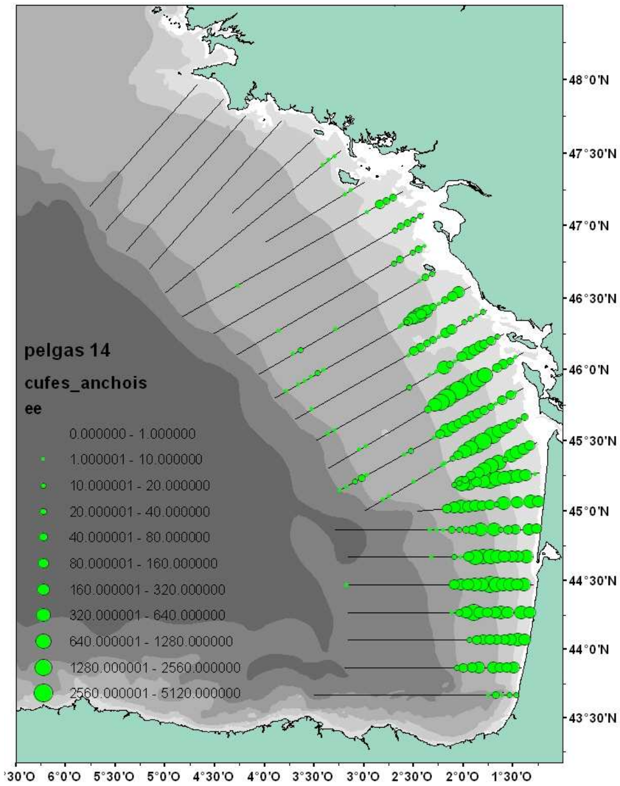


Figure 3.6.1 – Distribution of anchovy eggs observed with CUFES during PELGAS14.

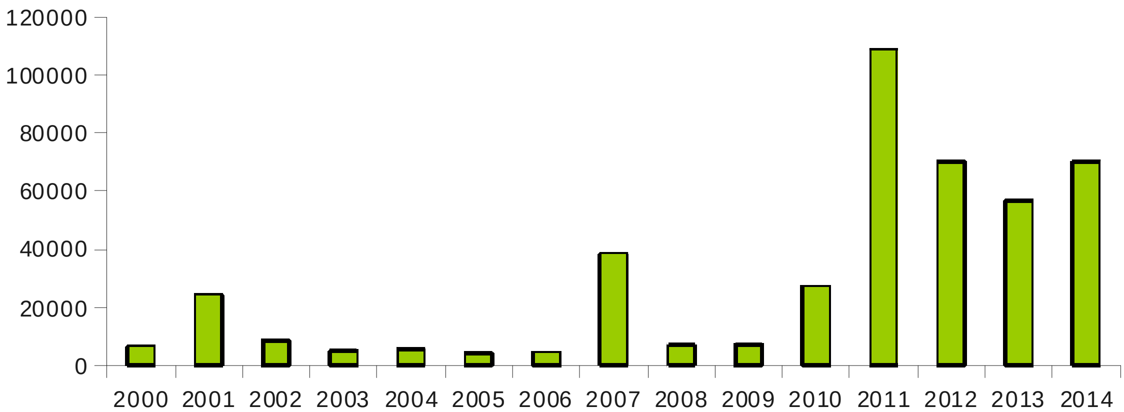


Figure 3.6.2 – Number of eggs observed during PELGAS surveys from 2000 to 2014

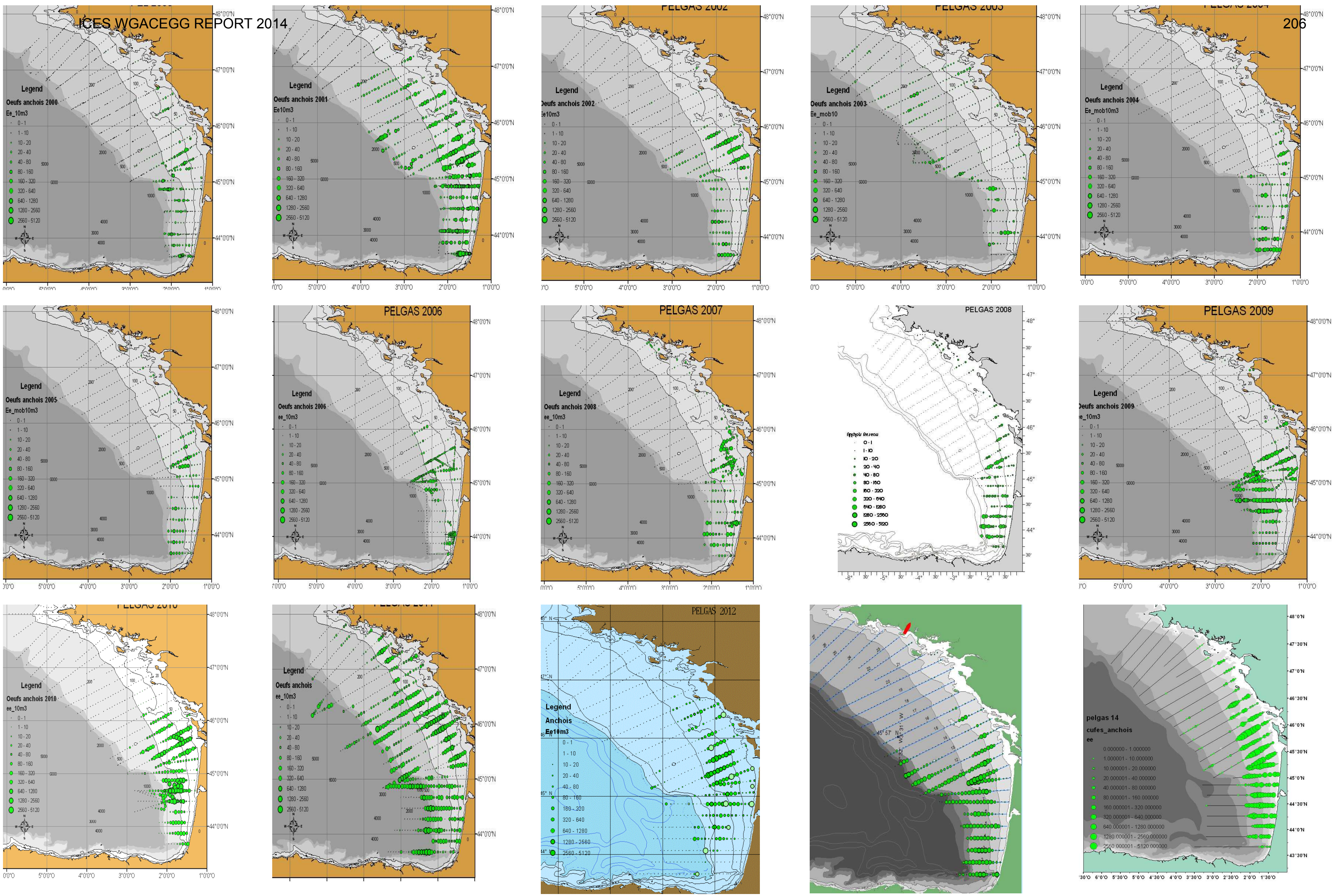


Figure 3.6.3 – distribution of anchovy eggs observed with CUFES during PELGAS from 2000 to 2014 (number for 10m^3).

3.7. Coherence between CUFES and Acoustic survey indices

Taking advantage of the fact that we have an egg survey (CUFES) providing Ptot and an acoustic survey providing B, we may simply estimate the daily fecundity (DF: # eggs g-1 d-1) by the ratio Ptot/B. Note that here, DF is the egg production by gramme of stock (i.e., both females and males). Because the two indices Ptot and B are linked through DF, the coherence between the egg (CUFES) and the acoustic survey indices of PELGAS can be investigated.

The daily egg production was estimated as described in Petitgas et al. (2009) with the developments made by Gatti (2012) and discussed at the benchmark workshop WKPELA 2013. Briefly, the eggs at each CUFES sample are staged in 3 stages, the duration which are temperature dependent. The CUFES egg concentration is converted into egg abundance (vertically integrated) by using a 1-dimensional distribution model which takes input account as parameters the egg buoyancy and dimension, the hydrological vertical profile, the tidal current and wind regime (Petitgas et al., 2006; Petitgas et al., 2009; Gatti, 2012). The complete serie is shown on figure 3.7.1.

In 2014 the estimates are : B=125 427 tonnes ; Ptot= 1.37 10^{13} egg d^{-1}

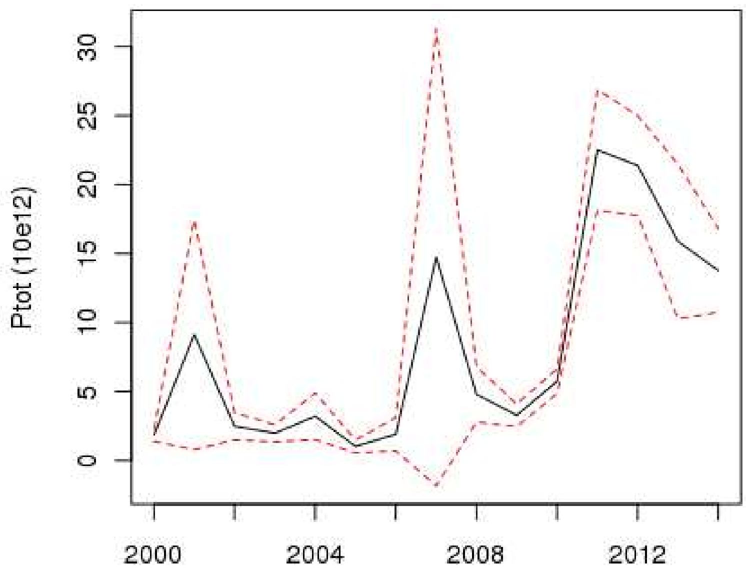


Figure 3.7.1 – Ptot serie from the CUFES index

The daily egg production Ptot depends on the spawning biomass (B) and the daily fecundity (DF). DF depends ultimately on environmental and trophic conditions, which determine individual fish fecundity (e.g., Motos et al., 1996). Daily egg production (Ptot) and spawning biomass (B) were linearly related (Fig 1). The slope of the linear regression is a (direct) estimate of the average DF over the series. Its value is : 92.26 eggs g-1. Residuals are particularly important for 2000, 2002 and 2007.

For first years of the serie (2000 to 2002) the mesh of the collector was 500 µm and is now 315 µm. But more investigation should be processed to asses the impact of the change of the mesh size on the aspect of the eggs collected, and on the number of them in each sample as well.

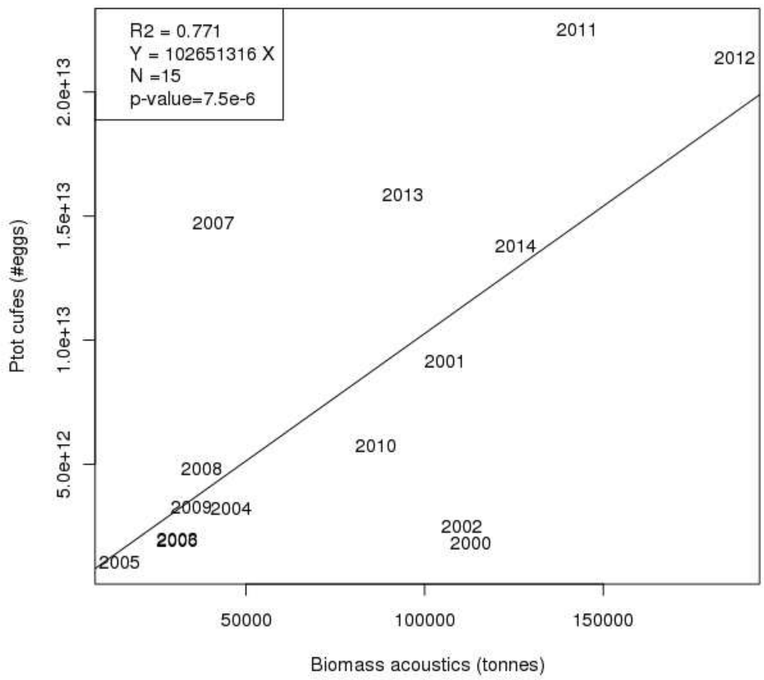


Figure 3.7.2 – Coherence between CUFES and Acoustic PELGAS survey indices

4. SARDINE DATA

4.1. Adults

The biomass estimate of sardine observed during PELGAS14 is **339 607** tons (table 2.3.), which is at the average level of the PELGAS series, and constituting a small decrease of the biomass compared to last year. It must be enhance that these survey don't cover the total area of potential presence of sardine. It is possible that some years, this specie could be present up to the North, in the Celtic sea, SW of Cornouailles or Western Channel where some fishery occurs, more or less regularly. It is also possible that sometimes, a small fraction of the population could be present in very coastal waters, when the R/V Thalassa is unable to operate in those waters. The estimate is representative of the sardine present in the survey area at the time of the survey and can be therefore considered as an estimate of the Bay of Biscay (VIIIab) sardine population.

Sardine was distributed all along the french coast of the bay of biscay, from the south to the North. Then, sardine appeared almost pure along the Landes's coast, where an upwelling occurred. Sardine was also present mixed with anchovy from the Gironde to the South coast of Brittany. Sardine appeared also close to the surface in the Northern part of the bay of Biscay, along the shelfbreak, sometimes mixed with mackerel, but in lower abundance than previous years. It must be noticed that, even adults appeared in lox quantity in this offshore area, eggs were well present (*see chapter 4.2).* an hypothesis could be that sardine was so closed to the surface that a part of it couldn't be detected by the echosounders in the blind layer. An other possibility could be that this sardine offshore is bigger than individuals along the coast, and presents an higher fecundity.

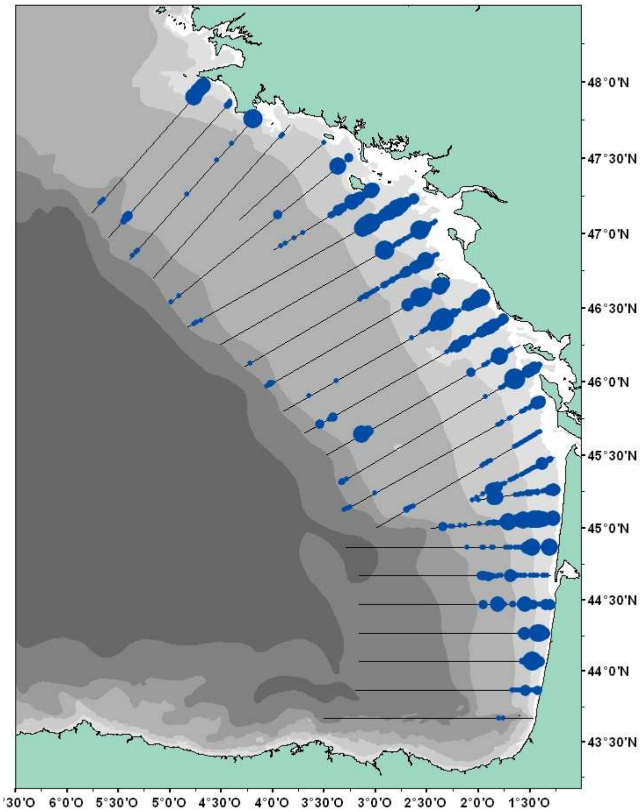


Figure 4.1.1 – distribution of sardine observed by acoustics during PELGAS14

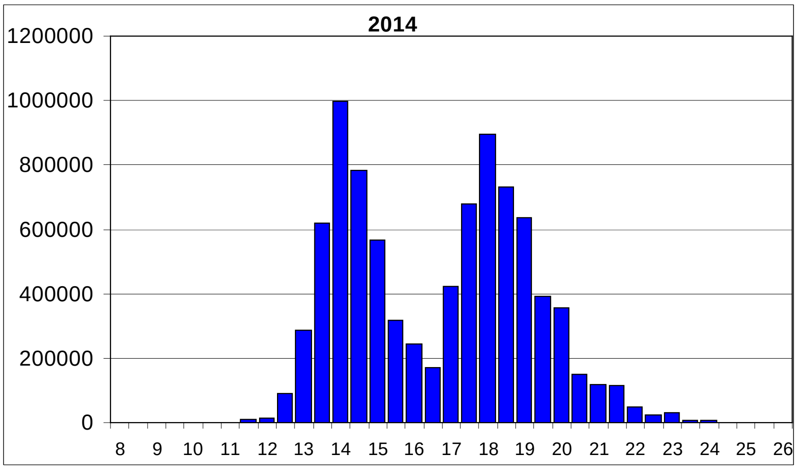


Figure 4.1.2. – length distribution of sardine as observed during PELGAS14

Length distributions in the trawl hauls were estimated from random samples. The population length distributions have been estimated by a weighted average of the length distribution in the hauls. Weights used are acoustic coefficients (Dev*Xe Moule in thousands of individuals per n.m.^{2}) which correspond to the abundance in the area sampled by each trawl haul. The global length distribution of sardine is shown on figure 4.1.2.

As usual, sardine shows a bimodal length distribution, the first one (about 14 cm, corresponding to the age 1, and present this year along the coast) and the second about 18 cm, which is mainly constituted by the 2 years old (still very well present a bit more offshore than the 1 year class, mainly between depths 60 and 80 m). The biggest individuals, along the shelf break are older (age 4 and more).

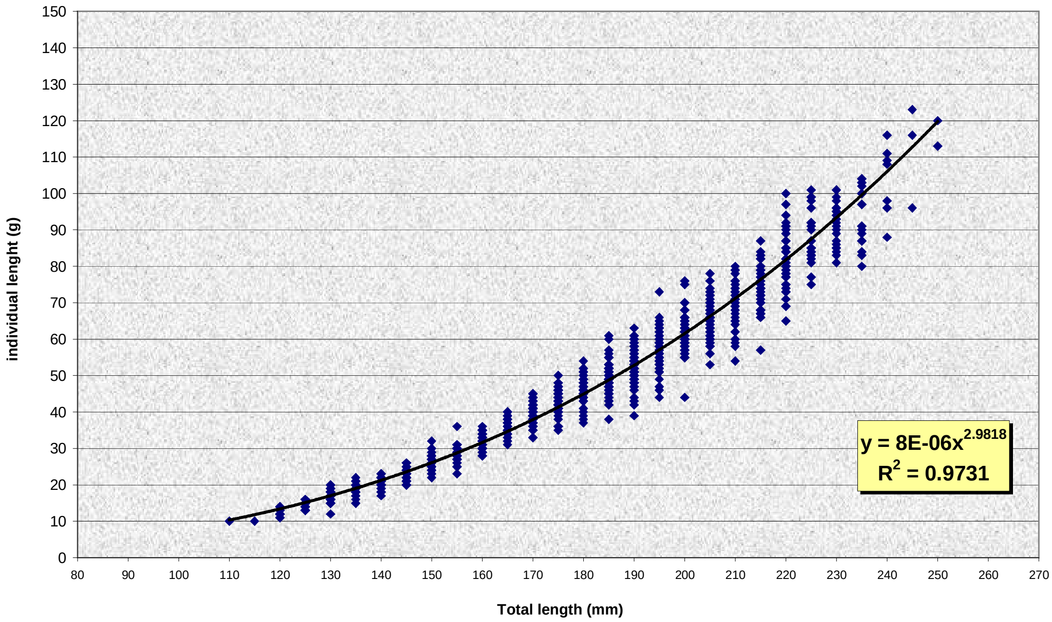


Figure 4.1.3 – Weight/length key of sardine established during PELGAS14

NB age	âge								
length (mm)	1	2	3	4	5	6	7	8	9
110	**100.00%**	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
115	**100.00%**	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
120	**100.00%**	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
125	**100.00%**	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
130	**100.00%**	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
135	**100.00%**	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
140	**97.67%**	**2.33%**	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
145	**100.00%**	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
150	**93.33%**	**6.67%**	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
155	**86.84%**	**13.16%**	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
160	**56.52%**	**43.48%**	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
165	**42.86%**	**57.14%**	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
170	**22.22%**	**73.61%**	**4.17%**	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
175	**4.55%**	**93.18%**	**2.27%**	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
180	**2.94%**	**90.20%**	**5.88%**	**0.98%**	0.00%	0.00%	0.00%	0.00%	0.00%
185	0.00%	**81.63%**	**16.33%**	**2.04%**	**0.00%**	0.00%	0.00%	0.00%	0.00%
190	0.00%	**60.00%**	**31.58%**	**5.26%**	**2.11%**	**1.05%**	0.00%	0.00%	0.00%
195	0.00%	**36.84%**	**48.68%**	**7.89%**	**6.58%**	0.00%	0.00%	0.00%	0.00%
200	0.00%	**25.37%**	**35.82%**	**26.87%**	**5.97%**	**2.99%**	**2.99%**	0.00%	0.00%
205	0.00%	**5.36%**	**48.21%**	**19.64%**	**17.86%**	**7.14%**	**1.79%**	0.00%	0.00%
210	0.00%	**1.79%**	**33.93%**	**12.50%**	**23.21%**	**23.21%**	**3.57%**	0.00%	**1.79%**
215	0.00%	0.00%	**18.60%**	**23.26%**	**27.91%**	**27.91%**	**2.33%**	0.00%	0.00%
220	0.00%	0.00%	**14.29%**	**17.14%**	**34.29%**	**28.57%**	**5.71%**	0.00%	0.00%
225	0.00%	0.00%	0.00%	**4.00%**	**40.00%**	**36.00%**	**20.00%**	0.00%	0.00%
230	0.00%	0.00%	0.00%	**7.41%**	**25.93%**	**40.74%**	**22.22%**	0.00%	**3.70%**
235	0.00%	0.00%	0.00%	0.00%	**10.53%**	**47.37%**	**36.84%**	0.00%	**5.26%**
240	0.00%	0.00%	0.00%	0.00%	0.00%	**57.14%**	**28.57%**	0.00%	**14.29%**
245	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	**66.67%**	0.00%	**33.33%**
250	0.00%	0.00%	0.00%	**100.00%**	0.00%	0.00%	0.00%	0.00%	0.00%

Table 4.1.4 : sardine age/length key from PELGAS14 samples (based on 1261 otoliths)

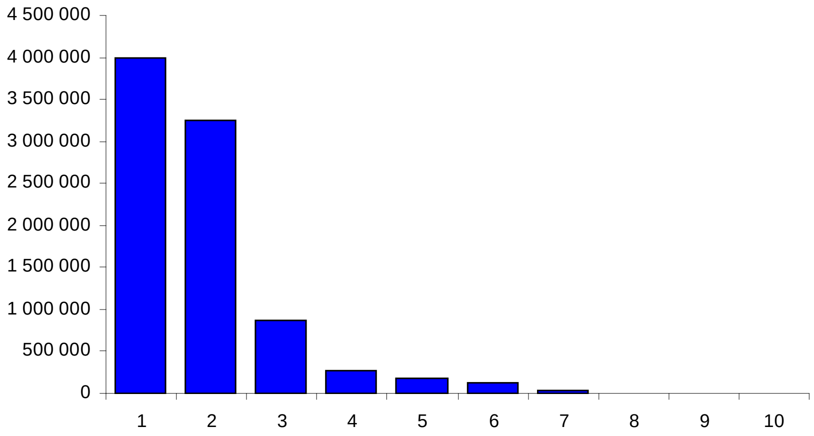


Figure 4.1.5.- Global age composition (nb) of sardine as observed during PELGAS 14

age	PEL14 % - N
1	45.72%
2	37.16%
3	9.90%
4	3.10%
5	2.10%
6	1.52%
7	0.46%
8	0%
9	0%

age	PEL14- % W
1	27.82
2	44.40
3	14.70
4	5.07
5	3.86
6	3.06
7	0.97
8	0
9	0.13

Figure 4.1.6 percentage by age of the sardine population observed during PELGAS14 in numbers (left) and biomass (right).

The relative high abundance of age 2 (37% in number, but 44 % in mass) confirms the (very) good recruitment observed last year.

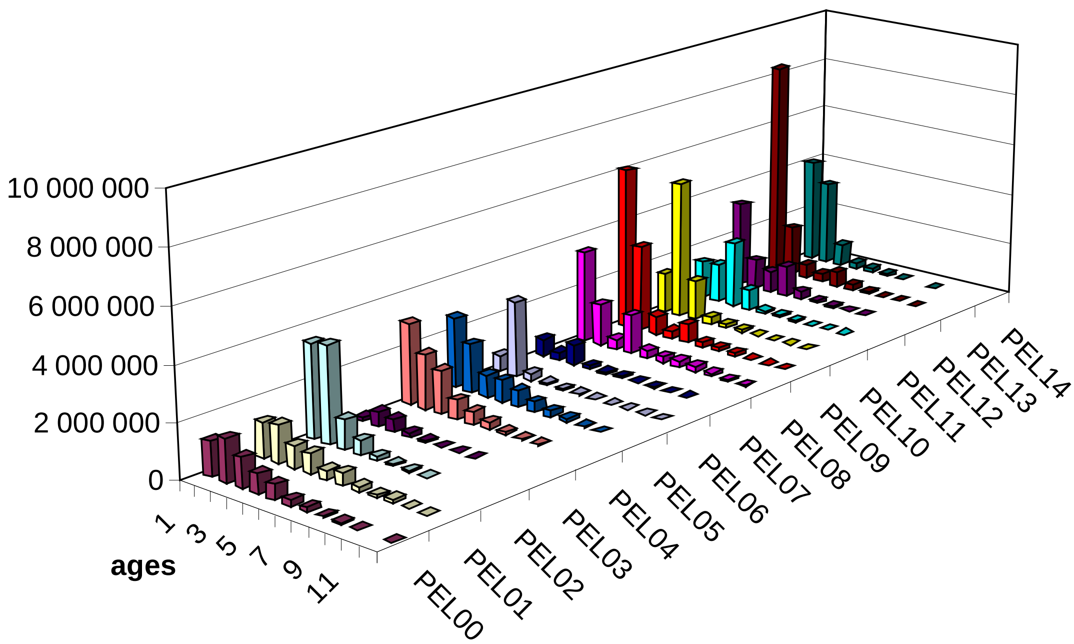


Figure 4.1.7- Age composition of sardine as estimated by acoustics since 2000

The series of age distribution in numbers since 2000 are shown in figure 4.1.7. We can observe that we can follow cohorts (i.e. the very low 2005 age class, or very high 2008 age class). 2003 and 2007 were atypical years in terms of environmental conditions and therefore fish (and particularly sardine) distributions.

The high abundance of age 2 (see above) should be followed next couple of years.

	age									
survey	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
PEL00	35.05	54.74	69.15	76.46	84.82	89.93	98.83	110.18	105.04	112.87
PEL01	41.28	58.85	76.83	83.84	93.68	96.92	103.41	105.35	112.71	120.97
PEL02	40.48	60.2	74.94	81.7	92.31	99.42	106.68	118.05		
PEL03	53.35	68.04	73.15	78.11	86.04	93.33	88.74	96.09		
PEL04	35.94	64.73	76.54	84.39	95.87	98.83	104.34	109.19	106.15	
PEL05	34.44	63.45	73.29	79.62	84.88	88.96	90.04	105.42	109.45	98.35
PEL06	39.17	58.37	70.78	81.18	86.37	82.48	91.25	97.22	107.02	112.02
PEL07	37.55	65.96	71.77	79.05	84.02	94.45	100.37	96.93	101.27	114.86
PEL08	33.44	60.33	71.1	75.18	83.82	92.84	90.45	95.67	99.48	101.41
PEL09	29.51	57.13	73.62	81.28	83.26	88.35	95.67	91.44	96.50	106.67
PEL10	30.33	50.55	64.04	73.05	78.43	87.58	93.16	105.88	106.96	116.01
PEL11	27.37	50.13	58.69	69.84	78.35	83.00	84.28	108.17	105.38	108.33
PEL12	22.88	44.66	57.40	65.45	78.42	87.83	95.26	92.27	99.83	
PEL13	21.16	44.33	55.82	68.30	77.42	84.27	89.28	99.10	113.27	89.17
PEL14	23.02	44.53	55.93	62.07	69.35	76.11	78.46		86.50	

Figure 4.1.8- mean Weight at age (g) of sardine for each PELGAS survey

4.2. Eggs

Sardine eggs were observed mainly along the coast between the 50 and the 100m isobaths, from the south of the bay of Biscay to the south of Brittany, except front of the Gironde plume, where the most important anchovy were detected. Then, another concentration was visible along the end of the continental slope, northern than the “fer à cheval”, according to the presence of a low abundance of adults close to the surface (see paragraph 4.1).

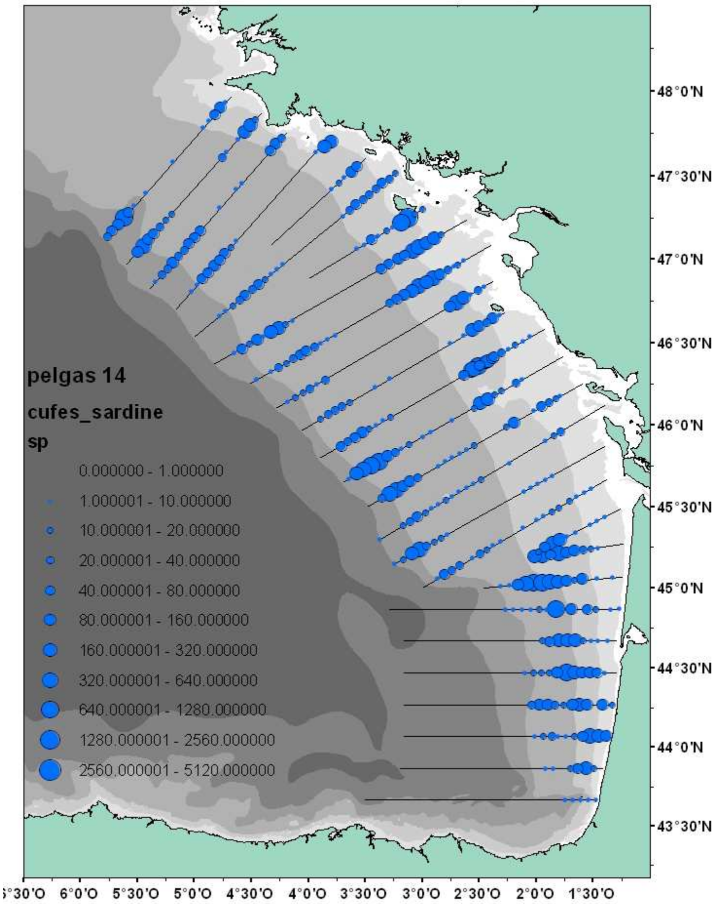


Figure 4.2.1. Distribution of sardine eggs observed with CUFES during PELGAS14.

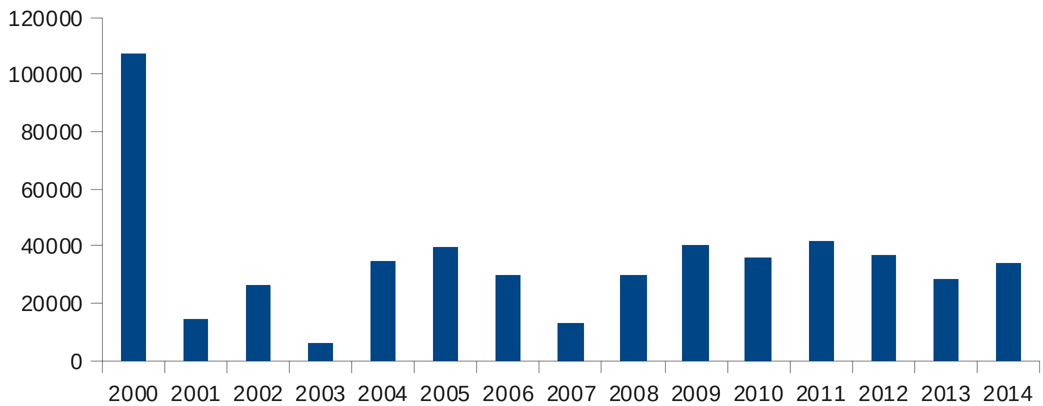


Figure 4.2.2. Number of eggs observed during PELGAS surveys from 2000 to 2014

The number of eggs collected by CUFES during the PELGAS14 survey was comparable to previous years but still far below the maximum observed in 2000.

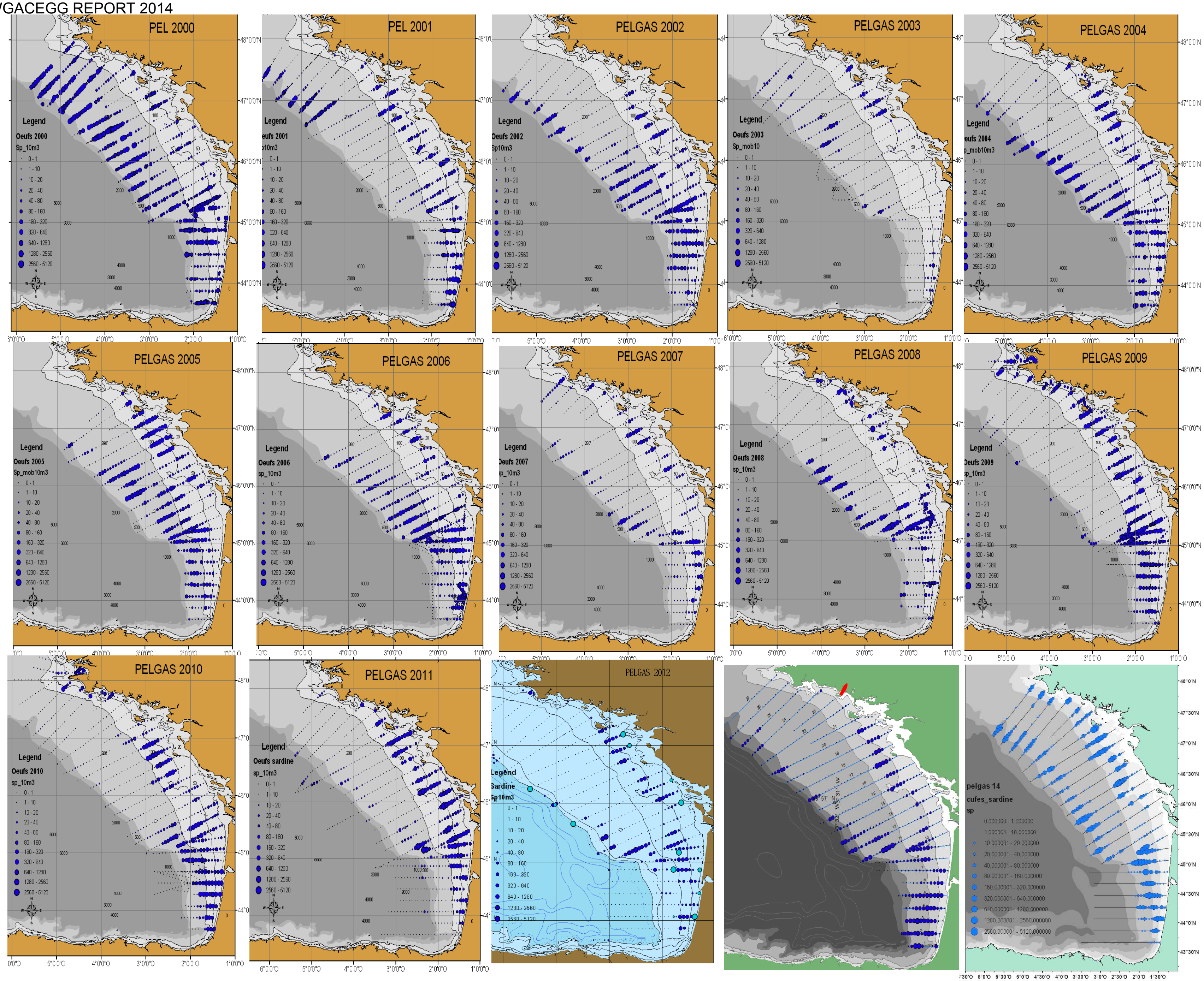


Figure 4.2.3 – distribution of sardine eggs observed with CUFES during PELGAS from 2000 to 2014 (number for $10m^3$).

5. Top predators

For the twelth consecutive year, monitoring program to record marine top predator sightings (marine birds and cetaceans) has been carried out , during two first legs of PELGAS survey (from 25th April to 25nd May 2014).

A total of 260 hours of sighting effort were performed for 30 days (Figure 5.1.), with an average of 8.5 hours of sighting effort per day. Weather conditions were generally not favorable with a majority of the effort deployed in limit conditions to detect most things as possible around the vessel.

During the survey, 3 247 sightings of animals or objects were recorded. Seabirds constitute the majority of sightings (68%). Other most frequent sightings concern either litter drifting at sea (13%), fishing ships (5%) and buoys (6%). Cetaceans only account for 2% of sightings.

5.1 – Birds

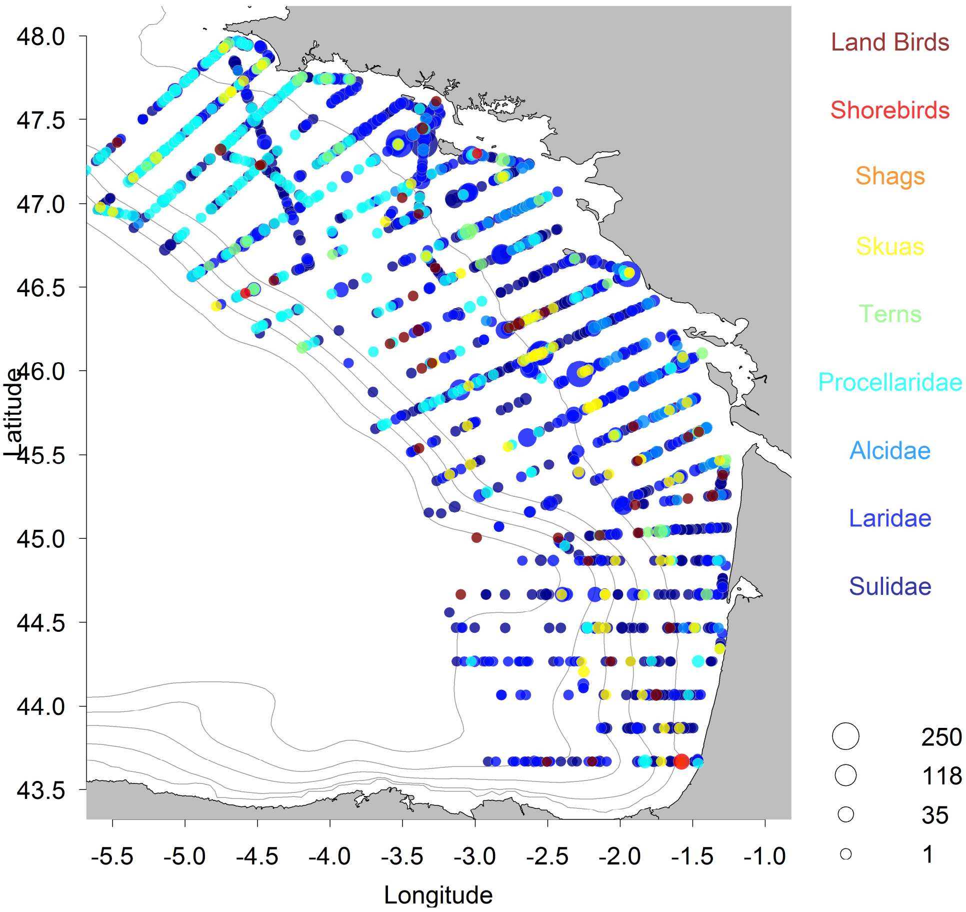


Figure 5.1. Distribution of birds observed during the PELGAS14 survey

Birds constitute the vast majority of sightings. Shorebirds and passerines accounted for less than 2% of bird sightings. 2202 sightings of seabirds were found all over the Bay of Biscay (Figure 5.1.), divided into 21 identified species and a raw estimate of 6060 individuals.

Northern gannets accounted for 47% of all seabird sightings : its distribution is homogeneous across the Bay of Biscay.

The second most sighted species is the Northern Fulmar (Fulmar glacialis), mostly present in the northern part of the Bay of Biscay. Few terns were sighted, even off known breeding colonies (e.g. Arcachon). A large number of skuas were sighted in 2014. Seabirds sightings have substantially decreased compared to 2013. The several winter storms may be to blame for an increased mortality rate of seabirds at sea, which could explain this decrease.

5.2 – Mammals

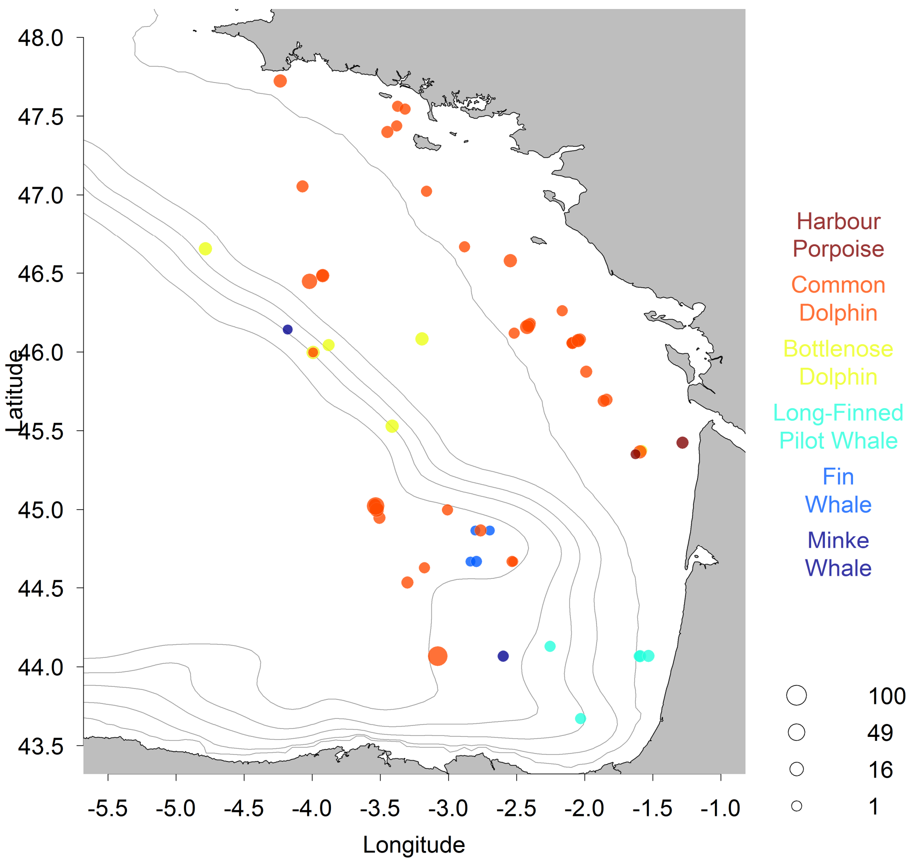


Figure 5.2. Distribution of mammals during the PELGAS14 survey.

A total of 76 sightings were recorded corresponding to a raw estimate of 559 individuals and 6 species of cetaceans clearly identified (Figure 5.2.). The greatest diversity of marine mammals was observed in the Southern part of the Bay of Biscay. The overall distribution pattern is similar to that of previous PELGAS spring surveys.

As usual, common dolphin is the most recorded species. Common dolphins were present on the inshore part of the continental shelf, a typical pattern during springtime. No striped dolphins were sighted in 2014. However, harbour porpoises were sighted twice off the Gironde estuary.

Pilot whales were only sighted in small pods in the southern part of the bay of Biscay. Bottlenose dolphins were sighted mainly on the continental slope. Large baleen whales (fin/minke whales) were sighted in the Cap Ferret canyon, although sometimes they were too far from the boat to permit an unambiguous identification at the species levels.

6. Hydrological conditions

After a very wet and stormy winter (numerous depressions), weather conditions became more stable between mid-march and the beginning of the survey (mid-April), and some very strong planktonic blooms occurred on the platform and even more offshore, kept by the strong mix in the water column and the high cumulated river discharges.

Wintery precipitation drove to desalinate water on the entire column for the whole platform (salinity <34 psu), explaining early planktonic blooms, with high chlorophyll concentrations since march. These early and strong blooms probably led to impressive abundance of gelatinous organisms, particularly salps, covering the whole platform in the northern part of the bay of Biscay during the survey.

Anti-cyclonic conditions between mid-march and mid-April led to a light thermal stratification, but sea surface temperature stayed cold (around 14 °C), closed to the average temperature, principally because of regular wind and fresh atmospheric temperature.

A West gust of wind at the beginning of the survey apparently led to a phenomena of downwelling along the Landes's coast, showed by temperature slightly upper than offshore and an important level of oxygen saturation on the whole water column.

The stratification of the water column was light, and the regular windy events during the survey can explain heterogeneous concentrations of chlorophyll at the surface, in the mixed layer of the column.

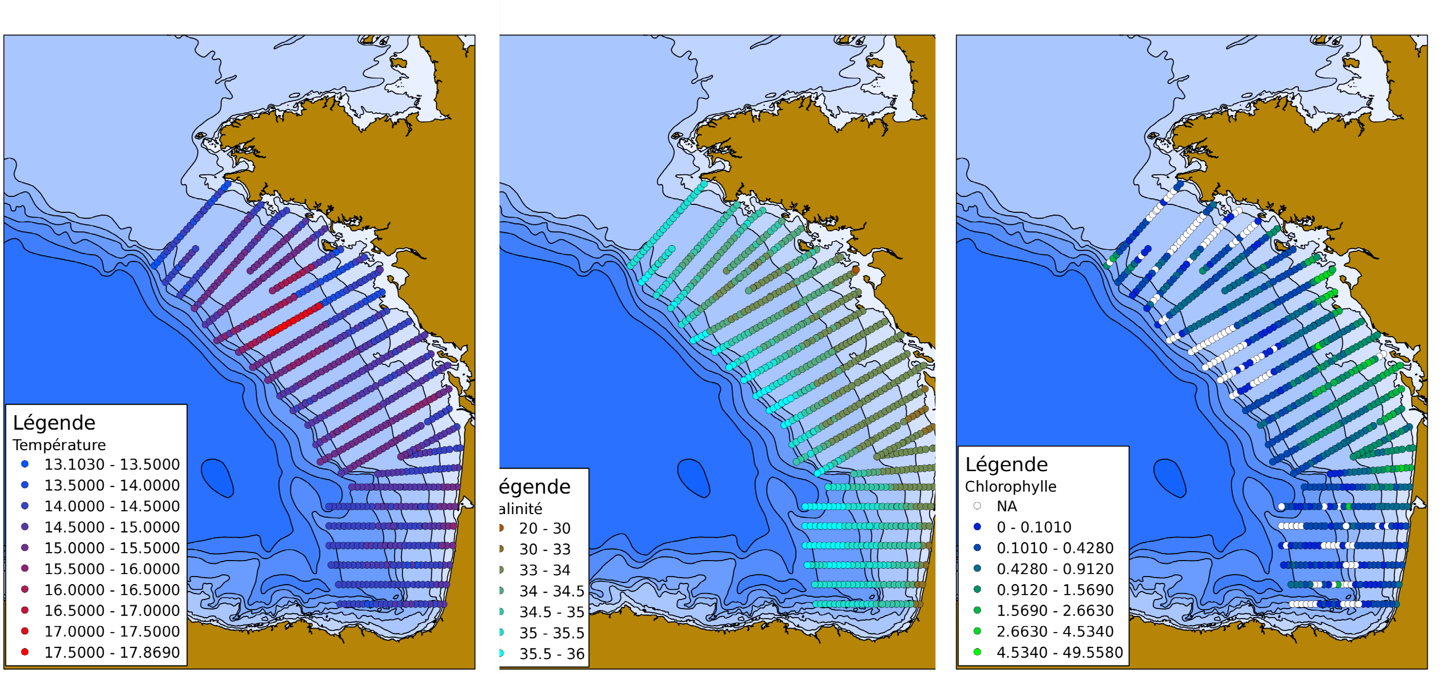


Figure 6.1. – Surface temperature, salinity and fluorescence observed during PELGAS14.

7. CONCLUSION

The Pelgas14 acoustic survey has been carried out with medium weather conditions (regular wind, cold temperatures) for the whole area, from the south of the bay of Biscay to the west of Brittany. The help of commercial vessels (two pairs of pelagic trawlers and a single one) during 18 days provided about 110 valid identification hauls instead of about 50 before 2007 when Thalassa was alone to identify echotraces. Their participation increased the precision of identification of echoes and some double hauls permitted to confirm that results provided by the two types of vessels (R/V and Fishing boats) were comparable and usable for biomass estimate purposes. These commercial vessels participated to the PELGAS survey in a very good spirit of collaboration, with the financial help of "France Filière Pêche" which is a groupment of French fishing organisations.

Temperature and salinity recorded during PELGAS13 were affected by rather bad weather conditions before and during the survey. During the whole survey, water column showed a light stratification, with a surface temperature around the average of the serie (14°C). It must be noticed that wintery precipitation drove to desalinate water on the entire column for the whole platform (salinity <34 psu), explaining early planktonic blooms, with high chlorophyll concentrations since march. These early and strong blooms probably led to impressive abundance of gelatinous organisms, particularly salps, covering the whole platform in the northern part of the bay of Biscay during the survey.

The PELGAS14 survey observed a high abundance of anchovy (125 427 tons), far from the highest level observed on the time series (186 865 tons in 2012) but anyway, one of the three best abundances in the bay of Biscay since 2000. In the South, anchovy was mostly concentrated in the middle of the platform, and the small individuals as usual were mostly present in the Gironde area.

The biomass estimate of sardine observed during PELGAS14 is 339 607 tons, which constitutes a small decrease of the last year level of biomass, but this specie is still at a high level of abundance in the bay of Biscay. The relative high proportion of age 2 (37% in number, but 44 % in mass) confirms the (very) good recruitment observed last year, maybe the best of the whole serie (since 2000). The global age structure of the population and his evolution trough years confirms the validity of age readings and the fact that we can follow sardine cohorts in the sardine population of the bay of Biscay. Geographical distribution looks as usual, with maximum around the Loire river but show a presence all along the coast from the south of the bay until the west point of Brittany, and in lower quantity, along the slope in the Northern area.

Concerning the other species, mackerel was less present this year compared to 2013, while horse mackerel seems to be a bit more abundant, but still showing a low biomass.

It must be noticed this year that wintery precipitation drove to desalinate water on the entire column for the whole platform (salinity <34 psu), explaining early planktonic blooms, with high chlorophyll concentrations since march. These early and strong blooms probably led to impressive abundance of gelatinous organisms, particularly salps, covering the whole platform in the northern part of the bay of Biscay during the survey.

Working Document to WGACEGG, 17-21 November 2014, Vigo, Spain

Index of biomass of Bay of Biscay anchovy (*Engraulis encrasicolus*, L.) and sardine (*Sardina pilchardus*) in 2014 applying the DEPM

by

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Abstract

The research survey BIOMAN 2014 for the application of the Daily Egg Production Method (DEPM) in the Bay of Biscay anchovy and sardine was conducted in May 2014 from the 5th to the 24th covering the whole spawning area of the species. Two vessels were used: the R/V Ramón Margalef to collect the plankton samples and the pelagic trawler Emma Bardán to collect the adult samples. The total area covered was 104,115Km^2 and the spawning area was 35,317Km^2 for anchovy and 55,533 Km^2 for sardine. During the survey 767 vertical plankton samples were obtained, 1,708 CUFES samples and 51 pelagic trawls were performed, from which 42 contained anchovy and 41 of them were selected for the analysis. Moreover, 6 extra samples were obtained from the commercial fleet. In total there were 47 samples for anchovy adult parameters estimates. For sardine 14 adult samples were obtain for the analysis.

Nor anchovy eggs neither sardine eggs were found in the Cantabrian Coast. The spawning area for anchovy started at 43º37'N in the French platform and the northern limit was found at 47ºN. The eggs, in the French platform where encountered in the historical common places: Between Adour and Arcachon passed the 200m depth from the coast and in the area of influence of Le Gironde, from the coast to the 100m depth line. The weather conditions during the survey were good in general with a mean Sea Surface Temperature (SST) of 14.8ºC. However sampling was stopped for 9 hours due to bad weather at R 59, two days before finishing the survey. The spawning area for sardine started at 43º37'N in the south of the French platform from coast to well passed the 200m depth until Arcachon and then from coast until 100m depth until 48ºN. Moreover an area was found around 200m depth from 45º30' to 48ºN. The spawning area further to the North wasn't covered completely.

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 (R), reviewed batch fecundity (F), spawning frequency (S) and weight of mature females (W_f), were estimated based on the adult samples obtained during the survey. The S estimate was obtained using the new procedures of staging and ageing of POFs (Alday *et al*., 2008; Alday *et al*., 2010; Uriarte *et al*., 2012). The index of biomass obtained resulted in 89,011t with a coefficient of variation of 12% for anchovy and 284,543t with a coefficient of variation of 23% for sardine.

Introduction

Anchovy (*Engraulis encrasicolus*) is one of the commercial species of high economic importance in the Bay of Biscay. The economy of the Spanish purse seine fleets (primarily from the Basque Country, Cantabria and Galicia) and the French fleet rely greatly on this resource (Uriarte *et al.*, 1996 and Arregi *et al.*, 2004). In order to provide proper advice on the fishery management, it is necessary to conduct annually a monitoring of the population. Thanks to that monitoring, ICES (International Council for the Exploration of the Sea) recommended a limited TAC of 17,100 t for 2014.

Anchovy is a short-lived species, for which the evaluation of its biomass has to be conducted by direct assessment methods as the Daily Egg Production Method (DEPM) (Barange *et al*, 2009). This method consists of estimating the spawning stock biomass (*SSB*) as the ratio between the total daily egg production (P_{tot}) and the daily fecundity (*DF*) estimates. In consequence, this method requires a survey to collect anchovy eggs (plankton sampling) for estimating the P_{tot} and to collect anchovy adults (adult sampling) for estimating the *DF*. Since 1987, AZTI-Tecnalia (Marine and Food Technological Centre, Basque country, Spain), either alone or in collaboration with other institutes, has conducted annually specific surveys to obtain anchovy biomass indices (Somarakis *et al*., 2004; Motos *et al*., 2005, Santos *et al,* 2010). In addition, the Basque fishery on anchovy has been continuously monitored. This information has been submitted annually to ICES, to advice on the exploitation of the fishery.

The survey for the application of the DEPM to estimate the Bay of Biscay anchovy biomass is one of the two surveys which give information on the adult anchovy population. The other one carried out at the same time in May is the acoustic French survey. The adult anchovy biomass indices provided by the acoustic and DEPM surveys together with the information supplied by the fleet are used as input variables for a two stage biomass model, a Bayesian base model (BBM) used to assess the Bay of Biscay anchovy population (Ibaibarriaga *et al*., 2008).

This year 2014 the results of JUVENA survey will be another input to the BBM. The JUVENA surveys were carried out annually from 2003 to 2014 between September and October in the Bay of Biscay. It is an acoustic survey to estimate abundance of anchovy juvenile every September-October, with the long term objective of forecasting the strength of the anchovy recruitment which will enter the fishery the next year. The annual biomass estimates for anchovy juveniles were compared with the estimates of anchovy recruitment the following year obtained by the BBM.

Apart from the anchovy SSB estimates the DEPM survey in the Bay of Biscay in 2014 gives information on the distribution and abundance of sardine eggs and adults and estimate an index of sardine SSB in de Bay of Biscay. Since 2011 AZTI is collaborating with the international eggs surveys for sardine from the Gulf of Cadiz to the Bay of Biscay applying the DEPM to sardine from 45ºN to 48ºN. Moreover gives information on the environmental conditions due to the recollection of different parameters in the area surveyed such as sea surface temperature, sea surface salinity, temperature and salinity in the water column, currents and winds.

This working document describes the BIOMAN2014 survey for the application of the DEPM for the Bay of Biscay anchovy and sardine in 2014. First, the data collection, the estimation of the total egg production and the reproductive parameters are described in detail. For anchovy, the Batch fecundity was revised from a preliminary one presented in June and the spawning frequency was estimated after histological reading of ovary POFs from the adults collected during BIOMAN 2014, utilizing the new procedures of staging and ageing of POFs (Alday *et al*., 2008 ; Alday *et al*., 2010; Uriarte *et al*., 2012). Then, the biomass index and the age structure of the population are given as they were used for the assessment and posterior management of this stock. Finally the historical trajectory of the population is showed.

Material and Methods

Survey description

The BIOMAN2014 survey was carried out in May, at the spawning peak covering the whole spawning area of anchovy in the Bay of Biscay. During the survey, icthyoplankton and adult samples were obtained for the estimation of total daily egg production and total daily fecundity respectively for anchovy and sardine. The age structure of the anchovy population was also estimated. In addition, extra plankton samples with the MIK net were collected. Moreover, adults of other species were taken for genetic analysis.

The collection of plankton samples was carried out on board R/V Ramón Margalef from the 5th to the 24th May. The area covered was the southeast of the Bay of Biscay (**Fig. 1**), which corresponds to the main spawning area and spawning season of anchovy. The sampling strategy was adaptive. The survey started from the West (transect 13, at 3º54’W), and covered the Cantabrian Coast eastwards up to Pasajes (transect 25, approx. 1º50’W) (**Fig. 1**) looking for the western limit of the spawning area. Then, the survey continued to the north, in order to find the Northern limit of the spawning area. When the egg abundances found were relatively high, additional transects separated by 7.5 nm were completed. This occurred from the Adour until Arcachon inside the 100m depth and the area of influence of Gironde. The survey was stopped after 11 days of survey to do gas oleo and change the crew. Moreover, the sampling was stopped for 9 hours due to bad weather at R 59, two days before finishing the survey.

The strategy of egg sampling was identical to that used in previous years, i.e. a systematic central sampling scheme with random origin and sampling intensity depending on the egg abundance found (Motos, 1994). Stations were located at intervals of 3 nmi along 15 nmi apart transects, perpendicular to the coast.

At each station a vertical plankton haul was performed using a PairoVET net (Pair of Vertical Egg Tow, Smith *et al*., 1985 in Lasker, 1985) with a net mesh size of 150 µm for a total retention of the anchovy and sardine eggs under all likely conditions. The net was lowered to a maximum depth of 100 m or 5 m above the bottom in shallower waters. After allowing 10 seconds at the maximum depth for stabilisation, the net was retrieved to the surface at a speed of 1 m s^{-1}. A 45 kg depressor was used to allow for correctly deploying the net. "G.O. 2030" flowmeters were used to detect sequential clogging of the net during a series of tows.

Immediately after the haul, the net was washed and the samples obtained were fixed in formaldehyde 4% buffered with sodium tetra borate in sea water. After six hours of fixing, anchovy, sardine and other eggs species were identified, sorted out and counted on board. Afterwards, in the laboratory, the sorting of the samples was finished and a percentage of the samples were checked to assess the quality of the sorting made at sea. According to that, a portion of the samples were sorted again to ensure no eggs were left in the sample. In the laboratory, anchovy eggs were classified into morphological stages (Moser and Alshtrom, 1985).

Sample depth, temperature, salinity and fluorescence profiles were obtained at each sampling station using a CTD RBR-XR420 coupled to the PairoVET. In addition, surface temperature and salinity were recorded in each station from the CT at 3m depth. At some points determinate before the survey, water was filtered from the surface to obtain chlorophyll samples to calibrate the chlorophyll data.

The Continuous Underway Fish Egg Sampler (CUFES, Checkley *et al*., 1997) was used to record the eggs found at 3m depth with a net mesh size of 350µm. The samples obtained were immediately checked under the microscope so that the presence/absence of anchovy eggs was detected in real time. When anchovy eggs were not found in six consecutive CUFES samples in the oceanic area transect was abandoned. The CUFES system had a CTD to record simultaneously temperature and salinity at 3 m depth, a flowmeter to measure the volume of the filtered water, a fluorimeter and a GPS (Geographical Position System) to provide sampling position and time. All these data were registered at real time using the integrated EDAS (Environmental Data Acquisition System) with custom software.

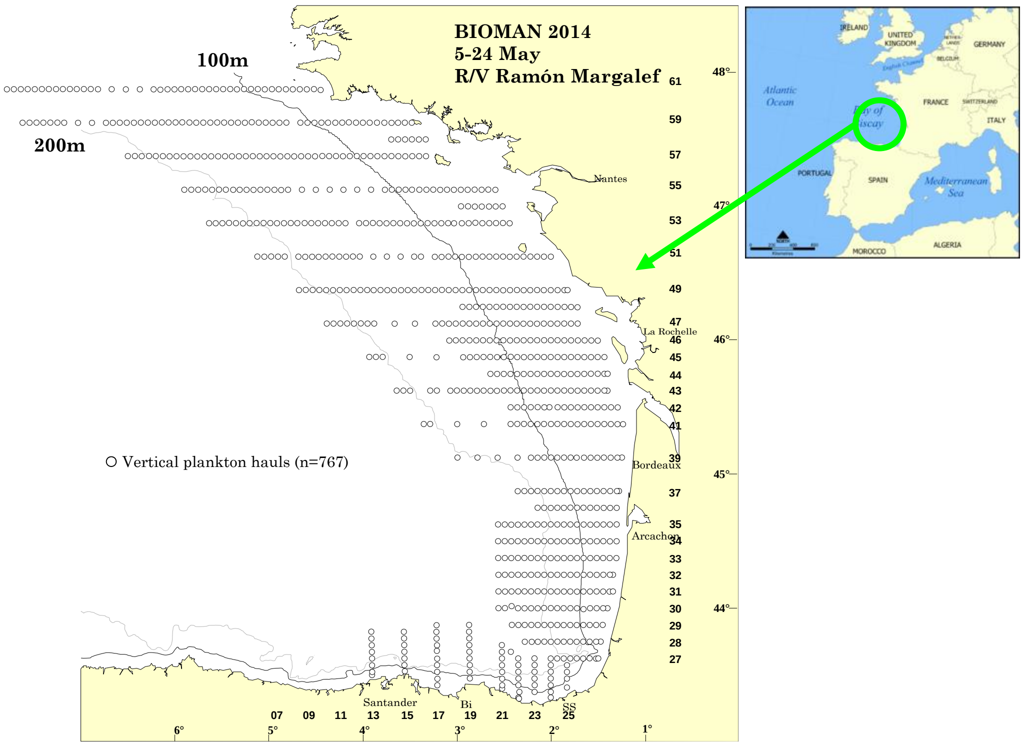

Figure 1: Vertical Plankton stations (PairoVET) during BIOMAN 2014.

The adult samples were obtained on board R/V Emma Bardán (pelagic trawler) from the 7th to the 30th May coinciding in space and time with the plankton sampling. When the plankton vessel encountered areas with anchovy or sardine eggs, the R/V Emma Bardán was directed to those areas to fish. In each haul, immediately after fishing, anchovy were sorted from the bulk of the catch and a sample of two kg was selected at random. A minimum of one kg or 60 anchovies were weighted, measured and sexed and from the mature females the gonads of 25 non-hydrated females (NHF) were preserved. If the target of 25 NHF was not completed 10 more anchovies were taken at random and processed in the same manner. Sampling was stopped when 120 anchovies had to be sexed to achieve the target of 25 NHF. Otoliths were extracted on board and read in the laboratory to obtain the age composition per sample.

For sardine the same protocol was followed. In some occasions, when there was too much work to do on board, the sardine samples were kept in formalin to be analysed afterwards in the laboratory on land and from those samples a sample of sardines were frozen to obtain afterwards the otoliths. Moreover, in each haul, 100 individuals of each species were measured.

This year 6 additional anchovy adult samples were obtained from the commercial Basque purse seine fleet. The spatial distribution of the pelagic hauls with anchovy is shown in **Figure 2**.

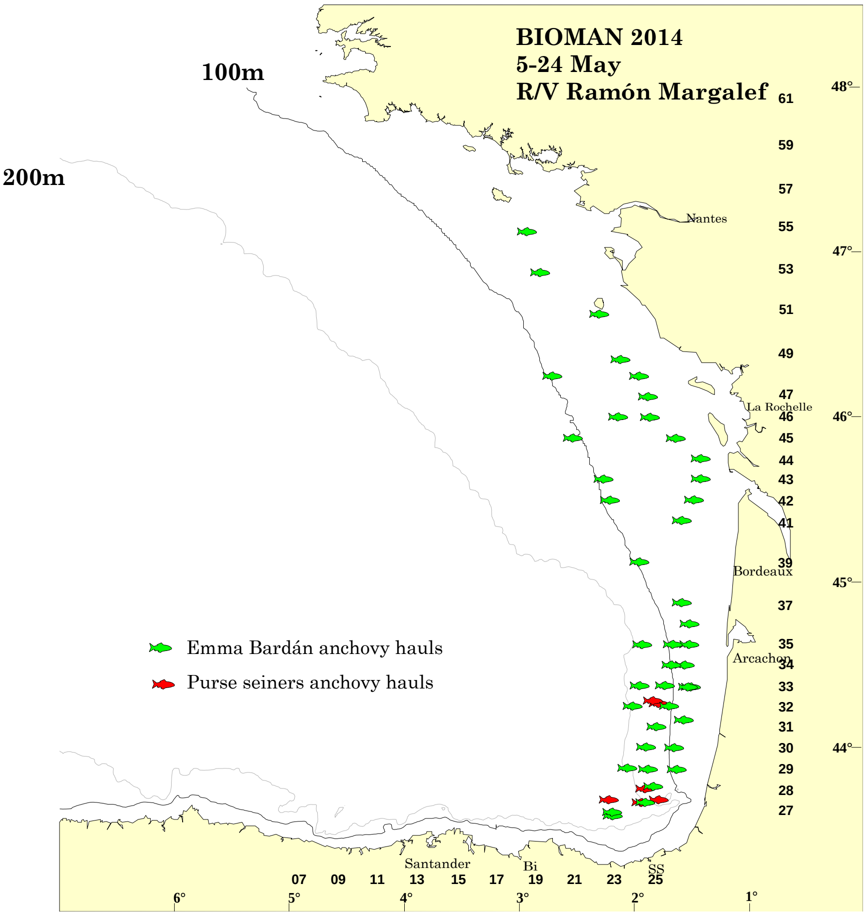

Figure 2: Spatial distribution of fishing hauls from pelagic trawler R/V Emma Bardán (green) and purse seines (red) in 2014.

Total egg production

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

(1) $$P_{tot} = P_0 \; SA.$$

A standard PairoVET sampling station represented a surface of 45 Nm^2 (i.e. 154 km^2). Since the sampling was adaptive, the area represented by each station was corrected according to the sampling intensity and the cut of the coast. The total area was calculated as the sum of the area represented by each station. The spawning area (*SA*) was delimited with the outer zero anchovy egg stations although it could contain some inner zero anchovy egg stations embedded. The spawning area was computed as the sum of the area represented by the stations within the spawning area.

The daily egg production per area unit (P_0) was estimated together with the daily mortality rate (*Z*) from a general exponential decay mortality model of the form:

(2) $$P_{i,j} = P_0 \exp\left(-Z \; a_{i,j}\right),$$

where $P_{i,j}$ and $a_{i,j}$ denote respectively the number of eggs per unit area in cohort *j* in station *i* and their corresponding mean age. Let the density of eggs in cohort *j* in station *i*, $P_{i,j,}$ be the ratio between the number of eggs $N_{i,j}$ and the effective sea area sampled R_i (*i.e.* $P_{i,j} = N_{i,j} / R_i$). The model was written as a generalised linear model (GLM, McCullagh and Nelder, 1989; ICES, 2004) with logarithmic link function:

(3) $$\log\left(E[N_{i,j}]\right) = \log(R_i) + \log(P_0) - Z \; a_{i,j} \;,$$

where the number of eggs of daily cohort *j* in station *i* (N_{ij}) was assumed to follow a negative binomial distribution. The logarithm of the effective sea surface area sampled ($\log(R_i)$) was an offset accounting for differences in the sea surface area sampled and the logarithm of the daily egg production $\log(P_0)$ and the daily mortality *Z* rates were the parameters to be estimated.

The eggs collected at sea and sorted into morphological stages had to be transformed into daily cohort frequencies and their mean age calculated in order to fit the above model. For that purpose the Bayesian ageing method described in ICES (2004), Stratoudakis *et al*., (2006) and Bernal *et al.*, (2011) was used. This ageing method is based on the probability density function (pdf) of the age of an egg *f(age | stage, temp)*, which is constructed as:

(4) $$f(age \mid stage, temp) \propto f(stage \mid age, temp)\, f(age) .$$

The first term *f(stage | age, temp)* is the pdf of stages given age and temperature. It represents the temperature dependent egg development, which is obtained by fitting a multinomial model like extended continuation ratio models (Agresti, 1990) to data from temperature dependent incubation experiments (Ibaibarriaga *et al.,* 2007, Bernal *et al.,* 2008). The second term is the prior distribution of age. A priori the probability of an egg that was sampled at time τ of having an age *age* is the product of the probability of an egg being spawned at time τ - *age* and the probability of that egg surviving since then (*exp(-Z age)*):

(5) $$f(age) \propto f(spawn = \tau - age)\exp(-Z\ age) .$$

The pdf of spawning time *f(spawn=*τ *- age)* allows refining the ageing process for species with spawning synchronicity that spawn at approximately certain times of the day (Lo, 1985a; Bernal *et al*., 2001). Anchovy spawning time was assumed to be normally distributed with mean at 23:00h GMT and standard deviation of 1.25 (ICES, 2004). The peak of the spawning time was also used to define the age limits for each daily cohort (spawning time peak plus and minus 12 hours). Details on how the number of eggs in each cohort and the corresponding mean age are computed from the pdf of age are given in Bernal *et al* (2011). The incubation temperature considered was the one obtained from the CTD at 10m in the way down.
Given that this ageing process depends on the daily mortality rate which is unknown, an iterative algorithm in which the ageing and the model fitting are repeated until convergence of the *Z* estimates was used (Bernal *et al.*, 2001; ICES, 2004; Stratoudakis *et al.,* 2006). The procedure is as follows:

Step 1. Assume an initial mortality rate value

Step 2. Using the current estimates of mortality calculate the daily cohort frequencies and their mean age.

Step 3. Fit the GLM and estimate the daily egg production and mortality rates. Update the mortality rate estimate.

Step 4. Repeat steps (1) - (3) until the estimate of mortality converged (i.e. the difference between the old and updated mortality estimates was smaller than 0.0001).

Incomplete cohorts, either because the bulk of spawning for the day was not over at the time of sampling, or because the cohort was so old that its constituent eggs had started to hatch in substantial numbers, were removed in order to avoid any possible bias. At each station, younger cohorts were dropped if they were sampled before twice the spawning peak width after the spawning peak and older cohorts were dropped if their mean age plus twice the spawning peak width was over the critical age at which less than 99% eggs were expected to be still unhatched. In addition, eggs younger than 4 hours and older than 90% of the survey incubation time (Motos, 1994) were removed.

Once the final model estimates were obtained the coefficient of variation of P_0 was given by the standard error of the model intercept (log (P_0)) (Seber, 1982) and the coefficient of variation of Z was obtained directly from the model estimates.
The analysis was conducted in R (www.r-project.org). The "MASS" library was used for fitting the GLM with negative binomial distribution and the "egg" library (http://sourceforge.net/projects/ichthyoanalysis/) for the ageing and the iterative algorithm.

Daily fecundity

The daily fecundity (DF) is usually estimated as follows:

(6) $$DF = \frac{R \cdot F \cdot S}{W_f} ,$$

where R is the sex ratio in weight, F is the batch fecundity (eggs per batch per female weight), S is the spawning frequency (percentage of females spawning per day) and W_f is the female mean weight.

From 1987 to 1993 the **sex ratio (*R*)** in numbers resulted to be not significantly different from 50%. Therefore, since 1994 the sex ratio in numbers is assumed to be 0.5 and the sex ratio in weight per sample is estimated as the ratio between the average female weight and the sum of the average female and male weights of the anchovies in each of the samples.

A linear regression model between total weight (W) and gonad free weight (W_{gf}) was fitted to data from non-hydrated females:

(7) $$E[W] = a + b * W_{gf} .$$

This model was used to correct the weight increase of hydrated anchovies. **The female mean weight (W_f)** per sample was calculated as the average of the individual female weights.

For **the batch fecundity (*F*)** the hydrated egg method was followed (Hunter and Macewicz., 1985). The number of hydrated oocytes in gonads of a set of hydrated females was counted. This number was deduced from a sub-sampling of the hydrated ovary. Three pieces of approximately 50 mg were removed from the extremes and the centre of one of the ovary lobule of each hydrated anchovy. Those were weighted with precision of 0.1 mg and the number of hydrated oocytes counted. Finally the number of hydrated oocytes in the sub-sample was raised to the gonad weight of the female according to the ratio between the weights of the gonad and the weight of the sub-samples

The model between the number of hydrated oocytes and the female gonad free weight was fitted as a Generalized Linear Model with Gamma distribution and identity link:

(8) $$E[F] = a + b * W_{gf}$$

The average of the batch fecundity for the females of each sample as derived from the gonad free weight - eggs per batch relationship was then used as the sample estimate of batch fecundity.

Once sex ratio, female mean weight and batch fecundity were estimated per sample, overall mean and variance for each of these parameters were estimated following equations for cluster sampling (Picquelle & Stauffer, 1985):

(9) $$y = \frac{\sum_{i=1}^{n} M_i y_i}{\sum_{i=1}^{n} M_i}$$ and

(10) $$Var(y) = \frac{n \sum_{i=1}^{n} M_i^2 (y_i - y)^2}{\left(\frac{\sum_{i=1}^{n} M_i}{n} \right)^2 n(n-1)} ,$$

where *Yi* and *Mi* are the mean of the adult parameter *Y* and the cluster sample size in sample *i* respectively. The variance equation for the batch fecundity was corrected according to Picquelle and Stauffer (1985) in order to account for the additional variance due to model fitting.

The weights *Mi* were taken to reflect the actual size of the catch and to account for the lower reliability when the sample catch was small (Picquelle and Stauffer, 1985). For the estimation of *W* and *F* when the number of mature females per sample was less than 20 the weighting factor was equal to the number of mature females per sample divided by 20, otherwise it was set equal to 1. In the case of R when the total weight of the sample was less than 800 g then the weighting factor was equal to the total weight of the sample divided by 800g, otherwise it was set equal to 1.

For the **spawning frequency (*S*)** in June a mean of the new historical series was presented. Here a proper estimate of this parameter is presented. Since 2013 the new procedure is applied. In this method staging and ageing of POFs are separated. The classification in stages (before and after spawning) is described in Alday *et al* 2008. Then, ageing is performed according to matrices depending on the time of the day based on historical samples from 1990 and laboratory experiments. The new estimator for S is described in Uriarte *et al* 2012.

SSB and numbers at age

The Spawning Stock Biomass (*SSB*) was estimated as the ratio between the total egg production (P_{tot}) and daily fecundity (*DF*) estimates and its variance was computed using the Delta method (Seber, *1982*).

To deduce the numbers at age for anchovy 2 regions, North (N) and South (S) were defined depending on the distribution of the adult samples (size, weight and age) and the distribution of anchovy eggs (**Figure 3**). Mean and variance of anchovy mean weights and proportions at age in the adult population were computed as a weighted average of the mean weight and age composition per samples (**equations 9 and 10**) where the weights were proportional to the population in numbers, in each region. In particular, the weighting factors were proportional to the egg abundance divided by the numbers of adult samples in the region and the mean weight of anchovy per sample. For sardine numbers at age were not estimate yet.

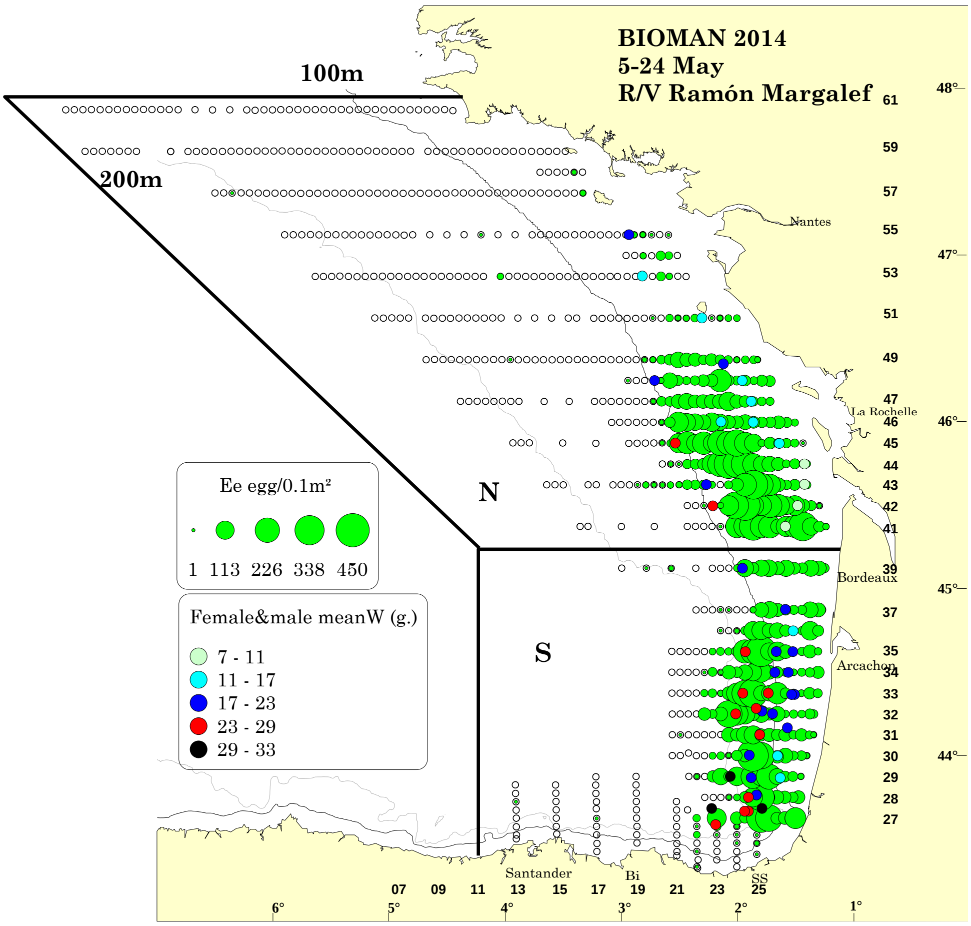

Figure 3: 2 regions defined to estimate the numbers at age: North (N) and South (S). The black lines represent the border of the regions, the red bubbles the abundance of anchovy eggs (egg/0.1m^2) in each station and the blue, red and black bubbles represent the mean weight of the individuals of each haul.

Results

Survey description

This year no anchovy eggs were found in the Cantabrian Coast. The spawning area started at 43º37’N in the French platform and the northern limit was found at 47º N. The eggs in the French platform where encountered in the historical common places: Between Adour and Arcachon passed the 200m depth from the coast and in the area of influence of Le Gironde, from the coast to the 100m depth line (**Figure 4**). The weather conditions during the survey were good in general with a mean Sea Surface Temperature (SST) of 14.8ºC. However sampling was stopped for 9 hours due to bad weather at R 59, two days before finishing the survey. The total area surveyed was 104,115 km^2 and the spawning area was 35,317 km^2. Total number of PairoVET samples obtained was 767. From those, 348 had anchovy eggs (45%) with an average of 290 eggs m^{-2} per station and a maximum of 6340 eggs m^{-2} in a station. A total of 22,310 anchovy eggs were encountered and classified. The number of CUFES samples obtained was 1,719 with 88,711 anchovy eggs in total (9,056eggm^{-3}) with a mean of 5 egg m^{-3} per station.

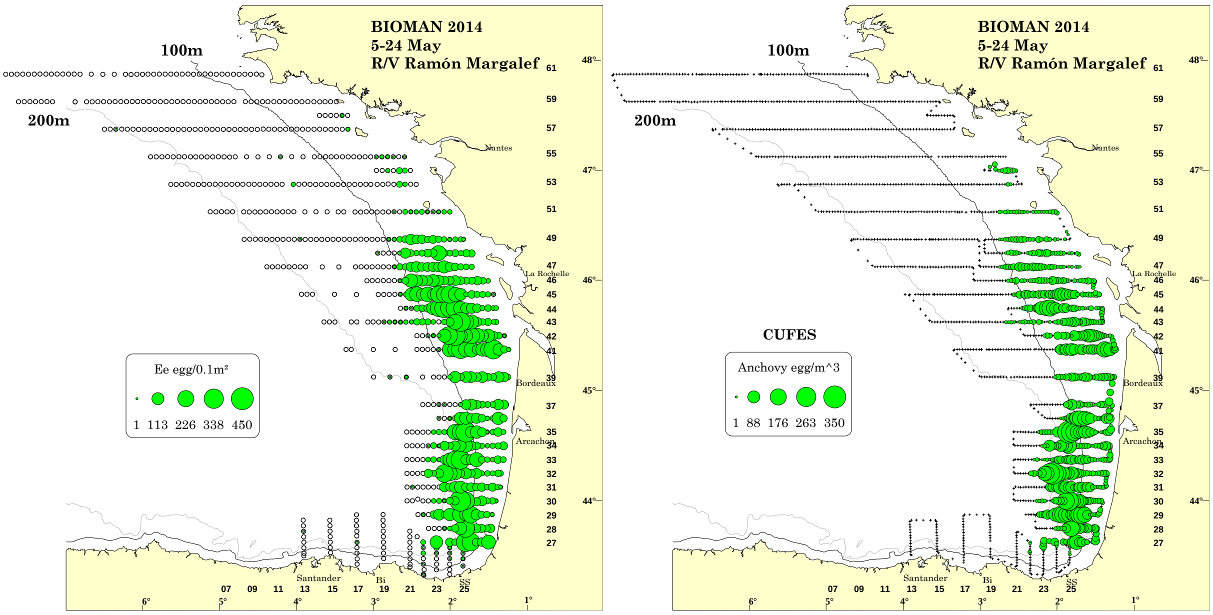

Figure 4: Distribution of anchovy egg abundances obtained with PairoVET (left) (eggs per 0.1m^2) and CUFES (right) (eggs per m^3) from the DEPM survey BIOMAN2014.

Sardine eggs were not found in the Cantabrian coast, they start to appear in the French platform at the Adour river location. From Adour to Arcachon from the coast up to the 200m depth passed and from Arcachon to 48ºN along the 100m depth isoline. From 45ºN to 48ºN appear as well between 100m and 200m depth nearest to the 200m (**Fig. 5**). The total area surveyed was 104,015 km2 and the spawning area for sardine in this coverage was 55,533 km2. From the 767 vertical tows performed with the PairoVET net, 430 (56%) had sardine eggs with an average of 150 eggs m-2 per station and a maximum of 5110 eggs m-2 in a station. A total of 11,536 anchovy eggs were encountered and classified in 11 stages (adapted from Gamulin and Hure, 1955). From the 1,719 CUFES samples obtained xxx had sardine eggs in total (xxxxeggm^{-3}) with a mean of xx egg m^{-3} per station.

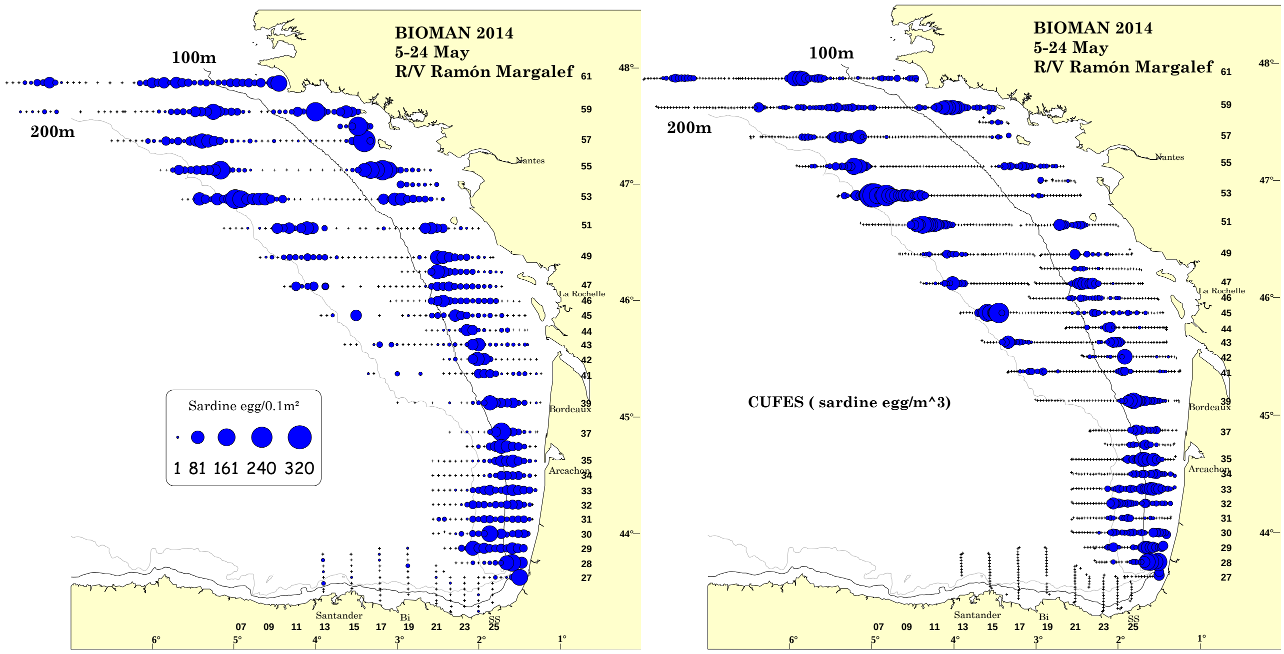

Figure 5: Distribution of sardine egg abundances obtained with PairoVET (left) (eggs per 0.1m^2) and CUFES (right) (eggs per m^3) from the DEPM survey BIOMAN2014.

Figure 6 shows the sea surface temperature and sea surface salinity maps overlapped with the abundance of anchovy eggs as observed during the BIOMAN2014 survey.

This year the mean SST of the survey (14.8ºC) was at levels of last year. The mean SSS (34.38 UPS) was at levels of last year (34.72 UPS). 2013 and 2012 have been cooler than 2011. This year the salinity with a mean of 34 is wide spread over the area more than in previous years and is under 32 in the area of the Gironde and Adour. Comparing with the last 3 years this year appears to be wormer than last but not as wormer as 2011. (**Fig.7**).

The adult samples covered adequately the positive spawning area as shown in **Figure 3.** Overall 51 pelagic trawls were performed of these, 42 provide anchovy and 41 were selected for the analysis because the other one had a small amount of anchovy. More over 6 hauls from the commercial fleet, purse seines, were added for the analysis. In total there were 47 adult anchovy samples for the analysis and 14 for sardine analysis. The spatial distribution of the samples and their species composition is shown in **Figure 8.** The most abundant species in the trawls ware: anchovy, sardine, mackerel, blue whiting and sprat.

Spatial distribution of mean weight and mean Length (males and females) for anchovy is shown in **Figure 9**. Less weight individuals were found all along the coast inside the 100 m depth isoline and in the influence of the Gironde estuary while heavier anchovies were found offshore, once passed the isoline of 100m depth.

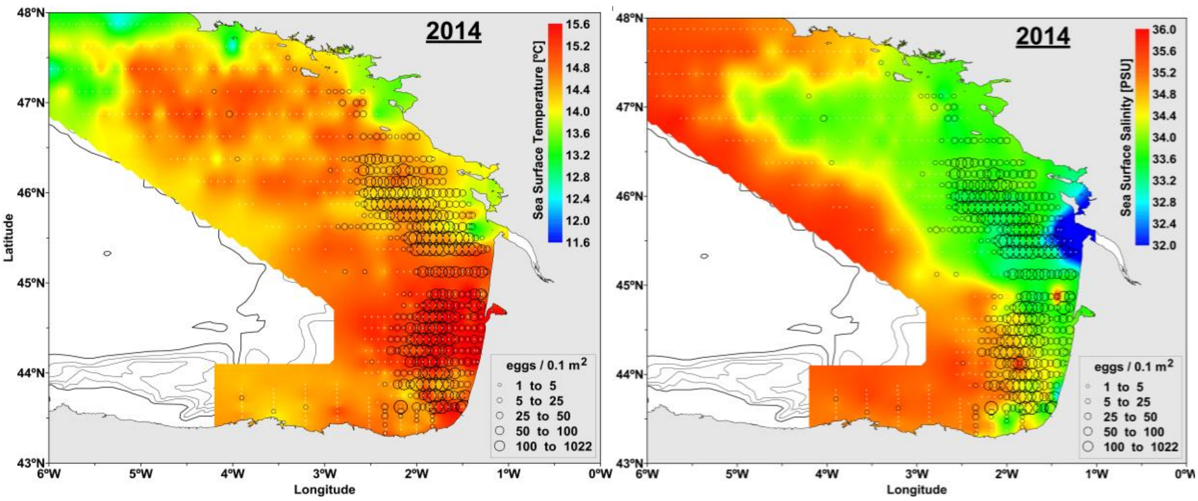

Figure 6: SST and SSS maps (left and right respectively) overlapped with anchovy egg distribution 2014.

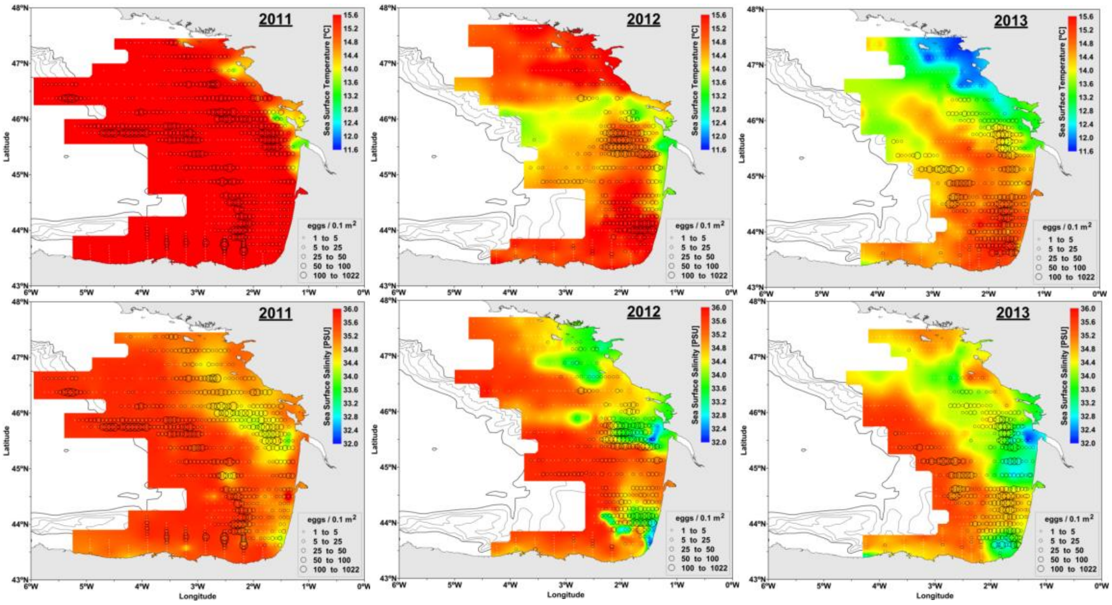

Figure 7: SST (top) and SSS (below) maps overlapped with anchovy egg distribution from 20011 to 2013.

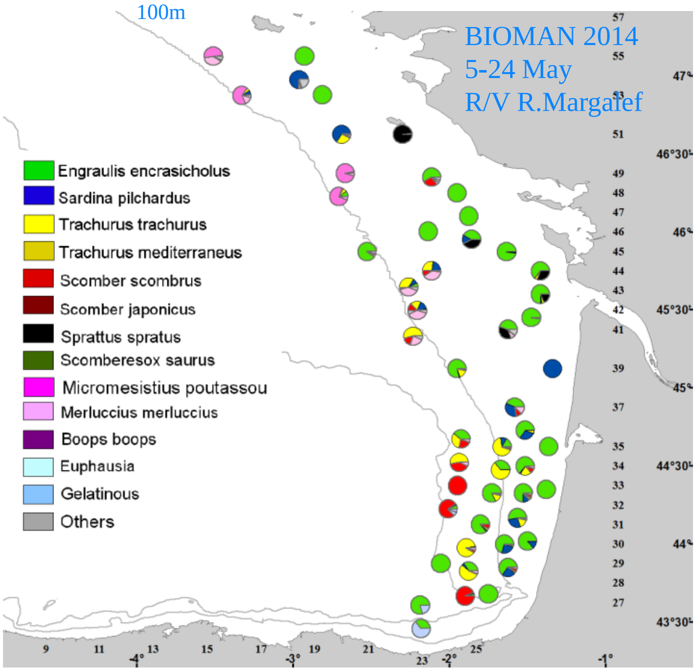

Figure 8: Species composition of the 41 pelagic trawls from the R/V Emma Bardán during BIOMAN14.

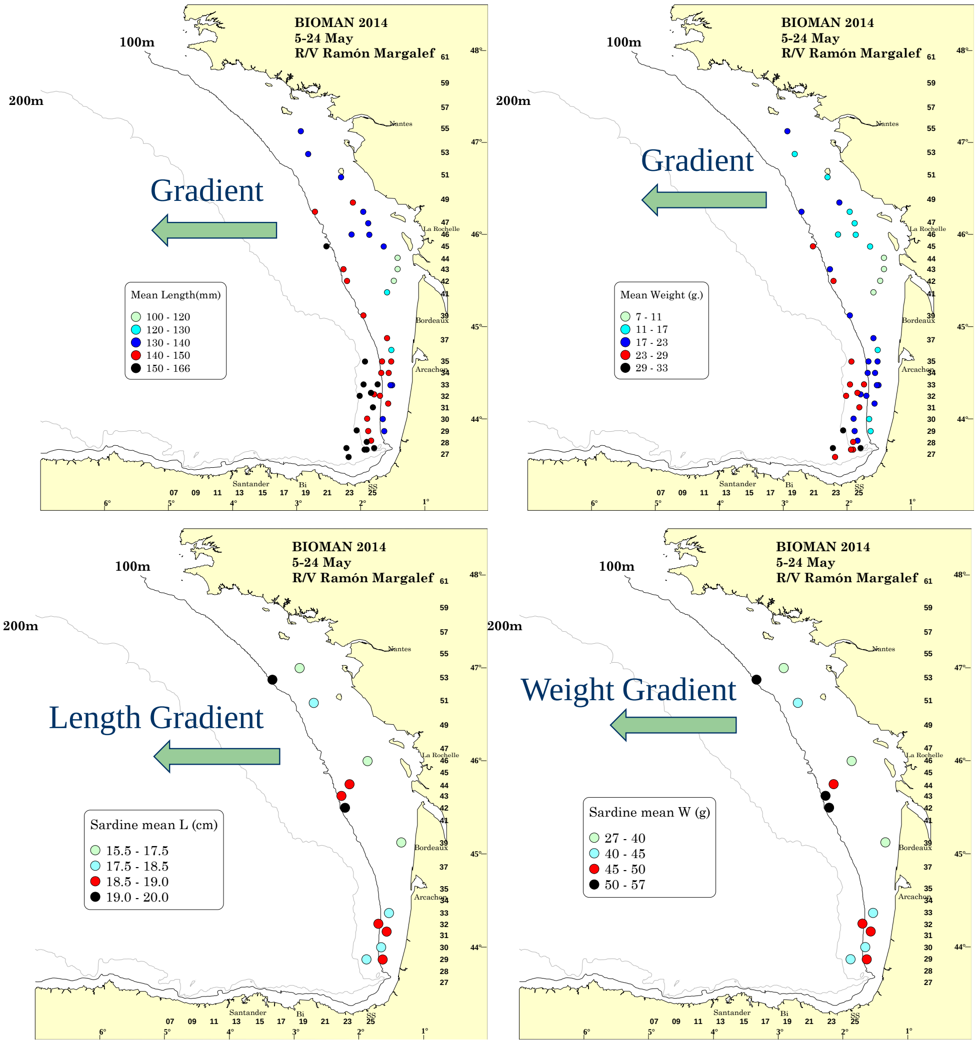

Figure 9: Anchovy (top) and sardine (male+female) size (left) and weight (right) per haul 2014

Anchovy total daily egg production estimates

As a result of the adjusted GLM (**Fig. 10**) the daily egg production (P_0) was 191.37 egg m^{-2} day^{-1} with a standard error of 21.7 and a CV of 0.11. The daily mortality z was 0.17 with a standard error of 0.056 and a CV of 0.34. Then, the total daily egg production as the product of spawning area and daily egg production was 6.76 E+12 with a standard error of 7.7 E+11 and a CV of 0.11, two times last year estimate.

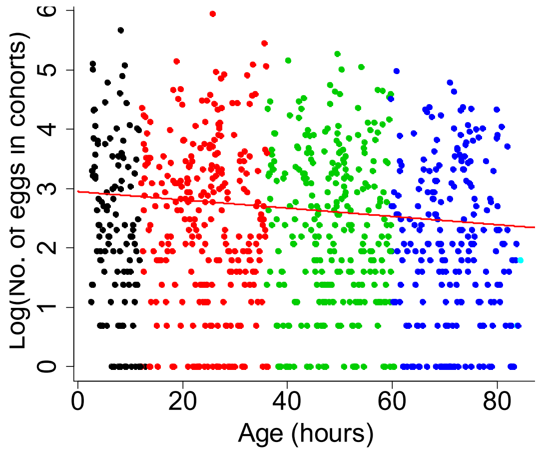

Figure 10: Exponential decay mortality model adjusted applying a GLM to the data obtained in the ageing of anchovy eggs following the Bayesian method (spawning peak 23:00h).The red line is the adjusted line. Data in Log scale.

Sardine total daily egg production estimates

For sardine 3 estimates of the total egg production were done: one with the data from 45ºN to the North, another with the data from 45ºN to the South and finally one with all the data. The results are showed on the table xx and figure 11. The compromise with the DCF is to estimate de sardine SSB from 45ºN to 48ºn to complete the triennial survey carried out by IPMA and IEO from Cadiz to 45ºN in the BoB. In another wd is specify the estimates of the French part of the bay of Biscay mixing the data from the IEO and AZTI.

Table 1: estimates of daily egg production (P_0)(egg/m^2/day) and daily mortality(z) resulted from the generalised linear model with their standard error and CV. Total daily egg production (P_{tot})(eggs/day) was calculated as the product between the spawning area (SA) and the daily egg production (P0) estimates with its standard error and CV.

	ALL AREA			NORTH 45ºN			SOUTH 45ºN		
Parameter	**Value**	**S.e.**	**CV**	**Value**	**S.e.**	**CV**	**Value**	**S.e.**	**CV**
P0	120.38	17.19	0.1428	127.10	19.97	0.1571	97.96	25.67	0.2621
z	0.30	0.093	0.3100	0.33	0.095	0.2859	0.18	0.173	0.940
Ptot	7.5.E+12	1.1.E+12	0.1428	6.4.E+12	1.0.E+12	1.6.E-01	1.2.E+12	1.0.E+12	0.1571

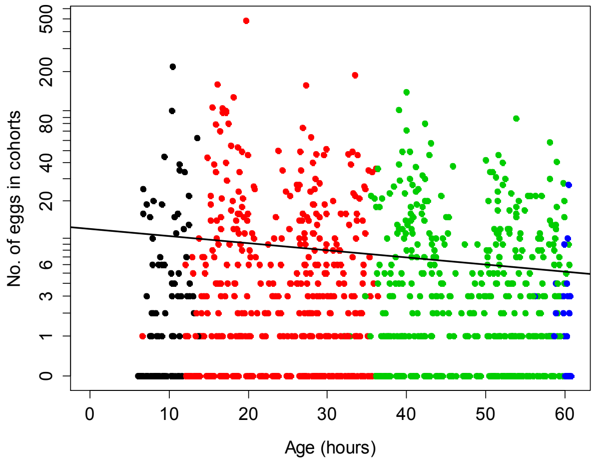

Figure 11: Exponential decay mortality model adjusted applying a GLM to the data obtained in the ageing of sardine eggs following the Bayesian method (spawning peak 21:00h).The black line is the adjusted line. Data in Log scale. Example for all the area.

Daily fecundity for anchovy

The linear regression model between gonad-free-weight and total weight fitted to non-hydrated females (hydrated females identified *a visu* following the mature scale adopted at ICES workshop WKSPMAT) is given in **Table 1**. The extra females taken not in random, for batch fecundity, were not considered. The model fitted the data adequately (**Figure 12**, R^2=99.3%, n= 933). The **female mean weight** was obtained as the weighted mean of the average female weights per sample (Lasker, 1985). W_f = 21.09g.

Table 1: Coefficients resulted from the linear regression model between gonad-free-weight and total weight fitted to non-hydrated females with their standard error and the P-Value.

Parameter	Estimate	Standard error	P-Value
Intercept	-0.5180	0.0593	0
Slope	1.1182	0.0030	0

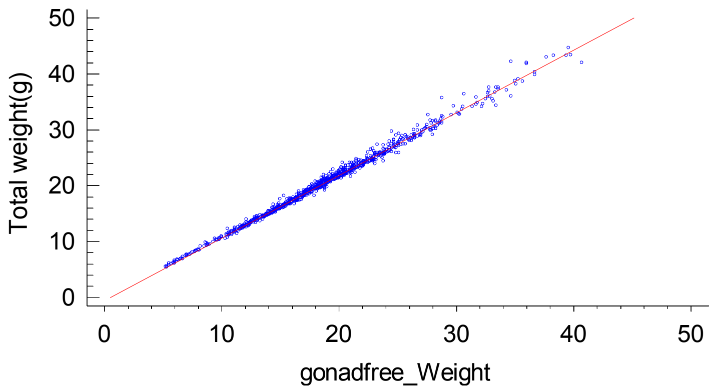

Figure 12: Linear regression model between gonad-free-weight and total weight fitted to non-hydrated females for 2014 for anchovy.

A revision of the preliminary **batch fecundity (*F*)** given in June was completed. From the 123 samples selected in June to estimate de preliminary *F*, 33 of them were removed due to the existence of POFs in the gonad and 22 were added to compensate the remove of those samples and complete the individuals by size for the estimation of the batch fecundity. In consequence, 112 ovaries were considered for the estimation of the batch fecundity. The females come from 12 samples, ranging from 9 to 37 g gonad free weight. It was tested whether the model coefficients changed between North and South strata (**Figure 3**). There were statistically significant differences among the regions at the 95% confidence level were found, so two models fitted to the two different regions North and South were then used to estimate batch fecundity. The coefficients of the generalised linear model with Gamma distribution and identity link are shown in **table 2** and the fitted model in **Figure 13**. Hence, the overall batch fecundity estimate was obtained as a weighted sample mean of the batch fecundity per sample (Lasker, 1985) F=7,972 egg/batch per average mature female.

The estimate of **spawning frequency (*S*)** following the procedures mentioned in material and methods was S=0.37 cv= 35%.

Estimates of the female mean weight, total mean weight, batch fecundity, sex ratio, new spawning frequency, daily fecundity and SSB with their CVs are given in **table 3**.

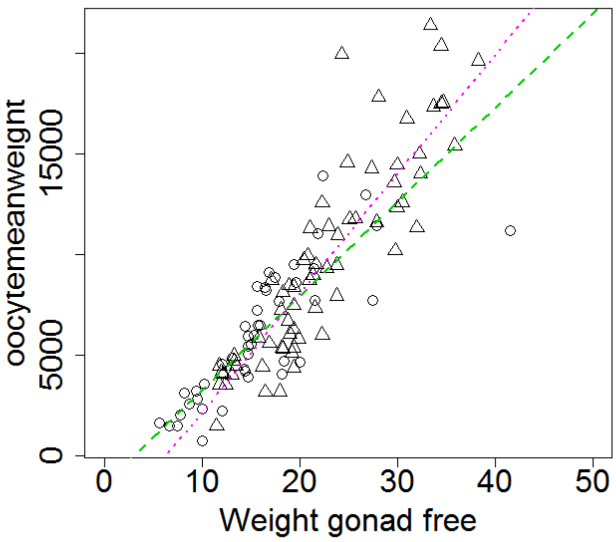

Figure 13: Generalised linear model between Weight gonad-free- and hydrated oocytes fitted to hydrated females. Circles represent samples from the South (pink line is the fitted model for the South) and triangles from the North (red line is the fitted model for the North).

Table 2: Coefficients of the generalised linear models with Gamma distribution and identity link between the number of hydrated oocytes and the female gonad free weight (W_{gf}).

Parameter	estimate	Standard error	Pr(>|t|)
Intercept	-1435.78	355.37	0.00010***
W_{gf}	467.68	33.11	<2e-16 ***
Stratum S	-2353.34	774.22	0.00297***
Wgf:stratums	124.37	51.93	0.01834*

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Table 3: All the parameters to estimate de Spawning Stock Biomass (SSB) using the Daily Egg Production Method (DEPM) for 2013: P_{tot} (total egg production), R (sex ratio), S (Spawning frequency) new, F (batch fecundity), W_f (female mean weight), DF (daily fecundity) and Wt (total mean weight(female and male) with correspondent Standard errors (S.e.) and coefficients of variation (CV).

Parameter	estimate	S.e.	CV
Ptot	6.76E+12	7.67E+11	0.1134
R'	0.54	0.0108	0.0199
S	0.37	0.0129	0.0348
F	7,972	471	0.0591
Wf	21.09	0.87	0.0412
DF	76.14	3.57	0.0468
BIOMASS	**89,011**	10,923	0.1227
Wt	17.07	1.17	0.0685

Anchovy SSB and Numbers at age

The *SSB* estimate obtained was 89,011twith a CV of 12% (**Table 3**).

For the purposes of producing population at age estimates, the age readings based on 2,405 otoliths from 47 samples were available. Estimates of anchovy mean weights and proportions at age in the population were the average of proportions at age in the samples, weighted by the population each sample represents.

Given that mean weights of anchovies change between different regions (**Figure 3**) proportionality between the amount of samples and approximate biomass, indices by regions was checked. The approximate index of biomass by regions was set equal to egg abundance divided by the daily fecundity assigned to each region (**Table 4**). According to that table, the 47 samples selected cannot be considered to be balanced between these regions and differential weighting factors were applied to each sample coming from one or the other region for the purposes of the number at age estimates and biomass estimates. The proportion by age, numbers by age, weight at age and biomass by age estimates are given in **table 5**. 73% of the population in numbers and 65% in mass correspond to age 1. **Figure 14** shows the distribution of anchovy age composition in space.

Table 4: Balance of the adult sampling to egg abundance by 2 regions (North-N and South-S) in the Bay of Biscay (see **Figure 3**). The 6^{th} row of the table corresponds to the weighting factor of each of the samples by region to obtain the population structure. Mean weight by regions arise from the 47 adult samples selected for the analysis.

Estrata	N	S	Addition
Total egg abundance	9.6E+12	9.2E+12	1.88E+13
% egg abundance	51%	49%	100%
Nº of adult samples	17	30	47
% Eggs per sample	0.03	0.02	
Proportion of SSB relative to South	1.84	1.00	
W. factor proportional to the population	1.84/wi	1/wi	
Mean weight of anchovies by region	16.32	30.00	
Standard Deviation	5.67	4.26	
CV	35%	14%	

Table 5: 2014 SSB (Spawning Stock Biomass) estimates and correspondent standard error (S.e.) and coefficient of variation (CV) of the percentage, numbers, weight and Spawning Stock Biomass (SSB) at age estimates.

Parameter	estimate	S.e.	CV
Biomass (Tons)	**89,011**	10,923	0.1227
Tot. Mean W (g)	17.07	1.17	0.0685
Population (millions)	5,245	782	0.1491
Percent. age 1	0.73	0.03	0.0464
Percent. age 2	0.21	0.03	0.1286
Percent. age 3	0.06	0.01	0.1819
Numbers at age 1	3,863	658	0.1704
Numbers at age 2	1,109	169	0.1524
Numbers at age 3	294	67	0.2264
Weight at age 1 (g)	15.3		
Weight at age 2 (g)	22.3		
Weight at age 3 (g)	22.7		
SSB at age 1 (Tons)	58,079		
SSB at age 2 (Tons)	24,358		
SSB at age 3 (Tons)	6,574		
Percet. at age 1 in mass	65.2		
Percent. at age 2 in mass	27.4		
Percent. at age 3 in mass	7.4		

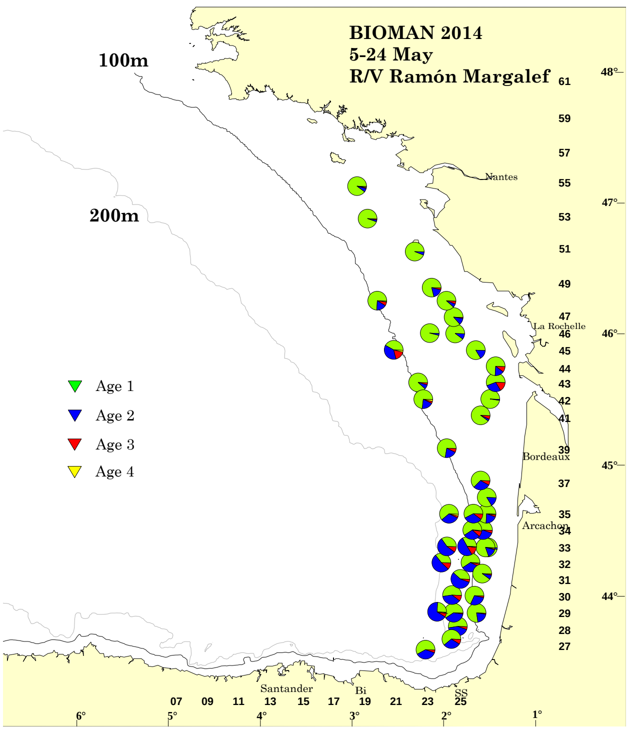

Figure 14: Anchovy age composition per haul 2014

Daily fecundity for sardine

Figure 15 shows the hauls with sardine used for the analysis. 1131 fish from 14 samples were measured, weighted, sexed, extracted otoliths (542 from fresh fish and 354 from frozen fish) and 373 ovaries analysed.

The linear regression model between gonad-free-weight and total weight fitted to non-hydrated females (hydrated females identified *a visu* following the mature scale adopted at ICES workshop WKSPMAT) is given in **Table 6**. The extra females taken not in random, for batch fecundity, were not considered. The model fitted the data adequately (**Figure 16**, R^2=99.1%, n= 251). The **female mean weight** was obtained as the weighted mean of the average female weights per sample (Lasker, 1985). W_f = 46.95g.

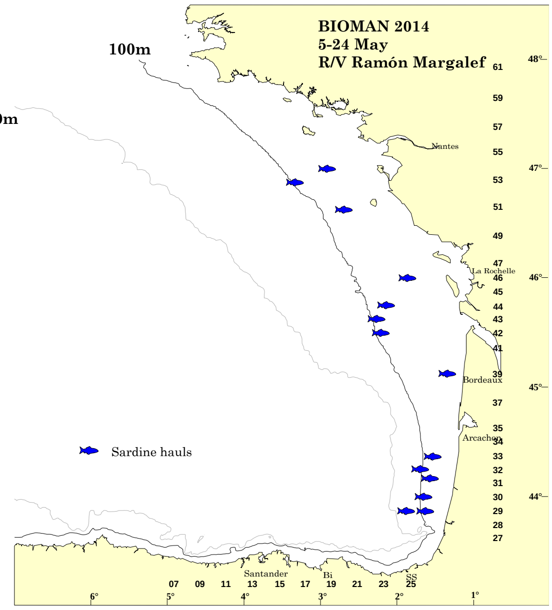

Figure 15: 14 pelagic hauls with sardine used for the analysis.

Table 6: Coefficients resulted from the linear regression model between gonad-free-weight and total weight fitted to non-hydrated females with their standard error and the P-Value.

Parameter	Estimate	Standard error	P-Value
Intercept	-1.1744	0.3029	0.0001
Slope	1.0860	0.0065	0.0000

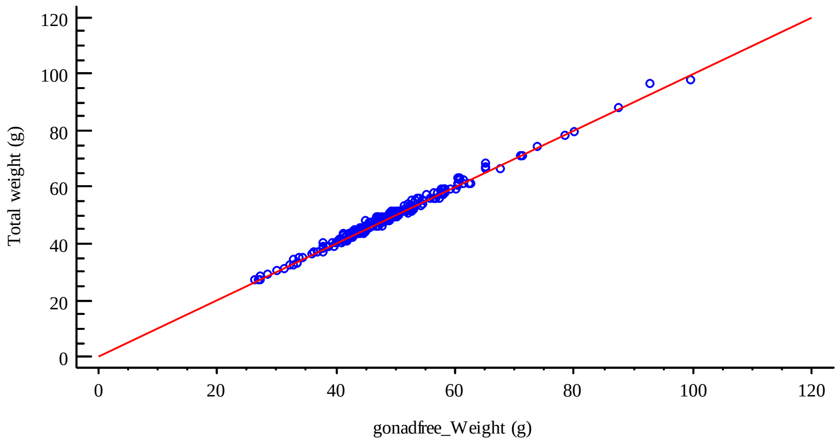

Figure 16: Linear regression model between gonad-free-weight and total weight fitted to non-hydrated females for 2014 for sardine.

For the **batch fecundity** 36 hydrated females from 7 samples, ranging from 25 to 91 g gonad free weight were examined. Due to the differences encountered in those females weight and the differences in the oocytes mean weight encountered in the gonads between North and South, different batch fecundity between these two regions were considered for the analysis. The models coefficients were no significantly different at 95% confidence level, so a unique stratum was considered. The coefficient of the generalised linear model with Gamma distribution and identity link for all the region are given in **table 7** and the fitted model is shown in **Figure 17**. The model fitted was used to estimate batch fecundity in each sample. Hence, the overall batch fecundity estimate was obtained as a weighted sample mean of the batch fecundity per sample (Lasker, 1985). F=18,464 egg/batch per average mature female. CV=6%

The estimate of **spawning frequency (*S*)** was estimates as follow:

$$S = \frac{(age1 + age2) * 2}{Tot_{female}}$$

Obtaining an S=0.37 CV= 35%.

Estimates of the female mean weight, total mean weight, batch fecundity, sex ratio, new spawning frequency, daily fecundity and SSB with their CVs are given in **table 8**.

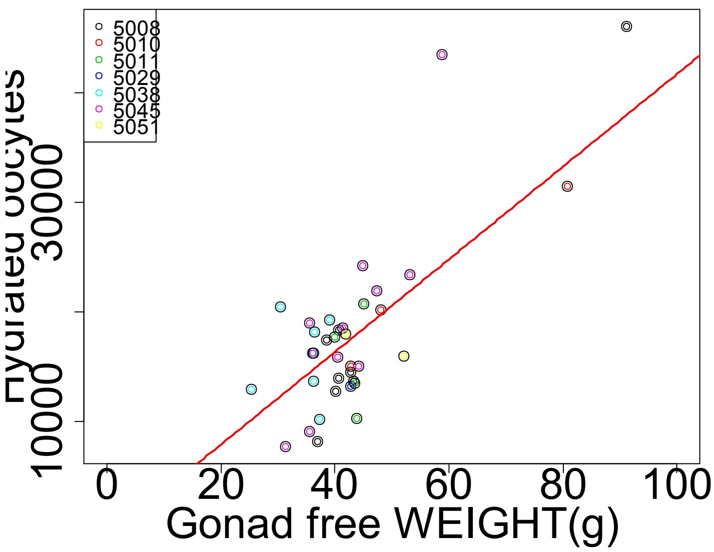

Figure 17: Generalised linear model between Weight gonad-free- and hydrated oocytes fitted to hydrated females. Colours represent each sample.

Table 8: Coefficients of the generalised linear models with Gamma distribution and identity link between the number of hydrated oocytes and the female gonad free weight (W_{gf}).

Parameter	estimate	Standard error	Pr(>|t|)
Intercept	-523.05	3832.3	0.892
W_{gf}	422.77	95.35	9.1 e-05 ***

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Table 8: All the parameters to estimate sardine Spawning Stock Biomass (SSB) using the Daily Egg Production Method (DEPM) for 2014: P_{tot} (total egg production), R (sex ratio), S (Spawning frequency) new, F (batch fecundity), W_f (female mean weight), DF (daily fecundity) and Wt (total mean weight (female and male) with correspondent Standard errors (S.e.) and coefficients of variation (CV).

Parameter	estimate	S.e.	CV
Ptot	7.52E+12	1.07E+12	0.1428
R'	0.52	0.0041	0.0078
S	0.13	0.0240	0.1793
F	18,464	1,140	0.0617
Wf	46.95	1.95	0.0415
DF	27.32	5.07	0.1856
BIOMASS	**284,543**	66,640	0.2342
Wt	41.74	3.29	0.0788

Anchovy and sardine historical perspective

The whole series of biomass index estimated with the DEPM, including the current estimate for 2014, taking into account the new S are presented in **figure 18**. The historical series of numbers at age in numbers is shown in **figure 19.** Sardine total egg abundance series is showed in **figure 20** these values were used in the assessment for sardine in the Bay of Biscay and Atlantic Iberian waters in Divisions VIIIa,b,d and Subarea VII. In order to provide a broader point of view for the interpretation of current survey results, distribution maps of anchovy and sardine egg abundances in the last 27 DEPM surveys were compiled (**Fig 21&22**).

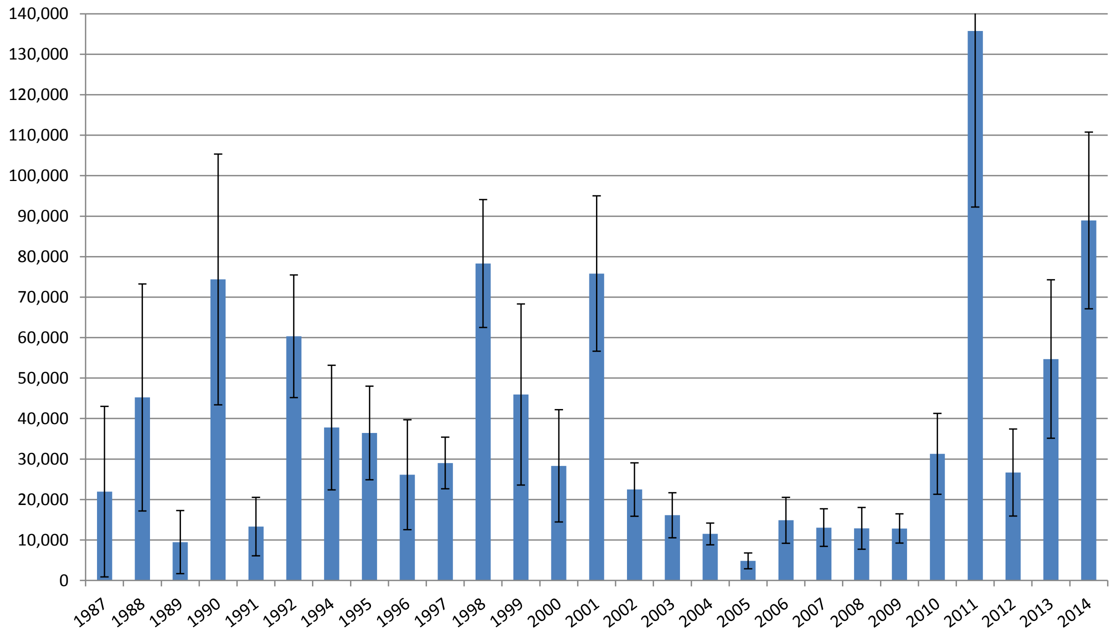

Figure 18: Series of anchovy biomass estimates (tonnes) obtained from the DEPM since 1987.

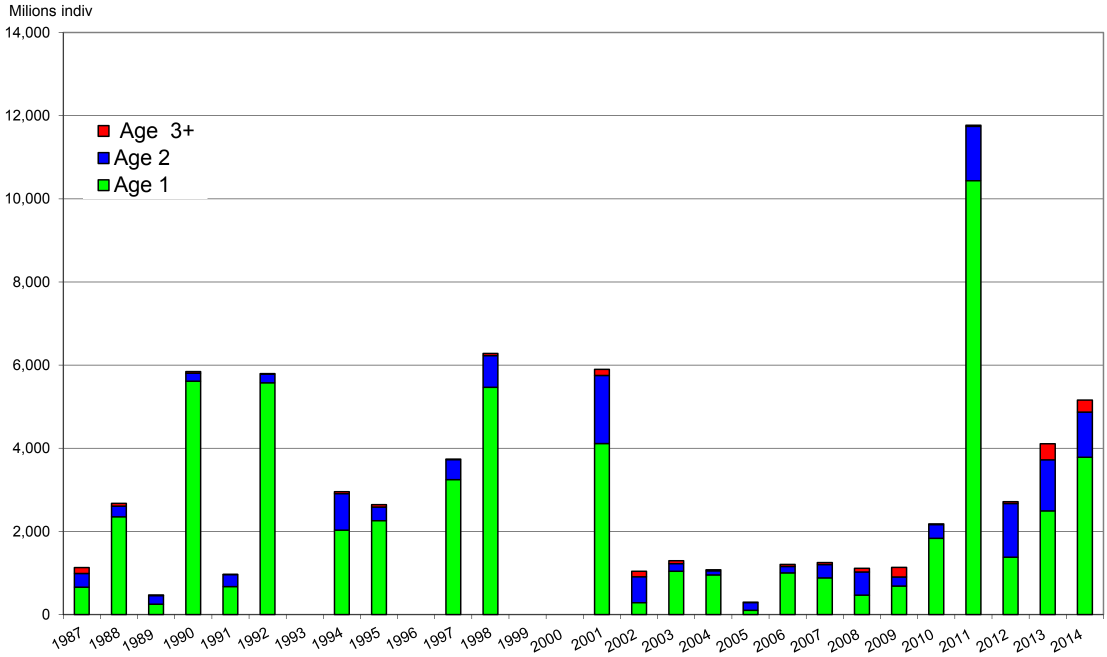

Figure 19: Historical series of anchovy numbers at age from 1987 to 2014. This year 73% of the biomass in numbers was year one.

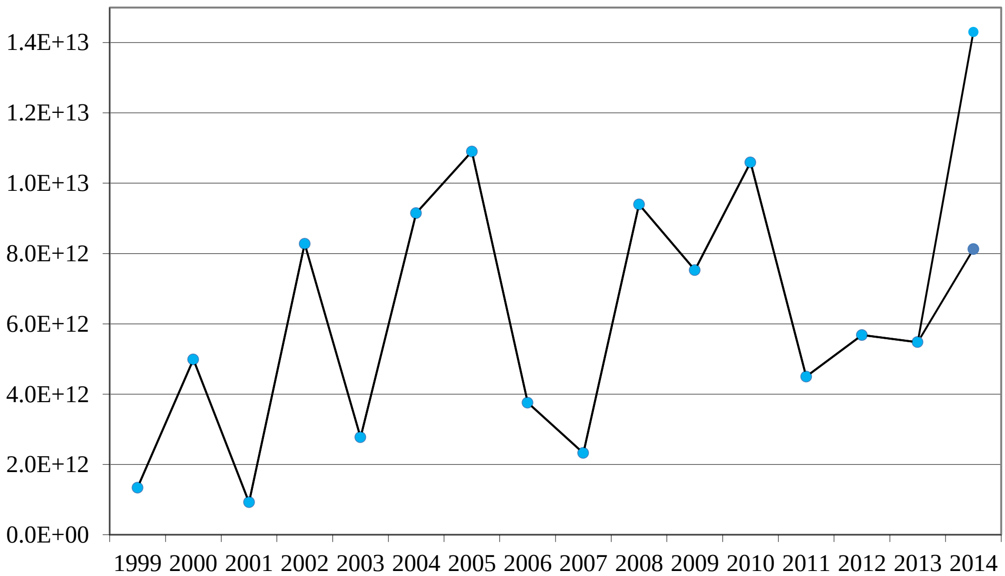

Figure 20: Historical series of sardine total egg abundance since 1999 to 2014.

Acknowledgements

We thank all the crew of the R/V Ramón Margalef and Emma Bardán and all the personal that participated in BIOMAN 2014 for their excellent job and collaborative support. This work has been founded by the Agriculture, Fisheries and Food Technology Department of the Basque Government and by the European Commission within the frame of the National Sampling Programme. The General Secretariat of Sea also collaborated providing the R/V Emma Bardán.

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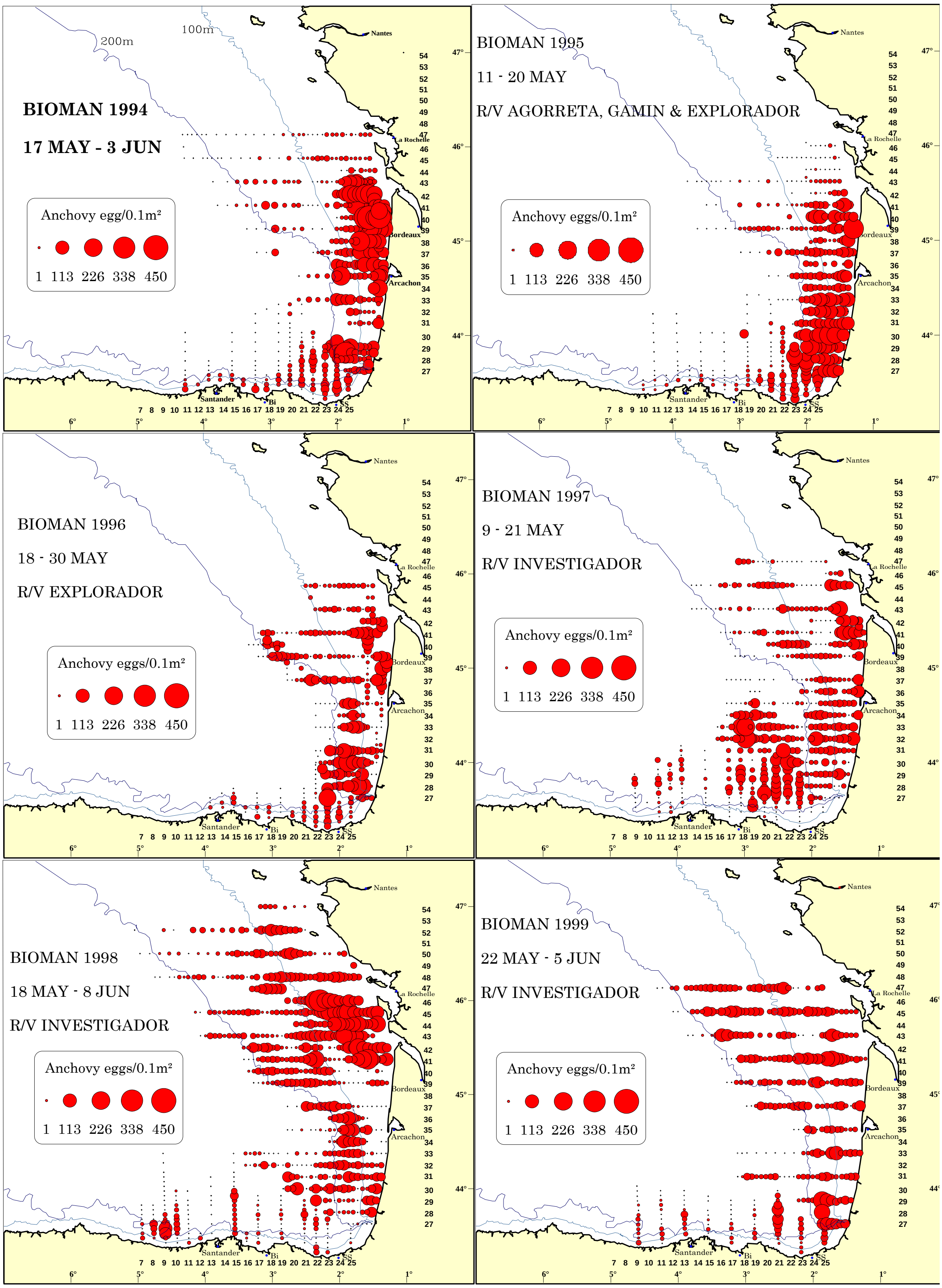
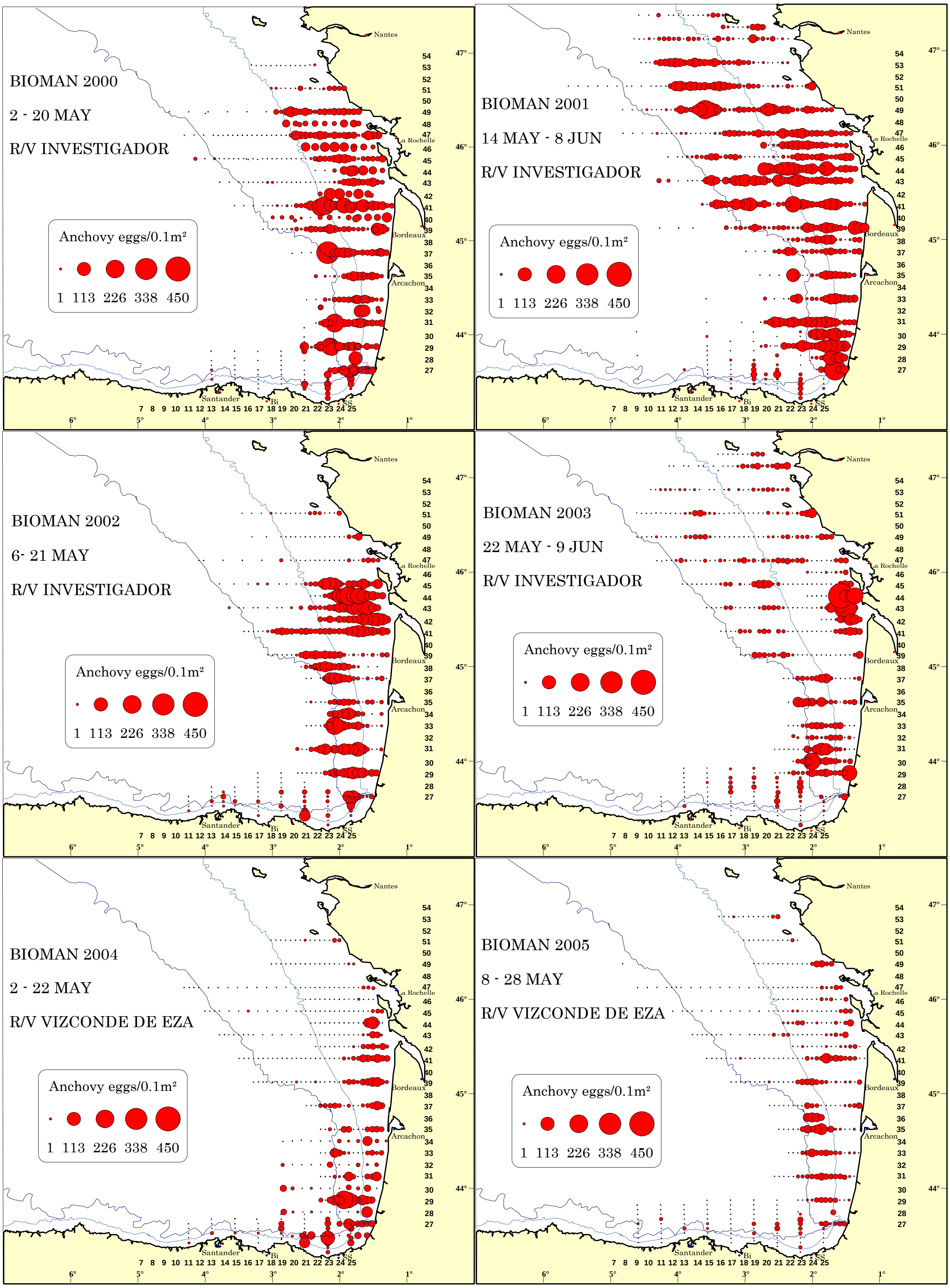
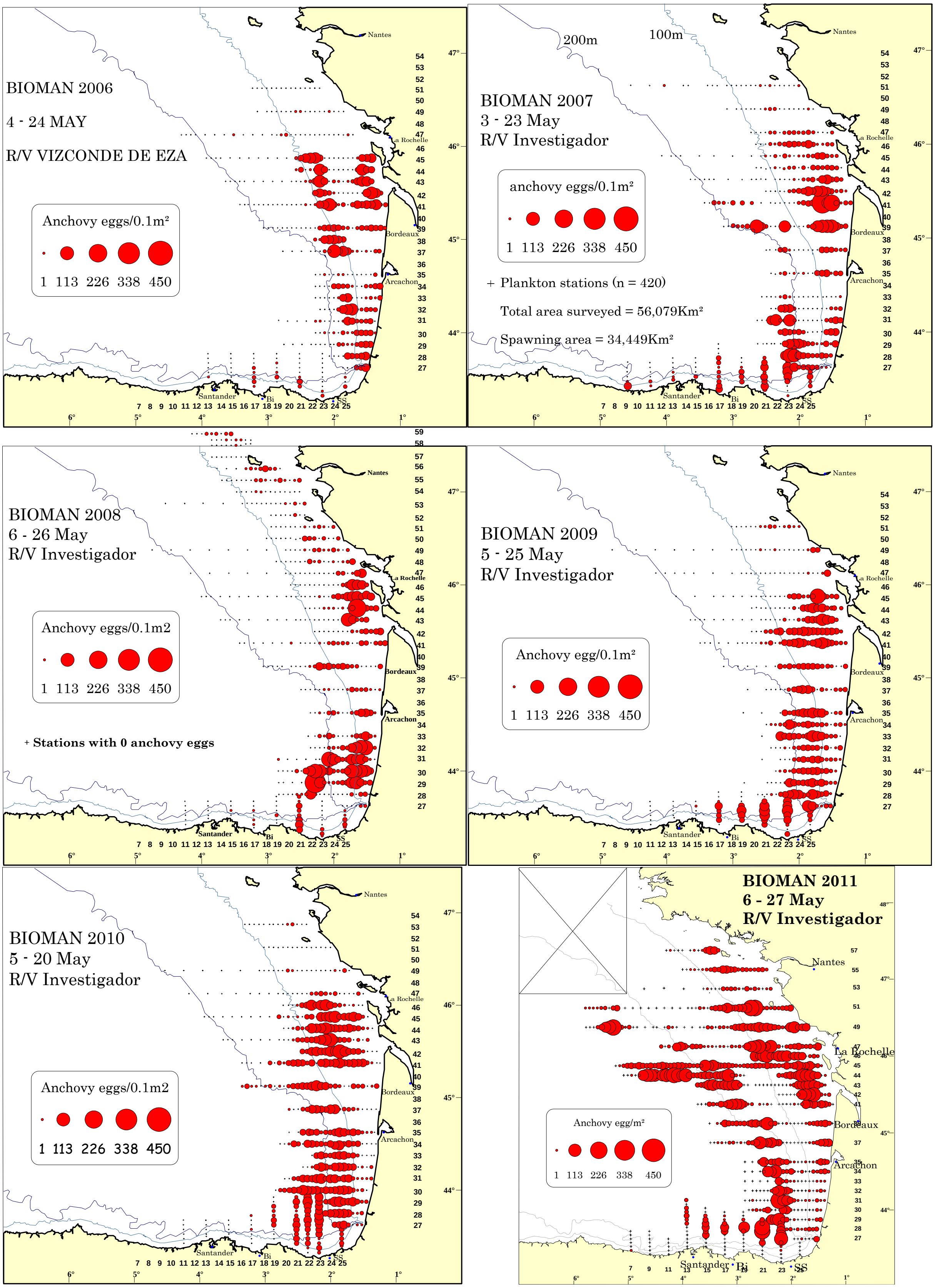

200m
100m
BIOMAN 1994
17 MAY - 3 JUN
Anchovy egg/0.1m²
1 113 226 338 450
BIOMAN 1995
11 - 20 MAY
R/V AGORRETA, GAMIN & EXPLORADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 1996
18 - 30 MAY
R/V EXPLORADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 1997
9 - 21 MAY
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 1998
18 MAY - 8 JUN
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 1999
22 MAY - 5 JUN
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450


BIOMAN 2000
2 - 20 MAY
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 2001
14 MAY - 8 JUN
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 2002
6- 21 MAY
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 2003
22 MAY - 9 JUN
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 2004
2 - 22 MAY
R/V VIZCONDE DE EZA
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 2005
8 - 28 MAY
R/V VIZCONDE DE EZA
Anchovy eggs/0.1m²
1 113 226 338 450
Nantes
La Rochelle
Bordeaux
Arcachon
Santander
Bi
SS
47°
46°
45°
44°
6°
5°
4°
3°
2°
1°
7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
54 53 52 51 50 49 48 47 46 45 44 43 42 41 40 39 38 37 36 35 34 33 32 31 30 29 28 27


BIOMAN 2006
4 - 24 MAY
R/V VIZCONDE DE EZA
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 2007
3 - 23 May
R/V Investigador
200m
100m
anchovy eggs/0.1m²
1 113 226 338 450
+ Plankton stations (n = 420)
Total area surveyed = 56,079Km²
Spawning area = 34,449Km²
BIOMAN 2008
6 - 26 May
R/V Investigador
Anchovy eggs/0.1m2
1 113 226 338 450
+ Stations with 0 anchovy eggs
BIOMAN 2009
5 - 25 May
R/V Investigador
Anchovy egg/0.1m²
1 113 226 338 450
BIOMAN 2010
5 - 20 May
R/V Investigador
Anchovy eggs/0.1m2
1 113 226 338 450
BIOMAN 2011
6 - 27 May
R/V Investigador
Anchovy egg/m²
1 113 226 338 450
Nantes
La Rochelle
Bordeaux
Arcachon
Santander
Bi
SS

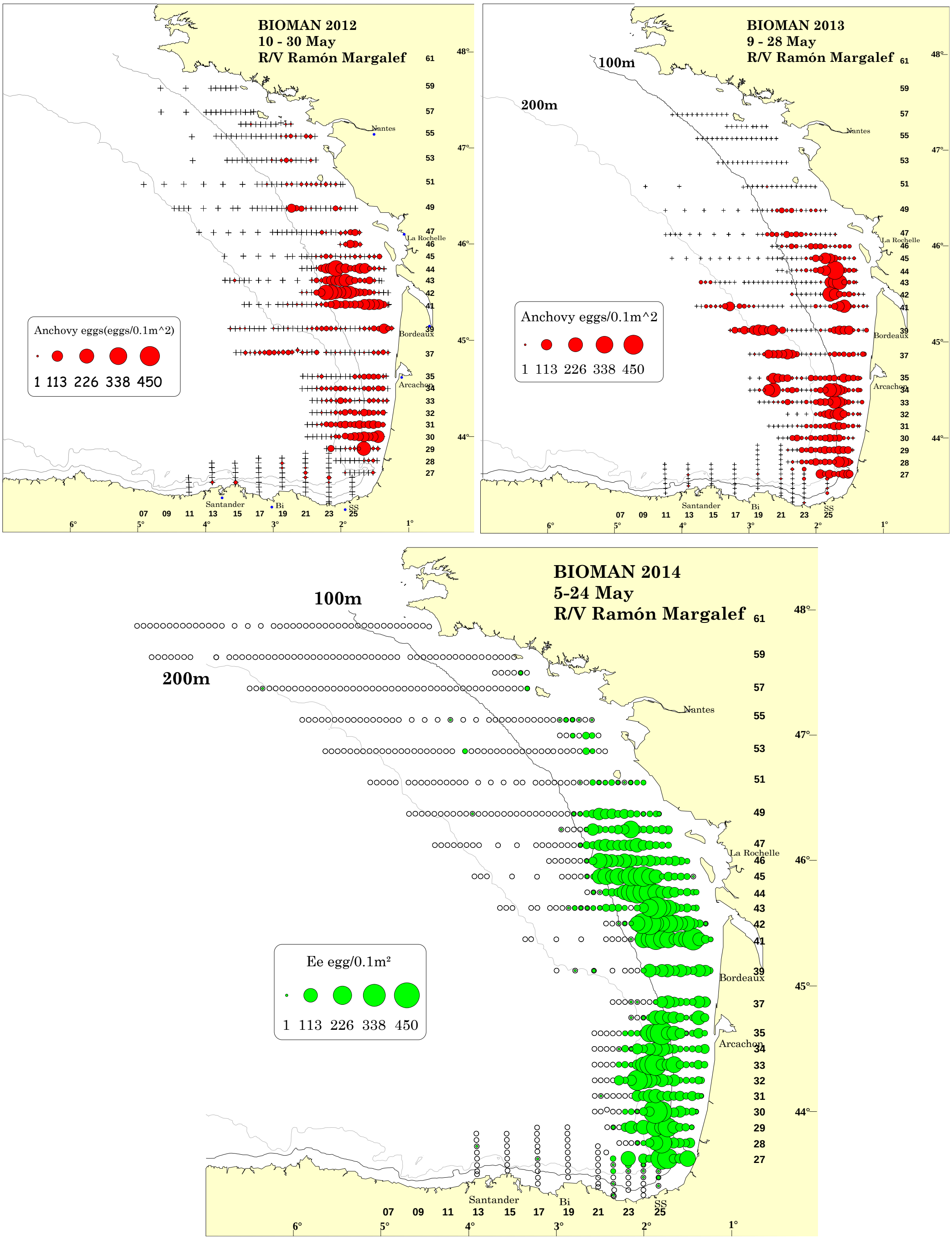
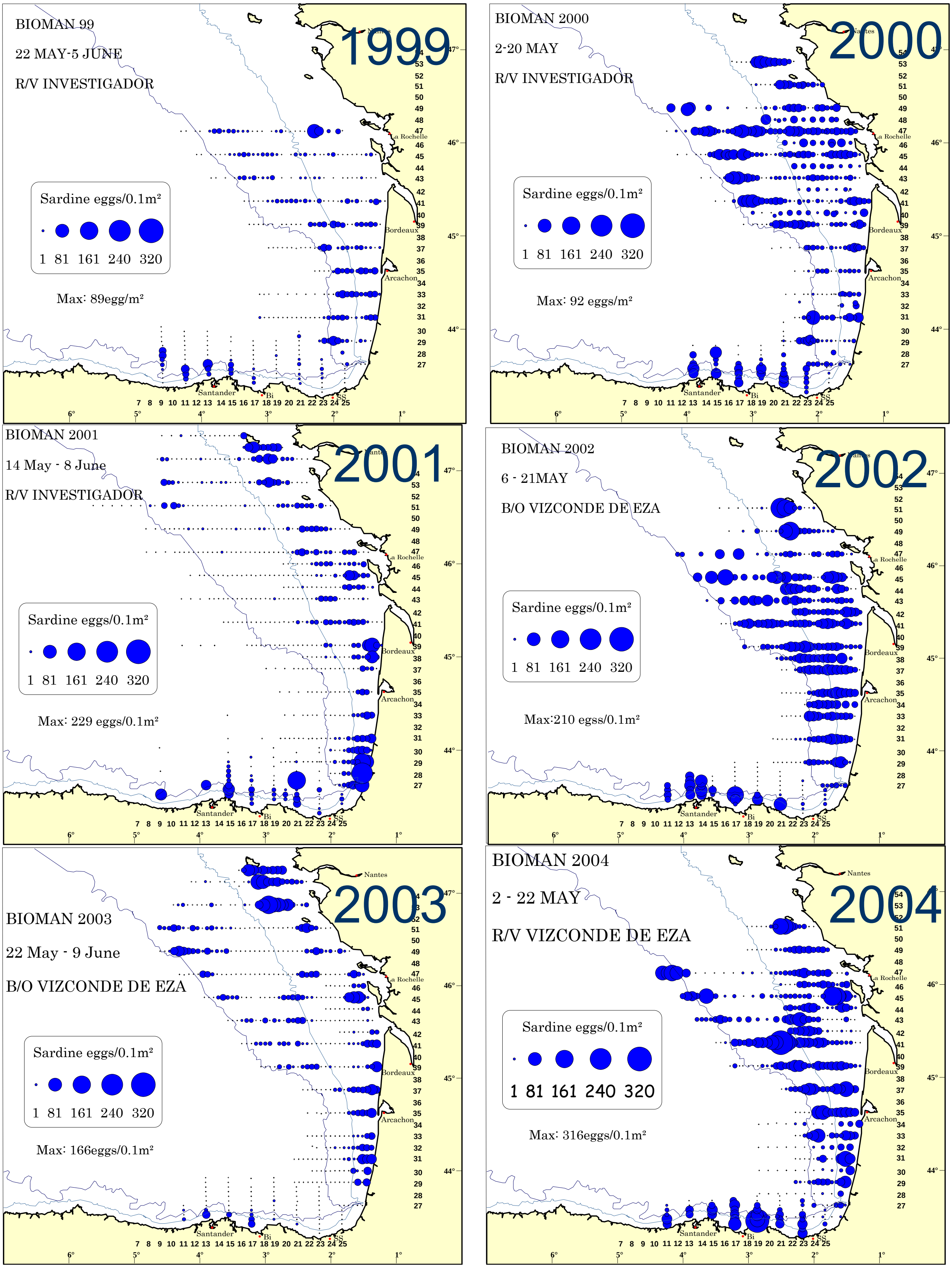
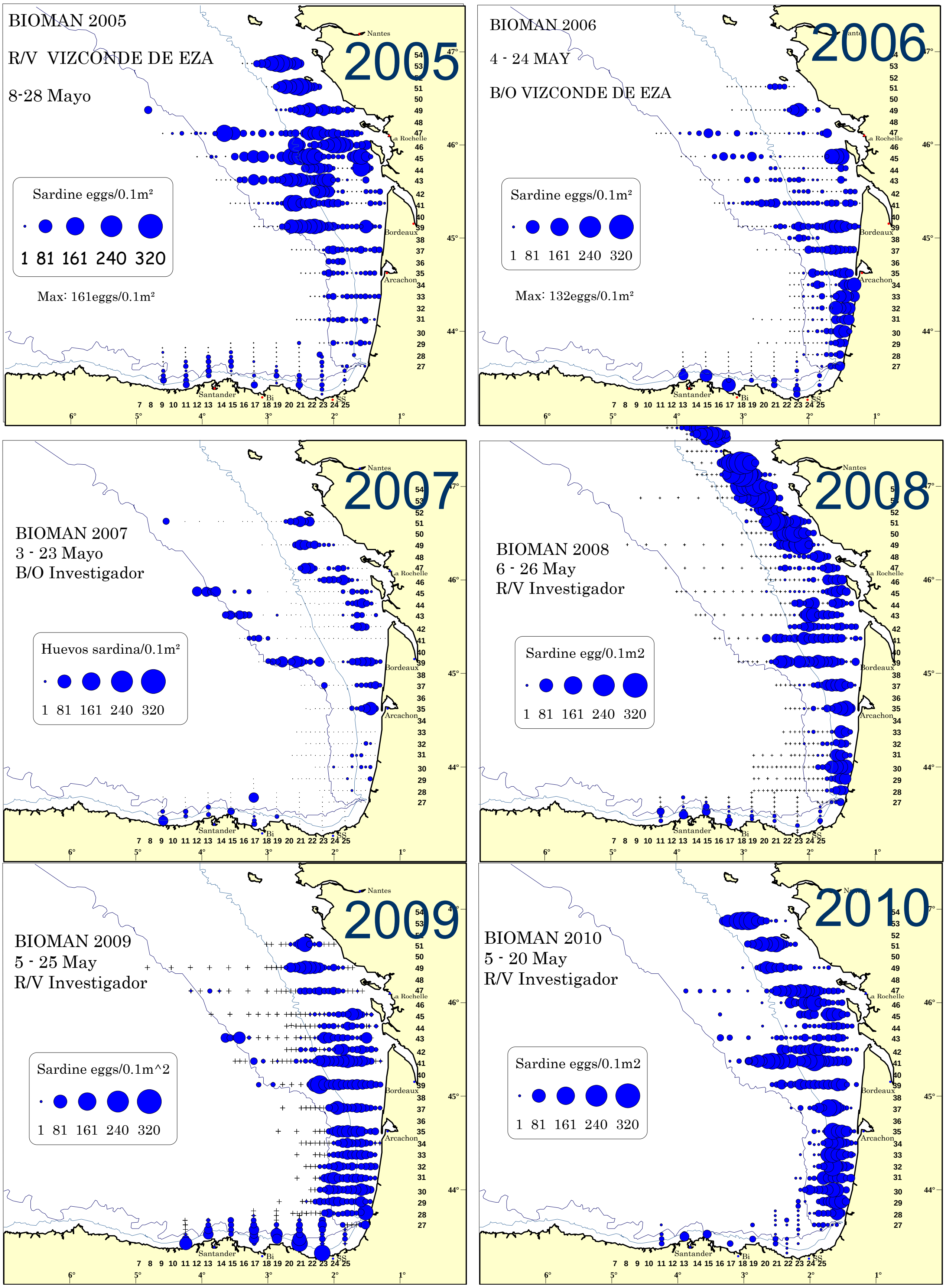


Figure 17: Anchovy egg distribution and abundance from 1994 to 2014.


BIOMAN 99
22 MAY-5 JUNE
R/V INVESTIGADOR
1999
Sardine eggs/0.1m²
1 81 161 240 320
Max: 89egg/m²
BIOMAN 2000
2-20 MAY
R/V INVESTIGADOR
2000
Sardine eggs/0.1m²
1 81 161 240 320
Max: 92 eggs/m²
BIOMAN 2001
14 May - 8 June
R/V INVESTIGADOR
2001
Sardine eggs/0.1m²
1 81 161 240 320
Max: 229 eggs/0.1m²
BIOMAN 2002
6 - 21MAY
B/O VIZCONDE DE EZA
2002
Sardine eggs/0.1m²
1 81 161 240 320
Max:210 egss/0.1m²
BIOMAN 2003
22 May - 9 June
B/O VIZCONDE DE EZA
2003
Sardine eggs/0.1m²
1 81 161 240 320
Max: 166eggs/0.1m²
BIOMAN 2004
2 - 22 MAY
R/V VIZCONDE DE EZA
2004
Sardine eggs/0.1m²
1 81 161 240 320
Max: 316eggs/0.1m²
Nantes
La Rochelle
Bordeaux
Arcachon
Santander


BIOMAN 2005
R/V VIZCONDE DE EZA
8-28 Mayo
2005
Sardine eggs/0.1m²
1 81 161 240 320
Max: 161eggs/0.1m²
BIOMAN 2006
4 - 24 MAY
B/O VIZCONDE DE EZA
2006
Sardine eggs/0.1m²
1 81 161 240 320
Max: 132eggs/0.1m²
BIOMAN 2007
3 - 23 Mayo
B/O Investigador
2007
Huevos sardina/0.1m²
1 81 161 240 320
BIOMAN 2008
6 - 26 May
R/V Investigador
2008
Sardine egg/0.1m2
1 81 161 240 320
BIOMAN 2009
5 - 25 May
R/V Investigador
2009
Sardine eggs/0.1m^2
1 81 161 240 320
BIOMAN 2010
5 - 20 May
R/V Investigador
2010
Sardine eggs/0.1m2
1 81 161 240 320
Nantes
La Rochelle
Bordeaux
Arcachon
Santander
Bi
SS
7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
6° 5° 4° 3° 2° 1°
47° 46° 45° 44°

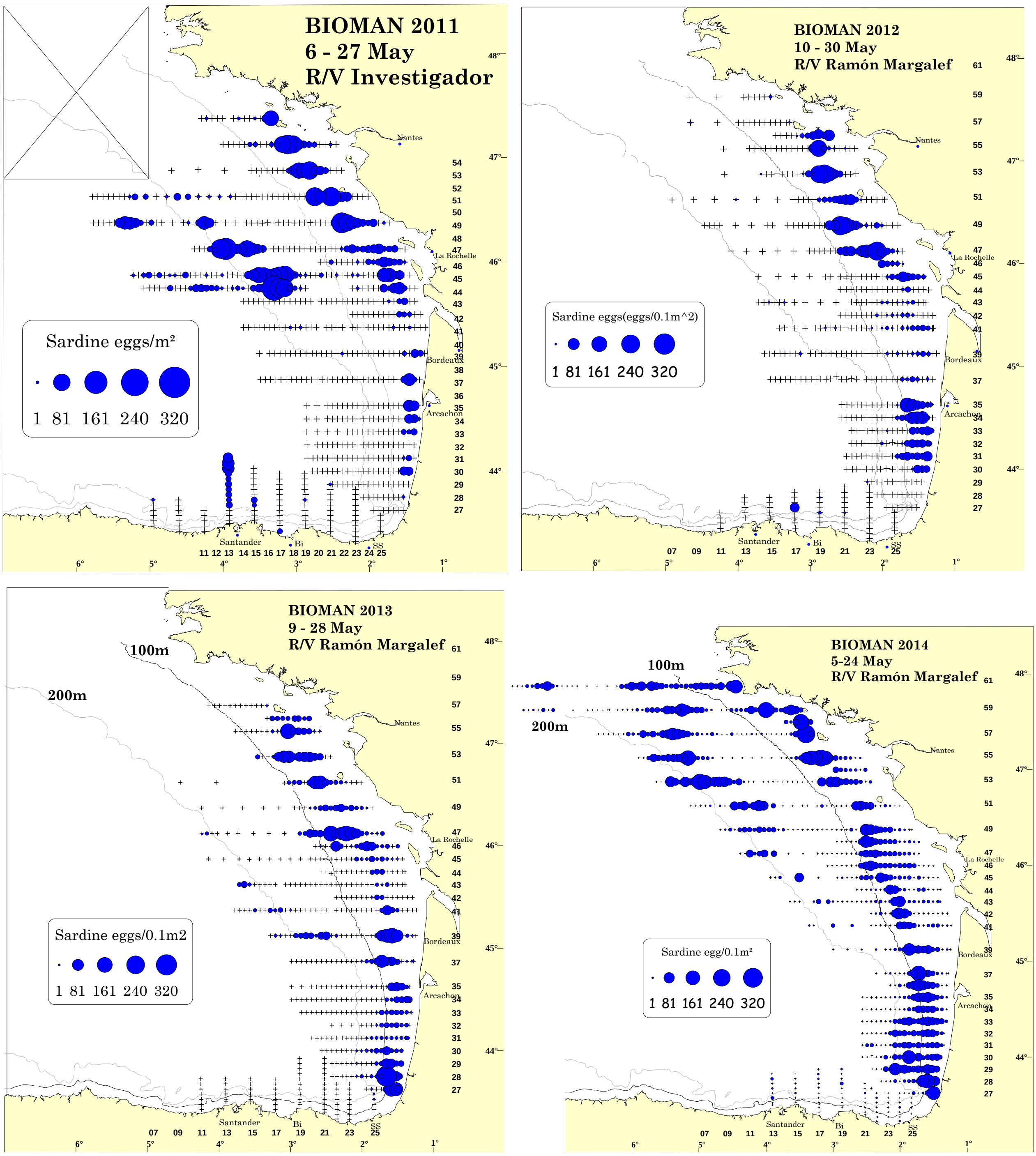


Figure 18: Sardine egg distribution and abundance from 1999 to 2014.

Preliminary sardine spawning stock biomass estimates at ICES divisions VIIIab applying the DEPM in 2014

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Introduction

The Daily Egg Production Method (DEPM) for sardine was first used to estimate the spawning stock biomass of the Atlanto-Iberian sardine stock in 1988 (Cunha *et al.,* 1992; García *et al.,* 1992). Afterwards was repeated in 1990, 1997, 1999, 2002, 2005 and 2008 based on coordinated surveys by IPIMAR (Instituto de Investigação das Pescas e do Mar, Portugal) and IEO (Instituto Español de Oceanografía, Spain). Since 1999 surveys have been planned and executed under the auspices of ICES on a triennial basis. DEPM surveys for the Atlantic-Iberian sardine took place 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) was surveyed by IPIMAR, while IEO covered the northwestern and north Iberian Peninsula (IXa N and VIIIc).

Sardine in Divisions VIIIab in the Bay of Biscay, beyond the boundaries of Atlanto-Iberian sardine stock has also been covered by the IEO in the inner part of the Bay of Biscay (VIIIb in April of 1997, 1999, 2002, 2008 and 2011 up to a maximum of 45°N) (ICES, 2012, Díaz *et al*., 2012), and by AZTI (Divisions VIIIabc in several years from 1999 to 2010 in May, up to a maximum of 48ºN, including the estimates of egg production in 1999, 2002 and 2008). The egg coverage of these areas VIIIab by AZTI and IEO were planned for 2008 within WGACEGG and estimations of Egg production for the areas covered in VIIIab in this year were reported to this WG (ICES CM 2008/LRC:17).

For 2011, a complete coverage of Divisions VIIIab was planned jointly by IEO and AZTI within the framework of WGACEGG (ICES 2010) and the initiative was by the first time funded by the DCF. In 2013 (ICES 2013) a sardine DEPM surveys in region VIIIab was planned and coordinated for 2014.

This working document provides a brief description of the sampling, laboratory analysis and estimation procedures conducted by AZTI and IEO in the VIIIab ICES divisions to obtain the Spawning Stock Biomass (SSB) estimate for 2014 in this area by the application of the Daily Egg Production Method. The Working Document provides in addition preliminary estimates of all parameters of the DEPM and of SSB. Current estimates are just provided provisionally until definitive estimates are produced before next WGACEGG.

The estimation was based on procedures and software adapted and developed during the WKRESTIM that took place in 2009, as well as the revision of the sardine DEPM historical series (1988-2008) in divisions IXa and VIIIc that was carried out in 2011. As this is the second time that SSB estimates are provided for this area by AZTI and IEO institutes, this estimation must be discussed and validated by the WGACEGG before used for assessment purposes of the sardine in Divisions VIIIabd.

Methodology

Plankton samples, along a grid of parallel transects perpendicular to the coast, were obtained for spawning area delimitation and daily egg production estimation; concurrently, fishing hauls were undertaken for the estimation of adult parameters (sex ratio, female weight, batch fecundity and spawning fraction) within the mature component of the population to obtain the

Daily fecundity and finally the Spawning Stock Biomass. All the methodology for the sampling survey and the estimates performance are described in the manual: annex 7 of WGACEGG 2010 report (ICES 2010: ICES CM 2010/SSGESST:24).

Surveying and sample processing

The ICES area VIIIab was surveyed from the French/Spanish border in the Bay of Biscay to 45ºN within the survey Sareva 0414 from the 9th to the 16th of April, while the remainder area of the Bay of Biscay from 45ºN to 48ºN latitude was sampled within the survey Bioman from the 11th to the 23th of May 2014 (**Figure 1**).

The protocol for collecting plankton samples, oceanographic parameters and adult fish samples and the differences between institutes are summarized on **table 1** below.

Fishing hauls were obtained with a pelagic trawler following sardine schools detection by the echo-sounder (**Figure 2**). The sampling procedure used for adults is summarized in **table 1**.

All sardine eggs from PairoVET samples were sorted, counted and staged according to the 11 stages of development classification (adapted from Gamulin and Hure, 1955).

The preserved ovaries were weighted in laboratory and the obtained weights corrected by a conversion factor (between fresh and formaldehyde fixed material) established previously. These ovaries were then processed for histology: they were embedded in resin, the histological sections were stained with haematoxylin and eosin, and the slides examined and scored for their maturity state (most advanced oocyte batch) and POF presence and age (Hunter and Macewicz 1985, Pérez et al. 1992a, Ganias et al. 2004, Ganias et al. 2007). Prior to fecundity estimation, hydrated ovaries were also processed histologically in order to check POF presence and thus avoid underestimating fecundity (Pérez et al. 1992b). The individual batch fecundity was then measured, by means of the gravimetric method applied to the hydrated oocytes, on 3 whole mount sub-samples per ovary, weighting on average 50-150 mg (Hunter et al. 1985).

Data analysis

Estimation of the Total Egg Production and area calculation (both surveyed and positive) was carried out using the R packages (*geofun, eggsplore and shachar*) available within the open source project *ichthyoanalysis* (http://sourceforge.net/projects/ichthyoanalysis). Some routines of the R packages used were updated since the 2008 versions. All the procedures are described in the Manual: annex 7 of WGACEGG 2010 report (ICES 2010: ICES CM 2010/SSGESST: 24).

The total surveyed area is calculated as the sum of the area represented by each station and the spawning area is delimited with the outer zero sardine egg stations. To avoid high and low extremes values detected in the area represented by each of the sampled stations, these values of area per station were forced to the minimum and maximum values of 25 and 175 km^2 respectively. The range 25-175 was selected to be a mean interval suitable according to the distance between transect and stations.

The eggs staged in the laboratory were transformed into daily cohort abundances using a multinomial model (Bayesian ageing method, Bernal *et al*. 2008). The Bayesian ageing method requires a probability function of spawning time. Spawning time distribution was assumed with a peak at 21:00 GMT for sardine. and the spawning curve considered in order to be more conservative and allow a longer spawning period that few eggs were excluded from the analyses (how.complete=0.99). The upper age cutting limit was estimated as the maximum age of unhitched eggs (at how. complete=0.99) for the whole strata corresponding with the percentile 95 of the incubation temperature of the eggs sampled in the strata, i.e. a value not dependent on the individual station. The lower age cutting excluded the first cohort of stations in which the sampling time is included within the daily spawning period.

Daily egg production (P_0) and mortality (z) rates are estimated by fitting an exponential decay mortality model to the egg abundance by cohorts and corresponding mean age:

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

The model was 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.

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

The adult parameters estimated for each fishing haul considered only the mature fraction of the population (determined by the fish macroscopic maturity data). Before the estimation of the mean female weight per haul (W), the individual total weight of the hydrated females was corrected by a linear regression between the total weight of non-hydrated females and their corresponding gonad-free weight (Wnov). The sex ratio (R) in weight per haul was obtained as the quotient between the total weight of females and the total weight of males and females. 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 modeling 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. The spawning fraction (S), the fraction of females spawning per day was determined, for each haul, as the average number of females with Day-1 and Day-2 POF, divided by the total number of mature females. The hydrated females are not included due to possible oversampling of active spawning females close to the peak spawning time. In this case, the number of females with Day-0 POF (of the mature females) was 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).

The mean and variance of the adult parameters for all the samples collected was then obtained using the methodology from Picquelle and Stauffer (1985) for cluster sampling (weighted means and variances). All estimations and statistical analysis were performed using the R software (http://www.R-project.org).

Preliminary results

Total egg production

Sea surface temperature and salinity in the area ranged from 11.8 to 15.5ºC and from 29.9 to 35.6 (**Figure 3**). Warmer waters were found between 45ºN and 47 ºN, and lower salinities were found in the innermost sector of Bay of Biscay due to the influence of the Gironde River. Notice that the sampling from 45ºN to the North started one month later.

A total of 1305 CUFES samples and 648 CalVET samples were obtained. From those 740 and 387 respectively were positive for sardine eggs (**Table 2** and **Figure 4**). The maximum sardine eggs/m^2 in a station was 4220. Sardine eggs were mostly found within the platform and below 45ºN during the April part of the sampling, a month later from 45ºN to the North, part of them were found over the 100m depth isoline and part over the 200m depth isoline from the Gironde area to the North.(**Figures 4 and 5**).

Surveyed, spawning area, mortality (hours^{-1}), daily egg production (egg/m^2/day) and total egg production (eggs/day) were estimated for the area covered by each institute (Table 6). The sampling covered a total area of 83424 km^2 of which 54426 km^2 (65.2 %) were considered the spawning area (**Figure 5**). Exponential mortality model adjusted applying a GLM to the data obtained in the ageing following the Bayesian method (spawning peak 21:00h) is shown in

figure 6. The total egg production in area VIIIab, calculated as the sum of values obtained for the area covered by each institute, was preliminarily estimated in 7.72 x 10^{12} egg/day (CV = 13%).

Adult parameters and spawning stock biomass

The linear regression model between gonad-free-weight and total weight fitted to non-hydrated females for areas VIIIb up to 45ºN and VIIIab 45-48ºN is given in **Table 3**. The model fitted the data adequately (**Figure 7**, R^2=99.6%, n= 98 VIIIb up to 45ºN, and R^2=98.8%, n= 199 VIIIab 45-48ºN).

For the batch fecundity 51 and 21 hydrated females from area VIIIb up to 45ºN and VIIIab 45-48ºN respectively, ranging from 25 to 96.5 g gonad free weight were examined. The females until 45ºN ranged from 31.6 to 96.5 g and those from 45ºN to the North ranged from 25 to 86.7 g gonad free weight. The coefficients of the generalised linear models with negative binomial and identity link are given in **Table 4** and the fitted models are shown in **Figure 8**.

Estimates of the mean female weight, batch fecundity, sex ratio, spawning frequency and spawning stock biomass with their CVs are given in **Table 5** for each of the areas sampled by IEO and AZTI. The *SSB* estimate from the application of the DEPM was 409598 tons with a CV of 30.

Discussion

Current estimates are just provided provisionally until definitive estimates are produced (before next WGACEGG). Despite the preliminary nature of results, this WD presents an essay of applying the DEPM method to estimate the spawning stock to the North of the Atlanto Ibero stock adding the estimations for area VIIIb up to 45ºN (area covered by IEO) and VIIIab 45-48ºN (area covered by AZTI). The coordinated work of AZTI and IEO allows achieving a complete coverage of the area. However it seems evident that the major problem might come from the lag in time of the southern and northern coverage of the areas. In the current application the lag in time between the SAREVA and BIOMAN surveys was longer than in former years, lasting in total an entire month and this has produced a major change in sea surface temperature in the area. In addition it seems that spawning may have suffered changes during such inner period as to apparently increase the amount of spawning, opposite to 2011, where a reduction on the amount of spawning was observed between both surveys (SAREVA and BIOMAN). A remarkable increase in the sardine SSB estimate from the 2011 to 2014 DEPM application in VIIIab area is highlighted (136560 tons to 409598 tons respectively). All these issues require further analysis in terms of implications for the best estimation procedures, reliability of the results and future planning of the next survey in 2017. Some of this discussion can be carried out within the frame of the estimations of the DEPM adult and egg parameters available from previous years in the same area VIIIab or in the neighborhoods (in VIIIc).

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Table 1. Characteristics of the egg and adult sampling in both surveys

DEPM Surveys	Spain (IEO)	Spain (AZTI)
Survey	**SAREVA0414**	**BIOMAN 2014**
Survey area	**VIIIb (until 45ºN)**	**VIIIab (45ºN-48ºN)**
SURVEY EGGS		
Sampling grid	8 (transect) x 3 (station)	15 or 7.5 (transect) x 3 (station)
PairofVET Eggs staged (n nets) (stages from Gamulin and Hure, 1955)	All (1 net)	max50 (2 nets)
Sampling maximum depth (m)	100	100
Temperature for egg ageing	10 m	
Peak spawning hour	(PDF 21 ± 2 * 3)	
Upper age cutting	0.95	
Egg ageing	Bayesian (Bernal et al, 2008)	
Egg production	GLM	
CUFES, mesh 335	3 nm (sample unit)	1.5nm(sample unit)
CUFES Eggs counted	All	All
Hydrographic sensor	CTD (SBE 37) CTD SBE 25	CTD(RBR)
Flowmeter	Y	Y
Clinometer	Y	NO
Environmental data	Temperature, and salinity in the water column	Temperature and salinity in the water column
SURVEY ADULTS		
Biological sampling:	On fresh material, on board of the R/V	On fresh and on formaldehyde and frosen(for otoliths)
Sample size	60 indiv randomly 100 (30 mature female); extra if needed and if hydrated found	60 indiv randomly max 120 (25 mature female); extra if needed for hydrated females
Fixation	Buffered formaldehyde 4% (distilled water)	Buffered formaldehyde 4% (tap water)
Preservation	Formalin	Buffered formaldehyde 4% (tap water)
Histology:		
- Embedding material	Resin	Resin
- Stain	Haematoxilin-Eosin	Haematoxilin-Eosin
S estimation	Day 1 and Day 2 POFs (according to Pérez et al. 1992a and Ganias et al. 2007)	Day 1 and Day 2 POFs (according to Pérez et al. 1992a and Ganias et al. 2007)
R estimation	The observed weight fraction of the females	The observed weight fraction of the females
F estimation	On hydrated females (without POFs), according to Pérez et al. 1992b	On hydrated females (without POFs), according to Pérez et al. 1992b

Table 2. Results from the analysis of ichthyoplankton and adult samples

Institute	**IEO**	**AZTI**
Survey area	VIIIb up to 45 ºN	VIIIab 45-48ºN
ICHTHYOPLANKTON		
R/V	Vizconde de Eza	Ramón Margalef
Date	09/04-16/04	11/05-23/05
Transects	11	18
PairoVET stations	128	520
Positive stations	77	310
Tot. Eggs (nº nets)	1449 (1 net)	8245 (2 nets)
Max eggs/m2	2619	4220
Temp (10m) min/mean/max	12.3/13.2/14.5	11.8/14.2/15.5
SSS	33.8/34.8/35.6	29.9/34.3/35.6
CUFES stations	122	1183
Positive CUFES stations	98	642
Tot. Eggs CUFES	12067	14812
Max eggs/m^3	90.7	94.8
Hydrographic stations	127	520
ADULTS		
Number Hauls R/V (total)	13	30
- Pelagic Trawls	13	30
Numer Hauls C/V	-	-
Number (+) trawls	3	8
Time range	During daylight hours	24hours
Total sardine individuals	324	623
Length range (mm)	151-247	133-234
Weight range (g)female &male	24-113.5	13.7-97.1
Female for histology	148	218
Hydrated females	51	21
Otholites	146	354

Table 3. Coefficients resulted from the linear regression model between gonad-free-weight and total weight fitted to non-hydrated females with their standard error and the P-Value

Institute	Area	Parameter	Estimate	Standard error	Pr(>|t|)
IEO	VIIIb up to 45ºN	Intercept	-1.468302	0.460827	0.00195**
		Slope	1.095110	0.007166	<2e-16***
AZTI	VIIIab 45-48ºN	Intercept	-1.416080	0.385605	0.00031***
		Slope	1.098898	0.008365	< 2e-16***

Table 4. Coefficients of the generalised linear model with negative binomial distribution and identity link between the number of hydrated oocytes and the female gonad free weight (wgf).

Institute	Area	Parameter	Estimate	Standard error	Pr(>|t|)
IEO	VIIIb up to 45ºN	Intercept	-4574.9	2212.5	0.0387*
		Slope	497.7	59.8	<2e-16***
AZTI	VIIIab 45-48ºN	Intercept	-15415.9	7074	0.0293*
		Slope	796.9	180.2	9.77e-06***

Table 5. All the parameter to estimate de Spawning Stock Biomass (SSB) using the Daily Egg Production Method (DEPM) for 2014 with correspondent coefficients of variation (CV %) in brackets.

Institute	**IEO**	**AZTI**	**IEO-AZTI**
Area	**VIIIb up to 45ºN**	**VIIIab 45-48ºN**	**VIIIab**
Eggs 2014			
Survey area (Km^2)	13480.4	69943.6	83424
Positive area (Km^2)	7913.8	46511.8	54425.6
P0 (eggs/m^2/day)	214.2 (27.6)	129.4 (15.2)	
Z (hour^{-1})	-0.021*** (28.7)	-0.013***(29.8)	
P0 tot (eggs/day)	1.70 x 10^{12} (27.6)	6.02 x 10^{12} (15.2)	7.72 (13)
Adults 2014			
Female Weight (g)	65.51 (22)	48.46 (5)	
Batch Fecundity	25545 (24)	21056 (12)	
Sex Ratio	0.59 (12)	0.482 (18)	
Spawning Fraction	0.084 (25)	0.089 (23)	
Spawning Biomass (tons)	86624 (51)	322974 (35)	409598 (30)

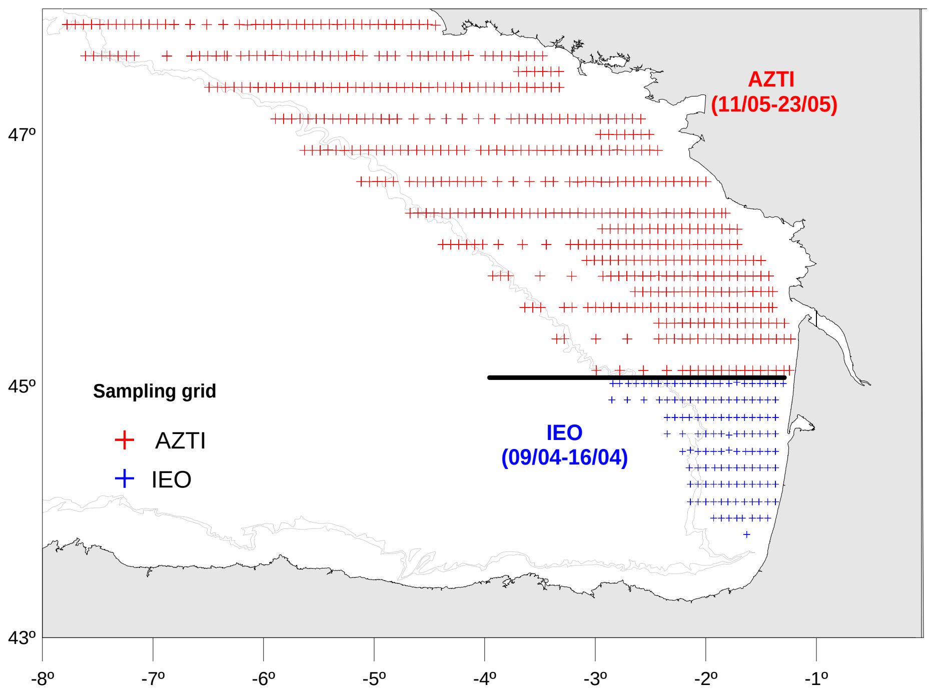


Figure 1. Plankton sampling grid by institute. Black line shows the limits for sampling coverage according to planned and coordinated sardine DEPM survey in VIIIab area.

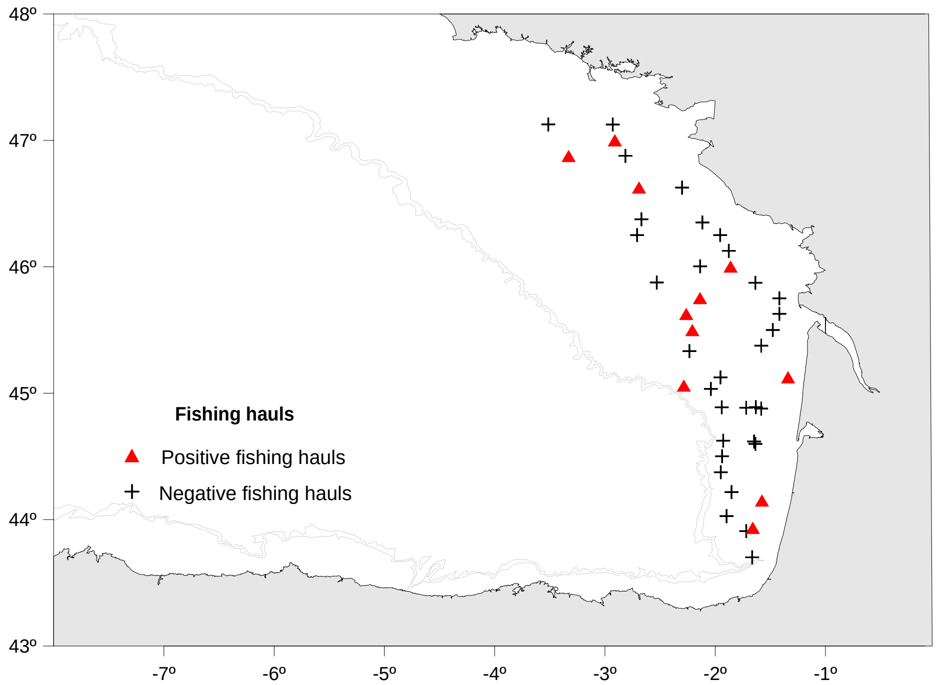


Figure 2. Spatial of sardine hauls (+, hauls without sardine presence or scarce presence).

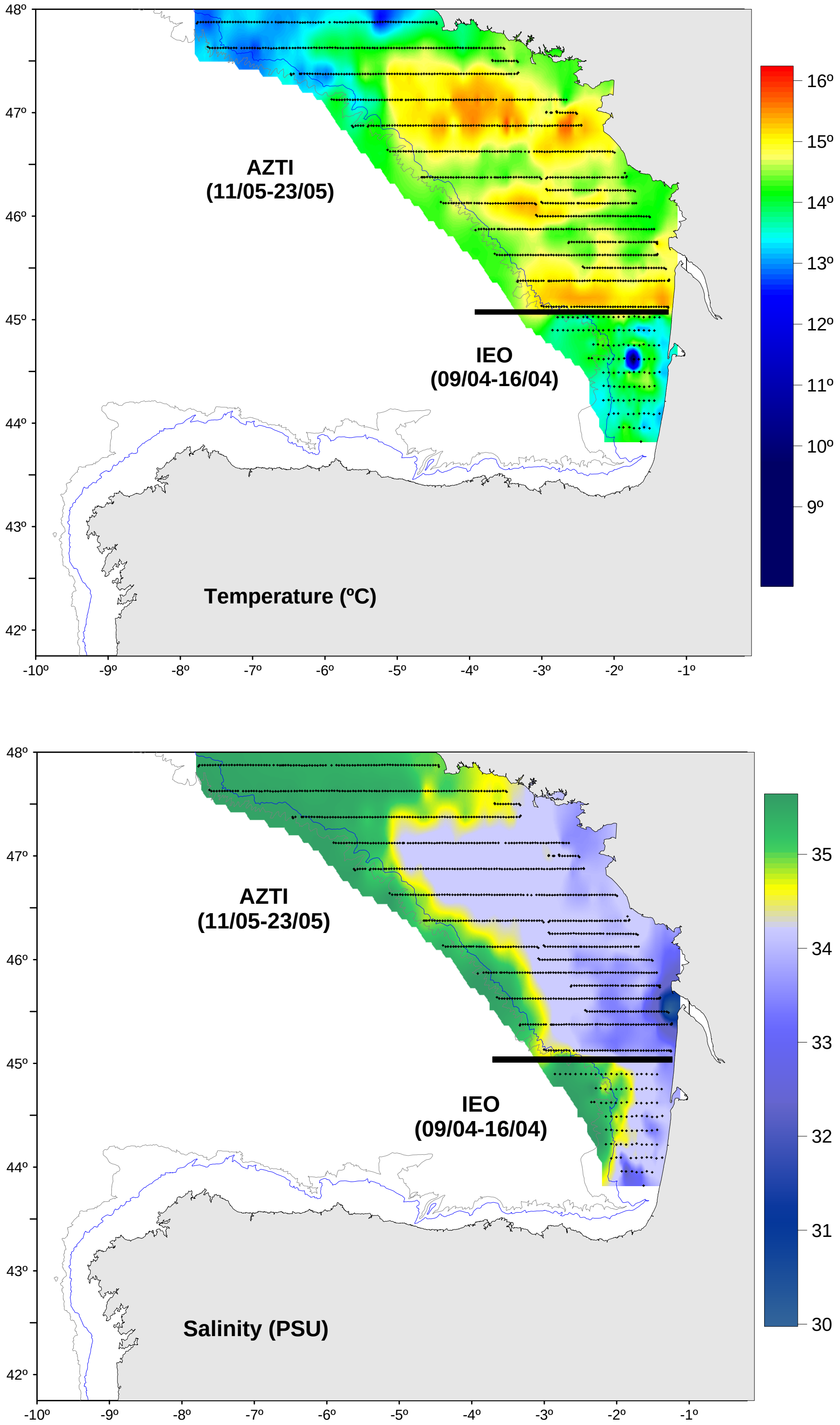
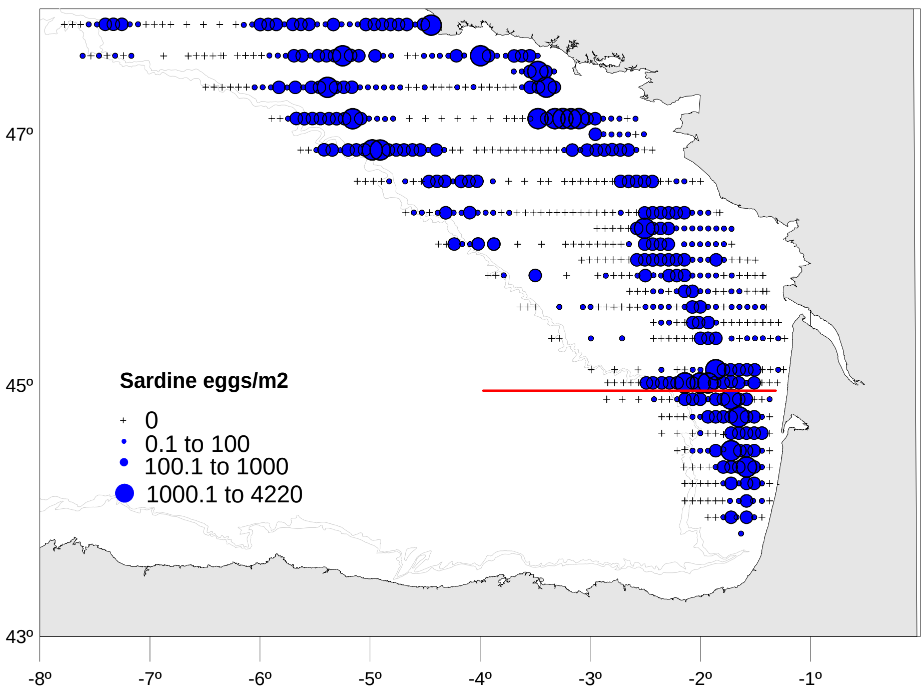


Figure 3. Sea surface temperature in ºC. Notice that until 45ºN was sampling from 9 to 16 of April and from 45ºN to the North was sampling from 11 to 23 May.



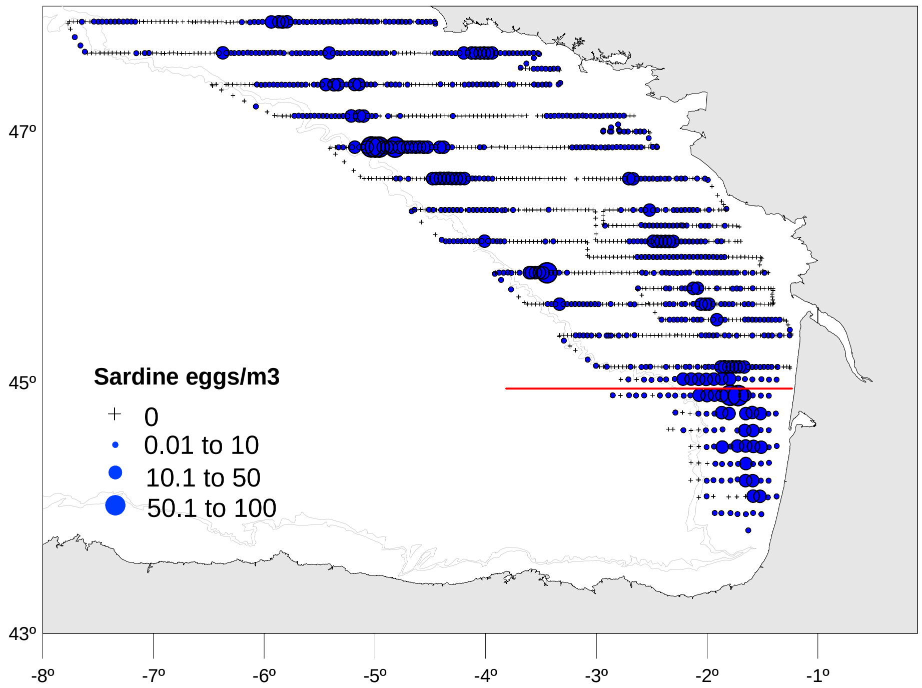


Figure 4. Sardine egg distribution. Egg/m^2 from PairoVET sampling (Upper panel) and egg/m^3 from CUFES sampling (down panel).

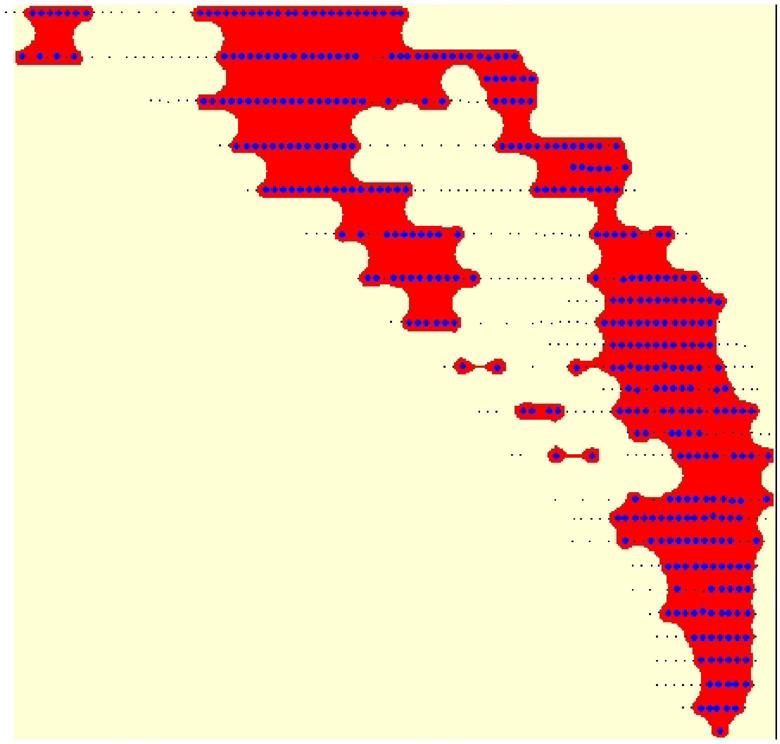


Figure 5. Delimitation of the spawning area for sardine in the region VIIIab.

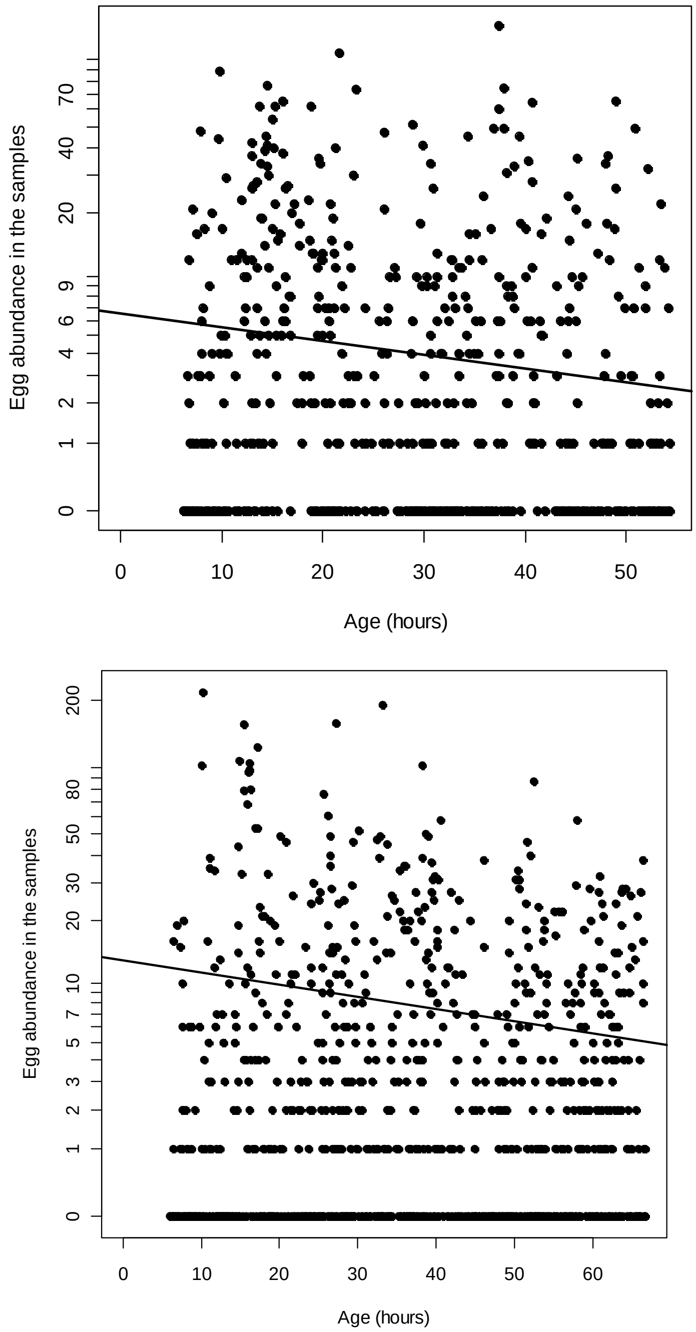


Figure 6. Exponential mortality model adjusted applying a GLM to the data obtained in the ageing following the Bayesian method (spawning peak 21:00h).The black line is the adjusted line. Data in Log scale. Upper panel area VIIIb up to 45ºN (IEO) and lower panel area VIIIab 45-48ºN (AZTI).

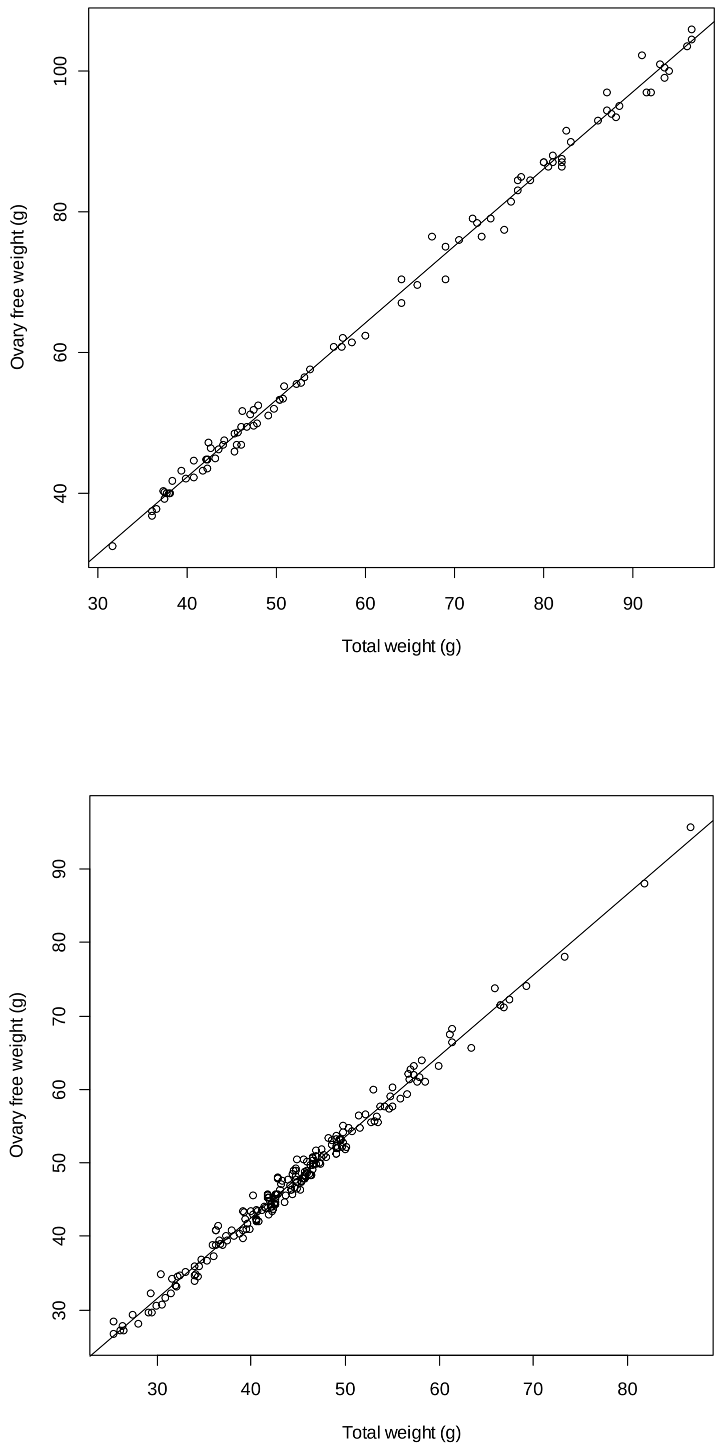


Figure 7. Linear regression model between gonad-free-weight and total weight fitted to non-hydrated females. Upper panel area VIIIb up to 45ºN (IEO) and lower panel area VIIIab 45-48ºN (AZTI).

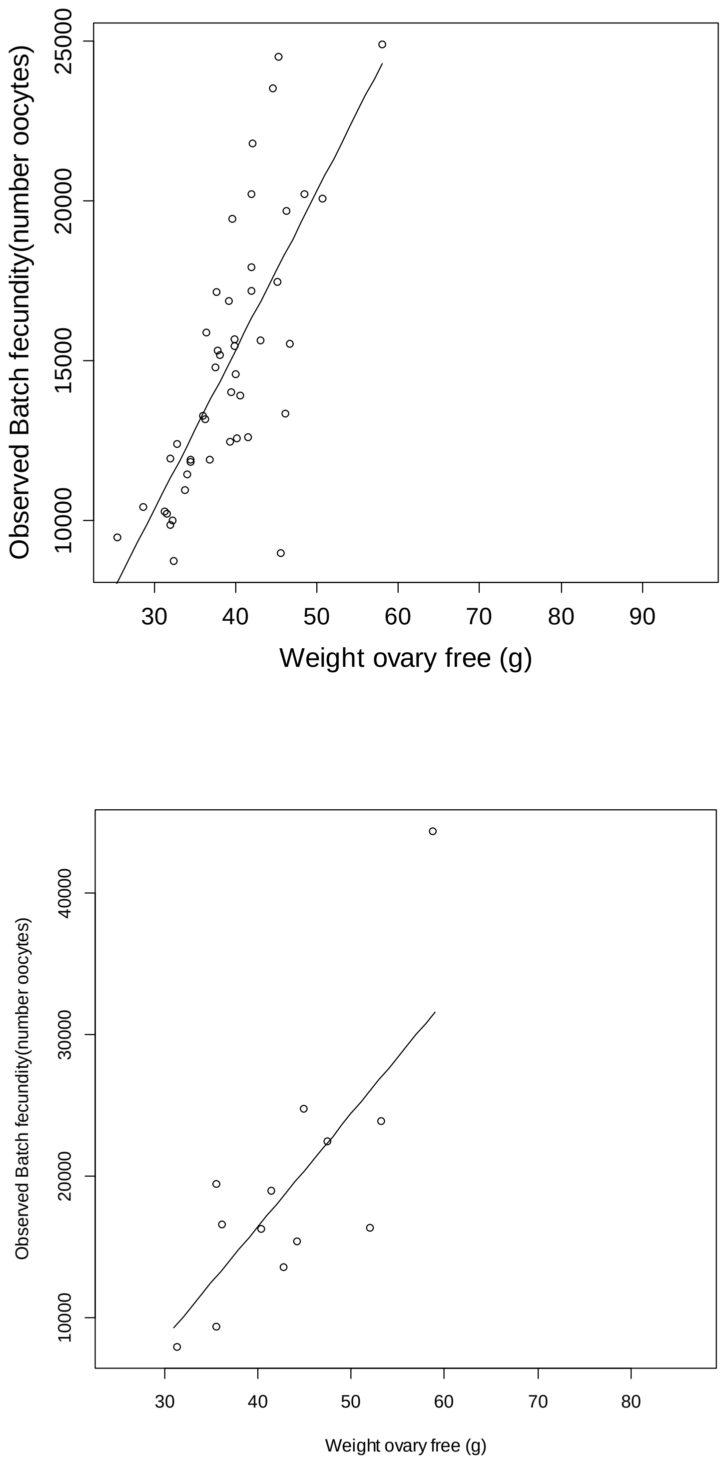


Figure 8. Generalised linear model between gonad-free-weight and hydrated oocyted fitted to hydrated females. Upper panel area VIIIb up to 45ºN (IEO) and lower panel area VIIIab 45-48ºN (AZTI).

CRUISE REPORT

PELACUS 0314

PELAGIC ECOSYSTEM ACOUSTIC-TRAWL SURVEY
R/V MIGUEL OLIVER

Coordinated by Pablo Carrera and Isabel Riveiro
Instituto Español de Oceanografía

Index

EXECUTIVE SUMMARY

The Spanish acoustic-trawl times PELACUS 0314 was carried out on board R/V Miguel Oliver from 9th March to 8th April, covering the north Spanish waters (Atlantic and Bay of Biscay) from the coast to the 1000 m isobath on a systematic grid with tracks 8 nmi apart and equally spaced. Acoustic , fishing stations, fish egg counting, microplastic, and apical predators observations were done during daytime whilst the oceanographic characterisation was done during night time. A total of 1903 nautical miles were steamed, 1075 corresponding to the survey track. Besides 52 fishing stations were performed (Figure 2).

PELCACUS 0314 was characterised by relative stable weather conditions along the surveyed area. Besides, there was an important increase in backscattering energy as compared with the previous year. This resulted in an increase of the biomass estimated for the majority of the fish species, but still sardine is at lowest productivity ever recorded. Good recruitment would be observed in horse mackerel, but for the rest of the fish species, no strong signals for age group 1 have been detected.

The reasons for this increase would be related to the weather stability which could have increased the fish availability either for a change in the behaviour (i.e. spatial pattern distribution) or for an increase in the food availability. This is relevant accounting the increase of the occurrence of mackerel subsurface layers observed this year. As PELACUS is a multidisciplinary survey series (we collect environmental and biological ancillary information, stomach contents, including CTD cats, plankton tows or continuous records of plankton, eggs, S, T and flourometry), we will try to explain this change of behaviour. Our main hypothesis is that these species could follow mackerel when is undertaking vertical migration, probably related with the spawning activity, just for feeding eggs and, therefore, changing the expected schooling behaviour by the dispersed one, used during the feeding activity.

TECHNICAL SUMMARY

Institution:	INSTITUTO ESPAÑOL DE OCEANOGRAFÍA
Survey name:	PELACUS 0314
Vessel name:	Miguel Oliver (70 mn length, 2x1000 kW diesel-electric
Dates:	09/03/2014-08/04/2014
Area:	NW-Spanish coast, Spanish Bay of Biscay (IXa-N and VIIIc)
Type:	Acoustic-Trawl
Main objective:	Biomass estimation by means of echointegration of the main pelagic fish population present in the surveyed area. Physical, chemical and biological characterisation of the pelagic ecosystem.
Sampling strategy	Systematic grid with tracks 8 nmi apart from 30 to 1000 isobath
Main sampling procedures	EK-60 at 18-38-120-200 kHZ acoustic frequencies. 1075 nmi prospected. Only day time
	CUFES, Intake at 5 m depth, 600 l min^{-1}. 3 nmi/sample, 358 samples (sardine and anchovy eggs)
	Pelagic fishing stations. 52 stations
	Marine mammals and birds observations. 169 legs (114.95 hours)
	Hydrological characterisation. 105 stations (CTD with rosette and plankton nets)

Personnel (1st leg)

ARAUJO FERNÁNDEZ, MARÍA HORTENSIA	LOUZAO ARSUARGA, MAITE
BLANCO GINER, MARIA DE LOS ANGELES	MIQUEL BATLE, JOAN
BURGOS CANTOS, CANDELARIA	MURCIA ABELLÁN, JOSÉ LUIS
CABRERO RODRÍGUEZ, AGUEDA HENAR	NOGUEIRA GARCIA, ENRIQUE
CARRERA LÓPEZ, PABLO	OLVEIRA DOMÍNGUEZ, BEATRIZ
CORDOBA SELLES, PILAR	OÑATE GARCIMARTÍN, MARÍA DOLORES
DUEÑAS LIAÑO, CLARA	OTERO PINZÁS, ROSENDO
FERNÁNDEZ LAMAS, ANGEL	PRECIADO RAMÍREZ, IZASKUN
GARABANA BARRO, DOLORES	SAAVEDRA PENAS, CAMILO
GÓMEZ GONZÁLEZ, ANTONIO	SANZ LLORENS, VANESSA
GONZÁLEZ GONZÁLEZ, ISABEL CRISTINA	VARELA ROMAY, JOSÉ

2nd leg

ANTOLÍNEZ BOJ, ANA	LOUREIRO CARIDE, MARÍA ISABEL
CARRERA LÓPEZ, PABLO	MURCIA ABELLÁN, JOSÉ LUIS
CASAS RODRÍGUEZ, GERARDO	NAVARRO RODRÍGUEZ, MARIA ROSARIO
DELGADO ALCARAZ, JAVIER	OÑATE GARCIMARTÍN, MARÍA DOLORES
FERNÁNDEZ LAMAS, ANGEL	OTERO PINZÁS, ROSENDO
GARCÍA. BARCELONA, SALVADOR	PÉREZ RODRÍGUEZ, MONTSERRAT
GÓMEZ PÉREZ, ELENA	RIVEIRO ALARCÓN, MARÍA ISABEL
GONZÁLEZ GONZÁLEZ, ISABEL CRISTINA	SANTOS ATIENZA, EVA MARÍA
GONZÁLEZ-QUIRÓS, RAFAEL	SOLLA COVELO, ANTONIO JOSÉ
GRANELL MIYAR, TERESA	VALEIRAS MOTA, XULIO
LÓPEZ LÓPEZ, LUCÍA	,

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INTRODUCTION

The Spanish acoustic-trawl times series PELACUS started in 1991 when R/V Cornide de Saavedra was rebuilt and a new EK-500 was also purchased. Since that and until 1996 all cruises were carried out on board of this vessel except that of 1995, called IBERSAR, which has been undertook on board R/V Noruega. In 1997 the series changed from R/V Cornide de Saavedra to the new R/V Thalassa (TH), a French/Spanish research vessel specially conceived for fish surveys.

This vessel was also used for the French acoustic survey (PELGAS). Survey strategy methods and analysing were established at the Planning Group for Acoustic Surveys in ICES Sub-Areas VIII and IX met for the first time in 1986. Since 1998 the Planning Group, only attended until then by Spanish and Portuguese members, incorporated French scientists. As a first joint recommendation, the Planning Group agreed that acoustic data will be only recorded during day time, living the night time available for physical, chemical and plankton characterisation of the water column. This recommendation was implemented in 1998. In 2000 under the frame of the DG FISH PELASSES project started, the spring acoustic surveys incorporated the Continuous Underwater Fish Egg Sampler (CUFES) together with the routinely collection of other systematic measurements (SSS, SST, Flourometry, CTD+rossete casts, plankton hauls to determine primary production or dry weight at different sizes among other biological descriptors of the water column, etc.). In addition, the 120 khz frequency started to be used to help discriminate between different fish species. During this period, acoustic estimates are also provided for non commercial species such as bogue or boar fish. In 2007, a new team used the survey as a platform to obtain data on presence, abundance and behavior of top predators (marine mammals and seabirds). Since 2007 data are also routinely collected on floating litter (type, number and position) and on other human pressures such as fishing (number of boats, type, activity, etc.).

Since the beginning of the time series (1982), biological data (length, weight, sex, maturity, etc.) and samples have been taken from individual fish taken by the hauls to provide biological data and to construct length-weight and age-length relationships needed for the assessment of first sardine and later, all the other target species. Fish stomachs have also been routinely examined to quantify the trophic relationships between species and isotope analysis of muscle of sardine and anchovy have been also carried out the study their trophic position.

Overall the evolution of this time series made it an essential platform for integrated data collection following the requirements posed by the Ecosystem Approach to Fisheries Management (EAFM), the Marine Strategy Framework Directive (2008/56/CE) and the revised CFP .

Acoustic data presented in this report includes estimates of abundance, distribution and mean size for the eleven main pelagic species found in northern and northwestern Spanish waters.

In 2013 R/V is substituted by the Spanish vessel Miguel Oliver (MO), built in 2007. In addition the surveyed area was extende from the 200 m isobath to the 1000 m one in order to make available the bulk of the blue whiting distribution.

On the other hand, both vessels , TH and MO have similar technical characteristics, as show in the following table:

	Thalassa	Miguel Oliver
Length	73.65 m	70.00 m
Width	14.90	14.40 m
Engine type	Diesel-electric	Diesel-electric
Engine power	2000 kW	2 x 1000 kW

Propeller	Fixed blades	Fixed blades
Tonnage	2803 GRT	2495 GRT
Propeller rpm at 10 knots	99	130

Table 1.: Main characteristics fro R/V Thalassa (left) and Miguel Oliver (right).

Intercalibration done after this survey gave rather similar results for both vessels although a slight difference between fishing gear performance was noticed. That used by R/V Miguel Oliver has a small rockhooper which makes accessible much fish located close to the sea bed (such as demersal species together with more horse mackerel) than that of the R/V Thalassa.

OBJECTIVES

Main objective of this survey was to achieve a biomass estimation by echointegration of the main pelagic fish distributed in the Spanish Cantabrian and NW waters (sardine, anchovy, horse mackerel, mackerel, blue whiting, bogue, boar fish, chub mackerel). Together with this, the following objectives were also foreseen:

- Determine the distribution area and density of the main fish species
- Determine the main biological characteristics (length, sex, maturity stage and age) of the main fish species
- Estimate the relative abundance and distribution area of sardine and anchovy eggs by means of CUFES
- Estimate the adults parameters needed to apply the Daily Egg Production Method to sardine.
- Characterise the main oceanographic conditions of the surveyed area
- Determine the distribution pattern, taxonomic diversity and dry biomass by size classes of the plankton population presented in the surveyed area.
- Determine the natural abundance of N15 in sardine, anchovy and mackerel and their trophic position.
- Determine the distribution area and density of apical predators
- Determine the distribution area and density of marine microplastics litter

MATERIAL AND METHODS

The methodology was similar to that of the previous surveys (see Iglesias et al. 2010 for further details). Survey design consisted in a grid with systematic parallel transects with random start, separated by 8 nm, perpendicular to the coastline, covering the continental shelf from 40 to 1000 m depth and from Portuguese-Spanish border to the Spanish -French one. (Figure 1)

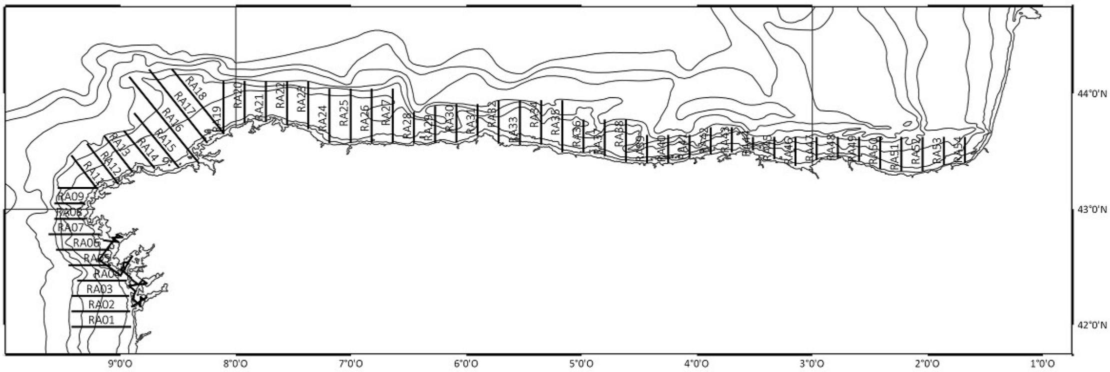


Figure 1 Survey track

The backscattering acoustic energy from marine organisms is measured continuously during daylight. Pelagic trawls are carried out whenever possible to help identify the species (and size classes) that reflect the acoustic energy. A continuous underwater fish egg sampler with an internal water intake located at 5 m depth is used to sample the composition of the ichthyoplankton while trained observers record marine mammal, seabird, floating litter and vessel presence and abundance. At night, data on the hydrography and hydrodynamics of the water masses are collected via the deployment of rosettes and conductivity, temperature and depth sensors. Information on the composition, distribution and biomass of phytoplankton and zooplankton is derived from the analyses of samples taken by plankton nets.

Sampling procedures

Acoustic

Acoustic equipment consisted on a Simrad EK-60 scientific echosounder, operating at 18, 38, 120 and 200 kHz. All frequencies were calibrated according to the standard procedures (Foote et al 1987). The elementary distance sampling unit (EDSU) was fixed at 1 nm. Acoustic data were obtained only during daytime at a survey speed of 8-10 knots. Data were stored in raw format and post-processed using SonarData Echoview software (Myriax Ltd.) (Higginbottom et al , 2000). All echograms were first scrutinized and also background noise was removed according to De Robertis and Higginbottom (2007). Fish abundance was calculated with the 38 kHz frequency as recommended at the PGAAM (ICES 2002), although echograms from 18, 120 and 200 kHz frequencies were used to visually discriminate between fish and other scatter-producing objects such as plankton or bubbles, and to distinguish different fish species according to the strength of their echo at each frequency. The 18, 120 and 200 kHz frequencies have been also used to create a mask allowing a better discrimination between fish species and plankton. The threshold used to scrutinize the echograms was –70 dB. The integration values were expressed as nautical area scattering coefficient (NASC) units or sA values (m2 nm -2) (MacLennan et al., 2002).

Main echosounder settings are shown in table 2

Transducer power	2000/2000/200/90 W for 18/38/120/200 kHz
Pulse duration	1.024 ms
Ping rate	Maximum, in case of ghost echo-bottom, change to time interval starting at 0.30 ms
Range (echograms, files)	200 m in shallower area (i.e. depth<100m); 400 when depth is between 100-200m; and 1000 when depth is>400m

Table 2: Main echosounder settings.

Acoustic tracks were steamed at 10 knot.

Fishing station

Fishing stations are used for both NASC allocation and length analysis. Therefore, they were located on account the results obtained during the acoustic prospection (i.e. oportunistic accounting the echotraces).

Two fishing gears were used. An adaptation of a “grandes mailles” , with a vertical opening of about 20 m and around 30 m horizontal one, was used as main fishing gear. It has a rope-rounded footrope, a kind of rockhopper with small rubber discs, which allows it to have a permanent contact with the sea bottom while preserving the net, making the demersal species be more available. As a second fishing gear used to identify school located on the seabed (i.e. horse mackerel schools) a GOV (14 m vertical opening) was used.

As general rig, 400 kg of clump weight were put at each side of the set back (2 m lower wing). Bridles (wings) had 100 m and a set of 20 mm steel wire were used at the beginning of the survey which were substituted by dyneema in the upper wing and polystil in lower wing. Besides a set of Apollo polyice doors (Thyborøn) wer used. Gear performance was controlled using a cabled Simrad Sonar 25/20 net sounder.

CUFES

CUFES system uses an internal pumping system with the intake located at 5 m depth. The sea water goes first to a tank of about $1m^3$ before to be pumped towards the concentrator.

Samples from CUFES were collected every three nmi while acoustically prospecting the transects. Once the sample is taken it is fixed in a buffered 4% formaldehyde solution. Anchovy and sardine eggs are sorted out and counted before being preserved in the same solution. The remaining ichthyoplankton (other eggs and larvae) are also preserved in the same way. Information on horse mackerel and mackerel (qualitative) was also recorded.

Plankton and hydrological characterisation

Continuous records of SSS, SST and flourometry are taken using a SeaBird Thermosalinograph coupled with a Turner Flourometer. Plankton and CTD and bottle rosette for water samples casts are performed at night. Five stations are placed over the transects, which are those of the acoustic prospection but that are extended onto open waters until the 1000-2000 m isobaths. The stations are evenly distributed over the surveyed area at a distance of 16-24 nmi.

Plankton was sampled using several nets (Bongo, WP2 and CalVet). Fractionated dried biomass at 53-200, 200-500, 500-1000 and >2000 µm fractions was calculated together with species composition and groups at fixed strata from samples collected at the CTD+bottle rosette carousel (pico and nanoplankton, microplankton and mesozooplankton). For this purpose, FlowCAM, LOPC and ZooImage techniques were used.

Water samples were stored at -20°C for further dissolved nutrients analysis (NO_3, NO_2, P, NH_4^+, SiO_4).

Top predator observations

Three observers placed above the bridge of the vessel at a height of 16 m above sea level work in turns of two prospecting an area of 180° (each observer cover a field of 90°). Observations are carried out with the naked eye although binoculars are used (7x50) to confirm species identification and determine predator behaviour. Observations are carried out during daylight while the vessel prospects the transects and while it covers the distance between transects at an average speed of 10 knots. Observers record species, number of individuals, behaviour, distance to the vessel and angle to the trackline and observation conditions (wind speed and direction, sea state, visibility, etc.). Observers also record presence, number and type of boats and type, size and number of floating litter. The same methodology is used on the PELGAS surveys and both observer teams shared a common database.

Marine Microplastic Litter characterisation

A “manta net neuston sampler” was used. This trawl device has a collector of 350 µm. Tows were performed for 15 min at 4 knots speed. The samples were evenly distributed along the surveyed area.

Fish Biological sampling

Catches from fishing trawl hauls were sorted and weighted. All fish species were measured (total length, 1cm classes for all species except clupeids measured at 0.5 cm). When needed, random subsamples of 80-200 specimen were taken. For the main species an additional biological sampling was done for weight, age, sex, maturity stage analysis, complemented by stomach contents analysis (sardine and anchovy); N^{15} isotope analysis (sardine, anchovy and mackerel); sampling for gonad microscopic maturity analysis (mackerel); and, sampling for estimation of fecundity adult parameters (sardine). Besides, specific sampling was also done for genetic purposes to boarfish, mackerel and hake.

Data analysis

NASC Allocation

Two pelagic gears have been used to identify the species and size classes responsible for the acoustic energy detected and to provide samples. Choice of net was also dependant on the availability of enough unobstructed ground for the net to be deployed and recovered and for effective fishing to occur. Haul duration is variable and ultimately depends on the number of fish that enters the net and the conditions where fishing takes place although a minimum duration of 20 minutes is always attempted. The quality of the hauls for ground-truthing of the acoustic data was classified on account of weather condition, haul performance and the catch composition in numbers and the length distribution of the fish caught as follows:

	0	1	2	3
Gear performance Fish behaviour	Crash	Bad geometry Fish escaping	Bad geometry No escaping	God geometry No escaping
Weather conditions	Swell >4 m height Wind >30 knots	Swell: 2 -4 m Wind: 30-20 knots	Swell: 1-2m Wind 20-10 knots	Swell <1 m Wind < 10 knots
Fish number	total fish caught <100	Main species >100 Second species <25	Main species > 100 Second species< 50	Main species > 100 Second species > 50
Fish length distribu-tion	No bell shape	Main species bell shape	Main species bell shape Seconds: almost bell shape	Main species bell shape Seconds: bell shape

Hauls considered as the best representation of the fish community for a specific area were used to allocate NASC of each EDSU within this area. This process involved the application of the Nakken and Dommasnes (1975, 1977) method for multiple species, but instead of using the mean backscattering cross section, the full length class distribution (1 cm length classes) has been used, as follows:

$$s_{A_i} = s_A \frac{w_{li} \cdot \sigma_{bs}}{\sum_{li} w_{li} \cdot \sigma_{bs}}$$

where w_{li} is the proportion in number of *l* length class and species *i* in the hauls, and σ_{bs} is its correspondent proportion of backscattering cross section. The target strength (TS) is also taken into account as follows:

$$\sigma_{bs} = 10^{TS/10} \quad \text{(in dB)}$$

This is computed from the formula TS =20 logL_T+ b_{20} (Simmonds and MacLennan, 2005), where L_T is the length class (0.5 cm). The b_{20} values for the most important species present in the surveyed area are shown in following table:

Species	WHB	MAC	HOM	PIL	JAA	ANE	BOG	MAS	BOC	HMM
b_{20}	-67.5	-84.9	-68.7	-72.6	-68.7	-72.6	-67.0	-68.7	-72.6	-68.7

Table 3.- b_{20} values from the length target strength relationship of the main fish species assessed in PELACUS survey (WHB is blue whiting; MAC-mackerel; HOM- horse mackerel; PIL-sardine; JAA-blue jack mackerel (Trachurus picturatus); BOG-bogue (Boops boops); MAS-chub mackerel (Scomber colias); BOC-board fish (Capros aper); and HMM-Mediterranean horse mackerel (Trachurus mediterraneus))

In addition and according with Fässler et al (2013) a new b_{20} = -66.20 value for boarfish was also used.

When possible, direct allocation was also done, accounting for the shape of the schools and also the relative frequency response (Korneliussen and Ona, 2003, De Robertis et al, 2010). Due to the aggregation pattern found in the surveyed area, fish schools were extracted using the following settings:

Sv threshold	-60 dB for all frequencies
Minimum total school length	2 m
Min. total school height	1 m
Min. candidate length	1 m
Min. candidate height	0.5 m
Maximum vertical linking distance	2.5 m
Max. horizontal linking distance	10 m
Distance mode	Vessel log
Main frequency for extraction	120 kHz

Table 4: Main morphological and backscattering energy characteristics used for schools detection

For all school candidates, several of variables were extracted, among them the NASC (s_A, m^2/nmi^2) together with the proportioned region to cell (ESDU, 1 nmi) NASC and the s_V mean and s_V max and geographic position and time. PRC_NASC values were summed for each ESDU and distances were referenced to a single starting point for each transect. Results for 38 and 120 kHz were compared. Besides, the frequency response for each valid school (i.e. those with length and s_V which allows them be properly measured) was calculated as the ratio $s_{A(fi)}/s_{A(38)}$, being f_i the s_A values for 18, 120 and 200 kHz.

Echointegration estimates

Once backscattering energy was allocated to fish species, the spatial distribution for each species was analysed taking into account both the NASC values and the length frequency distributions (LFD) to provide homogeneous assessment polygons. These are calculated as follows: an empty track determine the along-coast limit of the polygon, whilst three consecutive empty ESDU determine a gap or the across-coast limit. Within each polygon, the LDF is analysed.

LFD were obtained for all positive hauls for a particular species (either from the total catch or from a representative random sample of 100-200 fish). For the purpose of acoustic assessment, only those LFD which were based on a minimum of 30 individuals were considered. Differences in probability density functions (PDF) were tested using Kolmogorov-Smirnov test. PDF distributions without significant differences were joined, providing a homogeneous PDF strata. Spatial distribution was then analysed within each stratum and finally mean s_A value and surface (square nautical miles) were calculated using a GIS based system. These values, together with the length distributions, are used to calculate the fish abundance in number as described in Nakken and Dommasnes (1975). Numbers were converted into biomass using the length weight relationships derived from the fish measured on board. Biomass estimation was carried out on each strata (polygon) using the arithmetic mean of the backscattering energy (NASC, s_A) attributed to each fish species and the surface expressed in square nautical miles. For purposes of comparison, results are given by ICES Sub-Divisions (IXaN, VIIIcW, VIIIcEw , VIIIcEe and VIIIb)

Otoliths are taken from anchovy, sardine, horse mackerel, blue whiting, mackerel and hake (*Merluccius merluccius*) in order to determine age and to obtain the age-length key (ALK) for each species and area.

Centre of gravity

For each main specie, a centre of gravity (Woillez et al. 2007) was calculated as a weighted average of each sample location (allocated NASC value as weighting factor). Due to the particular topography of the NW Spanish area, instead longitude and latitude, we have used depth and a new variable called "distance from the origin" calculated as follows:

- Locations below 43º10 N: distance is calculated as (Lat-41.5)*60, being *Lat* the latitude of the middle point of any particular EDSU within this region.
- Location between 43º10' N and 8ºW (i.e. NW corner): distance is calculated as $((I.Lat-43.18333)^2+(I.Lon*(\cos(I.Lat*pi()/180))-6.714441)^2)^{0.5})*60+(43.1833-41.5)*60$, being *I.Lat* and *I.Lon* the coordinates at which a normal straight line from middle point of any particular EDSU within this region intercepts a line defined by the following geographical coordinates: 43º11N-9º12.50'W and 43º39.50'N-8º06'W.
- Location between 8ºW and the Spanish-French border: distance is calculated as 158.329+ (Lon+5.8755324052)*60, being *Lon* the corrected longitude (longitude multiplied by the cosine of

RESULTS

The survey started on 9th March and ended on 6th April. A total of 3260 nautical miles were steamed, 1075 of them corresponding to the survey track. Contrary to the previous year, weather conditions were in general good, although three tracks were interrupted due to the presence on air bubble. Besides, some pings were also removed due to the presence of bubbles sweep down. Also most of the tracks located in the NW corner (i.e. VIIIc-west), were sternway steamed in order to avoid bubbles sweep down. The last track, located in the French waters was not surveyed.

Calibration

All frequencies were calibrated on 9th March, with the following results:

		200 kHz	120 kHz	38 kHz	18 kHz
Main	TS	-39.10 dB	-39.50 dB	-42.30 dB	-42.70 dB
	Gain	27.00 dB	27.00 dB	26.50 dB	22.40 dB
	Two way Beam Angle	-20.70 dB	-21.00 dB	-20.60 dB	-17.00 dB
	Angles (deg)	7.0 x 7.0	7.0 x 7.0	7.1 x 7.1	11.0 x 11.0
	Pulse Duration	1.024 ms	1.024 ms	1.024 ms	1.024 ms
	Power	90 W	200 W	2000 W	2000 W
	Sample Interval	0.193 m	0.193 m	0.193 m	0.193 m
	Rec. Bandwidth	3.09 kHz	3.03 kHz	2.43 kHz	1.57 kHz
Beam Model Results	Transducer Gain	26.03 dB	26.73 dB	24.73 dB	22.94 dB
	Sa Corr	-0.27 dB	-0.37 dB	-0.58 dB	-0.80 dB
	Athw Beam Angle	6.57 deg	6.38 deg	6.95 deg	10.97 deg
	Along. Beam Angle	6.53 deg	6.51 deg	7.12 deg	10.63 deg
	Athw Offset Angle	-0.29 deg	-0.05 deg	0.05 deg	0.19 deg
	Along. Offset Angle	-0.09 deg	-0.01 deg	-0.17 deg	0.31 deg
Data dev from beam model	RMS	0.60 dB	0.52 dB	0.20 dB	0.55 dB
Data dev polynomial model	RMS	0.56 dB	0.44 dB	0.18 dB	0.51 dB

Table 5: Acoustic equipment calibration. Main in and outputs for each frequency.

Main oceanographic conditions

Figure 2a-c shows the sea surface temperature, salinity and flourometry from the continuous records. In the western areas (i.e. IXa-N) temperatures ranged from 13.18º to 22.27ºC, with a mean value of 14.13º (median, 14.07º). In the same way, salinity ranged from 28.28 to 36.31 ppm (mean 33.70 and median 33.91 ppm), with a strong correlation with longitude, being waters less saltier and warmer close to the coast due to the river flows. Fluorescence ranged from 0.84 to 2.75 (mean 1.20, median , 1.12). In the northern areas (VIIIc) temperature ranged from 12.58º to 14.92ºC (mean, 13.26º, median 13.18º) being 0.75º colder than that of the western area. In addition, salinity ranged from 31.64 to 36.04 ppm (mean 35.23, median 35.34 ppm), thus more salted than those from the western area. Fluorescence ranged from 0.94 to 3.63 (mean 1,64, median 1.52); complementary, all variables were correlated with latitude. Thus, interpolation was made using this two areas . The surveyed area can be divided in several areas according to the surface continuous records. IXaN area with low salinity, warmer waters and weak flourometry (i.e. chlorophyll); NW corner (VIIIc-W) with high flourometry values, salty waters from the coast to the self-beak, and temperatures in transition from warmer waters in the south to colder waters in the north ; from Cape Ortegal to Llanes Canyon, with lesser salty waters in coastal areas than in open waters, colder temperature through all the area and a weak chlorophyll density ; from Llanes Canyon to Suances , with warmer waters than that of the surrounded areas, but with almost same salinity as found in the surrounded areas, with a clear influence from the river flows and the chlorophyll increasing eastwards; from Suances to Laredo, characterised by an intrusion of colder waters, low salinity in coastal waters, and a moderate concentration of chlorophyll; and the inner part where both sea surface temperature and flourometry showed a clear west-eastward cline, and, as in the rest of the surveyed area except in VIIIc-west, an influence of the river flows in the coastal areas.

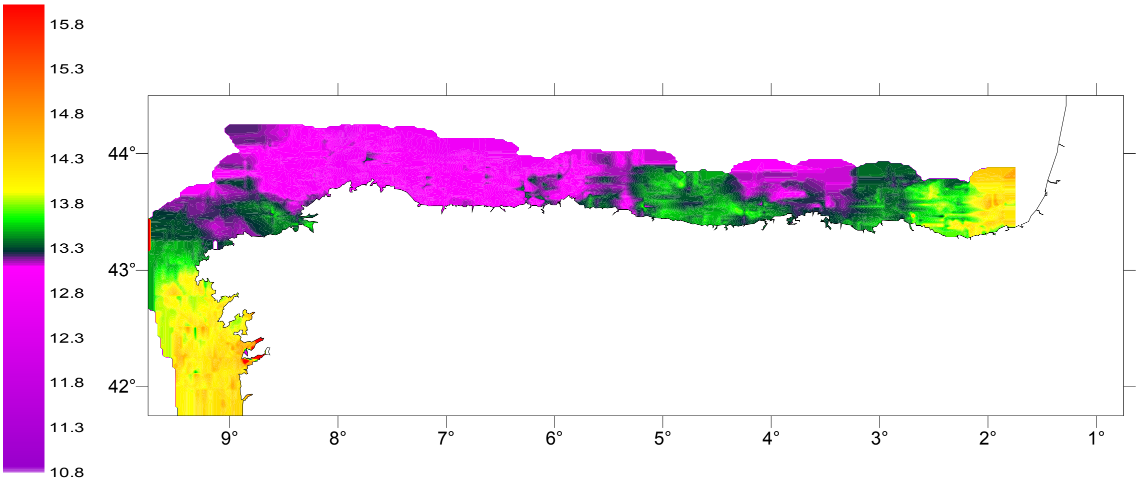


Figure 2a: Sea Surface Temperature during PELACUS 0314 survey

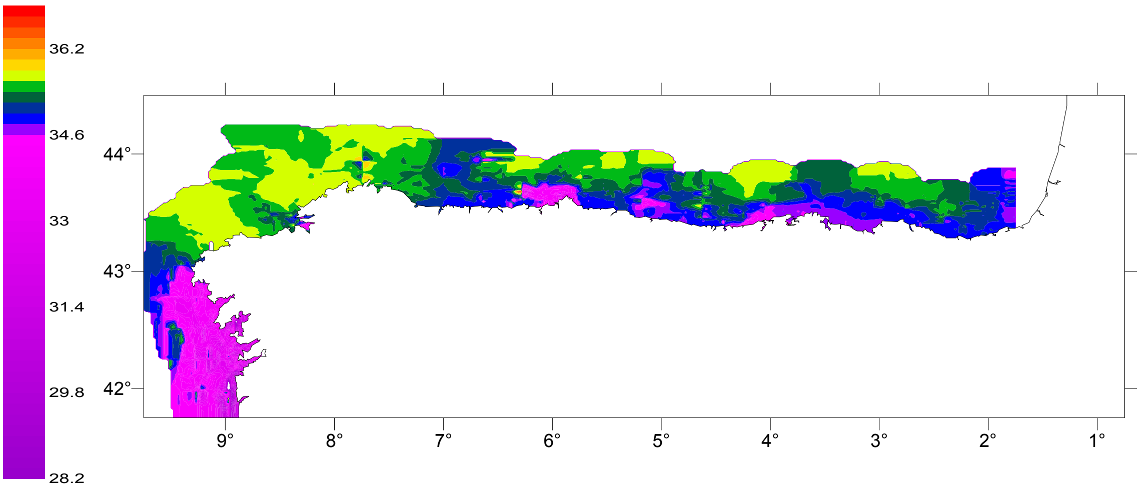


Figure 2b: Sea Surface Salinity during PELACUS 0314 survey

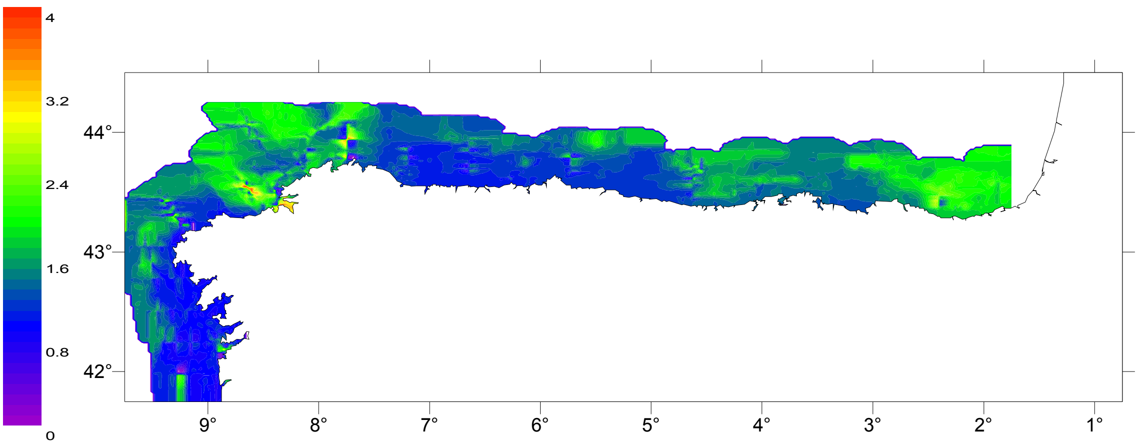


Figure 2c: Sea Surface Fluorescence during PELACUS 0314 survey

Fishing stations

Without including the trawl hauls done at the beginning of the survey for checking and setting up purposes, 52 fishing station were performed, one of them was removed. Figure 3 shows the location and the value for each ground-truth criteria (from 0 to 3).

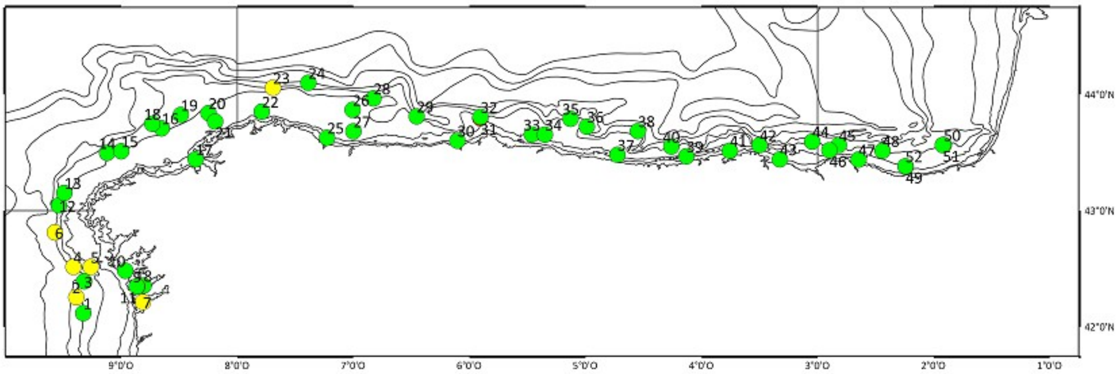


Figure 3: Fishing station and colour system according to ground-truth criteria (red bad; yellow, acceptable; and green good)

As it can be seen, most of the fishing stations were performed under good conditions. Mackerel was the most abundant fish species (34% of the total catch in number) and was also present in the 88% of the fishing hauls. Horse mackerel was also abundant (29% of the total catch in number) and a 67% of haul presence. Finally, blue whiting accounted the 21% of the total catch in number and was present in the 61% of the trawl hauls. Mackerel mainly occurred in the Cantabrian Sea although some adults together with juveniles has been caught in IXa-N and VIIIc-west; in these areas mean length was around 24 cm, without significant differences in length distribution (Kolmogorov Smirnov test) whilst in the Cantabrian Sea mean length increased up to 35cm, thus spawners, with a slight differences, but significant, in both mean length and length distribution between those hauls performed in shallower waters (<140 m depth) and those located close to the shelf edge. Horse mackerel showed a great variety in both mean lengths and length distributions along the surveyed area. On the contrary, the mean length of blue whiting samples was around of 22.5 cm in almost all the hauls and only in two samples obtained near the Llanes Canyon (4º30'W) mean length was lower (21.3 cm).

Figure 4 shows the fish proportion in number obtained in each trawl haul. Boarfish, sardine and bogue, although less representative, were also important. Boarfish mainly occurred in the Cantabrian Sea with a small patch located in the northern coastal waters of VIIIc-west (i.e. close to the Estaca de Bares Cape -8º W-). In the former area was found round Estaca de Bares Cape and in the inner part of the Bay of Biscay. Mean length was similar in almost the whole area (14.09 cm), and only small fish (8.76 cm) were found in the shelf-edge close to the Galicia Asturias border. Juvenile bogue, as shown in mackerel, were mainly located in IXaN whilst adults occurred in the Cantabrian Sea. For Sardine as well mean length in IXaN was 17.03 and in the Cantabrian Sea, except one single haul performed close to the Bilbao harbour the mean length was around 20 cm.

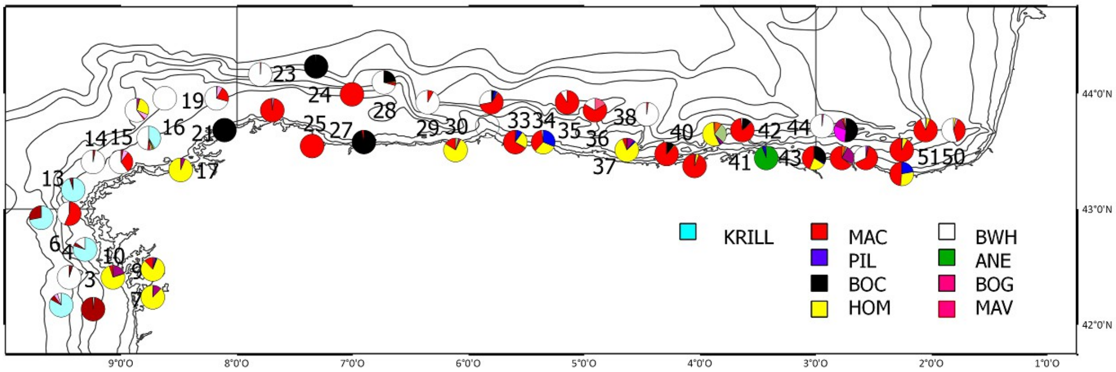


Figure 4: Fish proportion (% in number) at each fishing station. (KRILL -M. norvegica; MAC-mackerel; PIL-sardine; BOC-boarfish; HOM- horse mackerel; WHB-blue whiting; ANE- anchovy; BOG-bogue; and MAV-M. muelleri)

Finally it should be noted the presence of lantern fish, *Maurulicus muelleri*, over the shelf of IXaN. This fish species occurred in small schools during day time as shown in figure 5.

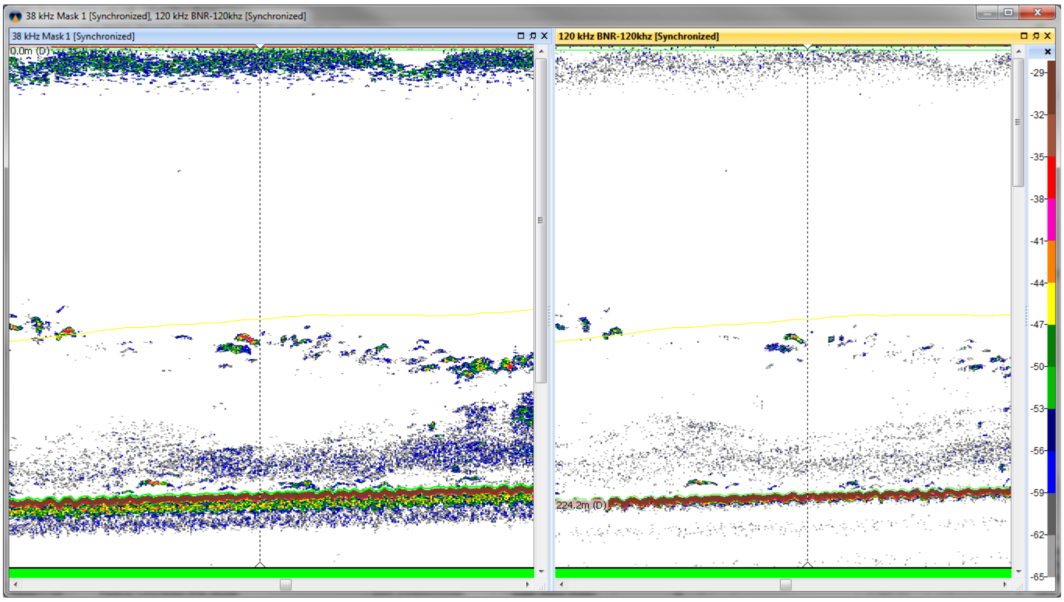


Figure 5: M. muelleri schools located at 140 m depth (total depth is 200). The yellow line is the depth sensor of the trawl door. M. muelleri represented 98% of the catch and 2% was krill (Meganyctiphanes norvegica).The fishing station was performed on 12th March at 13:30 GMT.

CUFES sardine eggs distribution

358 CUFES stations were done and 4214 were collected in 117 samples (33% positive stations). Last year the total egg number collected was 5939 but the number of positive stations was 105 (28% positive stations). The distribution of sardine eggs (obtained from the analysis of 358 CUFES stations) indicates a very coastal distribution, agreeing with that observed in previous years (figure 6)

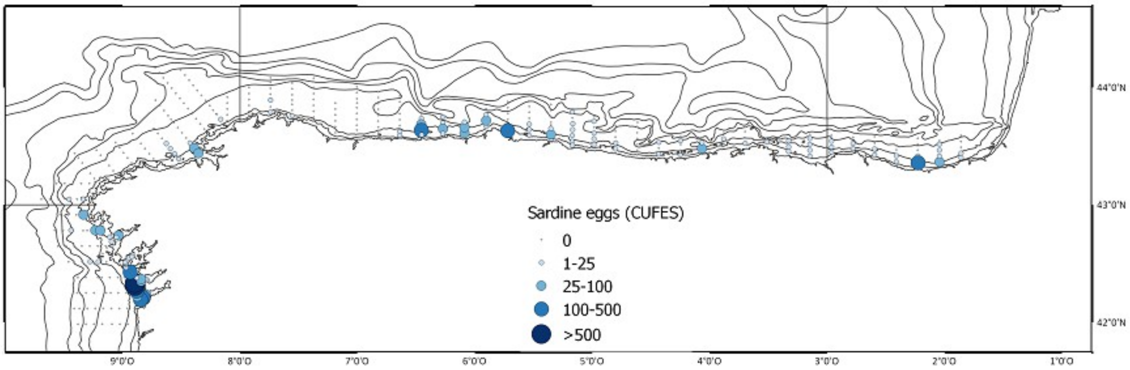


Figure 6. Number of sardine egg collected at the CUFES stations

Acoustic

A total of 251.893,2 s_A were attributed to fish species which is is 2.4 times higher than that of the previous year when only accounted for 105.384,67 s_A. Table 5 shows the fishing station used to allocate backscattering energy when echotraces were similar to those found around these fishing stations.

Fishing station	Transects
PE01	RA02
PE02	RA01, RA02
PE03	RA03, RA04
PE04	RA05, RA06, RA07, RA08
PE05	RA04, RA05, RA06, RA07
PE06	RA06, RA07, RA08, RA09, RA11, RA13
PE10	RA06, RA07, RIAS
PE11	RIAS
PE12	RA09, RA10, RA11
PE13	RA10
PE15-16	RA15, RA16
PE15-18	RA15, RA16
PE15	RA12, RA13, RA14
PE19-18	RA17
PE17	RA12, RA16, RA17
PE19	RA18
PE20	RA17, RA18, RA19
PE22	RA21, RA22
PE23	RA20, RA21, RA22, RA23
PE24	RA23
PE26	RA25, RA27
PE27	RA23, RA24, RA25, RA26, RA27
PE28	RA23, RA24, RA25, RA26, RA27
PE29	RA28, RA29, RA30, RA31, RA32
PE30	RA27, RA28, RA29, RA30, RA31, RA32, RA33
PE32	RA28, RA29, RA30, RA31, RA32, RA33
PE33	RA31, RA32, RA33, RA36
P33-P30	RA34, RA35
PE34	RA33, RA34, RA35, RA36, RA37, RA38
PE35	RA32, RA33, RA34, RA35, RA36,

PE36	RA34, RA36
PE37	RA35, RA36, RA37, RA38, RA39,
PE38	RA37, RA38, RA39, RA43
PE39	RA40, RA42
PE40	RA40, RA43, RA45, RA46
PE41	RA37, RA40, RA41, RA43, RA44,
PE42	RA41, RA42, RA44, RA45, RA46
PE43	RA45, RA46
PE44	RA46, RA47, RA48
PE45	RA48, RA49
PE46	RA47, RA48, RA49
PE47	RA48, RA49, RA50, RA51
PE48	RA50, RA51
PE49	RA49, RA50, RA51
P49-P52	RA52, RA53
P50-P51	RA50, RA51, RA52, RA53

Table 5: Fishing station used for backscattering energy allocation and transects

Table 6 shows the backscattering energy distributed by species and ICES subdivision, either by direct allocation (DA) or through the proportion found at the fishing stations (Fst). Direct assignation was feasible accounting for its special acoustic properties, morphology and geographical characteristics for some board fish, horse mackerel and especially, mackerel. On the other hand, only a 1.19% of the total energy attributed to fish remained unallocated.

		WHB	MAC	HAK	HOM	PIL	JAA	BOG	MAS	BOC	SBR	HMM	Other	total
IXa	**DA**	0	16	0	4543	0	0	0	0	0	0	0	174	4733
	Fst	5540	94	2213	56324	340	407	18209	14	0	1612	0	1087	85841
VIIIc-W	**DA**	0	5	0	84	0	0	0	0	3420	0	0	168	3677
	Fst	12278	77	1086	4456	1	4	775	1	0	54	0	124	18858
VIIIc-Ew	**DA**	0	7967	0	0	0	0	0	0	3096	0	0	2689	11063
	Fst	32385	6395	1286	29357	4989	400	4058	323	18048	3963	669	1	101874
VIIIc-Ee	**DA**	0	1400	0	0	0	0	0	0	0	0	0	0	1400
	Fst	5127	1749	294	2914	711	4	1917	962	6955	242	229	655	21758
Total	**DA**	0	9388	0	4627	0	0	0	0	6515	0	0	3030	23561
	Fst	55330	8315	4879	93052	6042	815	24959	1300	25003	5872	899	1867	228332
Total		55330	17703	4879	97679	6042	815	24959	1300	31518	5872	899	4897	251893

Table 6: Backscattering energy (s_A) allocated by species, both by direct allocation (DA) and by the fish proportion found at the ground-truth fishing stations, and by ICES Sub-Division (WHB-blue whiting; MAC-mackerel; HOM- horse mackerel; PIL-sardine; JAA-blue jack mackerel; BOG-bogue; MAS-chub mackerel; BOC-boarfish; SBR-sea breams and similar specie; HMM-mediterranean horse mackerel; Other species and- unallocated NASC)

Spatial patterns

Table 7 and figure 7 summarizes the spatial indices of the main fish species.

	BWH	MAC	HAK	HOM	PIL	JAA	BOG	MAS	BOC	ANE	HMM
Depth	246.79	163.18	182.37	67.16	136.98	100.06	57.50	197.11	165.79	54.60	94.30
s.d.	312.95	189.00	99.77	236.16	52.46	29.59	113.57	52.97	192.52	3.29	18.61
c. i.	37.36	22.56	11.91	28.20	6.26	3.53	13.56	6.32	22.99	0.39	2.22
Dist 200	3.90	4.84	5.53	8.38	5.38	6.10	7.81	3.11	5.61	8.70	4.27
s.d.	10.02	7.47	3.21	22.89	4.55	1.94	11.06	1.50	15.43	0.44	1.21
c. i.	1.20	0.89	0.38	2.73	0.54	0.23	1.32	0.18	1.84	0.05	0.14
Dist. Or	226.42	284.62	149.87	144.04	295.46	176.95	127.71	373.37	250.86	373.78	354.52
s.d.	353.30	147.04	114.13	570.87	86.91	50.76	285.73	29.69	219.17	0.70	14.13
c. i.	42.16	17.55	13.62	68.13	10.37	6.06	34.10	3.54	26.16	0.08	1.69

Table 7: Center of gravity according to the weighting average calculated using Distance to the Origin (Dist.Org.; expressed in nautical miles), distance to 200 m isobath (Dist 200) and depth (DEPTH, expressed in meters) together with its standard deviation and confidence interval. (WHB-blue whiting; MAC-mackerel; HAK -hake; HOM- horse mackerel; PIL-sardine; JAA-blue jack mackerel; BOG-bogue; MAS-chub mackerel; BOC-boarfish; ANE-anchovy ; HMM-mediterranean horse mackerel.

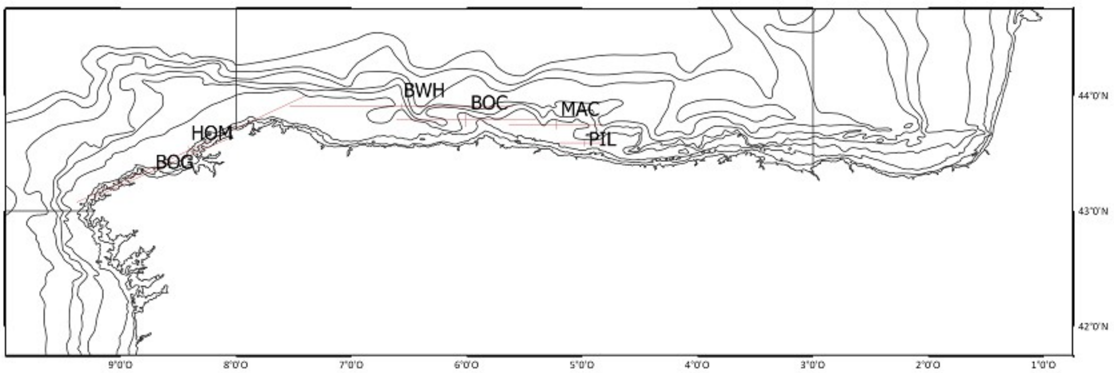


Figure 7 Centre of gravity of NASC distribution for the main fish species. Lines are proportional to the confidence intervals for both variables, Distance to the Origin (D.O.) and Depth

That of horse mackerel reflects the high abundance found within the Rías in IXaN and, in general in shallower waters. The center of gravity of mackerel remains more or less in the position as in the previous year. For blue whiting, although some fish have been detected over the continental shelf, the bulk of the distribution is still located on the self-edge, but this year the center has been estimated eastward than the previous year. On the other hand, sardine distribution, although the schools detected in the Rias, remains as well in more or less the same position as in the previous year.

Sardine distribution and assessment

A total of 9,669 tons of sardine (157 million fish) were estimated to be present in the surveyed area. That represents an important increase in relation to 2013 abundance and biomass, but still at the lower levels of the time series. Fish were mainly found in Cantabrian area (mainly in VIIIc East-West subdivision) and inside Rias Baixas (South Galicia, ICES sub-areas IXa-N) and was almost absent from the rest of the surveyed area (figure 8). Most fish in the entire surveyed area were assigned as belonging to the age 2 (38% of the abundance and 43% of the biomass) and age 3 (24.5% of the abundance and 25.5 % of the biomass) years classes. By subdivisions, the IXaN (South of Galicia) population was dominated by age 1 fish whilst the Cantabrian area was mainly composed by a population of age 2 and age 3 individuals.(figures 9 and 10 and table 8)

Contrary to the normal behaviour, and despite having detected more acoustic energy in the study area, sardine seemed to occur dispersed and not in dense schools, mixed with other species, mainly mackerel (which represented more than 70 percent of the biomass in the PELACUS catches) and horse mackerel

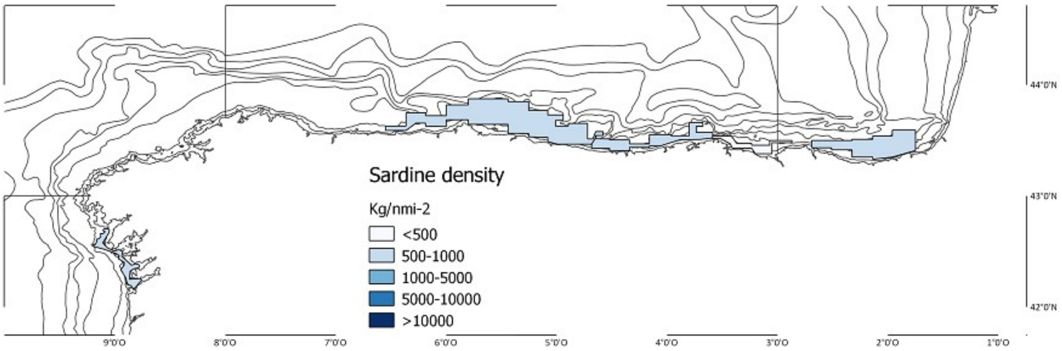


Figure 8. Sardine spatial distribution in PELACUS0314 cruise. Polygons are drawn to encompass the observed echoes, and polygon colour indicates the mean density expressed as kilograms per squared nautical mile (<500,; 500-1000; 1000-5000; 5000-10000; and >10000)

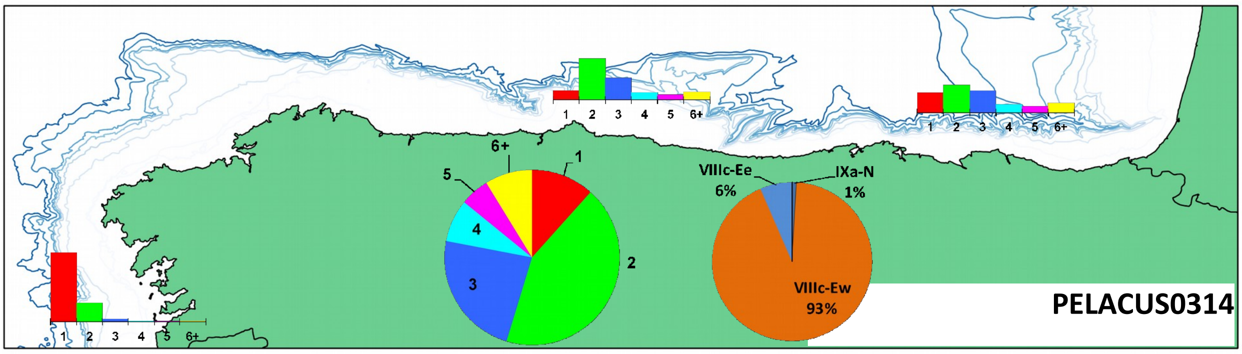


Figure 9. Sardine: relative abundance at age in each sub-area (i.e. the proportion of all age classes within sub-area sum to 1) estimated in the PELACUS0314. The pie chart shows the contribution of each sub-area and each age group to the total stock numbers.

		SURVEY:	PELACUS 0314 SARDINE						
Zone	**Area**	**No**	**Mean**	**Area**	**Fishing st.**	**PDF**	**No (million fish)**	**Biomass (tonnes)**	**Density (Tn/nmi-2)**
IXa	Rias Baixas	52	6.54	103	P08-P09-P11	S01	3	125	1
	Total	**52**	**7**	**103**			**3**	**125**	
VIIIc-Ew	Asturias-Occ	111	40.56	857	P32-P33-P34	S02	119	7506	9
	Asturias-Or	28	17.28	216	P37	S03	15	762	4
	Total	***139***	***35.88***	***1073***			***134***	***8268***	
VIIIc-Ee	Laredo	9	3.07	89	P43	S04	2	46	1
	Euskadi	32	15.49	224	P46-P49-P52	S05	11	763	3
	Total	**41**	***12.77***	**313**			**13**	**809**	3
VIIIb	Euskadi	12	15.49	138	P46-P49-P52	S05	7	468	3
	Total	***12***	***15.49***	***138***			***7***	***468***	3
	Total IXa	***52***	***7***	***103***			***3***	***125***	1
	Total VIIIc	***180***	***31***	***1386***			***147***	***9077***	7
	Total VIIIb	***12***	***15***	***138***			***7***	***468***	
	Total Spain	***244***	***24.74***	***1627***			***157***	***9669***	6

Table 8: Sardine acoustic assessment

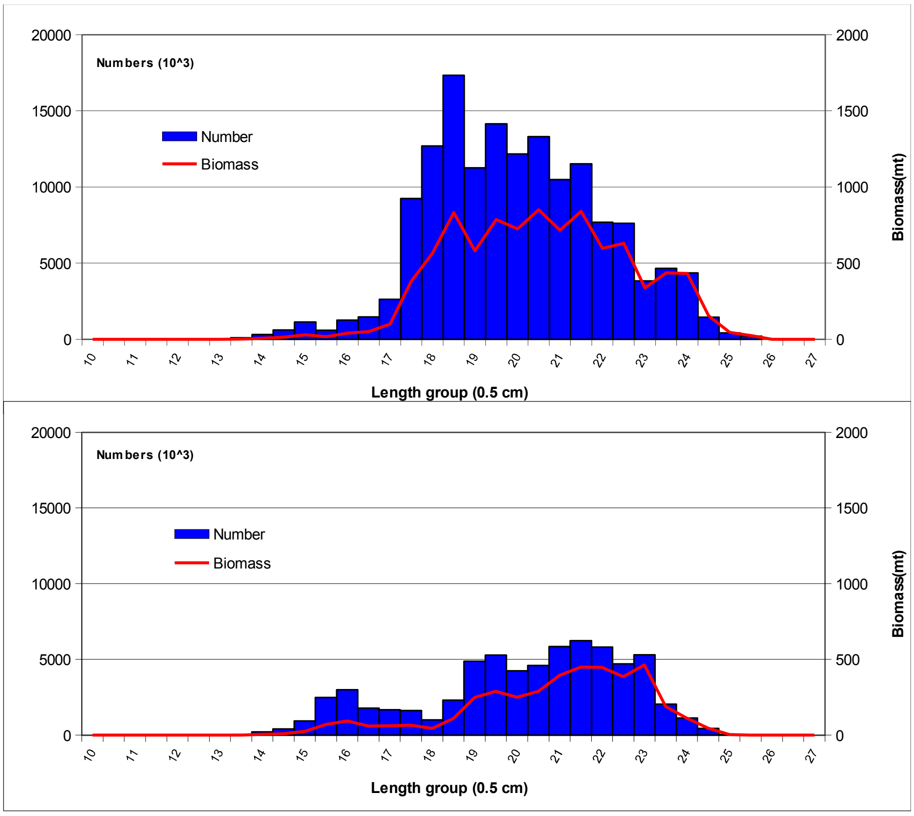


Figure 10. Sardine length distribution in both number and biomass during the PELACUS0314 (above) and PELACUS 0313 (below) surveys.

Mackerel distribution and assessment

Mackerel was the most important fish species, both in number and spatial distribution. Figure 11 shows the spatial distribution.

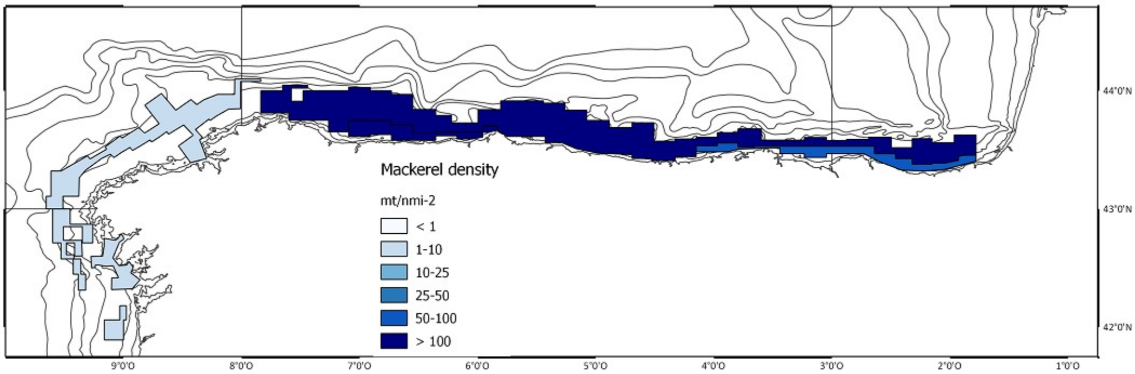


Figure 11. Mackerel: spatial distribution PELACUS0314 cruise. Polygons are drawn to encompass the observed echoes, and polygon colour indicates the mean density expressed as tonnes per squared nautical mile (<1,; 1-10; 10-25; 25-50; 50-100; and >500)

Table 9 shows the mackerel assessment. 808 422 mt has been estimated, corresponding to 2.802 million fish. The bulk of the distribution occurred in the central part of the Cantabrian Sea. In western areas (IXaN and VIIIc-west), where the juvenile mackerel fraction was distributed, density was scarce and, in some cases, very difficult to observe at 38 kHz and probably both abundance and distribution area would be greater; in these areas age group 1 was predominant (84% in number and 63% in weight). On the contrary, in the Cantabrian Sea (VIIIc-East), where the bulk of the biomass occurs, age groups 5, 6 and 7 where predominant and accounted for the 65% of the biomass (64% in weight)

		SURVEY:	PELACUS 0314 MACKEREL					
Zone	**Area**	**No**	**Mean**	**Surface**	**Fishing st.**	**PDF**	**No (million fish)**	**Biomass (tonnes)**
Ixa-N	Ixa-N-South	9	0.84	92.24	P03-P05-P08-P10-P12-P13-P15-P20	ST01	3	326
	Ixa-N-Rias Baixas	55	1.36	189.90	P03-P05-P08-P10-P12-P13-P15-P20	ST01	11	1081
	Ixa-N-North	25	1.07	229.58	P03-P05-P08-P10-P12-P13-P15-P20	ST01	10	1026
	Total	***89***	***1***	***512***			***24***	***2433***
VIIIc-w	Artabro	100	0.81	899.84	P03-P05-P08-P10-P12-P13-P15-P20	ST01	30	3040
	Total	***100***	***1***	***900***			***30***	***3040***
VIIIc-E	VIIIc-Ew-Coast	37	19.10	277.93	P18-P20-P22	ST02	108	29735
	VIIIc-Ee-Coast	48	14.64	382.41		ST02	114	31366
	VIIIc-offshore	365	44.11	2926.46	P32-P33-P34-P35-P36-P37-P38-P39-P40-P42-P44	ST03	2525	741848
	Total	***450***	***39***	***3587***			***2748***	***802949***
	Total VIIIc	***550***	***32***	***4998***			***2778***	***805989***
	Total Spain	***639***	***28***	***4998***			***2802***	***808422***

Table 9 Mackerel acoustic assessment

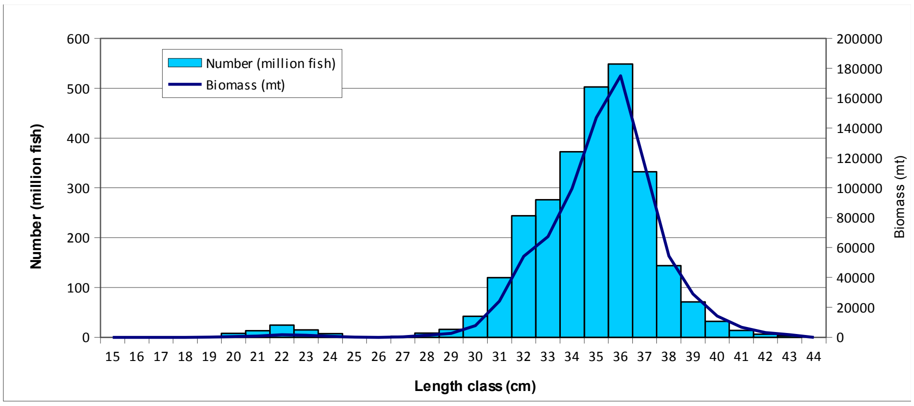
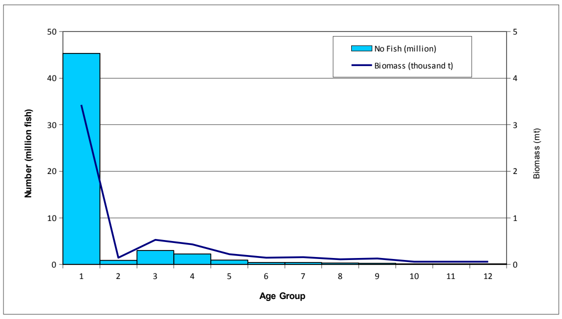
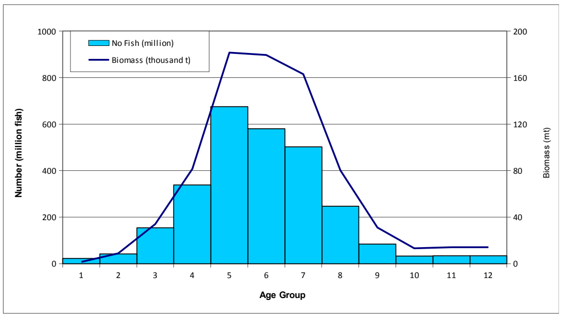


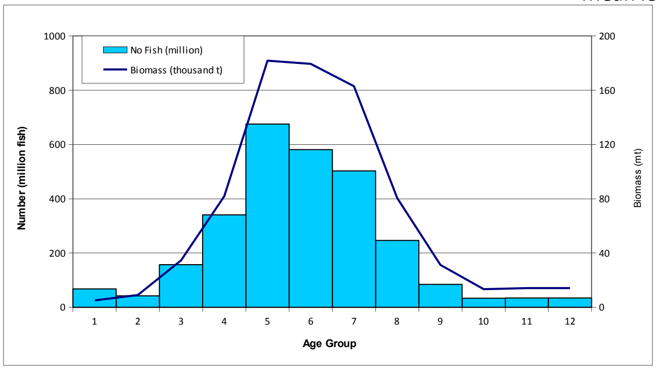
Figure 12. Mackerel length distribution in both number and biomass during PELACUS0314 survey.



Biomass: 5.47 thousand mt
Mean weight: 87.65 g
Number: 54 million fish
Mean length: 24.03 cm (s.d. 3.96)



Biomass: 802.95 thousand mt
Mean weight: 296.75 g
Number: 2748 million fish
Mean length: 35.31 cm (s.d. 2.51)



Biomass: 808.42 thousand mt
Mean weight: 290.99 g
Number: 2802 million fish
Mean length: 35.09 cm (s.d. 2.98)

Figure 13. Mackerel abundance and biomass by age group during PELACUS0314 survey.

Comparing with the previous year, the total mackerel biomass assessed is 47 % higher (379 149 t corresponding to 1,725 million fish). As in previous year juveniles were mainly located in the west part (VIIIc-w and IXaN), where age group 1 accounted for the 83% of total fish number and the 63% of the total biomass. In Cantabrian Sea (VIIIc-East), were the bulk of the population was located (97% of the fish number and 99% of the total biomass), age groups 4, 5 and 6 accounted for the 65% of the total biomass. On the other hand, age group 2 only represents the 1% of the total abundance. This result is consistent with that obtained the previous year when the strength of age class 1 was weak.

SURVEY: PELACUS 0314. MACKEREL

BIOMASS (thousand tonnes). ZONE: VIIIc+IXaN

Length	1	2	3	4	5	6	7	8	9	10	11	12	Total	No fish (milli
						AGE GROUPS								
10														
11														
12														
13														
14														
15														
16														
17														
18														
19	0.01												0.01	0
20	0.43												0.43	8
21	0.84												0.84	13
22	1.80												1.80	24
23	1.27												1.27	15
24	0.66												0.66	7
25	0.03												0.03	0
26														
27	0.05	0.14	0.05										0.23	2
28		0.32	0.95										1.27	9
29		0.23	0.70	1.64									2.58	16
30		0.64	3.53	2.25	1.28								7.70	42
31		1.34	10.72	8.04	4.02								24.11	120
32		3.87	3.87	23.19	23.19								54.11	244
33		2.59	5.18	20.74	36.29	2.59							67.40	276
34			7.11	10.67	35.57	24.90	17.78	3.56					99.59	372
35			2.49	4.98	42.36	52.33	24.92	19.94					147.03	503
36				7.00	24.50	56.01	52.51	28.00	7.00				175.03	549
37				3.39	10.17	33.91	37.30	13.57	6.78	3.39	3.39	3.39	115.30	332
38					4.34	6.51	21.70	8.68	6.51	2.17	2.17	2.17	54.26	144
39						3.23	6.45	3.23	6.45	3.23	3.23	3.23	29.03	71
40							2.36	2.36	2.36	2.36	2.36	2.36	14.15	32
41								1.11	2.22	1.11	1.11	1.11	6.65	14
42										1.06	1.06	1.06	3.18	6
43											0.88	0.88	1.75	3
44														
Biomass (thousand t)	5	9	35	82	182	179	163	80	31	13	14	14	808.42	2802
%	0.63	1.13	4.28	10.13	22.48	22.20	20.17	9.95	3.87	1.65	1.76	1.76		
M. weight	71.47	217.42	223.71	245.54	275.29	318.01	333.93	335.23	381.81	414.30	420.87	420.87	290.99	
No Fish (million)	68	43	157	340	676	581	502	247	85	33	35	35	2802	
%	2.43	1.53	5.62	12.15	24.12	20.74	17.93	8.81	3.02	1.18	1.24	1.24		
M. length	22.53	32.01	32.30	33.26	34.48	36.09	36.65	36.69	38.23	39.22	39.42	39.42	35.09	
s.d.	1.21	1.48	1.74	1.69	1.61	1.16	1.34	1.36	1.46	1.51	1.72	1.72	2.98	

Table 10. Mackerel abundance in number (thousand fish) and biomass (tons) by age group and ICES sub-area in PELACUS0314.

On the other hand given that in some cases NASC direct allocation was not feasible and, therefore, this was done using the Nakken and Dommasnes method, the change in the TS length relationship for boarfish, would result in a small decrease of a 1.29 % in the total abundance (i.e. from 808 to 798 thousand tonnes)

Behaviour:

This year, most of the mackerel occurs in a pelagic layer, at around 30-50 m depth. In some cases schools were also seen in the surface and, in general, they showed strong diving reaction from the upper layers to the bottom, especially when marine mammals were present, but also raising reaction from the bottom to the upper layers, as shown in figures 14 and 15. Yet, the relationship between this raising behaviour and explanatory variables was not studied. On the other hand the main difference between this year and the previous is both the thickness and the continuity of the subsurface layer. Until now, rather than a subsurface layer, mackerel occurred in scarce patches while the bulk of the distribution was located near the sea bottom. Over the subsurface patches, the spring artisanal hand-line fleet is concentrated (figure 16).

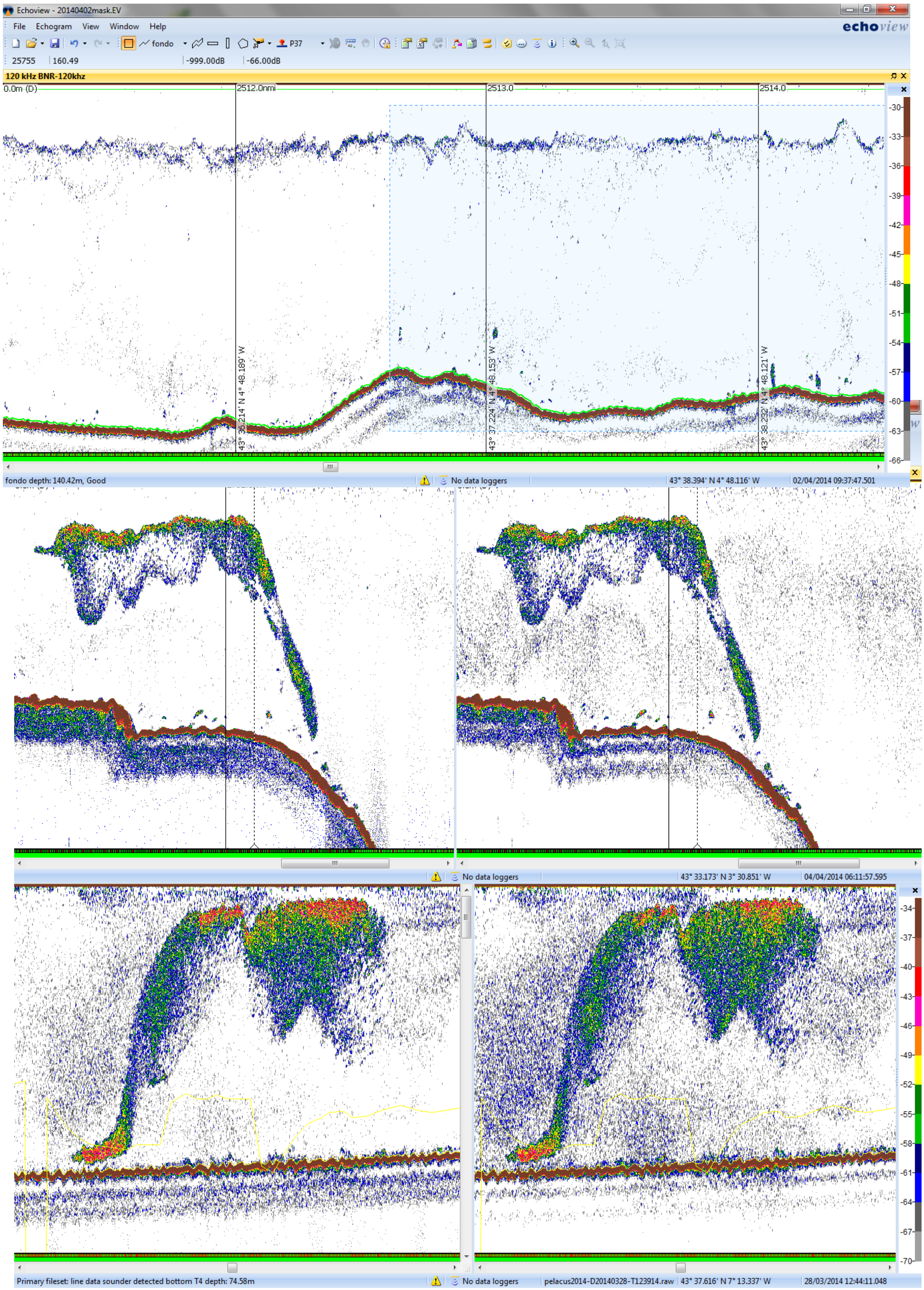


Figure 10. Mackerel occurrence during PELACUS 0314. Top panel subsurface layer (120 kHz echogram; threshold set at -70dB); Mid panel, diving reactions close to the self-edge(200 kHz left and, 120 kHz, right). Bottom panel, raising reaction.

Figure 15: Mackerel schools at the surface

Figure 16: Hand-line working over a mackerel schools.

Blue whiting distribution and assessment

As stated previously, main blue whiting distribution area is located around the self-edge at 247 m depth. Besides is the closest fish species to the 200 m isobath, occurring with lantern fish (Maurolicus muelleri) and krill (Meganyctiphanes norvegica).Besides, the density was in general low and no extension of the distribution area into open waters in pelagic layers has been detected. Instead, comparing to the previous year, it seems that the distribution is spreading through the continental shelf (figure 15). Mean length was rather homogeneous along the surveyed area at around 22.5 cm and only smaller fish were found, close to Santander.

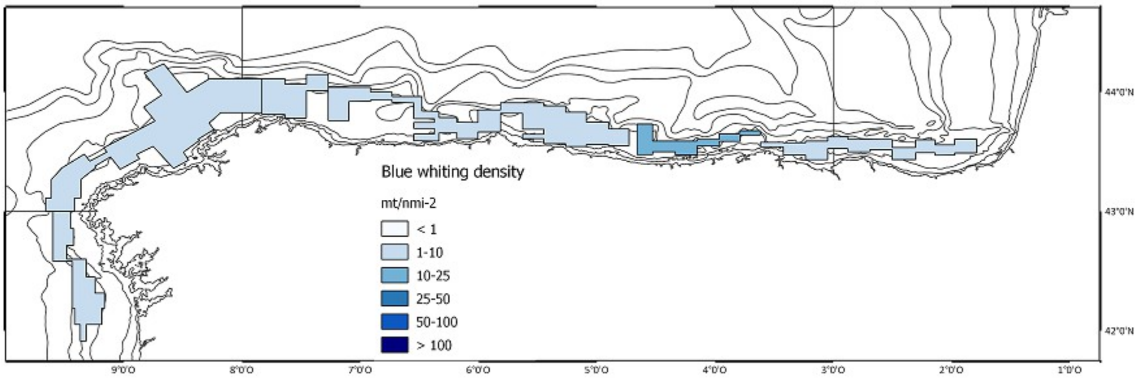


Figure 15. Blue whiting spatial distribution PELACUS0314 cruise. Polygons are drawn to encompass the observed echoes, and polygon colour indicates the mean density expressed as tonnes per squared nautical mile (<1,; 1-10; 10-25; 25-50; 50-100; and >100)

Table 11 shows the blue whiting assessment. A total of 24.117 tonnes corresponding to 414 million fish has been estimated. Comparing to previous years, blue whiting is increasing its biomass from 7146 mt (123 million fish) assessed in 2012, and 13.488 mt (corresponding to 299 million fish) in 2013. Besides length structure, as shown in figure 16, was significant different from that found in the previous year. According to the information got at the fishing station which, as it has been stayed, was similar along the surveyed area (up to 20 fishing stations with more than 31 sampled specimens), no signal of younger fish (length < 18cm) has been found.

		SURVEY:	PELACUS 0314 BLUE WHITING						
Zone	**Area**	**No**	**Mean**	**δ^2**	**Area**	**Fishing st.**	**PDF**	**No (million fish)**	**Biomass (tonnes)**
IXa	Ixa_N	58	95.52	235	479	P02-P03-P04-P06	S01	40	2407
	Total	**58**	**95.52**		**479**			**40**	**2407**
VIIIc-W	VIIIc_W	182	67.46	104	1643	P12-P14-P15-P16-P18-P19-P20	S02	94.37	5891.61
	Total	***182***	***67***		***1643***			***94***	***5892***
VIIIc-E	Estaca	43	84.00	215	351	P23-P24	S03	26	1548
	Asturias	136	150.80	457	1177	P24-P28-P29-P32-P34-P35-P36	S04	159	9201
	Cantabria	37	223.28	409	263	P38-P40	S05	58	2919
	Euskadi	59	86.89	158	477	P42-P44-P48	S06	38	2150
	Total	***275***	***136.39***		***2268***			***280***	***15818***
Total IXa		***58***	***96***		***479***			***40***	***2407***
Total VIIIc		***457***	***109***		***3910***			***374***	***21710***
Total Spain		***515***	***107.43***		***4389***			***414***	***24117***

Table 11: Blue whiting assessment

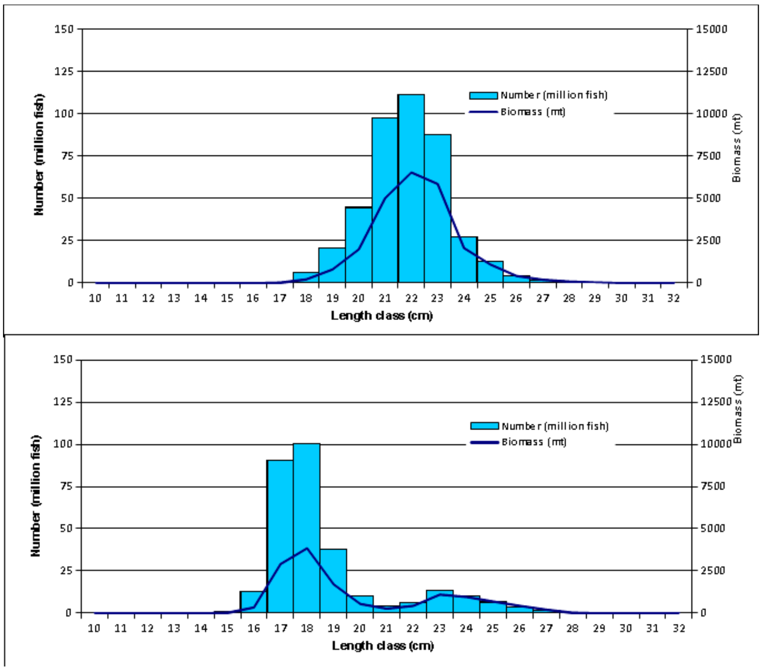


Figure 16. Blue whiting length distribution in both number and biomass during the PELACUS0314 (above) and PELACUS 0313 (below) surveys.

As in the case of mackerel, when the new TS boarfish length relationship is applied in multispecific areas, the total biomass decreases up to 22870 mt (5.5%).

Horse mackerel distribution and assessment

Horse mackerel density was higher than that found the previous year. In IXaN, the bulk of the distribution occurred within the Rías Baixas in a very dense and near bottom schools (figure 17).

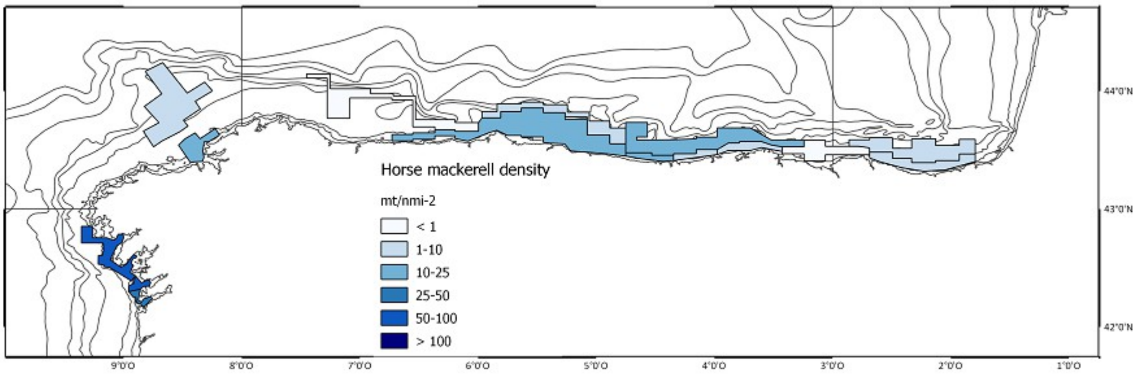


Figure 17. Horse mackerel spatial distribution PELACUS0314 cruise. Polygons are drawn to encompass the observed echoes, and polygon colour indicates the mean density expressed as tonnes per squared nautical mile (<1,; 1-10; 10-25; 25-50; 50-100; and >100

Total biomass was estimated to be 44.356 mt (556 million fish), 13024 of those located in IXaN (217 millions fish) and the remaining 31.332 in VIIIc (340 million fish). (table 12, figure 18).

		SURVEY:	PELACUS 0314 HORSE MACKEREL						
Zone	**Area**	**No**	**Mean**	**ó^2**	**Area**	**Fishing st.**	**PDF**	**No (million fish)**	**Biomass (tonnes)**
IXa	R Vigo	22	556.67	674.99	27.20	P07	S01	22	1307
	R Pontevedra	16	773.98	1259.80	31.13	P08-P11	S02	41	1907
	R Arousa	57	635.74	1446.86	173.65	P10	S03	154	9810
	Total	***95***	***641***		***232***			***217***	***13024***
VIIIc-W	Artabro_ Coast	15	262.10	451.09	116.91	P17	S04	43.39	2704.57
	Artabro_Shelf	59	7.79	9.56	494.24	P18-P19	S05	2.50	610.23
	Total	***74***	***59***		***611***			***46***	***3315***
VIIIc-E	VIIIcE_west_Coast	98	171.52	288.11	748.83	P30-P33-P34	S06	164	12046
	VIIIcE_west_Shelf	33	9.37	20.36	336.88	P30-P33-P34	S06	4	296
	VIIIcE_mid_Coast	32	25.35	75.07	244.75	P32-P36-P45	S07	3	978
	Llanes	6	182.38	179.84	50.03	P37	S08	16	718
	San Vicente	6	114.14	132.90	48.48	P39	S09	8	480
	Santander	11	85.72	104.78	81.59	P41	S10	16	499
	Abra Bilbao	22	1.42	3.71	180.29	P46	S11	0	22
	Donostia_Shelf	25	51.39	114.14	177.57	P49-P52	S12	16	715
	Donostia_Coast	44	33.32	46.14	343.45	P50-P51	S13	8	1542
	Cantabria_Shelf	52	169.91	732.69	471.35	P40	S14	57	10722
	Total	***329***	***98.08***		***2683***			***294***	***28017***
	Total IXa	***95***	***641***		***232***			***217***	***13024***
	Total VIIIc	***403***	***91***		***3294***			***340***	***31332***
	Total Spain	***498***	***195.84***		***3526***			***556***	***44356***

Table 12: Horse mackerel assessment

As in the previous years, length distribution showed a great heterogeneity along the surveyed although a clear mode around 20 cm has been found in almost all the fishing stations.

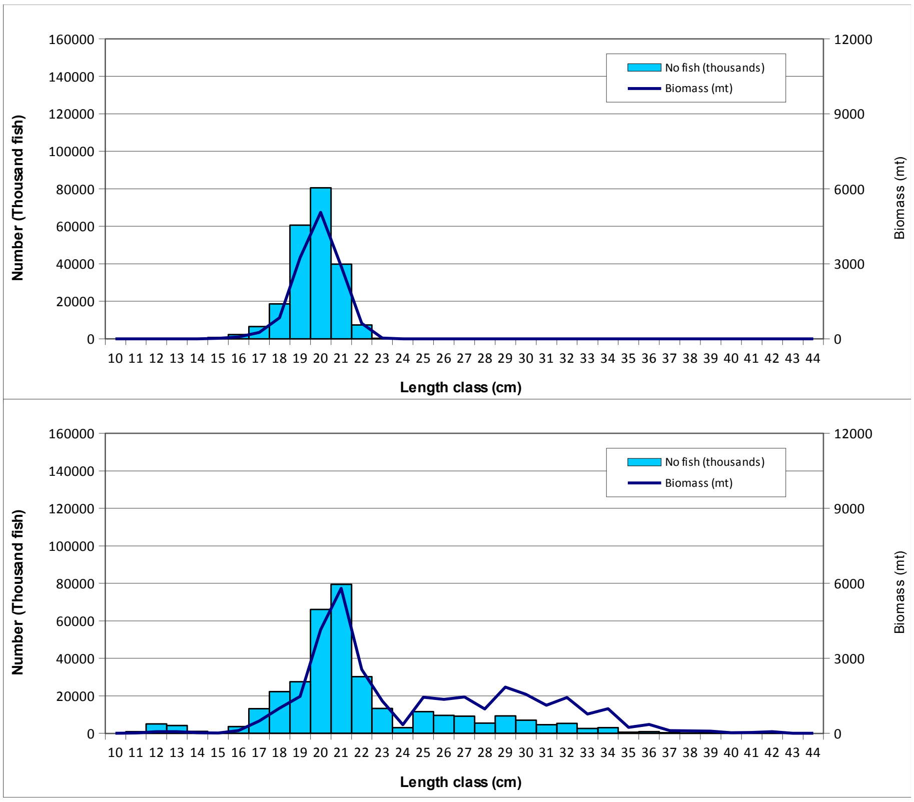


Figure 18. Horse mackerel length distribution in both number and biomass during the PELACUS0314 in IXaN (above) and VIIIc (below).

The total biomass assessed in Pelacus 0314 was significantly higher than that estimated last year (6.362 mt corresponding to 44 million fish). A total of 6.372 mt has been estimated, corresponding to 44million fish, which was smaller than that assessed the last year (18264 mt corresponding to 110 million fish). The bad weather conditions found last year as well as the behaviour observed of near-coast schools, mainly concentrated in shallower waters in a very hard and rough sea bed, thus no accessible to the pelagic year, which represented the 33% of the total backscattering energy and left as unallocated, would be a plausible explanation for such increase. On the other hand, as shown in figure 19, the main difference between both surveys is the lack of a 20 cm mode (mainly age group 1) during the previous survey as compared with 2014 survey. Given the presence of this length mode through the whole surveyed area, it seems that the strength of the 2013 recruitment would be higher than that of the previous ones.

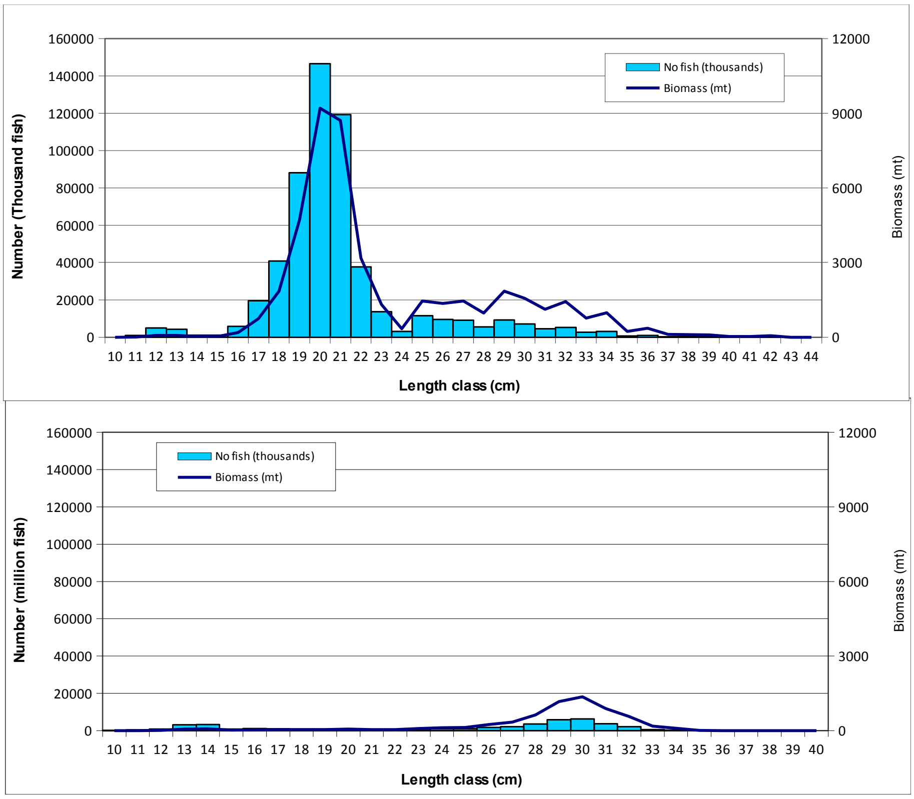


Figure 19: Horse mackerel length distribution in both number and biomass during the PELACUS0314 (above) and PELACUS 0313 (below) surveys.

On the other hand the differences between this assessment and that derived from the application of the new boarfish TS length relationship is almost negligible (0.25%)

Boarfish distribution and assessment

Boarfish spatial distribution and length structure remained very similar to those observed last year (figure 20). Smaller size was detected in the eastern part of Cape Ortegal (7ºW) with a principal mode located at 8 cm, while for the rest of the areas the main mode was estimated at 14 cm. Besides, as in previous years, boarfish occurred either in isolate, thick schools, mainly located in the western part and in near bottom layer, sometimes mixed with other fish species.

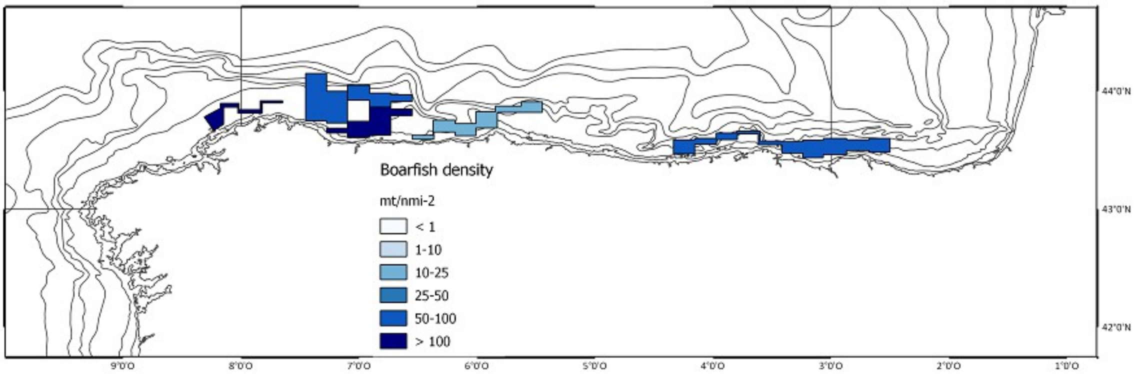


Figure 20. Board fish spatial distribution PELACUS0314 cruise. Polygons are drawn to encompass the observed echoes, and polygon colour indicates the mean density expressed as tonnes per squared nautical mile (<1,; 1-10; 10-25; 25-50; 50-100; and >100)

For the assessment we have kept the old TS/length relation ship for comparison purposes, but, together with this, we have used the new one estimation.

Accordingly, using the new TS estimation, a total of 25344 has been estimated corresponding to 581 million fish. (table 10). In the same way, using the old TS estimation which was so much lower than the new one (6.4 dB), the total biomass reached 98220 mt (2167 million fish), which was 6 times higher than that of the previous year (16067 tonnes, corresponding to 437 million fish), but still far from the maximum assessed in 2011 when more than 220 thousand tonnes were estimated. In 2012 the total biomass assessed were 33.238 corresponding to 518 million fish.

		SURVEY:	PELACUS 0314 BOAR FISH					
Zone	**Area**	**No**	**Mean**	**Area**	**Fishing st.**	**PDF**	**No (million fish)**	**Biomass (tonnes)**
VIIIc-W	Capelada	13	264.57	93.92	P21	S01	39.10	2321.75
	Total	***13***	***265***	***94***			***39***	***2322***
VIIIc-E	Estaca	34	136.59	310.86	P24	S02	74	3790
	Masma Coast	28	315.74	225.18	P27	S03	107	6763
	Masma Off-shore	17	301.03	144.32	P28	S04	184	2643
	Asturias_Occ	30	112.63	251.50	P32-P40-P42-P44-P45-P46	S05	47	2590
	Cantabria	55	186.94	423.37	P32-P40-P42-P44-P45-P46	S05	131	7235
	Total	***164***	***196.73***	***1355***			***542***	***23022***
Total VIIIc		***177***	***202***	***1449***			***581***	***25344***
Total Spain		***177***	***202***	***1449***			***581***	***25344***

Table 13: Boarfish acoustic assessment

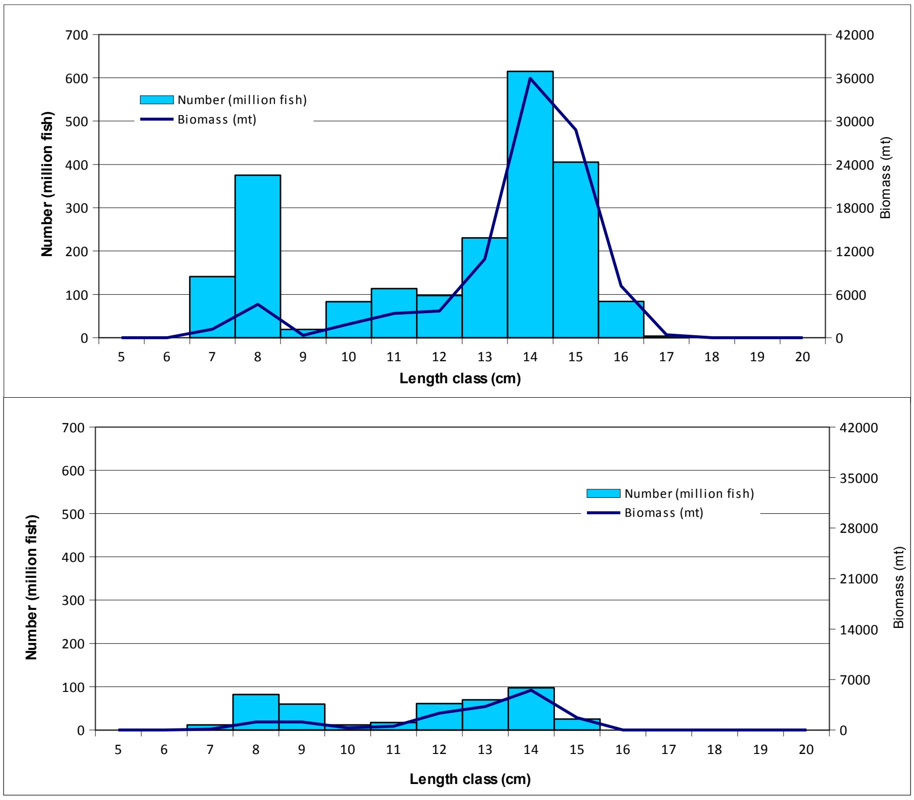


Figure 22. Boarfish length distribution in both number and biomass during the PELACUS0314 (above) and PELACUS 0313 (below) surveys.

<u>Boarfish frequency response:</u>

When possible boarfish schools were directly allocated. Nevertheless, relative frequency response seems to be highly variable, and, although there is a clear pattern with a weak response at high frequencies, specially at 200 kHz, in some cases responses at 18 kHz or at 120 kHz were higher than those reported by Fässler et al (2013), as shown in figure 22a-b. Whether this changes are related to the fish size (i.e. different frequency resonant in relation total size) or to physiological condition or behaviour (i.e. spawning) should be further investigated.

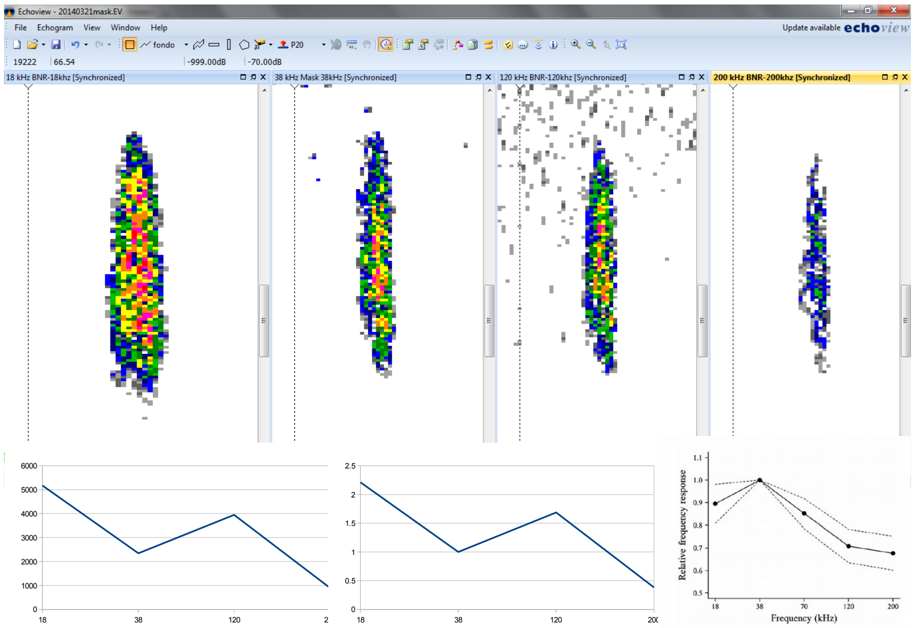


Figure 22a. Boarfish school as observed at 18, 38, 120 and 200 kHz and its absolute frequency response (left plot), relative one (middle plot) and the observed relative frequency response as found in Fässler et al (2003) (right plot).

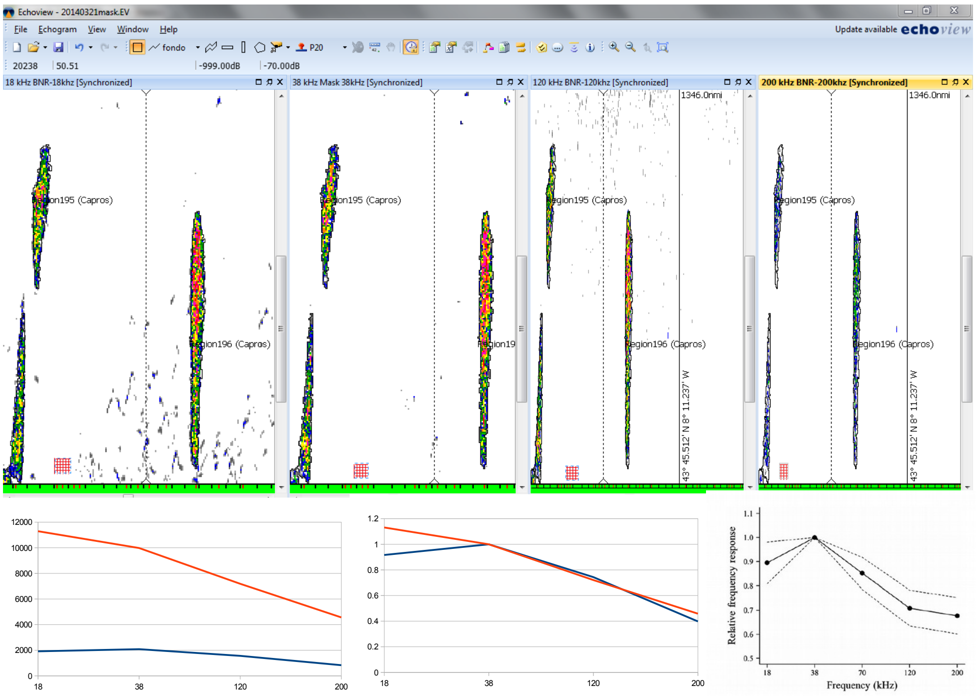


Figure 22b. Ib. Boarfish schools as observed at 18, 38, 120 and 200 kHz and its absolute frequency response (left plot), relative one (middle plot) and the observed relative frequency response as found in Fässler et al (2003) (right plot).

Other fish species

Only bogue (Boops boops) has an important contribution to the pelagic community; on the contrary, anchovy or Mediterranean horse mackerel had a lesser contribution, with only few tonnes.

Mackerel diet

The times series of mackerel stomach contents (1999-2014) has been presented this year. Data came from the biological samples obtained in different trawls hauls during PELACUS (i.e. only day time data). Figure 23 shows the percentage of non empty stomachs. 75% of stomachs analysed, ranging from to 56 to 92%, were full or partial full. Main prey has varied along time series, but copepods and mackerel eggs were the most important preys in number along the time series. In volume, three periods can be distinguished; from 2001 to 2004 salps accounted for around 54% of the stomach volume; 2006 to 2011 when copepods accounted for the 40% of the total stomach volume, reaching the maximum in 2009 and then showing a continuous declining trend; and since 2011 when crustacean became more important (Euphausiacea, Mysidacea, Decapoda, both adult and larvae) (figure 24). Since no long-term trends or cycles were detected in any zooplankton species (Bode et al, 2012) and only an increase in the zooplankton diversity related with inter-seasonal variability, the variability observed in the mackerel diet would be rather related to a variability in the zooplankton diversity which ultimately depends on the seasonal temperature.

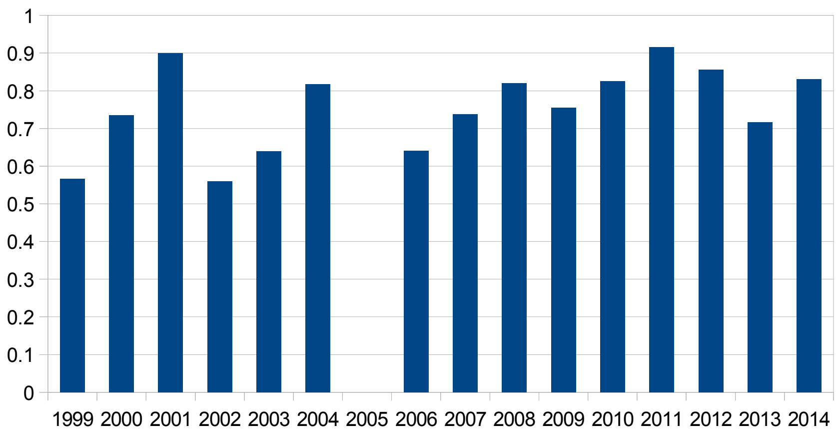
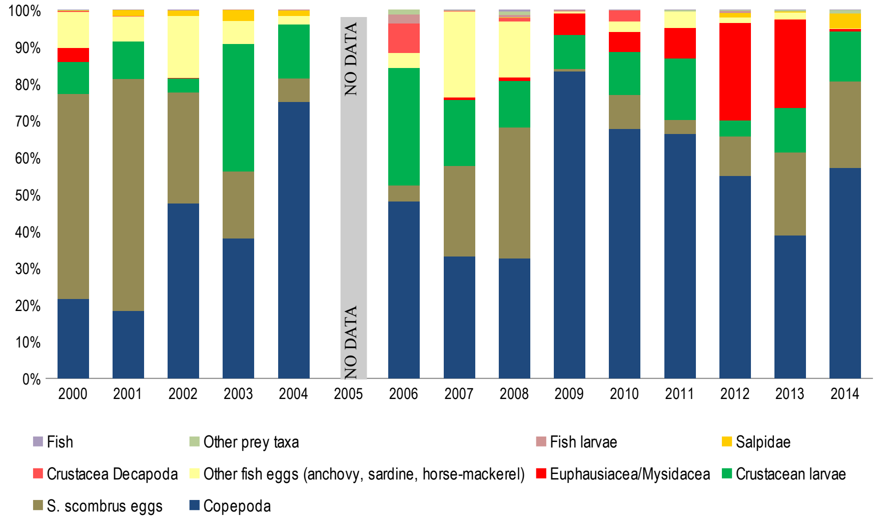


Figure 23:Percentage of non-empty mackerel stomachs taken during PELACUS time series (1999-2014)



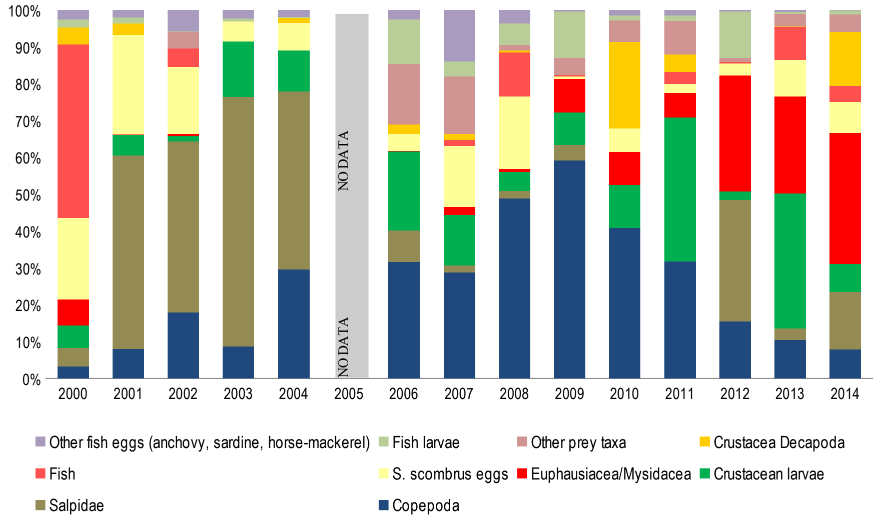


Figure 24: Mackerel diet in number (top panel) and in volume (bottom panel). All figures are in percentage.

Top predators

A total of 169 legs were done corresponding to 114.95 hours (5.6 hour on average and round 51 nmi per day. Overall 8908 marine birds, 1431 marine mammals. 2022 human activities, 37 inland birds, 12222 pelagic organism (sunfish amond them) and 90 oceanographic phenomena were recorded (table 14)

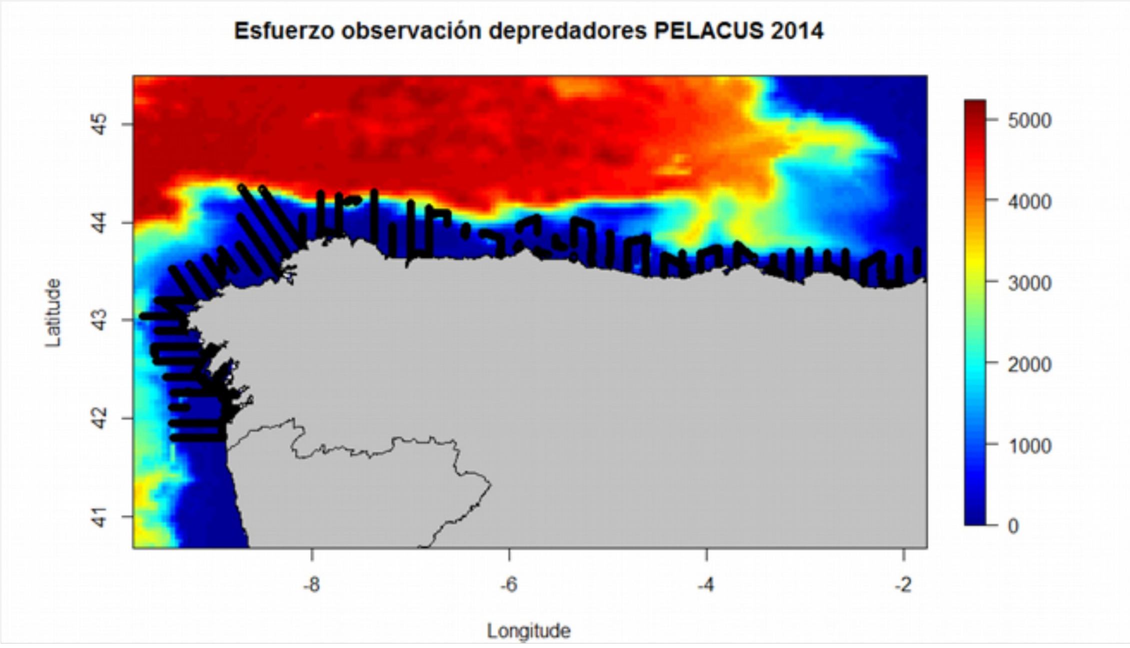


Figure 25: Surveyed track

Marine birds:

22 taxa were recorded. Gannet (*Morus bassanus*), yellow legged gull (*Larus michahellis*), lesser black-backed gull (*Larus fuscus*) and skua (*Stercorarius skua*) were the most abundance species. Higher concentrations were located in the NW area. Gannets were mainly located in coastal waters with most of the specimen undertaking a northward migration.(figure 26)

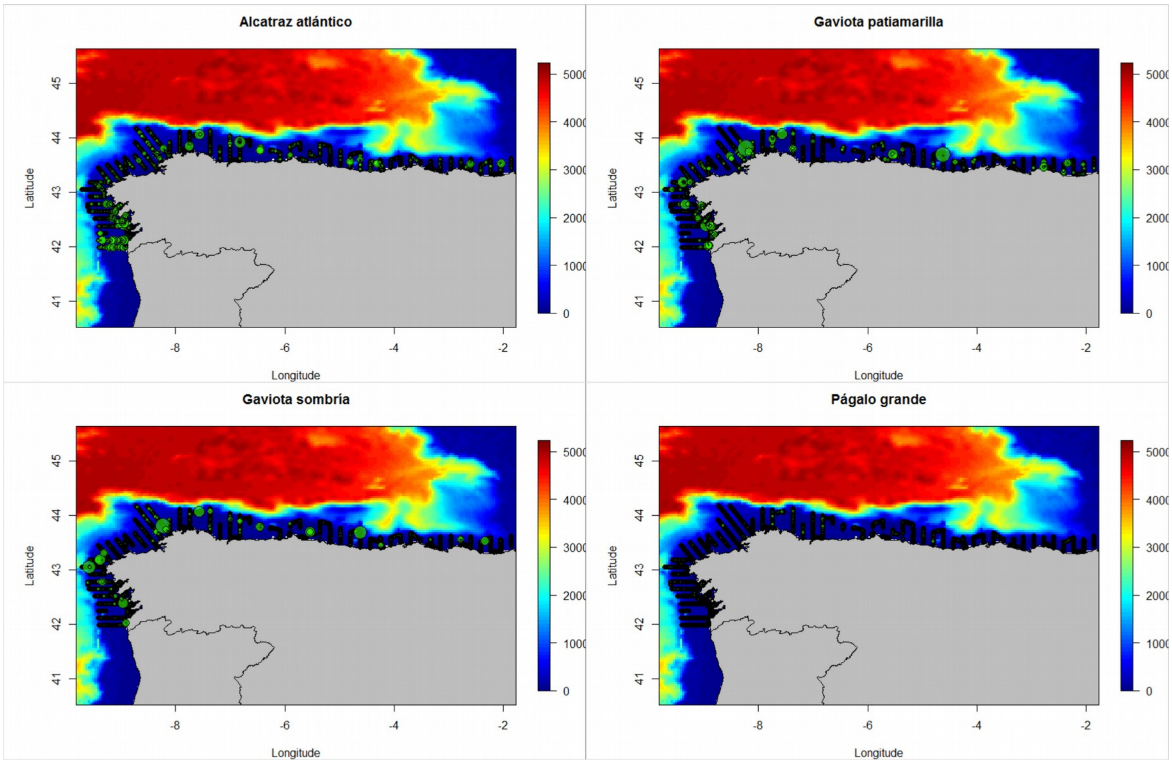


Figure 26 Observations of gannet (right upper panel) yellow legged gull (left upper panel), lesser black-backed gull (right lower panel) and skua (left lower panel) during PELACUS 0314

Marine mammals:

379 specimen were watched. Bottlenose dolphin (*Tursiops truncatus*) was the most abundant followed by common dolphin (*Delphinus delphis*) and long-finned pilot whale (*Globicephala melas*). As in the case of marine birds, most of the observations have been made in the SW area (figure 27)

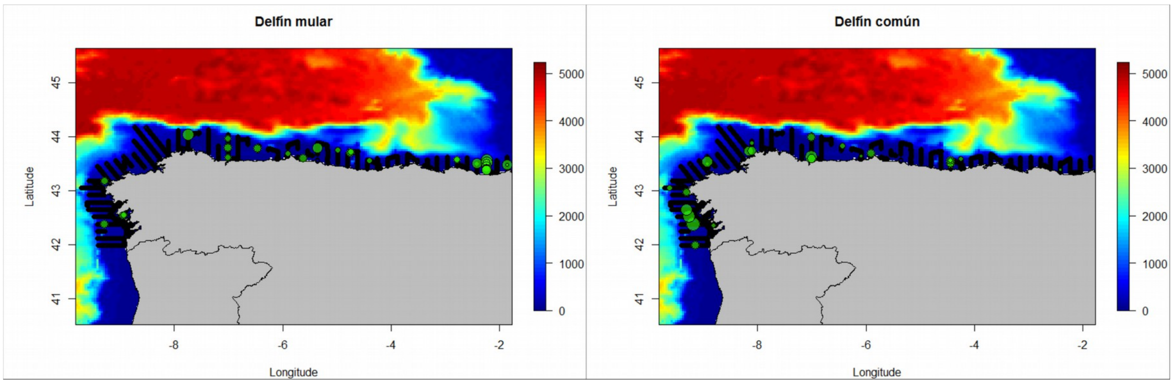


Figure 27. Observations of bottlenose dolphin(right panel) and common dolphin (left panel)during PELACUS 0314

Marine microplastic litter

Manta trawl hauls, as the rest of the methodology, was coordinated with PELGAS survey. In the Bay of Biscay most of the marine microplastic litter is concentrated at the inner part of the Bay of Biscay, as shown in figures 28 and 29.

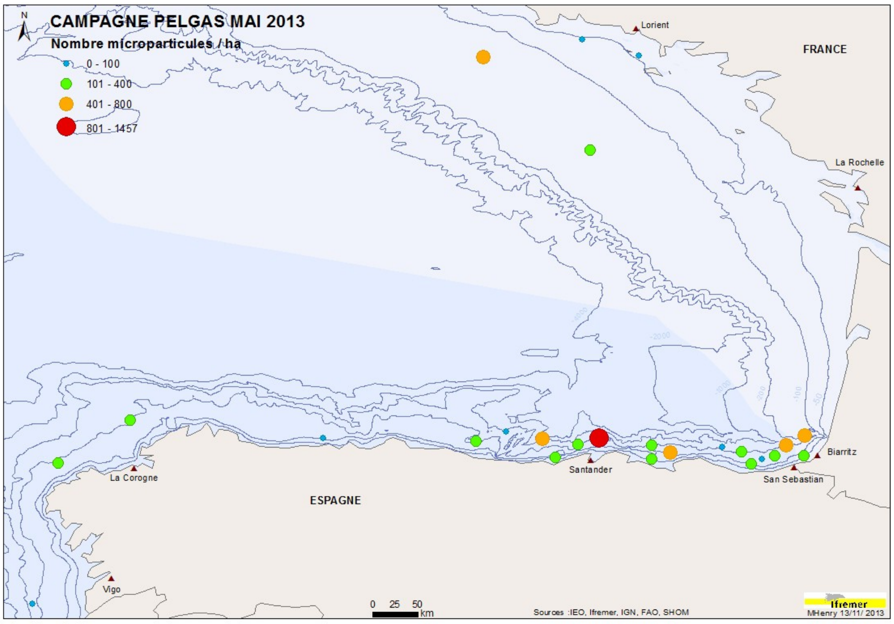


Figure 28. Total microplastic distribution (size < 5 mm) found during PELACUS and PELAGAS surveys

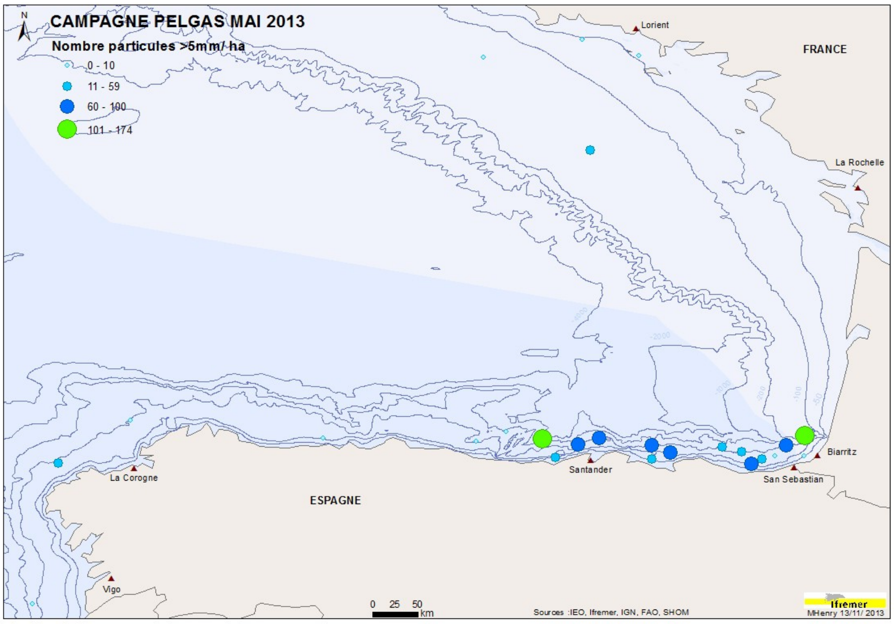


Figure 29. Microplastic distribution (size > 5 mm) found during PELACUS and PELAGAS surveys

CONCLUSIONS

PELACUS 0314 was characterised by relative stable weather conditions along the surveyed area. Besides, there was an important increase in backscattering energy as compared with the previous year. This resulted in an increase of the biomass estimated in the majority of the fish species, but still sardine is at lowest productivity ever recorded. Good recruitment would be observed in horse mackerel, but for the rest of the fish species, no strong signals for age group 1 have been detected.

The reasons for this increase would be related to the weather stability which could have increased the fish availability either for a change in the behaviour (i.e. spatial pattern distribution) or for an increase in the food availability. This is relevant accounting the increase of the occurrence of mackerel subsurface layers observed this year. As PELACUS is a multidisciplinary survey series (we collect environmental and biological ancillary information, stomach contents, including CTD cats, plankton tows or continuous records of plankton, eggs, S, T and flourometry), we will try to explain this change of behaviour. Our main hypothesis is that these species could follow mackerel when is undertaking vertical migration, probably related with the spawning activity, just for feeding eggs and, therefore, changing the expected schooling behaviour by the dispersed one, used during the feeding activity.

The challenges for the next years are to increase the number of school directly allocated accounting the relative frequency response and to investigate and also to update the list of TS/length relationship for the most important fish species.

ACKNOWLEDGEMENTS

We would like to thank all the participants and crew of the PELACUS surveys. We wish to thank and to send our warmest regard to our colleague and friend Pepe Zabala, now retired, for the extraordinary effort in providing all the diet analysis from the beginning up to 2013. We wish also to thank the captain and the crew of R/V Miguel Oliver for giving us all the solution we needed to overtake all the challenges dealing with this multidisciplinary survey. Also José Ignacio Díaz got us all the support from the IEO.

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Working Document to WGACEGG meeting 17-21 November 2014 at Vigo, Spain

Acoustic surveying of anchovy Juveniles in the Bay of Biscay:

JUVENA 2014 Survey Report

By

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1. Abstract

The project JUVENA aims at estimating the abundance of the anchovy juvenile population and their growth condition at the end of the summer in the Bay of Biscay. The long term objective of the project is to be able to assess the strength of the recruitment entering the fishery the next year. This year, the survey was coordinated between AZTI and IEO. AZTI leaded the assessment studies and IEO leaded the ecological studies. The survey took place in two research vessels: the Ramón Margalef and the Emma Bardán. The biomass of juveniles estimated for 2014 is 724,000 tonnes, which represents the highest biomass value of the temporal series. The area of occupation of the juvenile anchovy was also the largest in the series, but the mean size of the captured juveniles was small, less than 6 cm of mean size. This result foreseen a high recruitment value for the next year 2015. The JUVENA index will be used by ICES WGHANSA to update the CBBM assessment of anchovy in the Bay of Biscay by mid-December.

2. Materials and Methods

2.1 Data acquisition

The survey JUVENA 2014 took place between the 1st and 30th of September onboard the chartered R/V Ramon Margalef and the R/V Emma Bardán, both equipped with scientific echosounders. The acoustic equipment included three split beam echo sounders Simrad EK60 (Kongsberg Simrad AS, Kongsberg, Norway; Table 1) calibrated using Standard procedures (Foote *et al.* 1987). In the Ramon Margalef, the 38 kHz, 120 kHz and 200Khz transducers were installed looking vertically downwards, 3 m deep, at the end of a tube attached to the side of the boat, where as at the R/V Emma Bardan the same transducers were installed at the hull. For acoustic data processing the IFREMER Movies+ software was used.

The water column was sampled to depths of 200 m. Acoustic back-scattered energy by surface unit (S_A, MacLennan *et al.* 2002) was recorded for each geo-referenced ESDU (Echointegration Sampling Distance Unit) of 0.1 nautical mile (185.2 m). Fish identity and population size structure was obtained from fishing hauls and echotrace characteristic using a pelagic trawl (Table 1). Acoustic data, thresholded to -60 dB, was processed using Movies+ software (Ifremer) for biomass estimation and the processed data was represented in maps using ArcGIS. Hydrographic recording was made with CTD casts.

Sampling strategy

The sampling area covered the waters of the Bay of Biscay (being 8º40’ W and 47º30’ N the limits, Figure 1). Sampling was started from the Southern part of the sampling area, the Cantabrian Sea, moving gradually to the North to cover the waters in front of the French Coast. The acoustic sampling was performed during the daytime, when the juveniles are supposed to aggregate in schools (Uriarte 2002 FAIR CT 97-3374) and can be distinguished from plankton structures.

The vessels followed parallel transects, spaced 15 n.mi., perpendicular to the coast along the sampling area, taking into account the expected spatial distribution of anchovy juveniles for these dates, that is, crossing the continental shelf in their way to the coast from offshore waters (Uriarte et al. 2001).

During the summer, information from the commercial live bait tuna fishery was collected (Table 7), in order to have knowledge about the spatial distribution and relative abundance of anchovy previous to the beginning of the survey.

Data analysis

Biological processing

Each fishing haul was classified to species and a random sample of each species was measured to produce size frequencies of the communities under study. A complete biological sampling of the anchovy juveniles collected is performed in order to analyze biological parameters of the anchovy juvenile population, as the age, size or size-weight ratio. Using these and other environmental parameters we will try to obtain, in a long term, indexes of the state of condition of the juvenile population, in order to be able to improve the prediction of the strength of the recruitment.

Acoustic data processing

Acoustic data processing was performed by layer echo-integration by 0.1 nautical mile (s_A) of the first 65 m of the water column with Movies+ software, after noise filtering and bottom correction, increasing or decreasing this range when the vertical distribution of juveniles made it necessary.

The hauls were grouped by strata of homogeneous species and size composition. Inside each of these homogeneous strata, the echo-integrated acoustic energy s_A was assigned to species according to the composition of the hauls. Afterwards, the energy corresponding to each specie-size was converted to biomass using their corresponding conversion factor.

Each fish species has a different acoustic response, defined by its scattering cross section that measures the amount of the acoustic energy incident to the target that is scattered backwards. This scattering cross section depends upon specie *i* and the size of the target *j*, according to:

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

Here, L_j represents the size class, and the constants a_i and b_i are determined empirically for each species. For anchovy, we have used the following TS to length relationship:

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

The composition by size and species of each homogeneous stratum is obtained by averaging the composition of the individual hauls contained in the stratum, being the contribution of each haul weighted to the acoustic energy found in its vicinity (2 nm of diameter). Thus, given a homogeneous stratum with M hauls, if E_k is the mean acoustic energy in the vicinity of the haul *k*, w_i, the proportion of species *i* in the total capture of the stratum, is calculated as follows:

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

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

In order to distinguish their own contribution, anchovy juveniles and adults were separated and treated as different species. Thus, the proportion of anchovy in the hauls of each stratum (w_{ij})

was multiplied by a age-length key to separate the proportion of adults and juveniles. Then, separated w_i were obtained for each.

Inside each homogeneous stratum, we calculated a mean scattering cross section for each species, by means of the size distribution of such specie obtained in the hauls of the stratum:

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

Let s_A be the calibration-corrected, echo-integrated energy by ESDU (0.1 nautical mile). The mean energy in each homogeneous stratum, $E_m = < s_A >$, is divided in terms of the size-species composition of the haul of the stratum. Thus, the energy for each species, E_i, is calculated as:

$$E_i = \frac{w_i \langle \sigma_i \rangle E_m}{\left(\sum_i w_i \langle \sigma_i \rangle \right)}$$

Here, the term inside the parenthesis sums over all the species in the stratum. Finally, the number of individuals F_i of each species is calculated as:

$$F_i = H \cdot l \frac{E_i}{\langle \sigma_i \rangle}$$

Where l is the length of the transect or semi-transect under the influence of the stratum and H is the distance between transect (about 15 n.mi.). To convert the number of juveniles to biomass, the size-length ratio obtained in each stratum is applied to obtain the average weight of the juveniles in the stratum:

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

Thus, the biomass is obtained by multiplying F_i times $< W_i >$.

3. Results

Checking and calibrations

Calibration was performed in Vigo during the first days of the survey following the sphere method (Foote et al. 1987). The inter-ship calibration between EB and RM was performed along a 20 nautical miles transect over a pure juvenile distribution just after the sunset. The intercalibration analysis of the data registered by EB and RM didn't show any collection bias. Therefore, the recorded acoustic data was not corrected.

Sampling coverage

The survey JUVENA 2014 took place between the 1st and 30th of September (see Table 2). The survey sampled 3,000 n.mi. that provided a coverage of about 50,000 n.mi.2 along the continental shelf and shelf break of the Bay of Biscay, from the 8º40' W in the Cantabrian area up to 47º 30' N at the French coast (Figure 1). Seventy nine hauls were done during the survey to identify the species detected by the acoustic equipment, 59 of which were positive of anchovy (Figure 2, Tables 3, 4, 5 and 6).

The survey was covered by both vessels in coordination, in the Spanish region both vessels followed alternate transects, while in the French part they concentrated the sampling effort of each vessel in the most appropriate areas according to their efficiency: this is, oceanic and slope waters for the RM and continental shelf for the smaller pelagic trawler EB (Figure 1).

Spatial Distribution

This year, as usual, we have found anchovy distributed along two different strata: a pure juvenile anchovy stratum, located at the outer part of the continental shelf and slope waters, and a mixed juvenile-adult stratum located at the inner part of the continental shelf and coastal waters (Figure 4):

- **Pure juvenile 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), 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, Cantabric and French.
    - **Cantabric sub-stratum**: in this area, anchovy juveniles were extended along a strip around the shelf break edge, from 8º40' W to 1º30' W (Figure 4). Mean size was less than 6 cm in this area (Figure 3). The vertical distribution of juvenile anchovy extended from 5 to 150 m depth, deeper than usual.
    - **French sub-stratum**: this area was extended in front of the Southern French Coast (to the South of 45ºN), from coastal areas to the slope waters. Sizes in this area varied between 5 and 8 cm (Figure 3). The superficial aggregations of anchovy were composed by a majority of juvenile anchovy, mixed with small quantities of horse mackerel and jellyfish.

- **Mixed stratum**: Anchovy size in this stratum was bigger, between 11 and 15 cm (Figure 3), a mix of adult and juvenile (Figure 4), and was detected in schools close to the bottom, mixed also with superior proportions of other species, mainly small sardine in the most coastal area, and horse mackerel and blue whiting on the mid continental shelf (Figure 2).
- **Garonne:** Around the plume of the Gironde river, a positive area was found extending from the coast to about 100 m isobath. Here, anchovy included both adults and juveniles, and was found mixed with sardine, mackerel and horse mackerel plus other species (Figure 2), distributing along the whole water column. The sizes ranged from 9 to 13 cm (Figure 3).

Juvenile anchovy biomass estimations

The biomass of juveniles estimated for this year 2014 is 724,000 tones (Table 7). This value, is the maximum biomass of the JUVENA series, almost four times higher than the average (Figure 5). The area of distribution of juvenile anchovy this year was also the highest in the temporal series, see Figure 6, Table 8). The mean size of anchovy was small, less than 6 cm long (Figure 3). Almost the 90% of this biomass was located off-the-shelf or in the outer part of the shelf (Figure 4, Table 7) in the first layers water of the water column, although this year the vertical distribution was deeper than usual for this specie (5-150 m).

The biomass estimated foreseens a high recruitment of anchovy for next year (Figure 7). The index of juvenile anchovy provided by JUVENA will be used in December 2014 to update the assessment of anchovy in the Bay of Biscay based on the CBBM (ICES, 2014).

Predators observation in JUVENA 2014
by Maite Louzao, José Antonio Vázquez, Iñigo Krug and Iñaki Oyarzabal

As a part of the ecological activities conducted during the JUVENA survey, we assessed the spatial distribution of marine top predators in the Bay of Biscay, considering interactions within the community as well as with human activities. For that, we investigated the distribution and abundance of seabirds and marine mammals collecting information on the species present, number and behaviour of individuals sighted during at-sea observations.

Apart from recording information on seabirds and cetaceans, we also recorded other marine organisms such as tuna, ocean sunfish (Mola mola) or jellyfish, among others. Likewise, we also record and typify human activities such as fishing (the presence of fishing boats and their activity, fishing buoys, etc.), commercial vessels and various types of wastes and debris, in addition to registering the presence of oceanographic features such as fronts or slicks.

We followed the same methodology implemented in the PELACUS and PELGAS multidisciplinary surveys based on the distance sampling methodology. We performed observations during daylight acoustic sampling, as well as during certain between-transect navigation while vessel speed and course were constant.

Two observers were placed over the bridge of R/V Ramón Margalef, 10 meters high from the sea surface (Figure 8). Observers scanned the water to the front of the boat covering an area of 90º from the trackline to port or starboard, respectively continuously while the vessel was sailing at constant heading and speed during daytime. The temporal observations resolution was one minute. Observers recorded the environmental conditions that could affect sightings (i.e. wind speed and direction, sea state, swell height, glare intensity, visibility, etc. and they estimated the distance to the sightings and the angle of the sightings with respect to the trackline. Additional data collected from each sighting included: species, group size, movement direction, behaviour, presence of calves and/or juveniles, etc. All sightings were made with the naked eye while the identifications were supported with 10X42 binoculars.

A total of 140 observations periods (legs) were performed, travelling a total of 2427.13 km during 144.55 hours of observation. We observed an average of 5.56 hours per day (range: 0.93 - 9.25) and travelled an average of 99.32 km per day (range: 0.40 - 164.4). We recorded a total of 3844 seabirds (Figure 11), 1857 cetaceans (Figure 10), 981 of human activities and 239 of land birds. A complete list is given in Table 3.

During JUVENA 2014, we have tried to increase predator data collection implementing different new approaches which are at an experimental phase. In one hand, we have experimentally used a towed hydrophone to collect marine predator acoustic information, which is only focused on marine mammals (see Figure 11), thanks to the contribution of José Antonio Vázquez. This is an ongoing experimental project since JUVENA is not a marine mammal dedicated survey and we need to adapt to the acoustic sampling scheme already in place. The preliminary results have been highly positive since the number of acoustic detections of dolphins has been higher than visual detections when both approaches were running at the same time. Given the most abundant marine mammal species in the study area, we need to identify a highly sensitive hydrophone to collect acoustic information at very low frequency (2-20Hz) for fin whale detection. In addition, we also need to find an automatic algorithm for the discrimination of the main three species of dolphins (common, stripped and bottlenose dolphins). These are the main preliminary conclusions of this experiment.

Conclusions

- Good survey spatial coverage
- Good general performance of the equipment and different acoustic configurations for different tasks-scenarios.
- The survey maintains or even increases its recently acquired ecological scope
- The positive area of anchovy this year was the largest in the temporal series.
- The biomass estimate of this year (724,000 tones) is the maximum of the JUVENA series, about 20% higher than the previous maximum and almost 4 times higher than the average biomass of the temporal series.
- Since this year 2014, the JUVENA index is used as an input in the new CBBM so the typical log-log correlations between juvenile and recruitment indices are no longer valid.
- Nevertheless, the high juvenile abundance value foresees a high recruitment level for next year.
- At the end of the WGACEGG meeting this year, the WGHANSA will update the anchovy assessment using the JUVENA index and will report it to the commission.

4. Acknowledgements

This project is co-funded by the “Dirección de Innovación y Desarrollo Tecnológico, Viceconsejería de Política e Industria Alimentaria, Dpto.Agricultura, Pesca y Alimentación”, of the Basque Government and the “Secretaría General del Mar, Ministerio de Agricultura, Alimentacion y Medio Ambiente” of the Spanish Government, seeking for improving the scientific advice for management of this population. We acknowledge both for their support.

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6. Figures

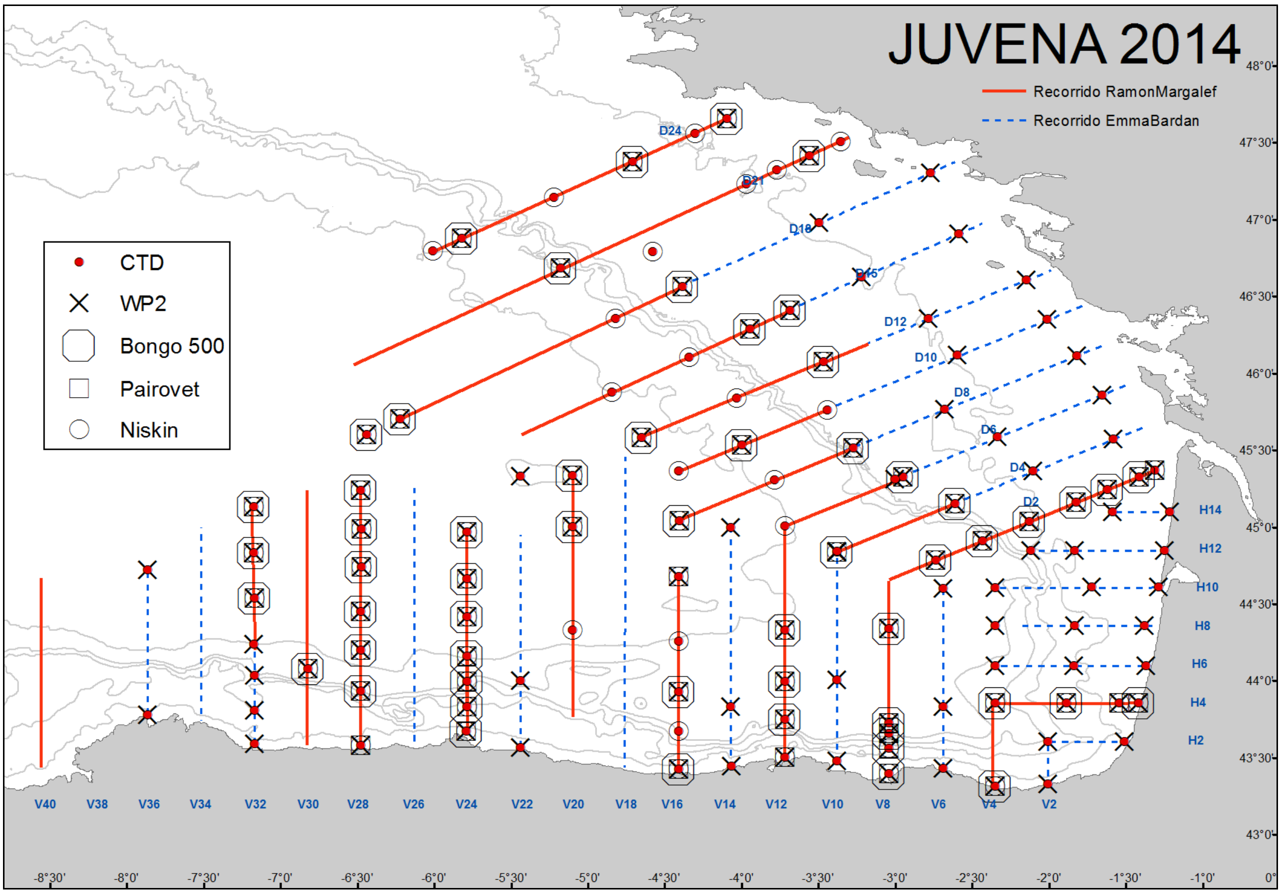


Figure 1. Visited transects (red solid line for the EB and dashed line for the RM) and stations of hydrography / plankton by the R/V Ramon Margalef and R/V Enma Bardán.

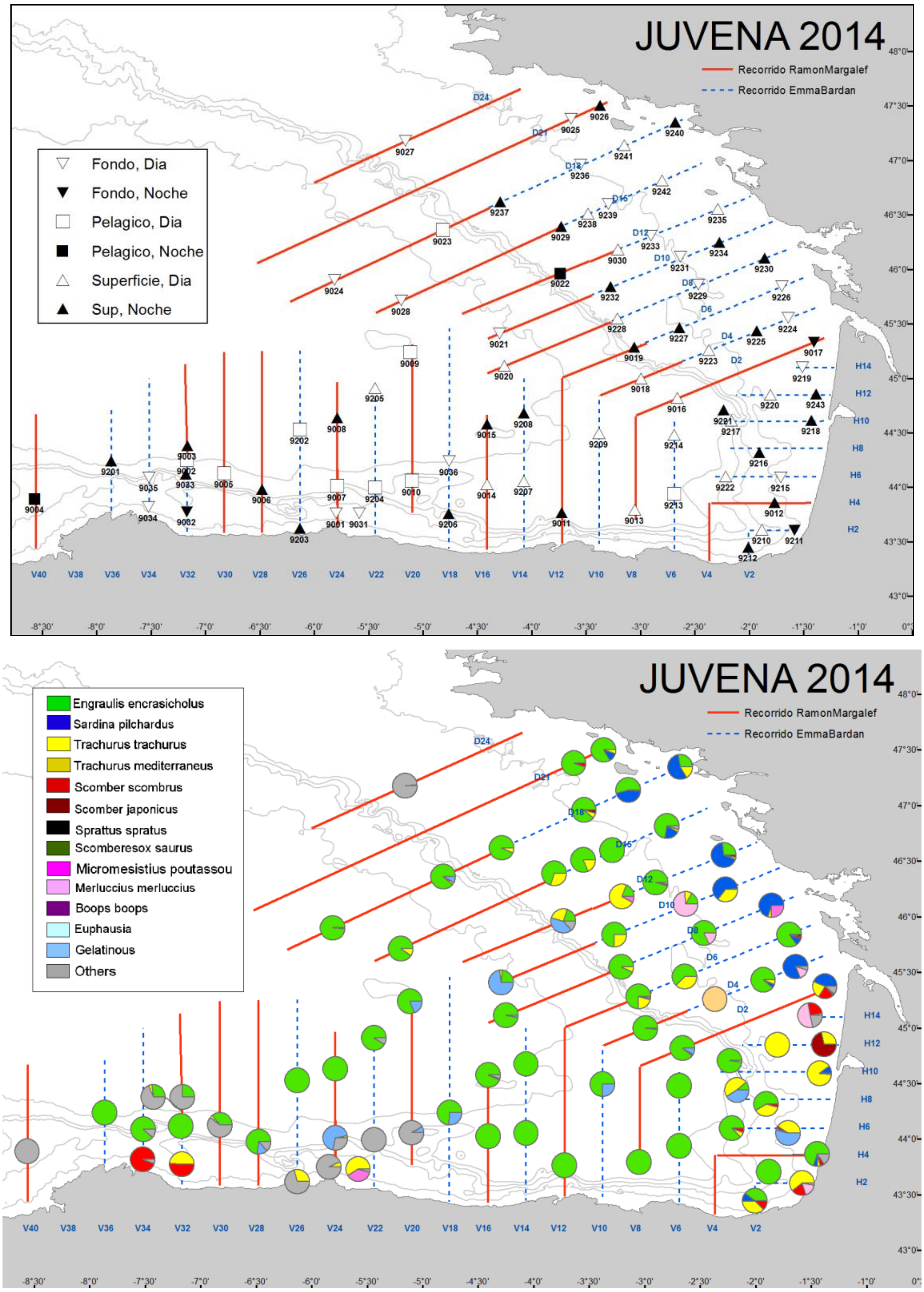


Figure 2. Top panel: position of the fishing stations. Hauls performed by RM are numbered from 9001 to 9031 and the transects are marked with dashed lines; hauls performed in the EB are numbered from 9201 to 9235 and the transects are marked with solid lines. Bottom panel: Species composition of the hauls.

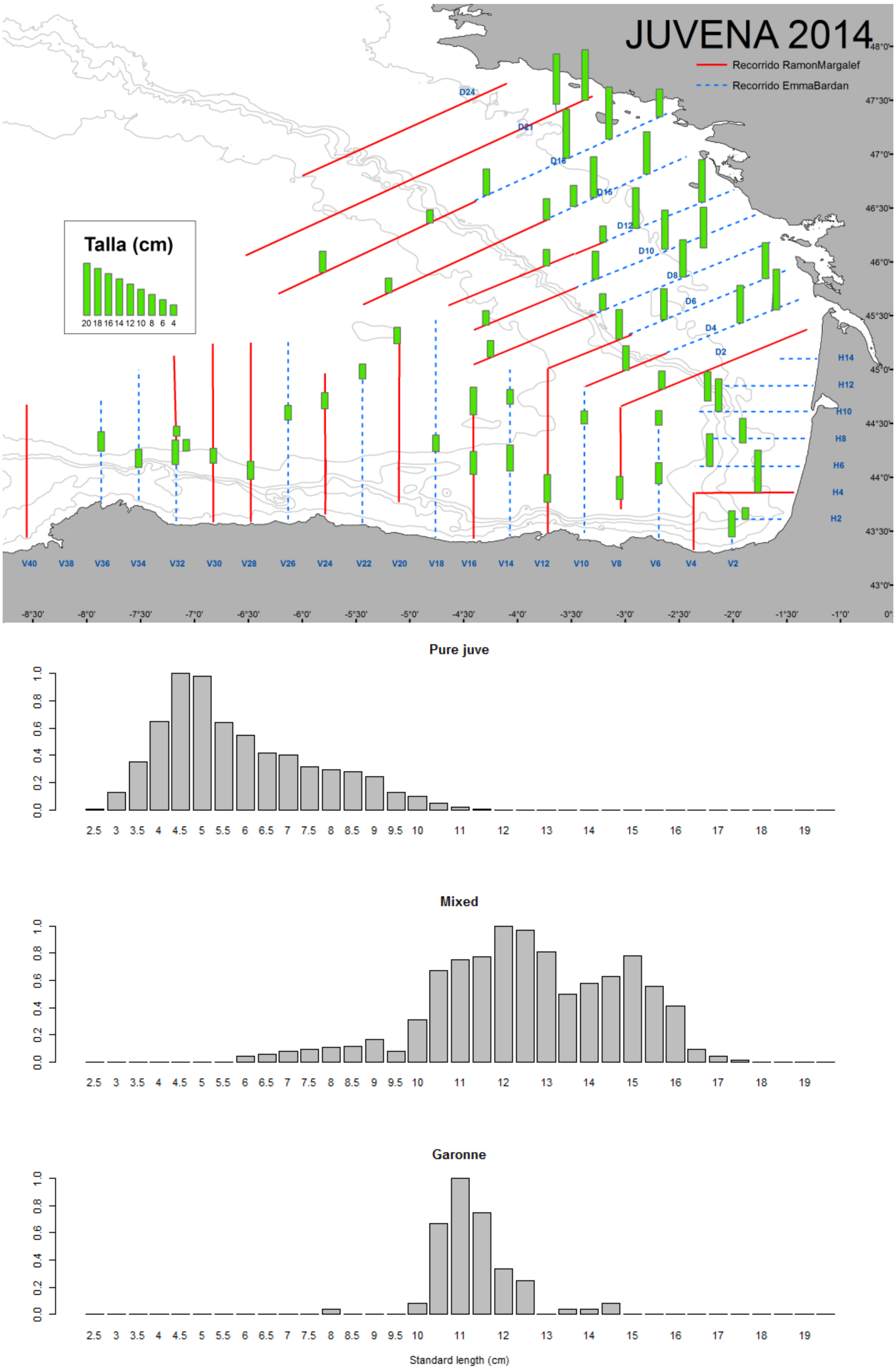


Figure 3: Top panel: Size of anchovy in the positive anchovy hauls. The length of the bars is proportional to the mode of the size (Standard length) of the captured anchovy. Bottom panel: Anchovy size distribution in the different areas distinguished.

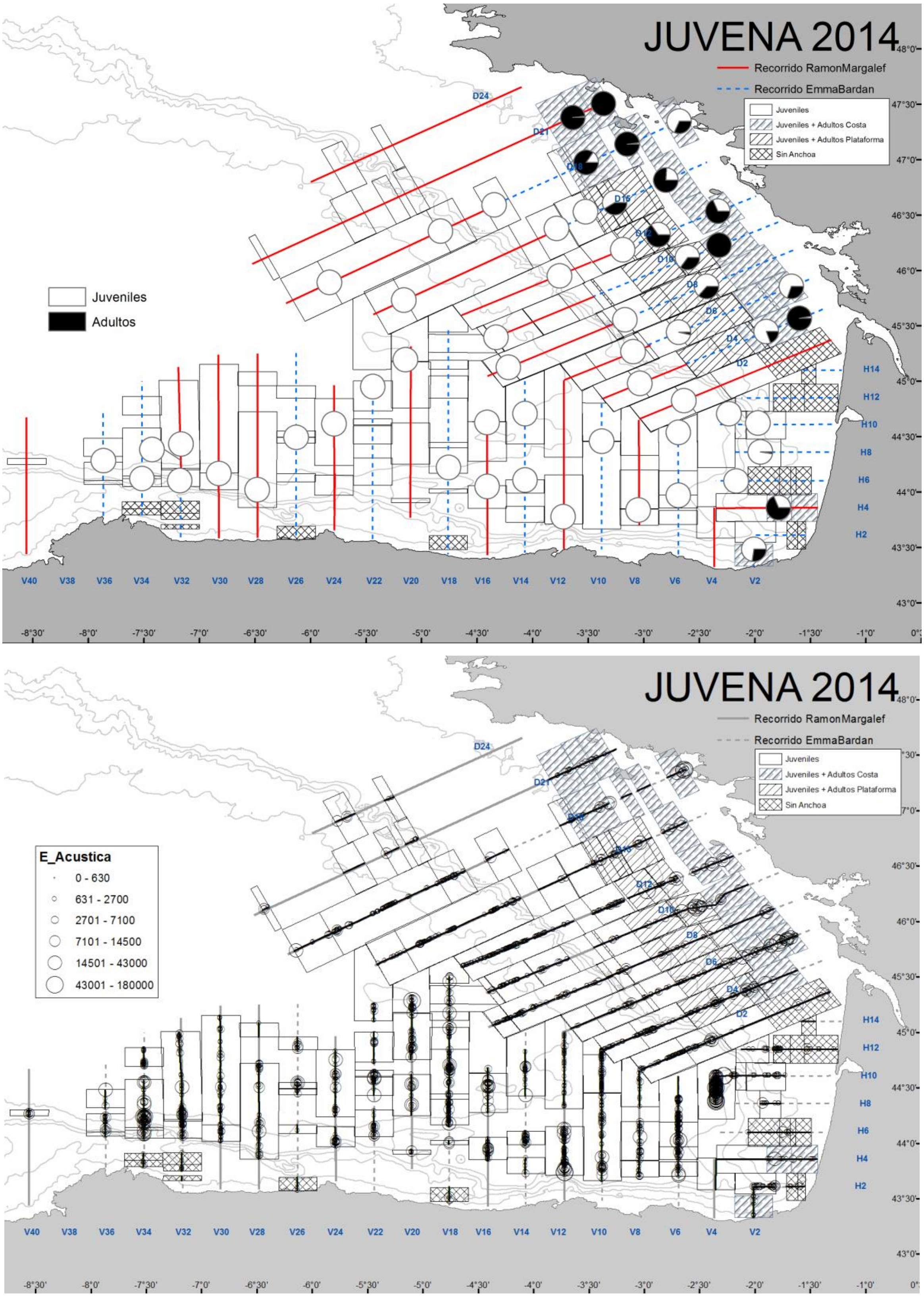


Figure 4: Top: positive area of distribution of anchovy. The pie charts show the percentage of juveniles (white) and adults (black) in the fishing hauls. Bottom: total acoustic energy (NASC) of all the identified species and the three subareas of the positive area of anchovy.

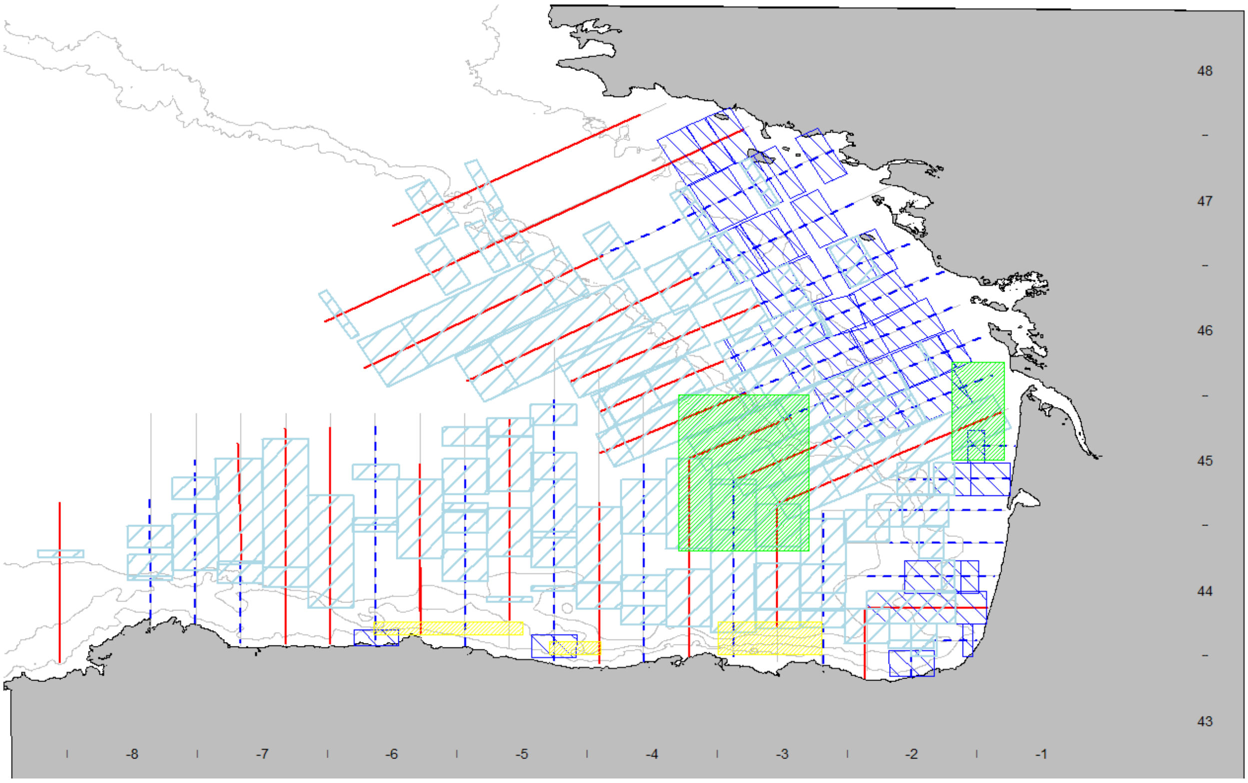


Figure 5. Approximated regions of presence of anchovy in the Bay of Biscay according to the reports of the live bait tuna fishery one week before the start of the survey.

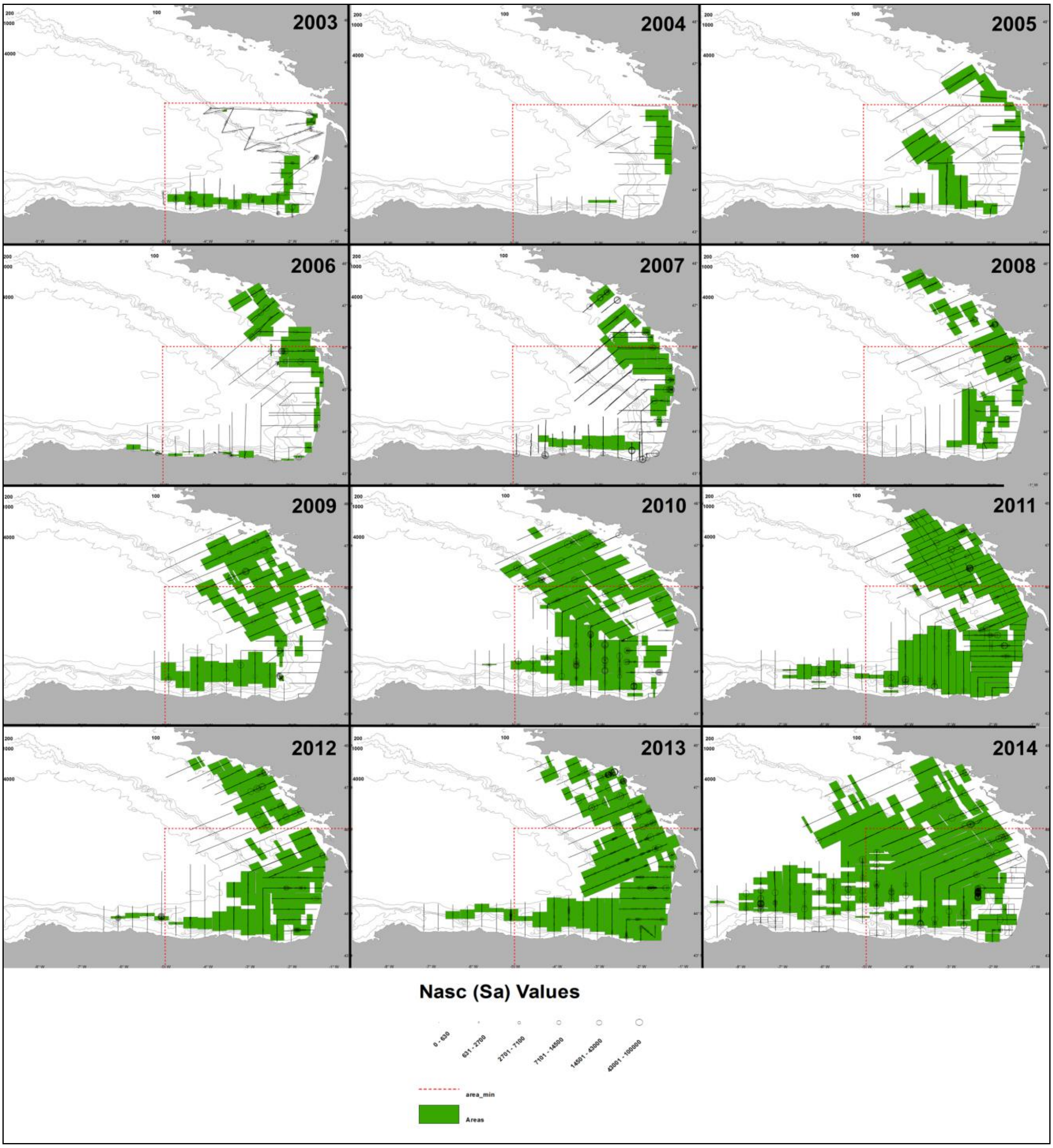


Figure 6: Positive area of presence of anchovy and total acoustic energy echo-integrated (from all the species) for the eight years of surveys. The area delimited by the dashed line is the minimum or standard area used for inter annual comparison.

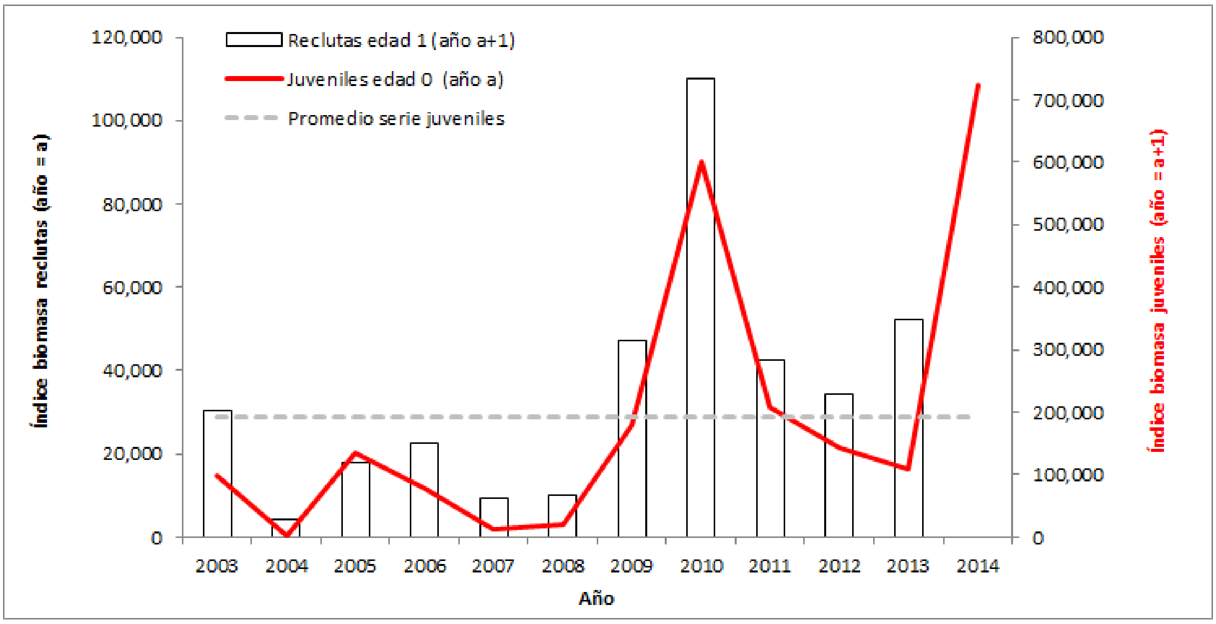


Figure 7: Temporal series of the estimated abundances of anchovy juveniles (blue) against the CBBM synthetic estimated abundances of age 1 anchovy next spring (red), based on PELGAS and BIOMAN surveys plus the catches.

Figure 8. Observation platform onboard R/V Ramón Margalef showing observer activities when they measure the distance and angle to an object or animal.

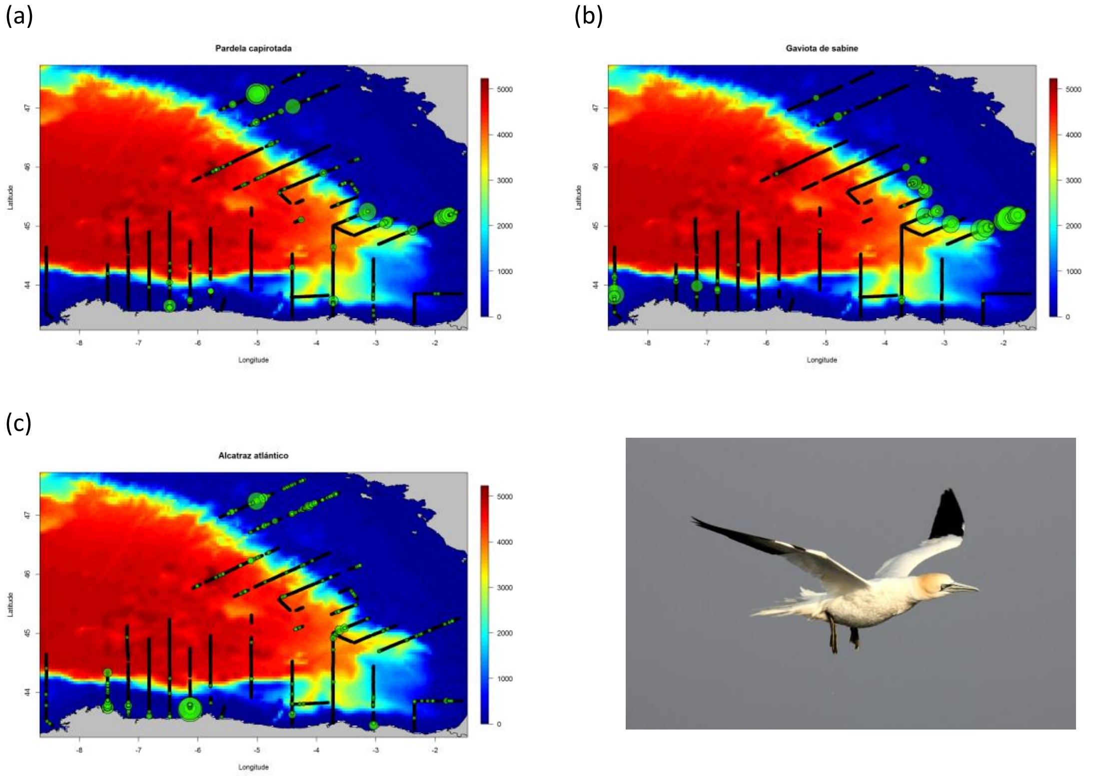
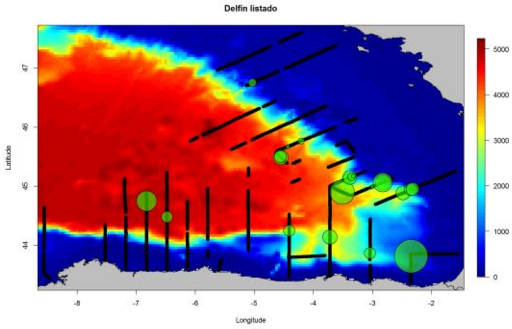
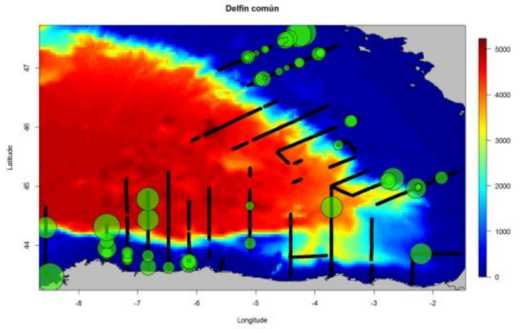


Figure 9. Distribution of the most abundant seabird species during JUVENA 2014, (a) great shearwater *Puffinus gravis*, (b) Sabine's gull *Xema sabini* and (c,d) northern gannet *Morus bassanus* . Black points represent the effort while the size of the green circles is proportional to observed abundances.

(a)



(b)



(c)

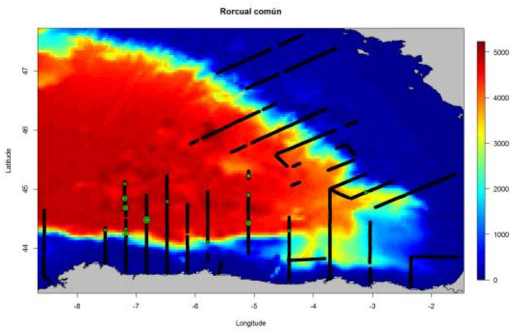


Figure 10. Distribution of the most abundant marine mammal species during JUVENA 2014, (a) striped dolphin *Stenella coeruleoalba* (b) common dolphin *Delphinus delphis,* (c,d) fin whale *Balaenoptera physalus*. Black points represent the effort while the size of the green circles is proportional to observed abundances.

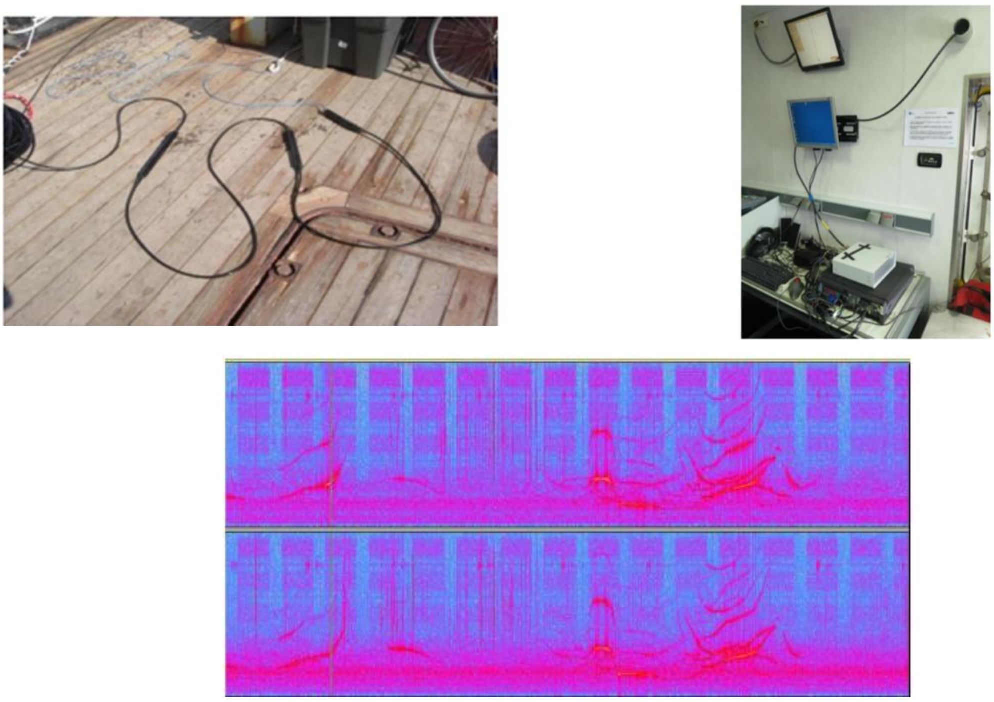


Figure 11. Illustration of the towed hydrophone used in JUVENA 2014, as well as the equipment for recording and processing the acoustic information. See below a figure of dolphin whistles detected during JUVENA 2014. Experimental study performed by José Antonio Vázquez.

7. Tables

Table 1:
Dimensions of the two vessels and installed equipment onboard

	R/V Ramón Margalef	R/VEmma Bardán
Echosounder	Simrad EK60, 38, 70, 120, 200 y 333 kHz	Simrad EK60, 38, 120 y 200 kHz
Multibeam Echosounder	Simrad ME70	No
Fishing gear	pelágico (15 m abertura vertical) puertas Polyice Apollo malla: 8 mm de lado	pelágico (15 m abertura vertical) puertas Polyice Apollo malla: 4 mm de lado
Fishing gear Echosounder	Simrad FE70	Scanmar Trawl Eye
Gear geometry	Depth sensor Scanmar	Simrad ITI: depth/temp and door opening sensors
Hidrography	**CTD-Roseta** CTD SeaBird SBE25 with fluorimeter Turner Scufa, Roseta SeaBird SBE32 with 12 Niskin-type bottels (SBE) de 5l. **Red WP2**: Double ring net, 35 cm diameter each, 200 µm mesh size **Red Bongo:** Double ring net, 60 cm diameter each, 500 µm mesh size. Flux control by fluorometer GO. Real time depth monitoring by acoustic sensor (Scanmar). Salinity temperture and fluorescence recording during the trawl with CTD RBR XR-420. **Red Bongo-Mik**: Net combining 35 cm 333 µm Bongo, inside a square Mik-type net of 120 cm side, 1000 µm mesh size. Net monitoring same as withe the Bongo (above). **Termosalingraph-Fluorimeter:** Continuous sampler of superficila wáter for salinity, temperatura and fluoresncence.	**CTD SeaBird SBE25** with fluorimeter , oxímeter y pH-meter **Red WP2**: doublé ring net, of 35 cm diameter each, 200 µm mesh size

Table 2:
Schedule of the survey

Activity	**Harbour**	**Date**	**Observations**
Instalation RM y EB	Vigo	27 August	
Checkings RM y EB	Vigo	28-31 August	Test equipment. Calibration
Scale EB	A Coruña	1-2 September	Bad weather
Instalation RM	Gijón	31 August	
Start survey assessment		1 September	
Start survey		3 September	
Scale RM	Pasaia	9-10 September	
Scale EB	Pasaia	9-11 September	
Intercalibration EB-RM		12 September	
Scale EB	Pasaia	16-18 September	Bad weather
Scale EB	La Pallice	22 September	
Scale RM	Pasaia	23 September	
Start ecology RM		24 sept	
End survey EB		28 September	
End survey RM	Pasaia	30 September	

Table 3:
Relation of fishing catches performed by Ramon Margalef

ST.	DATE (yyyymmdd)	TIME	LAT (Minutes Hex.)	LONG (Minutes Hex.W)	ICES	LAT (Degrees)	LONG (Degrees)	ESTIMATED CATCH (kg)
9001	20140902	14:40	43º48'04	5º48'64	16 E4	43.8007	-5.8107	69.05
9002	20140903	8:55	44º17'20	7º10'24	17 E2	44.2867	-7.1707	1.84
9003	20140903	22:45	44º26'01	7º10'00	17 E2	44.4335	-7.1667	6.15
9004	20140904	20:00	43º53'46	8º33'88	16 E1	43.8910	-8.5647	5.00
9005	20140905	12:15	44º10'06	6º49'60	17 E3	44.1677	-6.8267	1.87
9006	20140906	23:30	44º01'31	6º28'88	16 E3	44.0218	-6.4813	3.60
9007	20140907	10:00	44º01'73	5º47'28	17 E4	44.0288	-5.7880	1.20
9008	20140907	22:39	44º36'99	5º47'33	18 E4	44.6165	-5.7888	27.30
9009	20140908	9:23	45º11'72	5º08'81	19 E4	45.1953	-5.1468	11.75
9010	20140909	0:15	44º04'88	5º06'11	17 E4	44.0813	-5.1018	2.95
9011	20140909	22:07	43º46'65	3º43'59	16 E6	43.7775	-3.7265	55.10
9012	20140911	23:24	43º51'57	1º47'28	16 E8	43.8595	-1.7880	33.05
9013	20140912	13:25	43º50'26	3º03'08	16 E6	43.8377	-3.0513	43.55
9014	20140913	15:26	44º03'00	4º24'63	17 E5	44.0500	-4.4105	117.95
9015	20140913	21:38	44º37'72	4º24'70	18 E5	44.6287	-4.4117	21.25
9016	20140914	10:04	44º49'51	2º38'40	18 E7	44.8252	-2.6400	50.50
9017	20140914	22:36	45º20'84	1º22'30	19 E8	45.3473	-1.3717	31.55
9018	20140915	10:25	44º58'84	3º02'19	19 E7	44.9807	-3.0365	181.95
9019	20140915	22:49	45º16'03	3º05'79	19 E8	45.2672	-3.0965	38.65
9020	20140916	9:15	45º07'55	4º13'16	19 E5	45.1258	-4.2193	34.35
9021	20140917	9:15	45º23'86	4º19'83	19 E5	45.3977	-4.3305	2.65
9022	20140917	23:13	45º57'11	3º45'59	20 E6	45.9518	-3.7598	8.60
9023	20140918	10:30	46º21'33	4º49'85	21 E5	46.3555	-4.8308	4.80
9024	20140918	17:44	45º53'50	5º49'86	20 E4	45.8917	-5.8310	21.35
9025	20140919	17:20	47º22'81	3º38'39	23 E6	47.3802	-3.6398	1844.50
9026	20140919	22:35	47º30'33	3º21'82	24 E6	47.5055	-3.3637	178.10
9027	20140920	16:35	47º10'53	5º09'90	23 E4	47.1755	-5.1650	39.85
9028	20140921	9:35	45º43'96	5º09'66	20 E4	45.7327	-5.1610	9.00
9029	20140921	22:23	46º22'75	3º45'00	21 E6	46.3792	-3.7500	61.65
9030	20140922	10:20	46º11'20	3º11'40	21 E6	46.1867	-3.1900	0.85
9031	20140926	16:59	43º44'73	5º36'38	16 E4	43.7455	-5.6063	16.80
9032	20140927	10:33	43º48'20	7º10'30	16 E2	43.8033	-7.1717	332.20
9033	20140927	22:58	44º06'20	7º10'66	16 E2	44.1033	-7.1777	77.75
9034	20140928	9:50	43º50'80	7º31'41	16 E2	43.8467	-7.5235	6.00
9035	20140928	14:32	44º07'30	7º31'13	16 E2	44.1217	-7.5188	22.80
9036	20140929	10:54	44º13'31	4º45'52	16 E5	44.2218	-4.7587	7.50

Table 4:
Relation of fishing catches performed by Emma Bardan

ST.	DATE (yyyymmdd)	TIME	LAT (Minutes Hex.)	LONG (Minutes Hex.W)	ICES	LAT (Degrees)	LONG (Degrees)	ESTIMATED CATCH (kg)
9201	20140903	22:56	44º17º03	7º51º99	17 E2	44.2838	-7.8665	4000
9202	20140905	13:05	44º29º93	6º08º04	18 E3	44.4943	-6.1298	4700
9203	20140905	22:35	43º35º29	6º07º62	16 E3	43.5882	-6.1270	55
9204	20140906	11:45	44º02º15	5º26º30	17 E4	44.0302	-5.4400	1200
9205	20140907	0:40	44º57º10	5º26º40	18 E4	44.9517	-5.4400	4000
9206	20140907	22:20	42º42º87	4º45º70	16 E5	43.7145	-4.7617	500
9207	20140908	12:34	44º06º52	4º04º20	17 E5	44.1087	-4.0700	3000
9208	20140908	22:54	44º42º50	4º04º20	18 E5	44.7083	-4.0700	4000
9209	20140909	10:26	44º27º50	3º22º90	18 E6	44.4597	-3.3798	3000
9210	20140911	16:25	43º36º61	1º49º60	16 E8	43.6108	-1.8155	1000
9211	20140911	20:00	43º26º60	1º32º40	16 E8	43.6100	-1.5400	76
9212	20140911	22:54	43º29º03	2º00º57	15 E7	43.4838	-2.0095	125
9213	20140912	11:45	43º57º75	2º41º50	16 E7	43.9715	-2.6900	1500
9214	20140912	18:45	44º31º45	2º41º39	17 E7	44.5392	-2.6900	1900
9215	20140913	11:53	44º06º06	1º39º63	17 E8	44.0843	-1.6605	114
9216	20140913	22:00	44º21º66	1º57º10	17 E8	44.3610	-1.9517	134
9217	20140914	14:55	44º36º65	2º06º60	18 E7	44.6108	-2.1100	1500
9218	20140914	21:43	44º36º53	1º21º06	18 E7	44.6088	-1.3510	50
9219	20140915	8:55	45º06º00	1º28º20	19 E8	45.1000	-1.4700	55
9220	20140915	16:53	44º51'07	1º51'07	18 E8	44.8508	-1.8048	110
9221	20140915	21:50	44º42'37	2º12'39	18 E7	44.7071	-2.2341	1000
9222	20140919	0:15	44º06'00	2º10'45	17 E7	44.1000	-2.1692	1000
9223	20140919	9:40	45º16º62	2º19º50	19 E5	45.2770	-2.3250	114
9224	20140919	18:10	45º34º11	1º36º00	20 E8	45.5685	-1.6000	52
9225	20140919	22:05	45º26º95	1º53º90	20 E8	45.4492	-1.8983	75
9226	20140920	10:00	45º51º33	1º40º34	20 E8	45.8555	-1.6723	47
9227	20140920	21:30	45º26º56	2º41º21	19 E7	45.4427	-2.6868	126
9228	20140921	8:45	45º34º12	3º10º24	20 E6	45.5687	-3.1707	135
9229	20140921	14:52	45º52º20	2º26º15	20 E7	45.8700	-2.4358	105
9230	20140921	21:35	46º06º79	1º50º02	21 E8	46.1132	-1.8337	43
9231	20140923	15:25	46º07º06	2º36º44	21 E7	46.1177	-2.6073	106
9232	20140923	21:45	45º49º00	3º19º90	20 E6	45.8167	-3.3317	135
9233	20140924	9:55	46º19º40	2º52º24	21 E7	46.3233	-2.8707	107
9234	20140924	21:15	46º13º66	2º19º40	21 E7	46.2277	-2.3233	50
9235	20140925	0:30	46º32º13	2º20º05	22 E7	46.5355	-2.3342	45
9236	20140925	14:20	46º58º50	3º31º16	23 E6	46.9750	-3.5193	112
9237	20140925	21:25	46º35º52	4º20º86	22 E5	46.5920	-4.3477	143
9238	20140926	9:50	46º31º87	3º26º20	22 E6	46.5312	-3.4367	124
9239	20140926	13:00	46º36º70	3º15º75	22 E6	46.6117	-3.2625	115
9240	20140926	22:20	47º21'68	2º39'23	23 E7	47.3476	-2.6822	25
9241	20140927	0:45	47º09'48	3º06'76	23 E6	47.1407	-3.1503	63
9242	20140927	4:10	46º47'81	2º50'74	22 E7	46.8154	-2.8014	68
9243	20140927	21:10	44º51º02	1º19º07	18 E8	44.8503	-1.3178	38

Table 5:
Species composition of the fishing performed by Ramon Margalef**.**

STATION	BOARDING WEIGHT (kg)	BOARDING WEIGHT/ SPECIES (kg)	*SPECIES*	Fao
9001	69.1	5.19	Trachurus trachurus	HOM
		58.92	Capros aper	BOC
		4.95	Others	
9002	1.8	0.49	Engraulis encrasicholus	ANE
		0.09	Trachurus trachurus	HOM
		1.27	Capros aper	BOC
9003	6.2	1.59	Engraulis encrasicholus	ANE
		1.14	Myctophidae	LXX
		3.01	Euphasiacea	KRX
		0.41	Others	
9004	5.0	5.00	Myctophidae	LXX
9005	1.9	0.67	Engraulis encrasicholus	ANE
		0.06	Trachurus trachurus	HOM
		0.03	sarda sarda	BON
		0.03	Capros aper	BOC
		1.06	Others	
9006	3.6	2.61	Engraulis encrasicholus	ANE
		0.01	Trachurus trachurus	HOM
		0.33	Myctophidae	LXX
		0.01	Euphasiacea	KRX
		0.47	Thalia democratica	SPX
		0.04	Rhopilema spp	JEL
		0.12	Others	
9007	1.2	0.04	Trachurus trachurus	HOM
		0.34	Myctophidae	LXX
		0.82	Thalia democratica	SPX
9008	27.3	27.30	Engraulis encrasicholus	ANE
9009	11.8	9.48	Engraulis encrasicholus	ANE
		0.05	Trachurus trachurus	HOM
		2.22	Rhopilema spp	JEL
9010	3.0	2.71	Myctophidae	LXX
		0.24	Thalia democratica	SPX
9011	55.1	55.10	Engraulis encrasicholus	ANE
9012	33.1	23.05	Engraulis encrasicholus	ANE

STATION	BOARDING WEIGHT (kg)	BOARDING WEIGHT/ SPECIES (kg)	*SPECIES*	Fao
		2.00	Sardina pilchardus	PIL
		0.97	Trachurus trachurus	HOM
		1.83	Scomber scombrus	MAC
		0.13	Sprattus spratus	SPR
		4.13	sarda sarda	BON
		0.84	Loligo vulgaris	SQR
		0.09	Others	
9013	43.6	43.55	Engraulis encrasicholus	ANE
9014	118.0	117.95	Engraulis encrasicholus	ANE
9015	21.3	19.82	Engraulis encrasicholus	ANE
		0.29	Trachurus trachurus	HOM
		1.10	Myctophidae	LXX
		0.05	Thalia democratica	SPX
9016	50.5	45.28	Engraulis encrasicholus	ANE
		1.00	Trachurus trachurus	HOM
		4.21	Rhopilema spp	JEL
9017	31.6	13.75	Sardina pilchardus	PIL
		7.14	Trachurus trachurus	HOM
		6.45	Scomber scombrus	MAC
		0.34	Scomber Japonicus	MAS
		0.00	Mullus barbatus	MUT
		1.96	sarda sarda	BON
		1.44	Loligo vulgaris	SQR
		0.04	Solea solea	SOL
		0.22	Thalia democratica	SPX
		0.12	Rhopilema spp	JEL
		0.07	Others	
9018	182.0	178.56	Engraulis encrasicholus	ANE
		0.25	Trachurus trachurus	HOM
		3.15	Thalia democratica	SPX
9019	38.7	29.04	Engraulis encrasicholus	ANE
		8.15	Trachurus trachurus	HOM
		0.52	Loligo vulgaris	SQR
		0.59	Thalia democratica	SPX
		0.13	Rhopilema spp	JEL
		0.21	Others	
9020	34.4	33.15	Engraulis encrasicholus	ANE
		0.09	Trachurus trachurus	HOM
		0.01	Capros aper	BOC
		1.11	Rhopilema spp	JEL

STATION	BOARDING WEIGHT (kg)	BOARDING WEIGHT/ SPECIES (kg)	*SPECIES*	Fao
9021	2.7	0.62	Engraulis encrasicholus	ANE
		0.09	Trachurus trachurus	HOM
		0.00	Capros aper	BOC
		0.00	Myctophidae	LXX
		0.00	Euphasiacea	KRX
		0.02	Thalia democratica	SPX
		1.92	Rhopilema spp	JEL
9022	8.6	1.78	Engraulis encrasicholus	ANE
		2.22	Trachurus trachurus	HOM
		1.22	Loligo vulgaris	SQR
		3.39	Thalia democratica	SPX
9023	4.8	4.28	Engraulis encrasicholus	ANE
		0.15	Trachurus trachurus	HOM
		0.38	Thalia democratica	SPX
9024	21.4	20.89	Engraulis encrasicholus	ANE
		0.25	Myctophidae	LXX
		0.21	Thalia democratica	SPX
9025	1844.5	1738.30	Engraulis encrasicholus	ANE
		89.54	Scomber scombrus	MAC
		5.01	Sprattus spratus	SPR
		0.05	Loligo vulgaris	SQR
		6.56	Merluccius merluccius	HKE
		1.95	Thalia democratica	SPX
		3.11	Rhopilema spp	JEL
9026	178.1	146.89	Engraulis encrasicholus	ANE
		19.01	Sardina pilchardus	PIL
		8.50	Trachurus trachurus	HOM
		1.12	Scomber scombrus	MAC
		1.75	Scomber Japonicus	MAS
		0.52	Belone belone	GAR
		0.09	Loligo vulgaris	SQR
		0.09	Merluccius merluccius	HKE
		0.01	Thalia democratica	SPX
		0.13	Others	
9027	39.9	0.63	Trachurus trachurus	HOM
		38.20	Loligo vulgaris	SQR
		0.63	Capros aper	BOC
		0.38	Myctophidae	LXX

STATION	BOARDING WEIGHT (kg)	BOARDING WEIGHT/ SPECIES (kg)	*SPECIES*	Fao
9028	9.0	8.14	Engraulis encrasicholus	ANE
		0.86	Trachurus trachurus	HOM
9029	61.7	43.16	Engraulis encrasicholus	ANE
		18.50	Trachurus trachurus	HOM
9030	0.9	0.17	Engraulis encrasicholus	ANE
		0.68	Trachurus trachurus	HOM
9031	16.8	15.34	Trachurus trachurus	HOM
		0.07	Micromesistius poutassou	WHB
		0.40	Loligo vulgaris	SQR
		0.24	Merluccius merluccius	HKE
		0.24	Zeus faber	JOD
		0.30	Capros aper	BOC
		0.20	Others	
9032	332.2	157.69	Trachurus trachurus	HOM
		164.10	Scomber scombrus	MAC
		9.61	Micromesistius poutassou	WHB
		0.80	Others	
9033	77.8	77.75	Engraulis encrasicholus	ANE
9034	6.0	5.65	Scomber scombrus	MAC
		0.35	Others	
9035	22.8	20.06	Engraulis encrasicholus	ANE
		2.74	Myctophidae	LXX
9036	7.5	5.50	Engraulis encrasicholus	ANE
		0.01	Trachurus trachurus	HOM
		0.00	Loligo vulgaris	SQR
		0.00	Capros aper	BOC
		1.18	Thalia democratica	SPX
		0.81	Rhopilema spp	JEL

Table 6:
Species composition of the fishing performed by Emma Bardan**.**

STATION	BOARDING WEIGHT (kg)	BOARDING WEIGHT/ SPECIES (kg)	*SPECIES*	Fao
9201	20.3	20.30	Engraulis encrasicholus	ANE
9202	20.8	20.75	Engraulis encrasicholus	ANE
9203	3.6	1.05	Trachurus trachurus	HOM
		2.50	Others	
9204	4.6	4.60	Myctophidae	LXX
9205	25.0	22.65	Engraulis encrasicholus	ANE
		2.30	Euphasiacea	KRX
9207	11.8	11.75	Engraulis encrasicholus	ANE
9208	11.5	11.50	Engraulis encrasicholus	ANE
9209	19.1	14.30	Engraulis encrasicholus	ANE
		4.80	Thalia democratica	SPX
9210	0.0	0.01	Engraulis encrasicholus	ANE
9211	10.7	0.05	Sardina pilchardus	PIL
		6.37	Trachurus trachurus	HOM
		2.09	Scomber scombrus	MAC
		0.30	sarda sarda	BON
		1.84	Merluccius merluccius	HKE
9212	10.8	4.25	Engraulis encrasicholus	ANE
		1.20	Sardina pilchardus	PIL
		4.00	Trachurus trachurus	HOM
		1.35	Scomber scombrus	MAC
9213	1500.0	1500.00	Engraulis encrasicholus	ANE
9214	17.9	17.85	Engraulis encrasicholus	ANE
9215	1500.0	0.49	Sardina pilchardus	PIL
		612.18	Trachurus trachurus	HOM
		42.33	Scomber scombrus	MAC
		1.63	sarda sarda	BON
		29.31	Merluccius merluccius	HKE
		814.07	Rhopilema spp	JEL
9216	129.1	75.78	Engraulis encrasicholus	ANE
		47.71	Trachurus trachurus	HOM

STATION	BOARDING WEIGHT (kg)	BOARDING WEIGHT/ SPECIES (kg)	*SPECIES*	Fao
		5.61	Scomber scombrus	MAC
9217	4.7	0.50	Engraulis encrasicholus	ANE
		2.25	Trachurus trachurus	HOM
		1.90	Rhopilema spp	JEL
9218	44.3	4.60	Sardina pilchardus	PIL
		39.20	Trachurus trachurus	HOM
		0.50	Scomber scombrus	MAC
9219	8.0	0.20	Trachurus trachurus	HOM
		2.05	Scomber scombrus	MAC
		0.40	sarda sarda	BON
		4.00	Merluccius merluccius	HKE
		1.35	Others	
9220	1.3	1.25	Trachurus trachurus	HOM
9221	800.0	786.44	Engraulis encrasicholus	ANE
		13.56	Trachurus trachurus	HOM
9222	20.3	17.75	Engraulis encrasicholus	ANE
		1.30	Trachurus trachurus	HOM
		1.20	Scomber scombrus	MAC
9223	1.1	1.10	Trachurus mediterraneus	HMM
9224	211.8	0.50	Engraulis encrasicholus	ANE
		170.00	Sardina pilchardus	PIL
		0.25	Trachurus trachurus	HOM
		1.00	Scomber scombrus	MAC
		30.00	Merluccius merluccius	HKE
		10.00	Others	
9225	80.0	71.00	Engraulis encrasicholus	ANE
		4.00	Sardina pilchardus	PIL
		5.00	Trachurus trachurus	HOM
9226	1250.0	1065.00	Engraulis encrasicholus	ANE
		110.00	Sardina pilchardus	PIL
		50.00	Scomber scombrus	MAC
		25.00	Sprattus spratus	SPR
9227	12.0	7.50	Engraulis encrasicholus	ANE
		4.50	Trachurus trachurus	HOM
9228	10.0	9.25	Engraulis encrasicholus	ANE

STATION	BOARDING WEIGHT (kg)	BOARDING WEIGHT/ SPECIES (kg)	*SPECIES*	Fao
		0.75	Trachurus trachurus	HOM
9229	277.0	225.00	Engraulis encrasicholus	ANE
		1.35	Trachurus trachurus	HOM
		0.70	Scomber scombrus	MAC
		50.00	Merluccius merluccius	HKE
9230	8.3	7.75	Sardina pilchardus	PIL
		0.55	Trachurus trachurus	HOM
		0.04	Scomber scombrus	MAC
9231	14.5	1.95	Engraulis encrasicholus	ANE
		1.15	Trachurus trachurus	HOM
		0.02	Scomber scombrus	MAC
		0.05	Sprattus spratus	SPR
		2.80	Micromesistius poutassou	WHB
		8.50	Merluccius merluccius	HKE
		0.03	Myctophidae	LXX
9232	50.0	37.25	Engraulis encrasicholus	ANE
		12.75	Trachurus trachurus	HOM
9233	2000.0	1900.00	Engraulis encrasicholus	ANE
		15.00	Trachurus trachurus	HOM
		35.00	Scomber Japonicus	MAS
		50.00	Merluccius merluccius	HKE
9234	2.9	0.05	Engraulis encrasicholus	ANE
		1.85	Sardina pilchardus	PIL
		1.04	Trachurus trachurus	HOM
9235	13.0	3.59	Engraulis encrasicholus	ANE
		8.70	Sardina pilchardus	PIL
		0.32	Trachurus trachurus	HOM
		0.36	Scomber Japonicus	MAS
9236	1800.0	1602.00	Engraulis encrasicholus	ANE
		128.00	Trachurus trachurus	HOM
		70.00	Scomber Japonicus	MAS
9237	22.0	20.50	Engraulis encrasicholus	ANE
		1.50	Trachurus trachurus	HOM
9238	4.6	3.75	Engraulis encrasicholus	ANE

STATION	BOARDING WEIGHT (kg)	BOARDING WEIGHT/ SPECIES (kg)	***SPECIES***	Fao
		0.85	Trachurus trachurus	HOM
9239	600.0	594.00	Engraulis encrasicholus	ANE
		2.50	Trachurus trachurus	HOM
		3.50	Scomber Japonicus	MAS
9240	100.0	27.81	Engraulis encrasicholus	ANE
		55.85	Sardina pilchardus	PIL
		16.34	Trachurus trachurus	HOM
9241	20.6	11.09	Engraulis encrasicholus	ANE
		9.21	Sardina pilchardus	PIL
		0.26	Scomber Japonicus	MAS
9242	6.7	4.82	Engraulis encrasicholus	ANE
		1.33	Sardina pilchardus	PIL
		0.25	Trachurus trachurus	HOM
		0.26	sarda sarda	BON
9243	31.5	8.97	Trachurus trachurus	HOM
		22.32	Scomber Japonicus	MAS
		0.25	Boops boops	BOG

Table 7:
Synthesis of the abundance estimation (acoustic index of biomass) for Juvena 2014 by main strata

	E acust (m2/ n.m.2)	Area + (n.m.2)	Mean size (cm)	Biomass (t)
Pure juveniles	151	28112	5.8	668,162
Mixed area	678	7405	10.0	40,752
Garonne	455	1652	11.0	15,031
Total		37169	5.9	723,946

Table 8:
Synthesis of the abundance estimation (acoustic index of biomass) for the eight years of surveys.

Year	Sampled area (mn2)	Area+ (mn2)	Size juveniles (cm)	Biomass juveniles (year y)	Biomass Recruits (year y+1)
2003	16,829	3,476	7.9	98,601	30,429
2004	12,736	1,907	10.6	2,406	4,086
2005	25,176	7,790	6.7	134,131	18,049
2006	27,125	7,063	8.1	78,298	22,545
2007	23,116	5,677	5.4	13,121	9,205
2008	23,325	6,895	7.5	20,879	10,216
2009	34,585	12,984	9.1	178,028	47,374
2010	40,500	21,110	8.3	599,990	110,008
2011	37,500	21,063	6	207,625	42,433
2012	31,724	14,271	6.4	142,083	34,198
2013	33,250	18,189	7.4	105,271	52,344
2014	50,102	37,169	5.9	723,946	

Table 9:

List of commercial vessels of the live bait fleet that reported detections of anchovy.

Vessel	Harbour
Izaskun berria	Getaria
Ansia	Pasaia
Itsas Lagunak	Hondarribia
Arrantzale	Hondarribia
Gure gogoa	Orio

Table 10

List of taxa observed during JUVENA 2014.

Group	Scientific name	Number	Percentage(%)
Marine mammal	Delphinus delphis	1099	59.181
Marine mammal	Stenella coeruleoalba	546	29.402
Marine mammal	Globicephala melas	34	1.831
Marine mammal	Balaenoptera physalus	25	1.346
Marine mammal	Delphinidae sp.	15	0.808
Marine mammal	Tursiops truncatus	14	0.754
Marine mammal	Balaenopteridae sp.	10	0.539
Marine mammal	Ziphius cavirostris	9	0.485
Marine mammal	Grampus griseus	4	0.215
Marine mammal	Ziphiidae sp.	4	0.215
Marine mammal	Stenella longirostris	3	0.162
Marine mammal	Balaenoptera acutorostrata	2	0.108
Marine mammal	Mesoplodon sp.	2	0.108
Marine mammal	Medium Cetacean	1	0.054
Marine mammal	Physeter macrocephalus	1	0.054
Seabird	Larus fuscus	860	22.373
Seabird	Larus sabini	625	16.259
Seabird	Morus bassanus	551	14.334
Seabird	Puffinus gravis	391	10.172
Seabird	Larus michahellis	195	5.073
Seabird	Hydrobates pelagicus	189	4.917
Seabird	Larus fuscus/Larus michahellis	165	4.292
Seabird	Larus sp	160	4.162
Seabird	Phalaropus fulicarius	149	3.876
Seabird	Puffinus griseus	105	2.732
Seabird	Sterna hirundo / paradisaea	93	2.419
Seabird	Calonectris diomedea	79	2.055
Seabird	Catharacta skua	53	1.379
Seabird	Sterna hirundo	42	1.093
Seabird	Stercorarius parasiticus	41	1.067
Seabird	Sterna paradisaea	29	0.754
Seabird	Phalacrocorax carbo	28	0.728
Seabird	Sterna sandvicensis	28	0.728
Seabird	Hydrobates / Oceanites / Oceanodroma / Fregetta / Nesofregetta	20	0.520
Seabird	Sterna spp	9	0.234
Seabird	Puffinus puffinus	7	0.182
Seabird	Procellaridae sp	5	0.130
Seabird	Puffinus mauretanicus	5	0.130
Seabird	Puffinus spp	4	0.104
Seabird	Stercorarius pomarinus	3	0.078
Seabird	Calonectris / puffinus gravis / P. griseus	2	0.052
Seabird	Puffinus yelkouan / puffinus / mauretanicus	2	0.052
Seabird	Oceanodroma leucorhoa	1	0.026
Seabird	Rissa tridactyla	1	0.026
Seabird	Larus sp	1	0.026
Seabird	Stercorarius spp	1	0.026
Coastal bird	Melanitta nigra	35	42.169
Coastal bird	Anser sp	32	38.554
Coastal bird	Anas spp / Aythya spp	14	16.867
Coastal bird	Gavia immer	1	1.205
Coastal bird	Tadorna tadorna	1	1.205

Terrestrial bird	Passeriformes	104	43.515
Terrestrial bird	Ardea cinerea	58	24.268
Terrestrial bird	Limicole spp	21	8.787
Terrestrial bird	Motacilla alba	9	3.766
Terrestrial bird	Motacilla flava	8	3.347
Terrestrial bird	Calidris alpina	6	2.510
Terrestrial bird	Erithacus rubecula	6	2.510
Terrestrial bird	Egretta garzetta	5	2.092
Terrestrial bird	Motacilla spp	5	2.092
Terrestrial bird	Charadrius hiaticula	2	0.837
Terrestrial bird	Falco tinnunculus	2	0.837
Terrestrial bird	Oenanthe oenanthe	2	0.837
Terrestrial bird	Falconiformes	2	0.837
Terrestrial bird	Actitis hypoleucos	1	0.418
Terrestrial bird	Anthus pratensis	1	0.418
Terrestrial bird	Anthus spp	1	0.418
Terrestrial bird	Phoenicurus ochruros	1	0.418
Terrestrial bird	Phylloscopus collybita	1	0.418
Terrestrial bird	Phylloscopus spp	1	0.418
Terrestrial bird	Phylloscopus trochilus	1	0.418
Terrestrial bird	Streptopelia spp	1	0.418
Terrestrial bird	Tringa totanus	1	0.418
Oceanographic feature	Tidal front	82	
Other marine wildlife	Ostéichiens	219	57.180
Other marine wildlife	Thunnus spp. / Sarda spp.	79	20.627
Other marine wildlife	Mola mola	52	13.577
Other marine wildlife	Thunnus alalunga	22	5.744
Other marine wildlife	Ostéichiens	6	1.567
Other marine wildlife	Cnidaria	2	0.522
Other marine wildlife	Ostéichiens	1	0.261
Other marine wildlife	Selachimorpha	1	0.261
Other marine wildlife	Xiphiidae / Istiophoridae	1	0.261
Human activity	Plastic debris	382	38.940
Human activity	Micro debris	341	34.760
Human activity	Macro debris	85	8.665
Human activity	Fishing boat	34	3.466
Human activity	Fishing debris	31	3.160
Human activity	Fishing buoy	22	2.243
Human activity	Wood trash	20	2.039
Human activity	Commercial vessel	13	1.325
Human activity	Pleasant boat	11	1.121
Human activity	Sailing boat	11	1.121
Human activity	Trawling boat	7	0.714
Human activity	Small boat	6	0.612
Human activity	Longline boat	5	0.510
Human activity	Ferry	3	0.306

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JUVESAR13 SURVEY REPORT

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1. Introduction

The JUVESAR13 acoustic survey was carried out from 5 to 15th November 2013 onboard the Portuguese research vessel "Noruega". The main objective of the survey was the estimation of the spatial distribution and abundance of sardine (*Sardina pilchardus*), mainly focusing on recruits (TL < 16.0 cm) along the Portuguese West coast (Caminha-Cabo Espichel; Fig.1). The northern West coast, with 78% of sardine recruits in average, is the main area for sardine recruitment in the Iberian Peninsula (Silva *et al.*, 2009).

JUVESAR13 was also aiming to characterize the oceanographic conditions and zooplankton from the continental shelf. The spatial distribution and abundance of other pelagic species were also estimated, namely Chub mackerel (*Scomber colias*), Atlantic horse mackerel (*Trachurus trachurus*) and European anchovy (*Engraulis encrasicolus*). A census of birds and mammals was made along the acoustic survey.

The survey was included in the CERTIFICA project (PROMAR), "Certificação MSC em Portugal: obtenção de conhecimento e estudos de viabilidade para candidaturas de pescarias costeiras e artesanais".

This report describes the methodology carried out in the survey and presents the results regarding the specific diversity in the fishing stations, the distribution, abundance and sardine age structure, as well as the distribution of birds and mammals along the Portuguese West coast. Sardine recruits abundance was also compared with the historical data from previous surveys, carried out in the same period of the year.

2. Material and Methods

Acoustic data collection and fishing

Continuous acquisition of acoustic data was done within 42 transects perpendicular to the bathymetry, reaching out from the nearest point on the coast (conditioned by the depth of the water and the sea conditions) and the usual outer limit distribution of juveniles according to data from previous surveys in the same period of the year (Fig.1). The minimum depth was ranging from 10 to 20 m and the maximum depth was close to 50 m. The gap among transects was 4 nautical miles (nm) in the area of higher probability of founding juveniles (from the South of Matosinhos to the South of Figueira da Foz) and 8 nm in the rest of the area. The transects were performed at velocities fluctuating among 8-9 nautical knots and the acoustic signal was integrated over 1 nm intervals. The eco-integration was done with a scientific echo-sounder Simrad 38 kHz EK500. The software MOVIES+ (Weill *et al.*, 1993) was used to register the acoustic data and to do the eco-integration. Overall, 17 fishing hauls (11 pelagic trawls and 6 bottom trawls) were done along the survey in order to distribute the acoustic energy by species, estimate the length structure and do the biological sampling.

Biological sampling

In each fishing station, five fishing boxes (nearly 110 kg) were sampled. In each sample, the individuals were identified to the species level, weighted and counted. In the cases where the sample was very big, a sub-sample of 100 individuals per species was kept; otherwise the whole sample was processed. The processing of the samples was different depending if the species were or not pelagic species. For the pelagic species, the sub-sample individuals were grouped in length classes (0.5 cm: sardine and anchovy; 1cm: horse mackerel, Atlantic mackerel, chub mackerel, bogue), registering the number of individuals and weighted for length class. For the rest species, the number of individuals per length class was registered.

For the major pelagic species (sardine, anchovy, horse mackerel, chub mackerel and Atlantic mackerel), the biological sampling comprising 40-50 individuals was regularly done. The selection of these 40-50 individuals was done by selecting randomly half of the individuals in each length class. When two length strata were detected, the late procedure was repeated for each stratum. For each individual the total length (mm), total weight (g), eviscerated weight (g), sex, maturation stage, fat, color and stomach filling was registered. For 20 individuals from the initial sample (*i.e.* half of the individuals composing the initial samples per length class were selected), the stomachs were kept and the otholits collected. Both stomachs and otholits were identified with the name of the survey, the name of the species and the number of the individual. The otholits were keep dry in eppendorfs, and stomachs were keep in plastic bags and frozen at -20ºC.

Depending on time availability, biological data for non pelagic species was also collected (total length (mm), total weight (g), eviscerated weight (g), sex, maturation stage, fat, color and stomach filling) and stomachs of 20 selected individuals proportionally to the length frequency distribution.

Oceanography and plankton

Hydrological samples (temperature, salinity and fluorescence) and plankton samples were collected along eight perpendicular transects between 15 and 200 m deep, uniformly spaced 20 nm along the entire coast (Figure1). In each transect five CTD + fluorometer (CTDF) and plankton stations at different bathymetries (15, 20, 50, 100 and 200 m) were performed. In each station a vertical profile in the water column with CTDF from the surface to 5 m of distance from the ground were performed. An oblique plankton trawl with a WP2 net (200 µm) from the surface to 5 m from the ground, or in the 100 and 200 m depth stations, up to 70 m depth. The registered CTD data were transferred to a computer using TERM19 software. Plankton samples were concentrated and preserved in plastic bottles with formaline at 4% in saline water buffered with borax. A fluxometer was used for registering and counting the volume of filtered water by the plankton net.

Birds and mammals monitoring

Monitoring program to record top marine predator sightings (seabirds and cetaceans) was carried out along the Portuguese coast. All seabirds' species observed in a range of 300 m from the vessel were registered. For standardization, the method used is the ESAS ("European Seabirds At Sea"), widely used in Europe, which is based on the species identification, numerical count of the present individuals, flying or alight, wind direction and behavior codes. The association of seabirds with cetaceans, fishing vessels or other factors such as litter or pollution is also registered. For the cetaceans, and adaptation of the Buckland and Turnock (1992) method was used. This method consists on the seeking of all the species in a range of 500 m radius from the vessel with the naked eye. The species is then identified, group size estimated, the distance and the angle of the initial position of sighting calculated for a posterior determination of the animal position regarding the vessel's route that would allow the development of distribution models in the Portuguese coast waters. These records allow also the calculation of the detection function and the subsequent abundance estimation.

Comparison of sardine recruits abundance with previous surveys estimates

Abundance estimates of sardine with age 0 (recruits in number of individuals) from autumn surveys since 1984 were used for this comparison. The JUVESAR13 survey was covering the area comprised from Viana do Castelo to Cabo Espichel. In order to obtain comparable data with previous surveys, the abundance estimates from the North West area (OCN) and South West area (OCS) were joined together. Of importance is the fact that OCS area extends from Nazaré to Cabo São Vicente, covering an area that was not sampled during the JUVESAR13 survey. However, the historical data show that is unusual the occurrence of recruits in the Vicentine coast (from Cape Sines to Cape São Vicente), then the estimates can be considered comparable. Previous surveys were covering bathymetries up to 200 m, whereas JUVESAR13 was covering bathymetries just until 50 m depth. Also in this case the estimates are comparable due to the fact that sardine recruits appear mostly until 50 m depth.

Results

The programmed survey activities were integrally accomplished. It is considered that the quality of the data is good.

Diversity and fish community composition

Overall, 39 different species, corresponding to 33 fish species, 3 mollusca (cephaopoda), 1 cnidaria and 2 crustacea were captured during the whole survey (Table 1).
The main pelagic species fished were the Horse mackerel, Atlantic mackerel, Sardine and Chub mackerel. The crustacea *Polybius henslowii* was relativly abundant in the fishing trawls.
Horse mackerel was the dominant species in all the area, north of Peniche. Sardine appears mainly in Aveiro/Figueira da Foz area and in Ericeira/Lisbon area, being most abundante in Cabo da Roca (Figure 2). Atlantic mackerel was predominant in Figueira da Foz while Chub mackerel was found mainly off Cascais.
The northern zone was the area where greater species diversity was found: fishing station AF1 with 23 species and AF2 and AP3 with 13 species each.

Sardine abundance, distribution and age structure

A total of 22.7 thousand tonnes of sardine, corresponding to 2055 million individuals), were estimated in the surveyed area (Table 2). Sardine occurs in patches, South of Porto, Aveiro, Figueira da Foz, Ericeira and Lisbon (Figure3). Half of the sardine biomass was concentrate off Ericeira and only 5% in the Lisboa area. The remaining biomass was equally distributed over the remaining areas.

The sardine length structure spans from 8.5 to 24.0 cm but the major part were recruits with lengths less than16 cm (Figure 4). The length and age histograms show a dominant mode at 10.5 cm and a secondary mode at 12 cm, both belonging to age 0 sardine group.
The total sardine recruits were estimated to be 2002 million individuals, corresponding to 19.4 thousand tonnes. This abundance is considered very low and one of the lowest values of the historical series (Figure 5).

Horse mackerel abundance, distribution and length structure

In the surveyed area a total of 43.8 thousand tonnes (598 million individuals) of horse mackerel was estimated (Figure 6). Horse mackerel was distributed along the coast, with a major concentration off Aveiro and Figueira da Foz. The length structure shows a major distribution mode at 19 cm and a secondary mode at 13 cm.

Census of mammals and marine birds

Along the acoustic transects 28 different bird species were observed (Figure 7), being the *Morus bassanus* the most registered species (1469 individuals). The other birds founded were the *Melanitta nigra* (440 individuals), the *Hydrobates pelagicus* (177 individuals), the *Stercorarius skua* (58 individuals) and the *Puffinus mauretanicus* (52 individuals).
The mammals observation was less than the marine birds, mainly due to the weather and sea state, that doesn't allow a proper census. Nevertheless it was possible to observe 45 common dolphins (*Delphinus delphis*) and 11 non identified other mammals.

Conclusions

Although the weather conditions were not good, the objectives of the survey were accomplished.
The most dominant species were, by order of abundance, the Horse mackerel, the Atlantic mackerel, Sardine and Chub mackerel.
Horse mackerel prevailed over the northern part area, being mainly constituted by young individuals.
Sardine was not abundant, being constituted mainly by recruits. This is a major issue since this abundance is one of the lowest of the historical series.

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Table 1 - JUVESAR13 trawl species composition. The table shows the average percentage of each species per fishing trawl, in number and weight.

TAXON	FAO CODE	SPECIES	Common name	% average (number)	% average (kg)
Cefalópode	I_ALL	*Alloteuthis spp*	Lulas bicudas	11.39	1.86
Cefalópode	SQR	*Loligo vulgaris*	Lula-vulgar	3.66	0.74
Cefalópode	I_CTL	*Sepia spp*		0.85	0.05
Cnidário	I_CAG	*Catostylus tagi*		11.18	41.50
Crustáceo	PIQ	*Palaemon longirostris*	Camarao-de-agua-doce	4.25	0.45
Crustáceo	I_POH	*Polybius henslowi*	Pilado	17.80	9.28
Peixe	TSD	*Alosa fallax*	Savelha	0.09	0.44
Peixe	MSF	*Arnoglossus laterna*	Carta-do-Mediterrâneo	0.22	0.99
Peixe	I_ASO	*Aspitrigla obscura*	Cabra-de-bandeira	0.45	1.95
Peixe	TRG	*Balistes carolinensis*	Peixe-porco	0.11	0.80
Peixe	GAR	*Belone belone*	Agulha	0.09	0.06
Peixe	BOG	*Boops boops*	Boga-do-mar	0.73	2.78
Peixe	LYY	*Callionymus lyra*	Peixe-pau-lira	0.41	1.01
Peixe	COE	*Conger conger*	Congro	0.07	5.31
Peixe	BSS	*Dicentrarchus labrax*	Robalo-legítimo	0.06	0.37
Peixe	CET	*Dicologlossa cuneata*	Língua	0.07	0.26
Peixe	CTB	*Diplodus vulgaris*	Sargo-safia	0.16	1.27
Peixe	I_ECV	*Echiichtys vipera*	Peixe-aranha-menor	0.57	0.32
Peixe	ANE	*Engraulis encrasicholus*	Biqueirão	1.82	1.87
Peixe	GUG	*Eutrigla gurnardus*	Cabra-morena	0.26	0.85
Peixe	I_HYL	*Hyperoplus lanceolatus*	Galeota-maior	0.05	0.10
Peixe	MGC	*Liza ramada*	Tainha-fataça	0.14	0.66
Peixe	HKE	*Merluccius merluccius*	Pescada	1.04	3.15
Peixe	FLE	*Platichthys flesus*	Solha-das-pedras	0.17	3.71
Peixe	I_PON	*Pomatoschistus minutus*	Caboz-da-areia	0.43	0.02
Peixe	TUR	*Psetta maxima*	Pregado	0.07	1.63
Peixe	PIL	*Sardina pilchardus*	Sardinha	25.81	17.14
Peixe	MAS	*Scomber colias*	Cavala	10.72	13.58
Peixe	MAC	*Scomber scombrus*	Sarda	30.49	36.90

Peixe	BLL	*Scophthalmus rhombus*	Rodovalho	0.07	0.32
Peixe	SYC	*Scyliorhinus canicula*	Pata-roxa	0.09	1.31
Peixe	SOS	*Solea lascaris*	Linguado-da-areia	0.16	0.64
Peixe	OAL	*Solea senegalensis*	Linguado-branco	0.06	0.22
Peixe	I_SOV	*Solea vulgaris*	Linguado legitimo	0.39	1.67
Peixe	BRB	*Spondyliosoma cantharus*	Choupa	0.20	1.02
Peixe	JAA	*Trachurus picturatus*	Carapau-negrão	0.50	0.63
Peixe	HOM	*Trachurus trachurus*	Carapau	54.72	53.17
Peixe	I_TRU	*Trigla lucerna*	Cabra-cabaço	0.26	2.24
Peixe	BIB	*Trisopterus luscus*	Faneca	1.76	5.35

Table 2 – JUVESAR13: Sardine abundance (million) and biomass (thousand tonnes) in the considered areas.

Zone	N (million)	B (thousand ton.)	% N	% B
Aveiro	361	4.78	18	21
Figueira	229	5.69	11	25
Ericeira	1445	11.07	70	49
Lisboa	20	1.12	1	5
Total	2055	22.66	100	100

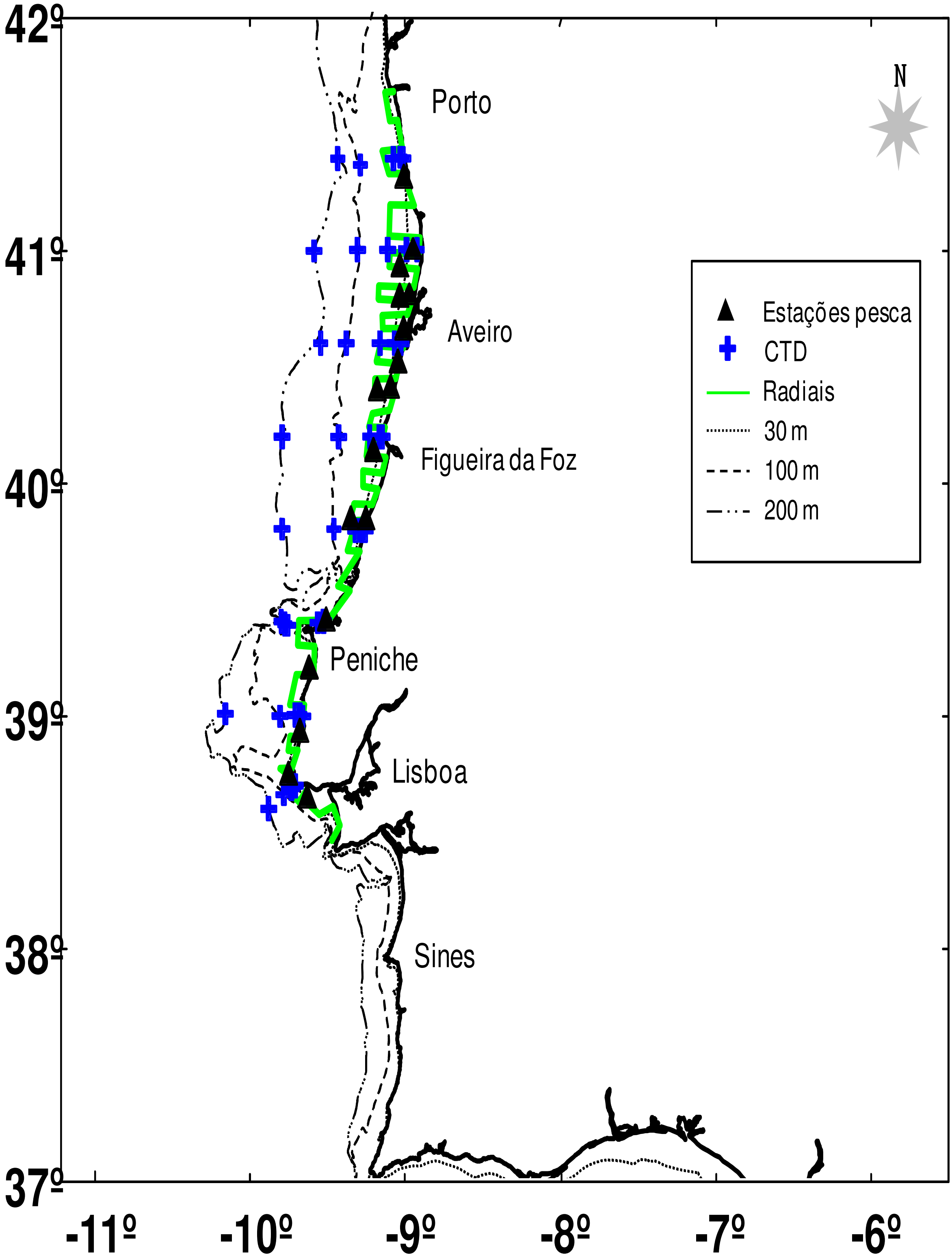


Figure 1 – JUVESAR13: acoustic survey transects and hidrographic/placton stations.

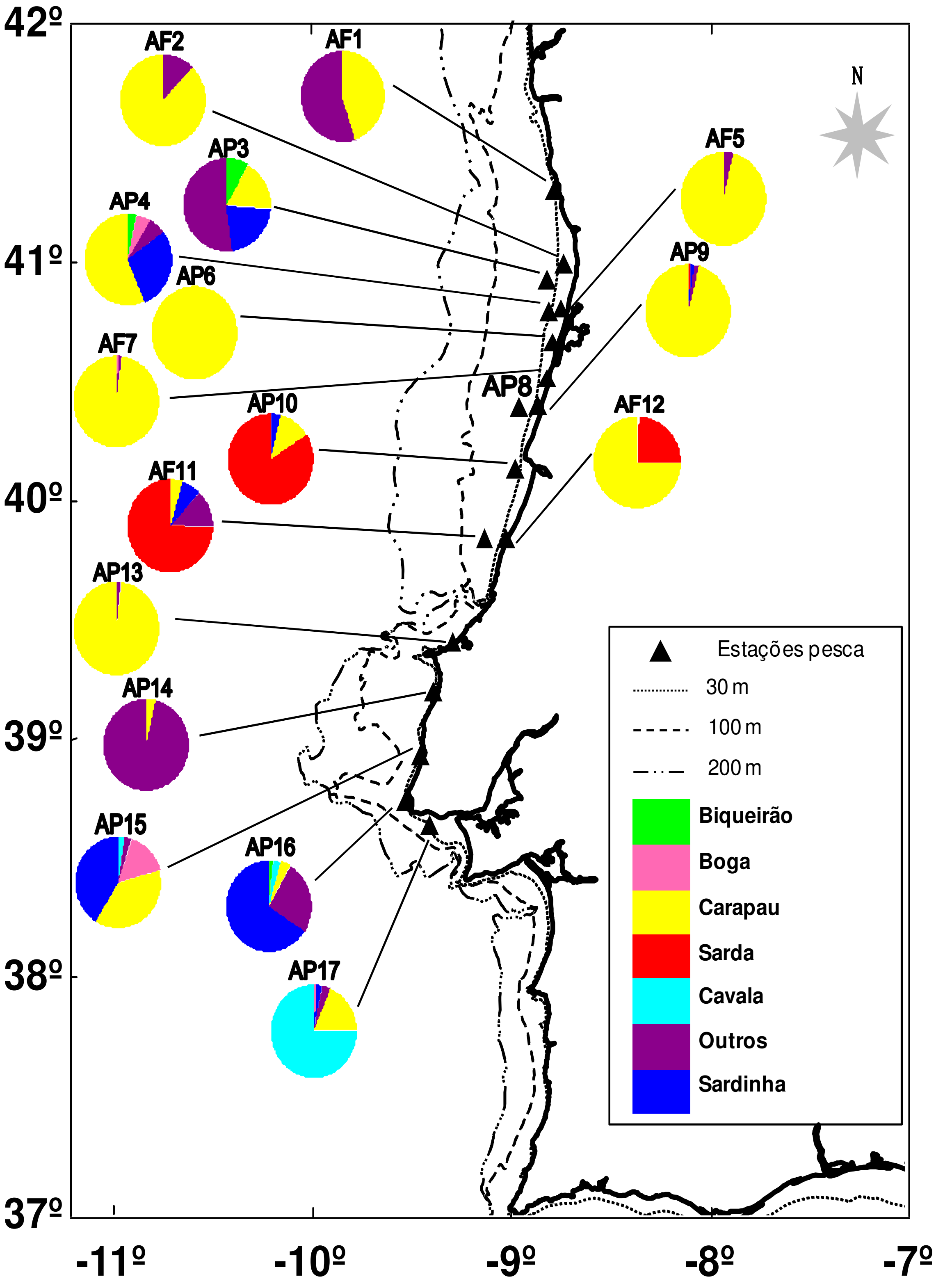


Figure 2 – Trawl species composition, in weight proportion.

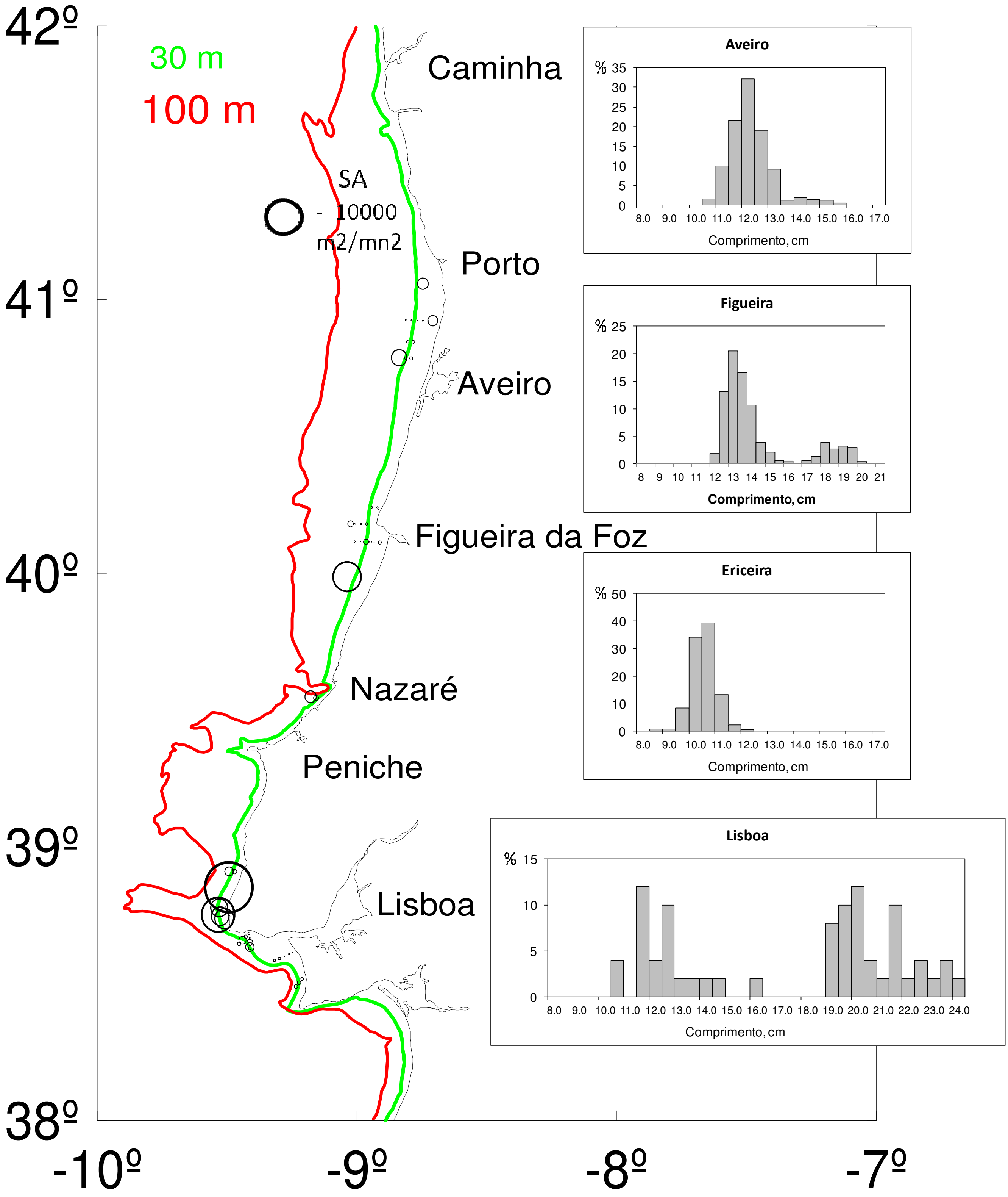
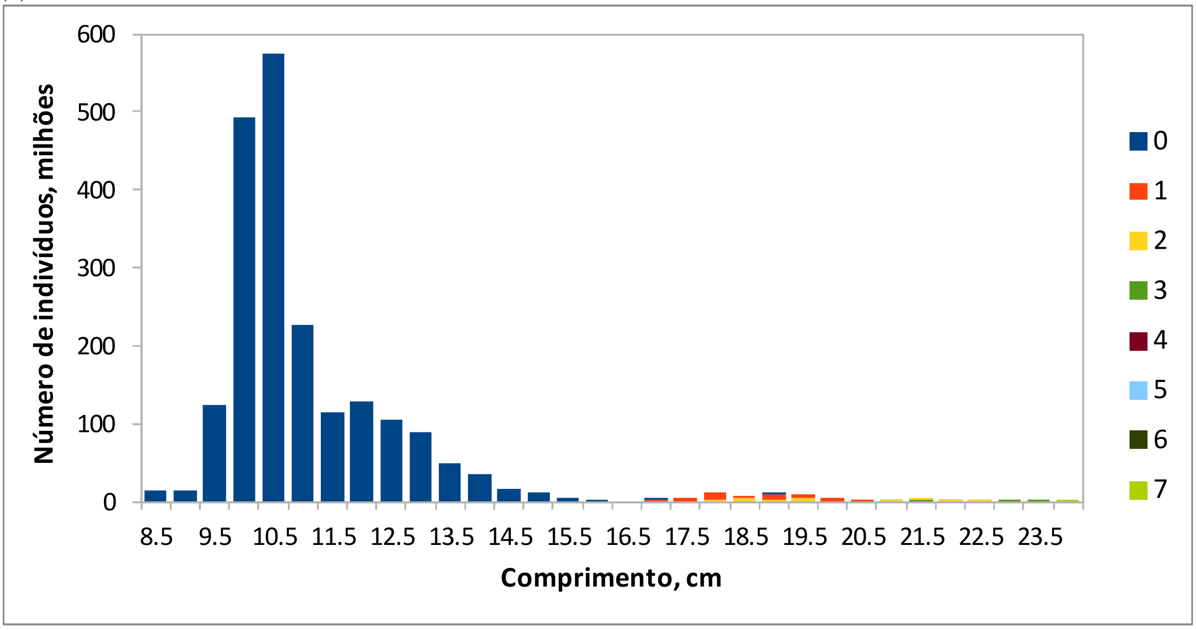


Figure 3 – JUVESAR13: acoustic sardine distribution map (SA, m^2/mn^2). On the right: sardine length frequency distribution (%), in each considered zone.

(a)



(b)

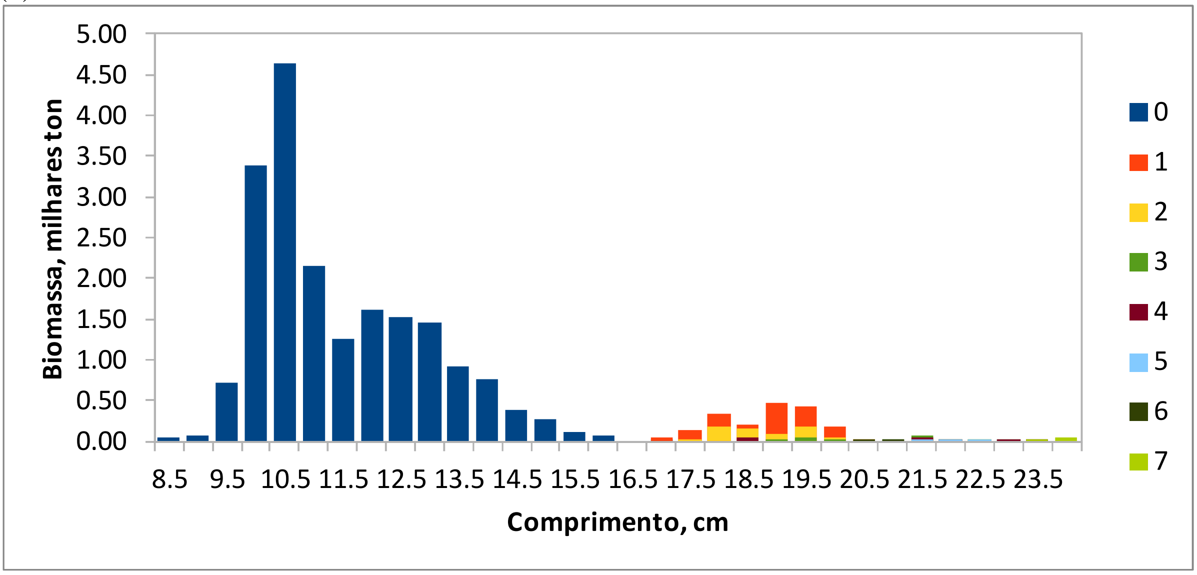


Figure 4 - JUVERSAR13: Length and age sardine distribution in number (a) and biomass (b).

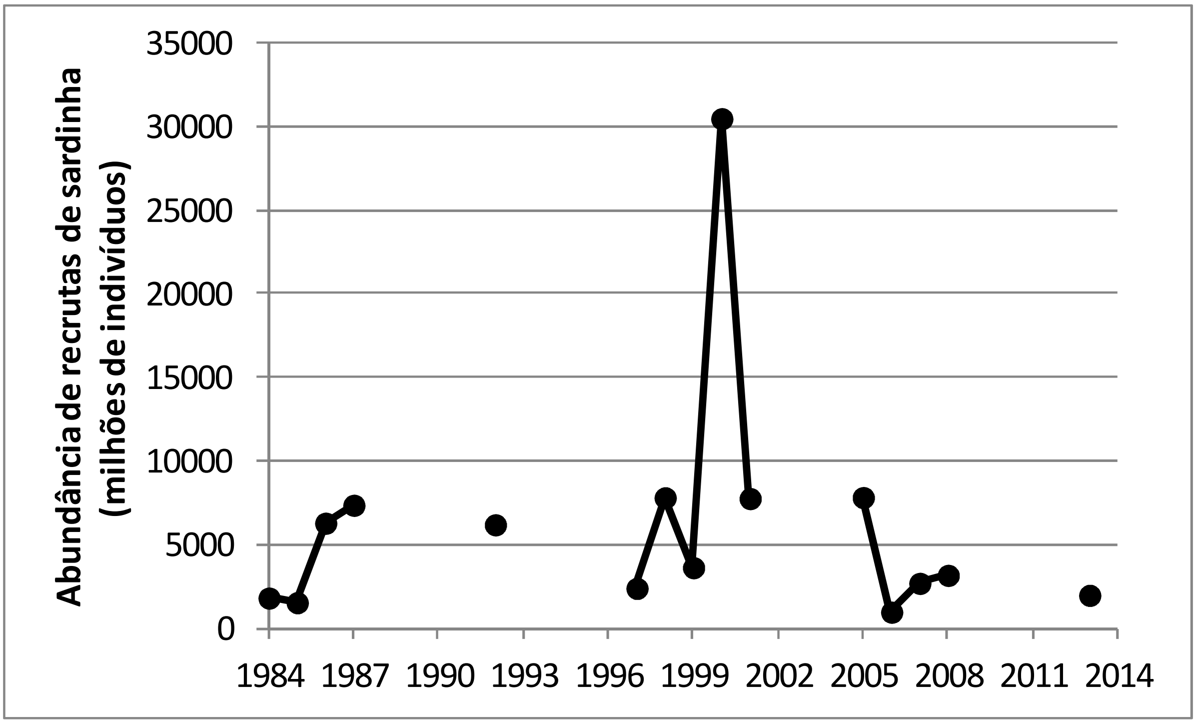


Figure 5 – Sardine recruits abundance (age 0) off the West Portuguese coast, estimated from autumn acoustic surveys (1984 – 2013).

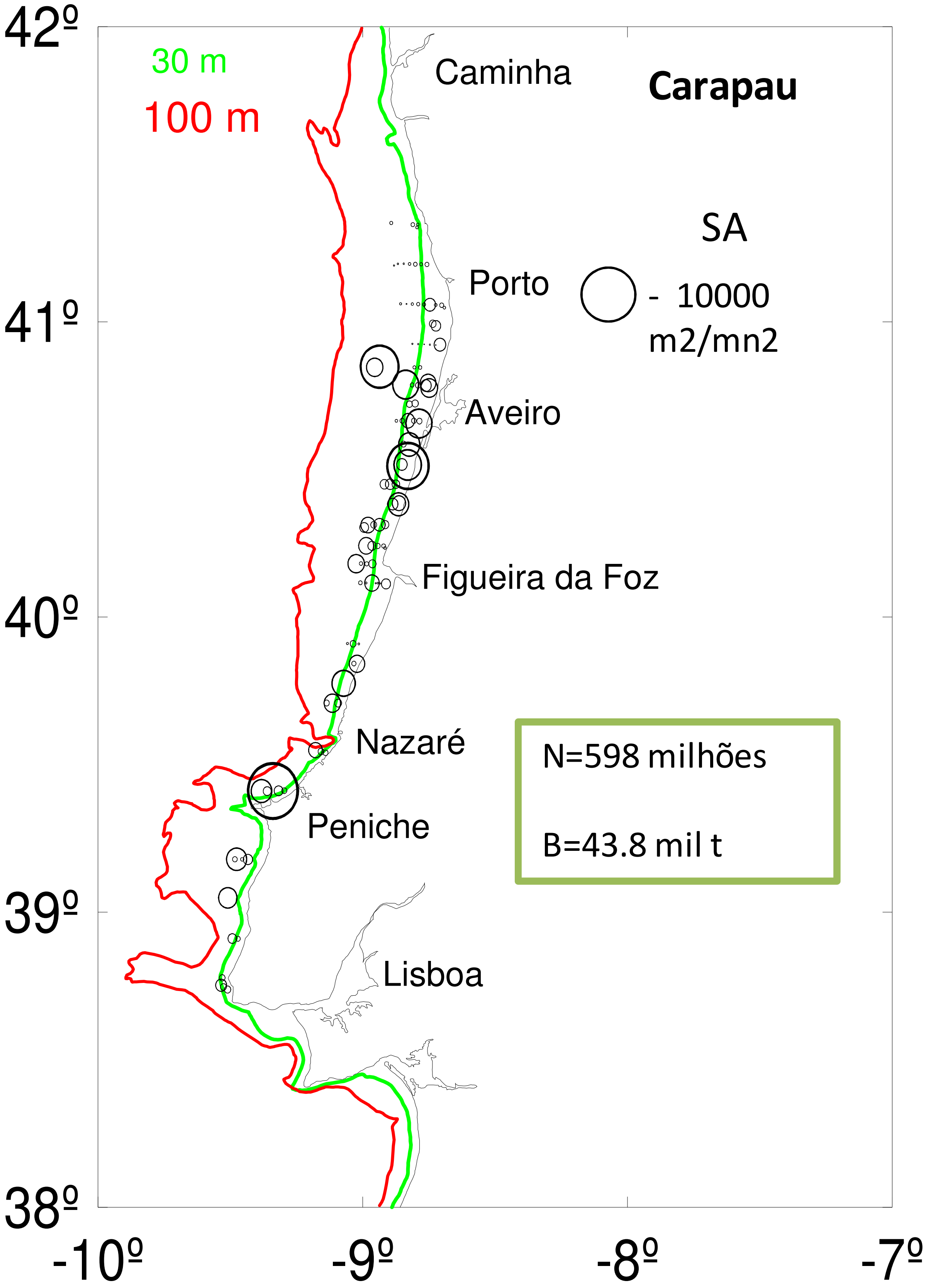


Figure 6 - JUVESAR13: spatial distribution and abundance of horse mackerel in the survey.

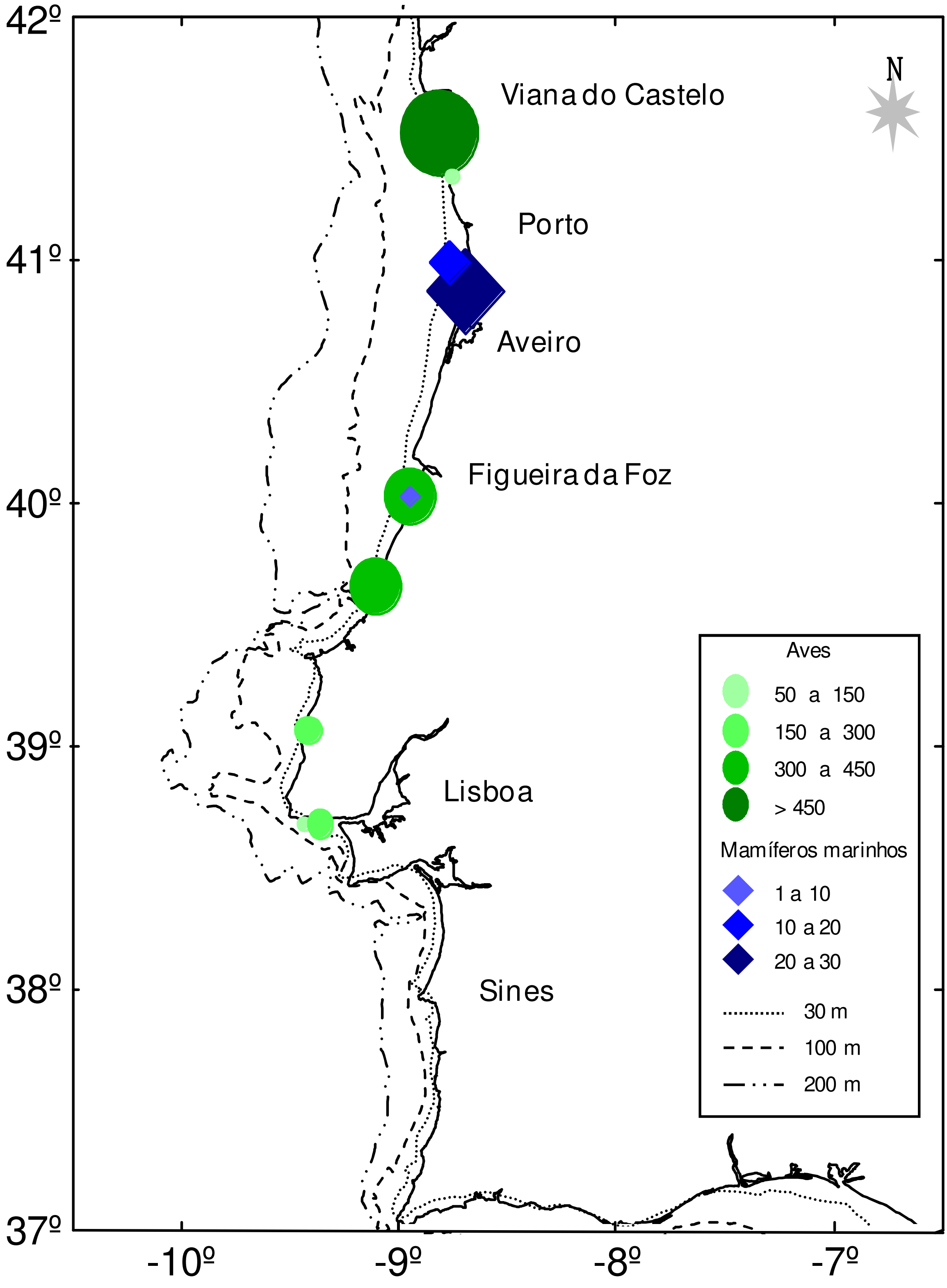


Figure 7 - JUVESAR13: marine mammals and sea birds spatial distribution.

Sardine spawning biomass estimation (ICES areas IXa and VIIIc) through the application of DEPM in 2014

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1. Background

Surveys for the application of the DEPM to estimate the sardine spawning biomass within the Atlanto-Iberian stock area are conducted every three years by IPMA (Instituto Portugués do Mar e da Atmosfera, Portugal) and IEO (Instituto Español de Oceanografía, Spain). DEPM surveys consisted of ichthyoplankton, adults and hydrographic sampling and are internationally coordinated and planned within the framework of ICES WGACEGG. Plankton samples, along a grid of parallel transects perpendicular to the coast, are obtained for spawning area delimitation and daily egg production estimation; concurrently, fishing hauls are undertaken for estimation of adult daily fecundity (sex ratio, female weight, batch fecundity and spawning fraction) within the mature component of the population.

In 2014, the Portuguese survey took place in March-May (later than usual) covering the Atlantic waters from the entrance of the Strait of Gibraltar to the northern border of Portugal (ICES area IXa), while the Spanish survey took place in March/April covering the northern stock area from the river Minho to the south of the Armorican shelf in French waters (ICES areas IXa North and VIIIc).

This working document provides a description of the surveys, laboratory analyses and estimation procedures used to obtain egg and preliminary adults parameters for the 2014 DEPM application to the Atlanto-Iberian sardine stock. A preliminary estimation of spawning stock biomass (SSB) is also presented.

2. Methodology

2.1 Surveying

In 2014, the Portuguese survey (PT-DEPM14-PIL) took place much later in the reproductive season than usual due to technical constraints with the research vessel (RV Noruega); moreover it was interrupted in several occasions owing to adverse weather conditions and additional logistical issues. The region north of Lisbon was surveyed during the second half of March (15-21), the survey was then interrupted only to be resumed on the 4th of April; by this time together with the acoustics survey (PELAGO14) and restarting from south. During the period from 4th April to 12th May both surveys were carried out concurrently; the night period was used for plankton sampling while during light hours the acoustics surveying took place; adult sampling was directed at both surveys. Plankton surveying was repeated in the area north of Lisbon during the acoustics coverage in the region (1-13 May); the egg results used for the estimations do not include the second coverage of the NW Portuguese shelf undertaken in May; comparative results using the repeated coverages are discussed elsewhere.

For the first time in the whole series, the Spanish DEPM survey (SAREVA 0414) was carried out on board RV Vizconde de Eza from 29th March to 21th April. The vessel is quite similar to Cornide de Saavedra which was used from 1988 to 2011. Before the cruise, the ship was tested, including CUFES system, during a small survey performed in February in Mediterranean waters. The SAREVA DEPM survey was coordinated with PELACUS acoustic survey to carry out the fishing hauls in ICES areas IXa North and VIIIc.

Plankton sampling

During both surveys, vertical plankton hauls were carried out following a pre-defined grid of sampling stations along transects perpendicular to the coast and spaced 8 nmiles (Figure 1). The inshore limit of the transects was dependent on bottom depth (as close to the shore as possible), while the offshore extension was decided adaptively. The main sampler for the DEPM is the PairoVET net that collects eggs through the water column at point stations. The PairoVET sampler (=double CalVET) includes 2 nets (Ø 25cm) with 150 µm mesh size and a CTDF probe; sampling covered the water column from bottom, or 150m (100 m for IEO) (beyond the 150 isobath) depth, to the surface. PairoVET samples were taken every 3 nm in the inner shelf (up to 200 m depth or 100 m where the platform is wider) and every 3 or 6 nm beyond the inner shelf, depending on the results of the CUFES sampler. For the period during which the Portuguese DEPM survey was conducted together with the acoustics survey (same vessel) some of the DEPM transects were adapted to the acoustics transect design in order to save ship time (this was done without loss of plankton sampling spatial resolution) .

CUFES was used as the auxiliary egg sampler, helping in defining vertical hauls density and offshore extension of the transects. The outer limit of a transect was reached when two consecutive CUFES samples were negative beyond the 200 m depth.

All plankton samples were preserved in formalin at 4% in distilled water and the 2 samples from each net stored in separate containers. For IPMA both nets (Table 1) were used for egg density estimates while IEO used 1 net (the other being used for plankton dried mass calculations). IEO counted total number of eggs from the CUFES onboard in order to obtain a preliminary data of sardine egg abundance and distribution. CUFES samples from IPMA are analysed in the laboratory since this task is not possible onboard.

Temperature, salinity and fluorescence.

The water column structure (temperature, salinity and fluorescence) was surveyed by CTD(F) profiling during the PairoVET hauls. IPMA used a CTDF system (RBR concerto) and IEO used a CTD (Sea Bird 37). Additional CTD casts (using a Sea Bird-25) were performed by IEO in each transect head and in alternate stations along the transects. The surface water layer was sampled continuously with the CT(F) probes associated with the CUFES water pump.

Adult fish surveying

Fishing hauls were conducted by either pelagic or bottom trawling following sardine schools detection by the echo-sounder. The number of samples and its spatial distribution was organized to ensure good and homogeneous coverage of the survey area (Figure 2). In the Portuguese survey, the samples collected by the RV were complemented with samples obtained from commercial purse-seiners from several ports (Matosinhos, Aveiro, Peniche, Sesimbra, Sines and Portimão). Samples from the fishing fleet were acquired within 1-2 weeks of the surveying by RV Noruega in each area but this was not possible for the northern region in

March since the sardine fishery was undergoing its seasonal closure in the area. Moreover, 6 additional samples (from Matosinhos, Peniche and Portimão) were collected from the purse-seine fleet at the end of January to be used as “reference” information for the adults parameters earlier in the reproductive season (in relation to the moment when the survey exceptionally and effectively took place this year). In the Spanish survey, fishing hauls for estimation of adult parameters were mainly undertaken during PELACUS acoustic survey which was carried out concurrently with RV Vizconde de Eza. Some fishing hauls were also conducted on board RV Vizconde de Eza during SAREVA DEPM survey.

Onboard the RV, and for each haul, a minimum of 60 sardines were randomly selected and biologically sampled. These were, in some occasions, also complemented by additional fish in order to achieve a minimum of 30 females per haul for histology, and/or to obtain extra hydrated females for the fecundity estimations. Individual biological information (length, total weight, sex, maturity state, gonad weight) was recorded for all fish, the ovaries were preserved for histology (with a 4% formaldehyde solution diluted in distilled water and buffered with sodium phosphate) and to obtain gonad weight for IPMA (measured in laboratory) and the otoliths removed for age determination. The biological sampling and ovaries fixation were always carried out in fresh material, with the exception of 8 commercial samples for which the ovaries were removed from the fish body and preserved immediately after the fish were landed, while the remaining body of the fish was frozen for posterior biological sampling in laboratory.

Details of the methodologies are summarized in Table 1.

2.2 Laboratorial analyses

Plankton samples

In the laboratory, all sardine eggs were sorted from PairoVET and CUFES samples. The eggs from the vertical hauls (2 nets –IPMA 1 net –IEO) were all counted and staged according to the 11 stages of development classification (adapted from Gamulin and Hure, 1955). For IEO and IPMA, the eggs from the CUFES sampler were all counted. A sub-sample, of a minimum of 100 staged per sample will also be staged for future analyses.

Adult fish samples

The preserved ovaries were weighed in laboratory and the weights obtained corrected by a conversion factor (between fresh and formaldehyde fixed material) established previously. These ovaries were then processed for histology: they were embedded in either resin (IEO) or paraffin (IPMA), the histological sections were stained with haematoxylin and eosin, and the slides examined and scored for their maturity state (most advanced oocyte batch) and POF presence and age (Hunter and Macewicz 1985, Pérez et al. 1992a, Ganias et al. 2004, Ganias et al. 2007). Prior to fecundity estimation, hydrated ovaries were also processed histologically in order to check for POF presence and thus avoid underestimating fecundity (Pérez et al. 1992b). The individual batch fecundity was then measured, by means of the gravimetric method applied to the hydrated oocytes, on 1-3 whole mount sub-samples per ovary, weighing on average 50-150 mg (Hunter et al. 1985).

2.3 Data analyses

Egg data

All calculations for area delimitation, egg ageing and model fitting for egg production (P_0) estimation were carried out using the R packages (*geofun, eggsplore and shachar*) available within the open source project *ichthyoanalysis* (http://sourceforge.net/projects/ichthyoanalysis). Some routines of the R packages used were updated since the 2008 versions.

To avoid high and low extremes values detected in the area represented by each of the sampled stations, this values were forced to the minimum and maximum values of 25 and 175 respectively (the extreme values usually occur on the borders of the survey area and therefore do not affect the estimation of the positive area). The range 25-175 was selected to be a mean interval suitable according to the distance between transect and stations (fixed to be 8 nm between transects and 3 between stations along the transects).

The model of egg development with temperature was derived from the incubation experiment data available within the *sardata* R library. Egg ageing was achieved by a multinomial Bayesian approach described by Bernal *et al*. (2008) and using *in situ* SST. Distribution of the daily spawning cycle was assumed as a normal (Gaussian) distribution, with a peak at 21:00 h GMT and a standard deviation of 3 h (spawning period form 21-6 h to 21+6 hours). Peak spawning time was taken from the literature (Bernal, 2008) and the spawning curve considered in order to be more conservative and allowing a longer spawning period and therefore few eggs are excluded from the analyses (how.complete=0.95). The upper age cutting limit was determined using a maximum age for the strata considered and it not dependent on the individual stations. The lower age cutting excluded the first cohort of stations in which the sampling time is included within the daily spawning period.

The strata definition (according to biological/ecological (geographical) reasons used in the analyses for mortality and/or egg production estimation were:

- No strata: unique strata for all Atlanto-Iberia, from the strait of Gibraltar to the Spanish-French Atlantic limit.
- Three strata (Stratum); **South (IXa S)**, encompassing from the strait of Gibraltar to Cape St. Vicente, **West (IXa W)**, from Cape St. Vicente to the northern limit between the Spain and Portugal, and **North (IXa N & VIIIc)**, between the Spanish-Portuguese northern limit and the Spanish-French Atlantic limit.

The maximun age and temperature was calculated for the different strata described previously. Estimates of egg production and mortality were initially estimated for the entire area (no strata) and for each stratum of the second set.

The exponential model: $E[P] = P0\ e^{-Z\ age}$ was fitted by a Generalized Linear Model (GLM), assuming a negative binomial distribution. Finally, the total egg production was calculated multiplying the daily egg production by the positive area (area with eggs defined by an automated procedure using the spatstat library)

The models used to estimate mortality and egg production were:

Model 1

1 strata for P0 and mortality

glm.nb(cohort ~ offset(log(Efarea)) + age, weights=Rel.area, data=aged.data)

Model 2

3 strata (Stratum) for P0 and 3 strata for mortality (age)

glm.nb(cohort ~ offset(log(Efarea)) -1 + Stratum+ Stratum:age, weights=Rel.area, data=aged.data)

Model 3

3 strata for P0 and 1 for mortality

glm.nb(cohort ~ offset(log(Efarea)) -1 + Stratum+ age, weights=Rel.area, data=aged.data)

Fish data

The adult parameters estimated for each fishing haul considered only the mature fraction of the population (determined by the fish macroscopic maturity data) and was based on the biological data collected from both surveys and commercial samples. Before the estimation of the mean female weight per haul (W), the individual total weight (Wt) of the hydrated females was corrected by a linear regression between the total weight of non-hydrated females and their corresponding gonad-free weight (Wnov). The sex ratio (R) in weight per haul was obtained as the quotient between the total weight of females on the total weight of males and females. The expected individual batch fecundity (Fexp) for all mature females (hydrated and non-hydrated) was estimated by modelling the individual batch fecundity observed (Fobs) in the sampled hydrated females and their gonad-free weight (Wnov) by a GLM. In case a geographical variability was observed in individual batch fecundity, a posterior post-stratification was carried out, Fobs being modelled against the Wnov and the Stratum (second set of strata used for the egg data analysis). The fraction of females spawning per day (S) was determined, for each haul, as the average number of females with Day-1 or Day-2 POF, divided by the total number of mature females (the number of females with Day-0 POF was corrected by the average number of females with Day-1 or Day-2 POF, and the hydrated females were not included) (Pérez et al. 1992a, Ganias et al. 2007). The mean and variance of the adult parameters for all the samples collected was then obtained using the methodology from Picquelle and Stauffer 1985 (weighed means and variances). All estimations and statistical analysis were performed using the R software. Final adult parameters include individual estimates for the Southern, Western and Northern areas, with three independent estimates.
Details on the methodologies used on board, during laboratorial work and for data analyses are summarized in Table 1.

3. Results

3.1 Temperature and salinity

Surface temperature and salinity distributions are presented in figure 3. Temperature values ranged from 12.3 to 19.9ºC. Temperature distribution followed the common patterns; the highest temperature values were observed in the southern area and the lowest values registered for the Cantabrian Sea. The higher temperatures recorded in the south were likely due to the period of surveying later than usual, already after the onset of spring. The winter/spring atmospheric conditions in the Atlanto-Iberian region during the first quarter of 2014 were very unstable with episodes of heavy rain and strong wind events, this background led to a highly variable hydrodynamic setting with agitated shelf waters for quite long periods.
For the area covered by the Portuguese survey the temperature data used for egg ageing was registered underway at 3m depth (CTF probe). During the Spanish survey the data for egg ageing were extracted from the SBE-37 records.

3.2 Eggs

In total 793 PairoVET hauls and 798 CUFES samples were obtained (Table 2). The percentage of stations with sardine eggs was 29% for the vertical tows and 36% for the surface samples. Considering only one of the PairoVET nets (to be comparable between IEO and IPMA) 2405 (Figure 4) sardine eggs were gathered in total, of which 2092 came from the south and West of Portugal. The egg numbers obtained in the north, 313, were the lowest in the whole survey series for this area. In the Western area the number of sardine eggs collected almost doubled compared to the 2011 survey. For the total area surveyed stage II eggs (Figure 4) were the most abundant (33.1%)

Sardine egg distribution, obtained from the PairoVET and CUFES systems, for the whole area is presented in Figure 1. The egg distribution pattern derived from the observations from the two samplers is similar. In the positive egg strata, the highest egg abundance per haul was 5500 egg/m^{2}reached in the South, while the lowest egg abundance per haul was 704 egg/ m^2 registered on the northern coast.

The surveys covered a total area of 80830 km2 of which 25320 km^2 (31.3 %) were considered the spawning area (Table 3). The northern stratum represented 30 % of the spawning area while 27 % were in the southern coast and 43 % in the western shores. The percentage of stations in the whole area with sardine eggs was 28.9% (S: 46.3%, W: 38.1%, N: 16.7%). The total area occupied by eggs was much smaller than in 2011, this is particularly clear for the North coast of Spain (around 40%), while in the west the spawning area increased to almost the double.

Table 3 shows the mortality values obtained using geographical stratification (no strata and 3 strata) as described above. Mortality value for the southern regions is much higher than for the western and northern strata. Mortality calculated for each one of the three strata defined shows negative and significantly different from zero values and was considered acceptable for egg production estimation, however significance obtained for mortality value estimate with a common slope for the whole Atlanto Iberian stock was much better than the obtained with three independent mortality estimates. For the 2014 DEPM data the options for GLM model with one or three slopes (mortality), give similar results for the egg production (intercept) by stratum.

Final egg production models (Table 3 and Figure 5) include individual egg production estimates for the Southern, Western and Northern areas, with three independent mortality estimates (Model 2), three egg productions with a common slope for the whole Atlanto Iberian stock (Model 3) and finally, egg production with a single mortality, estimated for the whole Atlanto Iberian stock, is considered using Model 1.

The results from different GLM models (Table 3) could be considered an option for the final egg production estimation (negative and statistically significant mortality), minimal differences in the estimates by areas are introduced due to the choice of model used.

Owing to standardization of criteria in the analyses, during the 2012 sardine DEPM historic series revision, the results achieved by GLM model 3 were recommended to be used for assessment modelling and therefore to maintain consistency within the series analyses it is here also considered more adequate.

Total egg production (eggs/day) estimated for the Atlanto Iberian stock varies from 1.94x10^{12} (model 1) to 1.99 x10^{12} (models 2 and 3). Using three P0s and one mortality estimates (Model 3), the added total egg production estimate was 1.99 x10^{12}; 0.71 x10^{12} corresponding to the south, 0.97 x10^{12} to the west and 0.31 x10^{12} to the north. The sum of total egg production for the 3 strata in 2014 was much lower than in 2011, in particular in the northern and southern regions but similar in the west (Table 3 and Figure 6). For all models used, the daily egg production per m^2 (eggs/m^2/day) was higher for the southern region.

3.3 Adults

For the 2014 survey an effort was made to guarantee the level of sampling already achieved in the 2002, 2005 and 2008 surveys, however a high percentage of fishing hauls (47 %) over the total resulted negative for sardine. On the whole, 44 fishing hauls which caught sardines were performed during the surveys covering the whole area, complemented by 20 samples obtained from the Portuguese purse-seine fleet (Figure 2). On the whole, almost 3330 sardines were sampled (Table 2), more than 1400 ovaries were collected, preserved and analysed histologically and *ca.* 1130 otoliths were removed for age determination. A total of 210 hydrated females were caught for batch fecundity estimation, which is a substantial number given the higher difficulty in obtaining sardines in 2014, and in comparison with 2011 (67 hydrated females).

All laboratory tasks are completed for the samples collected during IEO's survey whereas the weighing in laboratory of the preserved ovaries sampled during IPMA's survey and from the Portuguese commercial fleet as well as their histological processing and microscopical analysis are still in progress. Therefore, spawning fraction (S) could presently be estimated for the Iberian Northern area (North strata) only, being unavailable for the Portuguese and Cadiz coasts (West and South strata). The other three parameters (W, R, F) calculated for strata 1 and 2 (South and West Portuguese coasts) were based on 34 of the 44 samples collected in this area, the present results being thus preliminary.

Data were analysed and the parameters estimated for the two surveys jointly:

- The same linear regression between the non-hydrated females Wt and their corresponding Wnov was used for the whole surveyed area (Wt = 1.068 * Wnov - 0.770, R^2 = 0.995). 17025.80 11296.27 20928.15
- The geographical distribution of female weight (not shown) and mean observed batch fecundity (Fobs = 17026, 11296 and 20928 eggs/female, respectively, for South, West and North strata) suggest the need for a spatial stratification in view of the parameters estimation. Fobs data were thus modelled against the Wnov and the Stratum (GLM: Fobs ~ Wnov:Stratum, negative binomial distribution and identity link) with three different strata, and the model obtained was statistically significant (Figure 7).

For the first time in the historical series, the minimum mean female weight (W) was obtained for the North coast (Table 3), which corresponds to a drop of 48% in relation to the previous survey estimate for this stratum. Minimum mean weights by haul were observed in Mid-Eastern Cantabrian waters (24-37 g), in Galicia (45-52 g), the North of Portugal (13-37 g), the Lisboa area (32-37 g) and in the Gulf of Cadiz (30 g). Mean female weight (W) was similar for the West and North coasts (52.6 g and 48.7 g, respectively) whereas in the South coast mean weight estimate was the highest of the historical series (60.7 g).

The mode of individuals age distribution off the Northern Spanish coast is 1 year-old, these fish representing about half of the individuals for which otoliths were sampled. On the West coast, most individuals for which age data is available are also 1 year-old. On the contrary, female age distribution off the Southern Portuguese and Cadiz coasts is widespread with most fish being aged 1 to 7, with no clear modal ages (Figure 8). Overall, the age distribution for the three strata in 2014 contrasts with what had been observed in previous surveys.

Though the model obtained with the three strata was statistically significant, in 2014, the relationship between the Fobs and the female Wnov was very similar for the three areas considered, i.e., that the batch fecundity estimated for a fish of the same weight would be similar off the North, West and South coasts (Figure 7). Similarly to the mean weight, mean batch fecundity estimate (F) was lowest off the Northern Spanish coast, representing a decrease of 58% in relation to the previous survey and being the lowest estimate of the historical series. For the Portuguese and Cadiz areas, F estimates were almost identical: for the South stratum, the estimate is similar to the values obtained in 2008 and 2011, whereas for the West stratum, mean batch fecundity has doubled in relation to the previous survey (22585 and 11838 eggs/female, respectively) though female mean weights were similar for these two surveys.

Spawning fraction estimate for the Northern Spanish coast was lower than the one obtained during the 2011 survey, but almost identical to the one obtained in 2008 (0.093 *vs.* 0.114 and 0.09, respectively).

3.4 SSB estimate

In the present document final estimates of SSB were only calculated for the Northern area. SSB estimation for the North strata in 2014 (Figure 9) is the lowest for the whole series (23882 tons), even lower to those obtained in 1999 (41963) and 2002 (47747) when the model selected for the egg production estimate included a common mortality value for the three strata (model 3). Using egg production from model 2 (with three independent mortality estimates) the SSB estimation for the North stratum is slightly lower (21571). For the West and Southern areas, preliminary SSB estimates were calculated using an average estimate, the spawning fractions obtained by bootstrap during the 2011 historic series revision (WGACEGG 2012). The resulting values for these two strata were 67819 and 38994 tons, respectively, which represent a significant decrease in relation to the previous survey (42% and 83% of decrease, respectively), and were also the lowest estimates of the whole series; final SSB will be provided when the histological analysis of the ovaries is concluded and S estimated for the West and Southern areas. Total SSB for the stock was estimated as 130700 tonnes.

4. Remarks

The sardine stock in areas VIIIc and IXa has shown no strong recruitment for several years and biomass estimates from the research surveys (acoustics and DEPM) have been showing a decline in the population. As it occurred in 2011, also during the 2014 surveys was evident the low availability of sardine during the fishing operations in the majority of the area surveyed and the spawning area was for the joint strata the smallest of the time series, though only in the north it effectively reduced compared to 2011. For the first time the sardines caught in the Cantabrian Sea were smaller than the individuals observed in the southern and western regions. The drop in SSB which was observed between the 2008 and 2011 surveys was further accentuated and the biomass estimates from DEPM, for all strata, were in 2014 the lowest of the time series.

Main remarks:

- spawning area in 2014 for the whole area slightly reduced compared to 2011 and the smallest of the historic series; patchy egg distribution everywhere and very low numbers in the north
- spawning area reduction particularly evident in the north (around 40% of the total spawning area in 2011) while in the west it increased to more than double
- daily egg production per m^2 (eggs/m2/day) was higher for the southern stratum, intermediate in the west coast and lower in the north; for all strata daily egg production per m^2 was much lower than in recent surveys
- sum of total egg production for the 3 strata in 2014 much lower than in 2011, in particular in the northern and southern regions, similar in the west
- mortality value (single mortality for whole area) one of the lowest of the series but with high CV
- during the 2014 survey the availability of adult sardine for trawling was limited in the whole area; nevertheless, 44 samples were obtained, 12 in the south, 17 in the west and 15 in the north; extra samples (20) from purse-seiners were collected in Portugal
- the number of hydrated females collected was higher than in 2011
- for the first time, mean female weight and batch fecundity were lower for the north than for the west and south strata, and were the lowest observed off the Spanish coast in the whole series
- mean female weight obtained for the Spanish coast is much lower (48.7) than values reported from the whole historical series, which ranged between 70.1 g in 1997 and 85.8 g in 2011, whereas in the South coast mean weight estimate was the highest (60.7 g) observed since 1997 (values ranging between 38.8 g in 2002 and 56.3 g in 2008)
- batch fecundity doubled in the west area and increased slightly in the south in comparison to 2011; for the north the lowest values were observed which were similar to the estimates for west and south in previous years
- sardines were mainly aged 1 year off the North and West coast while age distribution in the South was much wider (mostly, 1-7 years old)
- spawning fraction for the north strata in 2014 was lower than in 2011 survey but similar to previous ones
- SSB estimation for the North strata in 2014 is the lowest of the whole series (23882 tons). For the west and south coasts, SSB estimates are still preliminary, but the results suggest also a substantial decrease of the biomass in these two strata, compared to 2011.
- despite the fact that the Portuguese survey was conducted later than usual the population was actively spawning and the results obtained for all parameters estimated were consistent

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Table 1. Surveying, processing and analyses for eggs and adults

DEPM Surveys	Portugal (IPMA)	Spain (IEO)
Survey	**PT-DEPM14-PIL**	**SAREVA 0414**
Survey area	(IXa S, IXa W) South-West	NW & N Spain (IXa N + VIIIc)
SURVEY EGGS		
Sampling grid	8 (transect) x 3(station)	8 (transect) x 3(station)
PairofVET Eggs staged (n egg) (stages Gamulin and Hure, 1955)	All (2 net)	All (1 net)
Sampling maximum depth (m)	150	100
Temperature for egg ageing	3-5 m	10 m
Peak spawning hour	(PDF 21 ± 2 * 3)	
Egg ageing	Bayesian (Bernal et al, 2008)	
Strata	No strata/Stratum (South,West,North)	
Egg production	GLM, negative binomial, log link	
CUFES, mesh 335	3nm (sample unit)	3 nm (sample unit)
CUFES Eggs counted	All	All
CUFES Eggs staged	Subsampled of a minimun of 100	No
Hydrographic sensor	CTDF (FSI)	CTD (SBE 37) CTD SBE 25
Flowmeter	Y	Y
Clinometer	Y	Y
Environmental data	Fluorescence, Temperature, Salinity	Fluorescence (surface only), Temperature, Salinity
SURVEY ADULTS		
Biological sampling:	On fresh material, onboard the R/V or in laboratory; on frozen material for certain commercial samples (ovaries removed before)	On fresh material, on board of the R/V
Sample size	60 indiv randomly ; extra if needed (30 females min for histology) and if hydrated females found	60 indiv randomly (30 mature female); extra if needed and if hydrated found
Sampling for age	Otoliths from the same females sampled for histology	Otoliths from random males and females
Fixation	Buffered formaldehyde 4% (distilled water)	Buffered formaldehyde 4% (distilled water)
Preservation	Formalin	Formalin
Histology:		
- Embedding material	Paraffin	Resin
- Stain	Haematoxilin-Eosin	Haematoxilin-Eosin
S estimation	Day 1 and Day 2 POFs (according to Pérez et al. 1992a and Ganias et al. 2007)	Day 1 and Day 2 POFs (according to Pérez et al. 1992a and Ganias et al. 2007)
R estimation	The observed weight fraction of the females	The observed weight fraction of the females
F estimation	On hydrated females (without POFs), according to Pérez et al. 1992b and Ganias et al. 2010	On hydrated females (without POFs), according to Pérez et al. 1992b

Table 2. General Sampling for DEPM 2014

Institute	IPMA	IPMA	IEO
Survey area	**IXa South**	**IXa West**	**IXa N & VIIIc**
SURVEY EGGS			
R/V	Noruega	Noruega	Vizconde de Eza
Date	15-26/4	15-21/3; 4-15/4	29/03-09/04 16/04-21/04
Transects	20	38	54
PairoVET stations	134	265	394
Positive stations	62	101	66
Tot. Eggs	2019	2164	313
Max eggs/m2	5500	1550	704
Temp (ºC) min/mean/max	14.5/16.3/19.1	12.8/14.9/18.5	12.3/13/14.9
Max age	52.7	58.3	74.2
CUFES stations	146	313	339
Positive CUFES stations	60	116	112
Tot. Eggs CUFES	2695	12709	2186
Max eggs/m3	78.3	61.7	25.2
Hydrographic stations	134	265	522
SURVEY ADULTS			
Number Hauls R/V	17	47	57
Number Hauls (Commercial Vessels)	4	16	---
Number (+) trawls	16	33	15
Date	26.03 - 11.04	16.03 - 11.05	15/03-07/04
Depth range (m)	23-66	21-134	36-167
Time range	01:00 – 18:30		7:30-20:30
Total sardine sampled	938	1635	755
Length range (mm)	135-236	85-265	132-252
Weight range (g)	20-97	4-136	15.5-120.4
Females for histology	444	705	262
Hydrated females	70	21	119
Otoliths	527	130	472
Female Ages Range	1-10	1-10	1-7

Table 3. DEPM parameters derived from 2014 sardine DEPM surveys with their CV (%) in brackets by institution and stratum (IXa South, IXa West and IXa North-VIIIc). Surveyed and positive areas (km^2), Mortality Z (hour^{-1}), Daily egg production P0 (eggs/m^2/day), Total egg production P0 tot (eggs/day) (x10^{12}), Females mean weight (g), Batch fecundity (number of eggs spawned per mature females per batch), Sex ratio (fraction of population that are mature females by weight), Spawning fraction (fraction of mature females spawning), Significant mortality values (hour^{-1}) are shown. ** Significance at p<0.01 and * Significance at p<0.001.**

Institute	**IPMA**	**IPMA**	**IEO**	**TOTAL**
Area	**IXa South**	**IXa West**	**IXa N & VIIIc**	
Survey area (Km^2)	14558.7	27357.3	38914.4	80830.5
Positive area (Km^2)	6824.8	11000.8	7494.5	25319.6
Z (hour^{-1})(CV%)				
Model 1	-0.016 ** (38.7)			
Model 2	-0.022 (61.2)	-0.013. (59.3)	-0.014 .(52.9)	
Model 3	-0.017 ** (36.4)			
P0 (eggs/m2/day)(CV%)				
Model 1	76.8 (22)			
Model 2	127.5 (46.6)	76.1 (28.4)	37.2 (33)	
Model 3	103.7 (27.4)	88.7 (23.2)	40.4 (26)	
P0 tot (eggs/day) (x10^{12}) (CV%)				
Model 1	1.94 (22)			1.94 (22)
Model 2	0.87 (46.6)	0.84 (28.4)	0.28 (33)	1.99
Model 3	0.71 (27.4)	0.97 (23.2)	0.3 (26)	1.99
Female Weight (g)				
Three strata (S, W and N)	60.7 (5)	52.6 (14)	48.7 (11.4)	
Batch Fecundity				
Three strata (S, W and N)	22673 (7)	22585 (14)	17118 (11.9)	
Sex Ratio				
Three strata (S, W and N)	0.602 (8)	0.505 (6)	0.40 (14.9)	
Spawning Fraction				
Three strata (S, W and N)	*0.081 (9)**	*0.066 (8)**	0.093 (34.4)	
Spawning Biomass (tons) (CV%)				
Model 2	47782 (49)	58730 (36)	21571 (53)	128087 (26)
Model 3	38994 (31)	67819 (32)	23882 (49)	130700 (21)

* Values estimated by bootstrap (WGACEGG 2012)

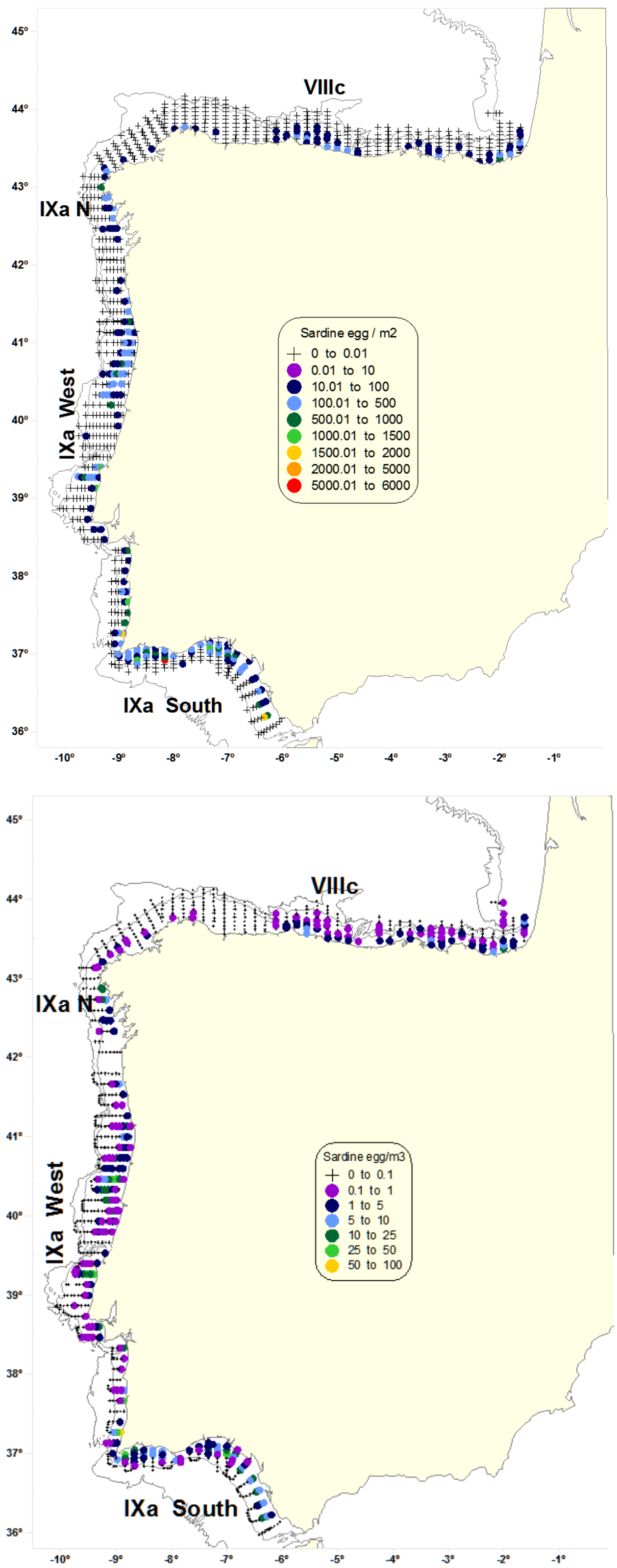


Figure 1. Sardine egg distribution. Upper panel: Egg/m^2 from PairoVET sampling; lower panel: Egg/m^3 from CUFES sampling; (+, egg absence).

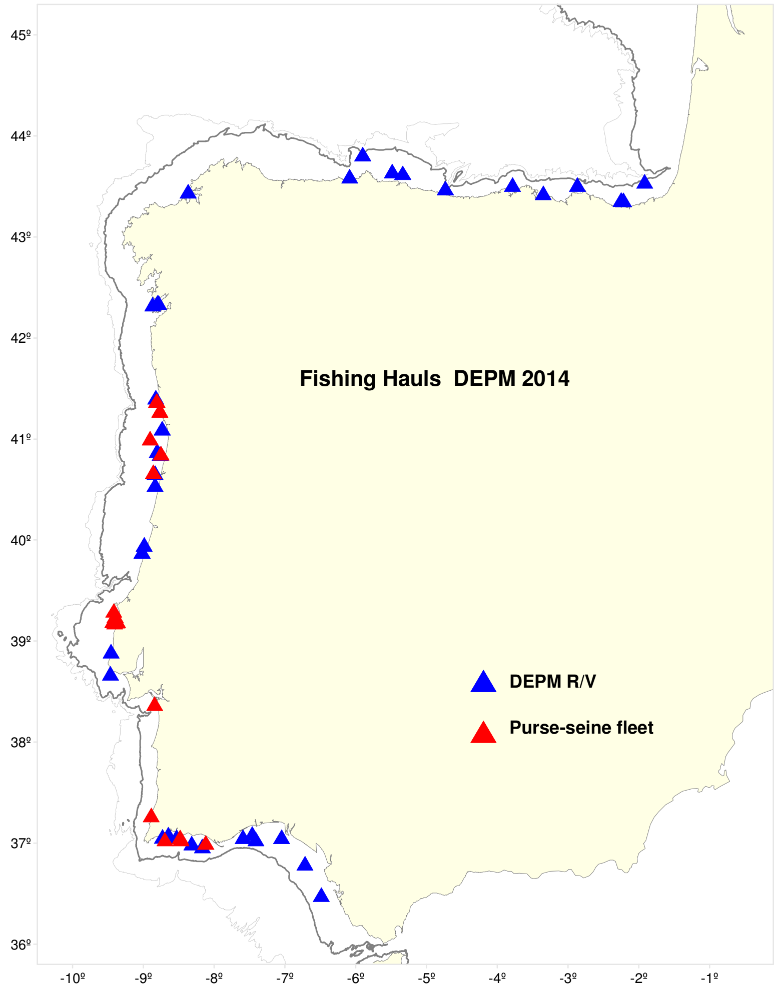


Figure 2. Spatial distribution of positive fishing hauls. Hauls with sardine presence from commercial purse-seine fleet (red triangles) and from research vessels (blue triangles).

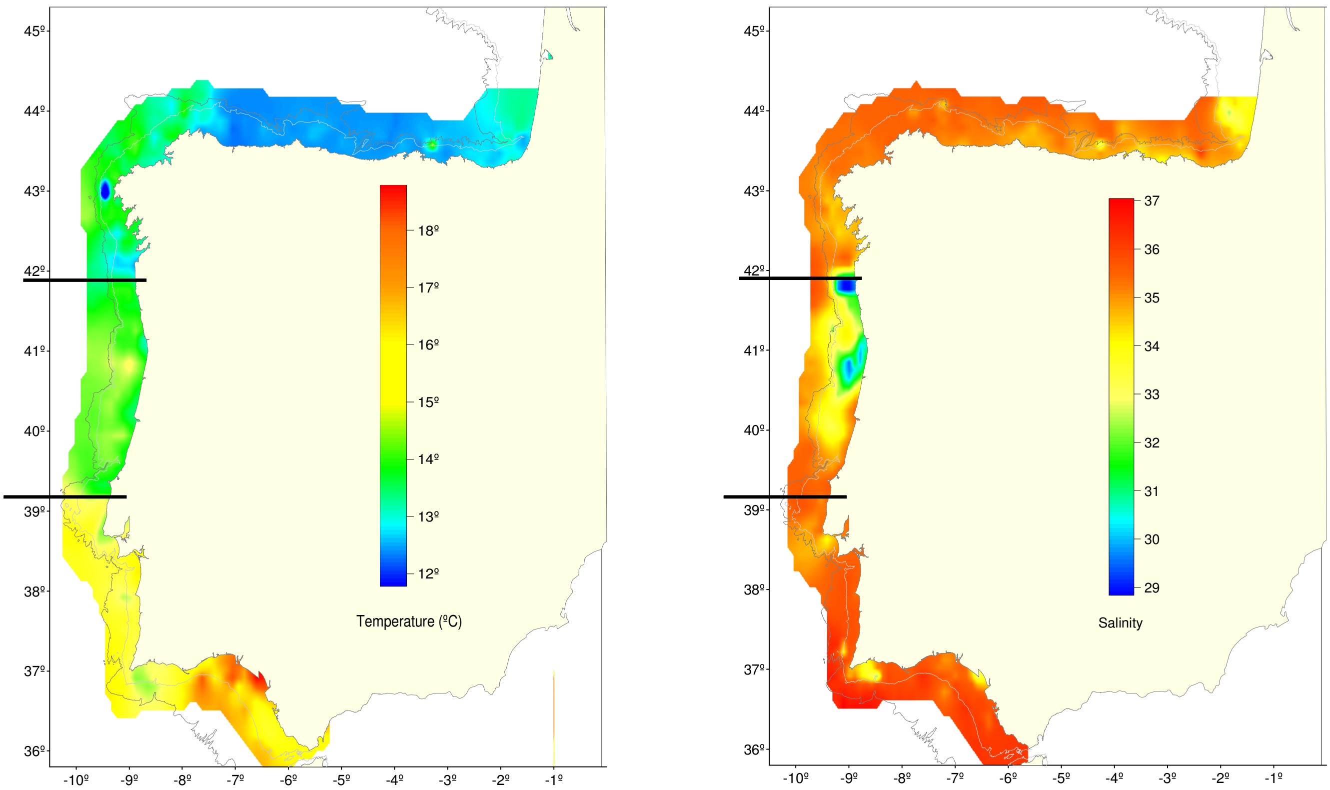


Figure 3. Distribution of sea surface temperature (left) and salinity (right).

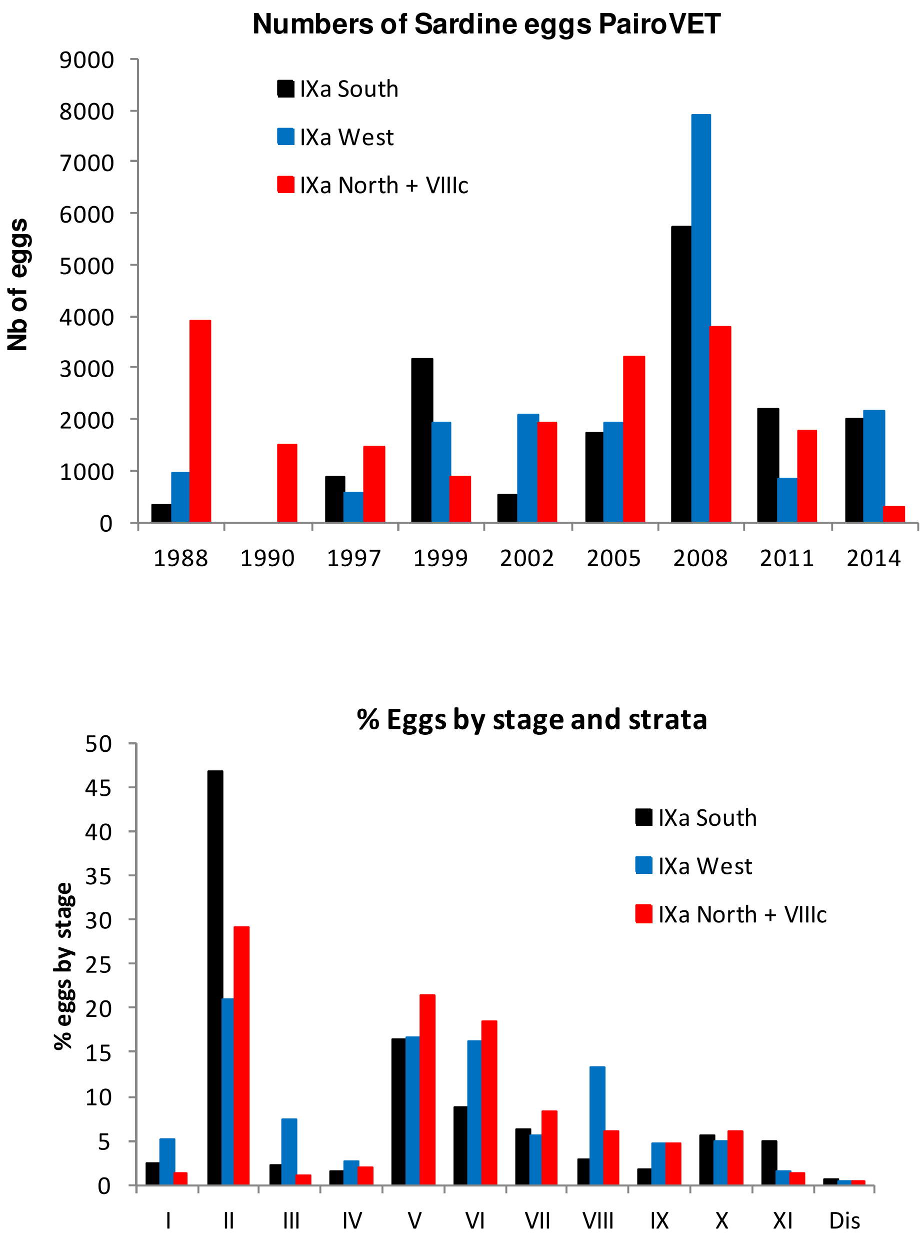


Figure 4. Number of sardine eggs (total eggs) counted by strata from CalVET sampler (upper pannel) and percentage of egg by development stages (lower panel). South (IXa S) in black, West (IXa W) in blue and North (IXa N + VIIIc) in red.

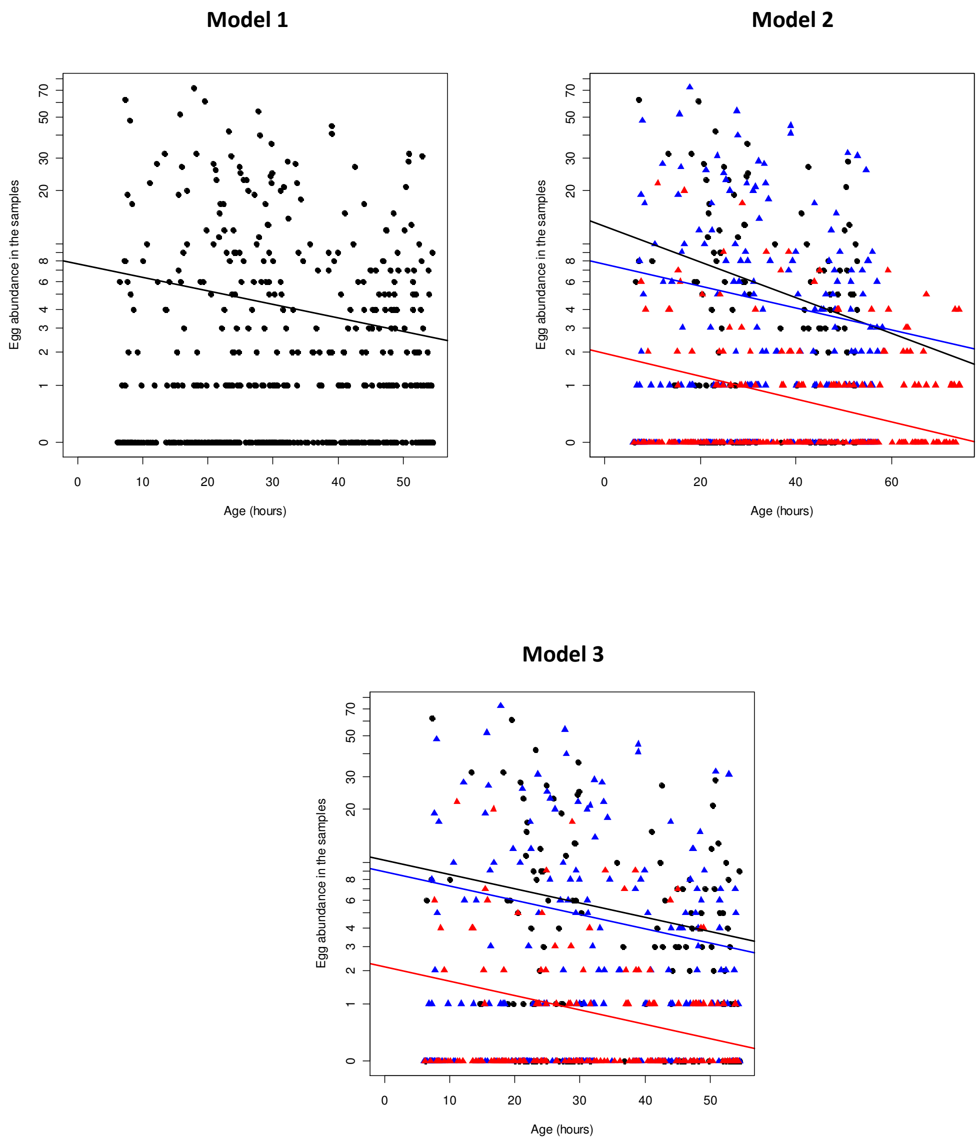
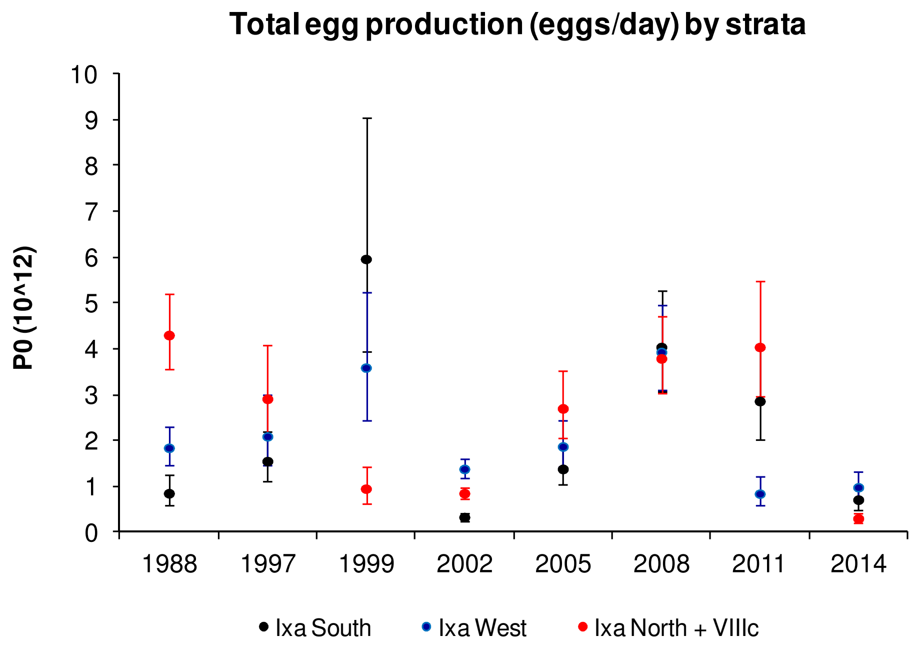


Figure 5. Abundance by age of eggs in the three spatial strata (black = south, blue = west, red = north) and its corresponding fitted mortality curve. Note that southern, western and northern mortality curves were forced to have a common slope (mortality) in Model 3



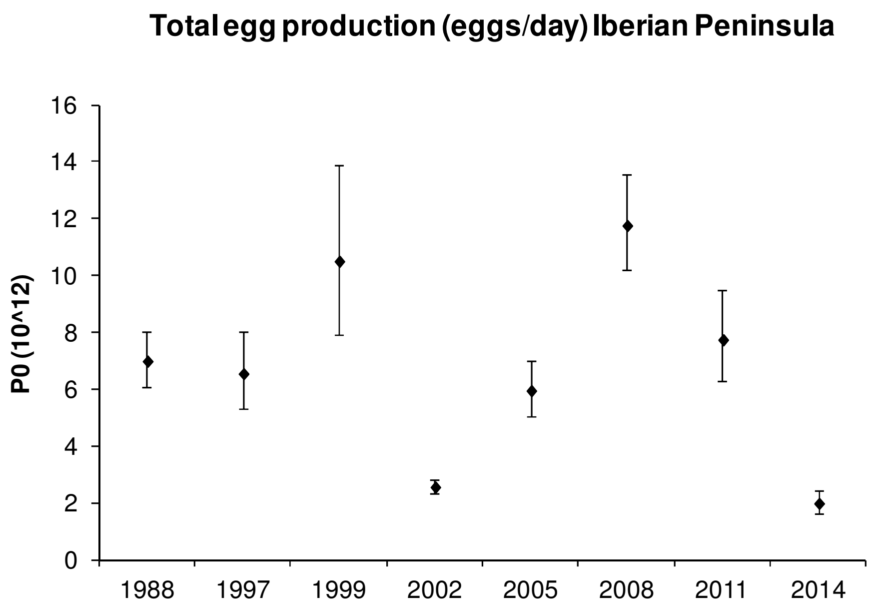
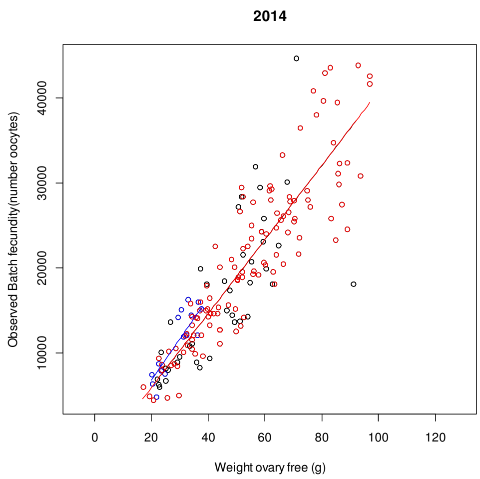
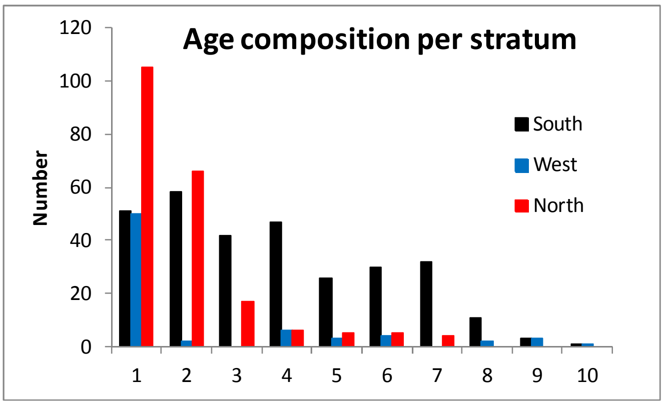


Figure 6. Total egg production (eggs/day*10^{12}) by spatial strata (top panel); black – IXa South, blue - IXa West , red – IXa North + VIIIc and for the total stock area off the Iberian Peninsula (bottom panel). Dots and lines indicate the estimates of egg production and their confidence intervals.




```
init.theta = 21.4605608)
Deviance Residuals:
    Min       1Q    Median       3Q      Max
-2.9682  -0.6637  -0.1172   0.5258   2.3213
Coefficients:
              Estimate Std. Error z value Pr(>|z|)
(Intercept)   -2834.42     595.58  -4.759 1.94e-06 ***
Wnov:Stratum1   436.16      20.12  21.676  < 2e-16 ***
Wnov:Stratum2   481.54      30.51  15.785  < 2e-16 ***
Wnov:Stratum3   436.35      15.57  28.017  < 2e-16 ***
 (Dispersion parameter for Negative Binomial(21.4606)
family taken to be 1)
    Null deviance: 950.29  on 171  degrees of freedom
Residual deviance: 173.35  on 168  degrees of freedom
  (3152 observations deleted due to missingness)
AIC: 3321.7
Number of Fisher Scoring iterations: 1
              Theta:  21.46 Std. Err.:  2.30
2 x log-likelihood:  -3311.728
```

Figure 7. Observed batch fecundity vs. gonad free weight of the hydrated females, the regression line of the corresponding model for the three geographical areas (black: South stratum, blue: West stratum, red: North stratum) (left panel) and results of the GLM obtained (right panel).



Females sampled randomly

Figure 8. Age composition per stratum of the female sardine sampled during the surveys (only considered the fish randomly sampled).

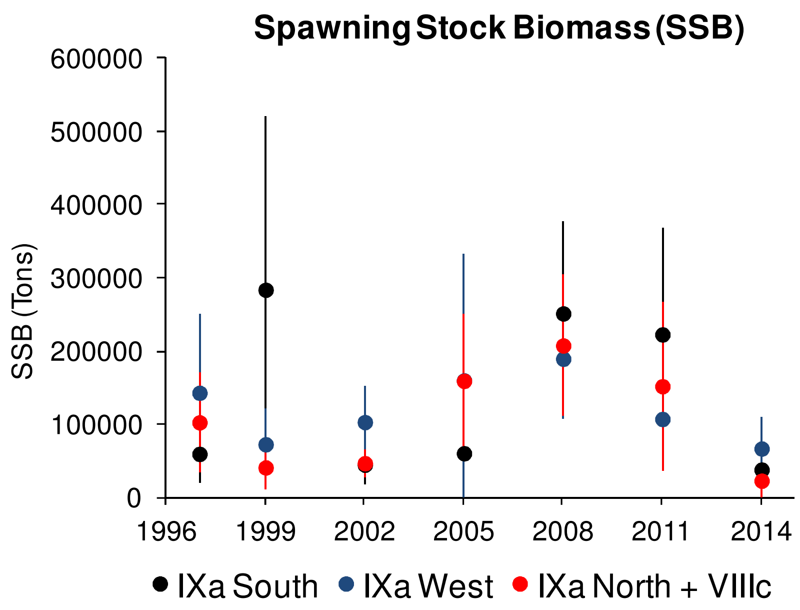


Figure 9. Spawning Stock Biomass (Tons) by spatial strata; black – IXa South, blue - IXa West , red – IXa North + VIIIc. Dots and lines indicate the estimates of SSB and their confidence intervals.

Working Document to be presented to the WGACEGG, Vigo, 17-21 Nov 2014

Acoustic survey carried out from 3 April to 12 May 2014 off the Portuguese Continental Waters and Gulf of Cadiz, onboard RV "Noruega"

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ABSTRACT

The main results of the Portuguese acoustic survey directed to sardine and anchovy estimates in ICES sub area IX show a reduction in sardine biomass. The sardine biomass was the lowest of the time series, following the tendency of the last years. In the Occidental south zone (OCS), the estimated biomass was very low (8 thousand tonnes). Age 1 was predominant in the survey area although the absolute number was low, indicating a low 2013 recruitment. Sardine egg distribution from CUFES surveying show a spawning area and densities slightly higher than during the last survey. The egg distribution in the southern and northwestern shores matched fairly the sardine acoustic energy mapping.

The anchovy abundance suffered a reduction in the West coast area. On the contrary in the South coast, anchovy biomass was higher, in relation to the last survey, in 2013. Age 1 anchovy was predominant in the West coast. Concerning Southern areas (Algarve and Cadis Bay) anchovy otoliths ageing still rise some difficulties due to their less clear structures than in the remaining areas, rising the need for an intercalibration between the Portuguese IPMA and the Spanish IEO-Cadiz readers. This action is being prepared to be undertaken this year and therefore, it was not considered as appropriate the inclusion of these ageing results in this document.

The 2014 spring acoustics survey took place one month later than planned and lasted longer than usual, and was interrupted several times due to bad weather and ship technical problems.

INTRODUCTION

This paper presents the main results of the Portuguese acoustic survey carried out from 3 April to 12 May, onboard R. V. "Noruega". The objectives of the survey were to estimate the spatial distribution and the abundance of sardine (*Sardina pilchardus*) and anchovy (*Engraulis encrasicolus*) by length classes and by age groups, in the surveyed area. All the 69 planned acoustic tracks were performed. Fish egg and larvae distributions, and surface, temperature, salinity and fluorescence were also monitored along the acoustics track. Exceptionally in 2014, part of the DEPM survey was conducted together with the acoustic survey. PNAB/EU Data Collection/DCF Programme supports the acoustics and the DEPM surveys.

MATERIAL AND METHODS

Survey execution and abundance estimation followed the methodologies adopted by the ICES WGACEGG. The survey area, over the shelf until the 200 m isobath, was covered following a parallel grid with a mean distance between transects of 8 nautical miles. Average survey speed was 8 knots and the acoustic signals were integrated over one nautical mile intervals. Echo integration was carried out with a Simrad 38 kHz EK500 scientific echo sounder. The acoustic data was recorded in MOVIES+ (Weill *et al*., 1993), which was also used to integrate the fish acoustic energy. The echogram bottom was manually corrected prior to the acoustic energy extraction. In the beginning of the survey, an acoustic calibration with a copper sphere was carried out, following the standard procedures (Foote *et al.*, 1981). For presentation purposes and results comparison, the surveyed area was divided, as usual, into 4 sub-areas or regions: OCN (from Caminha to Nazaré), OCS (from Nazaré to Cape S. Vicente), Algarve (from Cape S. Vicente to V. R. Santo António) and Cadiz (from V. R. Santo António to Cape Trafalgar).

To collect the biological data, a pelagic and a bottom trawl were used. The trawl samples were also used to identify the species and to split the acoustic energy by species and by length, within each species. Fishing was carried out according to the echogram information. Nevertheless, due to the presence of fixed commercial fishing gears it was not always possible to make hauls in some areas. Biological sampling of sardine and anchovy was performed in each haul. Sardine and anchovy otoliths were collected and used for age reading and for the production of the Age Length Keys (ALK's). For each species, the abundance (x 1 000) by age group and area was estimated from the combination of the ALK and the estimates of abundance at length from the echointegration in each area.

Fish egg and larvae were collected using the CUFES system (335 µm mesh net). The water was pumped, from 3 m depth, underway along the acoustics transects; plankton samples were taken every 3 miles. Concurrently, data on surface temperature, salinity and fluorescence were acquired by the sensors associated to the CUFES sampler and GPS information gathered from the vessel system; compilation was carried out using the EDAS software.

In 2014, exceptionally, due to logistical and technical issues with the research vessel that delayed the DEPM survey, part of the DEPM survey was undertaken simultaneously to the acoustic surveying. The CalVET plankton samples were collected after the daily acoustic observations, and the trawling results used for both surveys.

RESULTS

Trawl hauls

During the survey 44 trawl hauls were performed (Figure 1); 22 of these hauls had sardine sampled and 9 of them had anchovy sampled. Sardine was usually captured together with other pelagic species, being the most abundant chub mackerel (*Scombrus colias*), horse mackerel (*Trachurus trachurus*) and bogue (*Boops boops*). Off the south coast, some mediterranean horse mackerel (*Trachurus mediterraneus*) and blue jack mackerel (*Trachurus picturatus*) were also found. Anchovy was mainly found off Cadiz Bay, but it was also found, in less quantity, in the west coast, from Matosinhos to Figueira da Foz.

Spatial Distribution

Sardine

As seen in Figure 2, sardine was distributed mainly in the OCN zone and in the South (Algarve and Cadiz Areas). In the Southwest area sardine was not detected and only a few individuals were fished.

Anchovy

Anchovy was distributed mainly in the Algarve and Cadiz zones, sharing the space with other pelagic species (Figure 1). In the remaining area, anchovy was practically absent, with the exception of an area, off the North coast, from Matosinhos to Figueira da Foz.

Abundance estimates

Sardine

The estimated biomass for the Portuguese coast was 57 thousand tonnes corresponding to 2297 million individuals, the lowest value in the survey series (Table 1 and 2). In the OCS area the sardine estimated abundance was very low (8 thousand tonnes; 244 million individuals), and was found mixed with other pelagic species. On the contrary in the OCN area, sardine recovered from the minimum value found in the last year survey; the sardine biomass increased up to 29 thousand tonnes, corresponding to 1697 million individuals. Algarve showed also a recovery in the sardine abundance, with an estimation of 20 thousand tonnes (356 million individuals). The sardine abundance in Cadiz also recovered, in comparison with the 2013 survey (44 thousand tonnes; 1260 million individuals).

Anchovy

The total anchovy biomass estimated was 31 thousand tonnes (2371 x 10^6 individuals), and was mainly found in Cadiz, were the abundance doubled in relation to the last survey. On the contrary, in the West coast, the anchovy biomass declined to 1.9 thousand tonnes (130 x 10^6 individuals).

Anchovy with age 1 to 4 years was found in the West coast and the modal age was 1 year.

SARDINE LENGTH AND AGE STRUCTURE

The sardine length structure in the OCN area was bimodal (9 cm and 15 cm mode), with juveniles (individual total length ≤ 16 cm) contributing with 92%. In the OCS zone the length structure was roughly unimodal; 56 % of sardines in the OCS area were juveniles. In Algarve the sardine length distribution was trimodal with modes at 17cm, 19cm and 21 cm. In this area only 3% of the individuals were considered juveniles. In the Cadiz area, juveniles represented 61% of the sardine abundance estimated for this area (Figure 2).

Age 1 is predominant in all areas. However, the total abundance of age 1 fish (2828 thousand fish), corresponding to the survivors of the 2013 cohort, is 13% of the abundance of the 2004 strong cohort at the same age.

ENVIRONMENTAL SETTING

Surface temperature, salinity and fluorescence and location of the CUFES samples are shown in figure 6. In 2014, due to weather conditions and logistical constraints the survey was not carried out continuously in one same direction from start to finish, hence some, non synoptic, particular patterns may have been captured. The region of western Algarve was surveyed following days of fairly strong northwesterly and westerly winds (generating colder waters), as surveying progressed to the east, the weather improved (and the shore is less exposed to NW winds) and surface waters were warmer; the shallower shelf waters of the inner Cadiz Bay were warmer and with higher phytoplankton density. The southwestern region, up to Lisbon, was also surveyed during very mild atmospheric conditions. In contrast, the northwestern shelf was occupied during a period of intermittent northerly wind events that induced upwelling, lowering the temperature in the coastal strip; associated to these events higher phytoplankton production was detected and large volumes of zooplankton were observed. Globally the water temperatures were within the range observed for this period of the year, nonetheless the southern coast water temperatures were lower than during other recent spring surveys. Sections for temperature, salinity and fluorescence were obtained along the acoustic/DEPM transects since surveying was carried jointly for both surveys for the majority of the study area. The water structure patterns observed over the shelf were the characteristic for the region during this period of early spring. In figure 7 a few selected sections are shown to exemplify the conditions encountered; the river plumes are very clear and also an associated phytoplankton layer is visible in the more southern transects.

EGG DISTRIBUTION

The ichthyoplankton results from CUFES sampling are not yet fully available since priority had to be directed at processing the sardine DEPM samples (CalVET) that were in 2014 collected much later than usual. The CUFES results presented here (figure 8) were carried out in the south during the same period as the acoustic surveying (4-20, 25-26 Apr) while the results for the northwestern region were obtained earlier, during the second half of March (15-21), when the first leg of the DEPM took place, and therefore not contemporaneous to acoustics. Despite the time lag between surveying in the northern region, sardine eggs and adults were mainly observed in the area between Cabo Mondego and river Douro, where the distributions overlapped fairly well. Also, south of Cabo Carvoeiro and in the southern coast, Algarve and Cadiz Bay, eggs and fish schools occurred in parallel; the exception occurred in the southwestern region where sardine eggs are regularly observed but sardine schools rarely spotted. Sardine egg densities and spawning area were slightly higher than during the previous survey but still there was a considerable area of the northern platform where no eggs were collected. Anchovy eggs were mainly observed in the vicinity of the rivers Tagus, in the western coast, and off the coast between Guadiana and Guadalquivir. Fish eggs of other species were observed over the entire shelf surveyed. It is also noticeable that the surface plankton volume (displacement volume) observed in the southern region was much higher than over the northern shores, this fact may be due to an early start of spring conditions in the south or simply because the time lag between surveying in both coasts allowed such apparent mismatch in the plankton bloom.

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Table 1 – Sardine: Abundance (million) in each zone, Portugal and total area, for the acoustic surveys carried out between April 2005 and April 2014.

Survey	OCN	OCS	Algarve	Cadiz	Portugal	Total Area
SAR05ABR	16900	5900	1200	1229	24000	25229
SAR05NOV	16622	863	333	-	17818	-
SAR06ABR	9514	2856	716	3399	13086	16485
SAR06NOV	4577	1602	635	1317	6814	8131
PELAGO07	4181	1924	690	2077	6795	8873
SAR07NOV	4634	2141**	180***	2733	6955	9688
PELAGO08	3303	1493	472	1763	5268	7031
SAR08OUT	3962	555	9	3529	4526	8055
PELAGO09	5095	2589	275	1570	7959	9529
PELAGO10	4481	922	530	2928	5933	8861
PELAGO11	1889	397	465	71	2751	2821
PELAGO13	255	1575	197	493	3978	4471
PELAGO14	1697	244	356	1260	2297	3557

** the area between Capes Espichel and S. Vicente was not covered.

*** part of Algarve was not covered

Table 2 – Sardine: Biomass (thousand tonnes) in each zone, Portugal and total area, for the acoustic surveys carried out between April 2005 and April 2014.

Survey	OCN	OCS	Algarve	Cadiz	Portugal	Total Area
SAR05ABR	286	199	62	40	547	587
SAR05NOV	458	34	12	-	504	-
SAR06ABR	370	138	40	89	548	637
SAR06NOV	257	69	27	58	353	411
PELAGO07	215	89	40	107	344	452
SAR07NOV	258	114**	11***	133	384	517
PELAGO08	170	13	26	35	209	244
SAR08OUT	121	36	0.6	149	158	307
PELAGO09	112	84	14	84	210	294
PELAGO10	125	43	11	26	179	205
PELAGO11	90	15	20	2	125	127
PELAGO13	9	72	9	21	90	112
PELAGO14	29	8	20	44	57	101

** the area between Capes Espichel and S. Vicente was not covered.

*** part of Algarve was not covered

Table 3 – Anchovy: estimated abundance (billion) for the West coast, South coast (Algarve + Cadiz) and total area, for the acoustic surveys carried out between April 2005 and April 2014.

Survey	West	Alg+Cadiz	TOTAL
April 2014	130	2241	2371
April 2013	251	896	1147
April 2011	1558	0	1558
April 2010	62	963	1025
April 2009	127	2069	2196
April 2008	321	2032	2353
April 2007	103	3144	3247
April 2006	0	2247	2247
April 2005	59	1306	1365

Table 4 – Anchovy: estimated biomass (tonnes) for the West coast, South coast (Algarve + Cadiz) and total area, for the acoustic surveys carried out between April 2005 and April 2014.

Survey	West	Alg+Cadiz	TOTAL
April 2014	1947	28917	30864
April 2013	3955	12700	16655
April 2011	27050	0	27050
April 2010	1188	7395	8583
April 2009	2000	24800	26800
April 2008	5500	34200	39700
April 2007	1945	38020	39965
April 2006	0	24082	24082
April 2005	1062	14041	15103

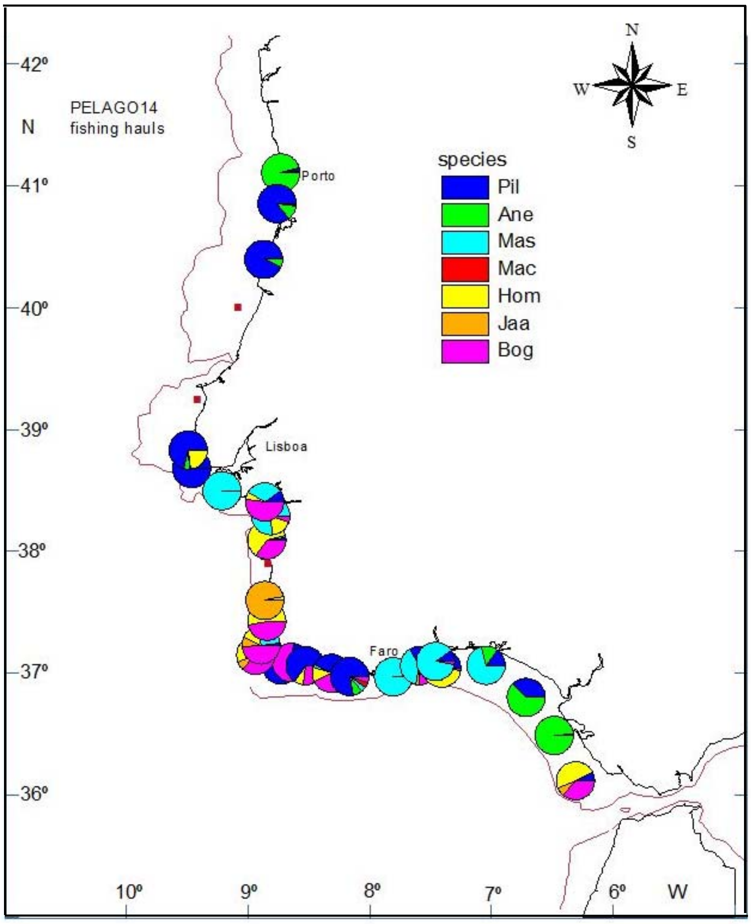

Figure 1 - Fishing trawl location and haul species composition (in number).

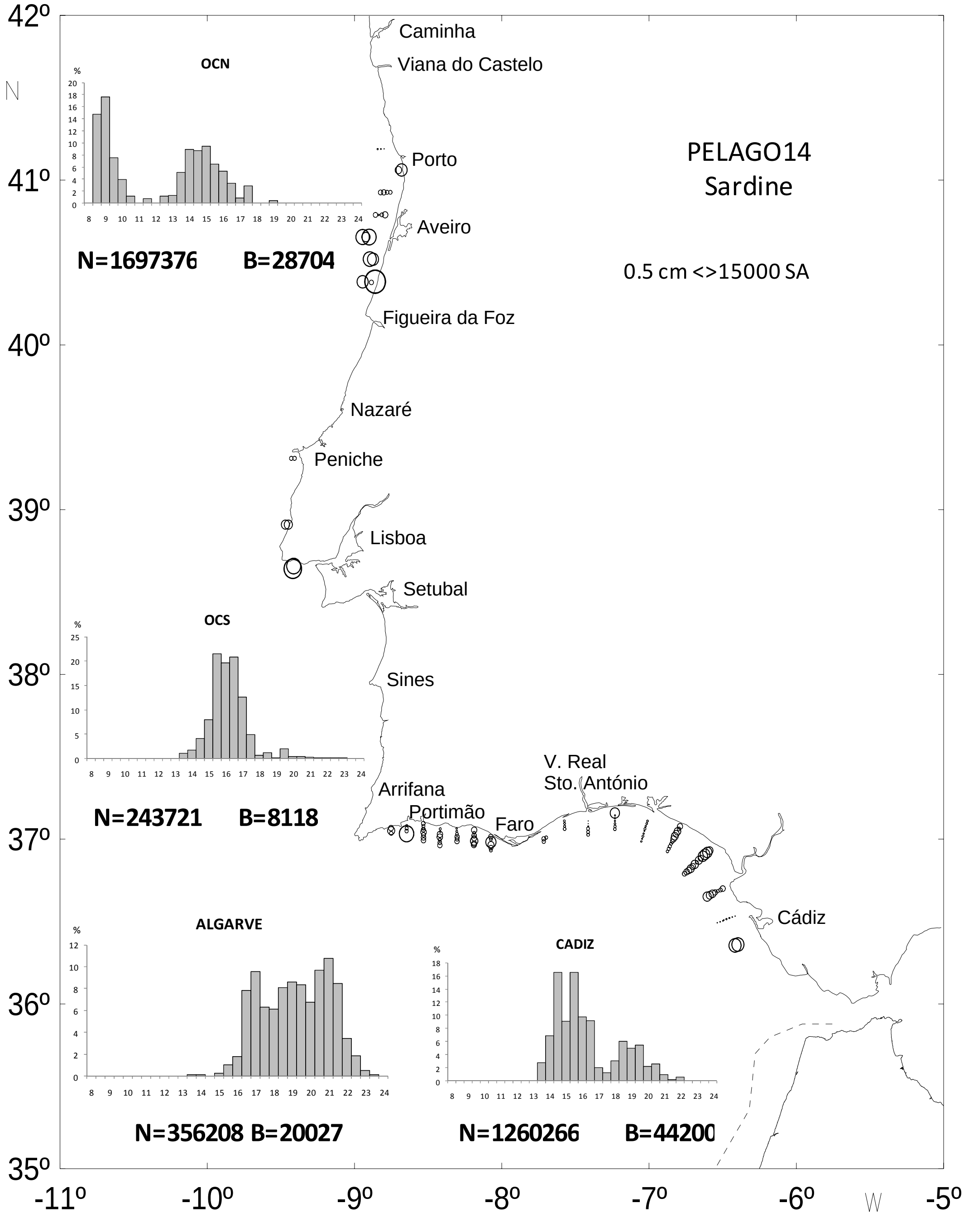

Figure 2 – Sardine acoustic energy spatial distribution. Circle area is proportional to the acoustic energy (S_A m^2/nm^2). Sardine abundance and length structure for each zone.

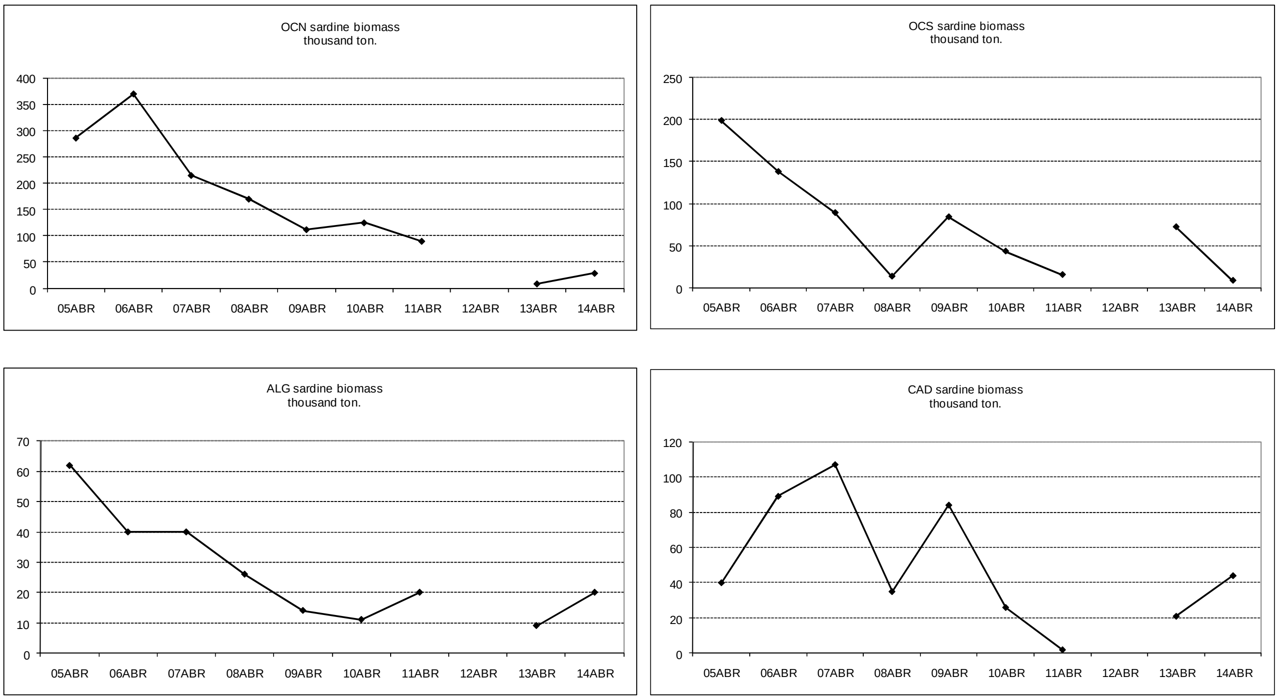

Figure 3 – Sardine biomass evolution for each zone, along the acoustic spring survey series, since 2005.

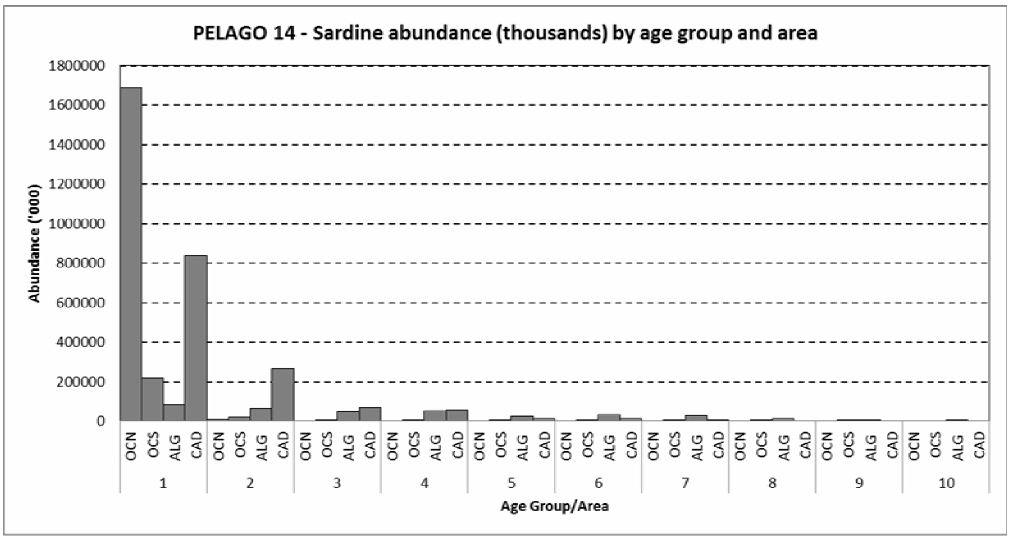

Figure 4 – Sardine abundance (x1000) per age group, for each zone.

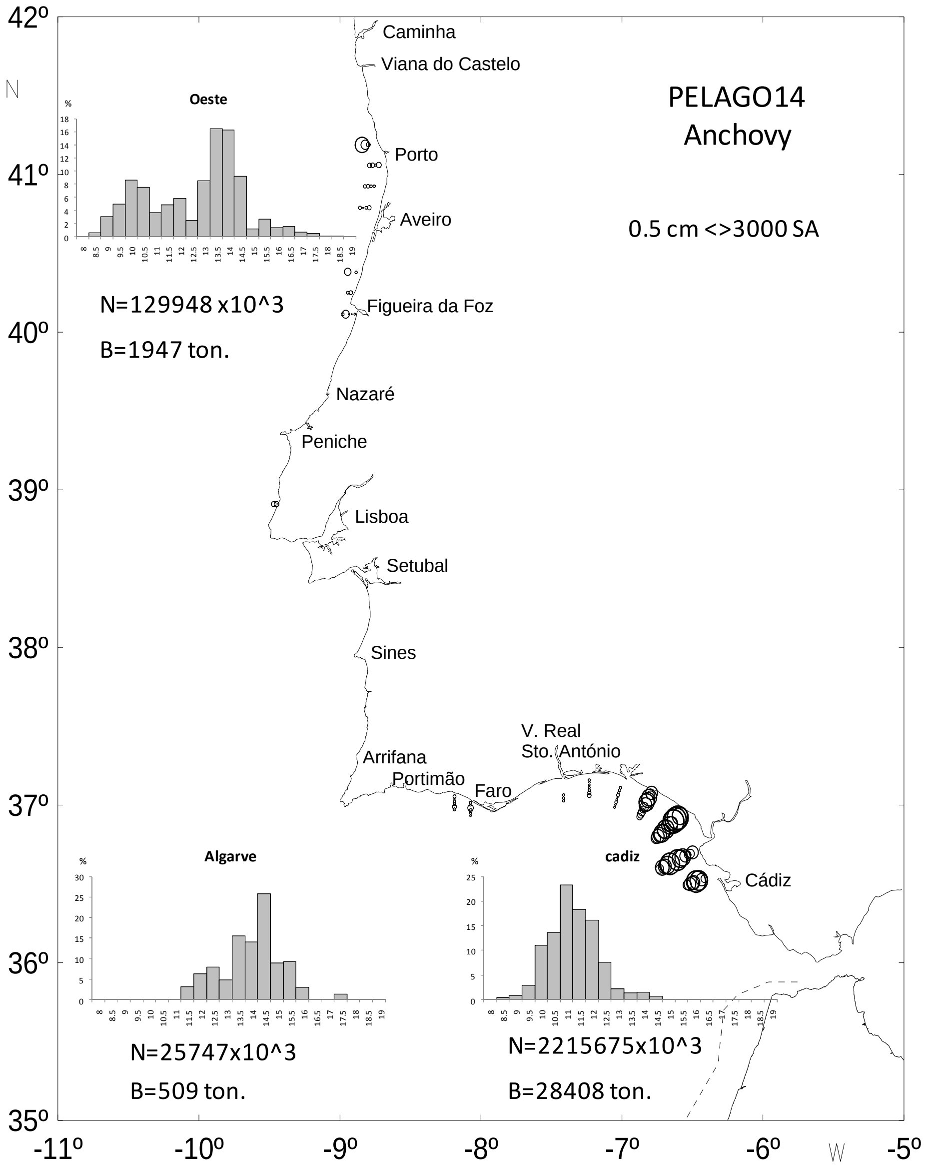

Figure 5 – Anchovy acoustic energy spatial distribution. Circle area is proportional to the acoustic energy (S_A m^2/nm^2). Anchovy abundance and length structure for the West coast, Algarve and Cadiz.

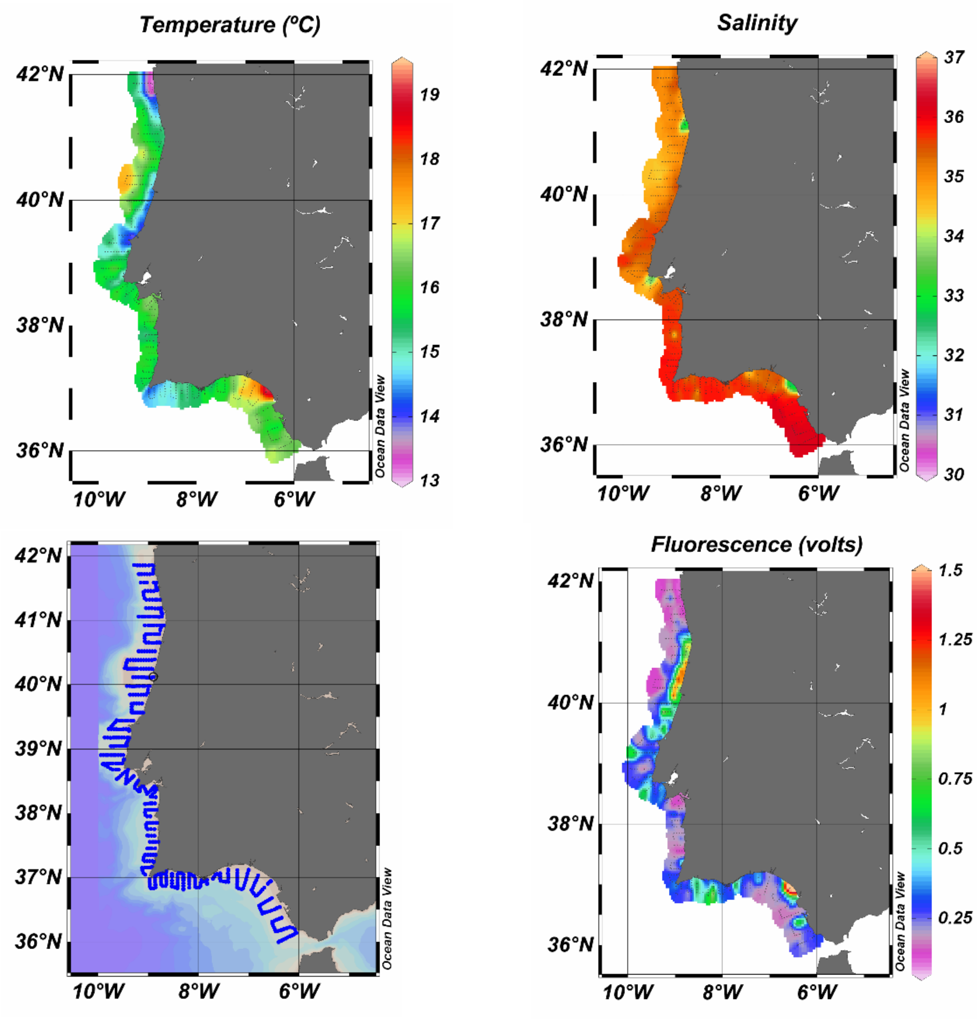

Figure 6. Surface temperature (top left), salinity (top right), fluorescence (bottom right) distributions and zooplankton samples location (bottom left); information collected by the CUFES system and associated CTF sensors, (4-20, 25-26 April, 3-12 May)

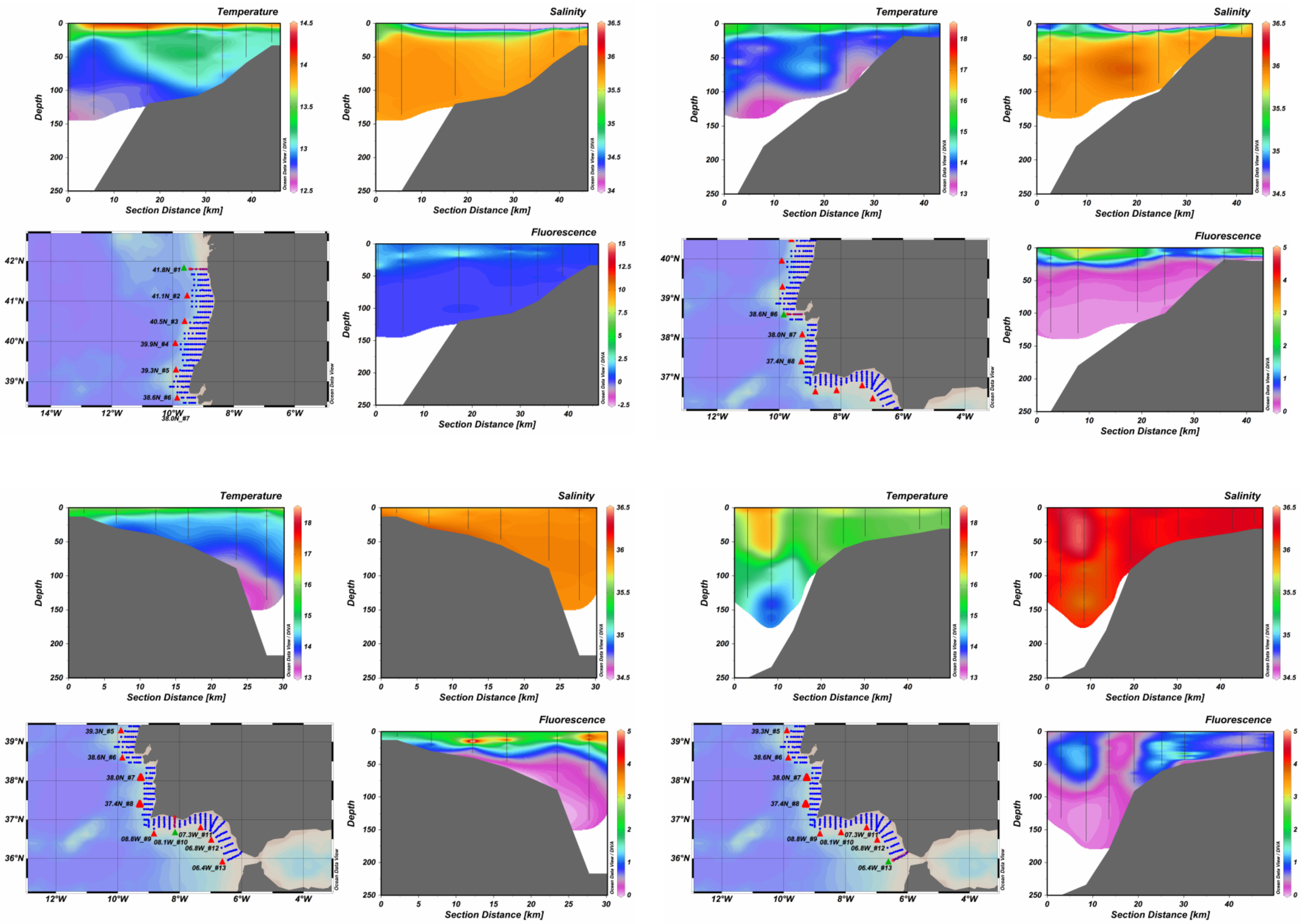

Figure 7. Temperature, salinity and choroplyll sections for 4 selected transects along the area surveyed. Top left panels, section at 41.8ºN; top right panels, section at 38.6ºN; bottom left panels, section at 8.1ºW and bottom right panels, section at 6.4ºW.

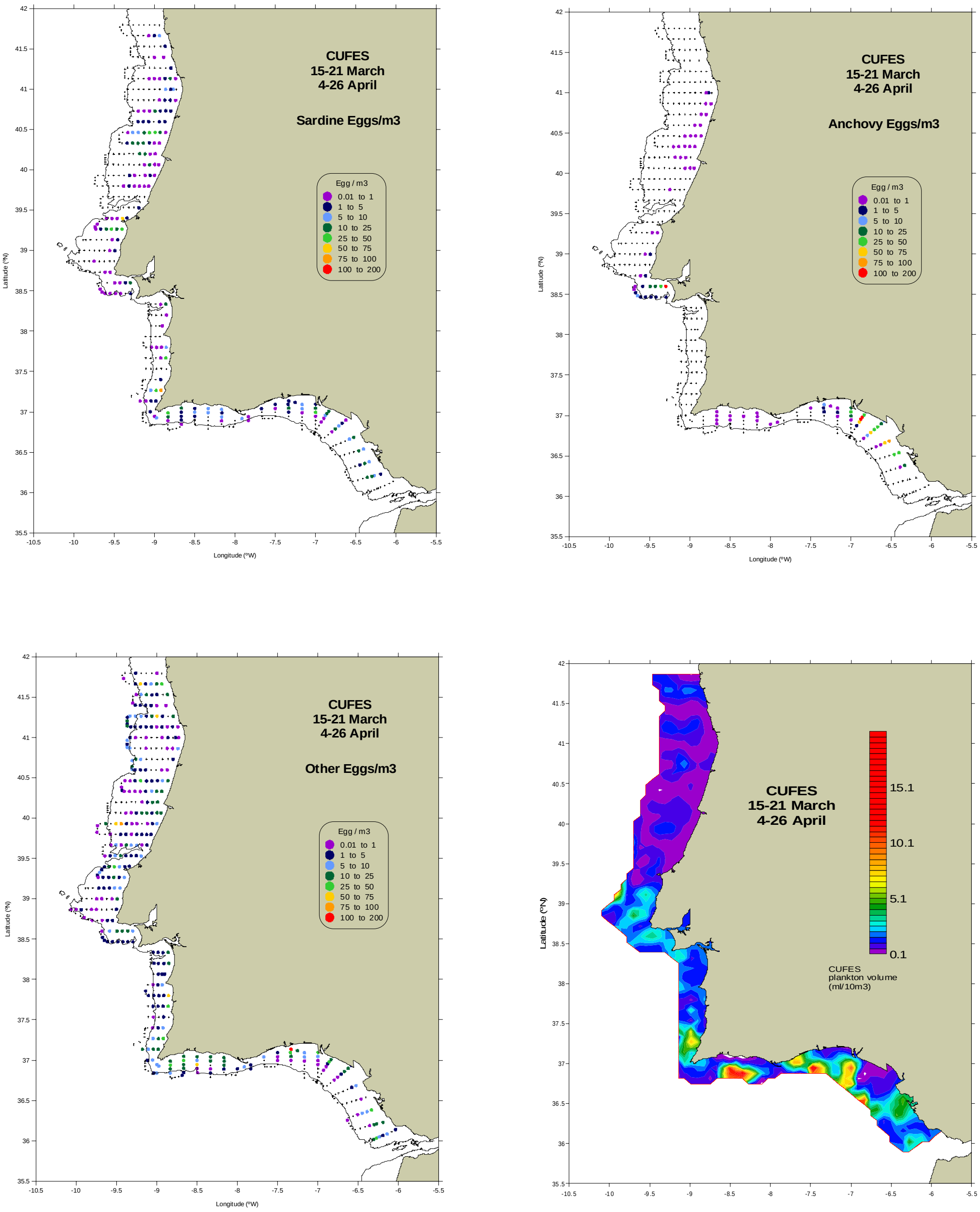

Figure 8. Egg and plankton volume distributions derived from CUFES observations. Sardine egg (eggs/m^3), top left panel; anchovy eggs (eggs/m^3) top right panel, other fish eggs (eggs/m^3), bottom left panel and plankton volume (displacement volume, ml/10m^3).

Working document presented in the:
ICES Working Group on Southern Horse Mackerel, Anchovy and Sardine (WGHANSA). Copenhagen, Denmark, 20-25 June 2014.
ICES Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VII, VIII and IX (WGACEGG). Vigo, Spain, 17-21 November 2014.

Acoustic assessment and distribution of the main pelagic fish species in the ICES Subdivision IXa South during the *ECOCADIZ 0813* Spanish survey (August 2013).

By

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ABSTRACT

The present working document summarises the main results from the Spanish (pelagic ecosystem-) acoustic survey conducted by IEO between 2nd and 13th August 2013 in the Portuguese and Spanish shelf waters (20-200 m isobaths) off the Gulf of Cadiz onboard the R/V "*Cornide de Saavedra*". The survey dates were somewhat delayed in relation to the usual ones and to the anchovy (*Engraulis encrasicolus*) peak spawning as well. Abundance and biomass estimates are given for all the mid-sized and small pelagic fish species susceptible of being acoustically assessed according to their occurrence and abundance levels in the study area. The distribution of these species is also shown from the mapping of their back-scattering energies. The bulk of the anchovy population was concentrated in the Spanish shelf, with a residual nucleus to the west of Cape Santa Maria. A delay of the usual survey dates may be the reason of a higher relative importance of smaller anchovies in the population as a probable consequence of the incorporation of the first waves of recently recruited juveniles to the adult population. The total biomass estimated for anchovy was 8.5 thousand tonnes (609 million fish), the lowest estimate in its series. Sardine showed a distribution pattern almost complementary to that described for anchovy, with higher densities occurring over the inner-middle shelf of both extremes of the surveyed area, mainly west to Cape Santa Maria, and in shallower waters than anchovy. Sardine yielded a total of 9.7 thousand tonnes (232 million fish). The 2013 sardine estimate was also the lowest one in its series and corroborates a clear recent decline in the population which has also been evidenced by the *PELAGO* surveys. Chub mackerel was present all over the surveyed area although showed a more "oceanic" distribution in the westernmost waters. The species was the most important in terms of assessed biomass, rendering estimates of 31.3 thousand tonnes (333 million fish). 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 in the study area during the survey.

INTRODUCTION

ECOCADIZ surveys constitute a series of yearly acoustic surveys conducted by IEO in the Subdivision IXa South (Algarve and Gulf of Cadiz, between 20 – 200 m depth) under the "pelagic ecosystem survey" approach onboard R/V *Cornide de Saavedra*. This series started in 2004 with the *BOCADEVA 0604* pilot acoustic - anchovy DEPM survey. The following surveys within this new series (named *ECOCADIZ* since 2006 onwards) are planned to be routinely performed on a yearly basis, although the series, because of the available ship time, has shown some gaps in those years coinciding with the conduction of the (initially triennial) anchovy DEPM survey (the true *BOCADEVA* series, which first survey started in 2005).

Results from the *ECOCADIZ* series are routinely reported to ICES Expert Groups on both stock assessment (formerly in WGMHSA, WGANC, WGANSA, at present in WGHANSA) and acoustic and egg surveys (WGACEGG).

The present Working Document summarises the main results from the *ECOCADIZ 0813* survey. After conducting this survey the RV *Cornide de Saavedra* was definitively out of service.

MATERIAL AND METHODS

The *ECOCADIZ 0813* survey was carried out between 2nd and 13th August 2014 onboard the Spanish R/V *Cornide de Saavedra* covering a survey area comprising the waters of the Gulf of Cadiz, both Spanish and Portuguese, between the 20 m and 200 m isobaths. The survey design consisted in a systematic parallel grid with tracks equally spaced by 8 nm, normal to the shoreline (**Figure 1**).

Echo-integration was carried out with a *Simrad™ EK60* echo sounder working in the multi-frequency fashion (18, 38, 70, 120, 200 kHz). Average survey speed was between 7.5 - 8 knots (see below) and the acoustic signals were integrated over 1-nm intervals (ESDU). Raw acoustic data were stored for further post-processing using *Myriax Software Echoview™* software package (by *Myriax Software Pty. Ltd.,* ex *SonarData Pty. Ltd.*). Acoustic equipment was previously calibrated during the *MEDIAS 07 2013* acoustic survey, a survey conducted in the Spanish Mediterranean waters just before the *ECOCADIZ* one, following the standard procedures (Foote *et al*., 1987).

Vessel self-noise tests and the revision/calibration of the *Scanmar* depth sensor were carried out on 2nd August after the finalization of the acoustic sampling and fishing hauls. Vessel self-noise tests were carried out with only one of the two R/V engines, since it was agreed to conduct the survey with only one engine in order to save fuel. With only one engine the maximum speed achievable by this R/V is of 8.6 knots (with good weather and sea conditions), or even decrease up to 7 knots with bad sea conditions.

Survey execution and abundance estimation followed the methodologies firstly adopted by the ICES *Planning Group for Acoustic Surveys in ICES Sub-Areas VIII and IX* (ICES, 1998) and the recommendations given more recently by the *Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES areas VIII and IX* (WGACEGG; ICES, 2006a,b).

Fishing stations were opportunistic, according to the echogram information, and they were carried out using a ca. 16 m-mean vertical opening pelagic trawl (*Tuneado* gear) at an average speed of 4 knots. Gear performance and geometry during the effective fishing was monitored with *Simrad™ Mesotech FS20/25* trawl sonar. Trawl sonar data from each haul were recorded and stored for further analyses.

Length frequency distributions (LFD) by 0.5-cm class were obtained for all the fish species in trawl samples (either from the total catch or from a representative random sample of 100-200 fish). Only those LFDs based on a minimum of 30 individuals and showing a normal distribution were considered for the purpose of the acoustic assessment.

Individual biological sampling (length, weight, sex, maturity stage, stomach fullness, mesenteric fat content) was performed in each haul for anchovy, sardine (in both species with otolith extraction), mackerel and horse-mackerel species, and bogue.

The following TS/length relationship table was used for acoustic estimation of assessed species (recent IEO standards after ICES, 1998; and recommendations by ICES, 2006a,b):

Species	**b_{20}**
Sardine (*Sardina pilchardus*)	-72.6
Round sardinella (*Sardinella aurita*)	-72.6
Anchovy (*Engraulis encrasicolus*)	-72.6
Chub mackerel (*Scomber japonicus*)	-68.7
Mackerel (*S. scombrus*)	-84.9
Horse mackerel (*Trachurus trachurus*)	-68.7
Mediterranean horse-mackerel (*T. mediterraneus*)	-68.7
Blue jack mackerel (*T. picturatus*)	-68.7
Bogue (*Boops boops*)	-67.0

Trawl samples provided biological data on species and they were also used to identify fish species and to allocate the back-scattering values into fish species according to the proportions found at the fishing stations (Nakken and Dommasnes, 1975). The *PESMA 2010* software (J. Miquel, unpublished) has got implemented the needed procedures and routines for the acoustic assessment following the above approach.

A *Continuous Underway Fish Egg Sampler* (CUFES), a *Sea-bird Electronics™ SBE 21 SEACAT* thermo-salinometer and a *Turner™ 10 AU 005 CE Field* fluorometer were used during the acoustic tracking to continuously monitor the anchovy egg abundance and to collect some hydrographical variables (sub-surface sea temperature, salinity, and *in vivo* fluorescence). Vertical profiles of hydrographical variables were also recorded by night from 146 CTD stations by using a *Sea-bird Electronics™ SBE 911+ SEACAT* profiler (**Figure 2**). Information on presence and abundance of sea birds, turtles and mammals was also recorded during the acoustic sampling by one onboard observer.

ECOCADIZ 0813 was also utilized this year as observational platform for the IFAPA (Instituto de Investigación y Formación Agraria y Pesquera)/IEO research project entitled *Ecology of the early stages of the anchovy life-cycle: the role of the coupled Guadalquivir estuary-coastal zone of influence in the species' recruitment process (ECOBOGUE)*. Thus, an *ad hoc* sampling grid of 4 stations including Carousel-CTD-LDCP, Bongo 40 and suprabenthic sledge samplings and 4 opportunistic Bongo 90 hauls were carried out in order to characterize the ichthyoplankton, mesozooplankton and suprabenthos species assemblages in the eastern sector of the study area (coastal area surrounding the Guadalquivir river mouth) and their relationships with environmental conditions (**Figure 3**).

RESULTS

Vessel self-noise tests

Results of the vessel self-noise tests (expressed in dB) are shown in the following enclosed table and revealed that the use of a single engine generated greater amount of self-noise than if the two vessel's engines were used. In any case, the tests' results advised to perform the acoustic sampling with a 40° blade pitch, equivalent to a speed of 8.6 knots.

Tests/Working freq.	18 kHz	38 kHz	70 kHz	120 kHz	200 kHz	Speed
Propeller: disengaged	-152	-158	-161	-163	-167	-
Propeller: engaged	-122	-144	-159	-165	-165	0.8
Blade pitch: 10°	-124	-144	-157	-163	-166	1.2
Blade pitch: 20°	-106	-119	-135	-146	-156	5.0
Blade pitch 30°	-110	-124	-140	-155	-163	7.0
Blade pitch: 40°	-115	**-130**	-143	-158	-164	8.6
Tacking to port	-115	-128	-145	-157	-165	-
Tacking to starboard	-116	-128	-145	-153	-164	-

Acoustic sampling

The acoustic sampling was carried out during the periods of 02 – 05 and 07 – 11 August (**Table 1**). The acoustic sampling started in the coastal end of the transect RA01 on 02 August towards the RA21. The acoustic sampling stopped on 06 August in order to dedicate that day to the sampling tasks of the *ECOBOGUE* project. Until 09 August the acoustic sampling started every day at 05:30 UTC. From then on (in the westernmost Algarve waters) the acoustic sampling started half an hour later. The whole 21-transect sampling grid was sampled. The foreseen start of transect RA09 by the coastal end had to be slightly displaced in order to avoid some tugs maneuvering in such shallow waters. As commented above, in order to save fuel, the acoustic sampling was carried out with only one of the two R/V engines. Such a limitation entailed navigation and acoustic sampling speeds of about 7,5 – 8 knots as an average, speeds quite lower than those ones considered as standard (10 knots). Lower speeds than the standard one negatively impacted in the progress of both the acoustic sampling and mainly in the number of fishing hauls per day (see below).

Groundtruthing hauls

Seventeen (17) fishing operations, 16 of them valid according to a correct gear performance and resulting catches, were carried out (**Table 1**, **Figure 4**). Such a number of fishing hauls was nearly the half of hauls that are usually carried out during a standard survey.

As usual in previous surveys, some fishing hauls were attempted by fishing over an isobath crossing the acoustic transect as close as possible to the depths where the fishing situation of interest was detected over that transect. In this way the mixing of different size compositions (*i.e.*, bi-, multi-modality of length frequency distributions) was avoided as well as a direct interaction with fixed gears. The mixing of sizes is more probable close to nursery-recruitment areas and in regions with a very narrow continental shelf. Given that all of these situations were not very uncommon in the sampled area, 31% of valid hauls (5 hauls) were conducted over isobath.

Because of the echo-traces usually occurred close to the bottom, all the pelagic hauls were carried out like a bottom-trawl haul, with the ground rope working very close to the bottom. According to the above, the sampled depth range in the valid hauls oscillated between 36-146 m.

During the survey were captured 1 species of Chondrichthyans, 38 species of Osteichthyes and 5 species of Cephalopods. The percentage of occurrence of the more frequent species in the trawl hauls is shown in the enclosed text table below (see also **Figure 5**). Chub mackerel and blue jack mackerel (13 hauls), and anchovy and horse-mackerel (12 hauls) stood especially out from the set of small and mid-sized pelagic fish species. They were followed by mackerel (11 hauls), bogue (10), sardine (9), and Mediterranean horse mackerel (6 hauls).

Species	# of positive fishing stations	Occurrence (%)	Total weight (kg)	Total number
Merluccius merluccius	14	88	150	1364
Scomber colias	13	81	2862	28981
Trachurus picturatus	13	81	279	5258
Engraulis encrasicolus	12	75	1324	65335
Trachurus trachurus	12	75	496	10360
Scomber scombrus	11	69	82	471
Boops boops	10	63	93	941
Spondyliosoma cantharus	10	63	10	87
Loligo media	10	63	6	1325
Sardina pilchardus	9	56	362	10122
Loligo vulgaris	7	44	1	28
Trachurus mediterraneus	6	38	340	1921

For the purposes of the acoustic assessment, anchovy, sardine, round sardinella, mackerel species, horse & jack mackerel species, and bogue were initially considered as the survey target species. All of the invertebrates, and both bentho-pelagic (*e.g.*, manta rays) and benthic fish species (*e.g.*, flatfish, gurnards, etc.) were excluded from the computation of the total catches in weight and in number from those fishing stations where they occurred. Catches of the remaining non-target species were included in an operational category termed as "*Others*". According to the above premises, during the survey were captured a total of 6 092 kg and 158 thousand fish (**Table 2**). 47% of the total fished biomass corresponded to chub mackerel, 22% to anchovy, 8% to horse mackerel, 6% to sardine and Mediterranean horse mackerel, and 5% to blue jack-mackerel. The most abundant species in groundtruthing trawl hauls was anchovy (42%) followed by a long distance by chub mackerel (19%), horse-mackerel and sardine (7% each). Total catches and yields of Mediterranean horse-mackerel and blue jack mackerel were very low, with those of bogue, mackerel and round sardinella being almost incidental. The species composition, in terms of percentages in number, in each valid fish station is shown in **Figure 5**.

Back-scattering energy attributed to the "pelagic assemblage" and individual species

A total of 320 nmi (ESDU) from 21 transects has been acoustically sampled by echo-integration for assessment purposes. From this total, 206 nmi (11 transects) were sampled in Spanish waters, and 114 nmi (10 transects) in the Portuguese waters. The enclosed text table below provides the nautical area-scattering coefficients attributed to each of the selected target species and for the whole "pelagic fish assemblage".

$S_{A\,(m^2\,nmi^{-2})}$	Total spp.	Sardine	Round sardinella	Anchovy	Mackerel	Chub mack.	Horse-mack.	Medit. h-mack.	Blue jack-mack.	Bogue
Total Area	89375	6062	6	10168	16	38545	16084	4832	5689	7973
(%)	(100.0)	(6.8)	(0.0)	(11.4)	(0.0)	(43.1)	(18.0)	(5.4)	(6.4)	(8.9)
Portugal	38858	3752	0	1194	5	3502	13950	0	3546	7149
(%)	(43.5)	(61.9)	(0.0)	(11.7)	(34.1)	(24.0)	(86.7)	(0.0)	(62.3)	(89.7)
Spain	50517	2310	6	8974	10	29284	2133	4832	2143	824
(%)	(56.5)	(38.1)	(100.0)	(88.3)	(65.9)	(76.0)	(13.3)	(100.0)	(37.7)	(10.3)

For this "pelagic fish assemblage" has been estimated a total of 89375 m^2 nmi^{-2}. Portuguese waters accounted for 43.5% of this total back-scattering energy and the Spanish waters the remaining 56.5%.

However, given that the Portuguese sampled ESDUs were almost the half of the Spanish ones, the (weighted-) relative importance of the Portuguese area (*i.e*., its density of "pelagic fish") is actually much higher. The mapping of the total back-scattering energy is shown in **Figure 6**. By species, chub mackerel accounted for 43.1% of this total back-scattering energy, a relative importance corroborated by its high frequency of occurrence in hauls. Horse mackerel is the following species in importance with 18.0%. Anchovy only contributed with 11.4%, followed by bogue with 8.9%, sardine with 6.8%, blue jack mackerel with 6.4%, Mediterranean horse mackerel with 5.4%, and negligible energetic contributions by mackerel and round sardinella.

Some inferences on the species' distribution may be carried out from regional contributions to the total energy attributed to each species: round sardinella, Mediterranean horse mackerel, anchovy, mackerel and chub mackerel seem to show greater densities in the Spanish waters, whereas bogue, horse mackerel, blue jack mackerel and sardine may be considered as typically "Portuguese species" in this survey.

According to the resulting values of integrated acoustic energy, the species acoustically assessed in the present survey finally were anchovy, sardine, chub mackerel, blue jack mackerel, horse mackerel, Mediterranean horse mackerel and bogue.

<u>Spatial distribution and abundance/biomass estimates</u>

Anchovy

Parameters of the survey's length-weight relationship for anchovy are given in **Table 11**. The back-scattering energy attributed to this species, positive valid fishing stations with anchovy and the coherent strata considered for the acoustic estimation are shown in **Figure 6**. The estimated abundance and biomass by size and age class are given in **Tables 3** and **4** and **Figures 8** and **9**.

The bulk of the anchovy population was concentrated in the central part of the surveyed area which corresponds to the Spanish shelf. In this area the species distributed all over the shelf showing spots of high density at different depths. A residual nucleus was also recorded to the west of Cape Santa Maria, in waters with a bathymetry between 75 and 108 m depth (**Figure 6**).

The size class range of the assessed population varied between the 7.5 and 18 cm size classes, with two modal classes at 11 and 14.5 cm. As usual, largest anchovies occurred in the westernmost waters whereas the smallest ones were observed in the central coastal part of the sampled area, coinciding with the location of the main recruitment area close to the Guadalquivir river mouth. The delay of the survey dates in relation to the rest of surveys in the series may be the reason of a higher relative importance of the first modal component in the population, as also happened in the previous survey (in 2010). This fact is a probable consequence of the incorporation of the first waves of recently recruited juveniles to the adult population that usually occur in mid-late summer (**Tables 3** and **4**, **Figures 7** and **8**).

Six sectors have been differentiated according to the S_A value distribution and the size composition in the fishing stations. The acoustic estimates by homogeneous stratum and total area are shown in **Tables 3** and **4**, and **Figures 7** and **8**. A total of 8 487 t and 609 millions of fish have been estimated for this species for the whole surveyed area.

A total of 107 stations were sampled by CUFES from which 68 stations (64%) were positive with anchovy eggs. These positive stations were distributed all over the acoustic transects but the easternmost one and rendered a total of 10 005 anchovy eggs. The spatial distribution of anchovy eggs resembled to the above described for the adult population. Total, maximum and mean anchovy egg densities were estimated at 769, 130 and 7 eggs m^{-3} respectively. Greater anchovy egg densities were mainly observed in the inner-middle shelf waters located between Cadiz Bay and Tinto-Odiel rivers mouths. However, the highest egg density (130 eggs m^{-3}) was recorded in a station with a bathymetry of 87.6 m depth located in the closest transect to the Portuguese-Spanish border (**Figure 9**). In that station were collected a total of 2014 eggs, accounting for 20% of the total of the collected anchovy eggs during the survey, with practically all of them belonging to the *no embryo* stage.

Sardine

Parameters of the survey's size-weight relationship for sardine are shown in **Table 11**. The back-scattering energy attributed to this species, positive valid fishing stations with sardine and the coherent strata considered for the acoustic estimation are shown in **Figure 10**. Estimated abundance and biomass by size class are given in **Table 5** and **Figure 11**.

Sardine preferably occurred over the inner-middle shelf of both extremes of the surveyed area, in shallower waters than anchovy, and curiously in those waters where anchovy was absent, resulting in a distribution pattern almost complementary to the one deployed by this last species (**Figure 10**). In any case, higher sardine densities were more constantly recorded in the waters west to Cape Santa Maria.

The size range of the assessed population ranged between 11 and 21.5 cm size classes, with two modal classes, a secondary one at 13 and the most important at 17 cm. As also evidenced in previous surveys, the size composition of the surveyed population evidences that the central coastal area might correspond with a recruitment area for the species (**Table 5**, **Figure 11**).

Five size-based homogeneous sectors were delimited for the acoustic assessment. The acoustic estimates by homogeneous stratum and total area are shown in **Table 5** and **Figure 11**. Sardine was the third most important species in terms of both biomass and abundance: 9 670 t and 232 millions of fish have been estimated for this species for the whole surveyed area.

Round sardinella and Mackerel

The occurrence of round sardinella during the survey was incidental and restricted to a very small coastal area between Rota and Chipiona, in the eastern waters of the Gulf (**Figure 12**). Acoustic integration for the species was considered negligible and therefore the species was not acoustically assessed. The same also applies to mackerel, although in this case the species showed a wider distribution, occurring in all transects but the two easternmost ones, with the species distributing over the middle and outer shelf waters of the Gulf (**Figure 12**).

Chub mackerel

Parameters of the survey's length-weight relationship are shown in **Table 11**. The back-scattering energy attributed to this species, positive valid fishing stations with chub mackerel and the coherent strata considered for the acoustic estimation are shown in **Figure 13**. Estimated abundance and biomass by size class are given in **Table 6** and **Figure 14**.

Chub mackerel was present all over the surveyed area although in the westernmost waters showed a more "oceanic" distribution than in the rest of the surveyed area, where the highest densities were mainly recorded in different locations over the inner shelf (**Figure 13**). The size class range for the assessed population oscillated between 19 and 32 cm size classes. Two mixed size cohorts may be differentiated in the sampled population, both corresponding to juvenile/sub-adult fish (with modes at 20 and 22 cm; **Table 6** and **Figure 14**). Larger fish were more frequent in the central area.

Seven sectors were differentiated for the purposes of acoustic assessment. The acoustic estimates by homogeneous stratum and total area are shown in **Table 6** and **Figure 14**. Chub mackerel in the sampled area was the most important species in terms of assessed biomass, rendering estimates of 31 267 t and 333 million fish.

Blue jack-mackerel

The survey's length-weight relationship for this species is given in **Table 11**. The back-scattering energy attributed to this species, the species' positive fishing stations and the coherent strata considered for the acoustic estimation are illustrated in **Figure 15**. Estimated abundance and biomass by size class are given in **Table 7** and **Figure 16**.

Blue jack mackerel occurred in 3 main locations: the area between Cape San Vicente and Cape Santa Maria, the area close to the Guadiana river mouth (where the highest densities were recorded), and the easternmost extreme of the surveyed area. Spots of high density were indistinctly recorded both in the inner and middle shelf (**Figure 15**). The sampled population showed a well bell-shaped length frequency distribution, with size classes ranging between 14.5 and 21.5 cm, and a modal class at 17.5 cm, all of them probably corresponding to juvenile/sub-adult fish. Larger fish were mainly recorded in the easternmost waters of the sampled area (**Table 7**, **Figure 16**).

The estimates for the four post-strata considered in the assessment are shown in **Table 7** and **Figure 16**. A total of 3 889 t and 76 millions of fish were estimated for the whole surveyed area.

Horse mackerel

The survey's length-weight relationship for horse mackerel is shown in **Table 11**. The back-scattering energy attributed to this species, the distribution of fishing stations and their coherent strata are shown in **Figure 17**. Estimated abundance and biomass by size class are given in **Table 8** and **Figure 18**.

The spatial distribution of acoustic energy attributable to horse mackerel resembled in a great extent to that previously described for sardine and blue jack mackerel, with highest densities occurring in both extremes of the surveyed area and a relatively scarce presence in the central part. Again, westernmost Portuguese shelf waters were those where the species recorded the highest values (**Figure 17**). The sampled population, which ranged between 10.5 and 22.5 cm size classes, was basically distributed amongst two cohorts with one main mode at 17 cm (sub-adults), and a secondary one at 12.5 cm (juveniles, which were located in the central part of the middle-inner shelf of the surveyed area) (**Table 8**, **Figure 18**).

The estimates for the four coherent strata considered in the assessment and for the whole surveyed area are given in **Table 8** and illustrated in **Figure 18**. During this survey were estimated 10 398 t and 228 million fish of horse mackerel in the surveyed area, the species ranking as the second most important one in terms of biomass.

Mediterranean horse-mackerel

The survey's length-weight relationship for this species is shown in **Table 11**. Positive fishing stations, back-scattering energy attributed to the species and coherent strata are represented in **Figure 19**. Estimated abundance and biomass by size class are given in **Table 9** and **Figure 20**.

Mediterranean horse-mackerel was only present over the Spanish inner shelf waters, with the densest concentrations being recorded in the easternmost waters **(Figure 19**). Size range of the sampled population oscillated between 17 and 38 cm size classes, showing 3 modal classes at 19, 28.5 and 35 cm, although the bulk of the sampled specimens occurred around the second mode, between 22.5 and 32 cm. Again, the smallest fish occurred in the central part of the surveyed area, in front of the Coto de Doñana National Park (**Table 9**, **Figures 19**, **20**).

The acoustic estimates, given in **Table 9** and **Figure 20**, were: 4 853 t and 26 millions of fish.

Bogue

Parameters of the survey's length-weight relationship for bogue are shown in **Table 11**. Positive fishing hauls, back-scattering energy attributed to bogue and coherent strata delimited for acoustic estimations are shown in **Figure 21**. Estimated abundance and biomass by size class are given in **Table 10** and **Figure 22**.

Bogue was mainly located in the westernmost Portuguese waters, where the species also recorded the highest densities. In the rest of the area the species showed a very scattered distribution with very low densities (**Figure 21**). The sampled population was composed by fish belonging to size classes comprised between 10.5 and 24 cm, although mainly distributed between the 19 and 24.5 cm size classes. Three modes were identified at 13.5, 17 and, the most important, at 21 cm. Large fish were mainly located in the western coherent strata, whereas juveniles were only observed in front of the Coto de Doñana and in the easternmost waters (**Table 10**, **Figure 22**).

The bogue acoustic estimates for the whole surveyed area, shown in **Table 10** and **Figure 22**, were: 4 783 t and 52 million fish.

(SHORT) DISCUSSION

No standard acoustic survey (neither *PELAGO* nor *ECOCADIZ*) was carried out in 2012 in the Gulf of Cadiz for different reasons. Spain could finally conduct between 10 and 27 November of that year the *ECOCADIZ-RECLUTAS 1112* survey, a survey aimed at obtaining acoustic estimates of Gulf of Cadiz anchovy and sardine juveniles in their main recruitment areas off the Gulf (Ramos *et al*., 2013). Although a probable underestimation should be assumed, since the surveyed area was restricted to the Spanish waters only, 2012 autumn acoustic estimates for anchovy (2 649 million fish, 13 680 t) and sardine (603 million fish, 22 119 t) were close to those ones estimated by IPMA five months after (5 April – 15 May 2013) during the *PELAGO 13* survey (Marques *et al*., 2013; **Table 12**). A further within-year comparison between *PELAGO 13* and *ECOCADIZ 0813* estimates reveals however marked decreases in the population levels of both species in mid-summer 2013, with the decrease exhibited by sardine being much more evident. During the *ECOCADIZ 0813* survey the greatest decreases in abundance and biomass were recorded in the Portuguese waters for anchovy and, more dramatically, in the Spanish ones for sardine. The above values are also illustrated in the context of their respective historical series in **Figure 23**. Anchovy and sardine biomass estimates in 2013 are amongst the lowest ones within their respective survey series. For both species, the 2013 *ECOCADIZ* survey estimates even were the lowest ones in the whole series. In their Portuguese counterparts, the anchovy estimate was about the half of the historical average (about 24 kt). In any case, Gulf of Cadiz anchovy has experienced a very fluctuating trend in the recent years. Since 2007 on the sardine biomass, as estimated by the *PELAGO* surveys, is experiencing a clear decreasing trend, which culminated in 2011 and it is still maintaining in the latest years. This decline is also corroborated, although based on less data points, by the Spanish summer surveys.

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Table 1. *ECOCADIZ 0813 s*urvey. Descriptive characteristics of the acoustic tracks.

Acoustic track	Location	Date	Start				End			
			Latitude	Longitude	UCT time	Mean depth (m)	Latitude	Longitude	UCT time	Mean depth (m)
R01	Trafalgar	02/08/2013	36º 13,670 N	6º 7,620 W	10:17	25	36º 2,070 N	6º 28,560 W	14:44	190
R02	Sancti-Petri	03/08/2013	36º 19,320 N	6º 14,630 W	5:38	31	36º 8,980 N	6º 34,070 W	9:38	208
R03	Cádiz	03/08/2013	36º 17,250 N	6º 36,600 W	11:00	172	36º 27,180 N	6º 19,110 W	17:18	24
R04	Rota	04/08/2013	36º 34,460 N	6º 23,260 W	5:35	23	36º 24,510 N	6º 40,740 W	9:50	214
R05	Chipiona	04/08/2013	36º 30,990 N	6º 46,430 W	10:49	189	36º 40,160 N	6º 29,810 W	14:35	25
R06	Doñana	05/08/2013	36º 37,920 N	6º 51,430 W	6:01	149	36º 46,410	6º 41,050 W	10:28	23
R07	Matalascañas	05/08/2013	36º 53,510 N	6º 41,050 W	10:28	23	36º 43,980 N	6º 58,190 W	14:11	211
R08	Mazagón	07/08/2013	36º 49,120 N	7º 6,730 W	5:37	191	37º 1,070 N	6º 44,520 W	8:25	21
R09	Punta Umbría	07/08/2013	37 º4,530 N	6º 55,870 W	9:47	28	36º 49,040 N	7º 6,860 W	11:54	200
R10	El Rompido	07/08/2013	36º 49.170 N	7º 6.810 W	14:44	195	37º 6.860 N	7º 6.910 W	16:41	24
R11	Isla Cristina	08/08/2013	36º 52,370 N	7º 16,710 W	5:36	200	37º 7,150 N	7º 16,950 W	9:13	20
R12	V. R. de Sto. Antonio	08/08/2013	37º 6,190 N	7º 26,510 W	10:11	30	36º 56,190 N	7º 26,500 W	12:56	241
R13	Tavira	08/08/2013	36º 57,070 N	7º 36,100 W	14:29	125	37º 4,940 N	7º 36,050 W	16:55	21
R14	Fuzeta	08/08/2013	36º 59,280	7º 45,930 W	18:19	78	36º 55,7 N	7º 45,850 W	18:34	160
R15	Cabo de Sta. María	09/08/2013	36º 56,000 N	7º 55,080 W	5:33	67	36º 51,870 N	7º 55,990 W	6:02	217
R16	Cuarteira	09/08/2013	36º 50,170 N	8º 5,900 W	7:52	122	37º 1,340N	8º 5,960 W	11:12	21
R17	Albufeira	09/08/2013	37º 2,450 N	8º 15,430 W	12:12	31	36º 49,380 N	8º 15,490 W	15:26	175
R18	Alfanzina	10/08/2013	37º 4,170 N	8º 25,300 W	6:04	32	36º 50,360 N	8º 25,240 W	10:18	213
R19	Portimao	10/08/2013	36º 51,480 N	8º 35,360 W	11:42	115	37º 6,020 N	8º 35,390 W	14:43	25
R20	Burgau	11/08/2013	37º 1,400 N	8º 45,040 W	10:04	60	36º 52,380 N	8º 45,030 W	11:10	229
R21	Ponta de Sagres	11/08/2013	36º 50,820 N	8º 54,970 W	12:10	161	37º 0,490 N	8º 55,010 W	13:23	25

Table 2. *ECOCADIZ 0813* survey. Descriptive characteristics of the fishing stations. Null hauls shadowed.

Fishing station	Date	Start		End		UTC Time		Depth (m)		Duration (min.)		Trawled Distance (nm)	Acoustic transect	Zone (landmark)
		Latitude	Longitude	Latitude	Longitude	Start	End	Start	End	Effective trawling	Total manoeuvre			
01	02/08/2013	36° 07.5001 N	6° 19.9345 W	36° 08.5708 N	6° 16.9120 W	12:13	12:41	42,81	35,86	00:28	00:58	2,672	R01	Trafalgar
02	03/08/2013	36° 15.4470 N	6° 21.8920 W	36° 16.4845 N	6° 19.9524 W	07:01	07:28	50,52	45,12	00:27	00:55	1,88	R02	Sancti-Petri
03	03/08/2013	36° 21.1015 N	6° 31.9429 W	36° 18.7477 N	6° 30.6034 W	13:09	13:47	97,68	95,96	00:38	01:08	2,588	R03	Cádiz
04	03/08/2013	36° 24.6126 N	6° 23.6392 W	36° 23.4348 N	6° 25.7391 W	15:36	16:08	50,52	56,67	00:32	10:22	2,063	R03	Cádiz
05	04/08/2013	36° 31.6408 N	6° 28.1515 W	36° 30.6189 N	6° 29.9770 W	07:24	02:50	46,66	54,38	00:26	00:59	1,791	R04	Rota
06	04/08/2013	36° 33.9931 N	6° 41.0815 W	36° 32.4217 N	6° 43.9122 W	11:54	12:35	95,03	119,96	00:41	01:13	2,768	R05	Chipiona
07	05/08/2013	36° 43.7650 N	6° 40.7755 W	36° 42.5242 N	6° 43.0849 W	07:35	08:07	39,53	59,51	00:32	00:56	2,232	R06	Coto Doñana
08	05/08/2013	36° 47.6104 N	6° 51.5898 W	36° 48.9349 N	6° 49.2508 W	12:11	12:43	87,58	64,8	00:32	01:06	2,297	R07	Matalascañas
09	05/08/2013	36° 44.4166 N	6° 57.3940 W	36° 45.5032 N	6° 55.4485 W	14:45	15:15	140,95	115,33	00:30	01:10	1,903	R07	Matalascañas
10	07/08/2013	36° 50.6850 N	7° 06.0118 W	36° 52.2754 N	7° 04.7218 W	12:19	12:48	145,93	115,87	00:29	01:09	1,896	R09	Punta Umbría
11	08/08/2013	36° 57.6747 N	7° 16.7926 W	36° 55.4401 N	7° 16.7557 W	06:45	07:17	99,08	119,77	00:32	01:07	2,232	R11	Isla Cristina
12	08/08/2013	37° 04.9612 N	7° 27.5697 W	37° 04.9858 N	7° 25.2487 W	10:47	11:13	39,66	37,73	00:26	00:51	1,857	R12	V. R. Sto. Antonio
13	08/08/2013	37° 01.0086 N	7° 36.0274 W	36° 59.0446 N	7° 36.0439 W	15:12	15:41	93,71	108,98	00:29	01:12	1,962	R13	Tavira
14	09/08/2013	36° 51.5641 N	8° 06.3967 W	36° 52.5043 N	8° 04.3080 W	08:56	09:26	104,07	103,62	00:30	00:01	1,921	R16	Quarteira
15	09/08/2013	36° 57.8074 N	8° 12.8953 W	36° 58.5202 N	8° 15.4957 W	13:30	14:01	52,57	50,04	00:31	01:00	2,202	R17	Albufeira
16	10/08/2013	36° 55.3374 N	8° 27.8494 W	36° 55.1391 N	8° 25.3438 W	08:09	08:39	106,72	103,76	00:30	01:03	2,019	R18	Alfanzina
17	11/08/2013	37° 01.9326 N	8° 44.5479 W	37° 02.0304 N	8° 45.1161 W	06:41	06:50	51,07	50,97	00:09	01:05	0,465	R20	Burgau

Table 2. *ECOCADIZ 0813* survey. Catches by species in number (upper panel) and weight (in kg, lower panel) from valid fishing stations.

Fishing station	**ABUNDANCE (nº)**										
	Anchovy	***Sardine***	***Chub mack.***	***Mackerel***	***Horse-mack.***	***Blue Jack-mack.***	***Medit. Horse-mack.***	***Bogue***	***Silvery lightfish***	**Other spp.**	**TOTAL**
01						29	17	30		10	**86**
02		441	264		367	300	302	27		65	**1766**
03	2628		1	8	18		2			290	**2947**
04	694	8469	6706		543	28	182	32		232	**16886**
05	4070	185	4519		231	12	1378	66		116	**10577**
06	6339			2	2	1			9	251	**6604**
07	8596	107	438	1	95	2	40	76		640	**9995**
08	350			5				1		100	**456**
09	7750		37	90						155	**8032**
10	5224		142	139		2			31835	174	**37516**
11	20663	2	81	19	2	4				69	**20840**
12		271	8717	44	852	1342		164		176	**11566**
13	12	234	7	31	30	1449		2		30	**1795**
14	8898		10	72	405	7				59	**9451**
15		404	3		484	16		186		66	**1159**
16	111	9	8056	60	7331	2066		357		95	**18085**
TOTAL	**65335**	**10122**	**28981**	**471**	**10360**	**5258**	**1921**	**941**	**31844**	**2528**	**157761**

Fishing station	**BIOMASS (kg)**										
	Anchovy	***Sardine***	***Chub mack***	***Mackerel***	***Horse-mack.***	***Blue Jack-mack.***	***Medit. Horse-mack.***	***Bogue***	***Silvery lightfish***	**Other spp.**	**TOTAL**
01						1,556	2,734	2,103		0,79	**7,183**
02		25,74	23,1		13,767	16,22	50,875	2,039		7,468	**139,209**
03	54,44		0,122	1,285	0,854		0,219			28,515	**85,435**
04	12,701	269,107	640,059		21,842	1,979	31,793	3,78		26,998	**1008,259**
05	56,034	6,862	476,077		8,804	0,794	247,517	8,361		12,221	**816,67**
06	108,547			0,268	0,015	0,023			0,004	19,955	**128,812**
07	93,6	4,496	72,7	0,256	3,546	0,161	7,15	12,4		26,188	**220,497**
08	6			1,078				0,119		8,251	**15,448**
09	172,16		5,222	10,7						20,88	**208,962**
10	117,24		18,2	22,08		0,136			22,34	15,672	**195,668**
11	461,477	0,127	10,352	3,236	0,033	0,196				6,297	**481,718**
12		16,884	719,557	16,613	34,13	65,851		16,003		18,219	**887,257**
13	0,331	13,61	0,546	5,446	1,553	74,94		0,171		5,51	**102,107**
14	237,798		1,358	10,683	19,167	0,446				6,219	**275,671**
15		24,78	0,358		21,226	0,976		12,425		14,724	**74,489**
16	3,248	0,434	894,281	10,075	371,554	115,802		35,812		13,085	**1444,291**
TOTAL	**1323,576**	**362,04**	**2861,932**	**81,72**	**496,491**	**279,08**	**340,288**	**93,213**	**22,344**	**230,992**	**6091,676**

Table 3. *ECOCADIZ 0813* survey. Anchovy (*E. encrasicolus*). Estimated abundance and biomass by size class. Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figure 6**.

***ECOCADIZ 0813* . *Engraulis encrasicolus* . ABUNDANCE (in number of fish).**								
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**TOTAL *n***	**Millions**
6	0	0	0	0	0	0	0	**0**
6,5	0	0	0	0	0	0	0	**0**
7	0	0	0	0	0	0	0	**0**
7,5	0	0	2108395	0	0	0	2108395	**2**
8	0	0	10541977	0	0	0	10541977	**11**
8,5	0	0	10541977	0	0	0	10541977	**11**
9	0	0	19015339	0	0	0	19015339	**19**
9,5	0	0	33774106	0	0	0	33774106	**34**
10	0	0	50641280	0	0	0	50641280	**51**
10,5	0	0	54897852	0	0	0	54897852	**55**
11	0	249819	59114625	0	0	0	59364444	**59**
11,5	0	499639	35882489	0	0	0	36382128	**36**
12	0	5959978	37990893	424102	0	0	44374973	**44**
12,5	1061277	9186217	14758767	2653834	0	0	27660095	**28**
13	3079196	8443898	8433580	6893501	1386595	0	28236770	**28**
13,5	6940750	2234100	4216790	12548190	7545128	0	33484958	**33**
14	8787371	1734461	0	13219247	12905746	2165248	38812073	**39**
14,5	7554796	499639	0	11312930	22877712	4759035	47004112	**47**
15	5626037	249819	0	6183753	18348680	11677680	42085969	**42**
15,5	3163653	0	0	3282773	11189921	13408748	31045095	**31**
16	452536	0	0	2388186	10320276	11243501	24404499	**24**
16,5	266812	0	0	791844	2967353	4324858	8350867	**8**
17	0	0	0	447198	1781239	2165248	4393685	**4**
17,5	0	0	0	148199	791469	434177	1373845	**1**
18	0	0	0	148199	0	0	148199	**0**
TOTAL *n*	36932428	29057570	341918070	60441956	90114119	50178495	608642638	**609**
Millions	**37**	**29**	**342**	**60**	**90**	**50**	**609**	

***ECOCADIZ 0813* . *Engraulis encrasicolus* . BIOMASS (t).**							
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**TOTAL**
6	0	0	0	0	0	0	**0**
6,5	0	0	0	0	0	0	**0**
7	0	0	0	0	0	0	**0**
7,5	0	0	5,404	0	0	0	**5,404**
8	0	0	33,139	0	0	0	**33,139**
8,5	0	0	40,162	0	0	0	**40,162**
9	0	0	86,862	0	0	0	**86,862**
9,5	0	0	183,227	0	0	0	**183,227**
10	0	0	323,487	0	0	0	**323,487**
10,5	0	0	409,706	0	0	0	**409,706**
11	0	2,163	511,807	0	0	0	**513,97**
11,5	0	4,986	358,082	0	0	0	**363,068**
12	0	68,149	434,407	4,849	0	0	**507,405**
12,5	13,829	119,703	192,318	34,581	0	0	**360,431**
13	45,496	124,762	124,609	101,854	20,487	0	**417,208**
13,5	115,742	37,255	70,318	209,251	125,821	0	**558,387**
14	164,67	32,503	0	247,721	241,846	40,575	**727,315**
14,5	158,453	10,479	0	237,276	479,834	99,815	**985,857**
15	131,575	5,842	0	144,618	429,116	273,103	**984,254**
15,5	82,21	0	0	85,305	290,779	348,437	**806,731**
16	13,023	0	0	68,729	297,004	323,573	**702,329**
16,5	8,478	0	0	25,16	94,283	137,415	**265,336**
17	0	0	0	15,642	62,303	75,735	**153,68**
17,5	0	0	0	5,691	30,392	16,672	**52,755**
18	0	0	0	6,231	0	0	**6,231**
TOTAL	**733,476**	**405,842**	**2773,528**	**1186,908**	**2071,865**	**1315,325**	**8486,944**

Table 4. *ECOCADIZ 0813* survey. Anchovy (*E. encrasicolus*). Estimated abundance (thousands of individuals) and biomass (tonnes) by age group. Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figure 6** and ordered from west to east.

Age class	POL06	POL05	POL03	POL04	POL02	POL01	TOTAL
	Number	Number	Number	Number	Number	Number	Number
0	0	140	167444	403	958	186	169131
I	35607	76721	161824	56519	28081	35140	393891
II	14572	13253	0	3520	19	1606	32970
III	0	0	0	0	0	0	0
TOTAL	50178	90114	329268	60442	29058	36932	595992

Age class	POL06	POL05	POL03	POL04	POL02	POL01	TOTAL
	Weight	Weight	Weight	Weight	Weight	Weight	Weight
0	0	2	1105	6	12	3	1128
I	889	1684	1630	1079	394	688	6364
II	426	386	0	102	0	42	957
III	0	0	0	0	0	0	0
TOTAL	1315	2072	2735	1187	406	733	8448

Table 5. *ECOCADIZ 0813* survey. Sardine (*S. pilchardus*). Estimated abundance and biomass by size class. Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figure 10**.

***ECOCADIZ 0813* . *Sardina pilchardus* . ABUNDANCE (in number of fish).**							
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**TOTAL *n***	**Millions**
8	0	0	0	0	0	0	**0**
8,5	0	0	0	0	0	0	**0**
9	0	0	0	0	0	0	**0**
9,5	0	0	0	0	0	0	**0**
10	0	0	0	0	0	0	**0**
10,5	0	0	0	0	0	0	**0**
11	0	0	36825	0	0	36825	**0**
11,5	0	0	184124	0	0	184124	**0**
12	0	3195967	405072	0	0	3601039	**4**
12,5	0	14275531	441897	0	0	14717428	**15**
13	294457	15866996	36825	0	0	16198278	**16**
13,5	147228	7274144	36825	0	0	7458197	**7**
14	147228	2811152	36825	0	0	2995205	**3**
14,5	147228	4960128	36825	0	0	5144181	**5**
15	1361863	4960128	36825	0	0	6358816	**6**
15,5	1509091	1651838	110474	0	1505941	4777344	**5**
16	2134811	4847806	110474	0	5722577	12815668	**13**
16,5	1509091	4078177	184124	0	15661787	21433179	**21**
17	1509091	4847806	405072	76766	37046166	43884901	**44**
17,5	1656320	3031445	184124	643122	21384367	26899378	**27**
18	1509091	4847806	368248	2203682	14155847	23084674	**23**
18,5	1361863	2918864	257773	2114660	18673667	25326827	**25**
19	1509091	1651838	331423	1552191	4216636	9261179	**9**
19,5	1214635	1267024	478722	809833	2710695	6480909	**6**
20	147228	0	184124	522010	0	853362	**1**
20,5	0	0	36825	76766	0	113591	**0**
21	0	0	36825	230298	0	267123	**0**
21,5	0	0	0	153532	0	153532	**0**
22	0	0	0	0	0	0	**0**
22,5	0	0	0	0	0	0	**0**
23	0	0	0	0	0	0	**0**
TOTAL *n*	16158316	82486650	3940251	8382860	121077683	232045760	**232**
Millions	**16**	**82**	**4**	**8**	**121**	**232**	

Table 5 (cont'd).

ECOCADIZ 0813 . *Sardina pilchardus* . BIOMASS (t).						
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**TOTAL**
8	0	0	0	0	0	**0**
8,5	0	0	0	0	0	**0**
9	0	0	0	0	0	**0**
9,5	0	0	0	0	0	**0**
10	0	0	0	0	0	**0**
10,5	0	0	0	0	0	**0**
11	0	0	0,414	0	0	**0,414**
11,5	0	0	2,376	0	0	**2,376**
12	0	47,122	5,972	0	0	**53,094**
12,5	0	239,166	7,403	0	0	**246,569**
13	5,578	300,575	0,698	0	0	**306,851**
13,5	3,139	155,101	0,785	0	0	**159,025**
14	3,519	67,183	0,88	0	0	**71,582**
14,5	3,928	132,342	0,983	0	0	**137,253**
15	40,418	147,209	1,093	0	0	**188,72**
15,5	49,648	54,344	3,635	0	49,544	**157,171**
16	77,606	176,229	4,016	0	208,03	**465,881**
16,5	60,434	163,317	7,374	0	627,202	**858,327**
17	66,386	213,259	17,819	3,377	1629,692	**1930,533**
17,5	79,825	146,097	8,874	30,995	1030,598	**1296,389**
18	79,476	255,31	19,394	116,057	745,518	**1215,755**
18,5	78,189	167,581	14,8	121,409	1072,112	**1454,091**
19	94,238	103,152	20,696	96,93	263,317	**578,333**
19,5	82,323	85,874	32,446	54,887	183,721	**439,251**
20	10,808	0	13,516	38,321	0	**62,645**
20,5	0	0	2,922	6,092	0	**9,014**
21	0	0	3,153	19,72	0	**22,873**
21,5	0	0	0	14,16	0	**14,16**
22	0	0	0	0	0	**0**
22,5	0	0	0	0	0	**0**
23	0	0	0	0	0	**0**
TOTAL	**735,515**	**2453,861**	**169,249**	**501,948**	**5809,734**	**9670,307**

Table 6. *ECOCADIZ 0813* survey. Chub mackerel (*S. colias*). Estimated abundance and biomass by size class. Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figure 13**.

***ECOCADIZ 0813* . *Scomber colias* . ABUNDANCE (in number of fish).**									
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**TOTAL *n***	**Millions**
13	0	0	0	0	0	0	0	0	**0**
13,5	0	0	0	0	0	0	0	0	**0**
14	0	0	0	0	0	0	0	0	**0**
14,5	0	0	0	0	0	0	0	0	**0**
15	0	0	0	0	0	0	0	0	**0**
15,5	0	0	0	0	0	0	0	0	**0**
16	0	0	0	0	0	0	0	0	**0**
16,5	0	0	0	0	0	0	0	0	**0**
17	0	0	0	0	0	0	0	0	**0**
17,5	0	0	0	0	0	0	0	0	**0**
18	0	0	0	0	0	0	0	0	**0**
18,5	0	0	0	0	0	0	0	0	**0**
19	0	0	0	0	0	7808826	0	7808826	**8**
19,5	0	0	0	0	0	19522061	874020	20396081	**20**
20	0	0	0	0	0	27312978	3053165	30366143	**30**
20,5	0	291024	0	0	0	14310211	5238217	19839452	**20**
21	3688690	589707	646142	0	0	9098356	13529596	27552491	**28**
21,5	15961106	2052485	161535	0	0	3904412	6549247	28628785	**29**
22	18412628	3224240	161535	0	0	13002768	7417359	42218530	**42**
22,5	17175463	2933216	323071	0	51422	13002768	3927185	37413125	**37**
23	10541533	6456139	484606	0	77133	14310211	4364195	36233817	**36**
23,5	4086622	3813948	928829	0	192858	6501385	874020	16397662	**16**
24	1968065	6157455	1251900	3274	204664	5211855	1311030	16108243	**16**
24,5	1354612	3224240	1574971	13096	216520	5211855	437010	12032304	**12**
25	1933855	2343510	1574971	11459	120603	5211855	0	11196253	**11**
25,5	1047885	880731	928829	13096	88989	3904412	0	6863942	**7**
26	0	880731	807677	14733	75133	2596971	0	4375245	**4**
26,5	0	1171755	928829	1637	45519	2596971	0	4744711	**5**
27	0	291024	2059578	1637	17807	1307441	0	3677487	**4**
27,5	0	291024	928829	1637	17807	1307441	0	2546738	**3**
28	0	0	928829	0	13856	0	0	942685	**1**
28,5	0	0	646142	0	0	0	0	646142	**1**
29	0	0	1090364	0	0	0	0	1090364	**1**
29,5	0	0	646142	0	0	0	0	646142	**1**
30	0	0	484606	0	0	0	0	484606	**0**
30,5	0	0	161535	0	0	0	0	161535	**0**
31	0	0	484606	0	0	0	0	484606	**0**
31,5	0	0	161535	0	0	0	0	161535	**0**
32	0	0	323071	0	0	0	0	323071	**0**
32,5	0	0	0	0	0	0	0	0	**0**
33	0	0	0	0	0	0	0	0	**0**
TOTAL *n*	76170459	34601229	17688132	60569	1122311	156122777	47575044	333340521	**333**
Millions	**76**	**35**	**18**	**0**	**1**	**156**	**48**	**333**	

Table 6 (cont'd).

ECOCADIZ 0813 . *Scomber colias* . BIOMASS (t).								
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**TOTAL**
13	0	0	0	0	0	0	0	**0**
13,5	0	0	0	0	0	0	0	**0**
14	0	0	0	0	0	0	0	**0**
14,5	0	0	0	0	0	0	0	**0**
15	0	0	0	0	0	0	0	**0**
15,5	0	0	0	0	0	0	0	**0**
16	0	0	0	0	0	0	0	**0**
16,5	0	0	0	0	0	0	0	**0**
17	0	0	0	0	0	0	0	**0**
17,5	0	0	0	0	0	0	0	**0**
18	0	0	0	0	0	0	0	**0**
18,5	0	0	0	0	0	0	0	**0**
19	0	0	0	0	0	430,085	0	**430,085**
19,5	0	0	0	0	0	1166,571	52,228	**1218,799**
20	0	0	0	0	0	1767,2	197,545	**1964,745**
20,5	0	20,349	0	0	0	1000,579	366,26	**1387,188**
21	278,205	44,476	48,733	0	0	686,207	1020,416	**2078,037**
21,5	1296,215	166,684	13,118	0	0	317,081	531,87	**2324,968**
22	1607,392	281,471	14,102	0	0	1135,12	647,523	**3685,608**
22,5	1609,194	274,817	30,269	0	4,818	1218,248	367,944	**3505,29**
23	1058,353	648,186	48,654	0	7,744	1436,722	438,158	**3637,817**
23,5	439,015	409,722	99,782	0	20,718	698,426	93,894	**1761,557**
24	225,907	706,792	143,701	0,376	23,493	598,25	150,488	**1849,007**
24,5	165,918	394,917	192,908	1,604	26,52	638,368	53,527	**1473,762**
25	252,422	305,893	205,577	1,496	15,742	680,292	0	**1461,422**
25,5	145,579	122,357	129,039	1,819	12,363	542,427	0	**953,584**
26	0	130,074	119,285	2,176	11,096	383,544	0	**646,175**
26,5	0	183,758	145,661	0,257	7,138	407,264	0	**744,078**
27	0	48,408	342,582	0,272	2,962	217,475	0	**611,699**
27,5	0	51,29	163,695	0,289	3,138	230,421	0	**448,833**
28	0	0	173,261	0	2,585	0	0	**175,846**
28,5	0	0	127,445	0	0	0	0	**127,445**
29	0	0	227,186	0	0	0	0	**227,186**
29,5	0	0	142,085	0	0	0	0	**142,085**
30	0	0	112,365	0	0	0	0	**112,365**
30,5	0	0	39,459	0	0	0	0	**39,459**
31	0	0	124,609	0	0	0	0	**124,609**
31,5	0	0	43,687	0	0	0	0	**43,687**
32	0	0	91,826	0	0	0	0	**91,826**
32,5	0	0	0	0	0	0	0	**0**
33	0	0	0	0	0	0	0	**0**
TOTAL	**7078,2**	**3789,194**	**2779,029**	**8,289**	**138,317**	**13554,28**	**3919,853**	**31267,162**

Table 7. *ECOCADIZ 0813* survey. Blue jack-mackerel (*T. picturatus*). Estimated abundance and biomass by size class. Estimated abundance and biomass by size class. Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figure 15**.

***ECOCADIZ 0813* . *Trachurus picturatus* . 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	0	0	0	**0**
11	0	0	0	0	0	**0**
11,5	0	0	0	0	0	**0**
12	0	0	0	0	0	**0**
12,5	0	0	0	0	0	**0**
13	0	0	0	0	0	**0**
13,5	0	0	0	0	0	**0**
14	0	0	0	0	0	**0**
14,5	236152	0	0	0	236152	**0**
15	314869	0	0	0	314869	**0**
15,5	118076	574977	0	0	693053	**1**
16	551021	275989	0	0	827010	**1**
16,5	787172	5427785	0	167142	6382099	**6**
17	1456269	10280592	0	1177957	12914818	**13**
17,5	2322158	9153634	1022971	2515096	15013859	**15**
18	1456269	4852808	3568773	3693053	13570903	**14**
18,5	1653062	275989	6637684	3016524	11583259	**12**
19	1456269	0	4254628	3183667	8894564	**9**
19,5	669096	0	848601	2515096	4032793	**4**
20	551021	0	511485	167142	1229648	**1**
20,5	118076	0	0	0	118076	**0**
21	118076	0	0	0	118076	**0**
21,5	118076	0	0	0	118076	**0**
22	0	0	0	0	0	**0**
22,5	0	0	0	0	0	**0**
23	0	0	0	0	0	**0**
23,5	0	0	0	0	0	**0**
24	0	0	0	0	0	**0**
24,5	0	0	0	0	0	**0**
25	0	0	0	0	0	**0**
25,5	0	0	0	0	0	**0**
26	0	0	0	0	0	**0**
26,5	0	0	0	0	0	**0**
27	0	0	0	0	0	**0**
27,5	0	0	0	0	0	**0**
28	0	0	0	0	0	**0**
TOTAL *n*	11925662	30841774	16844142	16435677	76047255	**76**
Millions	**12**	**31**	**17**	**16**	**76**	

Table 7 (cont'd)**.**

ECOCADIZ 0813 . Trachurus picturatus . BIOMASS (t).					
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**TOTAL**
10	0	0	0	0	**0**
10,5	0	0	0	0	**0**
11	0	0	0	0	**0**
11,5	0	0	0	0	**0**
12	0	0	0	0	**0**
12,5	0	0	0	0	**0**
13	0	0	0	0	**0**
13,5	0	0	0	0	**0**
14	0	0	0	0	**0**
14,5	6,546	0	0	0	**6,546**
15	9,629	0	0	0	**9,629**
15,5	3,971	19,337	0	0	**23,308**
16	20,318	10,177	0	0	**30,495**
16,5	31,737	218,837	0	6,739	**257,313**
17	64,029	452,014	0	51,792	**567,835**
17,5	111,067	437,813	48,928	120,296	**718,104**
18	75,593	251,903	185,25	191,702	**704,448**
18,5	92,921	15,514	373,114	169,563	**651,112**
19	88,459	0	258,44	193,387	**540,286**
19,5	43,833	0	55,592	164,765	**264,19**
20	38,857	0	36,069	11,787	**86,713**
20,5	8,947	0	0	0	**8,947**
21	9,597	0	0	0	**9,597**
21,5	10,278	0	0	0	**10,278**
22	0	0	0	0	**0**
22,5	0	0	0	0	**0**
23	0	0	0	0	**0**
23,5	0	0	0	0	**0**
24	0	0	0	0	**0**
24,5	0	0	0	0	**0**
25	0	0	0	0	**0**
25,5	0	0	0	0	**0**
26	0	0	0	0	**0**
26,5	0	0	0	0	**0**
27	0	0	0	0	**0**
27,5	0	0	0	0	**0**
28	0	0	0	0	**0**
TOTAL	**615,782**	**1405,595**	**957,393**	**910,031**	**3888,801**

Table 8. *ECOCADIZ 0813* survey. Horse mackerel (*T. trachurus*). Estimated abundance and biomass by size class. Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figure 17**.

***ECOCADIZ 0813* . *Trachurus trachurus* . ABUNDANCE (in number of fish).**						
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**TOTAL *n***	**Millions**
10	0	0	0	0	0	**0**
10,5	0	36363	0	0	36363	**0**
11	0	36363	0	0	36363	**0**
11,5	0	327267	0	0	327267	**0**
12	0	363630	0	0	363630	**0**
12,5	0	1418157	0	0	1418157	**1**
13	0	690897	0	0	690897	**1**
13,5	0	290904	0	0	290904	**0**
14	0	145452	0	0	145452	**0**
14,5	50650	109089	0	0	159739	**0**
15	1002859	36363	207396	0	1246618	**1**
15,5	3245639	0	1055836	0	4301475	**4**
16	5978250	0	3808552	5588103	15374905	**15**
16,5	5255795	0	6335017	32632875	44223687	**44**
17	2518284	0	2545319	55828023	60891626	**61**
17,5	1142183	0	1055836	43941502	46139521	**46**
18	530503	0	641043	22613200	23784746	**24**
18,5	320713	0	414793	12189257	12924763	**13**
19	151951	0	0	4457895	4609846	**5**
19,5	50650	0	0	5619913	5670563	**6**
20	50650	0	0	3160522	3211172	**3**
20,5	50650	0	0	1828186	1878836	**2**
21	50650	0	0	0	50650	**0**
21,5	50650	0	0	0	50650	**0**
22	50650	0	0	0	50650	**0**
22,5	50650	0	0	0	50650	**0**
23	0	0	0	0	0	**0**
23,5	0	0	0	0	0	**0**
24	0	0	0	0	0	**0**
24,5	0	0	0	0	0	**0**
25	0	0	0	0	0	**0**
25,5	0	0	0	0	0	**0**
26	0	0	0	0	0	**0**
26,5	0	0	0	0	0	**0**
27	0	0	0	0	0	**0**
27,5	0	0	0	0	0	**0**
28	0	0	0	0	0	**0**
TOTAL *n*	20551377	3454485	16063792	187859476	227929130	**228**
Millions	**21**	**3**	**16**	**188**	**228**	

Table 8 (cont'd)**.**

***ECOCADIZ 0813 . Trachurus trachurus* . BIOMASS (t).**					
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**TOTAL**
10	0	0	0	0	**0**
10,5	0	0,374	0	0	**0,374**
11	0	0,43	0	0	**0,43**
11,5	0	4,416	0	0	**4,416**
12	0	5,572	0	0	**5,572**
12,5	0	24,551	0	0	**24,551**
13	0	13,449	0	0	**13,449**
13,5	0	6,34	0	0	**6,34**
14	0	3,535	0	0	**3,535**
14,5	1,367	2,945	0	0	**4,312**
15	29,973	1,087	6,198	0	**37,258**
15,5	107,032	0	34,818	0	**141,85**
16	216,86	0	138,155	202,708	**557,723**
16,5	209,114	0	252,053	1298,374	**1759,541**
17	109,599	0	110,776	2429,711	**2650,086**
17,5	54,235	0	50,135	2086,518	**2190,888**
18	27,418	0	33,131	1168,699	**1229,248**
18,5	17,999	0	23,279	684,095	**725,373**
19	9,241	0	0	271,098	**280,339**
19,5	3,331	0	0	369,563	**372,894**
20	3,595	0	0	224,301	**227,896**
20,5	3,872	0	0	139,765	**143,637**
21	4,164	0	0	0	**4,164**
21,5	4,47	0	0	0	**4,47**
22	4,791	0	0	0	**4,791**
22,5	5,127	0	0	0	**5,127**
23	0	0	0	0	**0**
23,5	0	0	0	0	**0**
24	0	0	0	0	**0**
24,5	0	0	0	0	**0**
25	0	0	0	0	**0**
25,5	0	0	0	0	**0**
26	0	0	0	0	**0**
26,5	0	0	0	0	**0**
27	0	0	0	0	**0**
27,5	0	0	0	0	**0**
28	0	0	0	0	**0**
TOTAL	**812,188**	**62,699**	**648,545**	**8874,832**	**10398,264**

Table 9. *ECOCADIZ 0813* survey. Mediterranean horse-mackerel (*T. mediterraneus*). Estimated abundance and biomass by size class. Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figure 19**.

***ECOCADIZ 0813 . Trachurus mediterraneus* . ABUNDANCE (in number of fish).**					
Size class	**POL01**	**POL02**	**POL03**	**TOTAL *n***	**Millions**
10	0	0	0	0	**0**
10,5	0	0	0	0	**0**
11	0	0	0	0	**0**
11,5	0	0	0	0	**0**
12	0	0	0	0	**0**
12,5	0	0	0	0	**0**
13	0	0	0	0	**0**
13,5	0	0	0	0	**0**
14	0	0	0	0	**0**
14,5	0	0	0	0	**0**
15	0	0	0	0	**0**
15,5	0	0	0	0	**0**
16	0	0	0	0	**0**
16,5	0	0	0	0	**0**
17	0	0	35982	35982	**0**
17,5	0	0	71963	71963	**0**
18	0	0	107945	107945	**0**
18,5	0	0	215890	215890	**0**
19	0	0	179908	179908	**0**
19,5	0	0	215890	215890	**0**
20	0	0	143926	143926	**0**
20,5	0	0	179908	179908	**0**
21	0	0	71963	71963	**0**
21,5	0	0	71963	71963	**0**
22	0	0	35982	35982	**0**
22,5	0	148192	35982	184174	**0**
23	0	148192	35982	184174	**0**
23,5	0	148192	35982	184174	**0**
24	0	296384	0	296384	**0**
24,5	0	444575	0	444575	**0**
25	0	740959	0	740959	**1**
25,5	77257	862791	0	940048	**1**
26	154515	503055	0	657570	**1**
26,5	347658	1699278	0	2046936	**2**
27	849830	1307367	0	2157197	**2**
27,5	849830	1229179	0	2079009	**2**
28	1506517	1298293	0	2804810	**3**
28,5	1738290	1420126	0	3158416	**3**
29	927088	1239814	0	2166902	**2**
29,5	270400	906436	0	1176836	**1**
30	270400	302145	0	572545	**1**
30,5	231772	180313	0	412085	**0**
31	154515	180313	0	334828	**0**
31,5	231772	121833	0	353605	**0**
32	154515	58480	0	212995	**0**
32,5	0	58480	0	58480	**0**
33	77257	58480	0	135737	**0**
33,5	77257	58480	0	135737	**0**
34	115886	0	0	115886	**0**
34,5	695316	0	0	695316	**1**
35	1004345	0	0	1004345	**1**
35,5	965716	0	0	965716	**1**
36	424915	0	0	424915	**0**
36,5	309029	0	0	309029	**0**
37	77257	0	0	77257	**0**
37,5	77257	0	0	77257	**0**
38	38629	0	0	38629	**0**
38,5	0	0	0	0	**0**
39	0	0	0	0	**0**
TOTAL *n*	11627223	13411357	1439266	26477846	**26**
Millions	**12**	**13**	**1**	**26**	

Table 9 (cont'd)**.**

ECOCADIZ 0813 . Trachurus mediterraneus . BIOMASS (t).				
Size class	**POL01**	**POL02**	**POL03**	**TOTAL**
10	0	0	0	**0**
10,5	0	0	0	**0**
11	0	0	0	**0**
11,5	0	0	0	**0**
12	0	0	0	**0**
12,5	0	0	0	**0**
13	0	0	0	**0**
13,5	0	0	0	**0**
14	0	0	0	**0**
14,5	0	0	0	**0**
15	0	0	0	**0**
15,5	0	0	0	**0**
16	0	0	0	**0**
16,5	0	0	0	**0**
17	0	0	1,522	**1,522**
17,5	0	0	3,298	**3,298**
18	0	0	5,348	**5,348**
18,5	0	0	11,539	**11,539**
19	0	0	10,353	**10,353**
19,5	0	0	13,349	**13,349**
20	0	0	9,546	**9,546**
20,5	0	0	12,777	**12,777**
21	0	0	5,464	**5,464**
21,5	0	0	5,832	**5,832**
22	0	0	3,108	**3,108**
22,5	0	13,623	3,308	**16,931**
23	0	14,48	3,516	**17,996**
23,5	0	15,37	3,732	**19,102**
24	0	32,589	0	**32,589**
24,5	0	51,764	0	**51,764**
25	0	91,25	0	**91,25**
25,5	10,052	112,26	0	**122,312**
26	21,218	69,081	0	**90,299**
26,5	50,336	246,03	0	**296,366**
27	129,602	199,378	0	**328,98**
27,5	136,382	197,26	0	**333,642**
28	254,183	219,051	0	**473,234**
28,5	308,08	251,691	0	**559,771**
29	172,449	230,62	0	**403,069**
29,5	52,746	176,816	0	**229,562**
30	55,27	61,759	0	**117,029**
30,5	49,603	38,59	0	**88,193**
31	34,599	40,376	0	**74,975**
31,5	54,261	28,523	0	**82,784**
32	37,794	14,304	0	**52,098**
32,5	0	14,935	0	**14,935**
33	20,587	15,583	0	**36,17**
33,5	21,467	16,249	0	**37,716**
34	33,556	0	0	**33,556**
34,5	209,687	0	0	**209,687**
35	315,262	0	0	**315,262**
35,5	315,35	0	0	**315,35**
36	144,265	0	0	**144,265**
36,5	109,029	0	0	**109,029**
37	28,31	0	0	**28,31**
37,5	29,389	0	0	**29,389**
38	15,247	0	0	**15,247**
38,5	0	0	0	**0**
39	0	0	0	**0**
TOTAL	**2608,724**	**2151,582**	**92,692**	**4852,998**

Table 10. *ECOCADIZ 0813* survey. Bogue (*B. boops*). Estimated abundance and biomass by size class. Estimated abundance and biomass by size class. Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figure 21**.

***ECOCADIZ 0813 . Boops boops* . ABUNDANCE (in number of fish).**							
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**TOTAL *n***	**Millions**
10	0	0	0	0	0	0	**0**
10,5	0	0	38941	0	0	38941	**0**
11	0	0	38941	0	0	38941	**0**
11,5	0	0	38941	0	0	38941	**0**
12	0	0	155764	0	0	155764	**0**
12,5	46357	0	155764	0	0	202121	**0**
13	92714	0	389411	0	0	482125	**0**
13,5	139071	0	389411	0	0	528482	**1**
14	92714	0	311528	0	0	404242	**0**
14,5	46357	0	233646	0	0	280003	**0**
15	185428	0	194705	0	0	380133	**0**
15,5	231785	0	194705	0	0	426490	**0**
16	231785	0	116823	0	0	348608	**0**
16,5	139071	0	194705	0	0	333776	**0**
17	185428	0	350469	0	0	535897	**1**
17,5	0	0	116823	91682	0	208505	**0**
18	0	0	38941	183363	0	222304	**0**
18,5	0	0	0	91682	0	91682	**0**
19	0	0	0	275045	0	275045	**0**
19,5	0	0	0	275045	3139387	3414432	**3**
20	0	50136	0	531753	2052676	2634565	**3**
20,5	0	74082	0	183363	2052676	2310121	**2**
21	0	98027	0	348390	12316057	12762474	**13**
21,5	0	148163	0	183363	7244742	7576268	**8**
22	0	139932	0	275045	9297417	9712394	**10**
22,5	0	121973	0	183363	2052676	2358012	**2**
23	0	98027	0	275045	1086711	1459783	**1**
23,5	0	71837	0	91682	2052676	2216195	**2**
24	0	0	0	91682	1086711	1178393	**1**
24,5	0	0	0	0	1086711	1086711	**1**
25	0	0	0	0	0	0	**0**
25,5	0	0	0	0	0	0	**0**
26	0	0	0	0	0	0	**0**
26,5	0	0	0	0	0	0	**0**
27	0	0	0	0	0	0	**0**
27,5	0	0	0	0	0	0	**0**
28	0	0	0	0	0	0	**0**
TOTAL *n*	1390710	802177	2959518	3080503	43468440	51701348	**52**
Millions	**1**	**1**	**3**	**3**	**43**	**52**	

Table 10 (cont'd).

ECOCADIZ 0813 . Boops boops . BIOMASS (t).						
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**TOTAL**
10	0	0	0	0	0	**0**
10,5	0	0	0,467	0	0	**0,467**
11	0	0	0,535	0	0	**0,535**
11,5	0	0	0,609	0	0	**0,609**
12	0	0	2,757	0	0	**2,757**
12,5	0,924	0	3,105	0	0	**4,029**
13	2,072	0	8,703	0	0	**10,775**
13,5	3,47	0	9,716	0	0	**13,186**
14	2,572	0	8,644	0	0	**11,216**
14,5	1,425	0	7,183	0	0	**8,608**
15	6,294	0	6,609	0	0	**12,903**
15,5	8,659	0	7,274	0	0	**15,933**
16	9,502	0	4,789	0	0	**14,291**
16,5	6,239	0	8,735	0	0	**14,974**
17	9,078	0	17,159	0	0	**26,237**
17,5	0	0	6,227	4,887	0	**11,114**
18	0	0	2,254	10,614	0	**12,868**
18,5	0	0	0	5,751	0	**5,751**
19	0	0	0	18,657	0	**18,657**
19,5	0	0	0	20,135	229,821	**249,956**
20	0	3,953	0	41,93	161,86	**207,743**
20,5	0	6,281	0	15,546	174,031	**195,858**
21	0	8,92	0	31,704	1120,763	**1161,387**
21,5	0	14,448	0	17,88	706,459	**738,787**
22	0	14,599	0	28,695	969,986	**1013,28**
22,5	0	13,594	0	20,436	228,776	**262,806**
23	0	11,655	0	32,701	129,202	**173,558**
23,5	0	9,098	0	11,612	259,981	**280,691**
24	0	0	0	12,354	146,43	**158,784**
24,5	0	0	0	0	155,588	**155,588**
25	0	0	0	0	0	**0**
25,5	0	0	0	0	0	**0**
26	0	0	0	0	0	**0**
26,5	0	0	0	0	0	**0**
27	0	0	0	0	0	**0**
27,5	0	0	0	0	0	**0**
28	0	0	0	0	0	**0**
TOTAL	**50,235**	**82,548**	**94,766**	**272,902**	**4282,897**	**4783,348**

Table 11. *ECOCADIZ 0813* survey. Parameters of the size-weight relationships for survey's target species. Mackerel was not acoustically assessed because of the negligible backscattering energy attributed to the species. FAO codes for the species: PIL: *Sardina pilchardus*; ANE: *Engraulis encrasicolus*; MAS: *Scomber colias*; MAC: *Scomber scombrus*; JAA: *Trachurus picturatus;* HOM: *Trachurus trachurus*; BOG: *Boops boops*; HMM: *Trachurus mediterraneus*.

Parameter	PIL	ANE	MAS	MAC	JAA	HOM	HMM	BOG
n	347	555	443	213	266	439	228	260
a	0,0049376	0,0031904	0,0045302	0,0019810	0,0099823	0,0073594	0,0143861	0,0103193
b	3,1936283	3,2664826	3,1802800	3,3993235	2,9462604	3,0497220	2,8043959	2,9723640
r^2	0,98	0,95	0,97	0,95	0,95	0,91	0,99	0,97

Table 12. *ECOCADIZ 0813* survey. Comparison of anchovy (ANE) and sardine (PIL) acoustic estimates from the present survey with those ones derived from the same area during the *ECOCADIZ-RECLUTAS 1112* (10 -27 November 2012) *PELAGO13* (5 April – 15 May 2013) surveys. ALG: Portuguese (Algarve) waters; CAD: Spanish waters. Sardine estimates from the post-stratum 4 in the *ECOCADIZ 0813* survey (shared between Portuguese and Spanish waters) have been equally allocated between both countries for the purposes of this table.

ESTIMATE	SURVEY	ANE			PIL		
		ALG	CAD	TOTAL	ALG	CAD	TOTAL
ABUNDANCE (Millions)	*ECOCADIZ-R 1112*	?	2649	?	?	603	?
	PELAGO 13	262	634	897	197	493	690
	ECOCADIZ 0813	50	558	609	125	107	232
BIOMASS (t)	*ECOCADIZ-R 1112*	?	13680	?	?	22119	?
	PELAGO 13	5044	7656	12700	9492	21049	30541
	ECOCADIZ 0813	1315	7172	8487	6061	3609	9670

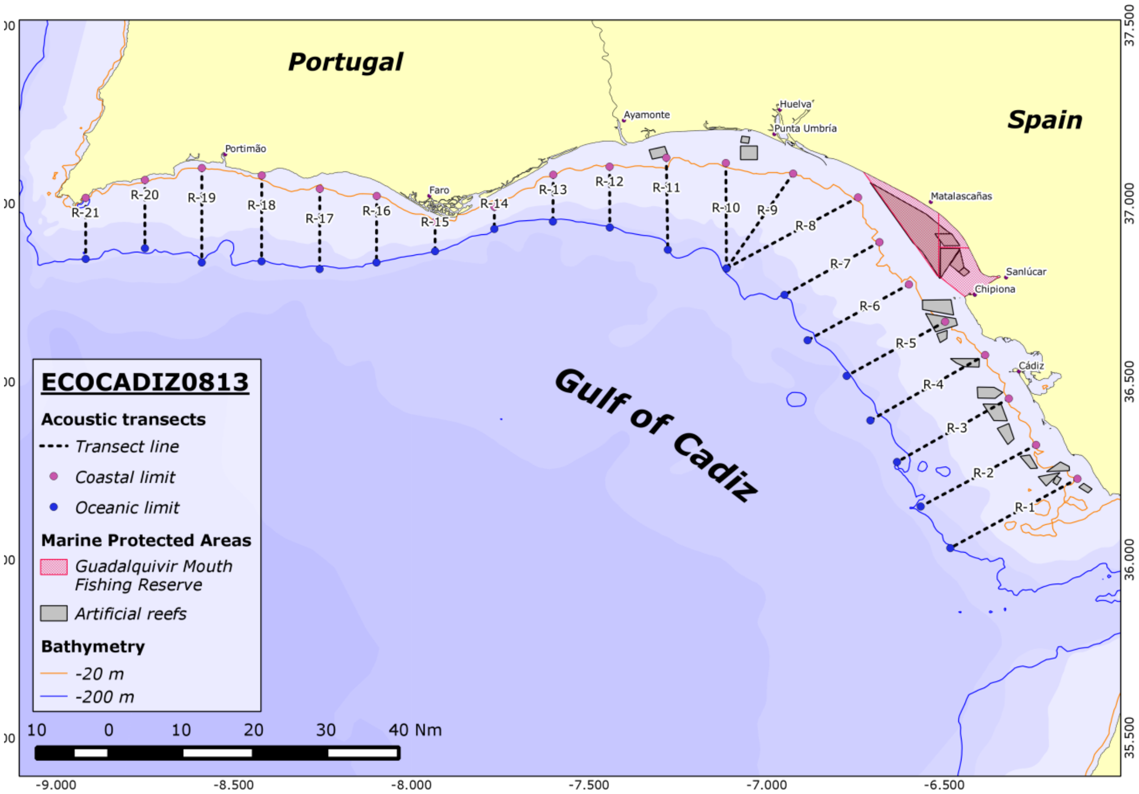


Figure 1. *ECOCADIZ 0813* survey. Location of the acoustic transects sampled during the survey. The different protected areas inside the Guadalquivir river mouth Fishing Reserve and artificial reef polygons are also shown.

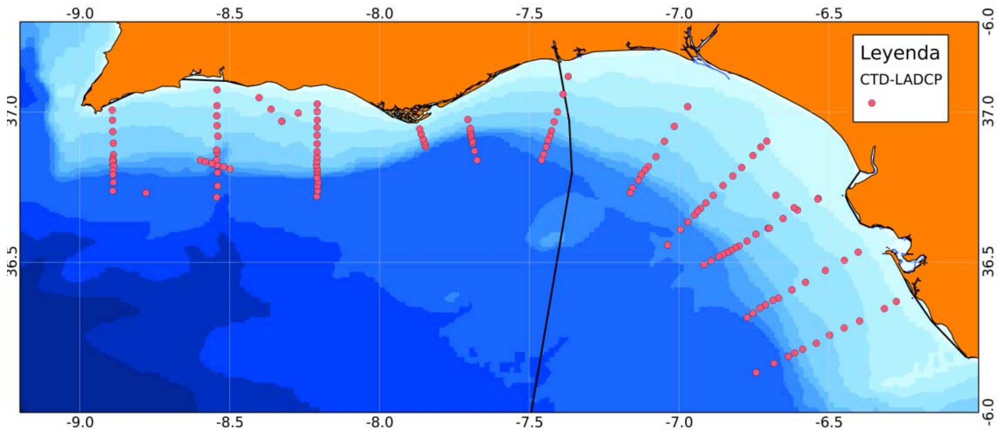


Figure 2. *ECOCADIZ 0813* survey. Sampling grid of CTD stations.

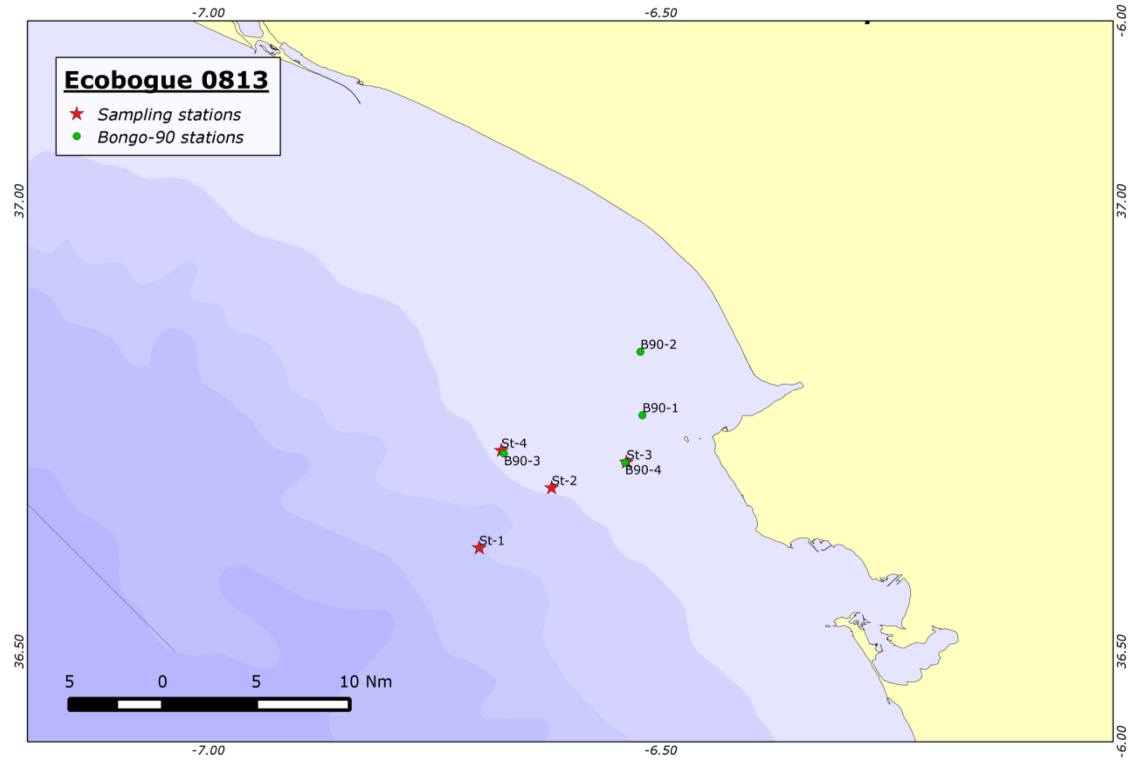


Figure 3. ***ECOCADIZ 0813.*** Location of the *ECOBOGUE* research project sampling stations.

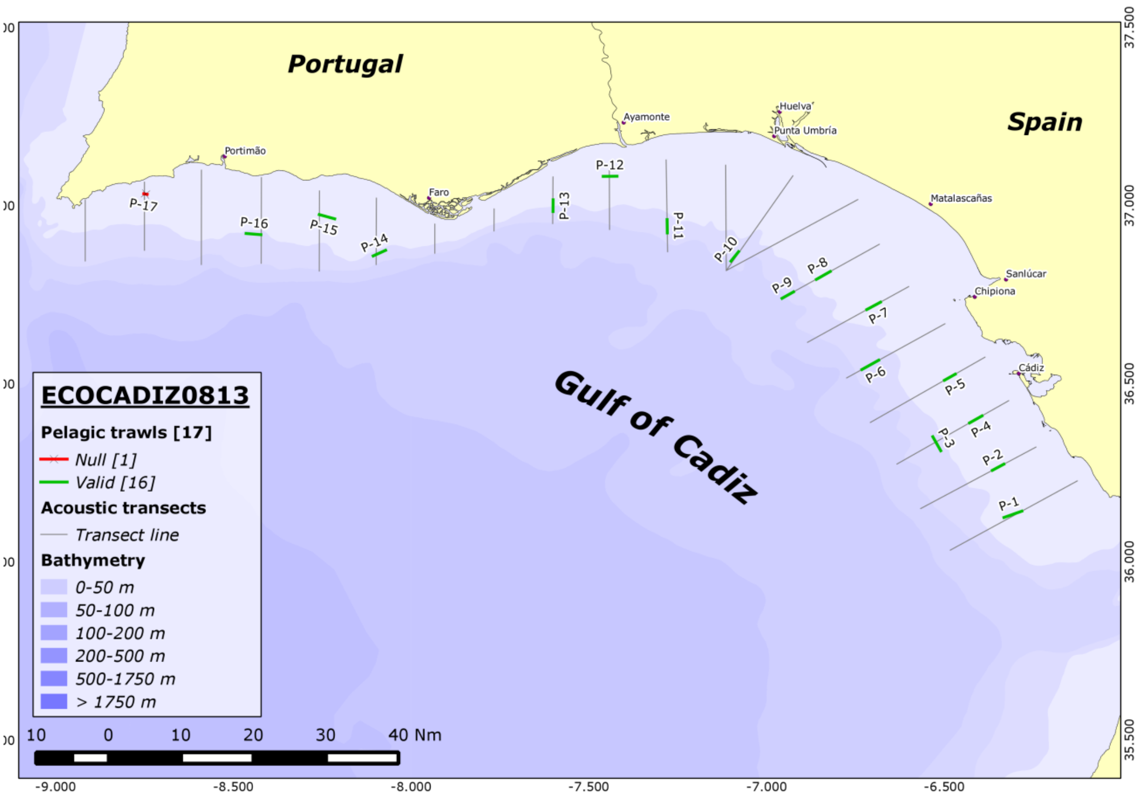


Figure 4. ***ECOCADIZ 0813.*** Location of groundtruthing fishing hauls. Null hauls in red.

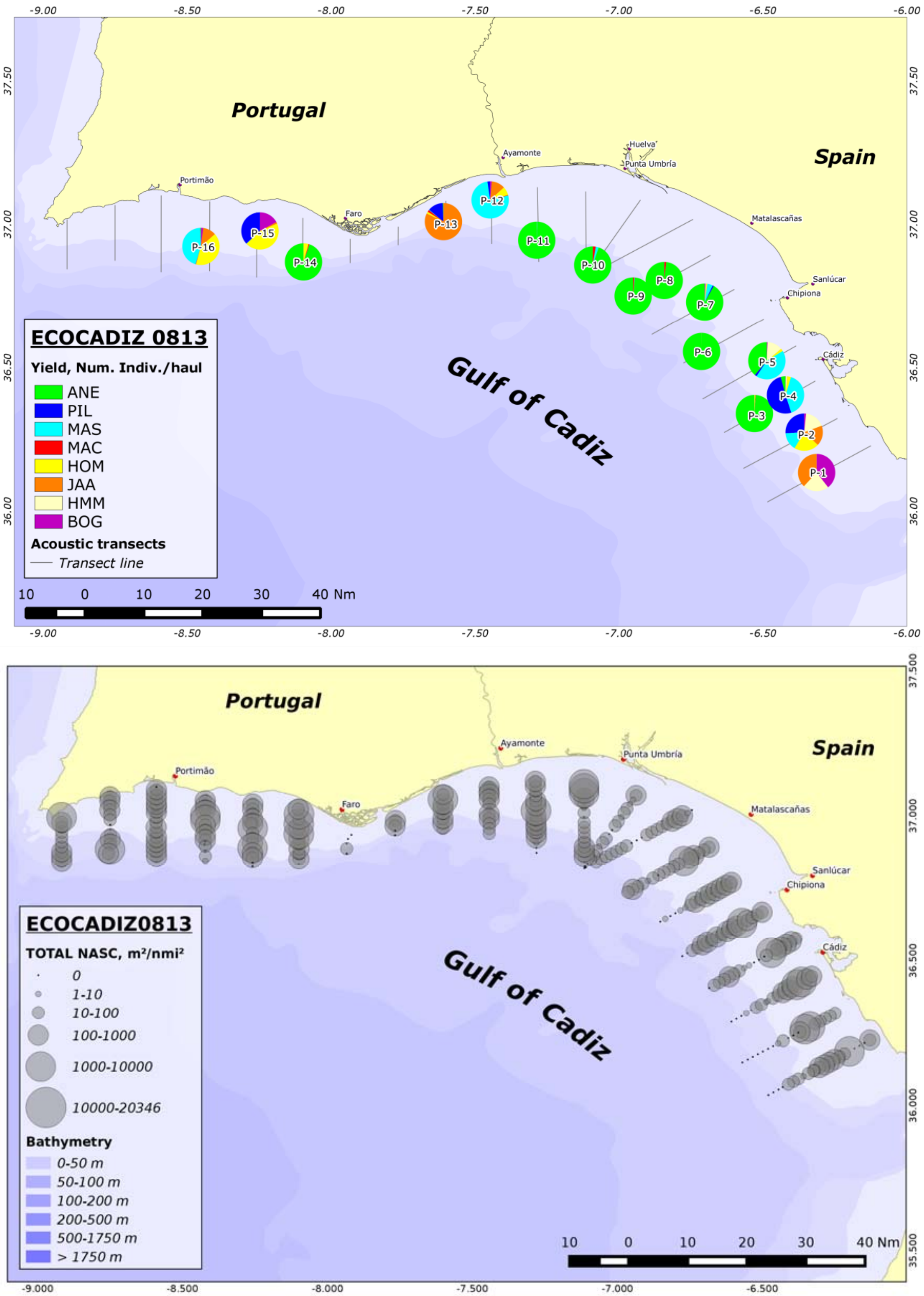


Figure 5. *ECOCADIZ 0813* survey. Top: species composition (percentages in number) in fishing hauls. Bottom: Distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the pelagic fish species assemblage.

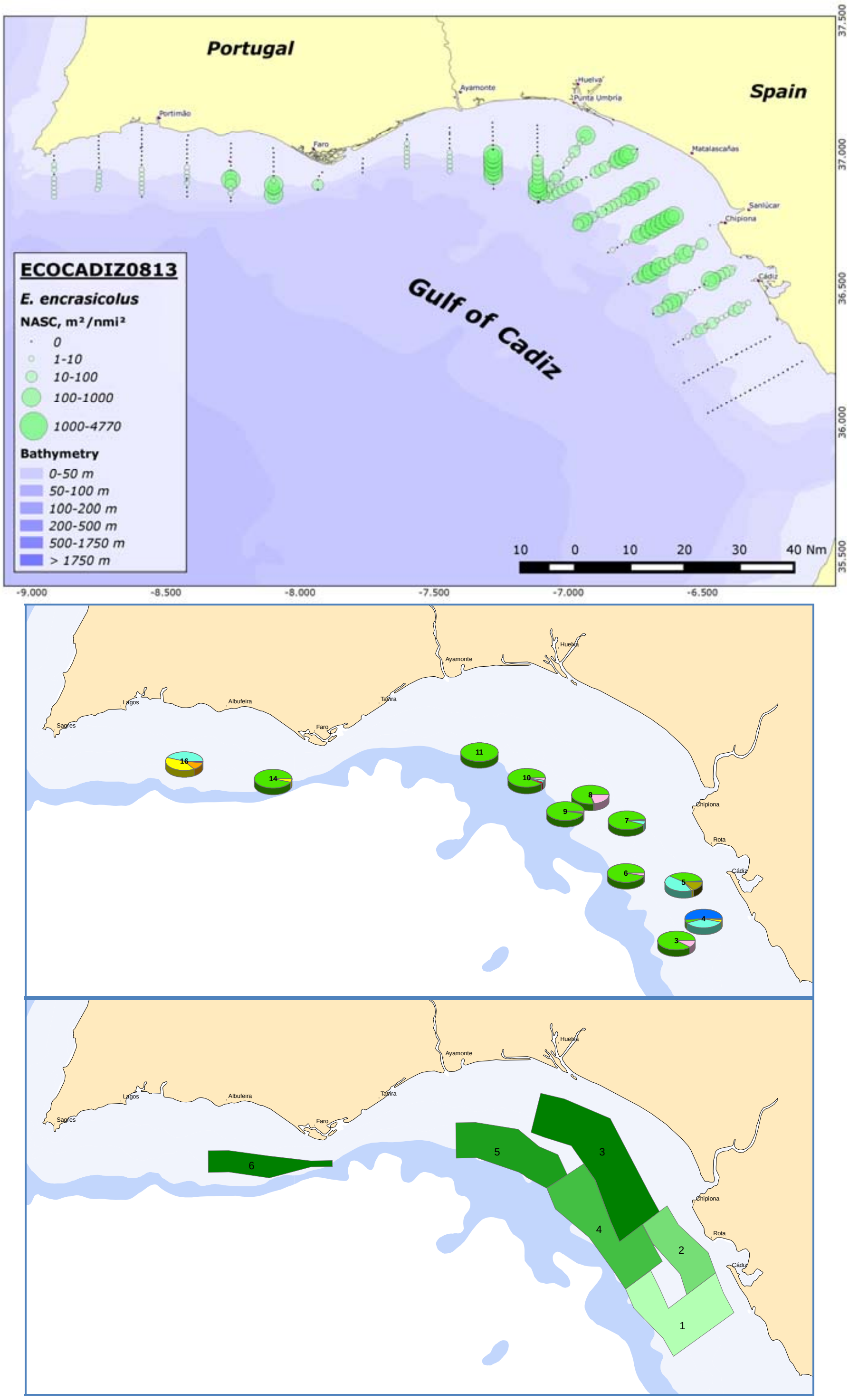


Figure 6. *ECOCADIZ 0813* survey. Anchovy (*Engraulis encrasicolus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Middle: valid fishing hauls for the species (more than 30 individuals showing a normal distribution). Bottom: 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. Bottom right: distribution of anchovy egg densities (eggs 100 m^{-3}) as sampled by CUFES.

***ECOCADIZ 0813*: Anchovy (*E. encrasicolus*)**

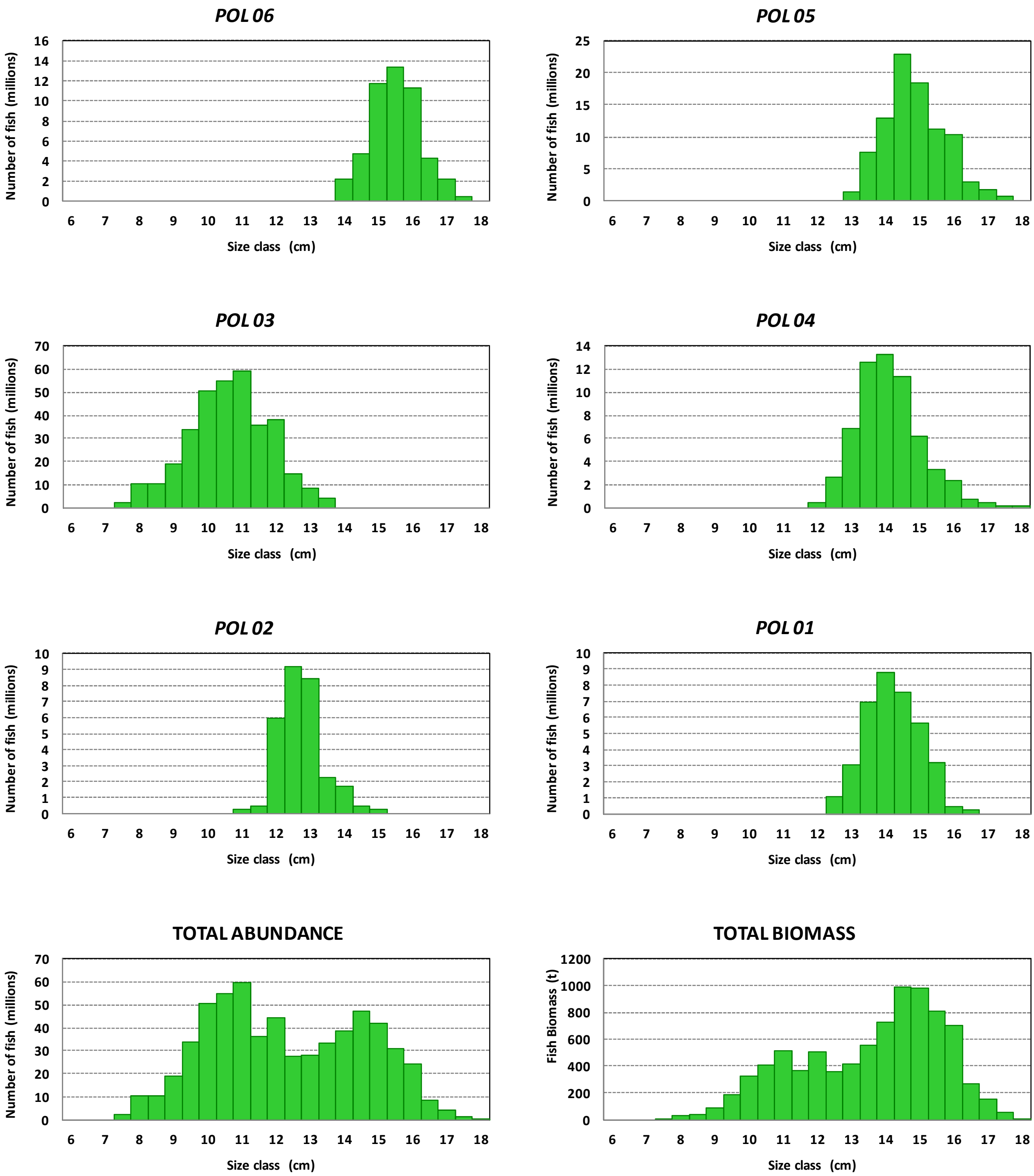


Figure 7. *ECOCADIZ 0813* survey. Anchovy (*E. encrasicolus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 6**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

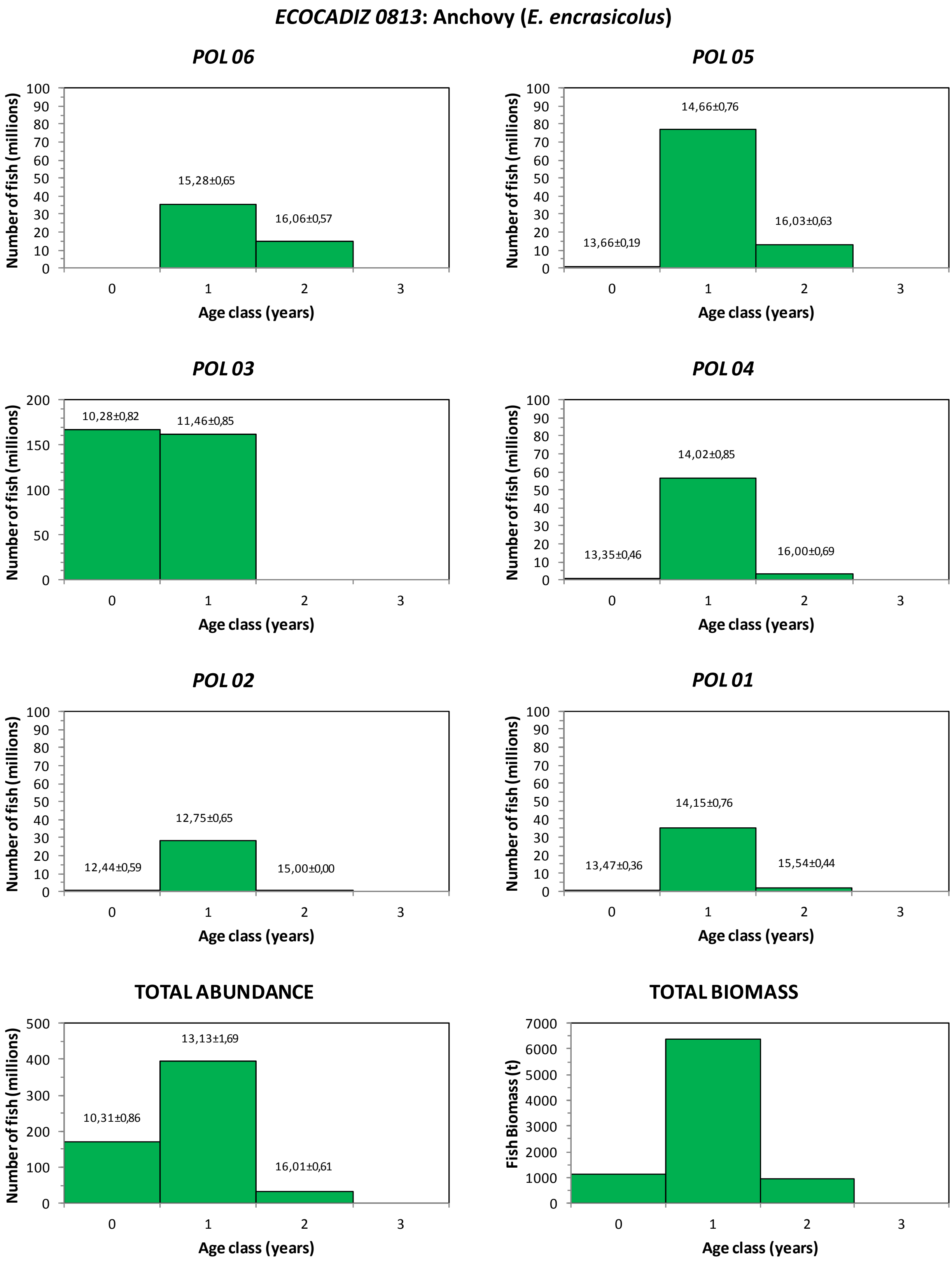


Figure 8. *ECOCADIZ 0813* survey. Anchovy (*E. encrasicolus*). Estimated abundances (number of fish in millions) by age class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 6**) and total sampled area. Post-strata ordered in the W-E direction. Mean length (±SD) by age group is also shown.The estimated biomass (t) by age class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

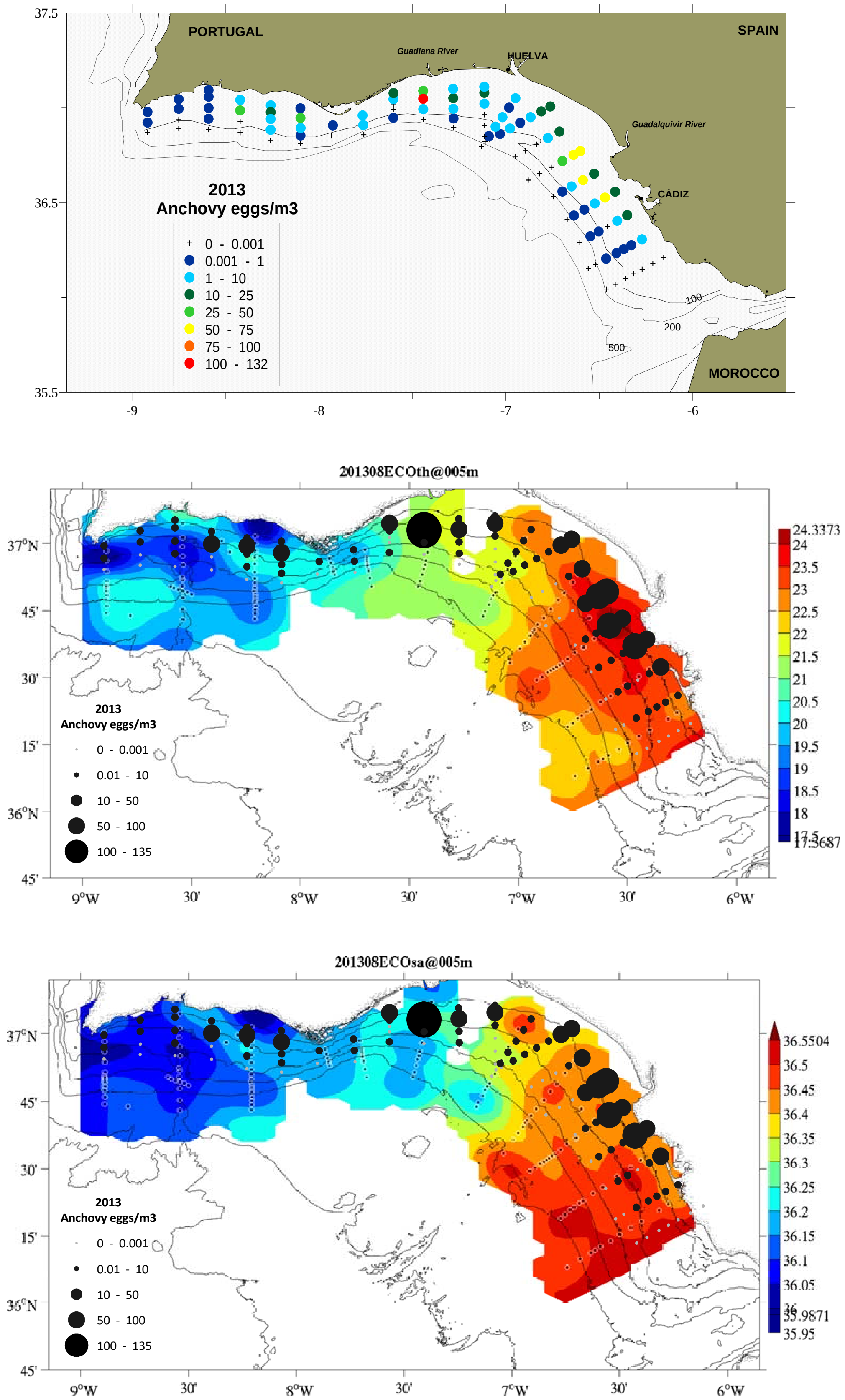


Figure 9. *ECOCADIZ 0813* survey. Anchovy (*Engraulis encrasicolus*). Distribution of anchovy egg densities (eggs m^{-3}) as sampled by CUFES. Middle and bottom panels show the same egg distribution superimposed to the distribution of sea temperature and salinity at 5 m depth respectively.

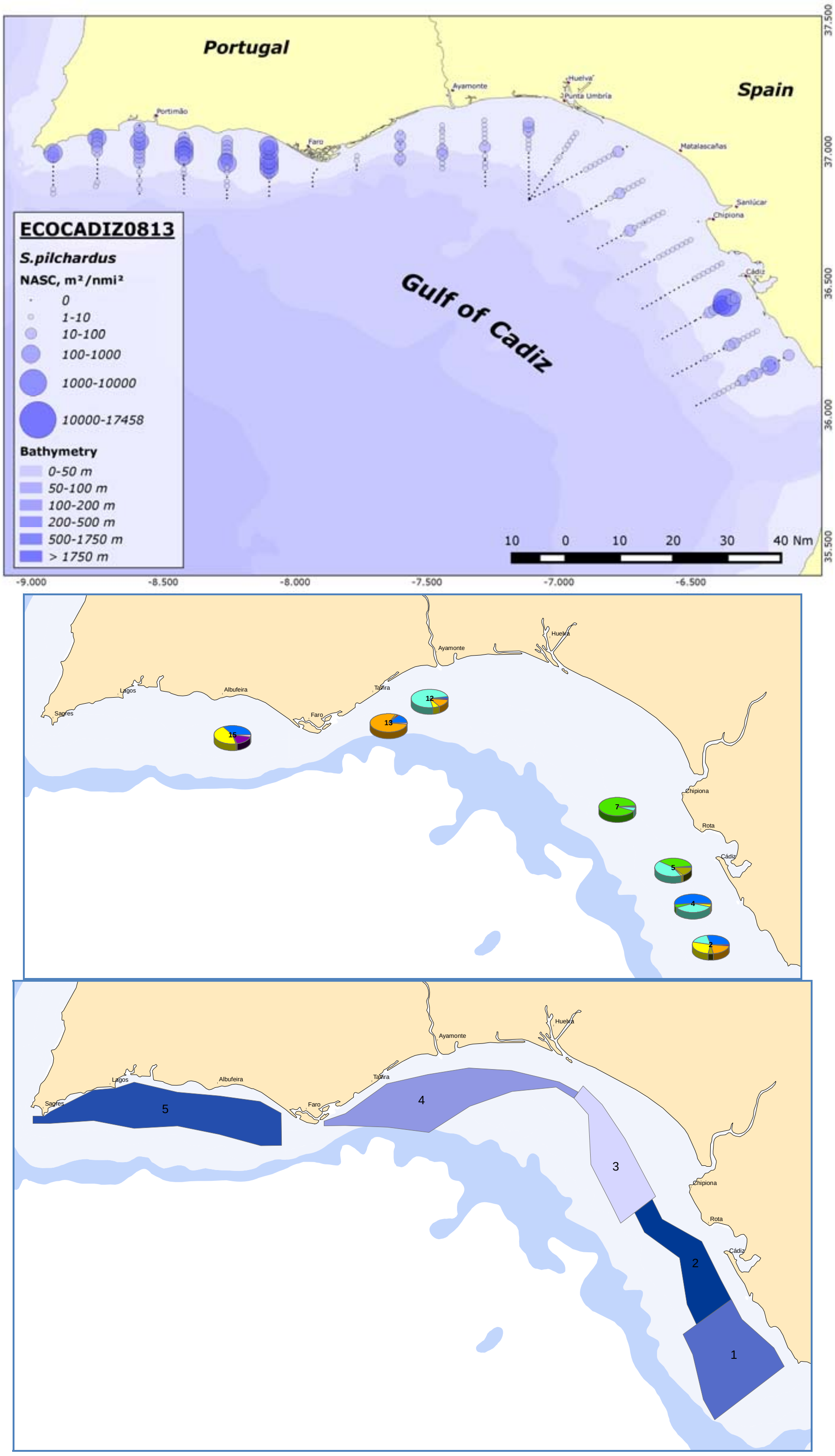


Figure 10. *ECOCADIZ 0813* survey. Sardine (*Sardina pilchardus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Middle: valid fishing hauls for the species (more than 30 individuals showing a normal distribution). Bottom: 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.

***ECOCADIZ 0813* Sardine (*S. pilchardus*)**

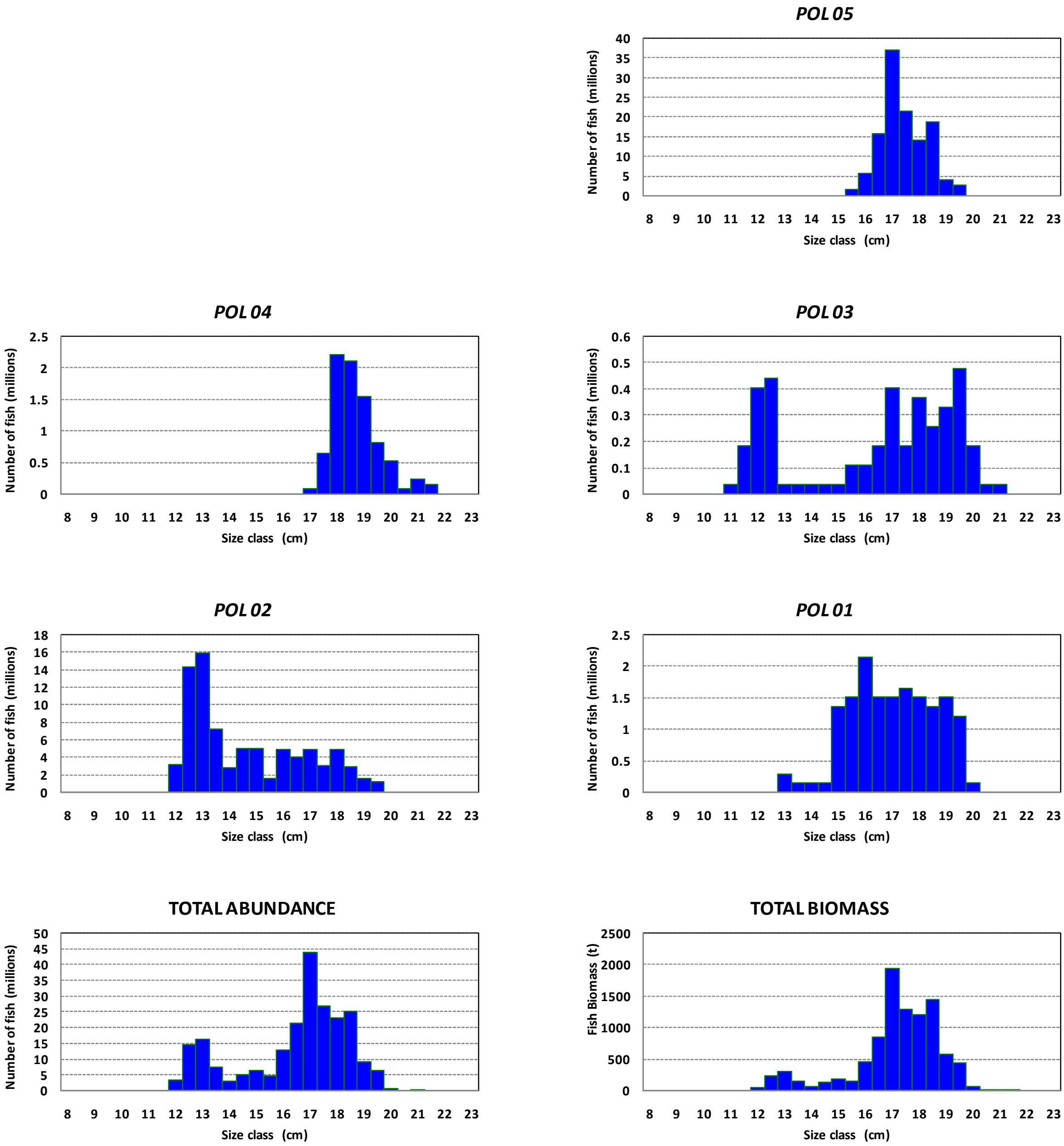
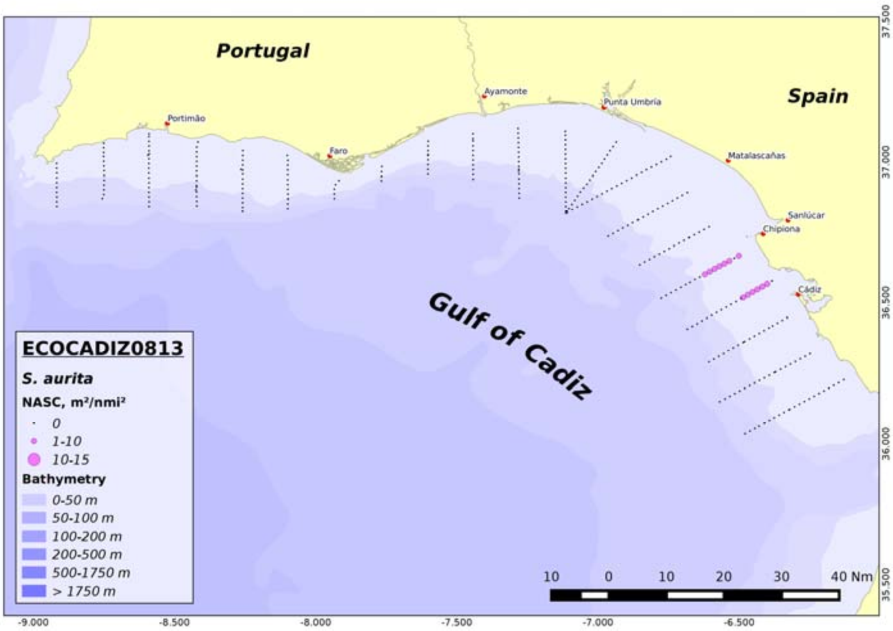


Figure 11. *ECOCADIZ 0813* survey. Sardine (*S. pilchardus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 10**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.



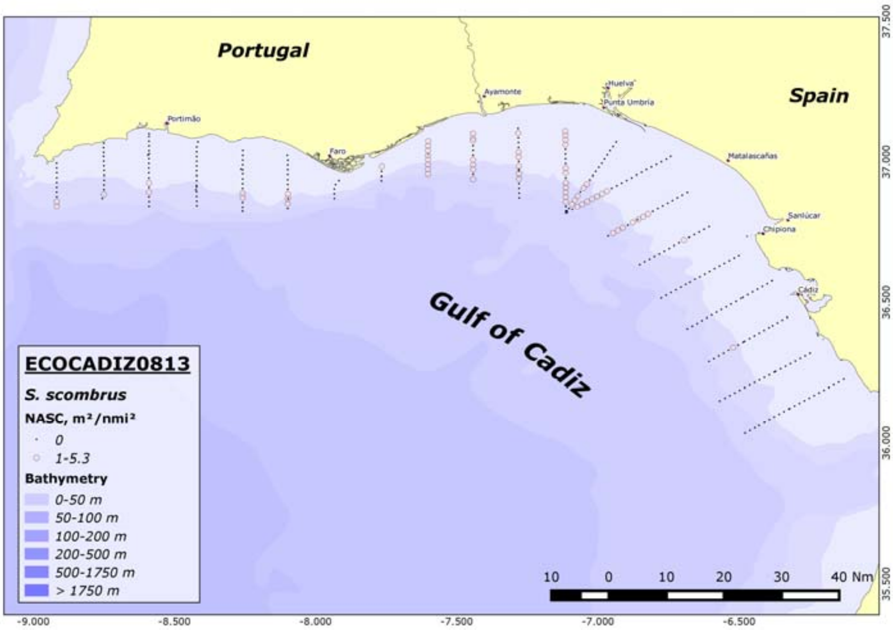


Figure 12. *ECOCADIZ 0813* survey. Round sardinella (*Sardinella aurita*) and Mackerel (*Scomber scombrus*). Distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species.

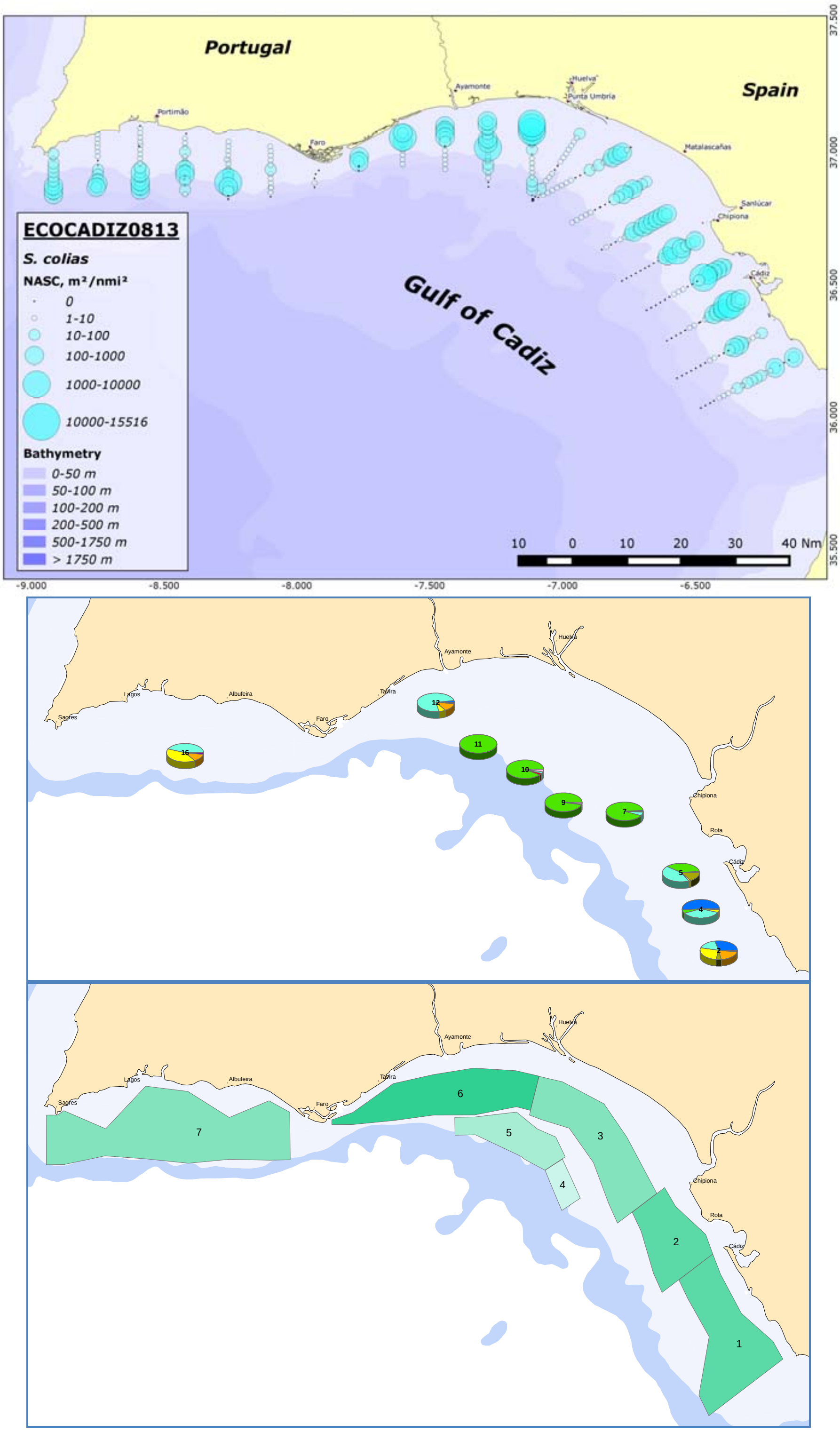


Figure 13. *ECOCADIZ 0813* survey. Chub mackerel (*Scomber colias*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Middle: valid fishing hauls for the species (more than 30 individuals showing a normal distribution). Bottom: 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.

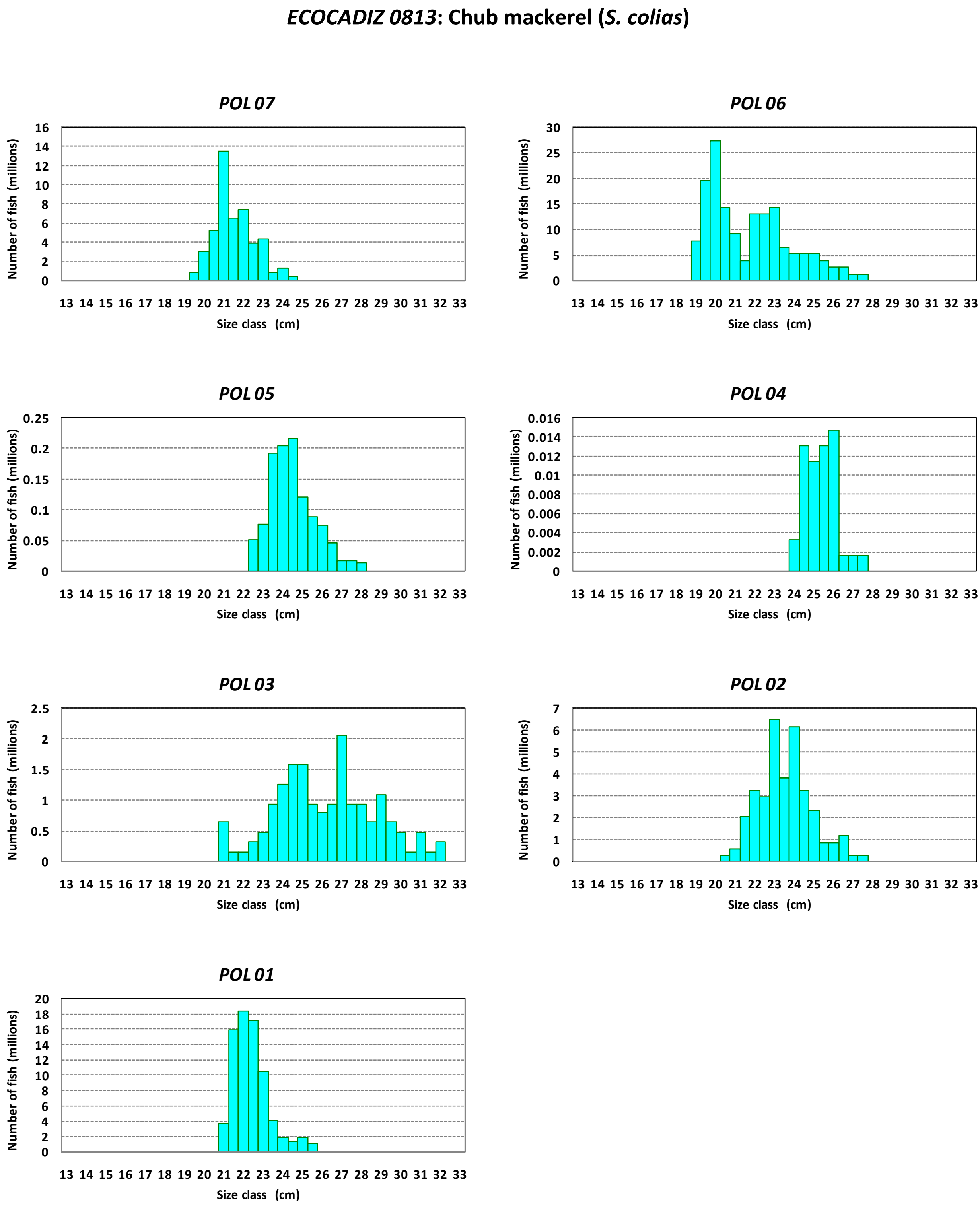
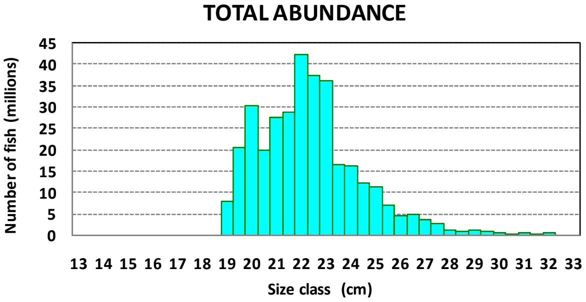


Figure 14. *ECOCADIZ 0813* survey. Chub mackerel (*S. colias*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 13**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

***ECOCADIZ 0813*: Chub mackerel (*S. colias*)**



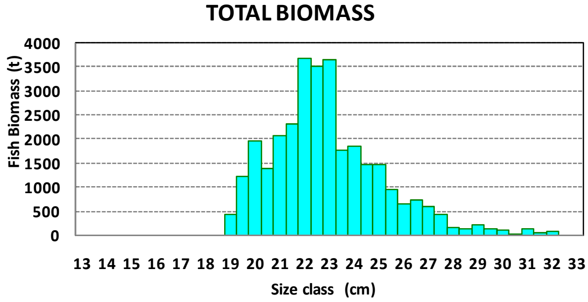


Figure 14. *ECOCADIZ 0813* survey. Chub mackerel (*S. colias*). Cont'd.

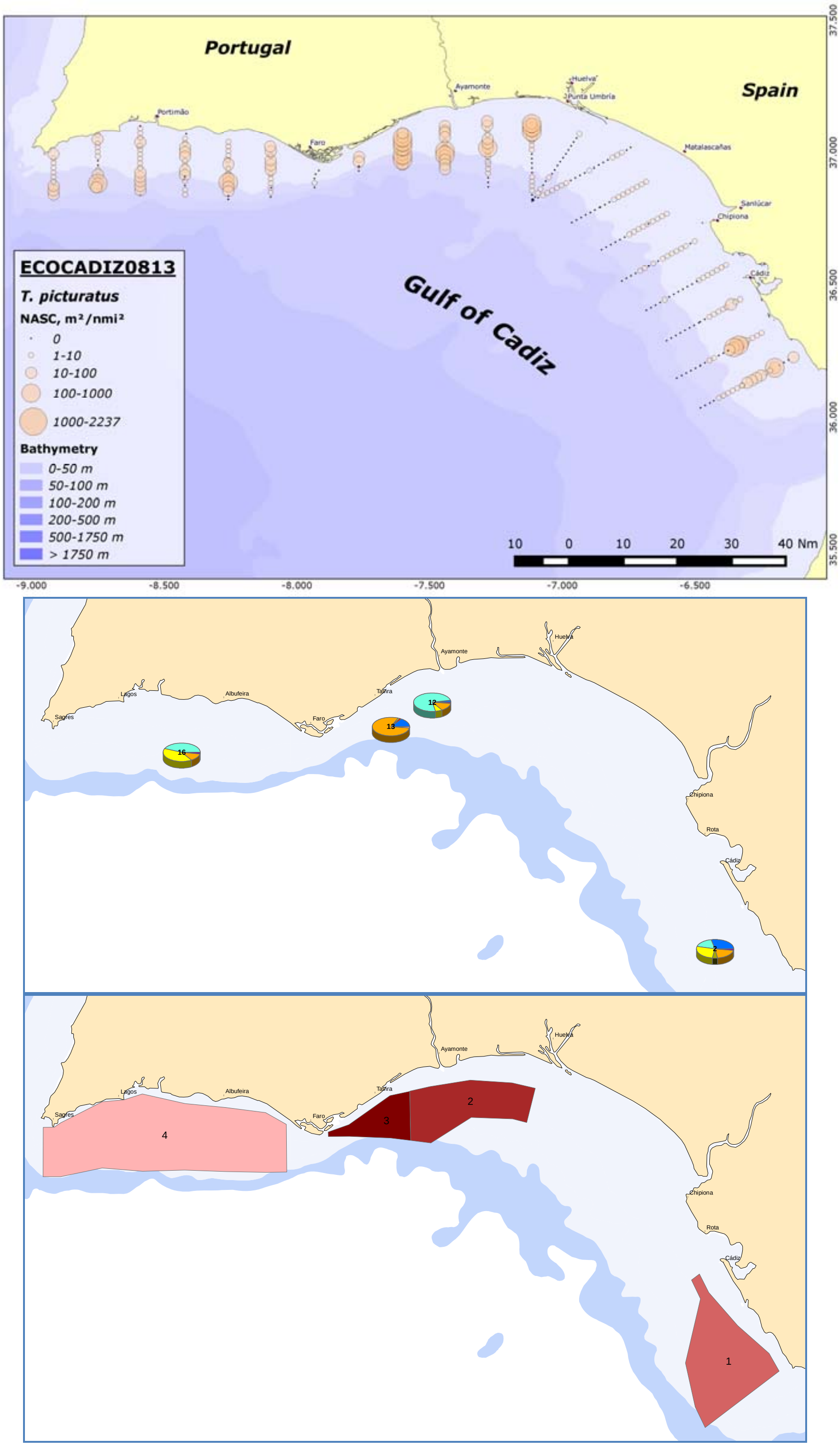


Figure 15. *ECOCADIZ 0813* survey. Blue jack mackerel (*Trachurus picturatus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Middle: valid fishing hauls for the species (more than 30 individuals showing a normal distribution). Bottom: 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.

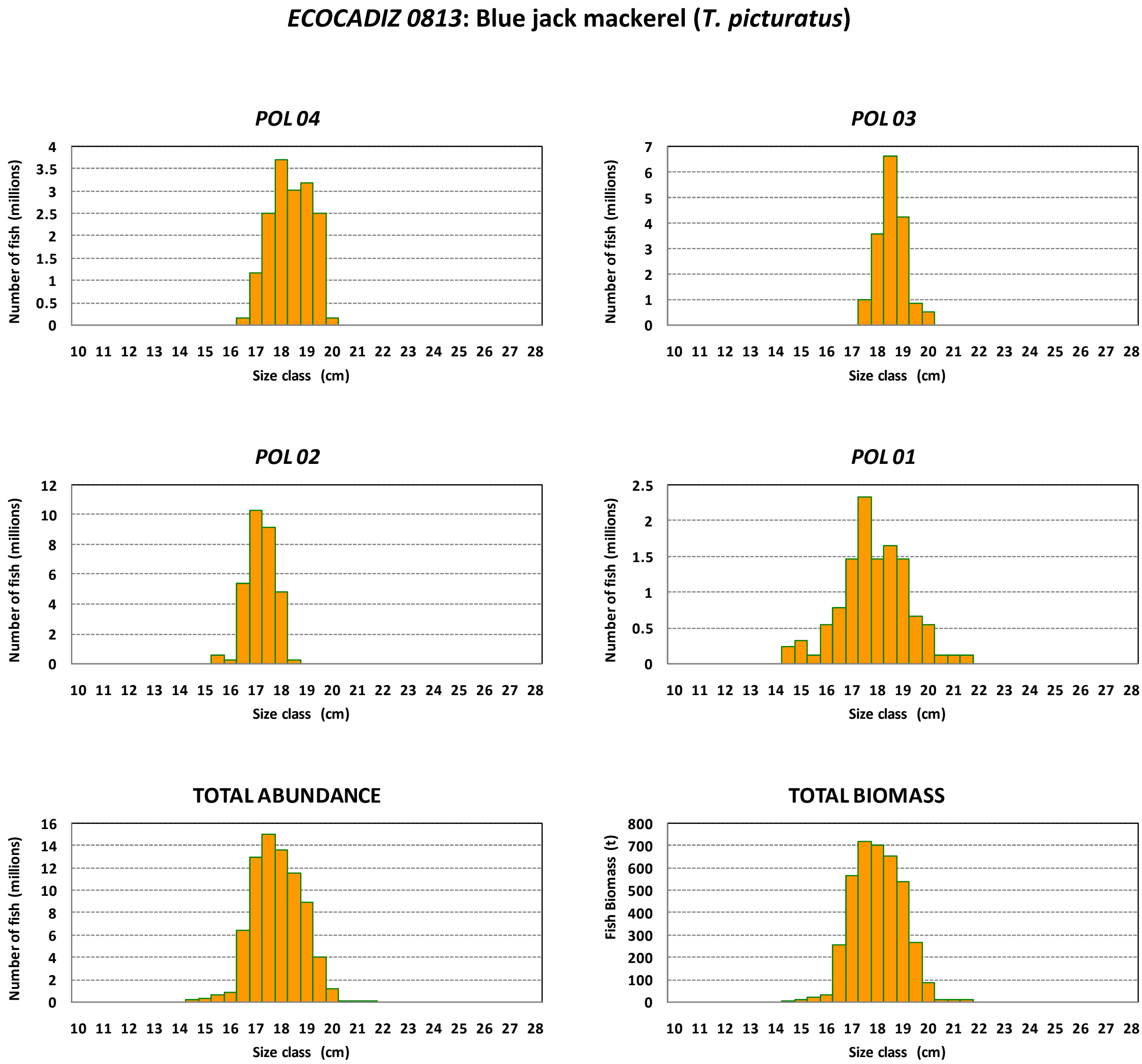


Figure 16. *ECOCADIZ 0813* survey. Blue jack mackerel (*T. picturatus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 15**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

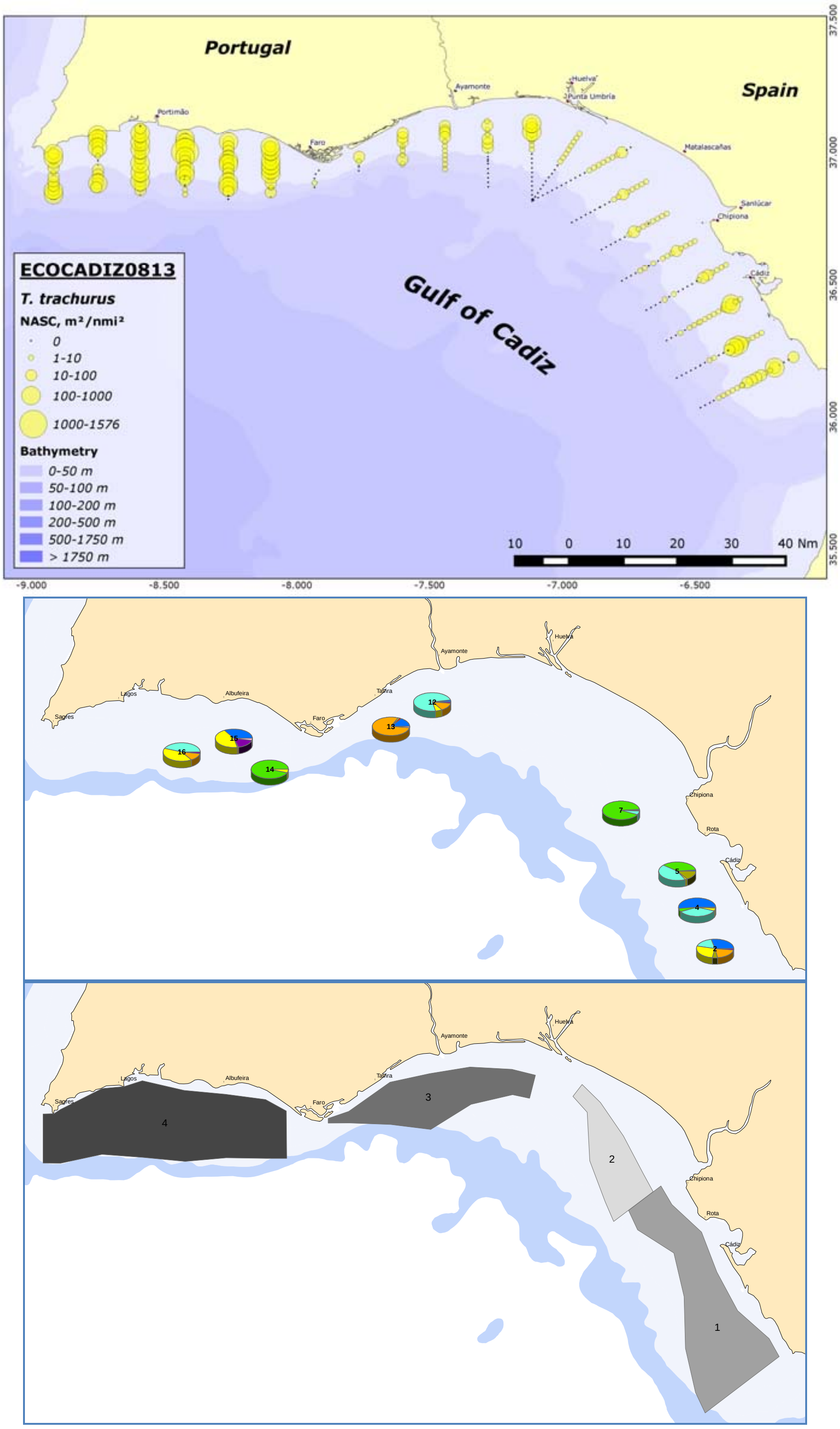


Figure 17. *ECOCADIZ 0813* survey. Horse mackerel (*Trachurus trachurus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Middle: valid fishing hauls for the species (more than 30 individuals showing a normal distribution). Bottom: 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.

***ECOCADIZ 0813*: Horse mackerel (*T. trachurus*)**

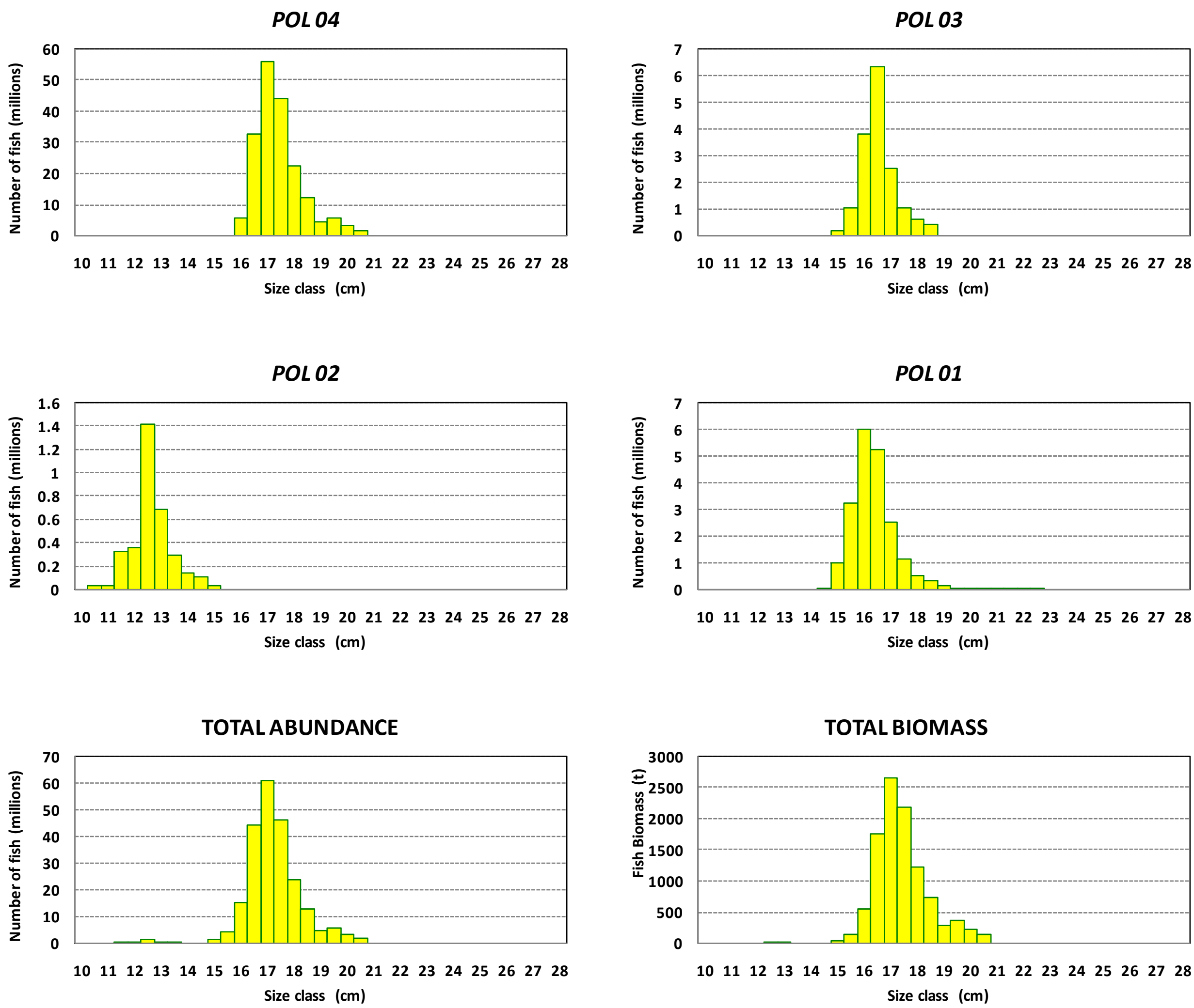


Figure 18. *ECOCADIZ 0813* survey. Horse mackerel (*T. trachurus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 17**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

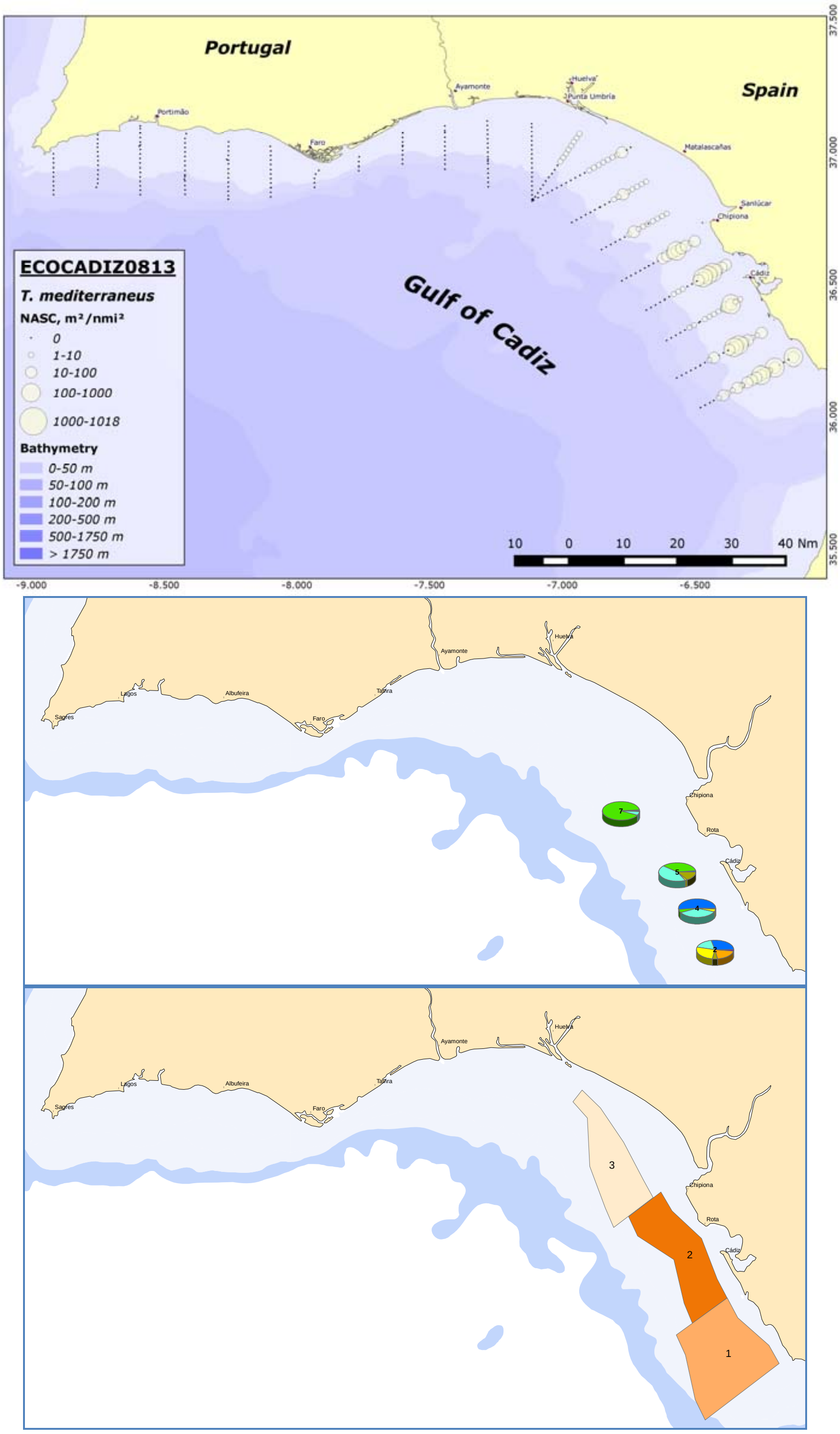


Figure 19. *ECOCADIZ 0813* survey. Mediterranean horse mackerel (*Trachurus mediterraneus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Middle: valid fishing hauls for the species (more than 30 individuals showing a normal distribution). Bottom: 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.

***ECOCADIZ 0813*: Mediterranean horse mackerel (*T. mediterraneus*)**

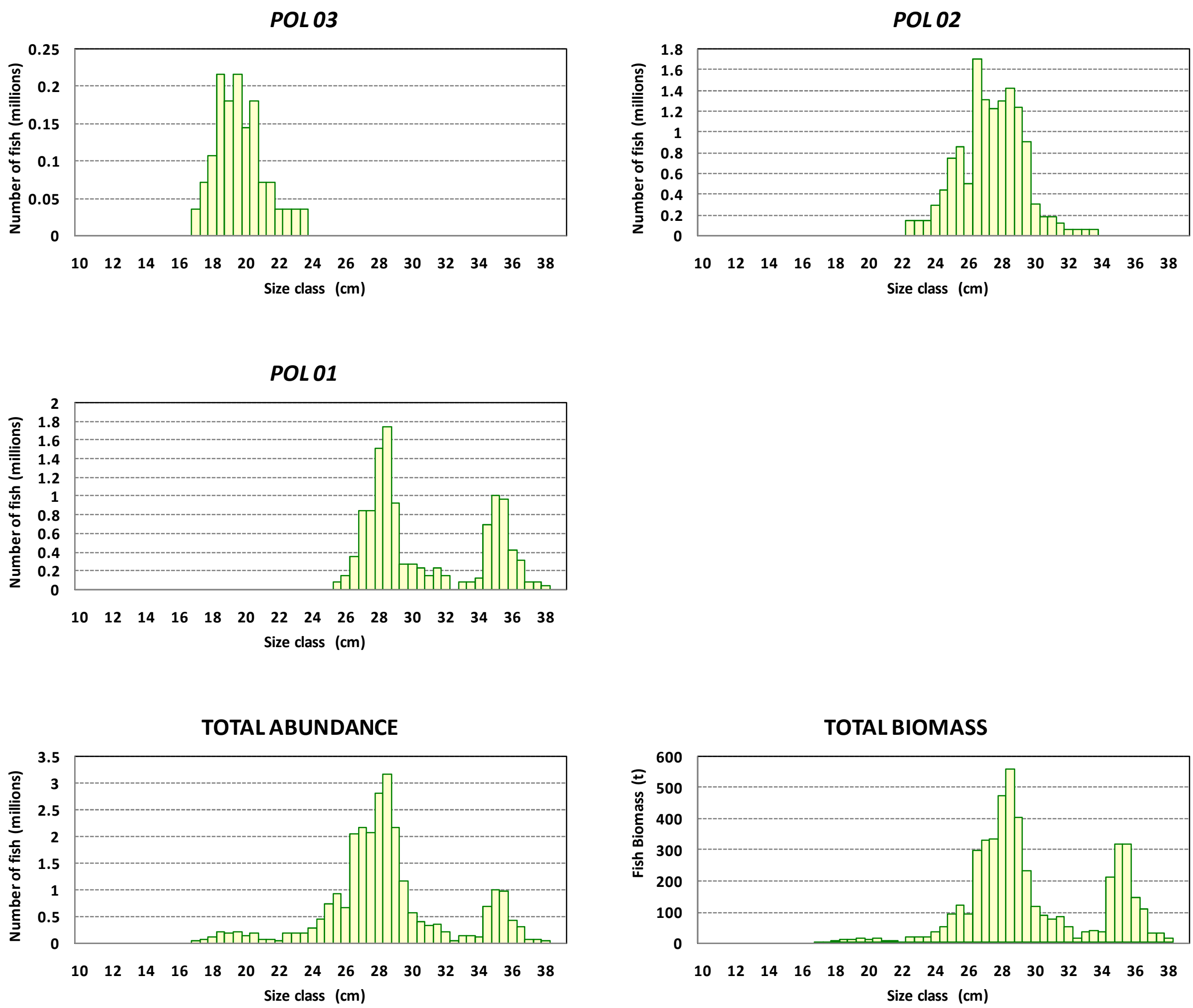


Figure 20. *ECOCADIZ 0813* survey. Mediterranean horse mackerel (*T. mediterraneus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 19**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

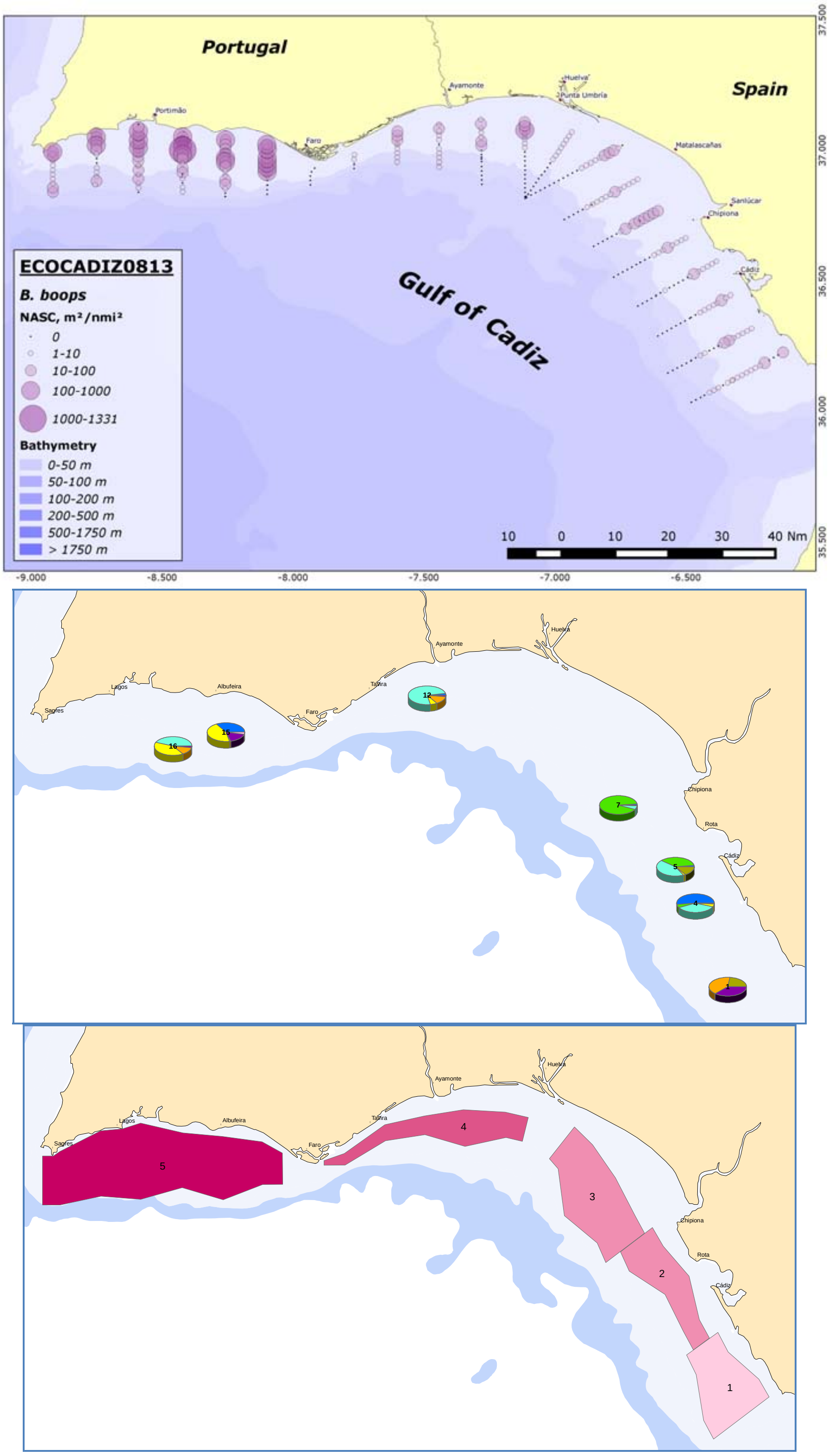


Figure 21. *ECOCADIZ 0813* survey. Bogue (*Boops boops*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Middle: valid fishing hauls for the species (more than 30 individuals showing a normal distribution). Bottom: 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.

***ECOCADIZ 0813*: Bogue (*B. boops*)**

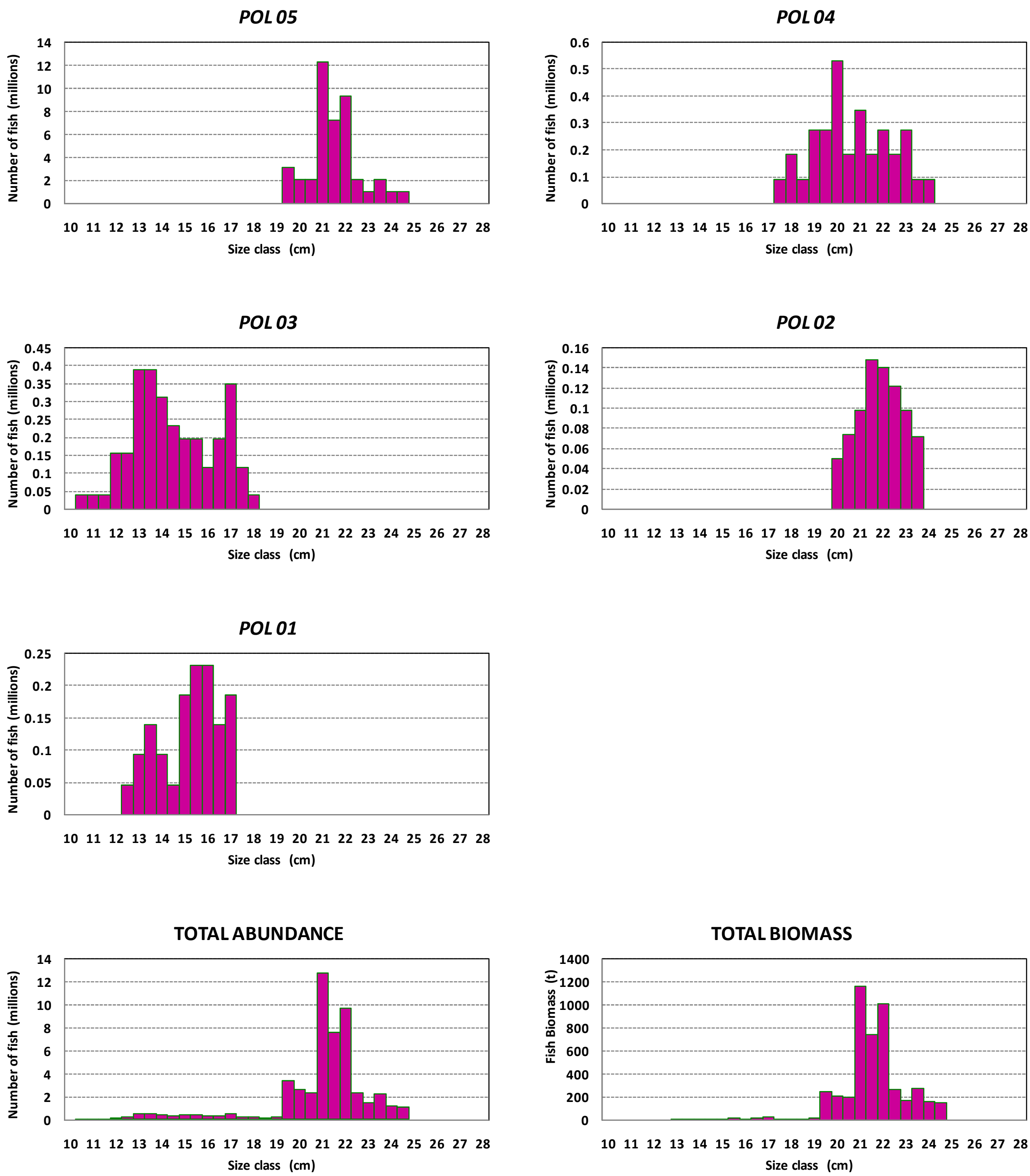
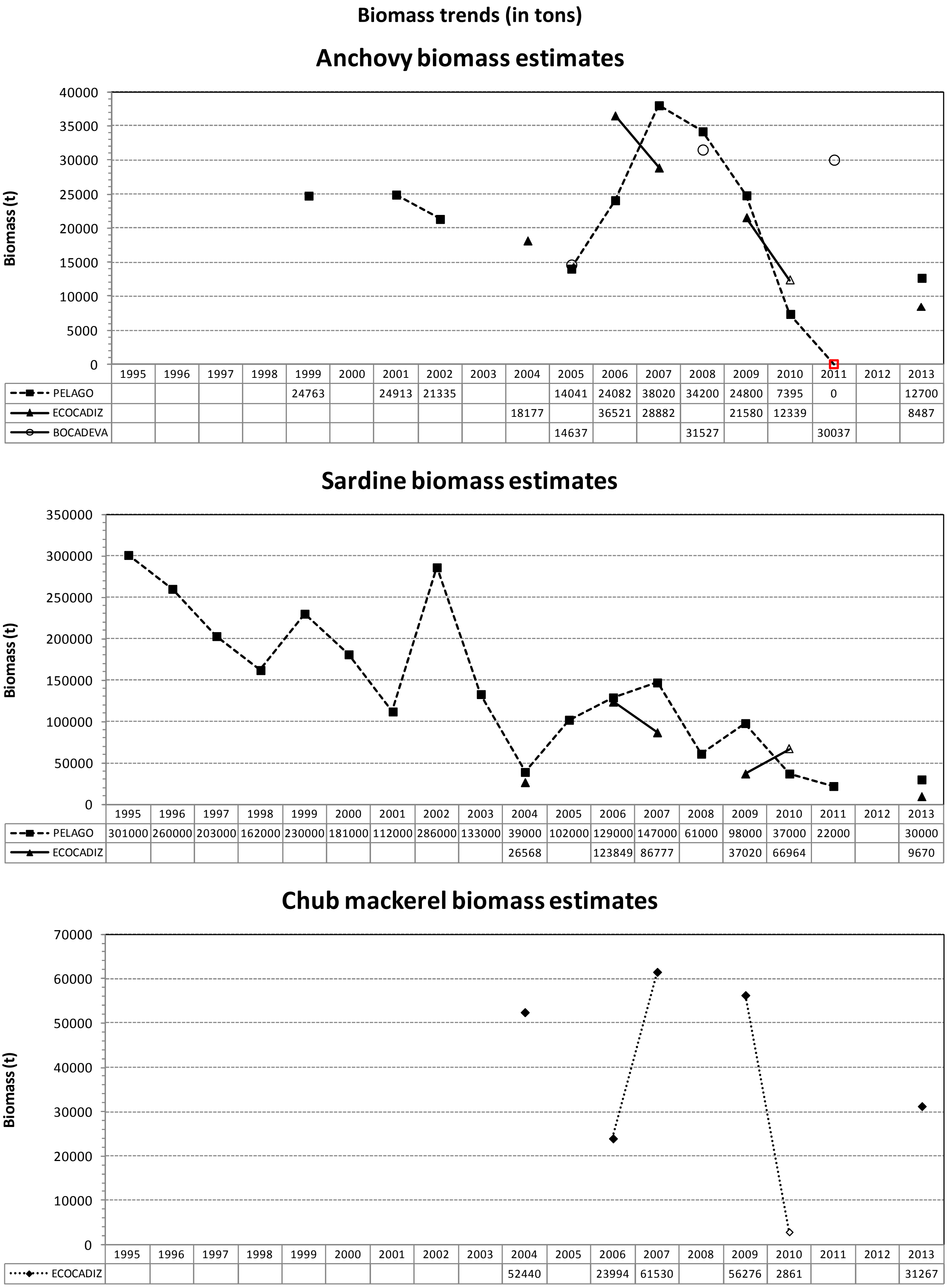


Figure 22. *ECOCADIZ 0813* survey. Bogue (*B. boops*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 21**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.



Anchovy biomass estimates

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
PELAGO					24763		24913	21335			14041	24082	38020	34200	24800	7395	0		12700
ECOCADIZ										18177		36521	28882		21580	12339			8487
BOCADEVA											14637			31527			30037		

Sardine biomass estimates

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
PELAGO	301000	260000	203000	162000	230000	181000	112000	286000	133000	39000	102000	129000	147000	61000	98000	37000	22000		30000
ECOCADIZ										26568		123849	86777		37020	66964			9670

Chub mackerel biomass estimates

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
ECOCADIZ										52440		23994	61530		56276	2861			31267

Figure 23. Trends in biomass estimates (in tons) for the main assessed species in Portuguese (*PELAGO*) and Spanish (*ECOCADIZ*) survey series. Gaps for the 2005, 2008 and 2011 anchovy acoustic estimates in the *ECOCADIZ* series are filled with the *BOCADEVA* Spanish egg survey estimates. Note that the *ECOCADIZ* survey in 2010 partially covered the whole study area. The anchovy null estimate in 2011 from the *PELAGO* survey should be considered with caution.

Working document presented in the:
ICES Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VIII and IX (WGACEGG). Vigo, Spain, 17-21 November 2014.

Acoustic assessment and distribution of the main pelagic fish species in the ICES Subdivision IXa South during the *ECOCADIZ 2014-07* Spanish survey (July-August 2014).

By

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ABSTRACT

The present working document summarises the main results obtained from the Spanish (pelagic ecosystem-) acoustic survey conducted by IEO between 24th July and 6th August 2014 in the Portuguese and Spanish shelf waters (20-200 m isobaths) off the Gulf of Cadiz onboard the R/V *Miguel Oliver*. *ECOCADIZ 2014-07* was conducted almost at the same time than the Gulf of Cadiz anchovy egg survey *BOCADEVA 0714*, with the acoustic survey providing anchovy adult samples to the egg survey. The 21 foreseen acoustic transects were sampled. A total of 24 valid fishing hauls were carried out, 20 of them for echo-trace ground-truthing purposes and the remaining 4 hauls were carried out by night aimed at capturing anchovy mature females with hydrated oocytes (DEPM adult parameters). CUFES sampling was carried during the egg survey. A total of 176 CTD (with coupled altimeter, oximeter, fluorimeter and transmissometer sensors) -LADCP casts, and sub-superficial thermosalinograph-fluorimeter and VMADCP continuous sampling were carried out to oceanographically characterize the surveyed area. Meso-zooplankton species assemblages were sampled from 22 *Multinet* samples. A census of top predator species was also carried out along the sampled acoustic transects. Abundance and biomass estimates are given for all the mid-sized and small pelagic fish species susceptible of being acoustically assessed according to their occurrence and abundance levels in the study area. The distribution of these species is also shown from the mapping of their back-scattering energies. Anchovy, horse-mackerel, blue jack mackerel and chub mackerel were the most frequent and abundant species in the catches of the ground-truthing hauls. Total catches and yields of sardine, mackerel, bogue and Mediterranean horse mackerel were very low. As usual, the bulk of the anchovy population was concentrated in the central part of the surveyed area, with the smallest anchovies mainly occurring in the surroundings of the Guadalquivir river mouth and larger/older anchovies occurring in the westernmost waters. The total biomass estimated for anchovy, 29.2 kt (1 962 million fish), was above the historical average and evidenced a clear recovery of the population in relation to the previous year. Sardine was mainly restricted to two areas, the densest one, located between the Guadiana and Tinto-Odiel rivers mouths, and a secondary area between the Capes San Vicente and Santa Maria, in the Portuguese western Algarve. The smallest sardines were captured further to the east than usual, in the inner shelf in front of Cadiz Bay, a third residual area which extended eastward to Cape Trafalgar. Sardine yielded a total of 8.7 kt (225 million fish). The 2014 sardine estimate is the lowest one in its series and denotes a clear recent decline in the population which is, however, contradictory to the opposite trend depicted by the recent estimates from the *PELAGO* surveys. Chub mackerel was present all over the surveyed area although showed the highest concentrations in the inner-mid shelf waters of the western Algarve. The species was the second most important one in terms of assessed biomass, rendering estimates of 22.3 kt (308 million fish). Acoustic estimates for mackerel (*S. scombrus*), jack and horse-mackerel species (*Trachurus spp*.), and bogue (*Boops boops*) are also given in the WD.

INTRODUCTION

ECOCADIZ surveys constitute a series of yearly acoustic surveys conducted by IEO in the Subdivision IXa South (Algarve and Gulf of Cadiz, between 20 – 200 m depth) under the "pelagic ecosystem survey" approach onboard R/V *Cornide de Saavedra* (until 2013, since 2014 on onboard R/V *Miguel Oliver*). This series started in 2004 with the *BOCADEVA 0604* pilot acoustic - anchovy DEPM survey. The following surveys within this new series (named *ECOCADIZ* since 2006 onwards) are planned to be routinely performed on a yearly basis, although the series, because of the available ship time, has shown some gaps in those years coinciding with the conduction of the triennial anchovy DEPM survey (the true *BOCADEVA* series, which first survey started in 2005).

Results from the *ECOCADIZ* series are routinely reported to ICES Expert Groups on both stock assessment (formerly in WGMHSA, WGANC, WGANSA, at present in WGHANSA) and acoustic and egg surveys on anchovy and sardine (WGACEGG).

The present Working Document summarises the main results from the *ECOCADIZ 2014-07* survey.

MATERIAL AND METHODS

The *ECOCADIZ 2014-07* survey was carried out between 24th July and 6th August 2014 onboard the Spanish R/V *Miguel Oliver* covering a survey area comprising the waters of the Gulf of Cadiz, both Spanish and Portuguese, between the 20 m and 200 m isobaths. The survey design consisted in a systematic parallel grid with tracks equally spaced by 8 nm, normal to the shoreline (**Figure 1**). This year *ECOCADIZ 2014-07* was conducted almost at the same time than the Gulf of Cadiz anchovy egg survey *BOCADEVA 0714*, with the acoustic survey providing anchovy adult samples to the egg one.

Echo-integration was carried out with a *Simrad™ EK60* echo sounder working in the multi-frequency fashion (18, 38, 70, 120, 200 kHz). Average survey speed was about 10 knots and the acoustic signals were integrated over 1-nm intervals (ESDU). Raw acoustic data were stored for further post-processing using *Myriax Software Echoview™* software package (by *Myriax Software Pty. Ltd.,* ex *SonarData Pty. Ltd.*). Acoustic equipment was previously calibrated during the *MEDIAS 07 2014* acoustic survey, a survey conducted in the Spanish Mediterranean waters just before the *ECOCADIZ* one, following the standard procedures (Foote *et al*., 1987).

Survey execution and abundance estimation followed the methodologies firstly adopted by the ICES *Planning Group for Acoustic Surveys in ICES Sub-Areas VIII and IX* (ICES, 1998) and the recommendations given more recently by the *Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES areas VIII and IX* (WGACEGG; ICES, 2006a,b).

Fishing stations for echo-trace ground-truthing were opportunistic, according to the echogram information, and they were carried out using a ca. 16 m-mean vertical opening pelagic trawl (*Tuneado* gear) at an average speed of 4 knots. Additionally, directed fishing hauls were planned to be conducted with the same gear by night with the aim of collecting anchovy mature females with hydrated oocytes. Gear performance and geometry during the effective fishing was monitored with *Simrad™ Mesotech FS20/25* trawl sonar. Trawl sonar data from each haul were recorded and stored for further analyses.

Ground-truthing haul samples provided biological data on species and they were also used to identify fish species and to allocate the back-scattering values into fish species according to the proportions found at the fishing stations (Nakken and Dommasnes, 1975). These samples also provided a part of the DEPM anchovy adult samples which were complemented with those ones collected during the night hauls (i.e. hydrated females).

Length frequency distributions (LFD) by 0.5-cm class were obtained for all the fish species in trawl samples (either from the total catch or from a representative random sample of 100-200 fish). Only those LFDs based on a minimum of 30 individuals and showing a normal distribution were considered for the purpose of the acoustic assessment.

Individual biological sampling (length, weight, sex, maturity stage, stomach fullness, and mesenteric fat content) was performed in each haul for anchovy, sardine (in both species with otolith extraction and with additional preservation of gonads in anchovy mature females), mackerel and horse-mackerel species, and bogue.

The following TS/length relationship table was used for acoustic estimation of assessed species (recent IEO standards after ICES, 1998; and recommendations by ICES, 2006a,b):

Species	b_{20}
Sardine (*Sardina pilchardus*)	-72.6
Round sardinella (*Sardinella aurita*)	-72.6
Anchovy (*Engraulis encrasicolus*)	-72.6
Chub mackerel (*Scomber japonicus*)	-68.7
Mackerel (*S. scombrus*)	-84.9
Horse mackerel (*Trachurus trachurus*)	-68.7
Mediterranean horse-mackerel (*T. mediterraneus*)	-68.7
Blue jack mackerel (*T. picturatus*)	-68.7
Bogue (*Boops boops*)	-67.0

The *PESMA 2010* software (J. Miquel, unpublished) has got implemented the needed procedures and routines for the acoustic assessment following the above approach.

CUFES sampling was not carried out during the survey but in the *BOCADEVA* egg survey. A *Sea-bird Electronics™ SBE 21 SEACAT* thermosalinograph and a *Turner™ 10 AU 005 CE Field* fluorometer were used during the acoustic tracking to continuously collect some hydrographical variables (sub-surface sea temperature, salinity, and *in vivo* fluorescence). Vertical profiles of hydrographical variables were also recorded by night from 176 CTD casts by using *Sea-bird Electronics™ SBE 911+ SEACAT* (with coupled *Datasonics* altimeter, *SBE 43* oximeter, *WetLabs ECO-FL-NTU* fluorimeter and *WetLabs C-Star 25 cm* transmissometer sensors) and *LADCP T-RDI WHS* 300 kHz profilers (**Figure 2**). *VMADCP RDI 150 kHz* records were also continuously recorded by night between CTD stations. Information on presence and abundance of sea birds, turtles and mammals was also recorded during the acoustic sampling by one onboard observer.

ECOCADIZ 2014-07 was also utilized this year as an observational platform for the IFAPA (Instituto de Investigación y Formación Agraria y Pesquera)/IEO research project entitled *Ecology of the early stages of the anchovy life-cycle: the role of the coupled Guadalquivir estuary-coastal zone of influence in the species' recruitment process (ECOBOGUE)*. Thus, 22 *Hydro-Bios Multinet Midi* stations were opportunistically carried out in the study area in order to characterize the mesozooplankton species assemblages and their relationships with environmental conditions. A greater sampling intensity was located in the coastal area surrounding the Guadalquivir river mouth (**Figure 3**). The locations of the *Multinet* stations were mainly those ones where the "acoustic population" showed well contrasted situations regarding the occurrence and density of different backscattering layers in the water column, some of them of unknown species composition but highly associated to different acoustically assessed species (*e.g.* anchovy). A sub-set of these stations was sampled several times throughout a day-night cycle at two different depths showing contrasted situations as to the location of these layers. Besides the objective of characterising mesozooplankton assemblages, the *Multinet* sampling is expected that also provides a characterisation of the vertical distribution of the different anchovy egg stages thus improving our understanding of the Gulf of Cádiz anchovy spawning dynamics and ecology. Both the *Multinet* behaviour during the sampling station and the selection of the layer to be sampled were monitored by a *Simrad* depth sensor coupled to the cable and visualised on display by using the *Simrad EK60* echosounder/*Echoview* software.

RESULTS

Acoustic sampling

The acoustic sampling was carried out during the periods of 24th – 26th July and 28th July – 04th August (**Table 1**). The acoustic sampling started in the coastal end of the transect RA01 on 24th August towards the RA21. The acoustic sampling stopped on 27th July in order to dedicate that day to some of the sampling tasks of the *ECOBOGUE* project. The acoustic sampling usually started at 06:00 UTC although this time might vary depending on the duration of the works related with the hydrographic sampling and/or the conduction of a DEPM fishing haul the previous night. The foreseen start of transects RA14 and RA15 by the coastal end had to be displaced to deeper waters in order to avoid the occurrence of open-sea fish farming/fattening cages. The whole 21-transect sampling grid was sampled.

Groundtruthing hauls

Twenty one (21) fishing operations, with 20 of them being considered as valid ones according to a correct gear performance and resulting catches, were carried out (**Table 2**, **Figure 4**).

As usual in previous surveys, some fishing hauls were attempted by fishing over an isobath crossing the acoustic transect as close as possible to the depths where the fishing situation of interest was detected over that transect. In this way the mixing of different size compositions (*i.e.*, bi-, multi-modality of length frequency distributions) was avoided as well as a direct interaction with fixed gears. The mixing of sizes is more probable close to nursery-recruitment areas and in regions with a very narrow continental shelf. Given that all of these situations were not very uncommon in the sampled area, 50% of valid hauls (10 hauls) were conducted over isobath.

Because of many echo-traces usually occurred close to the bottom, all the pelagic hauls were carried out like a bottom-trawl haul, with the ground rope working over or very close to the bottom. According to the above, the sampled depth range in the valid hauls oscillated between 39-137 m.

During the survey were captured 1 Chondrichthyan, 36 Osteichthyes, 5 Cephalopod, 5 Crustacean and 4 Echinoderm species. The percentage of occurrence of the more frequent species in the trawl hauls is shown in the enclosed text table below (see also **Figure 5**). Anchovy, horse-mackerel and blue jack mackerel (19 hauls) stood especially out from the set of small and mid-sized pelagic fish species. They were followed by mackerel (17 hauls), chub mackerel (16), twaite shad *Alosa fallax* (13), bogue (12), sardine (11), and Mediterranean horse mackerel (5 hauls).

For the purposes of the acoustic assessment, anchovy, sardine, mackerel species, horse & jack mackerel species, and bogue were initially considered as the survey target species. All of the invertebrates, and both bentho-pelagic (*e.g.*, manta rays) and benthic fish species (*e.g.*, flatfish, gurnards, etc.) were excluded from the computation of the total catches in weight and in number from those fishing stations where they occurred. Catches of the remaining non-target species were included in an operational category termed as "*Others*". According to the above premises, during the survey were captured a total of 6 116 kg and 253 thousand fish (**Table 3**). 46% of the total fished biomass corresponded to anchovy, 16% to blue jack-mackerel, 14% to chub mackerel, 13% to horse mackerel, 4% to sardine, 3% to mackerel and less than 1%

to bogue and Mediterranean horse mackerel. The most abundant species in ground-truthing trawl hauls was anchovy (71%) followed by a long distance by horse mackerel (9%), blue jack mackerel (8%), and chub mackerel (4%). Total catches and yields of sardine, mackerel, bogue and Mediterranean horse mackerel were very scarce.

Species	# of fishing stations	Occurrence (%)	Total weight (kg)	Total number
Engraulis encrasicolus	19	90,5	2793,671	180199
Trachurus trachurus	19	90,5	794,353	22665
Trachurus picturatus	19	90,5	985,397	19532
Merluccius merluccius	19	90,5	80,999	697
Scomber scombrus	17	81,0	162,123	1902
Scomber colias	16	76,2	872,48	11084
Alosa fallax	13	61,9	11,877	68
Boops boops	12	57,1	49,059	407
Astropecten irregularis	12	57,1	0,149	40
Sardina pilchardus	11	52,4	238,96	5748
Parapenaeus longirostris	10	47,6	0,412	98
Diplodus annularis	8	38,1	6,177	114
Spondyliosoma cantharus	8	38,1	9,138	69
Diplodus bellottii	7	33,3	6,855	115
Squilla mantis	6	28,6	0,65	22
Serranus hepatus	6	28,6	0,264	10
Eledone moschata	6	28,6	0,437	6
Trachurus mediterraneus	5	23,8	36,02	228

The species composition, in terms of percentages in number, in each valid fish station is shown in **Figure 5**. A first impression of the distribution pattern of the main species may be derived from the above figure. Thus, anchovy was widely distributed over the surveyed area, although the highest yields were recorded in the Spanish waters. The size composition of anchovy catches confirms the usual pattern exhibited by the species in the area during the spawning season, with the largest fish being distributed in the westernmost waters and the smallest ones concentrated in the surroundings of the Guadalquivir river mouth and adjacent shallow waters (**Figure 6**). Sardine showed more sparsely distributed than anchovy; with their highest yields being mainly recorded in the shallow waters located in front of Tinto-Odiel river mouths, in the central part of the surveyed area, as well as to the west of Cape Santa María. Small juvenile sardines were captured in relatively shallow waters in front the Bay of Cádiz. Larger sardines were more frequently captured in the Portuguese waters (**Figure 7**). Chub mackerel, horse mackerel and blue jack mackerel recorded the highest yields in those hauls carried out in both ends of the study area, although mackerel yields increased in the central and westernmost waters and the highest blue jack mackerel yields were mainly recorded in the westernmost waters. An almost opposite situation to the above-mentioned one was observed in this survey in relation to the yields of bogue and Mediterranean horse mackerel, with their relatively low catches being recorded in the easternmost sampled waters.

<u>**Directed fishing to the capture of anchovy hydrated females**</u>

Four (4) fishing hauls were carried out by night and directed to the capture of anchovy adult females with hydrated oocytes. These hauls were not considered for the acoustic assessment purposes. These hauls were carried out within the time range comprised between 18: 55 and 20:45 UTC and they were mostly concentrated in the mid-outer shelf of the central part of the study area in a depth range between 44 and 140 m (**Table 2**, **Figure 4**). The total number of hydrated females amounted to 171 females.

Back-scattering energy attributed to the "pelagic assemblage" and individual species

A total of 321 nmi (ESDU) from 21 transects has been acoustically sampled by echo-integration for assessment purposes. From this total, 207 nmi (11 transects) were sampled in Spanish waters, and 114 nmi (10 transects) in the Portuguese waters. The enclosed text table below provides the nautical area-scattering coefficients attributed to each of the selected target species and for the whole "pelagic fish assemblage".

$S_{A\,(m^2\,nmi^{-2})}$	Total spp.	Sardine	Anchovy	Mackerel	Chub mack.	Horse-mack.	Medit. h-mack.	Blue jack-mack.	Bogue	Blue whiting	Boarfish
Total Area	121118	6376	32979	79	31269	19764	928	27240	2238	7	237
(%)	(100.0)	(5.3)	(27.2)	(0.1)	(25.8)	(16.3)	(0.8)	(22.5)	(1.8)	(0.0)	(0.2)
Portugal	67751	1480	5575	32	27378	13749	0	19190	105	5	237
(%)	(55.9)	(23.2)	(16.9)	(40.0)	(87.6)	(69.6)	(0.0)	(70.4)	(4.7)	(70.2)	(100.0)
Spain	53367	4896	27404	48	3890	6015	928	8050	2133	2	0
(%)	(44.1)	(76.8)	(83.1)	(60.0)	(12.4)	(30.4)	(100.0)	(29.6)	(95.3)	(29.8)	(0.0)

For this "pelagic fish assemblage" has been estimated a total of 121 118 m^2 nmi^{-2}. Portuguese waters accounted for 56% of this total back-scattering energy and the Spanish waters the remaining 44%. However, given that the Portuguese sampled ESDUs were almost the half of the Spanish ones, the (weighted-) relative importance of the Portuguese area (*i.e.*, its density of "pelagic fish") is actually much higher. The mapping of the total back-scattering energy is shown in **Figure 8**. By species, anchovy (27%), chub mackerel (26%) and blue jack mackerel (23%) were the most important species in terms of their contributions to the total back-scattering energy. Horse mackerel was the following species in importance with 16%. Sardine only contributed with 5%, followed by bogue (2%), Mediterranean horse mackerel (1%), and negligible energetic contributions by mackerel, boarfish (*Capros aper*) and blue whiting (*Micromesistius poutassou*). Round sardinella was not recorded during the survey.

Some inferences on the species' distribution may be carried out from regional contributions to the total energy attributed to each species: Mediterranean horse mackerel, bogue, anchovy and sardine seemed to show greater densities in the Spanish waters, whereas boarfish, chub mackerel, horse mackerel, blue jack mackerel and blue whiting could be considered as typically "Portuguese species" in this survey.

According to the resulting values of integrated acoustic energy, the species acoustically assessed in the present survey finally were anchovy, sardine, mackerel, chub mackerel, blue jack mackerel, horse mackerel, Mediterranean horse mackerel and bogue.

Spatial distribution and abundance/biomass estimates

Anchovy

Parameters of the survey's length-weight relationship for anchovy are given in **Table 4**. The back-scattering energy attributed to this species and the coherent strata considered for the acoustic estimation are shown in **Figure 9**. The estimated abundance and biomass by size and age class are given in **Tables 5** and **6** and **Figures 10** and **11**.

Although widely distributed over the surveyed area, the bulk of the anchovy population was concentrated, as usual, in the central part of the surveyed area which corresponds to the Spanish western shelf. In this area the species distributed all over the shelf showing spots of high density at different depths. A residual nucleus, although also showing local spots of a very high density, was recorded to the west of Cape Santa Maria, in inner-mid shelf waters (**Figure 9**).

The size class range of the assessed population varied between the 9.5 and 18 cm size classes, with two modal classes at 12.5 and 14.0 cm. As usual, largest anchovies occurred in the westernmost waters whereas the smallest ones were observed in the central coastal part of the sampled area, coinciding with the location of the main recruitment area for the species, in the surroundings of the Guadalquivir river mouth (**Tables 5** and **6**, **Figures 10** and **11**).

Nine sectors have been differentiated according to the S_A value distribution and the size composition in the fishing stations. The acoustic estimates by homogeneous post-stratum and total area are shown in **Tables 5** and **6**, and **Figures 10** and **11**. A total of 29 219 t and 1 962 millions of fish have been estimated for this species for the whole surveyed area. Anchovy ranked as the first species among the assessed ones both in terms of abundance and biomass.

Egg distribution (as sampled either by CUFES or PairoVET samplers) resembled in a great extent the abovementioned adults' distribution pattern, both in the extension of the adults' distribution area and the location of density peaks (**Figure 12**). The total egg number sampled by CUFES (42 277 eggs) was the highest number ever recorded in the series of both acoustic and egg surveys carried out in the area.

Sardine

Parameters of the survey's size-weight relationship for sardine are shown in **Table 4**. The back-scattering energy attributed to this species and the coherent strata considered for the acoustic estimation are shown in **Figure 13**. Estimated abundance and biomass by size class are given in **Table 7** and **Figure 14**.

Sardine was mainly restricted to the inner-middle shelf of two well delimitated areas: the area comprised between Capes San Vicente and Santa Maria, in the Portuguese western Algarve, and the densest one, comprised between the Guadiana and Tinto-Odiel rivers mouths, over the Spanish shelf. A residual area with sardine occurrence was recorded in the easternmost waters, between Cadiz Bay and Cape Trafalgar. Unlike the widely distributed anchovy, sardine showed during the survey relatively important areas with very low or even null occurrence (**Figure 13**).

The size range of the assessed population ranged between 11.5 and 20.5 cm size classes. The length frequency distribution of the population was clearly polymodal, with two main modes at 14.0 and 17.5 cm size classes, and two secondary ones at 12.5 and 19.5 cm. The largest sardines were recorded in the westernmost part of their distribution whereas the smallest ones were recorded somewhat more eastward than usual (i.e., the coastal fringe comprised between Guadalquivir and Guadiana river mouths), in the surroundings of the Cadiz Bay (**Table 7**, **Figure 14, see also Figure 7**).

Three size-based homogeneous sectors were delimited for the acoustic assessment. Sardine was the fifth most important species in terms of both biomass and abundance: 8 697 t and 225 millions of fish have been estimated for this species for the whole surveyed area.

Mackerel

Parameters of the survey's length-weight relationship are shown in **Table 4**. The back-scattering energy attributed to this species and the coherent strata considered for the acoustic estimation are shown in **Figure 15**. Estimated abundance and biomass by size class are given in **Table 8** and **Figure 16**.

Mackerel was almost exclusively restricted to the inner-middle shelf waters of the central part of the surveyed area, between Cape Santa Maria and the Tinto-Odiel river mouth (**Figure 15**). The size class range for the assessed population oscillated between 17.5 and 33.5 cm size classes. The size composition of this population was characterised by a main modal class at 18.5 cm (juvenile fish), a secondary one at 28.5 cm and a much less important mode at 31.5 cm (**Table 8** and **Figure 16**).

Two coherent strata were differentiated for the purposes of acoustic assessment. From the eight assessed species in this survey mackerel was the sixth species in terms of abundance (19 millions) and the seventh in terms of biomass (1 404 t).

Chub mackerel

Parameters of the survey's length-weight relationship are shown in **Table 4**. The back-scattering energy attributed to this species and the coherent strata considered for the acoustic estimation are shown in **Figure 17**. Estimated abundance and biomass by size class are given in **Table 9** and **Figure 18**.

Chub mackerel was widely distributed over the surveyed area although showed the highest concentrations in the inner-mid shelf waters of the western Algarve (**Figure 17**). The size class range for the assessed population oscillated between 15.5 and 30.5 cm size classes. The size frequency distribution showed a main modal class at 19.5 cm (juveniles/sub-adults, **Table 9** and **Figure 18**.

Eight strata were differentiated for the purposes of acoustic assessment. Chub mackerel in the sampled area was the second most important species in terms of assessed biomass and the third in abundance, rendering estimates of 22 258 t and 308 million fish.

Blue jack-mackerel

The survey's length-weight relationship for this species is given in **Table 4**. The back-scattering energy attributed to this species, the species' positive fishing stations and the coherent strata considered for the acoustic estimation are illustrated in **Figure 19**. Estimated abundance and biomass by size class are given in **Table 10** and **Figure 20**.

The distribution pattern of blue jack mackerel mimics the previously described one for chub mackerel, suggesting the occupation of similar habitats by both species (**Figure 19**, see also **Figure 17** for comparison).

The sampled population was mainly characterised by juveniles/sub-adult fishes ranging between 9.0 and 23.0 cm size classes and two modal classes of similar importance at 14.5 and 19.5 cm. The smallest fishes were recorded in the easternmost waters from their distribution range (**Table 10**, **Figure 20**).

Nine post-strata were considered in the assessment. A total of 17 537 t and 358 million fish were estimated for the whole surveyed area. The species stood out as the second most important one in numbers and the third in biomass.

Horse mackerel

The survey's length-weight relationship for horse mackerel is shown in **Table 4**. The back-scattering energy attributed to this species, the distribution of fishing stations and their coherent strata are shown in **Figure 21**. Estimated abundance and biomass by size class are given in **Table 11** and **Figure 22**.

Horse mackerel also showed widely distributed over the surveyed area, sharing the same distribution pattern than the above described for chub mackerel and blue jack mackerel. Again, the westernmost Portuguese shelf waters were those ones where the species recorded the highest densities (**Figure 21**). The sampled population, which ranged between 9.0 and 30.5 cm size classes, was basically distributed amongst two cohorts with one main mode at 19.5 cm (sub-adults), and a secondary one at 11.5 cm (juveniles, which were located in outer shelf waters between Cadiz Bay and Cape Santa Maria) (**Table 11**, **Figure 22**).

Nine coherent post-strata were considered in the assessment. During this survey were estimated 12 613 t and 284 million fish of horse mackerel in the surveyed area, the species ranking as the fourth most important one in terms of abundance and biomass.

Mediterranean horse-mackerel

The survey's length-weight relationship for this species is shown in **Table 4**. Back-scattering energy attributed to the species and coherent strata are represented in **Figure 23**. Estimated abundance and biomass by size class are given in **Table 12** and **Figure 24**.

Mediterranean horse-mackerel was only present over the Spanish inner shelf waters, with the densest concentrations being recorded in the coastal fringe between Cadiz Bay and the Guadalquivir river mouth **(Figure 23**). Size range of the sampled population oscillated between 22.0 and 44.5 cm size classes, showing 2 modal classes at 24.0 and 29.0 cm, although the bulk of the sampled specimens occurred around the first mode, between 22.0 and 26.0 cm (**Table 12**, **Figures 23**, **24**).

The acoustic estimates were of only 876 t and 6 million fish.

Bogue

Parameters of the survey's length-weight relationship for bogue are shown in **Table 4**. Back-scattering energy attributed to bogue and coherent strata delimited for acoustic estimations are shown in **Figure 25**. Estimated abundance and biomass by size class are given in **Table 13** and **Figure 26**.

Although occurring all over the surveyed area, bogue showed their higher population levels in the Spanish inner shelf waters (**Figure 25**). The sampled population was composed by fish belonging to size classes comprised between 18.5 and 30.0 cm, with the length frequency distribution being featured by a single modal class at 21.5 cm (**Table 13**, **Figure 26**).

Bogue acoustic estimates for the whole surveyed area were: 1 422 t and 12 million fish.

Boarfish and Blue whiting

Boarfish and blue whiting showed an incidental (co-)occurrence in the surveyed area, with their distribution ranges being restricted to the outer shelf of the westernmost Portuguese waters.

(SHORT) DISCUSSION

A within-year comparison between *PELAGO 14* and *ECOCADIZ 2014-07* estimates reveals a similar perception for the Gulf of Cadiz anchovy population in 2014 but, conversely, marked between-surveys differences for sardine in the same area (**Figure 27**). Thus, both surveys estimate for anchovy very similar population levels (28.4 kt in *PELAGO vs* 29.2 kt in *ECOCADIZ*), which were above their respective historical means (at about 24 kt in both series). The trends depicted for Gulf of Cadiz sardine by both surveys series are however totally opposite. The Portuguese spring survey estimates for sardine show a two-fold increase in 2014 (64 kt) in relation to 2013 (30 kt), whereas the Spanish summer surveys indicate a (slight) decrease (from about 10 kt in 2013 to about 9 kt in 2014). As noted above, sardine biomass estimates from both series also evidence clear differences in the magnitude of the estimated populations, with the *PELAGO* surveys yielding in all the comparable cases, excepting 2010, much more sardine than the *ECOCADIZ* survey. Such differences are more remarkable in 2013 and 2014, especially outstanding the last year (*i.e.*, an eight-fold difference). In fact, the sardine estimate in 2014 from the Spanish survey is the lowest ever recorded throughout its series. Causes for such differences still remain unsolved and they should be conveniently explored.

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Table 1. *ECOCADIZ 2014-07 s*urvey. Descriptive characteristics of the acoustic tracks.

Acoustic track	Location	Date	Start				End			
			Latitude	Longitude	UTC time	Mean depth (m)	Latitude	Longitude	UTC time	Mean depth (m)
R01	Trafalgar	24/07/2014	36º 13,411 N	6º 7,352 W	10:02	26	36º 01,889 N	6º 28,096 W	12:07	233
R02	Sancti-Petri	24/07/2014	36º 08,868 N	6º 33,466 W	15:21	154	36º 19,240 N	6º 14,258 W	17:11	23
R03	Cádiz	25/07/2014	36º 16,917 N	6º 36,559 W	18:10	175	36º 27,171 N	6º 19,596 W	07:54	28
R04	Rota	25/07/2014	36º 34,318 N	6º 23,675 W	10:30	27	36º 24,239 N	6º 40,748 W	13:52	223
R05	Chipiona	26/07/2014	36º 40,777 N	6º 29,616 W	06:11	20	36º 30,969 N	6º 46,376 W	09:27	>200
R06	Doñana	26/07/2014	36º 36,990 N	6º 53,588 W	10:22	> 250	36º 46,246 N	6º 35,572 W	13:27	22
R07	Matalascañas	28/07/2014	36º 53,294 N	6º 40,516 W	07:29	21	36º 43,915 N	6º 58,162 W	10:49	213
R08	Mazagón	29/07/2014	37º 01,348 N	6º 44,320 W	10:01	20	36º 49,666 N	7º 06,371 W	14:12	198
R09	Punta Umbría	30/07/2014	37º 05,420 N	6º 55,330 W	06:13	24	36º 49,614 N	7º 06,492 W	09:38	196
R10	El Rompido	30/07/2014	36º 49,831 N	7º 06,435 W	09:44	152	37º 06,509 N	7º 06,541 W	11:29	22
R11	Isla Cristina	31/07/2014	37º 07,274 N	7º 16,511 W	07:14	25	36º 53,245 N	7º 16,430 W	10:28	232
R12	V. R. de Sto. Antonio	31/07/2014	36º 56,182 N	7º 26,301 W	11:36	129	36º 06,184 N	7º 26,322 W	12:45	22
R13	Tavira	01/08/2014	36º 57,113 N	7º 36,587 W	06:48	141	37º 04,686 N	7º 36,099 W	08:47	23
R14	Fuzeta	01/08/2014	36º 59,345 N	7º 45,687 W	13:06	70	36º 55,860 N	7º 45,955 W	13:29	188
R15	Cabo de Sta. María	01/08/2014	36º 56,441 N	7º 54,960 W	14:18	63	36º 52,447 N	7º 55,018 W	14:40	107
R16	Cuarteira	02/08/2014	37º 01,177 N	8º 5,491 W	06:11	26	36º 50,292 N	8º 05,565 W	09:03	215
R17	Albufeira	02/08/2014	36º 49,355 N	8º 15,234 W	13:07	221	37º 02,490 N	8º 15,297 W	14:28	22
R18	Alfanzina	03/08/2014	37º 04,163 N	8º 25,158 W	07:17	26	36º 50,365 N	8º 25,181 W	09:40	194
R19	Portimao	03/08/2014	36º 51,513 N	8º 35,184 W	13:28	114	37º 06,078 N	8º 35,334 W	16:40	23
R20	Burgau	04/08/2014	37º 03,911 N	8º 45,087 W	06:38	37	36º 52,302 N	8º 44,997 W	08:24	247
R21	Ponta de Sagres	04/08/2014	36º 50,816 N	8º 54,997 W	11:08	148	37º 0,464 N	8º 54,998 W	12:10	23

Table 2. *ECOCADIZ 2014-07* survey. Descriptive characteristics of the fishing stations. Hauls carried out by night for capturing anchovy mature females (with hydrated oocytes) in dark grey. Null hauls in light grey.

Fishing station	Date	Start		End		UTC Time		Depth (m)		Duration (min.)		Trawled Distance (nm)	Acoustic transect	Zone (landmark)
		Latitude	Longitude	Latitude	Longitude	Start	End	Start	End	Effective trawling	Total manoeuvre			
01	24-07-2014	36º 03.0661 N	6º 29.1069 W	36º 01.4769 N	6º 26.9999 W	13:18:00	13:48:00	155	193	00:30:00	01:07:00	2,332	R01	Trafalgar
02	25-07-2014	36º 24.6977 N	6º 23.8140 W	36º 23.3603 N	6º 26.1076 W	08:25:00	08:56:00	49,81	57,52	00:31:00	00:54:00	2,283	R03	Cádiz
03	25-07-2014	36º 30.8617 N	6º 30.1395 W	36º 31.8811 N	6º 27.4639 W	11:45:00	12:18:00	57,33	45,33	00:33:00	00:55:00	2,385	R04	Rota
04	25-07-2014	36º 25.9405 N	6º 37.7838 W	36º 27.1900 N	6º 35.9862 W	14:28:00	14:59:00	112,43	97,60	00:31:00	00:53:00	1,913	R04	Rota
05	26-07-2014	36º 35.7339 N	6º 38.2123 W	36º 37.1974 N	6º 35.7380 W	07:29:00	08:00:00	68,75	50,78	00:31:00	00:55:00	2,471	R05	Chipiona
06	26-07-2014	36º 41.3948 N	6º 45.1980 W	36º 40.1351 N	6º 47.3390 W	11:26:00	11:56:00	82,96	102,98	00:30:00	00:54:00	2,133	R06	Doñana
07	26-07-2014	36º 43.1034 N	6º 41.6839 W	36º 41.1490 N	6º 40.4823 W	14:25:00	14:55:00	49,52	53,40	00:30:00	00:43:00	2,178	R06	Doñana
08	28-07-2014	36º 49.0200 N	6º 48.5458 W	36º 50.4393 N	6º 45.9905 W	08:42:00	09:15:00	58,13	40,67	00:33:00	00:58:00	2,494	R07	Matalascañas
09	28-07-2014	36º 48.6918 N	6º 49.1544 W	36º 50.2800 N	6º 46.4465 W	19:20:00	19:55:00	64,29	43,80	00:35:00	01:01:00	2,691	R07	Matalascañas
10	29-07-2014	36º 56.0124 N	6º 54.7350 W	36º 57.7766 N	6º 51.3141 W	11:30:00	12:13:00	55,34	41,14	00:43:00	01:09:00	3,259	R08	Mazagón
11	29-07-2014	36º 50.5046 N	7º 04.8655 W	36º 51.5679 N	7º 02.7866 W	14:30:00	14:57:00	135,74	114,10	00:27:00	01:00:00	1,978	R08	Mazagón
12	30-07-2014	36º 57.8079 N	7º 00.6404 W	36º 59.4170 N	6º 59.5836 W	07:36:00	08:00:00	64,04	51,02	00:24:00	00:54:00	1,816	R09	Punta Umbría
13	30-07-2014	37º 00.3199 N	7º 00.6461 W	37º 03.3750 N	7º 03.6565 W	12:52:00	13:27:00	39,20	39,69	00:35:00	00:54:00	3,888	R09-R10	Pta. Umbría-El Rompido
14	30-07-2014	36º 50.3313 N	7º 05.0699 W	36º 52.8955 N	7º 00.5094 W	19:46:00	20:45:00	139,86	100,05	00:59:00	01:18:00	4,467	R08	Mazagón
15	31-07-2014	36º 55.6713 N	7º 17.0995 W	36º 54.9472 N	7º 14.7702 W	09:04:00	09:32:00	119,59	121,88	00:28:00	00:49:00	2,003	R11	Isla Cristina
16	31-07-2014	37º 02.0436 N	7º 25.0617 W	37º 01.1240 N	7º 22.3457 W	14:10:00	14:45:00	84,39	88,42	00:35:00	00:58:00	2,361	R11-R12	I. Cristina-V. R. S^{o} A^{tnio}
17	01-08-2014	36º 57.5608 N	7º 33.2494 W	36º 57.5992 N	7º 34.0288 W	07:21:00	07:31:00	130,87	133,48	00:10:00	00:44:00	0,626	R12-R13	V. R. S^{o} A^{tnio}-Tavira
18	01/08/2014	37º 02.3252 N	7º 36.0314 W	37º 02.9537 N	7º 33.8503 W	11:03:00	11:27:00	72,80	70,78	00:24:00	00:49:00	1,855	R13	Tavira
19	02/08/2014	36º 59.6720 N	8º 07.2883 W	36º 58.9430 N	8º 05.4370 W	7:15:00	7:38:00	40,19	40,49	00:23:00	00:47:00	1,652	R16-R17	Cuarteira-Albufeira
20	02/08/2014	36º 52.8879 N	8º 06.5282 W	36º 53.4500 N	8º 03.7177 W	11:02:00	11:33:00	98,32	98,19	00:31:00	00:59:00	2,324	R16	Cuarteiera
21	02/08/2014	36º 52.7650 N	8º 06.6110 W	36º 53.3512 N	8º 03.4923 W	19:39:00	20:14:00	100,62	99,95	00:35:00	01:01:00	2,57	R16	Cuarteiera
22	03/08/2014	36º 51.2313 N	8º 25.0432 W	36º 50.5084 N	8º 22.3123 W	11:19:00	11:49:00	135,07	137,21	00:30:00	01:01:00	2,308	R17-R18	Albufeira-Alfanzina
23	03/08/2014	36º 54.6695 N	8º 35.2694 W	36º 52.2422 N	8º 35.0457 W	14:16:00	14:47:00	103,15	114,02	00:31:00	00:58:00	2,431	R19	Portimao
24	04/08/2014	36º 54.1287 N	8º 44.9506 W	36º 57.4928 N	8º 44.7134 W	8:48:00	9:34:00	109,20	99,72	00:46:00	01:14:00	3,365	R20	Burgau
25	05/08/2014	36º 55.1925 N	7º 13.8008 W	36º 56.6606 N	7º 18.9188 W	18:55:00	19:54:00	117,49	114,62	00:59:00	01:43:00	4,357	R10-R11	El Rompido- I. Cristina

Table 3. *ECOCADIZ 2014-07* survey. Catches by species in number (upper panel) and weight (in kg, lower panel) from valid fishing stations.

Fishing station	ABUNDANCE (nº)									
	Anchovy	*Sardine*	*Chub mack.*	*Mackerel*	*Horse-mack.*	*Blue Jack-mack.*	*Medit. Horse-mack.*	*Bogue*	Other spp.	TOTAL
02	3528	105	331		48	2319	18	71	199	6619
03	8751	882	225	1	1849	256	85	44	129	12222
04	19592	8	2810	23	7344	611			70	30458
05	15497		3	2	11	11	1	6	1684	17215
06	7881			2	108				1395	9386
07	3002		16			3	123	56	1075	4275
08	8775	6	51	30	16	281	1	69	86	9315
10	4231	2282	137	42	1119	961		103	84	8959
11	45099		7	59	686	383			108	46342
12	6751	324		74	2000	28		14	45	9236
13	2800	1097	15	69	70	39		22	57	4169
15	30445			211	1589	12			21	32278
16	9903			19	378	14			41	10355
17	38		92	62	203	2626			40	3061
18	5773		2	1078	121	15		1	47	7037
19	158	1035	5701		2435	2838		13	66	12246
20	6808	4	3	9	2512	114			60	9510
22			352	113	626	3556			6346	10993
23	181	2	1259	102	1324	4813		4	14	7699
24	986	3	80	6	226	652		4	18	1975
TOTAL	**180199**	**5748**	**11084**	**1902**	**22665**	**19532**	**228**	**407**	**11585**	**253350**

Fishing station	BIOMASS (kg)									
	Anchovy	*Sardine*	*Chub mack.*	*Mackerel*	*Horse-mack.*	*Blue Jack-mack.*	*Medit. Horse-mack.*	*Bogue*	Other spp.	TOTAL
02	48,800	2,123	40,350		3,672	75,445	2,486	8,250	18,005	199,131
03	99,850	14,950	31,850	0,318	154,750	9,347	17,700	5,780	12,004	346,549
04	333,432	0,236	186,380	4,461	149,712	16,054			7,084	697,359
05	172,400		0,358	0,510	0,926	0,504	0,342	0,660	4,798	180,498
06	95,850			0,580	0,982				2,757	100,169
07	29,000		2,090			0,131	15,300	7,650	7,336	61,507
08	106,850	0,215	4,290	4,385	1,124	10,730	0,192	9,577	9,472	146,835
10	69,900	104,150	13,445	8,000	18,050	26,250		11,437	11,860	263,092
11	679,304		0,633	7,107	7,789	12,500			12,305	719,638
12	107,150	8,400		13,050	32,600	0,998		1,498	6,671	170,367
13	35,400	48,050	1,180	11,470	1,242	1,162		2,292	5,072	105,868
15	513,026			37,062	18,221	0,387			2,417	571,113
16	195,950			3,080	5,575	0,770			4,018	209,393
17	0,995		7,610	10,850	17,250	77,450			6,980	121,135
18	105,950		0,308	51,782	12,810	0,600		0,102	7,187	178,739
19	3,304	60,397	380,098		134,880	84,194		1,003	6,760	670,636
20	165,800	0,132	0,338	2,122	76,400	4,975			6,669	256,436
22			45,400	6,594	48,800	282,550			48,129	431,473
23	5,110	0,124	152,450	0,476	93,750	348,150		0,372	1,753	602,185
24	25,600	0,183	5,700	0,276	15,820	33,200		0,438	2,650	83,867
TOTAL	**2793,671**	**238,960**	**872,480**	**162,123**	**794,353**	**985,397**	**36,020**	**49,059**	**183,927**	**6115,990**

Table 4. *ECOCADIZ 2014-07* survey. Parameters of the size-weight relationships for survey's target species. FAO codes for the species: PIL: *Sardina pilchardus*; ANE: *Engraulis encrasicolus*; MAS: *Scomber colias*; MAC: *Scomber scombrus*; JAA: *Trachurus picturatus;* HOM: *Trachurus trachurus*; HMM: *Trachurus mediterraneus*; BOG: *Boops boops*.

Parameter	PIL	ANE	MAS	MAC	JAA	HOM	HMM	BOG
n	283	1387	527	528	509	815	67	162
a	0,00406628	0,001557943	0,0048981	0,00516014	0,01044924	0,0085963	0,05460536	0,01374845
b	3,26012604	3,563503211	3,15992882	3,10393697	2,92126322	2,98728612	2,41318866	2,89388192
r^2	0,94415235	0,959559234	0,95620265	0,98510914	0,92786862	0,98312027	0,94104483	0,91745366

Table 5. *ECOCADIZ 2014-07* survey. Anchovy (*E. encrasicolus*). Estimated abundance (absolute numbers and million fish) and biomass (t) by size class (in cm). Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figure 9**.

***ECOCADIZ 2014-07*. *Engraulis encrasicolus*. ABUNDANCE (in numbers and million fish)**											
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	**POL09**	**TOTAL *n***	**Millions**
6	0	0	0	0	0	0	0	0	0	0	0
6,5	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0
7,5	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0
8,5	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0
9,5	0	0	0	1624392	0	0	0	0	0	1624392	2
10	0	0	0	3332697	0	0	0	0	0	3332697	3
10,5	0	0	0	39097170	994062	0	0	0	0	40091232	40
11	0	718970	15870	124275057	2078372	0	0	0	0	127088269	127
11,5	5921729	718970	15870	238621897	28784015	0	0	0	0	274062481	274
12	35530369	3590962	79262	190719990	99703288	424976	0	0	0	330048847	330
12,5	41452102	12929793	285396	139926787	155409943	2140917	0	251680	0	352396618	352
13	41452102	17239722	380528	54831011	151270639	9004680	53468	796987	709936	275739073	276
13,5	11843457	16520755	364659	13734300	135049514	18001346	106936	1510082	7315783	204446832	204
14	4431225	12210826	269527	1624392	89740649	8571685	213872	2139282	17881821	137083279	137
14,5	1490503	9338832	206134	1688270	52632661	4714831	53468	964774	27467647	98557120	99
15	0	2153023	47523	1444220	24970986	2573912	534680	377520	29826824	61928688	62
15,5	0	0	0	0	4030514	857971	427744	461414	20187335	25964978	26
16	0	718970	15870	1546377	881579	0	427744	83893	13359719	17034152	17
16,5	0	0	0	0	0	0	160404	0	7888142	8048546	8
17	0	0	0	0	0	0	53468	0	3355522	3408990	3
17,5	0	0	0	0	0	0	0	0	836364	836364	1
18	0	0	0	0	0	0	0	0	349367	349367	0
18,5	0	0	0	0	0	0	0	0	0	0	0
TOTAL *n*	142121487	76140823	1680639	812466560	745546222	46290318	2031784	6585632	129178460	1962041925	1962
Millions	142	76	2	812	746	46	2	7	129	1962	

Table 5. *ECOCADIZ 2014-07* survey. Anchovy (*E. encrasicolus*). Cont'd.

ECOCADIZ 2014-07 . Engraulis encrasicolus . **BIOMASS (t)**										
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	**POL09**	**TOTAL**
6	0	0	0	0	0	0	0	0	0	0
6,5	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0
7,5	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0
8,5	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0
9,5	0	0	0	8,476	0	0	0	0	0	8,476
10	0	0	0	20,787	0	0	0	0	0	20,787
10,5	0	0	0	289,024	7,349	0	0	0	0	296,373
11	0	6,251	0,138	1080,46	18,070	0	0	0	0	1104,919
11,5	60,124	7,300	0,161	2422,745	292,246	0	0	0	0	2782,576
12	418,564	42,303	0,934	2246,767	1174,549	5,006	0	0	0	3888,123
12,5	563,235	175,685	3,878	1901,27	2111,649	29,090	0	3,420	0	4788,227
13	646,080	268,701	5,931	854,606	2357,731	140,349	0,833	12,422	11,065	4297,718
13,5	210,672	293,872	6,487	244,307	2402,269	320,209	1,902	26,861	130,134	3636,713
14	89,535	246,725	5,446	32,821	1813,245	173,194	4,321	43,225	361,309	2769,821
14,5	34,059	213,398	4,710	38,578	1202,688	107,737	1,222	22,046	627,652	2252,090
15	0	55,411	1,223	37,169	642,661	66,243	13,761	9,716	767,633	1593,817
15,5	0	0	0	0	116,383	24,774	12,351	13,324	582,919	749,751
16	0	23,209	0,512	49,919	28,458	0	13,808	2,708	431,267	549,881
16,5	0	0	0	0	0	0	5,769	0	283,711	289,480
17	0	0	0	0	0	0	2,136	0	134,04	136,176
17,5	0	0	0	0	0	0	0	0	36,995	36,995
18	0	0	0	0	0	0	0	0	17,063	17,063
18,5	0	0	0	0	0	0	0	0	0	0
TOTAL	2022,269	1332,855	29,420	9226,929	12167,298	866,602	56,103	133,722	3383,788	29218,986

Table 6. *ECOCADIZ 2014-07* survey. Anchovy (*E. encrasicolus*). Estimated abundance (thousands of individuals) and biomass (tonnes) by age group. Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figure 9** and ordered from west to east.

Age class	**POL09**	**POL08**	**POL07**	**POL06**	**POL05**	**POL04**	**POL03**	**POL02**	**POL01**	**TOTAL**
	Number	**Number**	**Number**	**Number**	**Number**	**Number**	**Number**	**Number**	**Number**	**Number**
0	437	36	11	306	9296	38229	16	703	2116	51150
I	106406	6252	1565	45007	727141	771517	1637	74179	139576	1873280
II	22335	298	456	977	9109	1096	28	1259	429	35988
III	0	0	0	0	0	0	0	0	0	0
TOTAL	129178	6586	2032	46290	745546	810842	1681	76141	142121	1960418

Age class	**POL09**	**POL08**	**POL07**	**POL06**	**POL05**	**POL04**	**POL03**	**POL02**	**POL01**	**TOTAL**
	Weight	**Weight**	**Weight**	**Weight**	**Weight**	**Weight**	**Weight**	**Weight**	**Weight**	**Weight**
0	12	1	0	5	125	360	0	11	27	541
I	2645	125	41	836	11800	8809	28	1289	1982	27555
II	716	8	14	23	208	28	1	30	8	1035
III	0	0	0	0	0	0	0	0	0	0
TOTAL	3373	133	56	864	12134	9197	29	1329	2017	29132

Table 7. *ECOCADIZ 2014-07* survey. Sardine (*S. pilchardus*). Estimated abundance (absolute numbers and million fish) and biomass (t) by size class (in cm). Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figure 13**.

***ECOCADIZ 2014-07* . *Sardina pilchardus* . ABUNDANCE (in numbers and million fish)**					
Size class	**POL01**	**POL02**	**POL03**	**TOTAL *n***	**Millions**
8	0	0	0	0	0
8,5	0	0	0	0	0
9	0	0	0	0	0
9,5	0	0	0	0	0
10	0	0	0	0	0
10,5	0	0	0	0	0
11	0	0	0	0	0
11,5	288392	0	0	288392	0,3
12	1889411	0	0	1889411	2
12,5	4866981	0	0	4866981	5
13	4034510	414385	0	4448895	4
13,5	744764	6987166	0	7731930	8
14	312177	27743705	0	28055882	28
14,5	62435	26207371	0	26269806	26
15	206631	10588726	321678	11117035	11
15,5	62435	8085119	321678	8469232	8
16	187306	8945693	0	9132999	9
16,5	0	21348547	1005244	22353791	22
17	124871	22067856	3618879	25811606	26
17,5	124871	20437105	5267480	25829456	26
18	0	12604513	8604891	21209404	21
18,5	62435	3120870	12867121	16050426	16
19	81761	880568	3618879	4581208	5
19,5	0	880568	4624124	5504692	6
20	0	0	1326922	1326922	1
20,5	62435	0	0	62435	0,1
21	0	0	0	0	0
21,5	0	0	0	0	0
22	0	0	0	0	0
22,5	0	0	0	0	0
23	0	0	0	0	0
TOTAL *n*	13111415	170312192	41576896	225000503	225
Millions	13	170	42	225	

Table 7. *ECOCADIZ 2014-07* survey. Sardine (*S. pilchardus*). Cont'd

***ECOCADIZ 2014-07*. *Sardina pilchardus*. BIOMASS (t)**				
Size class	**POL01**	**POL02**	**POL03**	**TOTAL**
8	0	0	0	0
8,5	0	0	0	0
9	0	0	0	0
9,5	0	0	0	0
10	0	0	0	0
10,5	0	0	0	0
11	0	0	0	0
11,5	3,611	0	0	3,611
12	27,101	0	0	27,101
12,5	79,535	0	0	79,535
13	74,74	7,677	0	82,417
13,5	15,568	146,052	0	161,62
14	7,331	651,544	0	658,875
14,5	1,641	688,7	0	690,341
15	6,053	310,206	9,424	325,683
15,5	2,032	263,129	10,469	275,63
16	6,75	322,364	0	329,114
16,5	0	849,197	39,986	889,183
17	5,467	966,153	158,438	1130,058
17,5	6,001	982,112	253,131	1241,244
18	0	663,131	452,709	1115,84
18,5	3,587	179,316	739,305	922,208
19	5,119	55,127	226,557	286,803
19,5	0	59,934	314,731	374,665
20	0	0	97,984	97,984
20,5	4,992	0	0	4,992
21	0	0	0	0
21,5	0	0	0	0
22	0	0	0	0
22,5	0	0	0	0
23	0	0	0	0
TOTAL	249,528	6144,642	2302,734	8696,904

Table 8. *ECOCADIZ 2014-07* survey. Mackerel (*S. scombrus*). Estimated abundance (absolute numbers and million fish) and biomass (t) by size class (in cm). Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figure 15**.

***ECOCADIZ 2014-07*. *Scomber scombrus*. ABUNDANCE (in numbers and million fish)**				
Size class	**POL01**	**POL02**	**TOTAL *n***	**Millions**
13	0	0	0	0
13,5	0	0	0	0
14	0	0	0	0
14,5	0	0	0	0
15	0	0	0	0
15,5	0	0	0	0
16	0	0	0	0
16,5	0	0	0	0
17	0	0	0	0
17,5	0	178900	178900	0
18	0	1995424	1995424	2
18,5	49983	7252338	7302321	7
19	54292	3811949	3866241	4
19,5	99967	1444963	1544930	2
20	18097	0	18097	0
20,5	0	0	0	0
21	0	0	0	0
21,5	0	0	0	0
22	0	0	0	0
22,5	0	0	0	0
23	0	0	0	0
23,5	19409	0	19409	0
24	0	0	0	0
24,5	0	0	0	0
25	0	0	0	0
25,5	18097	0	18097	0
26	77635	0	77635	0
26,5	76324	0	76324	0
27	337106	0	337106	0
27,5	491739	13762	505501	1
28	583238	13762	597000	1
28,5	795273	41285	836558	1
29	356889	13762	370651	0
29,5	477576	27523	505099	1
30	267639	0	267639	0
30,5	91798	0	91798	0
31	51295	0	51295	0
31,5	69392	0	69392	0
32	31886	13762	45648	0
32,5	18097	13762	31859	0
33	31886	0	31886	0
33,5	0	13762	13762	0
34	0	0	0	0
TOTAL *n*	4017618	14834954	18852572	19
Millions	4	15	19	

Table 8. *ECOCADIZ 2014-07* survey. Mackerel (*S. scombrus*). Cont'd.

***ECOCADIZ 2014-07*. *Scomber scombrus*. BIOMASS (t)**			
Size class	**POL01**	**POL02**	**TOTAL**
13	0	0	0
13,5	0	0	0
14	0	0	0
14,5	0	0	0
15	0	0	0
15,5	0	0	0
16	0	0	0
16,5	0	0	0
17	0	0	0
17,5	0	6,962	6,962
18	0	84,640	84,640
18,5	2,306	334,545	336,851
19	2,718	190,81	193,528
19,5	5,418	78,321	83,739
20	1,060	0	1,060
20,5	0	0	0
21	0	0	0
21,5	0	0	0
22	0	0	0
22,5	0	0	0
23	0	0	0
23,5	1,865	0	1,865
24	0	0	0
24,5	0	0	0
25	0	0	0
25,5	2,235	0	2,235
26	10,177	0	10,177
26,5	10,608	0	10,608
27	49,627	0	49,627
27,5	76,594	2,144	78,738
28	96,023	2,266	98,289
28,5	138,260	7,177	145,437
29	65,457	2,524	67,981
29,5	92,324	5,321	97,645
30	54,487	0	54,487
30,5	19,664	0	19,664
31	11,552	0	11,552
31,5	16,417	0	16,417
32	7,918	3,418	11,336
32,5	4,714	3,585	8,299
33	8,706	0	8,706
33,5	0	3,935	3,935
34	0	0	0
TOTAL	678,130	725,648	1403,778

Table 9. *ECOCADIZ 2014-07* survey. Chub mackerel (*S. colias*). Estimated abundance (absolute numbers and million fish) and biomass (t) by size class (in cm). Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figure 17**.

***ECOCADIZ 2014-07* . *Scomber colias* . ABUNDANCE (in numbers and million fish)**										
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	**TOTAL *n***	**Millions**
13	0	0	0	0	0	0	0	0	0	0
13,5	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0
14,5	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0
15,5	0	0	0	0	0	0	328015	0	328015	0,3
16	0	0	0	10150	0	0	0	0	10150	0,01
16,5	0	0	0	10150	0	0	0	0	10150	0,01
17	0	0	0	0	0	0	0	0	0	0
17,5	0	456537	68311	10150	0	0	0	4457	539455	1
18	0	228268	0	10150	4929020	0	656029	2229	5825696	6
18,5	0	2265125	0	101498	19677273	87366	1312059	22114	23465435	23
19	0	2941150	25430	101498	31980426	87366	2296103	28714	37460687	37
19,5	0	5206274	93741	111648	54102802	571932	3280147	50827	63417371	63
20	0	6338835	281223	91349	36870627	397200	2624118	61884	46665236	47
20,5	0	3845443	707046	121798	34425526	378586	3280147	37542	42796088	43
21	45438	2493392	783335	81199	14748251	378586	5248236	24342	23802779	24
21,5	33128	228268	1250543	50749	12303146	1056498	2296103	2229	17220664	17
22	45438	0	926439	10150	7374125	677912	1968088	0	11002152	11
22,5	99384	228268	1260017	0	4929020	2007917	328015	2229	8854850	9
23	465742	228268	433801	10150	0	1438387	984044	2229	3562621	4
23,5	916321	0	390919	0	0	1266056	656029	0	3229325	3
24	1531589	0	212912	30450	0	2458557	328015	0	4561523	5
24,5	884094	0	101719	10150	0	2201263	0	0	3197226	3
25	917222	0	152578	10150	0	1292777	656029	0	3028756	3
25,5	1120243	0	76289	50749	0	1393052	0	0	2640333	3
26	530046	228268	101719	10150	0	590546	0	2229	1462958	1
26,5	310461	0	76289	71049	0	948116	0	0	1405915	1
27	331279	0	25430	0	0	630176	0	0	986885	1
27,5	66256	0	0	10150	0	1223124	0	0	1299530	1
28	111694	0	0	10150	0	397200	0	0	519044	1
28,5	0	0	0	0	0	465952	0	0	465952	0,5
29	111694	0	0	10150	0	87366	0	0	209210	0,2
29,5	0	0	0	0	0	291220	0	0	291220	0,3
30	0	0	0	0	0	87366	0	0	87366	0,1
30,5	0	0	0	0	0	145610	0	0	145610	0,1
31	0	0	0	0	0	0	0	0	0	0
31,5	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0
32,5	0	0	0	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0	0	0	0
33,5	0	0	0	0	0	0	0	0	0	0
34	0	0	0	0	0	0	0	0	0	0
TOTAL *n*	7520029	24688096	6967741	933787	221340216	20560131	26241177	241025	308492202	308
Millions	8	25	7	1	221	21	26	0	308	

Table 9. *ECOCADIZ 2014-07* survey. Chub mackerel (*S. colias*). Cont'd.

ECOCADIZ 2014-07 . Scomber colias .BIOMASS (t)									
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	**TOTAL**
13	0	0	0	0	0	0	0	0	0
13,5	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0
14,5	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0
15,5	0	0	0	0	0	0	9,755	0	9,755
16	0	0	0	0,333	0	0	0	0	0,333
16,5	0	0	0	0,367	0	0	0	0	0,367
17	0	0	0	0	0	0	0	0	0
17,5	0	19,810	2,964	0,440	0	0	0	0,193	23,407
18	0	10,814	0	0,481	233,501	0	31,078	0,106	275,98
18,5	0	116,873	0	5,237	1015,280	4,508	67,698	1,141	1210,737
19	0	164,913	1,426	5,691	1793,169	4,899	128,744	1,610	2100,452
19,5	0	316,559	5,7	6,789	3289,629	34,775	199,444	3,090	3855,986
20	0	417,106	18,505	6,011	2426,151	26,136	172,672	4,072	3070,653
20,5	0	273,311	50,253	8,657	2446,76	26,908	233,133	2,668	3041,69
21	3,482	191,063	60,025	6,222	1130,128	29,010	402,161	1,865	1823,956
21,5	2,732	18,826	103,134	4,185	1014,658	87,131	189,363	0,184	1420,213
22	4,026	0	82,094	0,899	653,439	60,071	174,397	0	974,926
22,5	9,447	21,699	119,776	0	468,546	190,870	31,181	0,212	841,731
23	47,421	23,242	44,169	1,033	0	146,454	100,194	0,227	362,74
23,5	99,787	0	42,571	0	0	137,873	71,441	0	351,672
24	178,139	0	24,764	3,542	0	285,955	38,151	0	530,551
24,5	109,679	0	12,619	1,259	0	273,085	0	0	396,642
25	121,213	0	20,164	1,341	0	170,843	86,696	0	400,257
25,5	157,505	0	10,726	7,135	0	195,862	0	0	371,228
26	79,193	34,105	15,198	1,516	0	88,233	0	0,333	218,578
26,5	49,235	0	12,098	11,267	0	150,359	0	0	222,959
27	55,703	0	4,276	0	0	105,961	0	0	165,94
27,5	11,799	0	0	1,808	0	217,824	0	0	231,431
28	21,046	0	0	1,913	0	74,843	0	0	97,802
28,5	0	0	0	0	0	92,803	0	0	92,803
29	23,491	0	0	2,135	0	18,375	0	0	44,001
29,5	0	0	0	0	0	64,619	0	0	64,619
30	0	0	0	0	0	20,434	0	0	20,434
30,5	0	0	0	0	0	35,868	0	0	35,868
31	0	0	0	0	0	0	0	0	0
31,5	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0
32,5	0	0	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0	0	0
33,5	0	0	0	0	0	0	0	0	0
34	0	0	0	0	0	0	0	0	0
TOTAL	973,898	1608,321	630,462	78,261	14471,26	2543,699	1936,108	15,701	22257,711

Table 10. *ECOCADIZ 2014-07* survey. Blue jack-mackerel (*T. picturatus*). Estimated abundance (absolute numbers and million fish) and biomass (t) by size class (in cm). Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figure 19**.

***ECOCADIZ 2014-07*. *Trachurus picturatus*. ABUNDANCE (in numbers and million fish)**											
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	**POL09**	**TOTAL *n***	**Millions**
8	0	0	0	0	0	0	0	0	0	0	0
8,5	0	0	0	0	0	0	0	0	0	0	0
9	0	67451	0	0	0	251296	0	0	0	318747	0,3
9,5	0	0	0	0	0	0	0	0	0	0	0
10	0	323766	0	0	0	0	0	0	0	323766	0,3
10,5	0	256315	0	0	0	0	0	0	0	256315	0,3
11	0	67451	0	0	0	0	0	0	0	67451	0,1
11,5	0	323766	0	64755	0	0	0	0	0	388521	0,4
12	64567	134902	0	77584	0	0	0	0	0	277053	0,3
12,5	0	323766	0	172679	20164	0	0	0	2028218	2544827	3
13	0	391217	0	928216	59307	502593	875862	549417	1550990	4857602	5
13,5	196635	782434	0	2067195	354657	753889	2170614	0	2624752	8950176	9
14	1165369	1038749	389816	4403372	453108	753889	3484407	0	3101980	14790690	15
14,5	2158615	1497416	1481302	4338546	591887	1005185	15689353	536687	5249505	32548496	33
15	2091113	1106199	1481302	2573610	413965	753889	15689353	1086104	4652970	29848505	30
15,5	2545853	971297	4210016	2751306	512415	502593	10015292	0	1550990	23059762	23
16	1506520	67451	2962604	2272569	177922	1507778	3046476	1081110	3698515	16320945	16
16,5	1302194	458668	4443904	2201656	256207	4272036	1751724	1081110	3101980	18869479	19
17	979522	188863	2105008	1412982	98450	5528516	437931	1086104	0	11837376	12
17,5	460215	134902	1715191	919396	78286	7287593	0	536687	2028218	13160488	13
18	53779	67451	857596	172679	59307	1759074	0	3219763	3698515	9888164	10
18,5	250414	67451	233890	129510	20164	3015556	0	7515642	12527230	23759857	24
19	266515	0	857596	172679	0	753889	0	15028542	13004454	30083675	30
19,5	53779	0	623706	0	20164	0	437931	21994766	14078220	37208566	37
20	134447	0	233890	0	0	0	437931	26886343	1550990	29243601	29
20,5	134447	0	233890	77584	0	0	0	21083812	2028218	23557951	24
21	53779	0	0	0	0	0	0	11367399	1073762	12494940	12
21,5	53779	0	0	64755	0	0	0	8144899	0	8263433	8
22	134447	0	0	0	0	0	0	2716630	0	2851077	3
22,5	0	0	0	0	0	0	0	1086104	0	1086104	1
23	0	0	0	0	0	0	0	1081110	0	1081110	1
23,5	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0
24,5	0	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0	0
25,5	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0
26,5	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0
27,5	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0	0
TOTAL *n*	13605989	8269515	21829711	24801073	3116003	28647776	54036874	126082229	77549507	357938677	358
Millions	14	8	22	25	3	29	54	126	78	358	

Table 10. *ECOCADIZ 2014-07* survey. Blue jack-mackerel (*T. picturatus*). Cont'd.

***ECOCADIZ 2014-07* . *Trachurus picturatus* .BIOMASS (t)**										
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	**POL09**	**TOTAL**
8	0	0	0	0	0	0	0	0	0	0
8,5	0	0	0	0	0	0	0	0	0	0
9	0	0,468	0	0	0	1,744	0	0	0	2,212
9,5	0	0	0	0	0	0	0	0	0	0
10	0	3,033	0	0	0	0	0	0	0	3,033
10,5	0	2,760	0	0	0	0	0	0	0	2,760
11	0	0,829	0	0	0	0	0	0	0	0,829
11,5	0	4,520	0	0,904	0	0	0	0	0	5,424
12	1,018	2,127	0	1,223	0	0	0	0	0	4,368
12,5	0	5,739	0	3,061	0,357	0	0	0	35,949	45,106
13	0	7,759	0	18,409	1,176	9,968	17,370	10,896	30,760	96,338
13,5	4,345	17,291	0	45,682	7,837	16,660	47,968	0	58,004	197,787
14	28,585	25,480	9,562	108,011	11,114	18,492	85,469	0	76,089	362,802
14,5	58,561	40,623	40,186	117,700	16,057	27,270	425,637	14,560	142,414	883,008
15	62,532	33,080	44,297	76,961	12,379	22,544	469,172	32,479	139,142	892,586
15,5	83,655	31,916	138,338	90,406	16,838	16,515	329,094	0	50,964	757,726
16	54,235	2,428	106,655	81,813	6,405	54,280	109,674	38,920	133,148	587,558
16,5	51,219	18,041	174,791	86,597	10,077	168,031	68,900	42,523	122,009	742,188
17	41,984	8,095	90,225	60,563	4,220	236,963	18,771	46,552	0	507,373
17,5	21,443	6,286	79,916	42,838	3,648	339,552	0	25,006	94,501	613,190
18	2,718	3,408	43,336	8,726	2,997	88,889	0	162,701	186,893	499,668
18,5	13,694	3,688	12,790	7,082	1,103	164,901	0	410,982	685,033	1299,273
19	15,739	0	50,644	10,197	0	44,52	0	887,487	767,957	1776,544
19,5	3,423	0	39,697	0	1,283	0	27,873	1399,899	896,035	2368,210
20	9,205	0	16,014	0	0	0	29,985	1840,890	106,195	2002,289
20,5	9,885	0	17,197	5,704	0	0	0	1550,209	149,127	1732,122
21	4,239	0	0	0	0	0	0	896,005	84,636	984,880
21,5	4,537	0	0	5,463	0	0	0	687,133	0	697,133
22	12,121	0	0	0	0	0	0	244,918	0	257,039
22,5	0	0	0	0	0	0	0	104,485	0	104,485
23	0	0	0	0	0	0	0	110,824	0	110,824
23,5	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0
24,5	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0
25,5	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0
26,5	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0
27,5	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0
TOTAL	483,138	217,571	863,648	771,340	95,491	1210,329	1629,913	8506,469	3758,856	17536,755

Table 11. *ECOCADIZ 2014-07* survey. Horse mackerel (*T. trachurus*). Estimated abundance (absolute numbers and million fish) and biomass (t) by size class (in cm). Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figure 21**.

***ECOCADIZ 2014-07*. *Trachurus trachurus*. ABUNDANCE (in numbers and million fish)**											
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	**POL09**	**TOTAL *n***	**Millions**
8	0	0	0	0	0	0	0	0	0	0	0
8,5	0	0	0	0	0	0	0	0	0	0	0
9	469419	0	0	0	0	0	0	0	0	469419	0,5
9,5	702389	0	282448	0	21745	0	0	0	0	1006582	1
10	938837	0	1930061	182086	177914	0	0	332210	127535	3688643	4
10,5	1171808	0	1741762	1075961	710921	0	0	2221059	127535	7049046	7
11	469419	0	800269	8111200	1755190	0	0	2999379	127535	14262992	14
11,5	2813035	0	188299	18870963	1066014	0	0	2221059	127535	25286905	25
12	4920200	0	0	18137551	449624	0	0	446110	0	23953485	24
12,5	3515424	0	0	16062572	52564	0	0	446110	127535	20204205	20
13	5622592	0	94149	5887173	21745	0	0	223055	127535	11976249	12
13,5	1641226	0	0	2598470	0	0	2148629	0	255070	6643395	7
14	1171808	0	0	858798	0	0	1604310	95296	510140	4240352	4
14,5	232971	0	0	539877	0	0	0	0	255070	1027918	1
15	0	0	0	440321	0	0	1059990	0	255070	1755381	2
15,5	232971	0	0	264615	0	0	544319	0	0	1041905	1
16	0	0	0	175706	0	0	1059990	0	0	1235696	1
16,5	0	0	0	0	0	0	1604310	0	0	1604310	2
17	0	0	0	0	0	0	5901568	0	0	5901568	6
17,5	232971	0	0	0	0	0	9654503	0	768867	10656341	11
18	0	236000	0	264615	0	0	6990206	61696	510140	8062657	8
18,5	702389	1191238	0	446701	0	0	13951764	0	2540111	18832203	19
19	232971	1191238	0	0	0	0	6990206	161359	6458272	15034046	15
19,5	0	5012189	0	175706	0	56555	11803134	1127724	15024382	33199690	33
20	469419	3584950	0	0	0	180191	2692948	1965950	10716301	19609759	20
20,5	0	3101712	0	0	0	288482	2692948	4379148	11733306	22195596	22
21	0	2146476	0	0	0	527637	544319	2771715	1501928	7492075	7
21,5	0	1438476	0	0	0	846807	544319	2800947	2522207	8152756	8
22	0	719238	0	0	0	552618	0	1124115	258727	2654698	3
22,5	0	236000	0	0	0	516225	0	95296	255070	1102591	1
23	0	236000	0	0	0	61374	0	190592	510140	998106	1
23,5	0	0	0	0	0	71899	0	0	1020279	1092178	1
24	0	0	0	0	0	0	0	0	0	0	0
24,5	0	0	0	0	0	15343	0	0	765209	780552	0,8
25	0	0	0	0	0	0	0	0	0	0	0
25,5	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0
26,5	0	236000	0	0	0	0	0	33221	510140	779361	0,8
27	0	236000	0	0	0	0	0	33221	0	269221	0,3
27,5	0	483238	0	0	0	0	0	33221	0	516459	0,5
28	0	0	0	0	0	12934	0	33221	0	46155	0,05
28,5	0	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	33221	0	33221	0,03
29,5	0	483238	0	0	0	0	0	0	0	483238	0,5
30	0	0	0	0	0	0	0	33221	0	33221	0,03
30,5	0	236000	0	0	0	0	0	0	0	236000	0,2
31	0	0	0	0	0	0	0	0	0	0	0,0
TOTAL *n*	25539849	20767993	5036988	74092315	4255717	3130065	69787463	23862146	57135639	283608175	284
Millions	26	21	5	74	4	3	70	24	57	284	

Table 11. *ECOCADIZ 2014-07* survey. Horse mackerel (*T. trachurus*). Cont'd.

***ECOCADIZ 2014-07*. *Trachurus trachurus*.BIOMASS (t)**										
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	**POL09**	**TOTAL**
8	0	0	0	0	0	0	0	0	0	0
8,5	0	0	0	0	0	0	0	0	0	0
9	3,105	0	0	0	0	0	0	0	0	3,105
9,5	5,437	0	2,186	0	0,168	0	0	0	0	7,791
10	8,438	0	17,346	1,636	1,599	0	0	2,986	1,146	33,151
10,5	12,142	0	18,047	11,149	7,366	0	0	23,014	1,321	73,039
11	5,571	0	9,498	96,270	20,832	0	0	35,599	1,514	169,284
11,5	38,019	0	2,545	255,044	14,407	0	0	30,018	1,724	341,757
12	75,313	0	0	277,628	6,882	0	0	6,829	0	366,652
12,5	60,641	0	0	277,078	0,907	0	0	7,695	2,200	348,521
13	108,8	0	1,822	113,920	0,421	0	0	4,316	2,468	231,747
13,5	35,474	0	0	56,165	0	0	46,442	0	5,513	143,594
14	28,180	0	0	20,653	0	0	38,581	2,292	12,268	101,974
14,5	6,211	0	0	14,392	0	0	0	0	6,800	27,403
15	0	0	0	12,967	0	0	31,216	0	7,512	51,695
15,5	7,555	0	0	8,581	0	0	17,652	0	0	33,788
16	0	0	0	6,256	0	0	37,738	0	0	43,994
16,5	0	0	0	0	0	0	62,529	0	0	62,529
17	0	0	0	0	0	0	251,143	0	0	251,143
17,5	10,798	0	0	0	0	0	447,46	0	35,635	493,893
18	0	11,884	0	13,325	0	0	352,010	3,107	25,689	406,015
18,5	38,345	65,032	0	24,386	0	0	761,657	0	138,670	1028,090
19	13,759	70,351	0	0	0	0	412,823	9,529	381,408	887,870
19,5	0	319,572	0	11,203	0	3,606	752,555	71,902	957,939	2116,777
20	32,251	246,297	0	0	0	12,380	185,014	135,067	736,244	1347,253
20,5	0	229,204	0	0	0	21,318	198,998	323,602	867,045	1640,167
21	0	170,309	0	0	0	41,865	43,188	219,918	119,168	594,448
21,5	0	122,345	0	0	0	72,023	46,295	238,226	214,519	693,408
22	0	65,470	0	0	0	50,303	0	102,325	23,551	241,649
22,5	0	22,957	0	0	0	50,216	0	9,270	24,812	107,255
23	0	24,497	0	0	0	6,371	0	19,784	52,954	103,606
23,5	0	0	0	0	0	7,953	0	0	112,858	120,811
24	0	0	0	0	0	0	0	0	0	0
24,5	0	0	0	0	0	1,920	0	0	95,741	97,661
25	0	0	0	0	0	0	0	0	0	0
25,5	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0
26,5	0	37,243	0	0	0	0	0	5,243	80,505	122,991
27	0	39,362	0	0	0	0	0	5,541	0	44,903
27,5	0	85,097	0	0	0	0	0	5,850	0	90,947
28	0	0	0	0	0	2,402	0	6,171	0	8,573
28,5	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	6,846	0	6,846
29,5	0	104,761	0	0	0	0	0	0	0	104,761
30	0	0	0	0	0	0	0	7,570	0	7,570
30,5	0	56,473	0	0	0	0	0	0	0	56,473
31	0	0	0	0	0	0	0	0	0	0
TOTAL	490,039	1670,854	51,444	1200,653	52,582	270,357	3685,301	1282,700	3909,204	12613,134

Table 12. *ECOCADIZ 2014-07* survey. Mediterranean horse-mackerel (*T. mediterraneus*). Estimated abundance (absolute numbers and million fish) and biomass (t) by size class (in cm). Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figure 23**.

***ECOCADIZ 2014-07*. *Trachurus mediterraneus*. ABUNDANCE (in numbers and million fish)**				
Size class	**POL01**	**POL02**	**TOTAL *n***	**Millions**
20	0	0	0	0
20,5	0	0	0	0
21	0	0	0	0
21,5	0	0	0	0
22	0	40140	40140	0,04
22,5	0	521822	521822	0,5
23	16269	642243	658512	0,7
23,5	0	923224	923224	0,9
24	16269	1003504	1019773	1
24,5	0	802803	802803	0,8
25	48807	240841	289648	0,3
25,5	0	280981	280981	0,3
26	0	40140	40140	0,04
26,5	48807	0	48807	0,05
27	130151	80280	210431	0,2
27,5	195226	40140	235366	0,2
28	244033	0	244033	0,2
28,5	162689	40140	202829	0,2
29	178957	160561	339518	0,3
29,5	65075	40140	105215	0,1
30	81344	40140	121484	0,1
30,5	32538	0	32538	0,0
31	32538	40140	72678	0,1
31,5	32538	0	32538	0,03
32	16269	0	16269	0,02
32,5	0	0	0	0
33	0	0	0	0
33,5	16269	0	16269	0,02
34	0	0	0	0
34,5	0	0	0	0
35	0	0	0	0
35,5	0	0	0	0
36	0	0	0	0
36,5	0	0	0	0
37	0	0	0	0
37,5	0	0	0	0
38	16269	0	16269	0,02
38,5	0	0	0	0
39	16269	0	16269	0,02
39,5	0	0	0	0
40	0	0	0	0
40,5	0	0	0	0
41	0	0	0	0
41,5	0	0	0	0
42	16269	0	16269	0,02
42,5	0	0	0	0
43	0	0	0	0
43,5	0	0	0	0
44	0	0	0	0
44,5	16269	0	16269	0,02
45	0	0	0	0
TOTAL *n*	1382855	4937239	6320094	6
Millions	1	5	6	

Table 12. *ECOCADIZ 2014-07* survey. Mediterranean horse-mackerel (*T. mediterraneus*). Cont'd.

***ECOCADIZ 2014-07* . *Trachurus mediterraneus* . BIOMASS (t)**			
Size class	**POL01**	**POL02**	**TOTAL**
20	0	0	0
20,5	0	0	0
21	0	0	0
21,5	0	0	0
22	0	3,910	3,910
22,5	0	53,630	53,630
23	1,762	69,562	71,324
23,5	0	105,264	105,264
24	1,951	120,316	122,267
24,5	0	101,112	101,112
25	6,451	31,834	38,285
25,5	0	38,939	38,939
26	0	5,827	5,827
26,5	7,415	0	7,415
27	20,677	12,754	33,431
27,5	32,407	6,663	39,07
28	42,293	0	42,293
28,5	29,414	7,257	36,671
29	33,731	30,263	63,994
29,5	12,778	7,882	20,660
30	16,628	8,205	24,833
30,5	6,919	0	6,919
31	7,194	8,875	16,069
31,5	7,475	0	7,475
32	3,881	0	3,881
32,5	0	0	0
33	0	0	0
33,5	4,331	0	4,331
34	0	0	0
34,5	0	0	0
35	0	0	0
35,5	0	0	0
36	0	0	0
36,5	0	0	0
37	0	0	0
37,5	0	0	0
38	5,858	0	5,858
38,5	0	0	0
39	6,235	0	6,235
39,5	0	0	0
40	0	0	0
40,5	0	0	0
41	0	0	0
41,5	0	0	0
42	7,448	0	7,448
42,5	0	0	0
43	0	0	0
43,5	0	0	0
44	0	0	0
44,5	8,556	0	8,556
45	0	0	0
TOTAL	263,404	612,293	875,697

Table 13. *ECOCADIZ 2014-07* survey. Bogue (*B. boops*). Estimated abundance (absolute numbers and million fish) and biomass (t) by size class (in cm). Polygons (*i.e.*, coherent or homogeneous post-strata) numbered a s in **Figure 25**.

***ECOCADIZ 2014-07* . *Boops boops* . ABUNDANCE (in numbers and million fish)**						
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**TOTAL *n***	**Millions**
10	0	0	0	0	0	0
10,5	0	0	0	0	0	0
11	0	0	0	0	0	0
11,5	0	0	0	0	0	0
12	0	0	0	0	0	0
12,5	0	0	0	0	0	0
13	0	0	0	0	0	0
13,5	0	0	0	0	0	0
14	0	0	0	0	0	0
14,5	0	0	0	0	0	0
15	0	0	0	0	0	0
15,5	0	0	0	0	0	0
16	0	0	0	0	0	0
16,5	0	0	0	0	0	0
17	0	0	0	0	0	0
17,5	0	0	0	0	0	0
18	0	0	0	0	0	0
18,5	0	0	95463	0	95463	0,1
19	42012	29752	47732	5451	124947	0,1
19,5	42012	0	95463	5451	142926	0,1
20	42012	67696	334121	5451	449280	0,4
20,5	126035	23376	381853	16353	547617	0,5
21	672186	65724	525047	87215	1350172	1
21,5	420116	133420	954631	54509	1562676	2
22	378105	184577	859168	49058	1470908	1
22,5	420116	498323	620511	54509	1593459	2
23	420116	579231	381853	54509	1435709	1
23,5	126035	577999	381853	16353	1102240	1
24	42012	759096	47732	5451	854291	0,9
24,5	42012	314948	143195	5451	505606	0,5
25	126035	356095	0	16353	498483	0,5
25,5	0	91072	47732	0	138804	0,1
26	42012	72100	0	5451	119563	0,1
26,5	0	65724	0	0	65724	0,1
27	0	23376	0	0	23376	0,02
27,5	0	37944	0	0	37944	0,04
28	0	0	0	0	0	0
28,5	0	0	0	0	0	0
29	0	23376	0	0	23376	0,02
29,5	0	0	0	0	0	0
30	0	23376	0	0	23376	0,02
30,5	0	0	0	0	0	0
31	0	0	0	0	0	0
TOTAL *n*	2940816	3927205	4916354	381565	12165940	12
Millions	3	4	5	0,4	12	

Table 13. *ECOCADIZ 2014-07* survey. Bogue (*B. boops*).Cont'd.

***ECOCADIZ 2014-07*. *Boops boops*. BIOMASS (t)**					
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**TOTAL**
10	0	0	0	0	0
10,5	0	0	0	0	0
11	0	0	0	0	0
11,5	0	0	0	0	0
12	0	0	0	0	0
12,5	0	0	0	0	0
13	0	0	0	0	0
13,5	0	0	0	0	0
14	0	0	0	0	0
14,5	0	0	0	0	0
15	0	0	0	0	0
15,5	0	0	0	0	0
16	0	0	0	0	0
16,5	0	0	0	0	0
17	0	0	0	0	0
17,5	0	0	0	0	0
18	0	0	0	0	0
18,5	0	0	6,339	0	6,339
19	3,010	2,132	3,420	0,391	8,953
19,5	3,242	0	7,367	0,421	11,03
20	3,485	5,616	27,72	0,452	37,273
20,5	11,221	2,081	33,997	1,456	48,755
21	64,116	6,269	50,081	8,319	128,785
21,5	42,862	13,612	97,395	5,561	159,430
22	41,198	20,112	93,615	5,345	160,27
22,5	48,817	57,904	72,102	6,334	185,157
23	51,986	71,676	47,252	6,745	177,659
23,5	16,586	76,066	50,252	2,152	145,056
24	5,872	106,107	6,672	0,762	119,413
24,5	6,230	46,702	21,234	0,808	74,974
25	19,803	55,95	0	2,569	78,322
25,5	0	15,145	7,937	0	23,082
26	7,386	12,676	0	0,958	21,020
26,5	0	12,204	0	0	12,204
27	0	4,579	0	0	4,579
27,5	0	7,835	0	0	7,835
28	0	0	0	0	0
28,5	0	0	0	0	0
29	0	5,621	0	0	5,621
29,5	0	0	0	0	0
30	0	6,195	0	0	6,195
30,5	0	0	0	0	0
31	0	0	0	0	0
TOTAL	325,814	528,482	525,383	42,273	1421,952

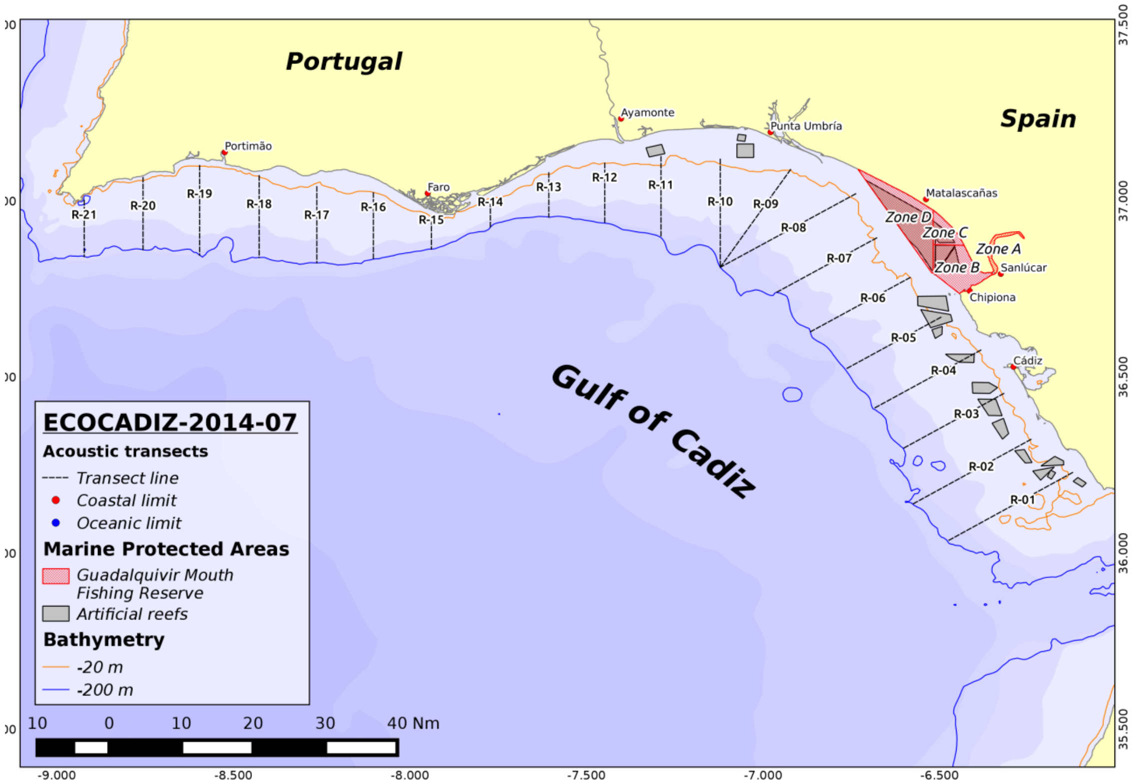


Figure 1. *ECOCADIZ 2014-07* survey. Location of the acoustic transects sampled during the survey. The different protected areas inside the Guadalquivir river mouth Fishing Reserve and artificial reef polygons are also shown.

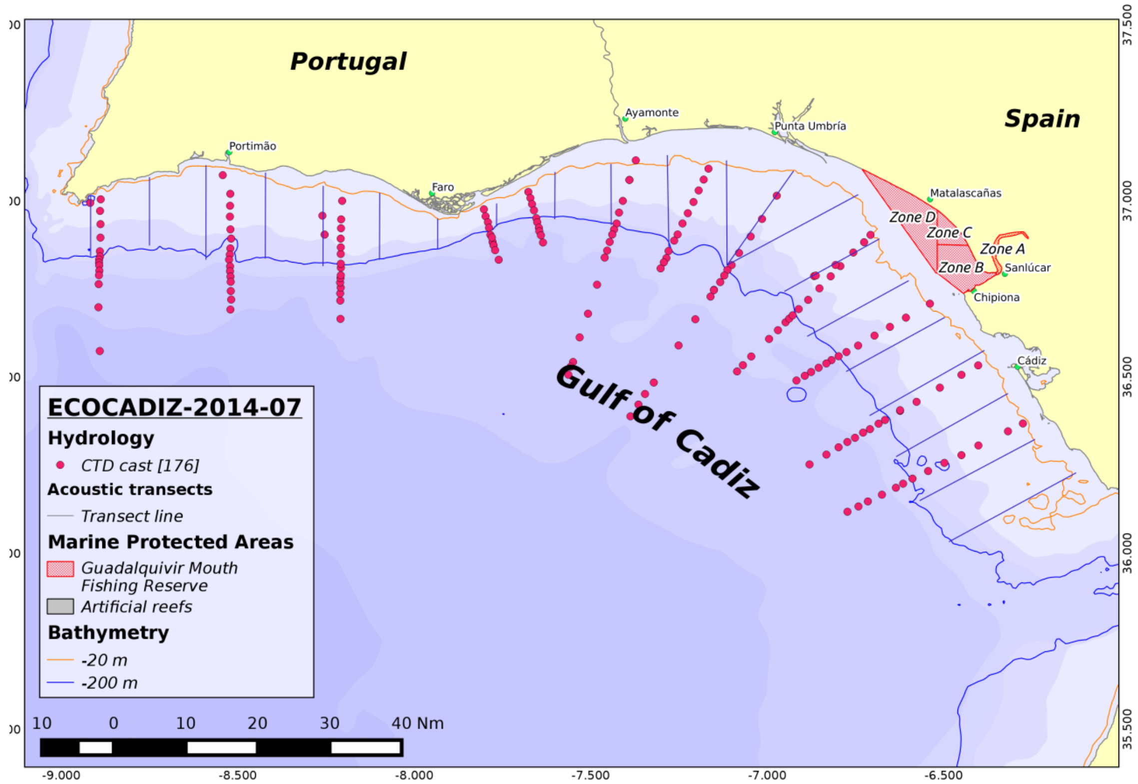


Figure 2. *ECOCADIZ 2014-07* survey. Location of CTD-LADCP stations.

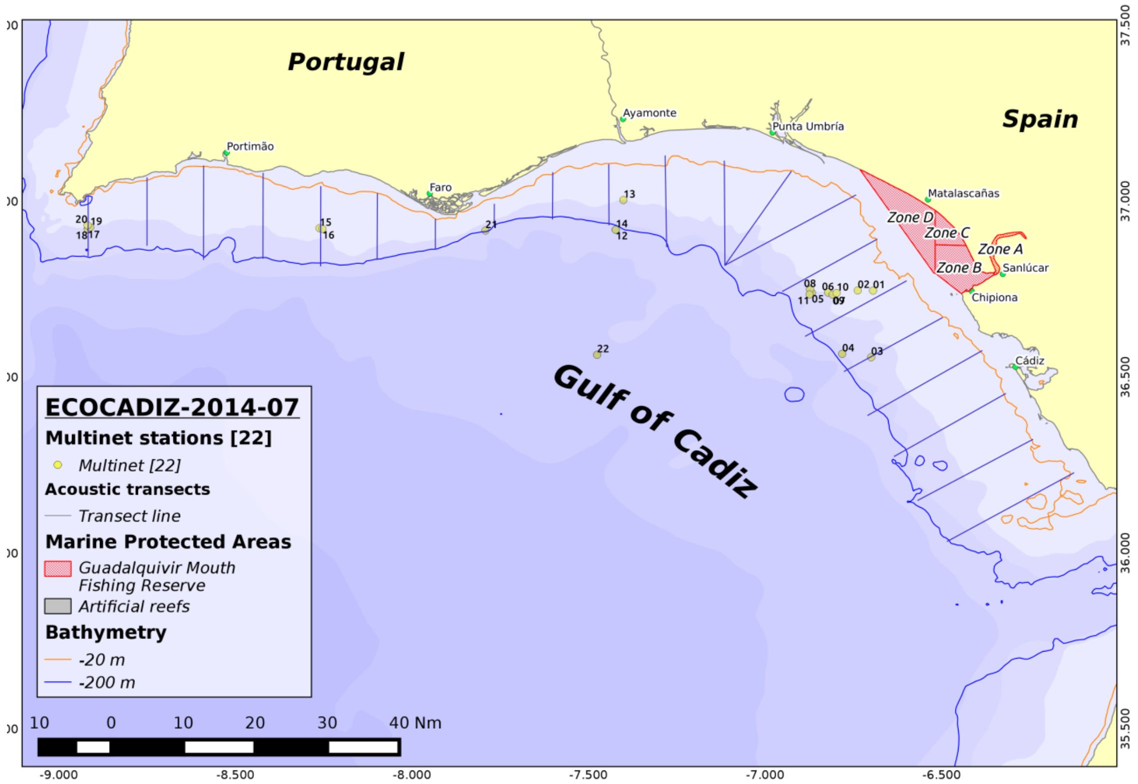


Figure 3. *ECOCADIZ 2014-07* survey. Location of the *Multinet* sampling stations.

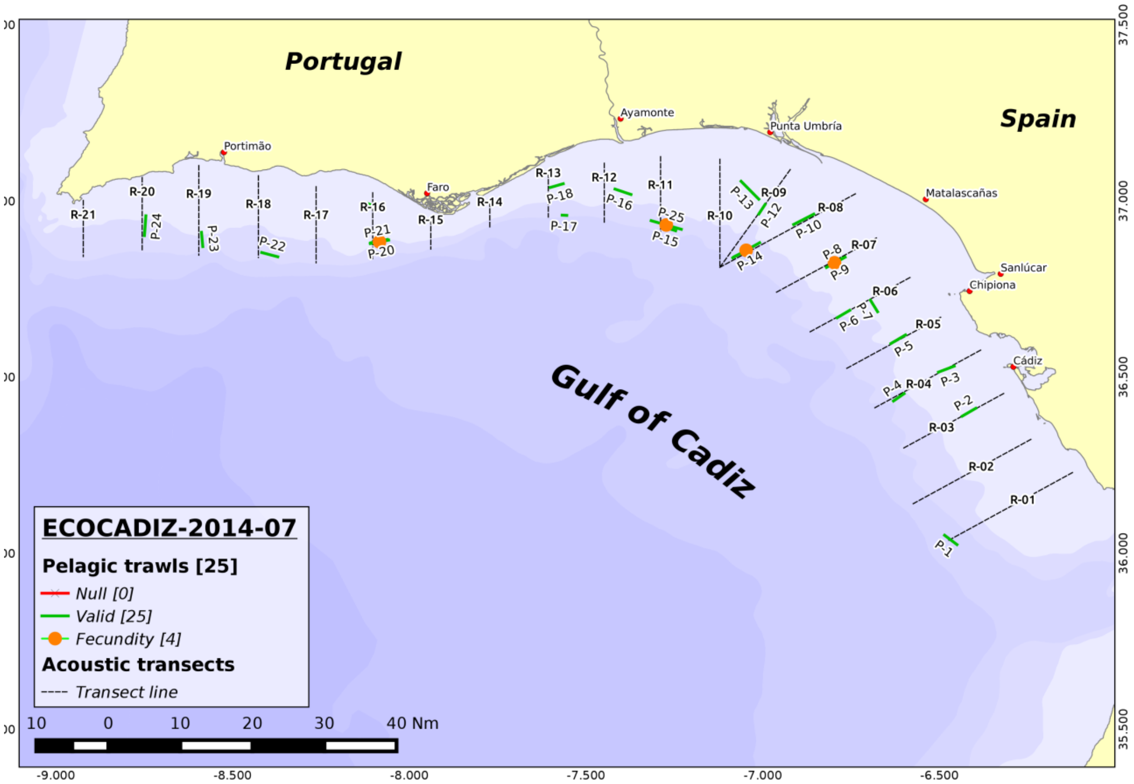


Figure 4. *ECOCADIZ 2014-07* survey. Location of ground-truthing fishing hauls. Null hauls in red. Hauls carried out by night for the collection of anchovy hydrated females are indicated.

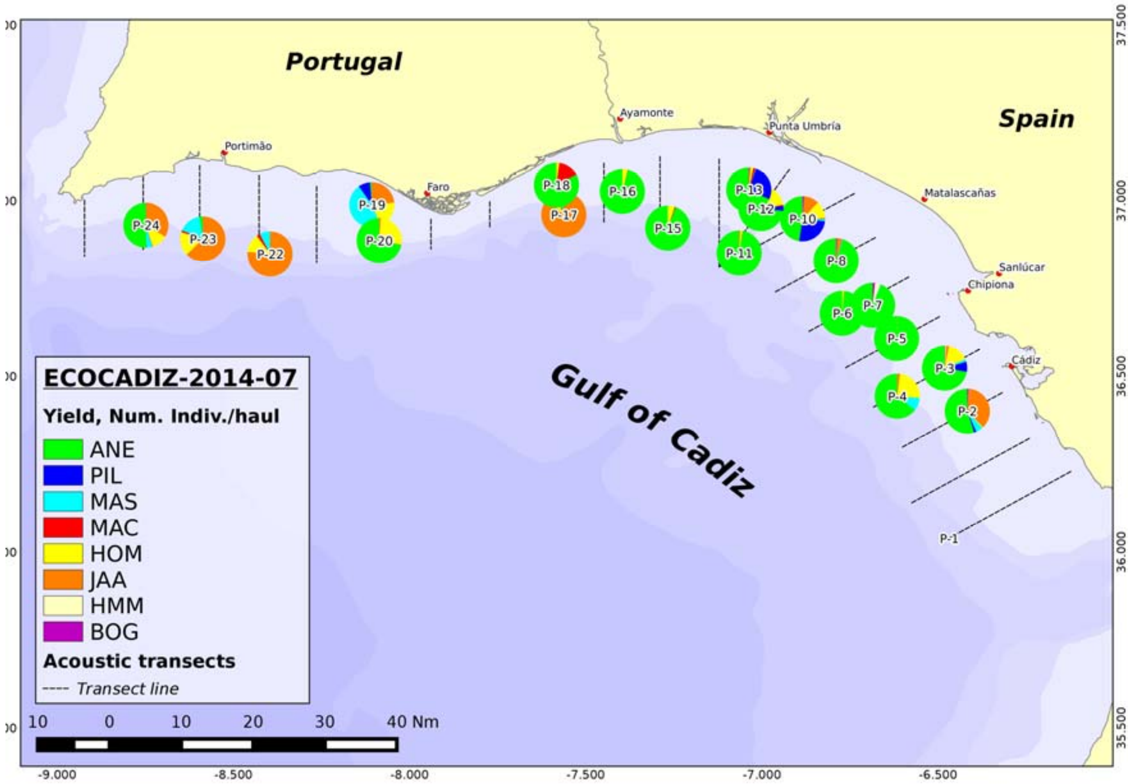


Figure 5. *ECOCADIZ 2014-07* survey. Species composition (percentages in number) in fishing hauls.

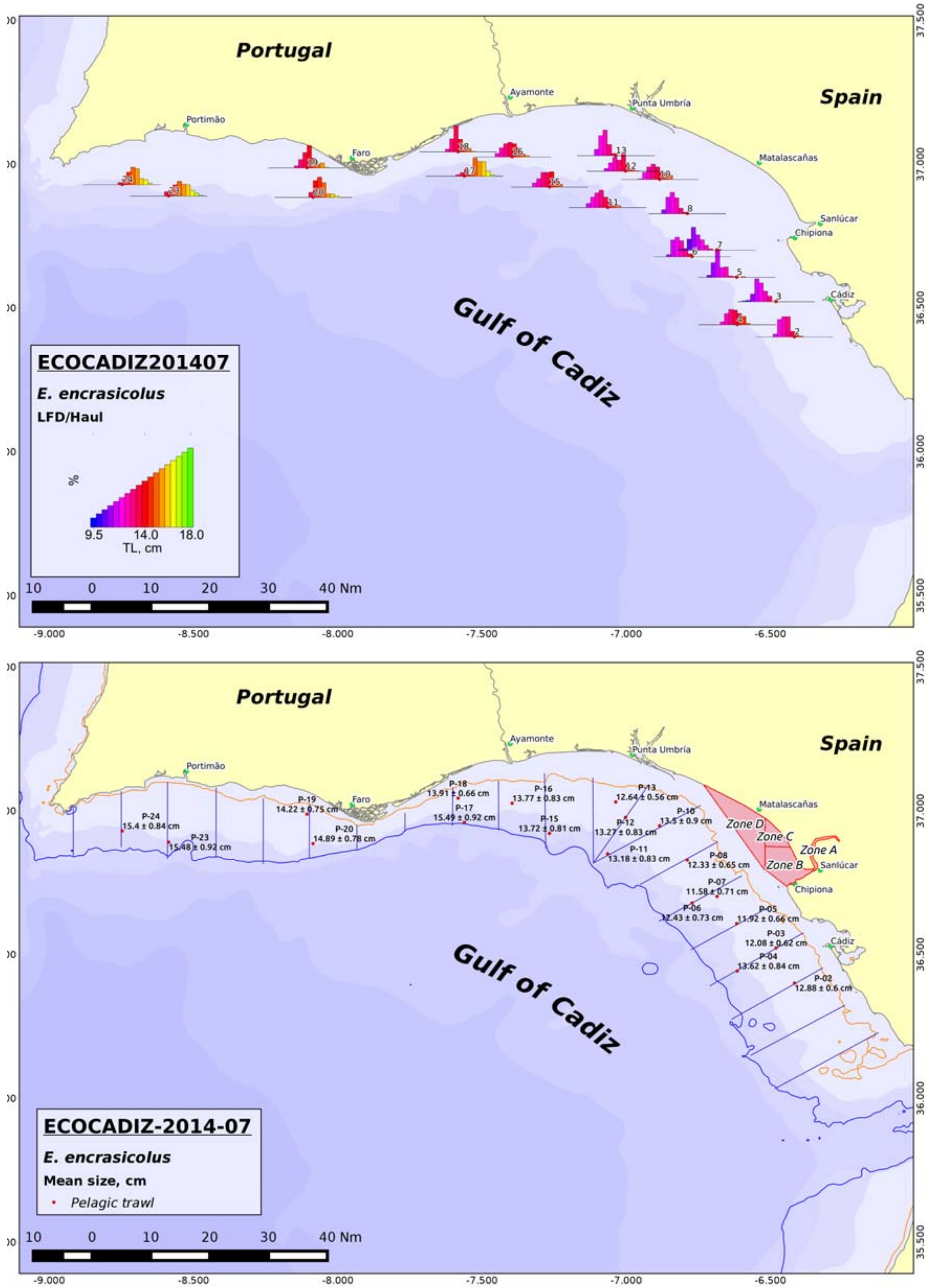


Figure 6. *ECOCADIZ 2014-07* survey. *Engraulis encrasicolus*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

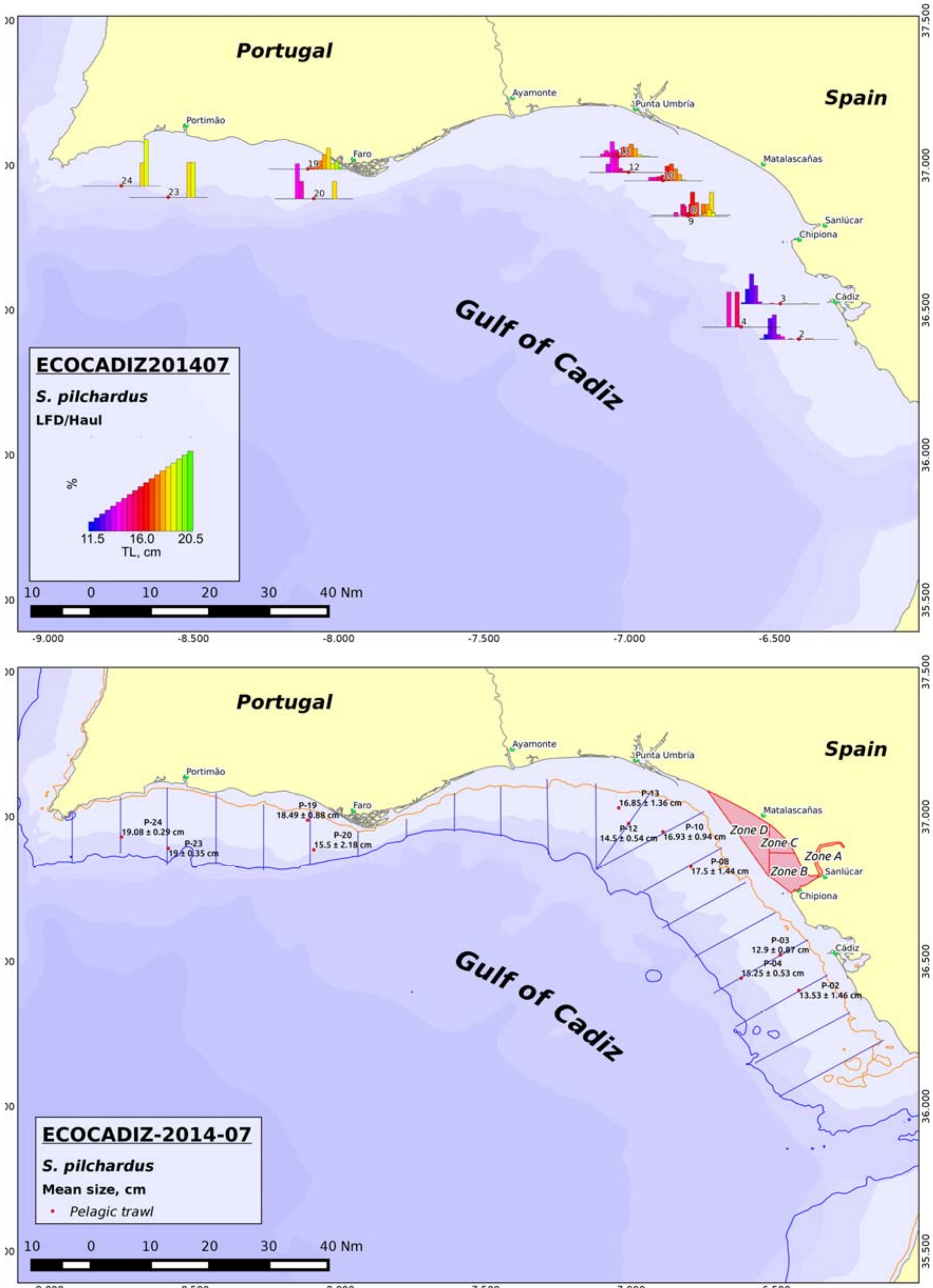


Figure 7. *ECOCADIZ 2014-07* survey. *Sardina pilchardus*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

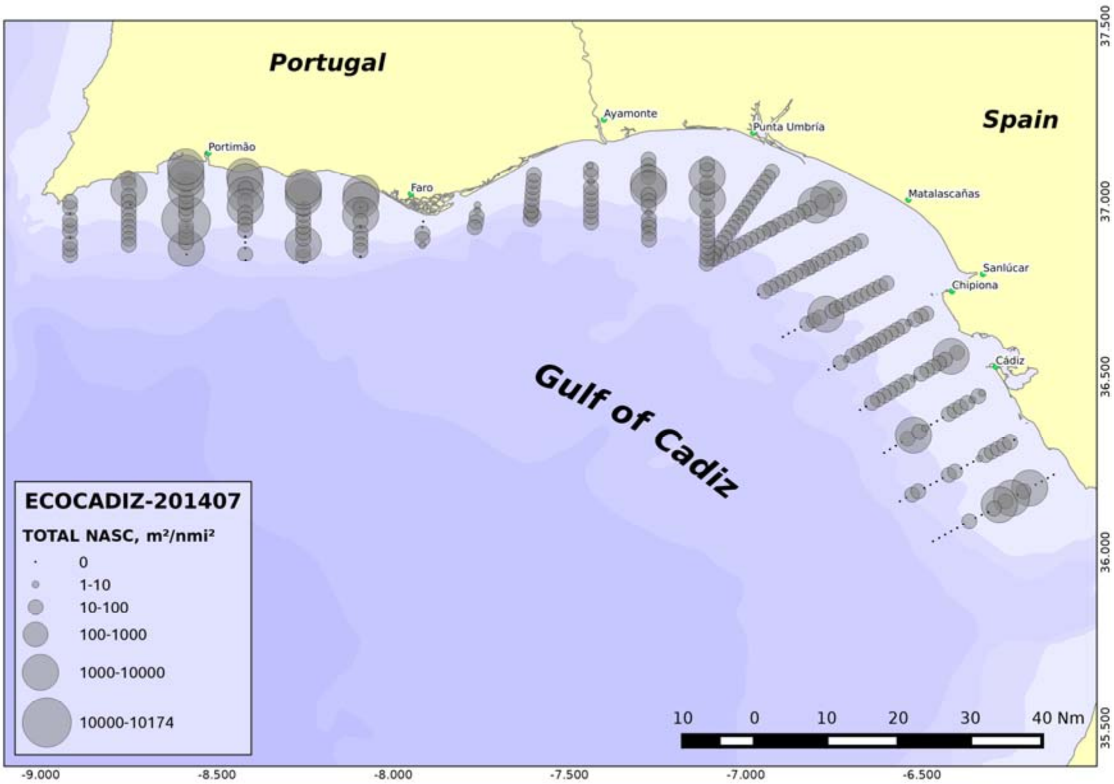


Figure 8. *ECOCADIZ 2014-07* survey. Distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the pelagic fish species assemblage.

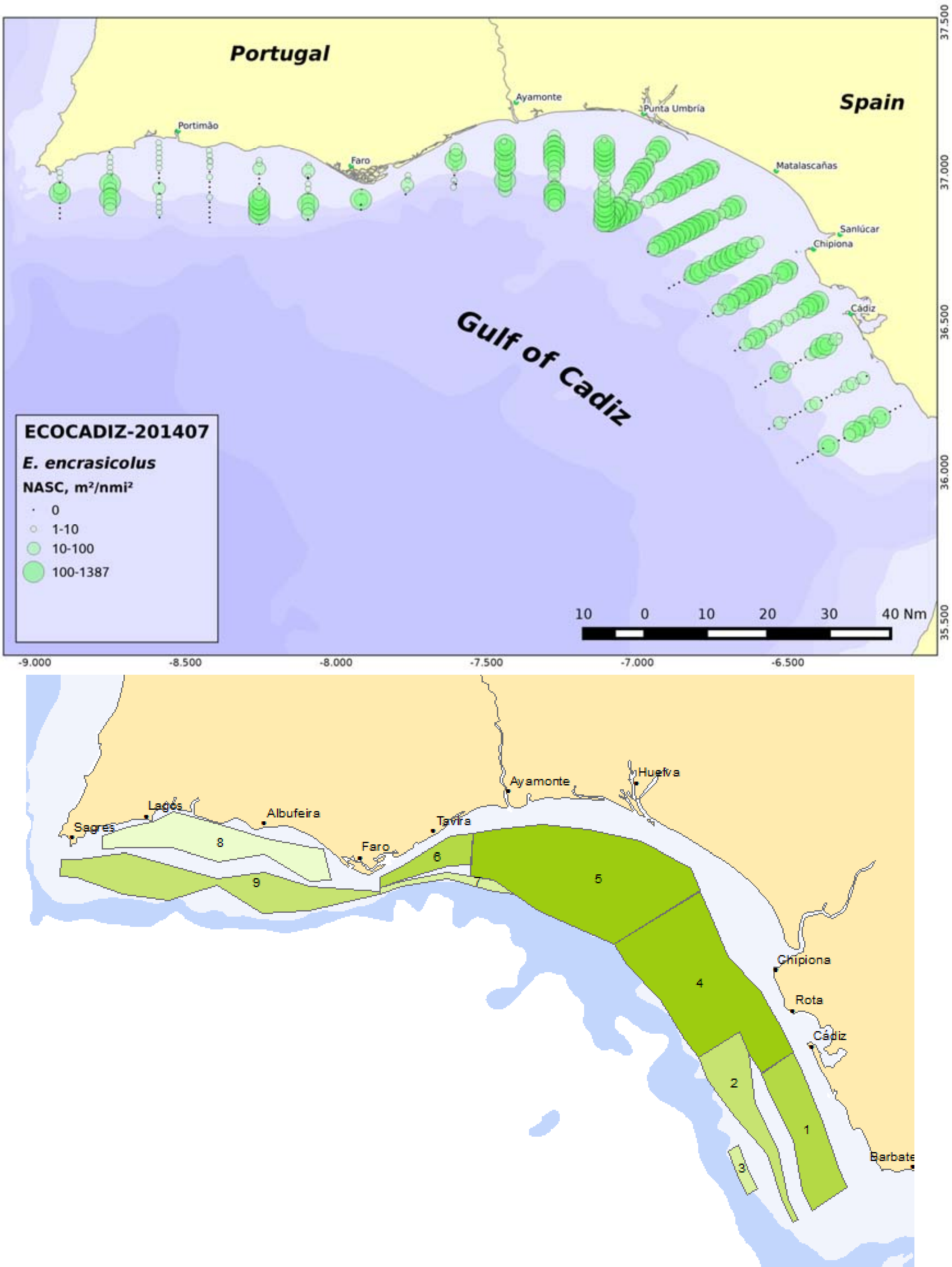


Figure 9. *ECOCADIZ 2014-07* survey. Anchovy (*Engraulis encrasicolus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

***ECOCADIZ 2014-07*: Anchovy (*E. encrasicolus*)**

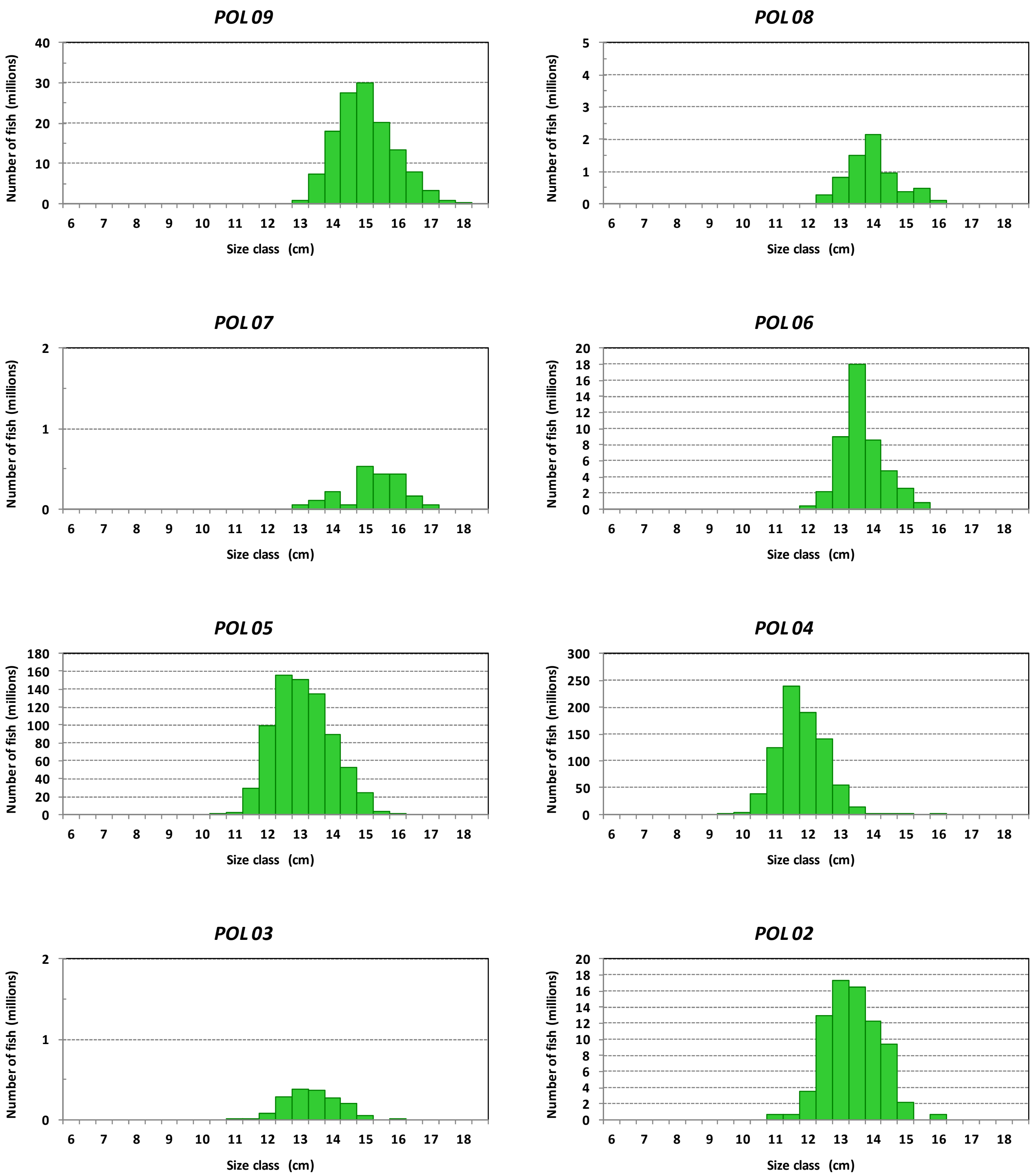


Figure 10. *ECOCADIZ 2014-07* survey. Anchovy (*E. encrasicolus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 9**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

***ECOCADIZ 2014-07*: Anchovy (*E. encrasicolus*)**

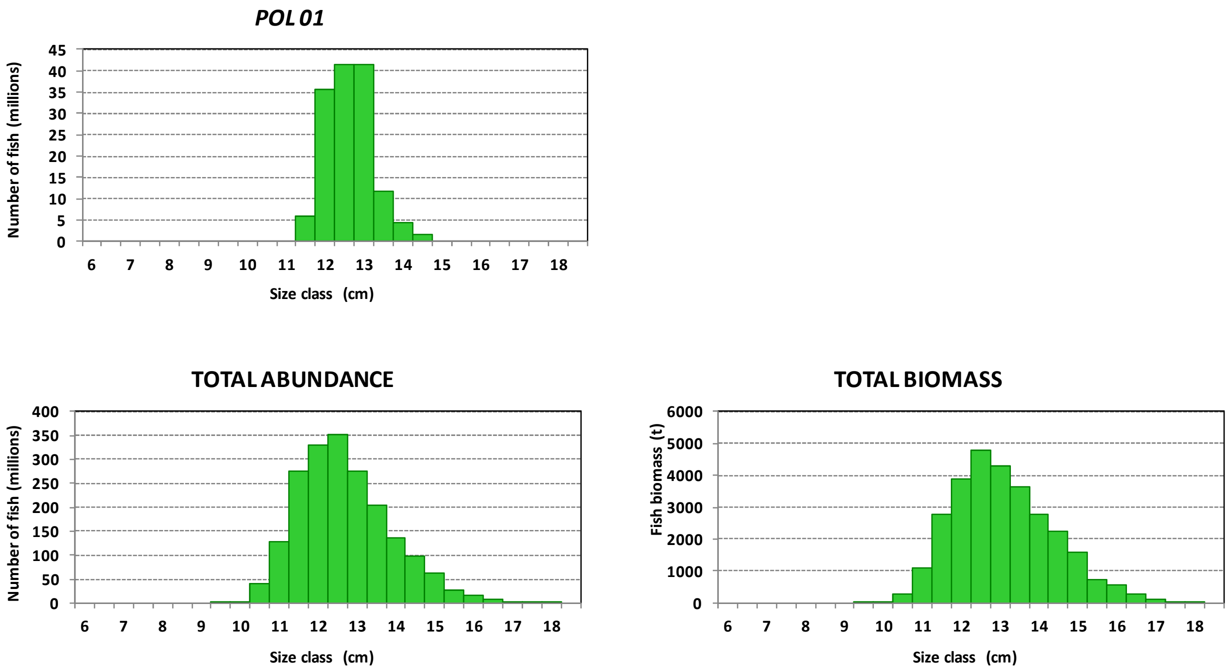


Figure 10. *ECOCADIZ 2014-07* survey. Anchovy (*E. encrasicolus*). Cont'd.

***ECOCADIZ 2014-07*: Anchovy (*E. encrasicolus*)**

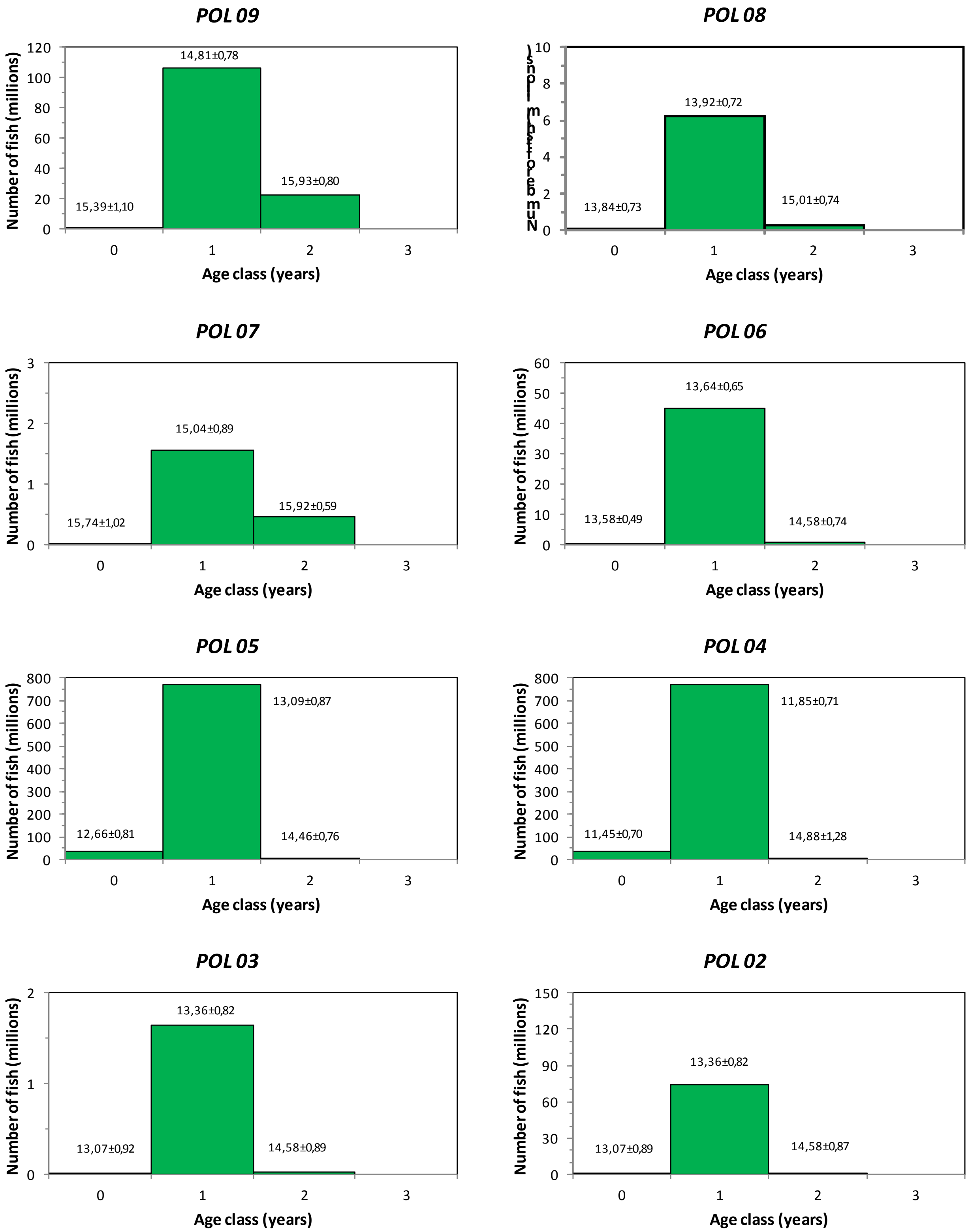


Figure 11. *ECOCADIZ 2014-07* survey. Anchovy (*E. encrasicolus*). Estimated abundances (number of fish in millions) by age class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 9**) and total sampled area. Post-strata ordered in the W-E direction. Mean length (±SD) by age group is also shown.The estimated biomass (t) by age class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

ECOCADIZ 2014-07: Anchovy (*E. encrasicolus*)

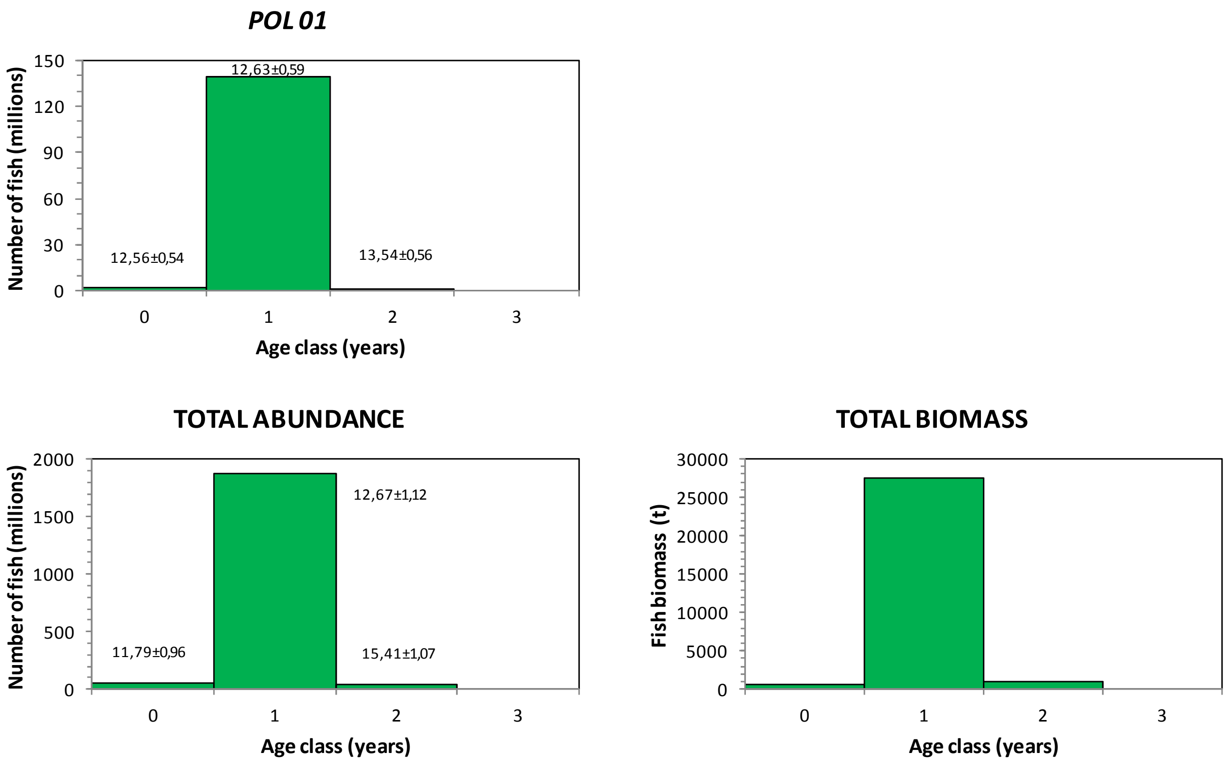
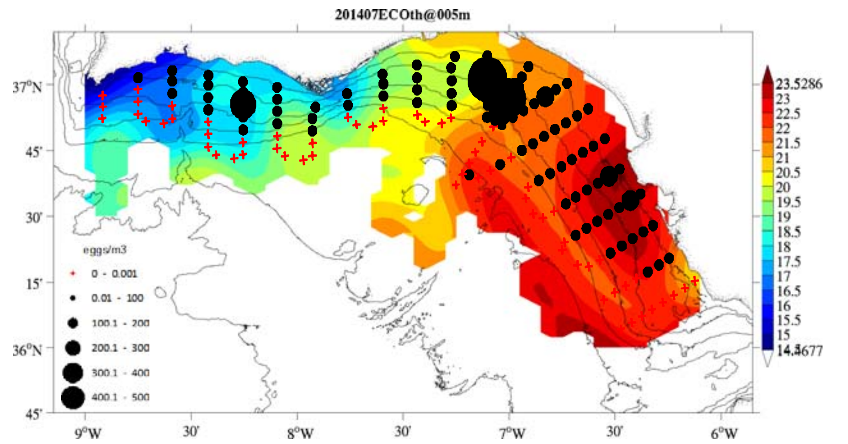
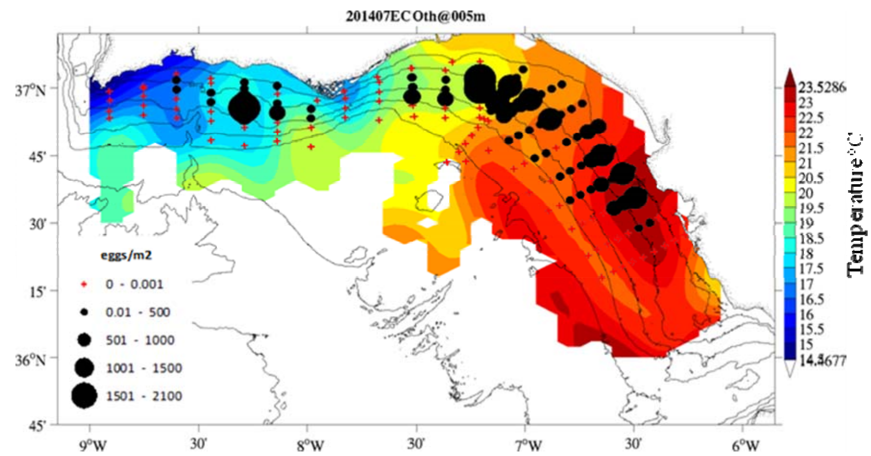


Figure 11. *ECOCADIZ 2014-07* survey. Anchovy (*E. encrasicolus*). Cont'd.



BOCADEVA 0714. CUFES sampling	
Number st	153
Positive st	88 (57.5 %)
Total Anchovy eggs (in number)	41941
Max density by st (eggs/m^3)	472.9
Mean density (eggs/m^3)	23.9



BOCADEVA 0714 . Pairovet sampling.	
Number st	151
Positive st	70 (46.4 %)
Total Anchovy eggs (in number)	3087
Max density by st (eggs/m^2)	2024.4
Mean density (eggs/m^2)	218.7

Figure 12. *ECOCADIZ 2014-07* survey. Anchovy (*E. encrasicolus*). Distribution of anchovy egg densities as sampled by CUFES (eggs m^{-3}, top) and PairoVET (eggs m^{-2}, bottom). Egg distribution superimposed to the distribution of sea temperature at 5 m depth.

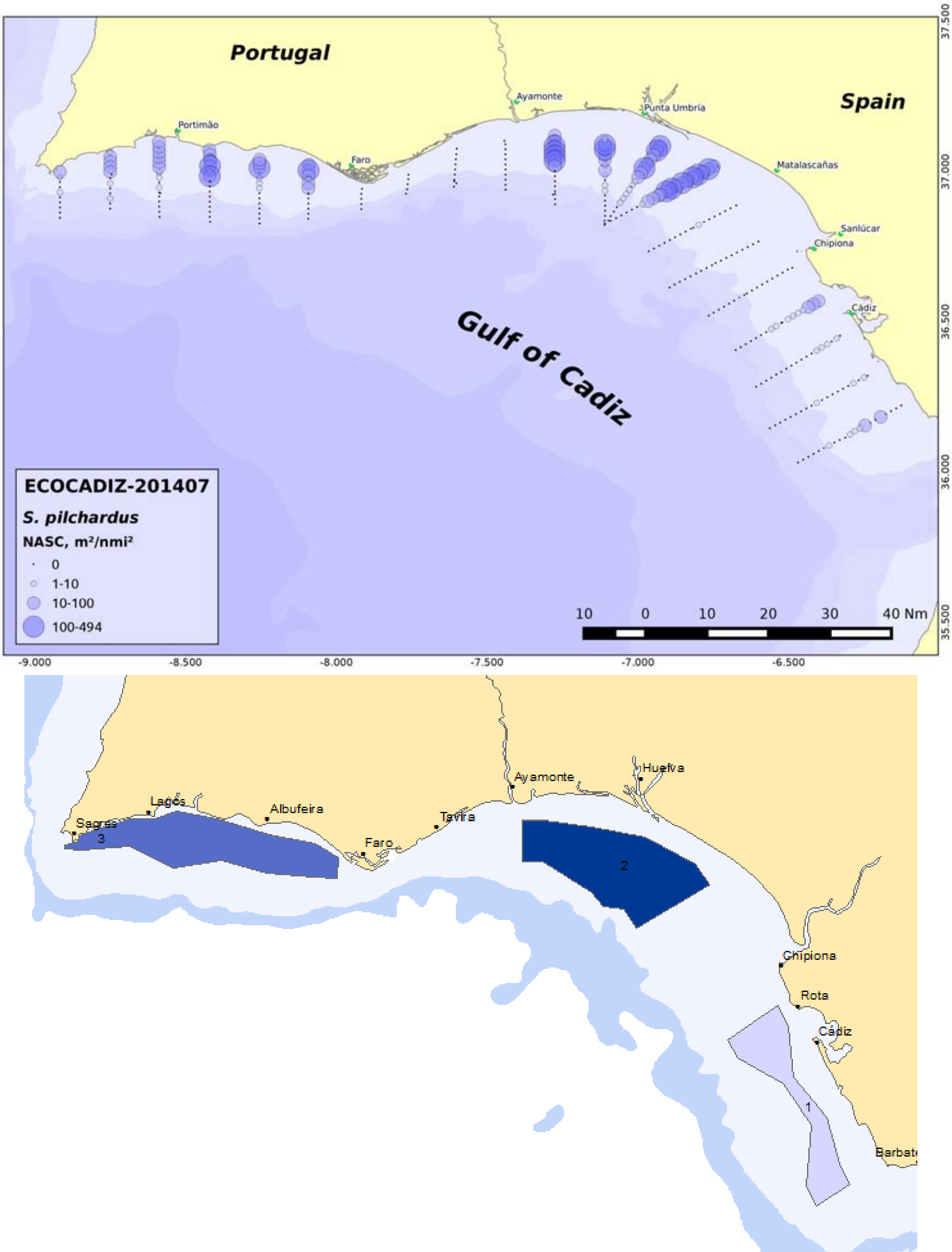


Figure 13. *ECOCADIZ 2014-07* survey. Sardine (*Sardina pilchardus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

***ECOCADIZ 2014-07*: Sardine (*S. pilchardus*)**

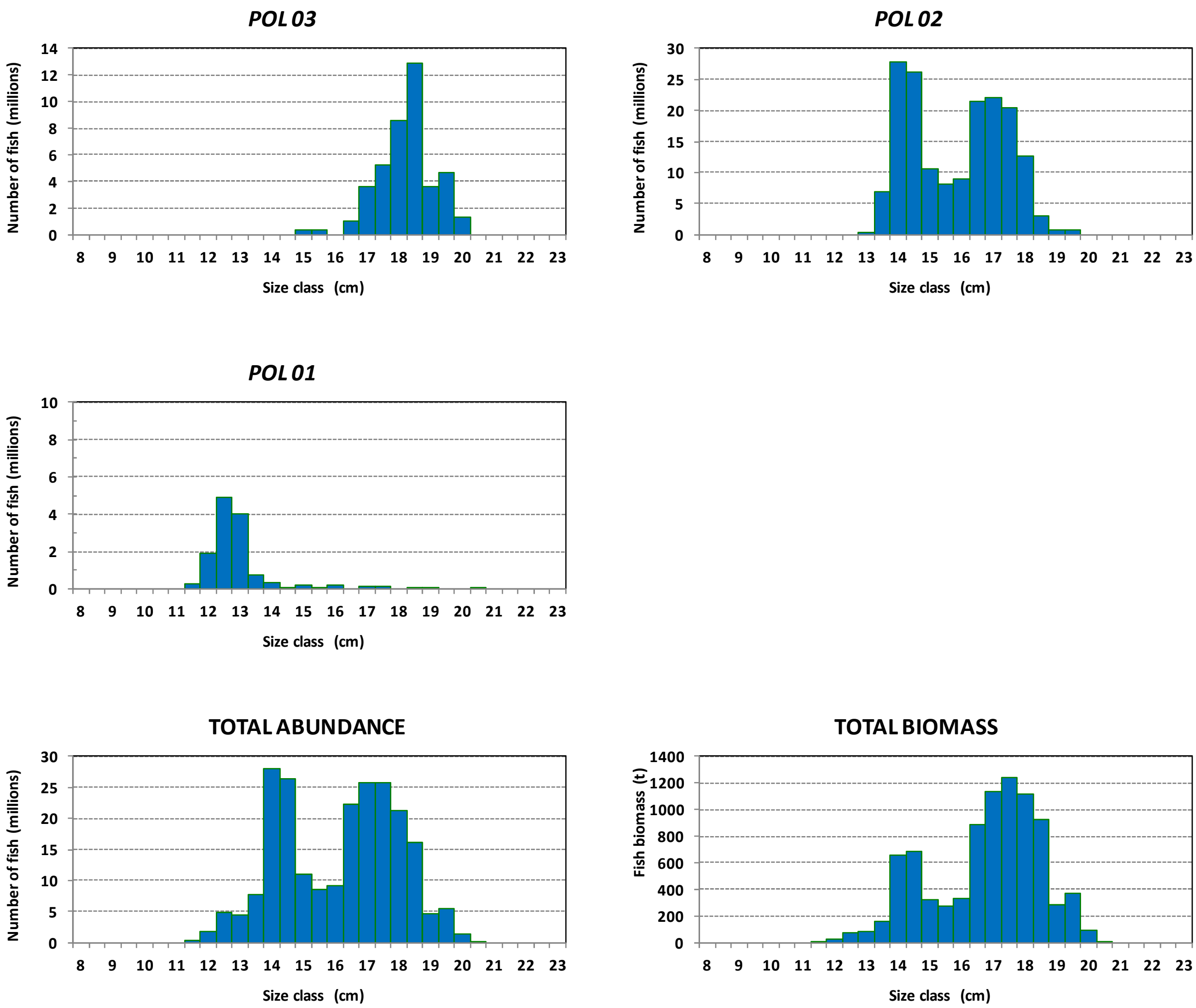


Figure 14. *ECOCADIZ 2014-07* survey. Sardine (*S. pilchardus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 13**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

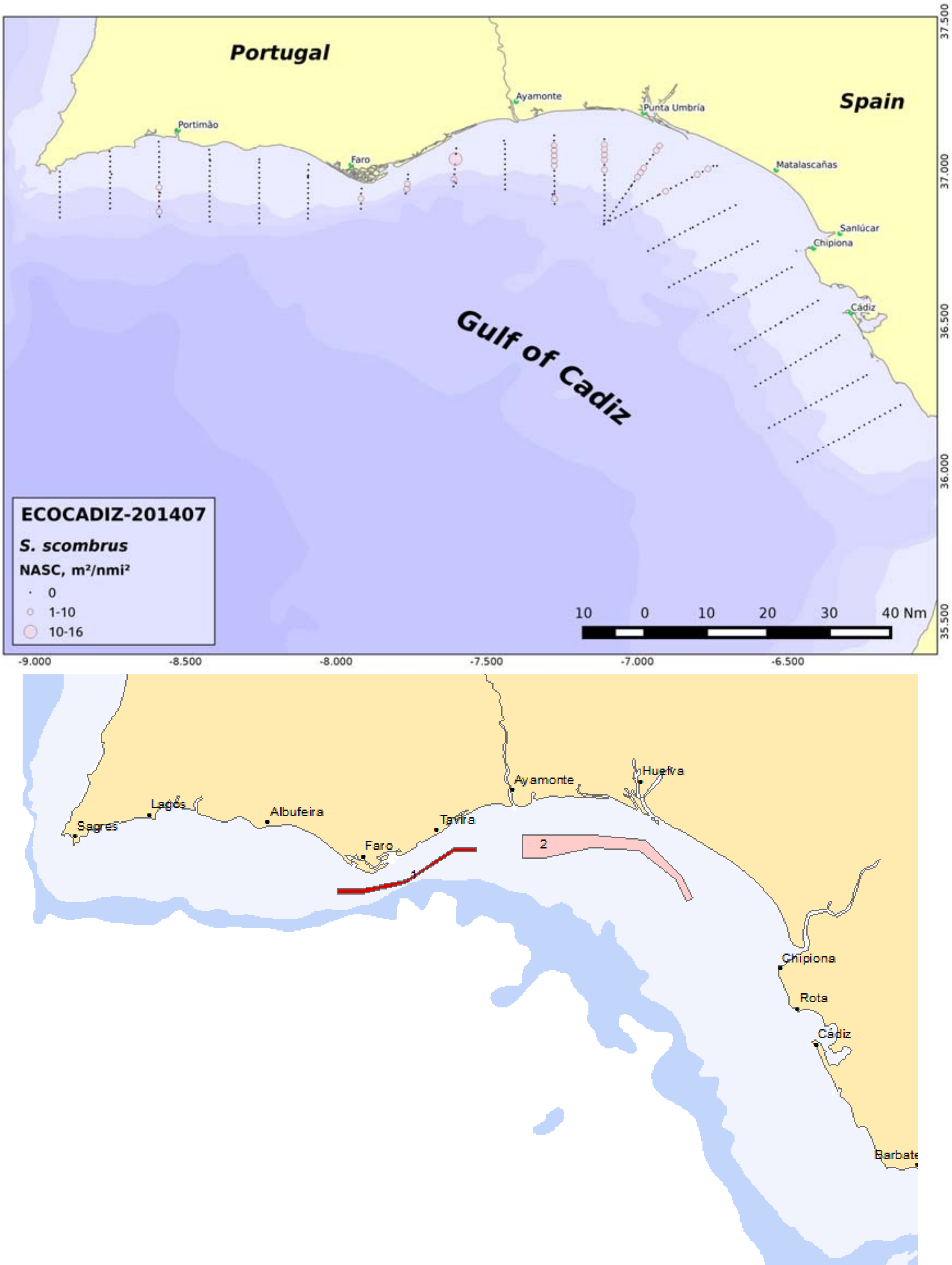


Figure 15. *ECOCADIZ 2014-07* survey. Mackerel (*Scomber scombrus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

***ECOCADIZ 2014-07*: Mackerel (*S. scombrus*)**

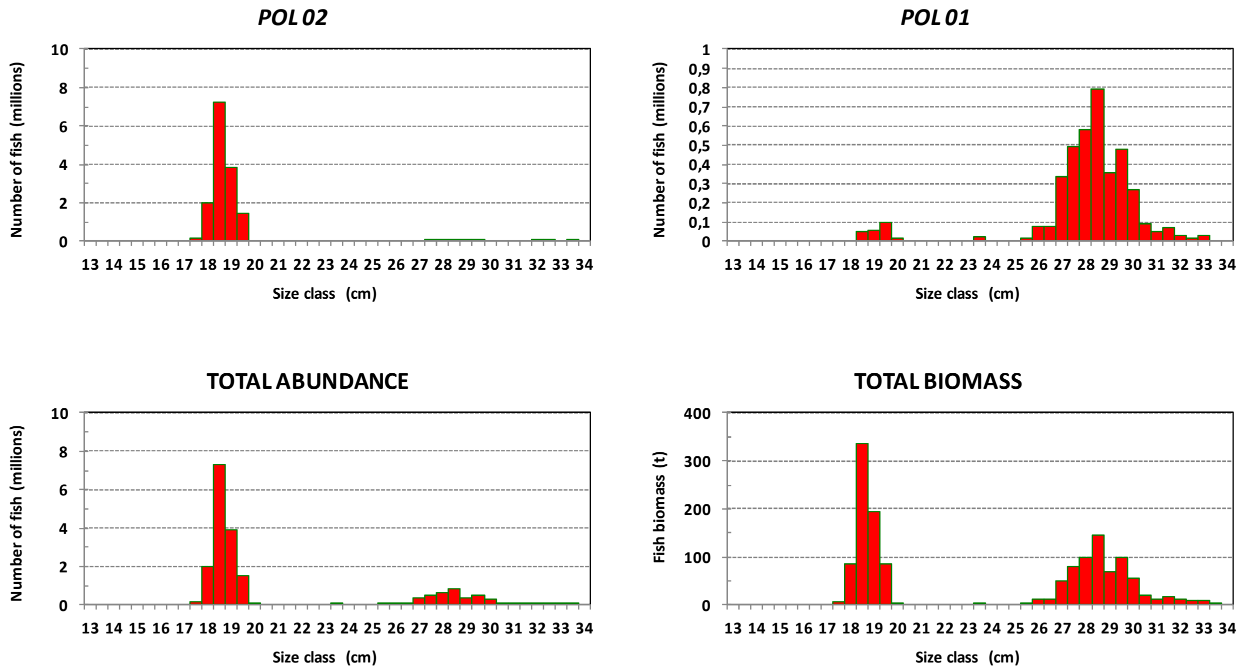


Figure 16. *ECOCADIZ 2014-07* survey. Mackerel (*S. scombrus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 15**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

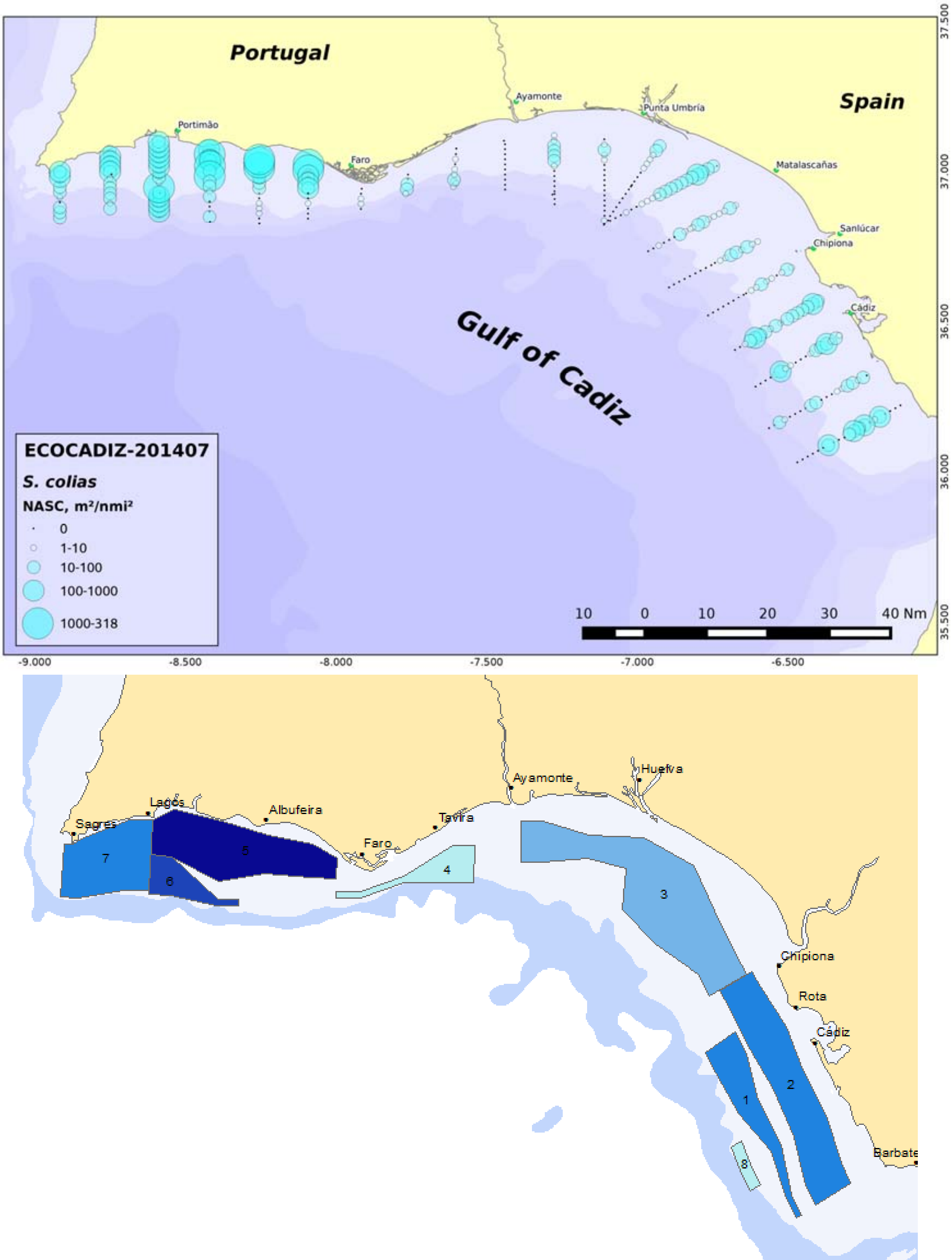


Figure 17. *ECOCADIZ 2014-07* survey. Chub mackerel (*Scomber colias*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

***ECOCADIZ 2014-07*: Chub mackerel (*S. colias*)**

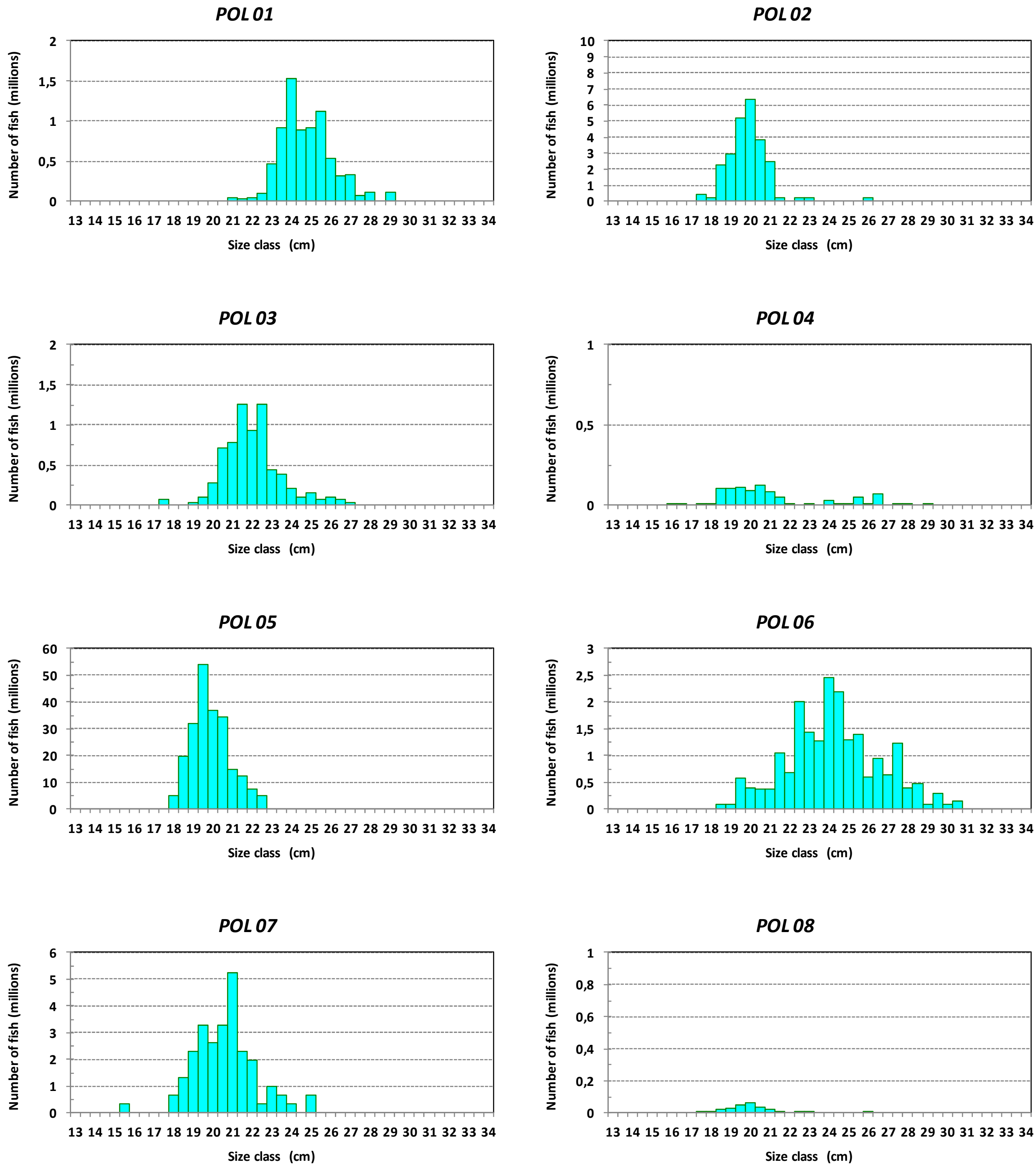


Figure 18. *ECOCADIZ 2014-07* survey. Chub mackerel (*S. colias*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 17**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

ECOCADIZ 2014-07: Chub mackerel (*S. colias*)

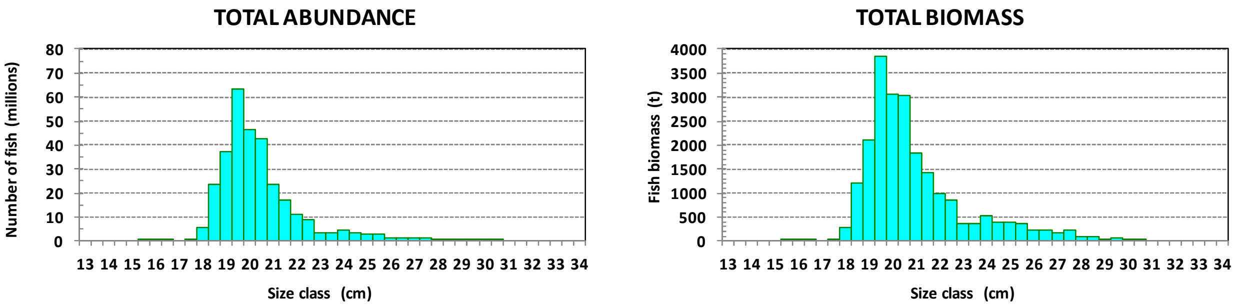


Figure 18. *ECOCADIZ 2014-07* survey. Chub mackerel (*S. colias*). Cont'd.

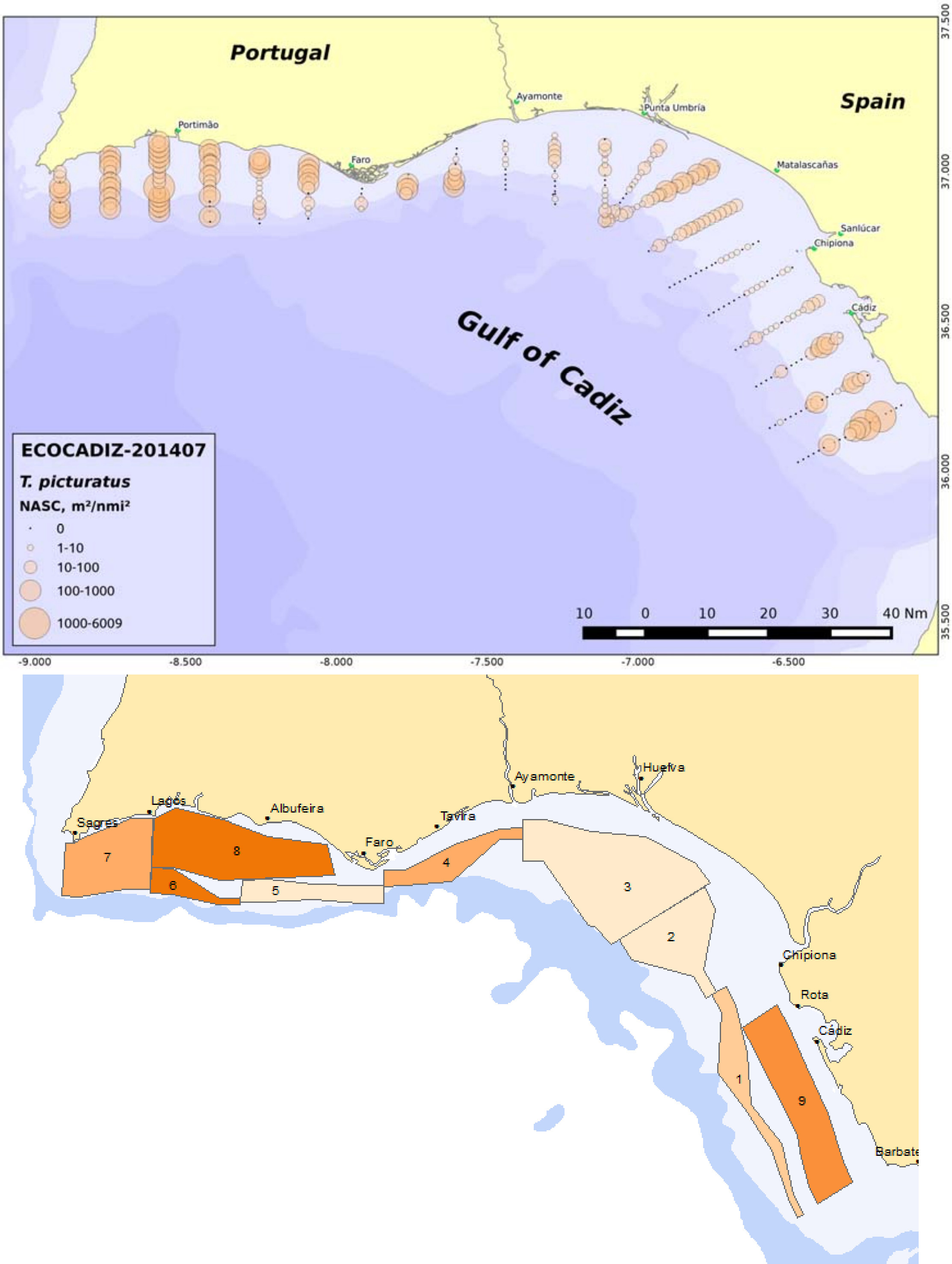


Figure 19. *ECOCADIZ 2014-07* survey. Blue jack mackerel (*Trachurus picturatus*).Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

***ECOCADIZ 2014-07*: Blue jack mackerel (*T. picturatus*)**

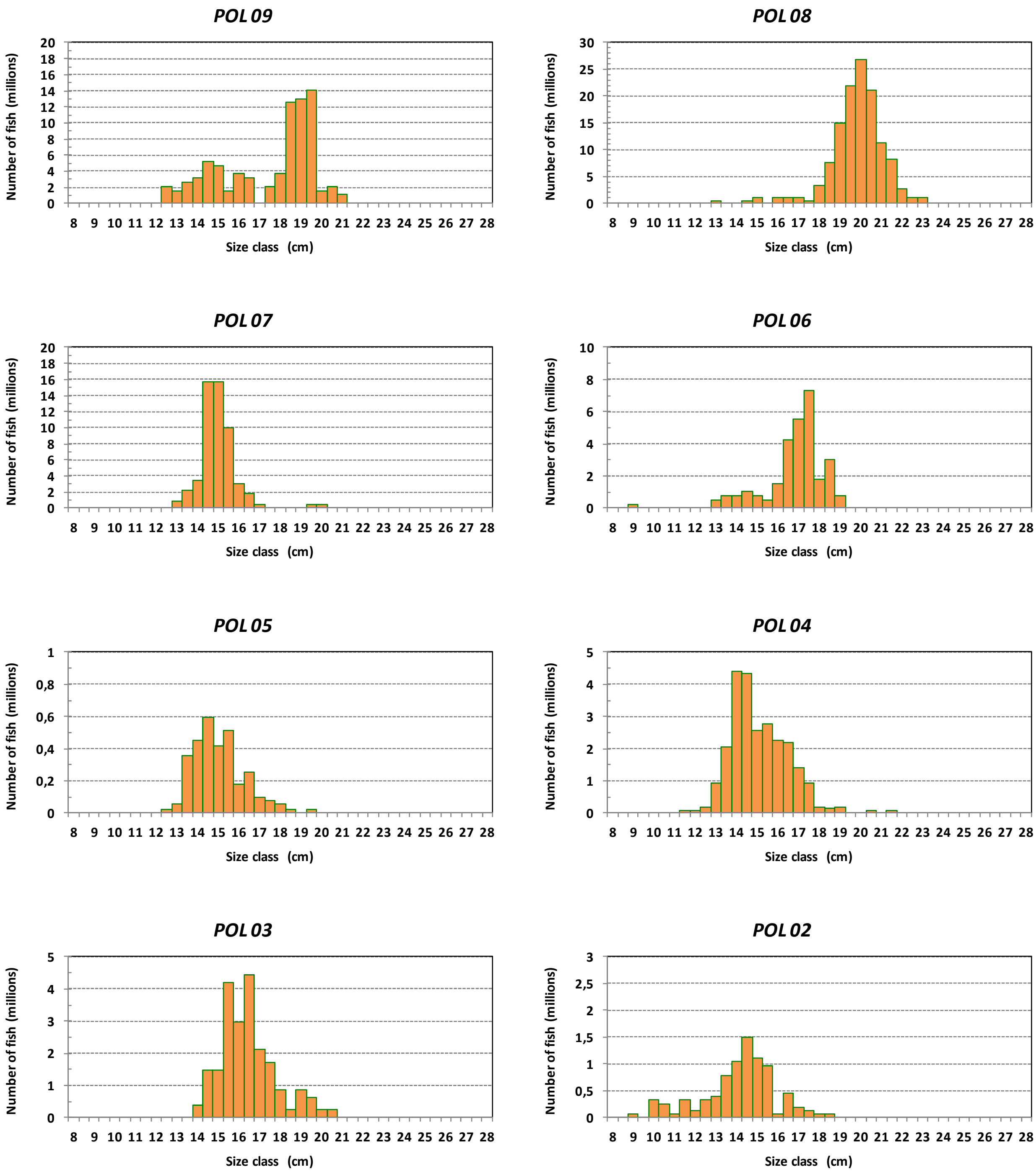


Figure 20. *ECOCADIZ 2014-07* survey. Blue jack mackerel (*T. picturatus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 19**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

ECOCADIZ 2014-07: Blue jack mackerel (*T. picturatus*)

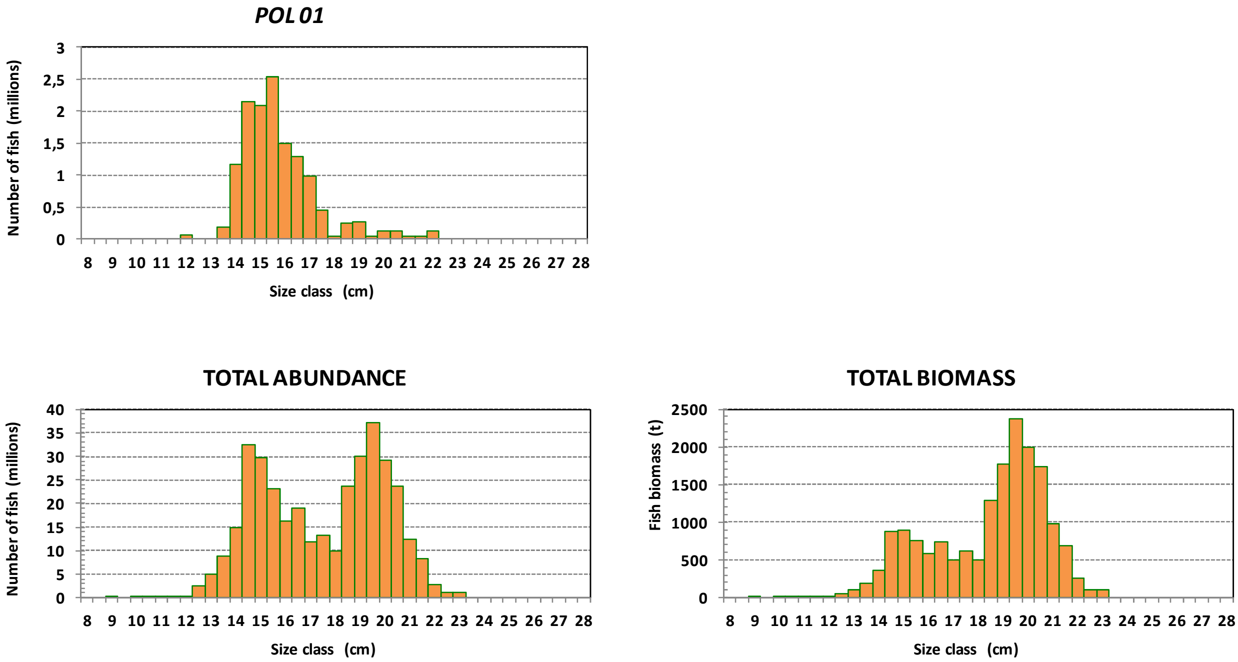


Figure 20. *ECOCADIZ 2014-07* survey. Blue jack mackerel (*T. picturatus*). Cont'd.

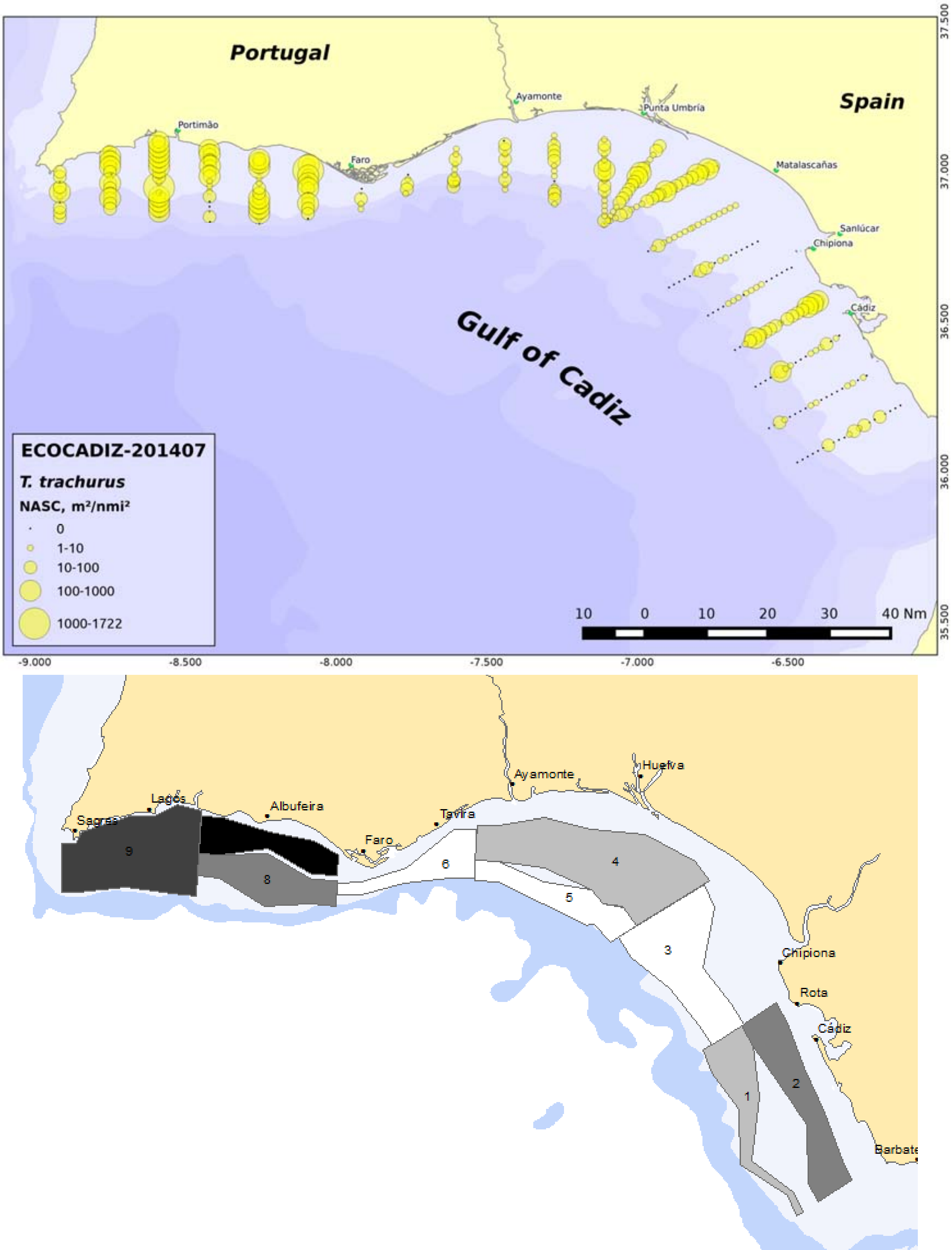


Figure 21. *ECOCADIZ 2014-07* survey. Horse mackerel (*Trachurus trachurus*).Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

***ECOCADIZ 2014-07*: Horse mackerel (*T. trachurus*)**

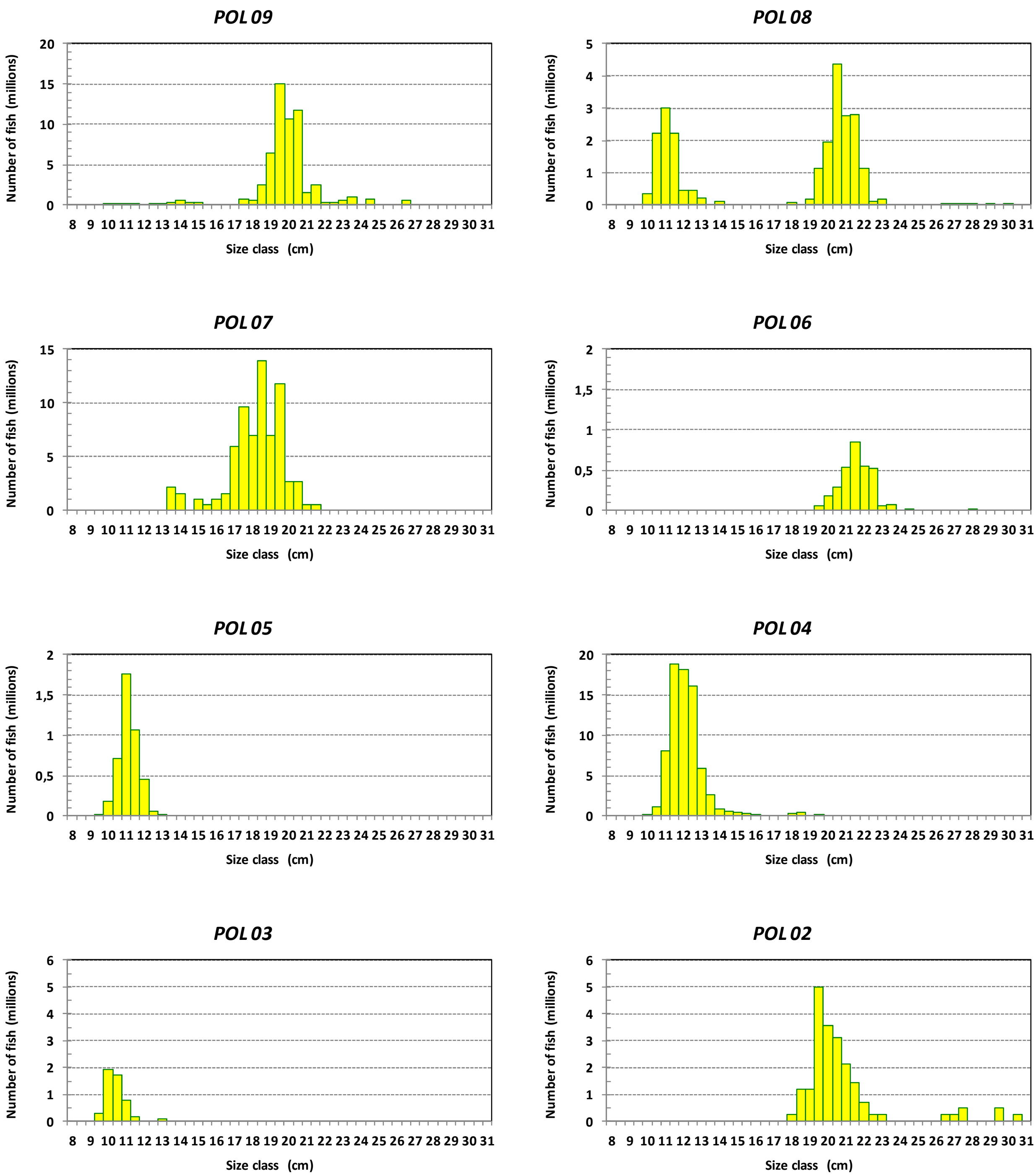


Figure 22. *ECOCADIZ 2014-07* survey. Horse mackerel (*T. trachurus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 21**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

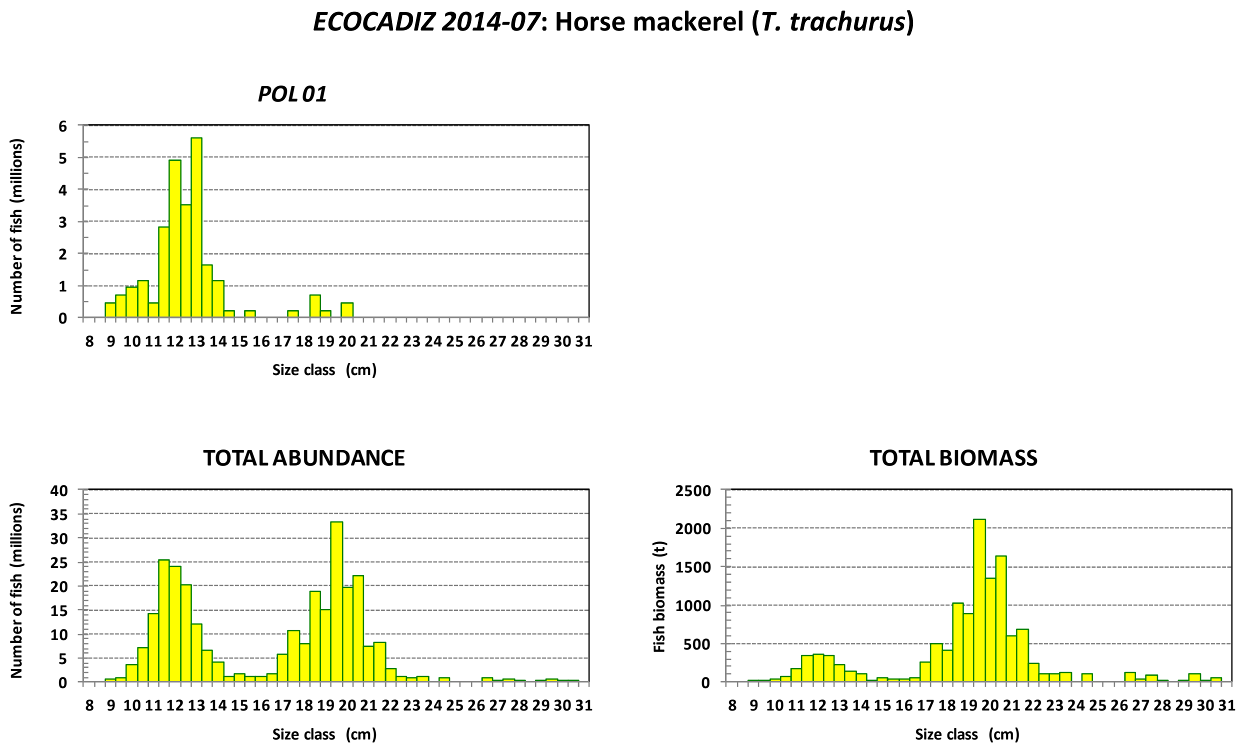


Figure 22. *ECOCADIZ 2014-07* survey. Horse mackerel (*T. trachurus*). Cont'd.

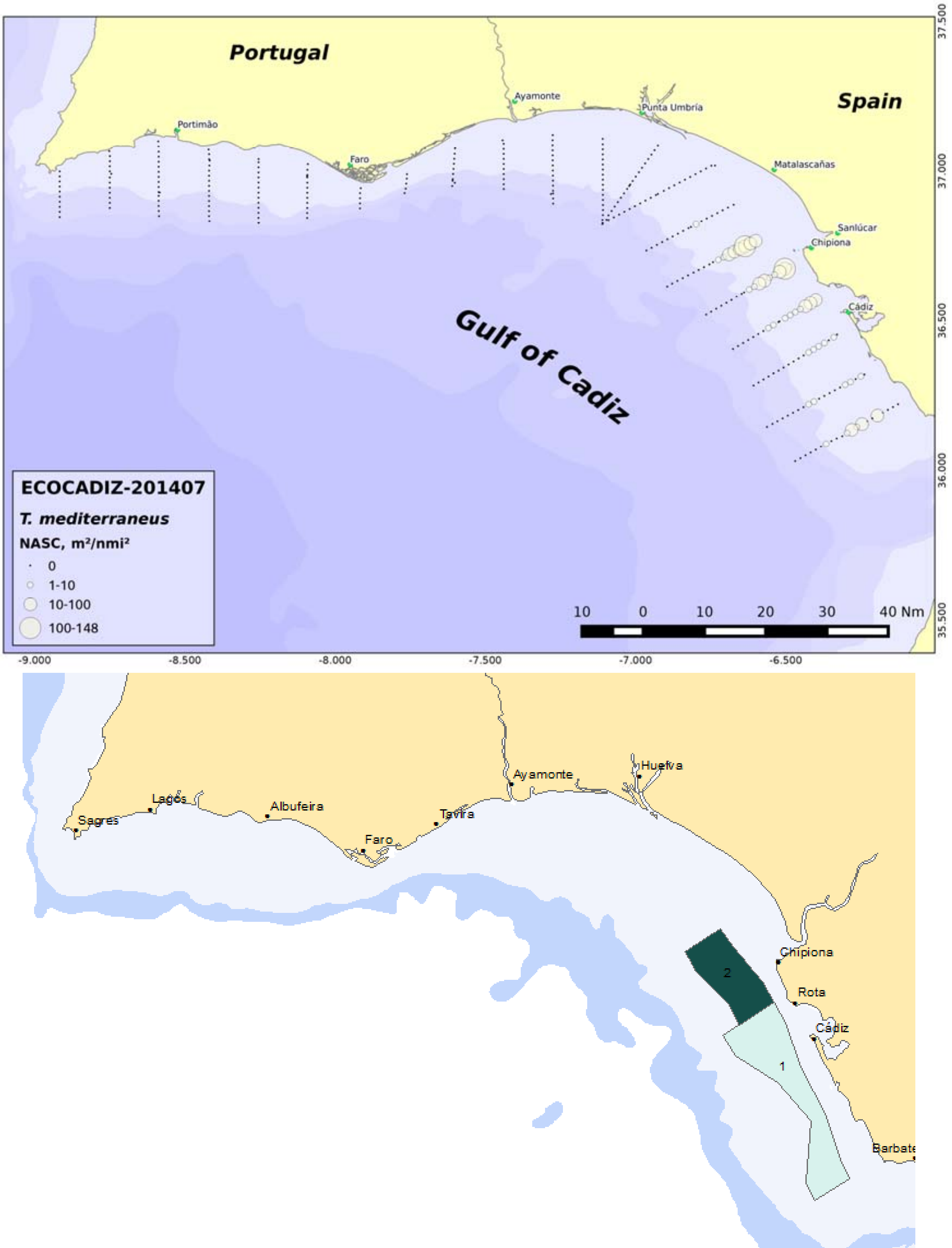


Figure 23. *ECOCADIZ 2014-07* survey. Mediterranean horse mackerel (*Trachurus mediterraneus*).Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

***ECOCADIZ 2014-07*: Mediterranean horse mackerel (*T. mediterraneus*)**

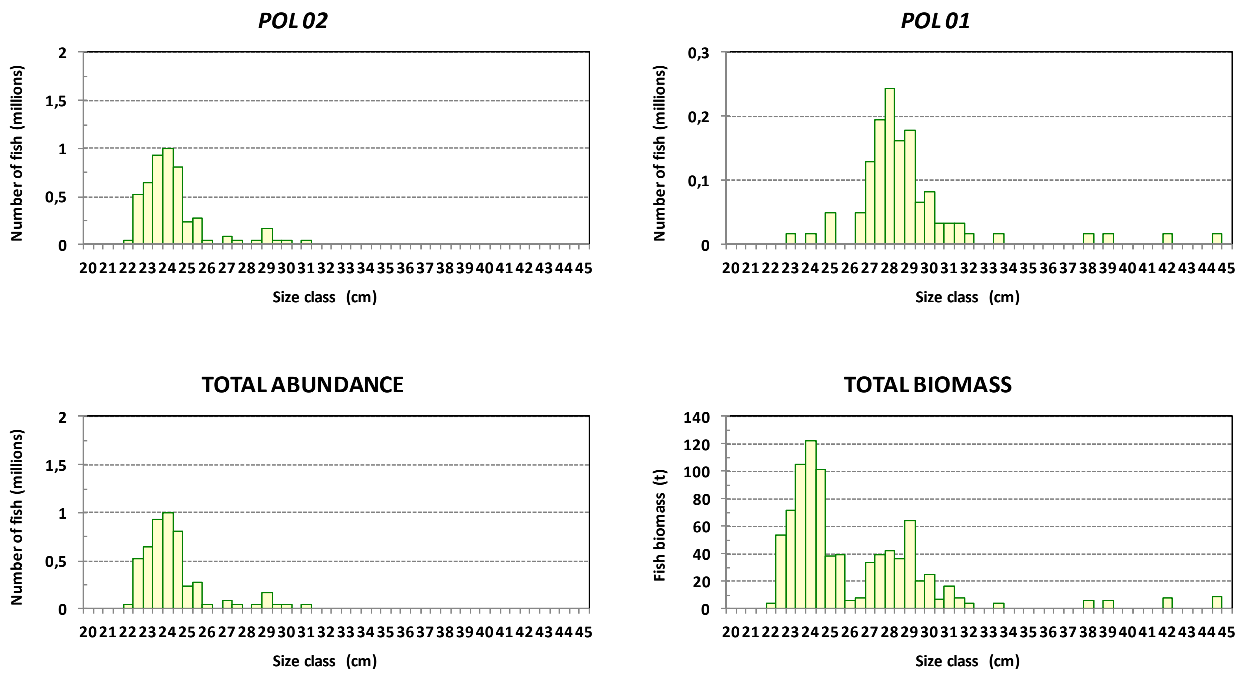


Figure 24. *ECOCADIZ 2014-07* survey. Mediterranean horse mackerel (*T. mediterraneus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 23**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

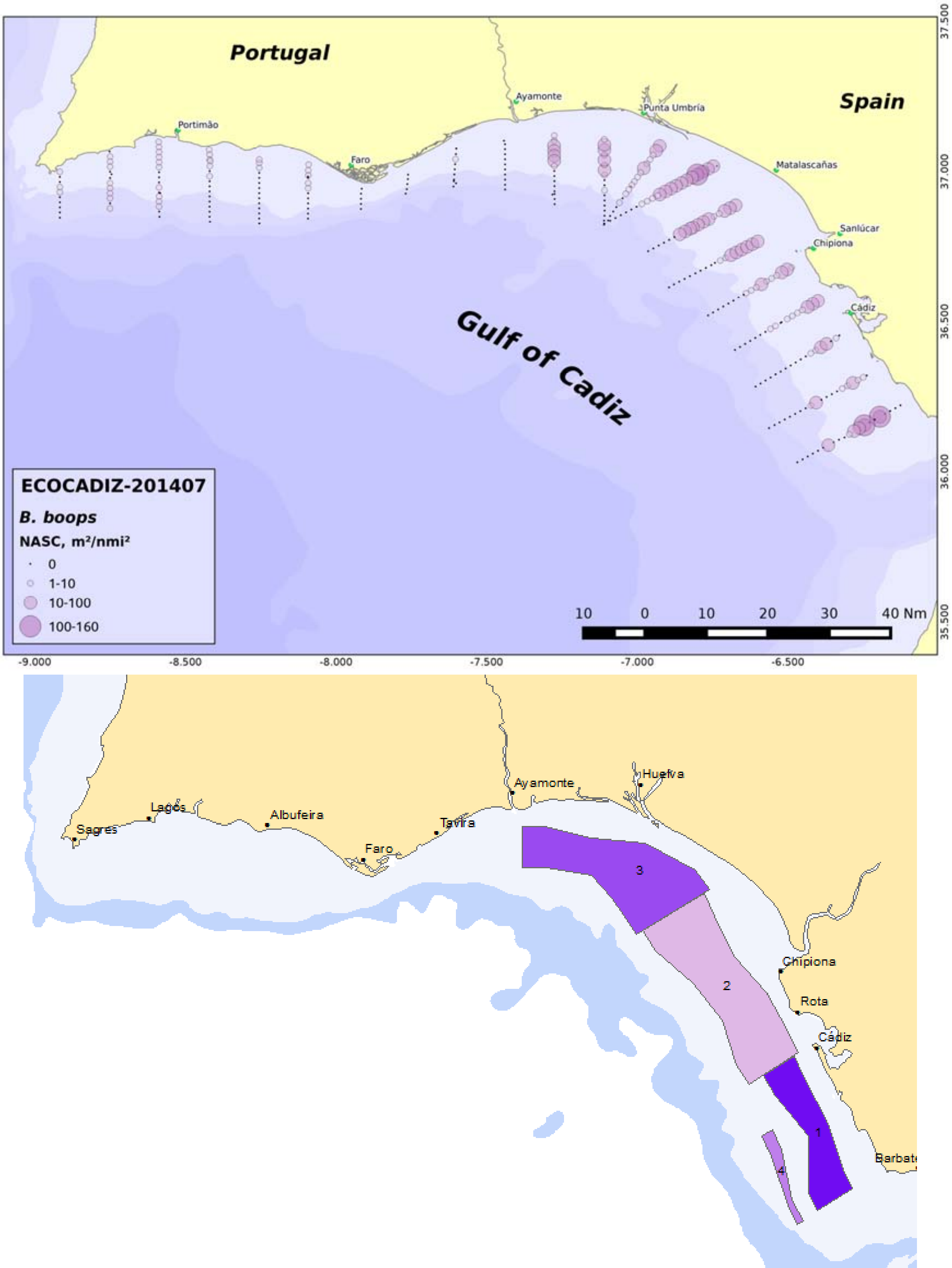


Figure 25. *ECOCADIZ 2014-07* survey. Bogue (*Boops boops*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

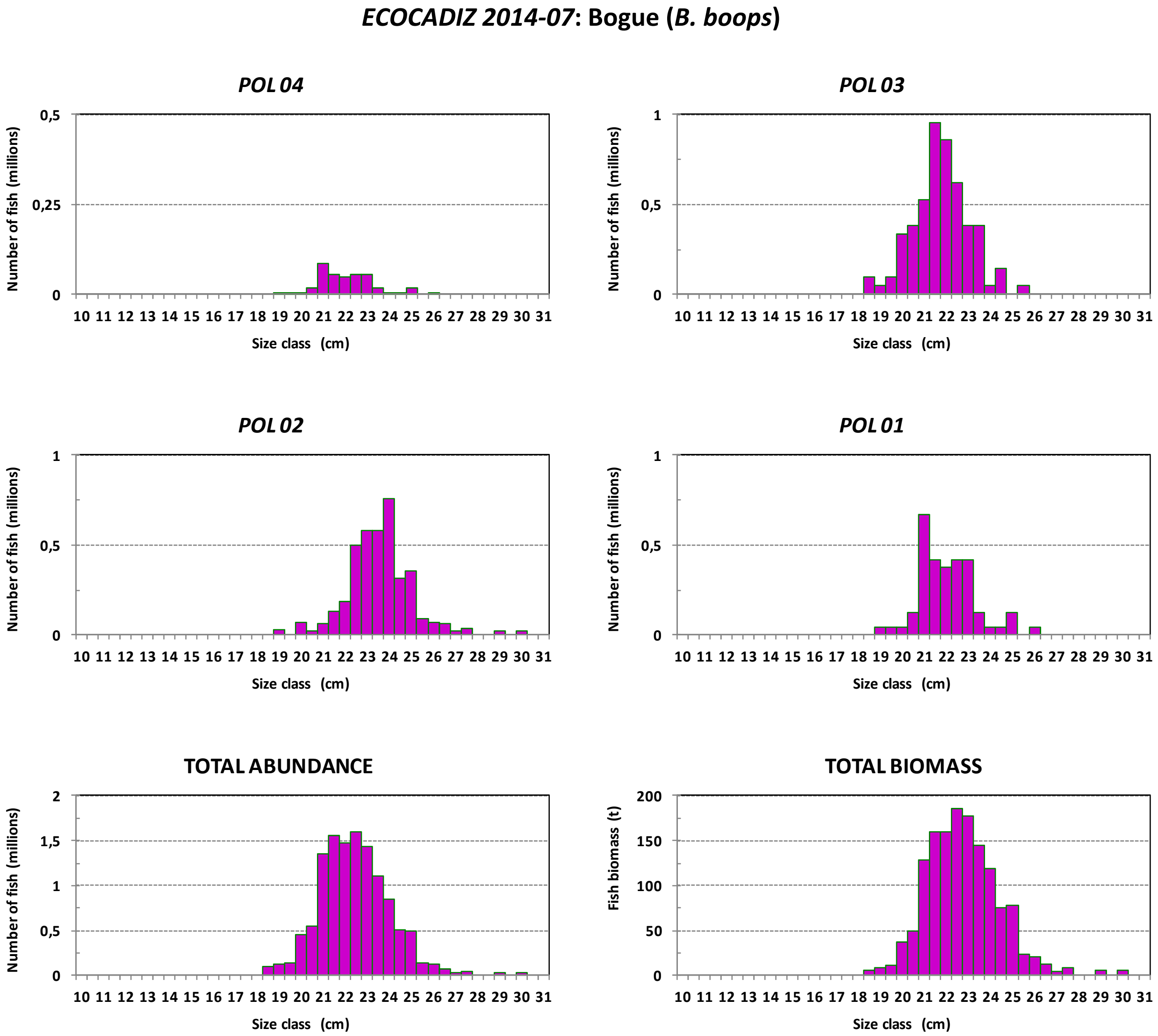
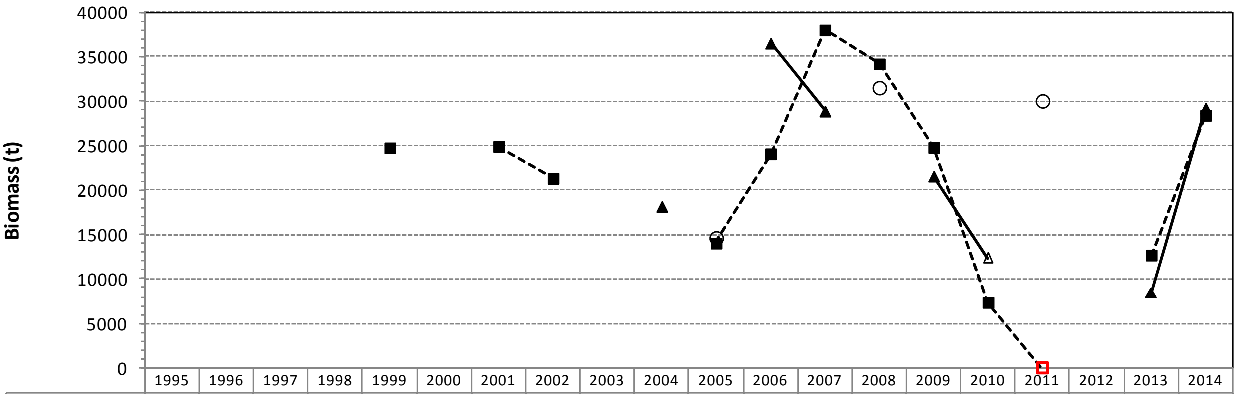


Figure 26. *ECOCADIZ 2014-07* survey. Bogue (*B. boops*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 25**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

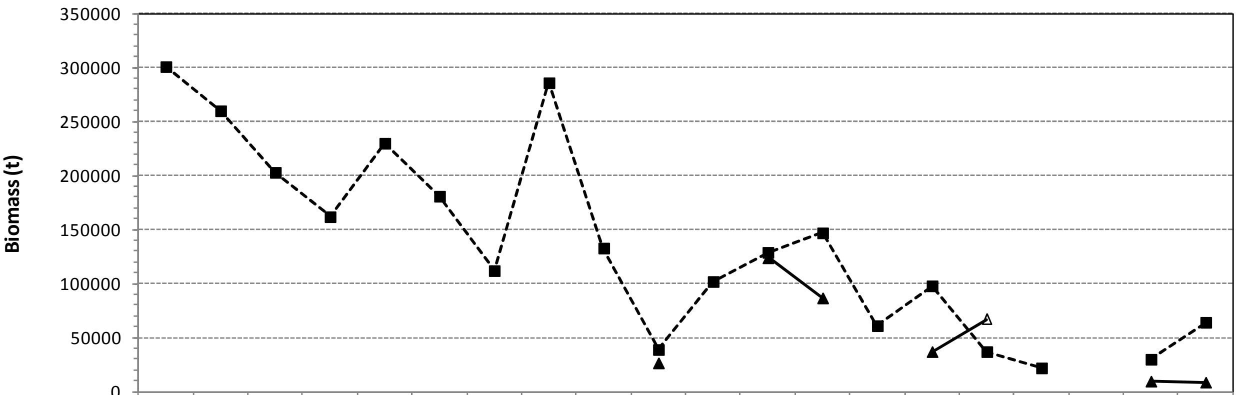
Biomass trends (in tons)

Anchovy biomass estimates



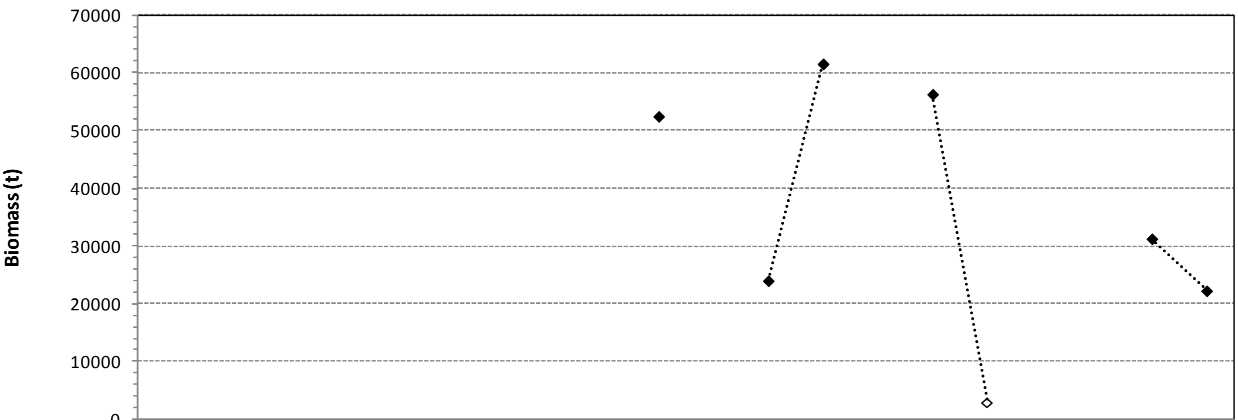
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
PELAGO					24763		24913	21335			14041	24082	38020	34200	24800	7395	0		12700	28408
ECOCADIZ										18177		36521	28882		21580	12339			8487	29219
BOCADEVA											14637			31527			30037			

Sardine biomass estimates



	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
PELAGO	301000	260000	203000	162000	230000	181000	112000	286000	133000	39000	102000	129000	147000	61000	98000	37000	22000		30000	64227
ECOCADIZ										26568		123849	86777		37020	66964			9670	8697

Chub mackerel biomass estimates



	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
ECOCADIZ										52440		23994	61530		56276	2861			31267	22258

Figure 27. Trends in biomass estimates (in tons) for the main assessed species in Portuguese (*PELAGO*) and Spanish (*ECOCADIZ*) survey series. Gaps for the 2005, 2008 and 2011 anchovy acoustic estimates in the *ECOCADIZ* series are filled with the *BOCADEVA* Spanish egg survey estimates. Note that the *ECOCADIZ* survey in 2010 partially covered the whole study area. The anchovy null estimate in 2011 from the *PELAGO* survey should be considered with caution.

Working document presented in the ICES Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VII, VIII and IX (WGACEGG). Vigo, Spain, 17-21 November 2014.

The *ECOCADIZ-RECLUTAS 2014-10* Spanish acoustic survey (October-November 2014, ICES Subdivision IXa South): sampling methods and main results from echo-trace ground-truthing fishing hauls.

By

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ABSTRACT

The present working document summarises the sampling methods and the main results obtained from the ground-truthing pelagic hauls carried out during the *ECOCADIZ-RECLUTAS 2014-10* Spanish (pelagic ecosystem-) acoustic survey. The survey was conducted by IEO between 13th and 31st October 2014 in the Portuguese and Spanish shelf waters (20-200 m isobaths) off the Gulf of Cadiz onboard the R/V *Ramón Margalef*. The survey's main objective is the acoustic assessment of anchovy and sardine juveniles (age 0 fish) in the recruitment areas of the Gulf of Cadiz. The acoustic assessment of both these population fractions as well as the population levels of other pelagic species is still in progress. Only 19 from the 21 foreseen acoustic transects were sampled because of a vessel's engine malfunction. A total of 15 valid fishing hauls were carried out but they showed a different representativeness. Neither CUFES sampling nor top predator census was carried out during the survey. A total of 184 CTD (with coupled altimeter, oximeter, fluorimeter and transmissometer sensors)-LADCP casts, VMADCP and sub-superficial thermosalinograph-fluorimeter continuous sampling were carried out to oceanographically characterize the surveyed area. Anchovy showed a relatively widespread distribution and high occurrence frequency in the hauls but rendering low yields, with higher catches being recorded in the central part of the sampled area, where the species also recorded the smallest sizes. Chub mackerel was other of the most frequently captured species, mainly in the central and western waters, although the yields from positive hauls were not very high on average. Sardine was quite less frequent in catches and showed a rather scattered distribution, with positive hauls mainly located in the central waters of the Gulf, and locally showing very high yields. Smallest sardines were also captured in similar waters than anchovy recruits.

INTRODUCTION

During the 2007 and 2008 ICES *Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES areas VIII and IX* (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) do not sample but, however, used to form a great part of the recruitment areas of these species.

The general objective of these surveys should initially be focused in the acoustic assessment by vertical echo-integration and mapping of the abundance and biomass of recruits of small pelagic species (especially anchovy and secondarily sardine), as well as the mapping of both the oceanographic and biological conditions featuring the recruitment areas of these species in the Division IXa. The long term objective of the surveys would be to be able to assess the strength of the incoming recruitment to the fishery the next year.

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 dates back to 2009 (*ECOCADIZ-RECLUTAS 1009* survey). However, that survey was unsuccessful as to the achievement of their objectives because of the succession of a series of unforeseen problems which led to drastically reduce the foreseen sampling area to only the 6 easternmost transects. The continuation of this survey series was not guaranteed for next years and in fact no survey of these characteristics was carried out in 2010 and 2011. In 2012, the *ECOCADIZ-RECLUTAS 1112* survey was financed by the Spanish Fisheries Secretariat and planned and conducted by the IEO with the aim of obtaining an autumn estimate of Gulf of Cadiz anchovy biomass and abundance, although the survey was restricted to the Spanish waters only.

ECOCADIZ-RECLUTAS 2014-10 survey is the third survey within its series. The survey has been conducted with the R/V *Ramón Margalef*, a vessel which required during the first part of the survey some specific adjustments (specially the echo-trace ground-truthing fishing) for the proper conduction of an acoustic survey with the peculiarities of the present one. The present Working Document will only show those results obtained from the echo-trace ground-truthing hauls carried out during the survey since the acoustic assessment is not yet available.

MATERIAL AND METHODS

The *ECOCADIZ-RECLUTAS 2014-10* survey was carried out between 13th and 31st October 2014 onboard the Spanish R/V *Ramón Margalef* covering a survey area comprising the waters of the Gulf of Cadiz, both Spanish and Portuguese, between the 20 m and 200 m isobaths. The survey design consisted in a systematic parallel grid with tracks equally spaced by 8 nm, normal to the shoreline (**Figure 1**).

Echo-integration was carried out with a *Simrad™ EK60* echo sounder working in the multi-frequency fashion (18, 38, 70, 120, 200 kHz). Average survey speed was about 10 knots and the acoustic signals were integrated over 1-nm intervals (ESDU). Raw acoustic data were stored for further post-processing using *Myriax Software Echoview™* software package (by *Myriax Software Pty. Ltd.,* ex *SonarData Pty. Ltd.*). Acoustic equipment was calibrated during 14th and 15th October in the Bay of Algeciras following the standard procedures (Foote *et al*., 1987).

Survey execution and abundance estimation followed the methodologies firstly adopted by the ICES *Planning Group for Acoustic Surveys in ICES Sub-Areas VIII and IX* (ICES, 1998) and the recommendations given more recently by the *Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES areas VIII and IX* (WGACEGG; ICES, 2006a,b).

Fishing stations for echo-trace ground-truthing were opportunistic, according to the echogram information, and they were carried out using a *Gloria HOD 352* pelagic trawl gear (ca. 10 m-mean vertical opening net) at an average speed of 4 knots. Gear performance and geometry during the effective fishing was monitored with *Simrad™ Mesotech FS20/25* trawl sonar. Trawl sonar data from each haul were recorded and stored for further analyses.

Ground-truthing haul samples provided biological data on species and they were also used to identify fish species and to allocate the back-scattering values into fish species according to the proportions found at the fishing stations (Nakken and Dommasnes, 1975).

Length frequency distributions (LFD) by 0.5-cm class were obtained for all the fish species in trawl samples (either from the total catch or from a representative random sample of 100-200 fish). Only those LFDs based on a minimum of 30 individuals and showing a normal distribution were considered for the purpose of the acoustic assessment.

Individual biological sampling (length, weight, sex, maturity stage, stomach fullness, and mesenteric fat content) was performed in each haul for anchovy, sardine (in both species with otolith extraction and with additional preservation of gonads in anchovy mature females), mackerel and horse-mackerel species, and bogue.

The following TS/length relationship table was used for acoustic estimation of assessed species (recent IEO standards after ICES, 1998; and recommendations by ICES, 2006a,b):

Species	b_{20}
Sardine (*Sardina pilchardus*)	-72.6
Round sardinella (*Sardinella aurita*)	-72.6
Anchovy (*Engraulis encrasicolus*)	-72.6
Chub mackerel (*Scomber japonicus*)	-68.7
Mackerel (*S. scombrus*)	-84.9
Horse mackerel (*Trachurus trachurus*)	-68.7
Mediterranean horse-mackerel (*T. mediterraneus*)	-68.7
Blue jack mackerel (*T. picturatus*)	-68.7
Bogue (*Boops boops*)	-67.0

The *PESMA 2010* software (J. Miquel, unpublished) has got implemented the needed procedures and routines for the acoustic assessment following the above approach.

CUFES sampling was not carried out during the survey. A *Sea-bird Electronics™ SBE 21 SEACAT* thermosalinograph and a *Turner™ 10 AU 005 CE Field* fluorometer were used during the acoustic tracking to continuously collect some hydrographical variables (sub-surface sea temperature, salinity, and *in vivo* fluorescence). Vertical profiles of hydrographical variables were also recorded by night from 184 CTD casts by using *Sea-bird Electronics™ SBE 911+ SEACAT* (with coupled *Datasonics* altimeter, *SBE 43* oximeter, *WetLabs ECO-FL-NTU* fluorimeter and *WetLabs C-Star 25 cm* transmissometer sensors) and *LADCP T-RDI WHS 300 kHz* profilers (**Figure 2**). *VMADCP RDI 150 kHz* records were also continuously recorded by night between CTD stations. Census of top predators was not recorded during the survey.

RESULTS

Acoustic sampling

The acoustic sampling was carried out during the periods of 19^{th} – 22^{nd} and 24^{th} – 30^{th} October (**Table 1**). The acoustic sampling started in the coastal end of the transect RA01 on 19^{th} October and it was conducted in the east-westerly direction. The acoustic sampling stopped on 23^{rd} October because of the R/V's refuelling and victualling. In order to perform the acoustic sampling with daylight, this sampling started at 06:45 UTC until 25^{th} October and at 07:45 UTC since 26^{th} October on, although this time might vary depending on the duration of the works related with the hydrographic sampling the previous night. The foreseen start of transects RA14 and RA15 by the coastal end had to be displaced to deeper waters in order to avoid the occurrence of farming/fattening cages. The 30^{th} October, at ca. 22:30 UTC, the R/V's engine cooling system showed a serious malfunctioning which forced to stop the survey preventing from the sampling of the last two westernmost transects.

Groundtruthing hauls

Seventeen (17) fishing operations, with 15 of them being considered as valid ones according to a correct gear performance, were carried out for the purposes of echo-trace ground-truthing (**Table 2**, **Figure 3**). Nine trial fishing hauls were carried out with the R/V's gear during the three previous days to the acoustic sampling in order to test different configurations of towing warp lengths, angles of attack of the doors (by adjusting the backstraps) and weights. Unfortunately, during the first true fishing haul of the survey this gear suffered of serious damages caused by an unexpected entanglement with a bottom elevation and it had to be replaced by a spare gear with identical characteristics. Before restarting the groundtruthing hauls, three additional trial fishing hauls were carried out with this new spare gear.

As a precautionary measure, almost the whole of the fishing hauls (15 from 17) were attempted by fishing over an isobath crossing the acoustic transect as close as possible to the depths where the fishing situation of interest was detected over that transect. In this way, besides avoiding risky situations, the mixing of different size compositions (*i.e.*, bi-, multi-modality of length frequency distributions) was also avoided as well as a direct interaction with fixed gears. The mixing of sizes is more probable close to nursery-recruitment areas and in regions with a very narrow continental shelf.

Because of many echo-traces usually occurred close to the bottom, all the pelagic hauls were carried out like a bottom-trawl haul, with the ground rope working over or very close to the bottom. According to the above, the sampled depth range in the valid hauls oscillated between 43-126 m. Notwithstanding the above, the representativeness of the valid hauls might be questionable in some cases since the distances between the ground-rope and the bottom resulted much higher than the recommended ones.

During the survey were captured 1 Chondrichthyan, 18 Osteichthyes and 1 Cephalopod species. The percentage of occurrence of the more frequent species in the trawl hauls is shown in the enclosed text table below (see also **Figure 4**). Atlantic bonito (*Sarda sarda*), chub mackerel (17 hauls) and anchovy (9 hauls) stood especially out as the most frequent species within the set of small and mid-sized pelagic fish species. They were followed by mackerel and Mediterranean horse mackerel (8 hauls), sardine (6), horse mackerel (5), blue jack mackerel (4) and bogue (3).

Species	# of fishing stations	Occurrence (%)	Total weight (kg)	Total number
Sarda sarda	13	87	30	60
Scomber colias	13	87	922	8230
Engraulis encrasicolus	9	60	102	12496
Trachurus mediterraneus	8	53	267	1387
Scomber scombrus	8	53	383	2122
Sardina pilchardus	6	40	813	12398
Trachurus trachurus	5	33	146	1455
Merluccius merluccius	4	27	2	7
Trachurus picturatus	4	27	60	606
Boops boops	3	20	8	42

For the purposes of the acoustic assessment, anchovy, sardine, mackerel species, horse & jack mackerel species, and bogue were initially considered as the survey target species. All of the invertebrates, and both bentho-pelagic (*e.g.*, manta rays) and benthic fish species (*e.g.*, flatfish, gurnards, etc.) were excluded from the computation of the total catches in weight and in number from those fishing stations where they occurred. Catches of the remaining non-target species were included in an operational category termed as "*Others*". According to the above premises, during the survey were captured a total of 2 764 kg and 39 thousand fish (**Table 3**). 33% of this "total" fished biomass corresponded to chub mackerel, 29% to sardine, 14% to mackerel, 10% to Mediterranean horse mackerel, 5% to horse mackerel, 4% to anchovy, and less or equal to 2% to blue jack-mackerel and bogue. The most abundant species in ground-truthing trawl hauls were anchovy and sardine (32% each) followed by chub mackerel (21%), with each of the remaining species accounting for less than 5%.

The species composition, in terms of percentages in number, in each valid fish station is shown in **Figure 4**. The relatively low representativeness of some fishing hauls makes very difficult to advance an informed opinion about the distribution pattern of the main species. Catches from these hauls, as they are, indicated that anchovy, sardine and mackerel showed more abundant in the central part of the sampled area (Spanish waters), horse mackerel and blue jack mackerel in the westernmost waters (Portuguese waters), chub mackerel in central and western waters, and Mediterranean horse mackerel in the central and the easternmost waters. The size composition of anchovy catches indicates that smallest recruits were concentrated in the surroundings of the Guadalquivir river mouth and adjacent shallow waters, the typical recruitment area for the species (**Figure 5**). For sardine is more difficult to advance some spatial pattern regarding its body size because the low number of positive hauls although the smallest sardines seem to be more frequent in the central waters (**Figure 6**).

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Table 1. *ECOCADIZ-RECLUTAS 2014-10* survey. Descriptive characteristics of the acoustic tracks.

Acoustic track	Location	Date	Start				End			
			Latitude	Longitude	UTC time	Mean depth (m)	Latitude	Longitude	UTC time	Mean depth (m)
R01	Trafalgar	19/10/2014	36º 13,77' N	6º 07,48' W	07:00	26	36º 02,019º N	6º 28,682' W	09:09	240
R02	Sancti-Petri	19/10/2014	36º 13,905' N	6º 33,62' W	10:11	138	36º 19,190' N	6º 14,782' W	13:31	28
R03	Cádiz	21/10/2014	36º 27,27' N	6º 19,07' W	06:47	21	36º 17,351' N	6º 36,923' W	10:36	227
R04	Rota	21/10/2014	36º 24,798' N	6º 40,895' W	11:32	190	36º 34,320' N	6º 22,378' W	15:58	20
R05	Chipiona	22/10/2014	36º 40,89' N	6º 28,58' W	06:47	20	36º 31,16' N	6º 46,36' W	08:30	215
R06	Doñana	22/10/2014	36º 37,95' N	6º 51,46' W	09:23	177	36º 48,073' N	6º 32,987' W	11:09	19
R07	Matalascañas	24/10/2014	36º 44,147' N	6º 58,405' W	12:15	153	36º 54,862' N	6º 38,558' W	16:13	20
R08	Mazagón	25/10/2014	37º 01,88' N	6º 42,992' W	06:50	20	36º 49,207' N	7º 05,943' W	11:03	180
R09	Punta Umbría	25/10/2014	36º 49,207' N	7º 06,371' W	11:15	165	36º 06,210' N	6º 54,71' W	15:54	18
R10	El Rompido	26/10/2014	37º 08,858' N	7º 07,256' W	07:42	18	36º 50,103' N	7º 07,323' W	11:40	182
R11	Isla Cristina	27/10/2014	37º 06,870' N	7º 17,480' W	07:45	23	36º 53,476' N	7º 17,356' W	12:10	160
R12	V. R. de Sto. Antonio	27/10/2014	36º 56,314' N	7º 26,927' W	13:09	128	37º 06,712' N	7º 26,885' W	16:59	20
R13	Tavira	28/10/2014	37º 03,834 ' N	7º 36,84' W	07:43	33	36º 57,024' N	7º 36,382' W	08:26	166
R14	Fuzeta	28/10/2014	36º 59,012' N	7º 46,529' W	14:07	74	36º 55,682 'N	7º 46,316' W	14:25	225
R15	Cabo de Sta. María	28/10/2014	36º 51,79' N	7º 56,352' W	15:24	108	36º 55,38' N	7º 56,360' W	15:36	74
R16	Cuarteira	29/10/2014	37º 01,64' N	8º 6,210' W	07:47	20	36º 50,020' N	8º 6,09' W	11:52	230
R17	Albufeira	29/10/2014	36º 49,35' N	8º 15,805' W	15:42	155	37º 03,106' N	8º 15,800' W	16:55	20
R18	Alfanzina	30/10/2014	37º 03,995' N	8º 25,60' W	07:41	32	36º 50,331' N	8º 25,542' W	11:25	212
R19	Portimao	30/10/2014	36º 51,149' N	8º 35,717' W	12:25	116	37º 05,946' N	8º 35,737' W	17:17	25
R20	Burgau									
R21	Ponta de Sagres									

Table 2. *ECOCADIZ-RECLUTAS 2014-10* survey. Descriptive characteristics of the fishing stations. Null hauls in light grey.

Fishing station	Date	Start		End		UTC Time		Depth (m)		Duration (min.)		Trawled Distance (nm)	Acoustic transect	Zone (landmark)
		Latitude	Longitude	Latitude	Longitude	Start	End	Start	End	Effective trawling	Total manoeuvre			
01	19-10-2014	36º 13.3224 N	6º 25.5412 W	36º 12.9268 N	6º 26.4351 W	11:38:00	11:51:00	66,37	81,71	00:13:00	00:59:00	0,824	R02	Sancti-Petri
02	21-10-2014	36º 23.4745 N	6º 25.9828 W	36º 24.6391 N	6º 23.7936 W	08:18:00	08:50:00	56,63	50,33	00:32:00	01:12:00	2,116	R03	Cádiz
03	21-10-2014	36º 30.0100 N	6º 29.5755 W	36º 31.6584 N	6º 30.6332 W	14:03:00	14:32:00	55,48	55,03	00:29:00	01:25:00	1,854	R04	Rota
04	22-10-2014	36º 39.9540 N	6º 37.8190 W	36º 36.6010 N	6º 34.0519 W	13:29:00	14:40:00	46,7	49,08	01:11:00	01:59:00	4,517	R05-R06	Chipiona-S.Bda.
05	22-10-2014	36º 40.2970 N	6º 42.6199 W	36º 40.7980 N	6º 43.0410 W	16:12:00	16:23:00	70,59	70,55	00:11:00	00:54:00	0,604	R06	Doñana
06	24-10-2014	36º 48.8157 N	6º 47.3091 W	36º 50.3647 N	6º 48.6020 W	14:18:00	14:50:00	54,94	55,38	00:32:00	01:15:00	1,863	R07	Matalascañas
07	25-10-2014	36º 55.9120 N	6º 51.5580 W	36º 57.5134 N	6º 52.9360 W	08:30:00	09:00:00	45,91	44,51	00:30:00	01:16:00	1,944	R08	Mazagón
08	25-10-2014	36º 52.0953 N	7º 01.1476 W	36º 53.9695 N	7º 04.6516 W	12:46:00	13:38:00	106,28	105,12	00:52:00	01:51:00	3,377	R08-R09	Mazagón-El Rompido
09	26-10-2014	37º 02.4643 N	7º 05.1210 W	37º 02.8768 N	7º 08.6172 W	09:03:00	09:46:00	43,26	44,33	00:43:00	01:21:00	2,829	R10	El Rompido
10	26-10-2014	36º 51.5979 N	7º 05.5513 W	36º 53.0742 N	7º 08.6755 W	12:47:00	13:32:00	125,81	124,99	00:45:00	01:58:00	2,908	R09-R10	Pta. Umbría-El Rompido
11	26-10-2014	36º 55.0066 N	7º 05.2417 W	36º 55.9957 N	7º 08.6737 W	15:24:00	16:12:00	100,13	100,75	00:48:00	01:42:00	2,924	R09-R10	Pta. Umbría-El Rompido
12	27-10-2014	36º 58.6225 N	7º 25.1179 W	36º 58.9702 N	7º 29.3158 W	14:28:00	15:22:00	107,25	108,05	00:54:00	01:56:00	3,381	R12	V.R. Sto. Antonio
13	28-10-2014	36º 58.4131 N	7º 34.1183 W	36º 58.4092 N	7º 38.1076 W	11:56:00	12:46:00	113,94	119,5	00:50:00	01:49:00	3,197	R13	Tavira
14	29-10-2014	36º 55.8771 N	8º 10.3510 W	36º 56.2012 N	8º 07.5787 W	10:06:00	10:51:00	53,73	48,05	00:45:00	01:19:00	2,246	R16	Cuarteira
15	29-10-2014	36º 52.6560 N	8º 04.9711 W	36º 51.5830 N	8º 06.3238 W	13:09:00	13:32:00	104,87	106,31	00:23:00	01:35:00	1,525	R16	Cuarteira
16	30-10-2014	36º 54.4287 N	8º 27.7320 W	36º 54.5662 N	8º 26.1766 W	10:00:00	10:18:00	109,52	113,65	00:18:00	01:13:00	1,255	R18	Alfanzina
17	30-10-2014	36º 54.4996 N	8º 37.5625 W	36º 54.3625 N	8º 33.1114 W	14:34:00	15:30:00	103,47	106,26	00:56:00	01:45:00	3,573	R19	Portimao

Table 3. *ECOCADIZ-RECLUTAS 2014-10* survey. Catches by species in number (upper panel) and weight (in kg, lower panel) from valid fishing stations.

Fishing station	ABUNDANCE (nº)									
	Anchovy	*Sardine*	*Chub mack.*	*Mackerel*	*Horse-mack.*	*Blue Jack-mack.*	*Medit. Horse-mack.*	*Bogue*	Other spp.	TOTAL
01	2				1		11		7	21
02							3		7	10
03	797	2332	29	3			13		9	3183
04	4632	165	37				920	25	2	5781
06	1776	5719	7				1		2	7505
07			2				422	7	8	439
08	4786		75	198					6	5065
09	28	4179	2				10		38	4257
10			2860	1341					6	4207
11	401	2	17	209					3	632
12	14		38	79					2	133
13			41	189	619	586			3	1438
14		1	36		9	1	7	10	1	65
15			5082	101	815	18			3	6019
17	60		4	2	11	1				78
TOTAL	**12436**	**12398**	**8226**	**2120**	**1444**	**605**	**1387**	**42**	**97**	**38755**

Fishing station	BIOMASS (kg)									
	Anchovy	*Sardine*	*Chub mack.*	*Mackerel*	*Horse-mack.*	*Blue Jack-mack.*	*Medit. Horse-mack.*	*Bogue*	Other spp.	TOTAL
01	0,039				0,13		2,598		1,211	3,978
02							0,559		2,025	2,584
03	6,285	175,96	2,951	0,625			2,613		3,994	192,428
04	28,726	3,164	6,65				194,3	5,348	0,769	238,957
06	10,295	403,95	0,482				0,225		0,686	415,638
07			0,379				63,6	1,197	1,738	66,914
08	50,56		8,035	33,15					2,505	94,25
09	0,348	230,18	0,164				1,385		42,6	274,677
10			320,55	237,26					1,724	559,534
11	4,484	0,033	1,926	49,45					0,397	56,29
12	0,225		4,608	13,65					5,153	23,636
13			5,396	31,65	62,75	57,95			1,546	159,292
14		0,076	4,092		0,731	0,731	1,59	1,143	0,273	8,636
15			566,35	16,4	81,8	1,71			1,167	667,427
17	1,224		0,434	0,449	0,848	0,041				2,996
TOTAL	**100,962**	**813,363**	**921,583**	**382,185**	**145,411**	**60,391**	**266,87**	**7,688**	**65,788**	**2764,241**

Table 4. *ECOCADIZ-RECLUTAS 2014-10* survey. Parameters of the size-weight relationships for survey's target species. FAO codes for the species: PIL: *Sardina pilchardus*; ANE: *Engraulis encrasicolus*; MAS: *Scomber colias*; MAC: *Scomber scombrus*; JAA: *Trachurus picturatus;* HOM: *Trachurus trachurus*; HMM: *Trachurus mediterraneus*; BOG: *Boops boops*.

Parameter	PIL	ANE	MAS	MAC	JAA	HOM	HMM	BOG
n	221	352	363	305	73	110	145	44
a	0,0016023	0,0045636	0,0016899	0,0025982	0,0041819	0,0142347	0,0366703	0,0046249
b	3,5669120	3,1023796	3,5031825	3,2873954	3,2167303	2,8268307	2,5443128	3,2466318
r^2	0,9808466	0,9835999	0,9311246	0,6899539	0,8737951	0,8107723	0,9656370	0,9225715

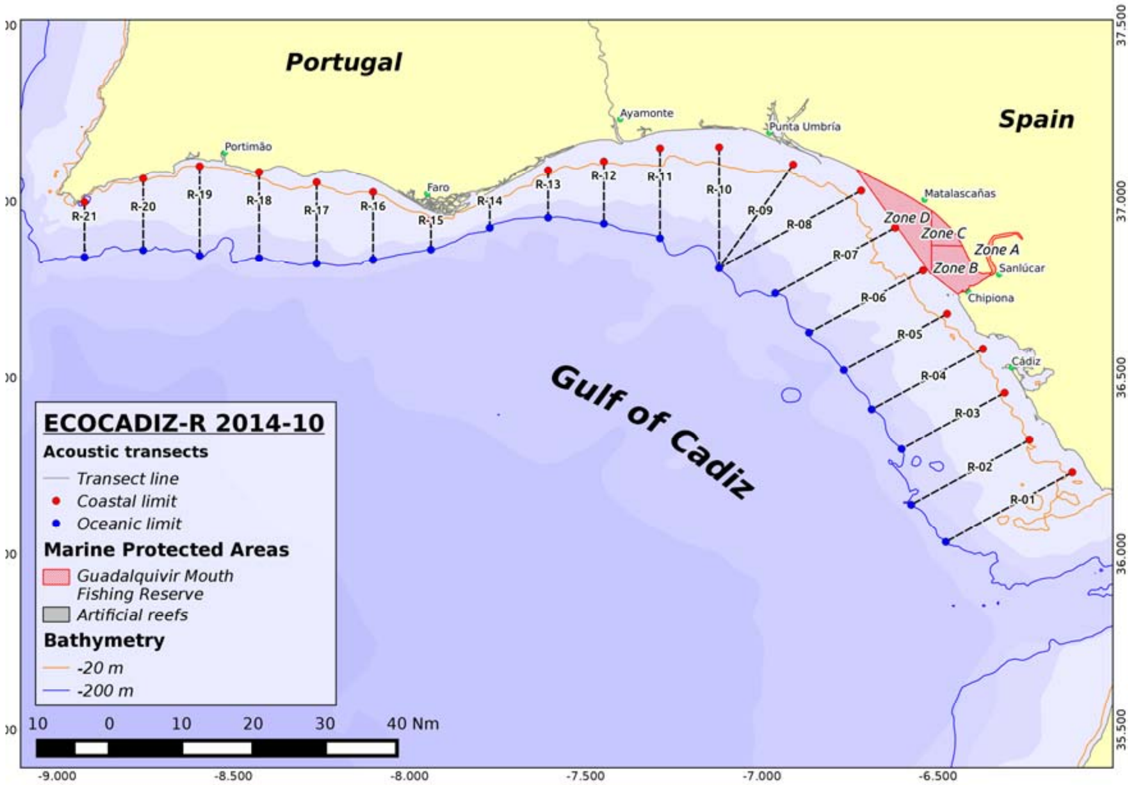

Figure 1. *ECOCADIZ-RECLUTAS 2014-10* survey. Location of the acoustic transects sampled during the survey. The two westernmost transects (R20 and R21) were not sampled because of a failure in the R/V engine cooling system the 30th October which forced to stop the survey. The different protected areas inside the Guadalquivir river mouth Fishing Reserve and artificial reef polygons are also shown.

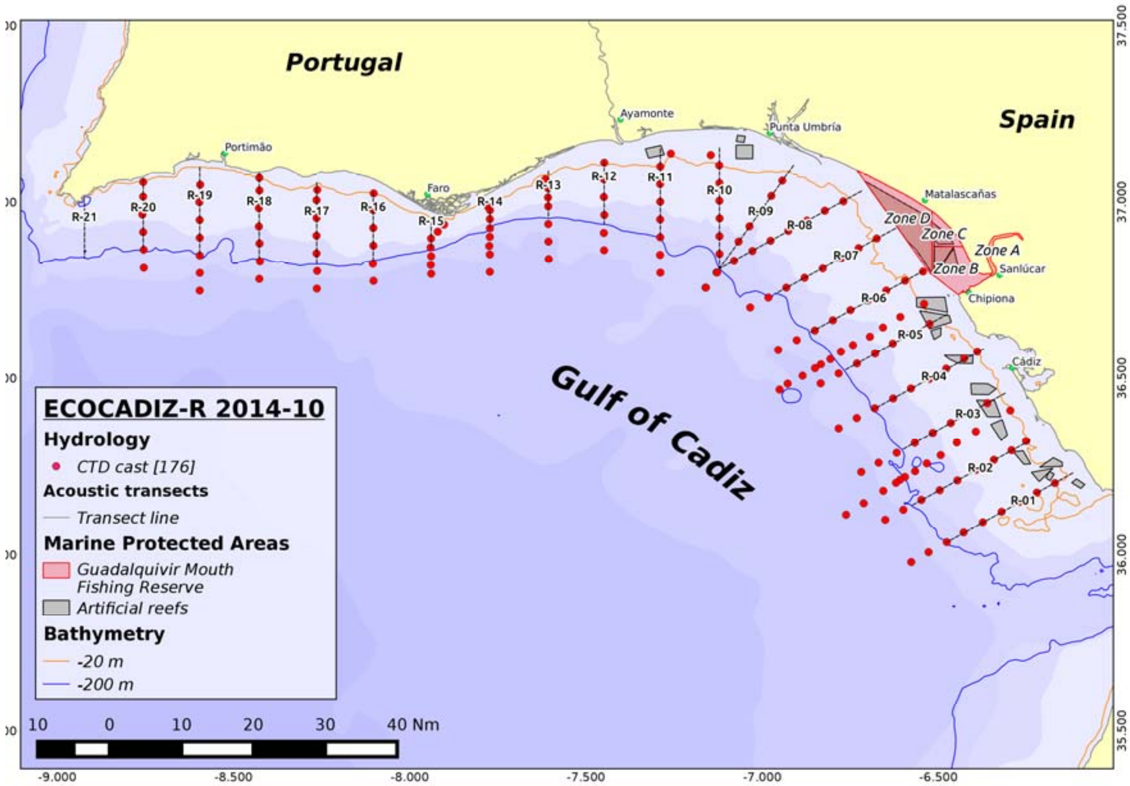

Figure 2. *ECOCADIZ-RECLUTAS 2014-10* survey. Location of CTD-LADCP stations.

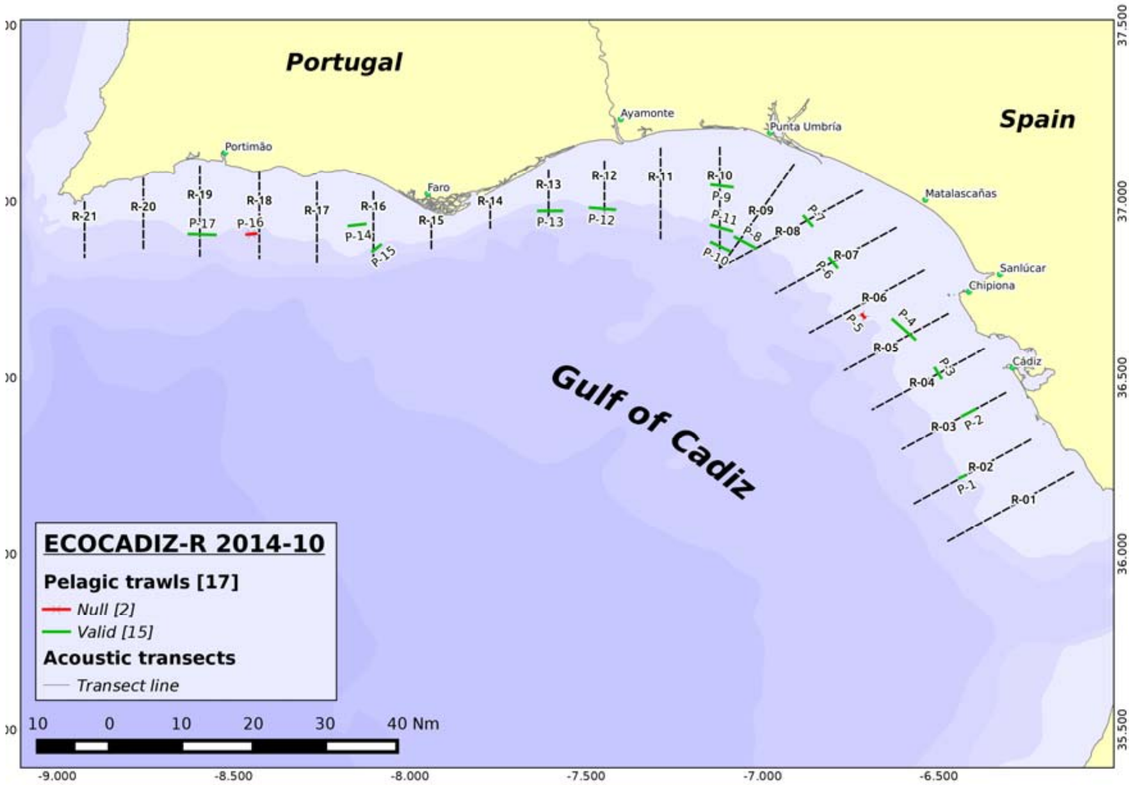

Figure 3. *ECOCADIZ-RECLUTAS 2014-10* survey. Location of ground-truthing fishing hauls. Null hauls in red. Hauls carried out by night for the collection of anchovy hydrated females are indicated.

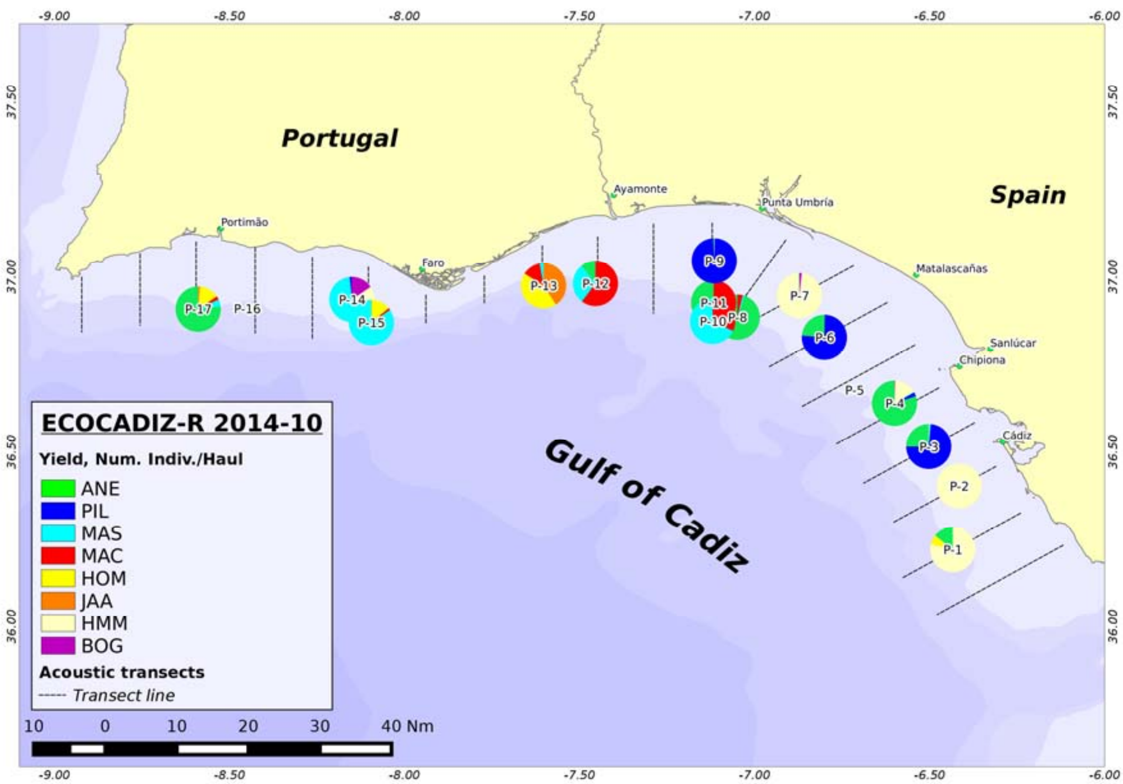

Figure 4. *ECOCADIZ-RECLUTAS 2014-10* survey. Species composition (percentages in number) in fishing hauls.

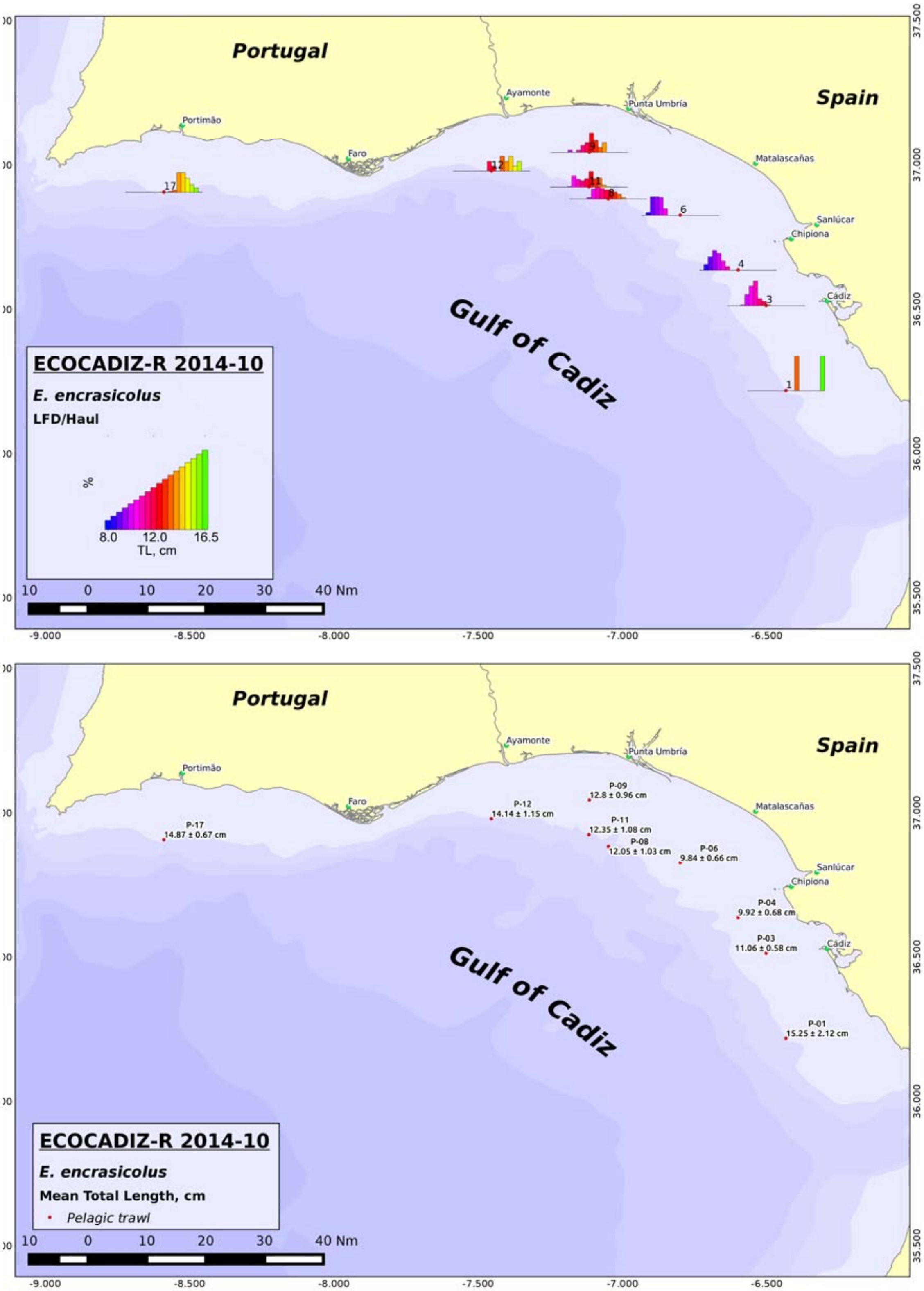

Figure 5. *ECOCADIZ-RECLUTAS 2014-10* survey. *Engraulis encrasicolus*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

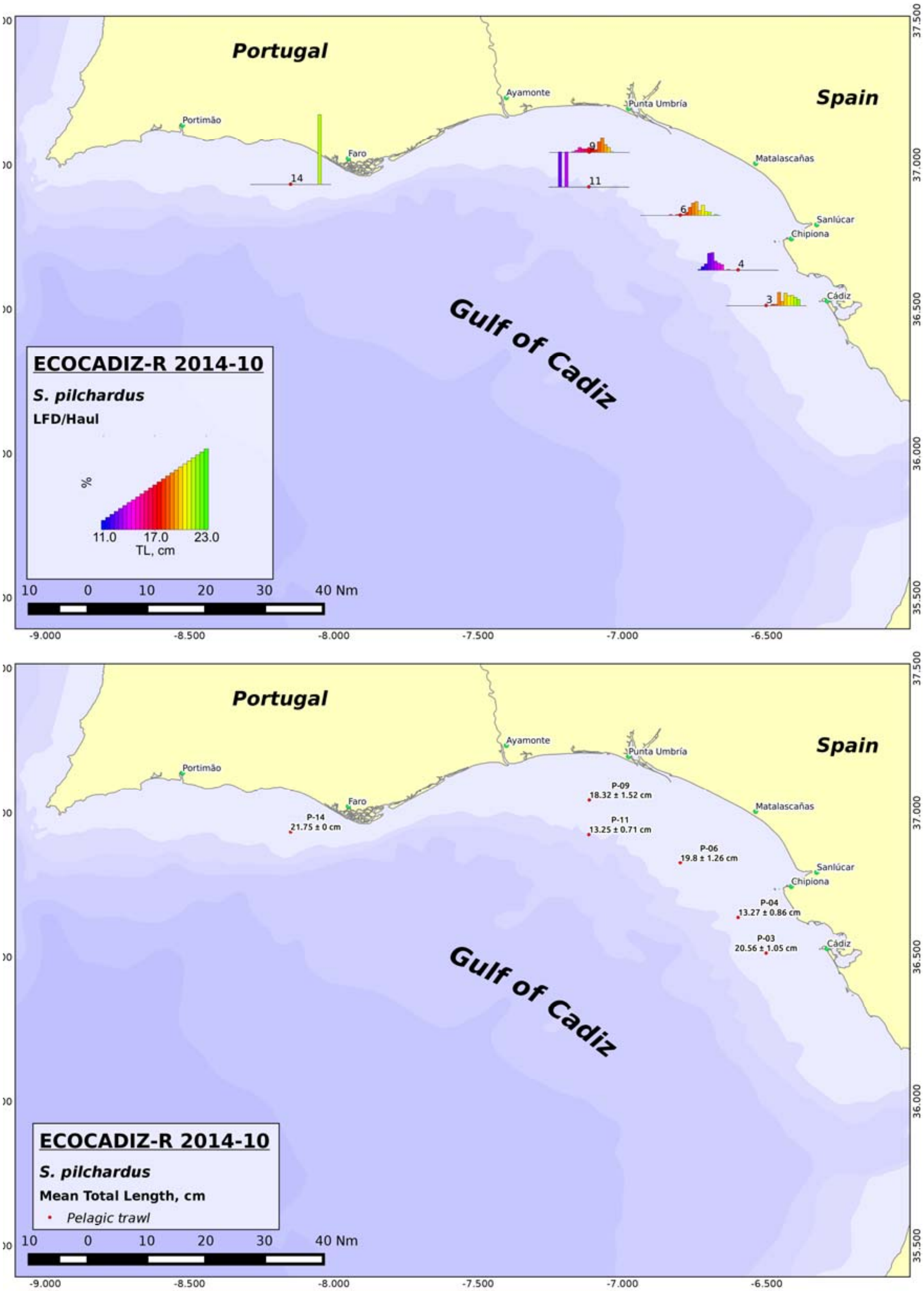

Figure 6. *ECOCADIZ-RECLUTAS 2014-10* survey. *Sardina pilchardus*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul

Working Document for the ICES Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VIII and IX. Vigo (Spain), 24 - 31 November 2014

BOCADEVA 0714
Gulf of Cadiz Anchovy Egg Survey and 2014 SSB preliminary estimates.

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Introduction

The Daily Egg Production Method (DEPM) to estimate the anchovy spawning stock biomass (SSB) in the Gulf of Cádiz ((ICES, Subdivision IXa South) is conducted every three years by IEO (Spain). The first survey of this series was carried out in 2005 (Jiménez *et al*., 2005). The DEPM survey *BOCADEVA 0714* (the fourth Anchovy DEPM survey in the series) is one of the research activities developed in 2014 under the project ICTIOEVA12 (*Métodos de Producción de Huevos, Estimación de la biomasa de especies pelágicas de interés comercial: sardina, anchoa, caballa y jurel*).

The survey has been carried out on board R/V *Ramón Margalef* (IEO) from 24st to 31 July 2014. The survey dates are determinate by the reproductive cycle of the species in the study area, and they should coincide with the maximum peak spawning.

The surveyed area extended from Strait of Gibraltar to Cape San Vicente (Spanish and Portuguese waters in the Gulf of Cadiz). Plankton samples, along a grid of parallel transects perpendicular to the coast, are obtained for the spawning area delimitation and density estimation of the daily egg production. The fishing hauls for estimation of adult parameters (sex ratio, female mean weight, batch fecundity and spawning fraction) are undertaken in the ECOCADIZ 201407 survey, carried out during the same period.

The survey objectives also included to characterize oceanographic and meteorological conditions in the study area during the survey

This working document provides a brief description of the survey, laboratory analysis and estimation procedures used to obtain the Gulf of Cadiz anchovy SSB by DEPM for 2014 in the South-Atlantic Iberian Stock. Results are preliminary, because the estimation of the spawning fraction is not available yet.

Methodology

Table I presents a summarised description of the methodology used to obtain eggs and adults samples. Sampling grid was established in 21 transects perpendicular to the coast, 8 nm between transects and 3 nm between stations (*Study Group on Spawning Biomass of Sardine and Anchovy*, ICES 2003).

Table I. *BOCADEVA 0714*. Gulf of Cadiz Anchovy DEPM survey. General sampling.

Eggs Parameters	**Anchovy DEPM survey *BOCADEVA0711***
Survey area	(36º13'-36º50'N –6º07'–8º55'W)
R/V	*Ramón Margalef*
Date	24-31 July
Transects (Sampling grid)	21 (8x3)
Pairovet stations (150 µm)	151
Sampling maximum depth (m)	100
Hydrographic sensor	CTD SBE25PLUS and mini CTD Valeport
Flowmeter	Yes
CUFES stations	153
CUFES (335µm)	3 n miles (sample unit)
Environmental data	Temperature and Salinity
Adults Parameters	
Survey area	(36º11'-36º47'N –6º12'–8º54'W)
R/V	*Miguel Oliver*
Date	24/07-06/08
Gears	Pelagic trawl
Trawls	25 (1 null; 23 positive for anchovy)
Trawls time	From 07:15 to 19:46 hrs GMT
Biological sampling:	On fresh material, on board of the R/V
Sample size	At least 60 individuals randomly picked; up to 120 (adding batches of 10 randomly picked anchovies) if a minimum of 30 mature females were not found for spawning fraction estimation. A minimum of 150 hydrated females for batch fecundity estimation.
Fixation	4% Phosphate buffered Formaldehyde
Preservation	4% Phosphate buffered Formaldehyde

Egg sampling and processing

The strategy of egg sampling was identical to that used in previous *BOCADEVA* surveys. An adaptive sampling was carried out in the E-W direction using a PairoVET net in fixed stations as main sampler and a continuous recording with CUFES (Continuous Underwater Fish Egg Sampler) as secondary sampler.

- *Vertical sampling (PairoVET)*

The sampling grid was established on the continental shelf following a systematic sampling scheme, with the transects being perpendicular to the coast and equally spaced 8 nm. Egg samples were always taken every 3 nm in the inner shelf, up to 100 m depth (ICES, 2003). The inshore limit of transects was determined by bottom depth (as close to the shore as possible), while the offshore extension was decided adaptively depending on the results of the most recent CUFES sample.

Vertical hauls of plankton were carried out with a PairoVET sampler equipped with nets of 150 µm of mesh size. Hauls were carried out up to a maximum depth of 100 m or of 5 m above the bottom in shallower depths, with a speed of about 1 m/s. Sampling depth and temperature of the water column were recorded using a mini CTD Valeport fitted to the net. Flowmeters were used to calculate the volume of filtered water during each haul. Egg samples were analysed onboard. A preliminary identification and counting of anchovy eggs and larvae, as well as other commercial species were carried out. Samples were sorted, counted and preserved in a 4 % buffered formaldehyde solution. In the laboratory, anchovy eggs were classified in 11 developmental stages, according to the key proposed by Moser and Ahlstrom (1985).

- *Continuous sampling (CUFES)*

During the CUFES sampling (Checkley *et al.*, 2000) the volume of filtered water (600 l/min, approximately) was also integrated each 3 nm (at a fixed depth of 5 m). The CUFES collector was arranged with a 335 µm net. Anchovy eggs were classified in three stages: No-Embryo (I-III), Early Embryo (IV-VI) and Late Embryo (VII-XI).

Adult sampling and processing

Adult anchovy samples for DEPM purposes were obtained during the ECOCADIZ 201407 survey from pelagic trawl hauls (Ramos et al., 2014).

Except for searching anchovy females with hydrated gonads, fishing stations were mostly conducted during daylight hours and carried out over isobath, once echotraces supposedly belonging to anchovy were detected by echo-sounder.

For the estimation of spawning fraction (S), a minimum of 30 mature, non-hydrated females per sample is sought, so a minimum of 60 random anchovies are sampled, adding batches of 10 random individuals to the sampling until the goal is achieved or a maximum of 120 anchovies are sampled. Sex-ratio (R), along with other parameters used in the DEPM is also obtained from this random sampling.

When hydrated females (HF) appeared, an additional sampling was done in order to obtain a minimum of 150 HF for the whole area prospected. These females were sampled as described above. Gonads from both hydrated and non-hydrated females were preserved in 4% buffered formaldehyde.

Mean female weight (*W*) was estimated after correction for the increase in weight due to the hydration in hydrated females. Sex ratio (*R*) was estimated as the weight ratio of females in the mature population.

The individual batch fecundity (*Fobs*) was estimated by the hydrated oocyte method (Hunter *et al*., 1985). The spawning fraction (*S*) is currently being determinate by histological analysis of the post-ovulatory follicles, POFs (Hunter and Macewicz, 1985). Post-ovulatory follicles (POF's) were assigned to stages-ages according to the Motos's classification (1996) (Day-0 POFs (0-6 h); Day-1 POFs (7-30 h); Day-2 POFs (31-54 h); Day-2+ POFs (older than 54 h), although considering as the peak spawning time the species-specific for the study area.

Data analysis and estimation

- *Egg Production (z, P_0 and P_{tot}) estimation and area calculation*

All calculations for area delimitation, egg ageing and model fitting for egg production (P_0) estimation were carried out using the R packages *geofun, spatstat, eggsplore and shachar* available at *ichthyoanalysis* (http://sourceforge.net/projects/ichthyoanalysis).

The surveyed area (*A*) was calculated as the sum of the area represented by each station. The spawning area (*A+*) was delimited with the outer zero Anchovy egg stations, and was calculated as the sum of the area represented by those stations. The model of egg development with temperature was derived from the incubation experiment carried out in Cádiz in July 2007 (Bernal *et al*., 2012). A multinomial model was applied (Ibaibarriaga *et al.*, 2007, Bernal *et al.*, 2008) considering only the interaction Age*Temp (other interactions were not significant).

$$N_{i,t} \sim \text{Mult}\,(N\,,\,p_{i,t})$$

$$p_{i,t} = f\,(\text{Age, Temp})$$

Egg ageing was performed by a multinomial Bayesian approach described by Bernal *et al*. (2008) and using *in situ* SST; a normal probability distribution was used with peak spawning assumed to be at 22:00h with 2h standard deviation. This method uses the multinomial development model and the assumption of probabilistic synchronicity (assuming a normal distribution).

$$p(age \mid stage, temp, time)\ a\ p\,(stage \mid age, temp)\ p\,(age \mid time)$$

ageing development model synchronicity

Daily egg production (P_0) and mortality (z) rates were estimated by fitting an exponential mortality model to the egg abundance by cohorts and corresponding mean age. The model was fitted using a generalized linear model (GLM) with negative binomial distribution. The ageing process and the GLM fitting were iterative until the value of z converged. [depm.control (spawn.mu=22; how.complete=0.95; spawn.sig=2), initial z = 0.01].

$$P_{age} = P_0\, e^{-z\, age}$$

$$\log\left(\frac{N_{age}}{area}\right) = \log(P_0) - z\, age \;\rightarrow\; \log(N_{age}) = \log(area) + \log(P_0) - z\, age$$

Finally, the total egg production was calculated as: $P_{tot} = P_0\, A+$

- *Adult parameters*

The adult parameters estimated for each fishing haul considered only the mature fraction of the population (determined by the fish macroscopic maturity data).

Before the estimation of the mean female weight per haul (W), the individual total weight of the hydrated females was corrected by a linear regression between the total weight of non-hydrated females and their corresponding gonad-free weight (Wnov). The sex ratio (R) in weight per haul was obtained as the quotient between the total weight of females and the total weight of males and females. The expected individual batch fecundity for all mature females (hydrated and non-hydrated) was estimated by modelling the individual batch fecundity observed (Fobs) in the sampled hydrated females and their gonad-free weight (Wnov) by a GLM. The fraction of females spawning per day (S) is determines, for each haul, as the average number of females with Day-1 or Day-2 POF, divided by the total number of mature females (the number of females with Day-0 POF is corrected by the average number of females with Day-1 or Day-2 POF, and the hydrated females are not included).

The mean and variance of the adult parameters for all the samples collected was then obtained using the methodology from Picquelle and Stauffer (1985; *i.e.*, weighted means and variances). All estimations and statistical analysis were performed using the R software v.2.8.1.

- *Spawning Stock Biomass*

The spawning Stock Biomass was computed according to: $SSB = \frac{P_{total} * W}{F * S * R}$

However, the SSB estimates for 2014 should still be considered with caution because the spawning fraction parameter (S) has not been estimate yet, using instead as two alternatives: 1) the 2011value estimate for this parameter; 2) the mean of the S 2008-2011 values.

Results

The surveyed area (14595 km^2) extends from Cabo de Trafalgar (Spain) to Cabo de San Vicente (Portugal), from (36º13'-36º50'N –6º07'–8º55'W). This area includes the continental shelf of the Gulf of Cadiz. The survey was carried out from East to West, starting in the radial 1- station 1, located close the Strait of Gibraltar (**Fig. 1**).

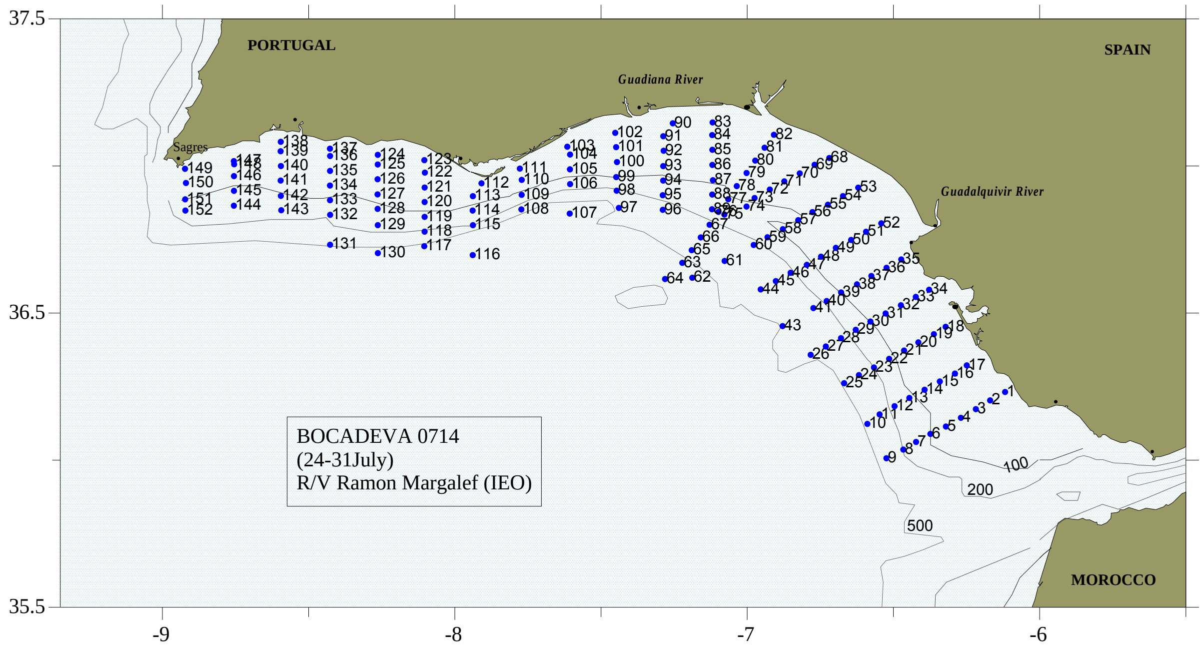

Figure 1. *BOCADEVA 0714* survey. PairoVET stations locations.

Distribution and abundance of anchovy eggs

The icthyoplankton sampling almost covered the whole 24 hours' day-time period. A total of 151 PairoVET stations were carried out. In 70 stations (46.43%) there was presence of anchovy eggs (positive stations). A total of 3097 anchovy eggs were caught, and a maximum density (in number/m^2) of 2024.4 was obtained (**Table II**). Only 16 Sardine eggs were caught.

Table II. *BOCADEVA 0714*. Number and density of anchovy eggs sampled by the PairoVET net during the survey.

By PairoVET	Anchovy eggs
N stations	151
N positive stations	70
N total eggs	3097
N medium eggs	20.4
N máximum eggs	195
Total density (eggs/m^2)	33019
Mean density (eggs/m$^{2)}$	218.7
Maximum density (eggs/m^2)	2024.4

Anchovy eggs were caught mainly in the coastal area located between the radial 3 and 12 and the radial 17, in Portuguese waters (**Fig. 2**). High abundances were also found in stations located close to Huelva. In these stations (all of them with a density > 1000 eggs/m^2 and located inside isobaths of the 130 m) the temperature (SST) ranged between 17.9 and 23.6 ºC (mean 21.6 ºC). In the total area, the SST ranged between 15.1 and 23.9 ºC (mean 20.6 ºC), very similar to 2011 (**Fig. 2**).

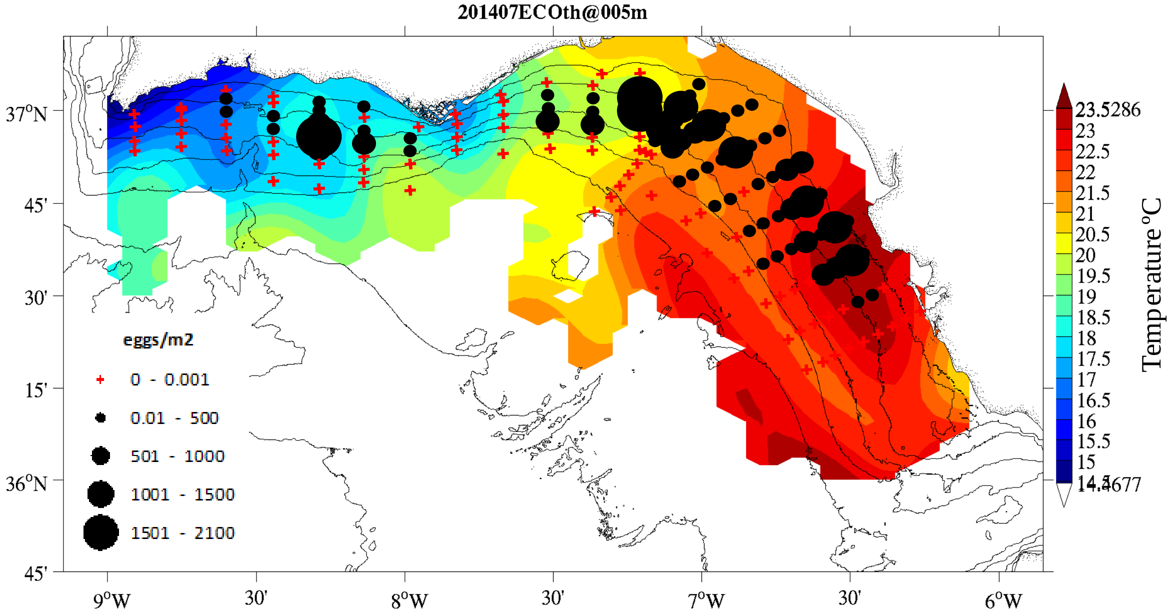

Figure 2. Gulf of Cadiz anchovy DEPM 2014 survey. Abundance distribution of anchovy eggs sampled with PairoVET and SST.

98.5% of the anchovy eggs have been classified into 11 stages according to the degree of embryonic development. Eggs in stage I have not been found. The most abundant development stages were II (32.4%), and IX and VI (14.8 and 11.7%, respectively). XI stage eggs, right before the hatching, represented 0.6% (**Fig. 3**).

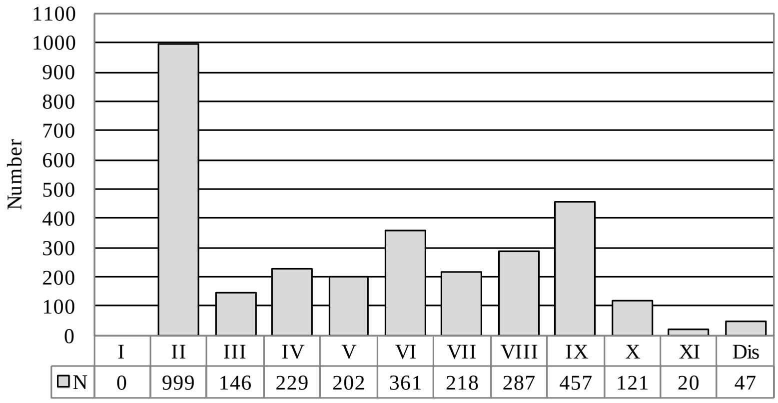

Figure 3. Gulf of Cadiz anchovy DEPM 2014 survey. Number of anchovy eggs classified into the different developmental stages (PairoVET).

Eggs in Stage II were caught between 22:56 and 13:44 hrs GMT, approximately, with a maximum peak of abundance about 05:21 hrs GMT (**Fig. 4**), coincident with the peak spawning for this species in the GoC, which is fixed at 22:00 hrs GMT (Jimenez *et al.*, 2009).

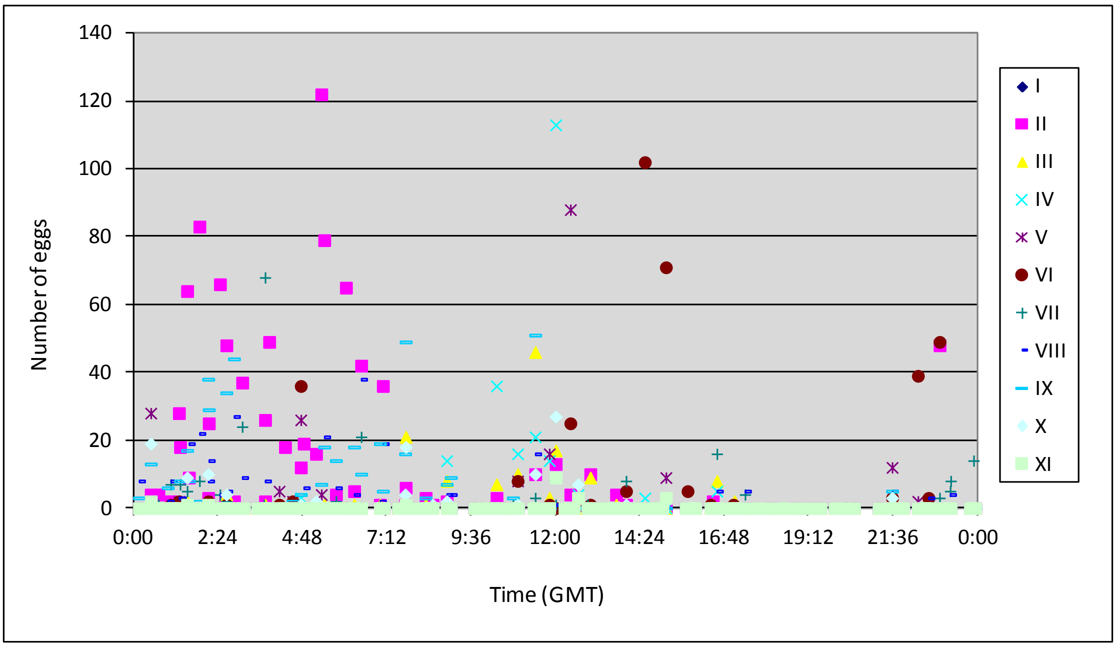

Figure 4. Gulf of Cádiz Anchovy DEPM 2014survey. Number of eggs caught by development stage by the sampling time (PairoVET).

<u>Adults. Results of the pelagic hauls</u>

See Ramos et al., 2014.

Eggs parameters

The cumulative plot of the total dens and temperature by range of temperature is show in **Fig. 5**. The mean temperature into the 0-10 m stratum has been used for the estimates. Daily egg production (P_0) and mortality (z) rates were estimated by fitting an exponential mortality model to the egg abundance by cohorts and corresponding mean age (**Fig. 6**). The model was fitted using a generalized linear model (GLM) with negative binomial distribution (**Table V, Fig. 7**). The ageing process and the GLM fitting were iterative until the value of z converged. [depm.control (spawn.mu=22; how.complete=0.95; spawn.sig=2), initial z = 0.01].

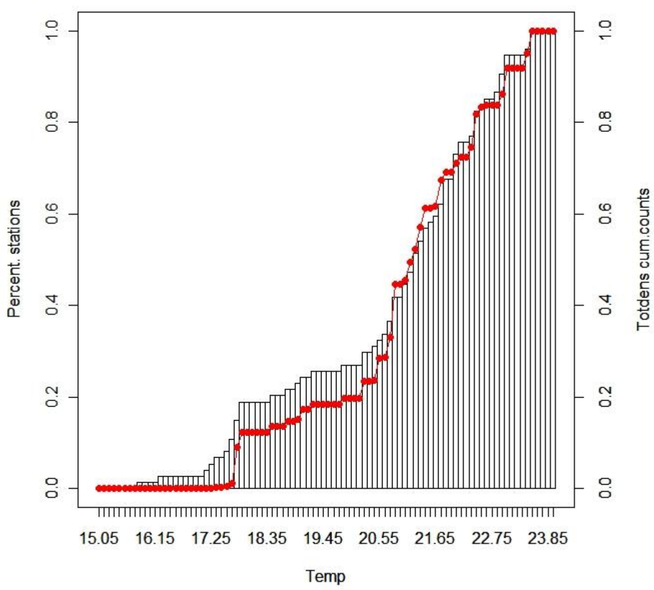

Figure 5. Cumulative plot of total dens and temperature by range of temperature (inter=0.1)

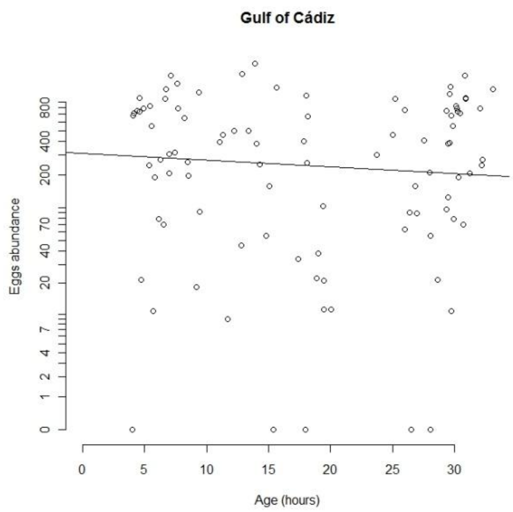

Figure 6. Gulf of Cádiz Anchovy DEPM 2014 survey. Exponential mortality model.

Table V. Gulf of Cádiz Anchovy DEPM 2014 survey. Egg production and mortality. Selected Generalized lineal model (GLM).

```
glm.nb(formula = cohort ~ offset(log(Efarea)) + age, data = aged.data,
    weights = Rel.area, init.theta = 0.446838357531435, link = log)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-1.9229  -1.2004  -0.4613   0.3059   1.4731

Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  5.74784    0.34859  16.489   <2e-16 ***
age         -0.01389    0.01657  -0.838    0.402
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for Negative Binomial(0.4468) family taken to be 1)

    Null deviance: 98.34  on 94  degrees of freedom
Residual deviance: 97.66  on 93  degrees of freedom
AIC: 662.47

Number of Fisher Scoring iterations: 1


              Theta:  0.4468
          Std. Err.:  0.0690

 2 x log-likelihood:  -656.4690
```

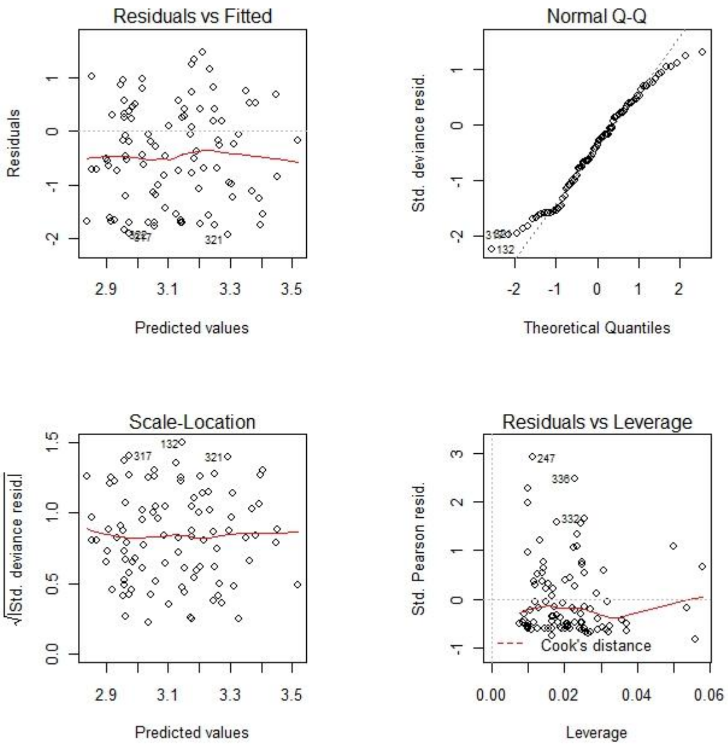

Figure 7. Gulf of Cádiz Anchovy DEPM 2014 survey. Residual inspection plots for the Generalized Linear Model fitted to Anchovy egg production data.

Adult parameters by haul

The total weight of hydrated females was corrected for the increase of weight due to the hydration process by a linear regression model between individual data of gonad-free-weight (Wnov) and its corresponding total weight (Wt) from non-hydrated females (**Table VI**, **Fig. 8**).

Table VI. Gulf of Cádiz Anchovy DEPM 2014 survey. Results of the linear regression model for the relationship between non-hydrated females total weight (Wt) and ovary-free weight (Wnov).

```
lm(formula = Wt ~ Wnov, data = adults.dat[which.weight, ])

Residuals:
     Min       1Q   Median       3Q      Max
-1.22006 -0.17345 -0.01925  0.13338  1.26607

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) -0.136729   0.032988  -4.145 3.84e-05 ***
Wnov         1.068078   0.001786 598.171  < 2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.3013 on 671 degrees of freedom
Multiple R-squared: 0.9981,     Adjusted R-squared: 0.9981
F-statistic: 3.578e+05 on 1 and 671 DF,  p-value: < 2.2e-16
```

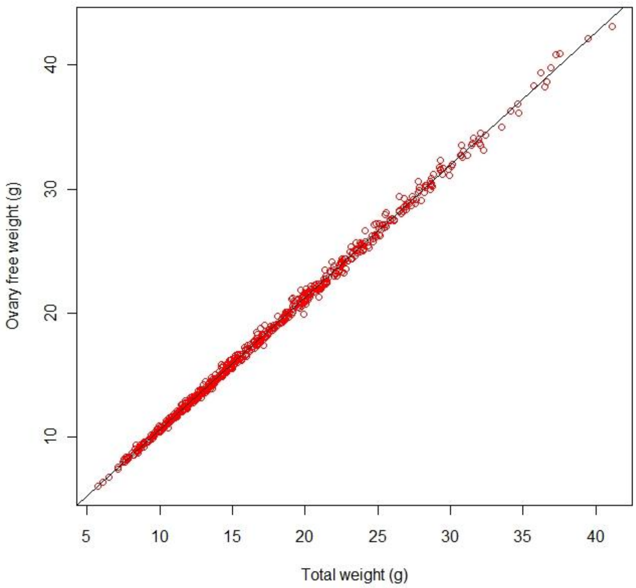

Figure 8. Gulf of Cadiz anchovy DEPM 2014 survey. Plot of the linear regression model for the relationship between non-hydrated females total weight (Wt) and ovary-free weight (Wnov).

The expected female weight (Wexp) for all mature females was also estimated using this linear regression model.

The expected batch fecundity for all mature females (Fexp) was estimated by modelling the observed individual batch fecundity (Fobs) in hydrated females in function of their gonad-free-weights (Wnov) by a GLM model (**Fig. 9**). Results of this model and the residual inspection plots are shows in **Table VII** and **Fig. 10**.

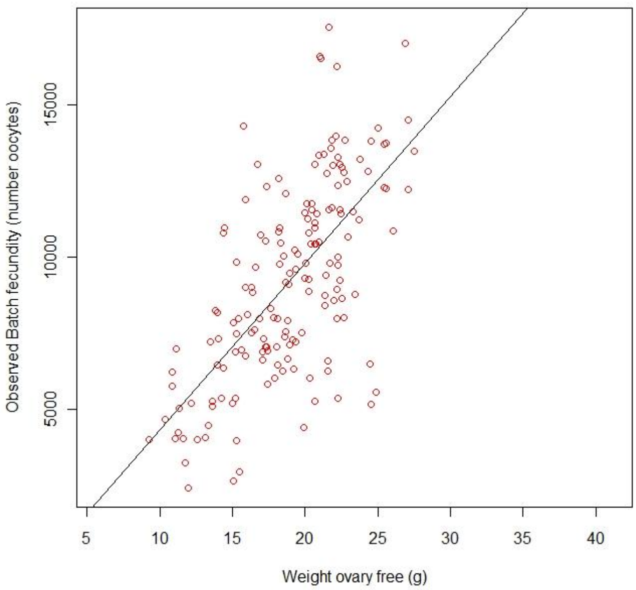

Figure 9. Gulf of Cadiz anchovy DEPM 2014 survey. Generalized linear model for the relationship between observed individual batch fecundity (Fobs) and ovary-free weight (Wnov).

Table VII. Gulf of Cadiz anchovy DEPM 2014 survey. Batch fecundity. Selected Generalized lineal model (GLM).

```
glm.nb(formula = Fobs ~ Wnov, data = adults.dat, na.action = "na.omit",
    link = identity, init.theta = 12.8447839708990)

Deviance Residuals:
      Min         1Q     Median         3Q        Max
-3.032258  -0.685285   0.005756   0.541384   2.599268

Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept) -1176.20     737.26  -1.595    0.111
Wnov          549.08      42.86  12.810   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for Negative Binomial(12.8448) family taken to be 1)

    Null deviance: 296.48  on 166  degrees of freedom
Residual deviance: 169.19  on 165  degrees of freedom
  (1322 observations deleted due to missingness)
AIC: 3084.4

Number of Fisher Scoring iterations: 1

              Theta:  12.84
          Std. Err.:  1.39

 2 x log-likelihood:  -3078.432
```

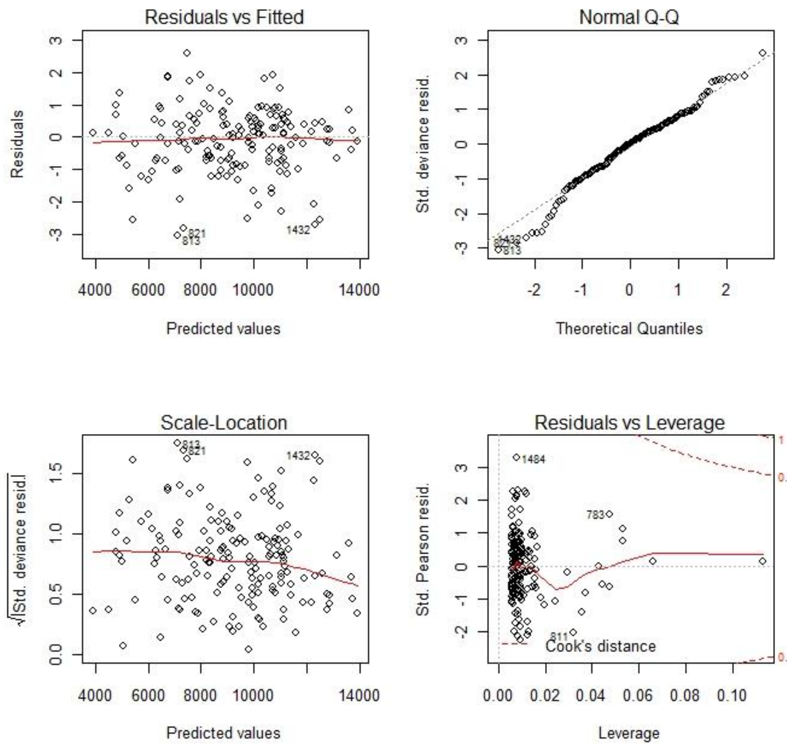

Figure 10. Gulf of Cadiz anchovy DEPM 2014 survey. Residual inspection plots for the Generalized Linear Model fitted to the anchovy batch fecundity data.

Preliminary SSB 2014 estimates

The total spawning area (A+) was 6214 Km^2. The spawning fraction (S) has not been estimated yet. In order to obtain a preliminary estimate of the SSB for 2014 two alternatives has been tested: 1) SSB1: S1 = derived from the mean 2008 and 2011 S values; 2) SSB2: S2 = derived from the 2011 S value.

The values of the mean estimates and their associated variances for the egg and adult parameters, and the preliminary SSB are summarized in the **Table VIII**, and the historical series is shown in **Table IX.**

Table VIII. Gulf of Cadiz anchovy DEPM 2014 survey. Summary of the results for eggs, adults and a preliminary SSB estimates (CVs in brackets).

Parameters	**Gulf of Cádiz 2014**
Eggs	
P_0 (eggs/m^2/day)	313.5 (0.34)
Z (day^{-1})	-0.33 (1.19)
P_{tot} (eggs/day) ($x10^{12}$)	1.95 (0.34)
Positive area (Km^2)	6214
Adults	
Female Weight (g)	18.22 (0.08)
Batch Fecundity	7502 (0.08)
Sex Ratio	0.54 (0.008)
Spawning Fraction 1	0.247
Spawning Fraction 2	0.276 (0.04)
SSB 2014	
Spawning Stock Biomass 1 (tons) (CV)	35275 (0.30)
Spawning Stock Biomass 2 (tons)	31569 (0.30)

SSB1estimated from S1 = 2008-2011 mean value
SSB2 estimated from S2 = derived from the 2011 survey.

Table IX. Anchovy SSB in the Gulf of Cadiz by DEPM. Historical series.

Parameter	Total Gulf of Cádiz		
Eggs	**2005**	**2008**	**2011**
P_0 (eggs/m^2/day) (CV)	50.8(0.8) / 224.5(0.69)	184(0.44) / 348(0.35)	276 (0.32)
Z (day^{-1}) (CV)	-0.039(0.75)	-1,43(0,29)	-0.29 (1.14)
P_{total} (eggs/day) ($x10^{12}$) (CV)	0.07(0.76) / 1.06(0.65)	0.31(0.44) / 1.80(0.35)	1.87 (0.36)
Surveyed area (km2)	11982	13029	13107
Positive area (Km^2)	6139	6863	6770
Adults			
Female Weight (g) (CV%)	25.2(0.03) / 16.7(0.04)	23.67 (0.06)	15.17 (0.11)
Batch Fecundity(CV%)	13820(0.05) / 11160(0.05)	13.778 (0.07)	7486 (0.12)
Sex Ratio (CV%)	0.53(0.01) / 0.54(0.01)	0.528 (0.005)	0.53 (0.007)
Spawning Fraction (CV%)	0.26(0.07) / 0.21(0.07)	0.218 (0.065)	0.276 (0.04)
SSB			
Spawning Biomass –tons (CV)	**14673**	**31527(0.32)**	**32757 (0.40)**

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Physical oceanography conditions in the Gulf of Cádiz during ECOCADIZ - BOCADEVA 201407 cruises

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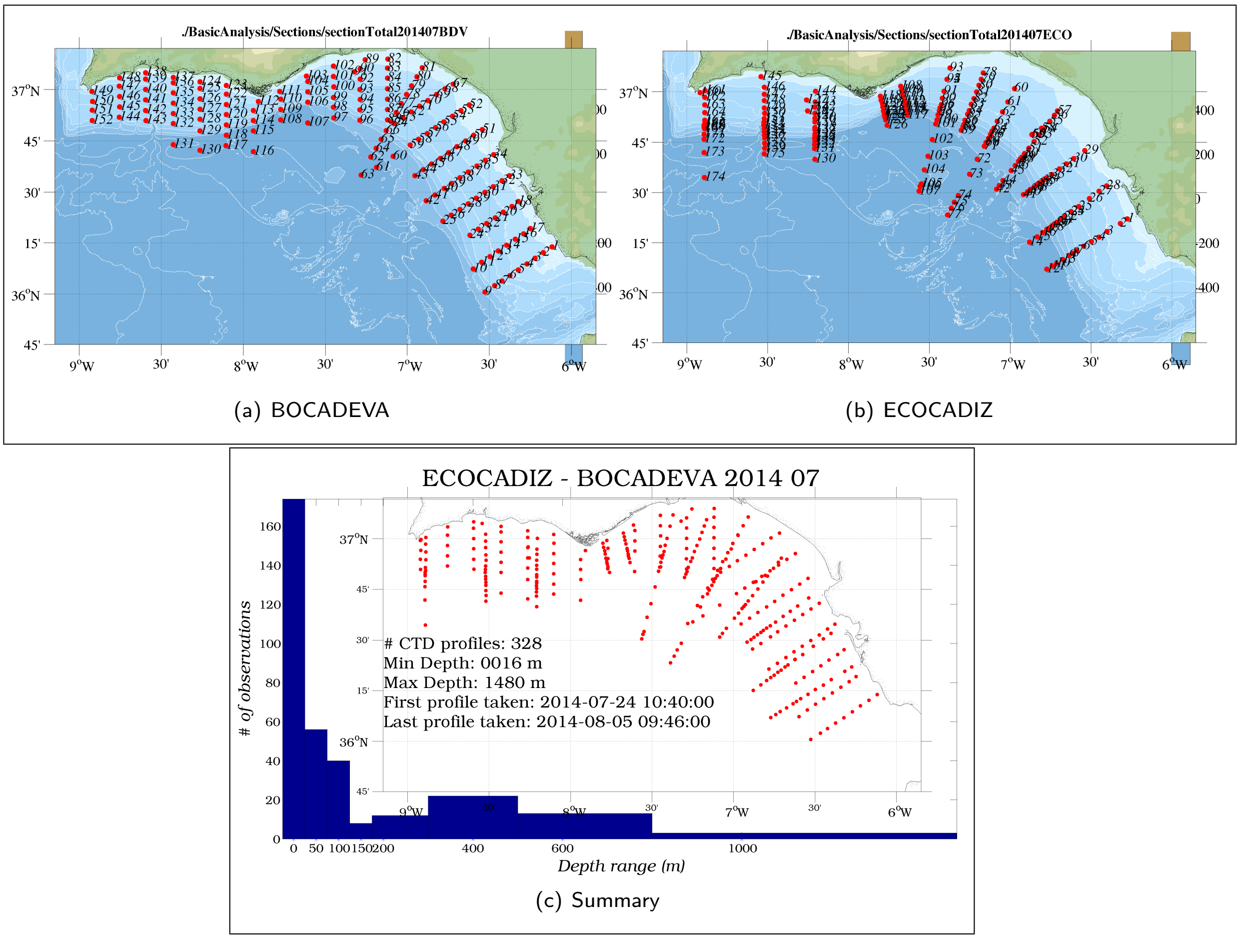
November 22, 2014

1 Setting

The contermporary and complementary ECOCADIZ 201407 and BOCADEVA 0714 cruises were conducten between July-August 2014. ECOCADIZ 201407 cruise was carried out onboard R/V Miguel Oliver between 24 July 2014 18:38 GMT and 5 August 2014 09:31 GMT whereas BOCADEVA0714 cruise was carried out onboard R/V Ramón Margalef between 24 July 2014 10:46 GMT and 30 July 2014 02:28 GMT. (Time stamps indicate deployments of the first and last CTD casts of each cruise.) Hydrographic sampling consisted of a particular observational grid of CTD profiles and ADCP transects.

For both R/V's the sampling design was build upon the realization of across-bathymetry hydrographic transects from the eastern part of the study area (close to the Strait of Gibraltar) westwards towards Cape St Vicente. Trabsects were separated less than 8 miles while maximum station distance was kept at less than 3 miles, at least over th continental shelf. Yet, due to unsteady wind conditions, this observational strategy avoided a fully-synoptic description of the oceanographic conditions.

A total of 328 full-depth CTD profiles were acquired from 10:40 UTC 24 July and 09:46 UTC 5 August 2014, 176 (including LADCP profiles) during ECOCADIZ and 152 during BOCADEVA. Depth range was 16-1480 m. The continental shelf was densely sampled with most of observations taken over grounds shallower than 200 m. During ECOCADIZ we used a SBE911+ system including dissolved oxygen, transmisivity, fluorescence and turbidity sensors attached to a Lowered-ADCP. In BOCADEVA we rather used a SBE25+ including dissolved oxygen, fluorescence and turbidity sensors. In both cases temperature, salinity and fluorescence were recorded underway, as well as current velocities velocities with a T-RDI 150 kHz OS ADCP. This document describes the data and characterizes oceanographic conditions at the time of the cruises based on these *in situ* and other remotely sensed data.



(a) BOCADEVA (b) ECOCADIZ

(c) Summary

Figure 1: CTD grid.

2 Ocean Wind

The wind time series at the RAYO ocean buoy (Puertos del Estado, fig. 2) illustrates how the cruise took place under a generally upwelling-favorable wind regime, onset from the beginning of July. Upwelling-favorable winds relaxed towards the 3rd week of july to increase again until the first week of August. During the first days of the cruise timespan winds were relatively weak, with peak velocities not exceeding 5 m/s. Starting in July 27 a vigorous westward wind burst occurred for three days, hence locally boosting coastal upwelling. After a brief calm perid, sustained northwesterlies peaked towards the last days of the cruise.

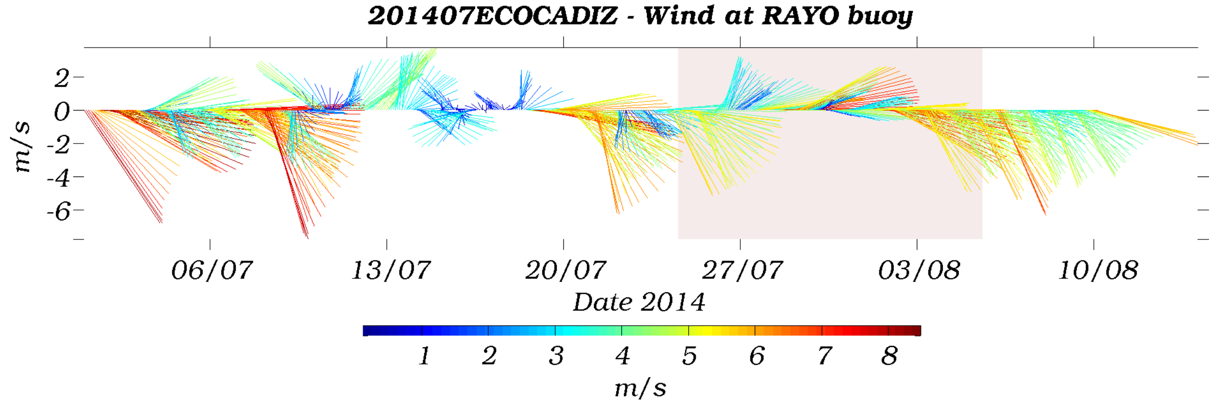
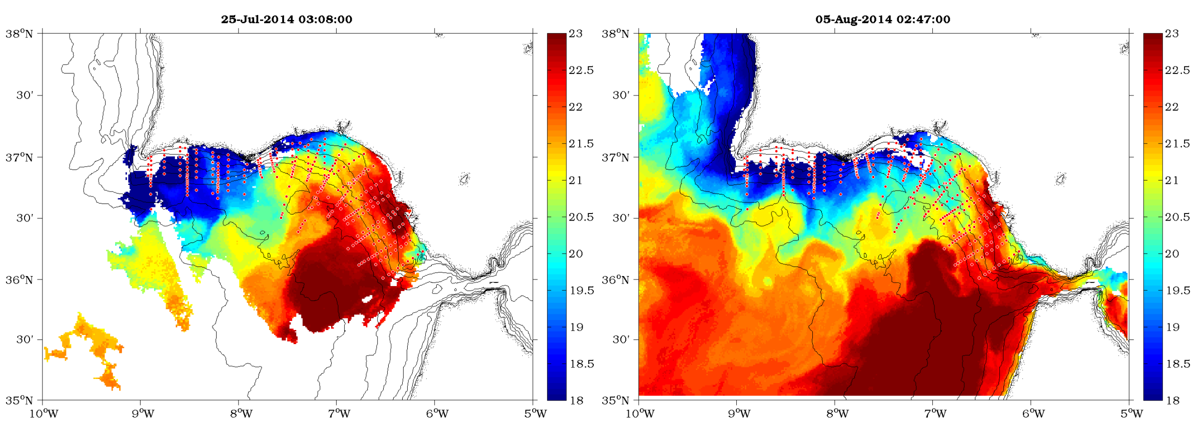


Figure 2: Subtinertial wind stick series at RAYO ocean Buoy (Deep-water Network, Puertos del Estado). Sticks align windward (oceanographic convention). A pink shade indicate the cruise period. Abscissa stand represent date 2014, ordinate wind speed (m/s). Positive to the north.

3 Satellite Ocean Sea Surface Temperature and Chl-a

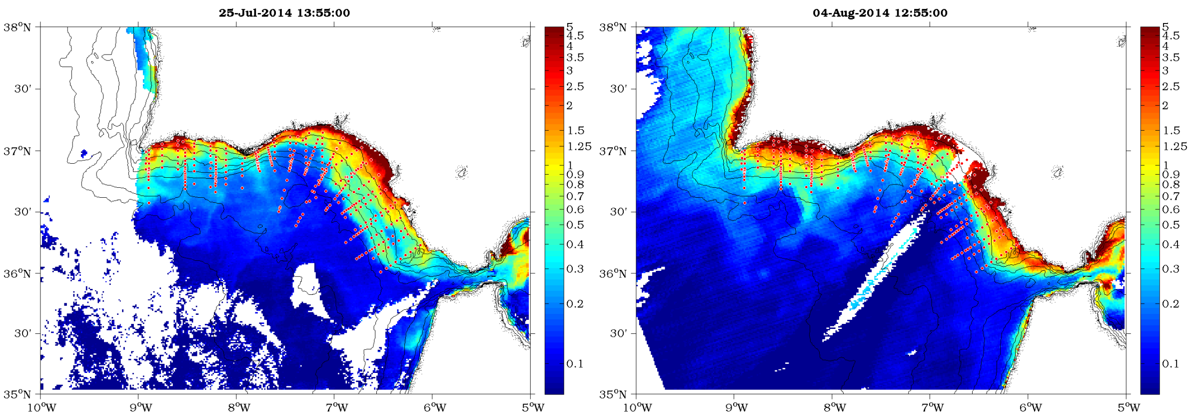
The satellite SST/Chl-a images showed the wind effect on the surface distribution of water masses. During the first half of the cruise upwelling was strong particularly west of Cape St. Maria in the Portuguese EEZ. Cold water (¿ 21 °C) filaments were seen to stretch from this cape towards the Strait of Gibraltar. An inner component extends inshore past the mouth of Tinto-Odiel river. An offshore one is seen to spread between the 100-200 isobaths. The eastern Gulf of Cadiz was occupied by warmer (¿ 23 °C) waters not only offshore but also inshore the 100 m isobath. This latter warm water pool was constrained by the upwelled filaments and the cold spot observed over the Trafalgar banks. The offshore warm pool seems to have an origin in southern latitudes.



(a) 25 July 2014 (b) 5 August 2014

Figure 3: AVHRR Sea Surface Temperature (SST) images. Station grid and 20, 50, 100, 200, 500, 1000 m isobaths are also annotated.

Towards the end of the cruise the intensification of upwelling-favorable winds caused boosting and expansion of the coastal upwelling, particularly east of 7°W. A number of intensified upwelling filaments rooted west of Cape St. Maria stretched towards the Strait of Gibraltar. This caused the southward retreat of the offshore warm water pool, which was particularly evident SW of the cape.

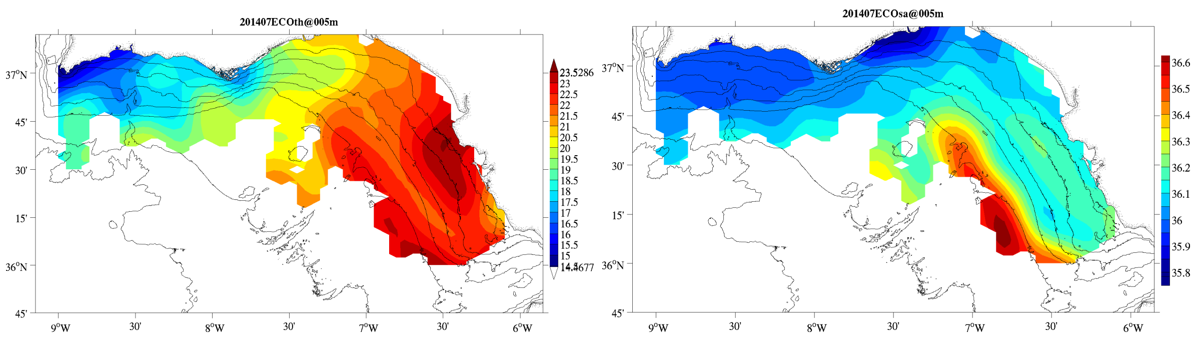


(a) 25 July 2014 (b) 4 August 2014

Figure 4: MODIS AQUA Sea Surface Chl-*a* concentration (mg m^3). Station grid and 20, 50, 100, 200, 500, 1000 m isobaths are also annotated.

4 In situ CTD data

The temperature distribution at 5 m from CTD observations accurately mimicks the satellite SST (fig. 5). This map shows that during the cruise the oceanographic conditions in the northern Gulf of Cadiz were dissimilar at both sides of Cape St. Maria. The 20.5 °C isotherm approximately run along the front separating freshly upwelled waters to the west and warmer pools to the east. However, as suggested by satellite imagery, a number of mesoscale filaments running parallel to the bathymetry seemed to disrupt the pattern. An inshore band extended past the Tinto-Odiel mouths approaching the Guadalquivir estuary. Another filament with near-surface temperatures below 21 °C was seen entering the Strait of Gibraltar between the 100-200 m isobats. In addition, an offshore projection of the cold coastal band occurred at about 7.5 °W.

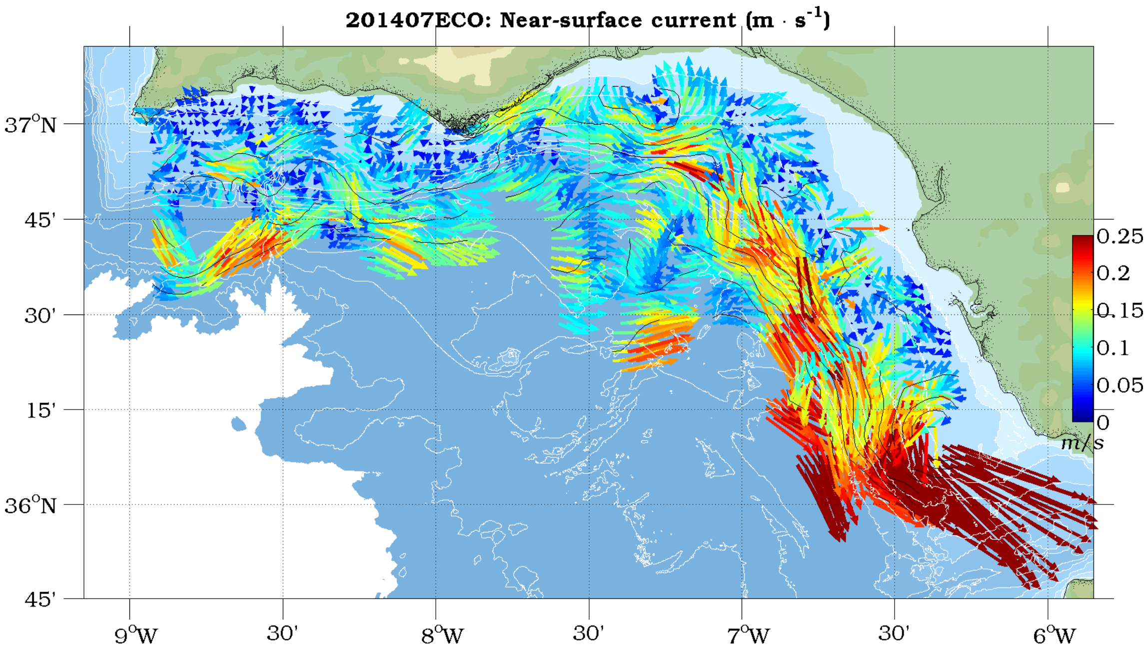


(a) Temperature (°C) (b) Salinity

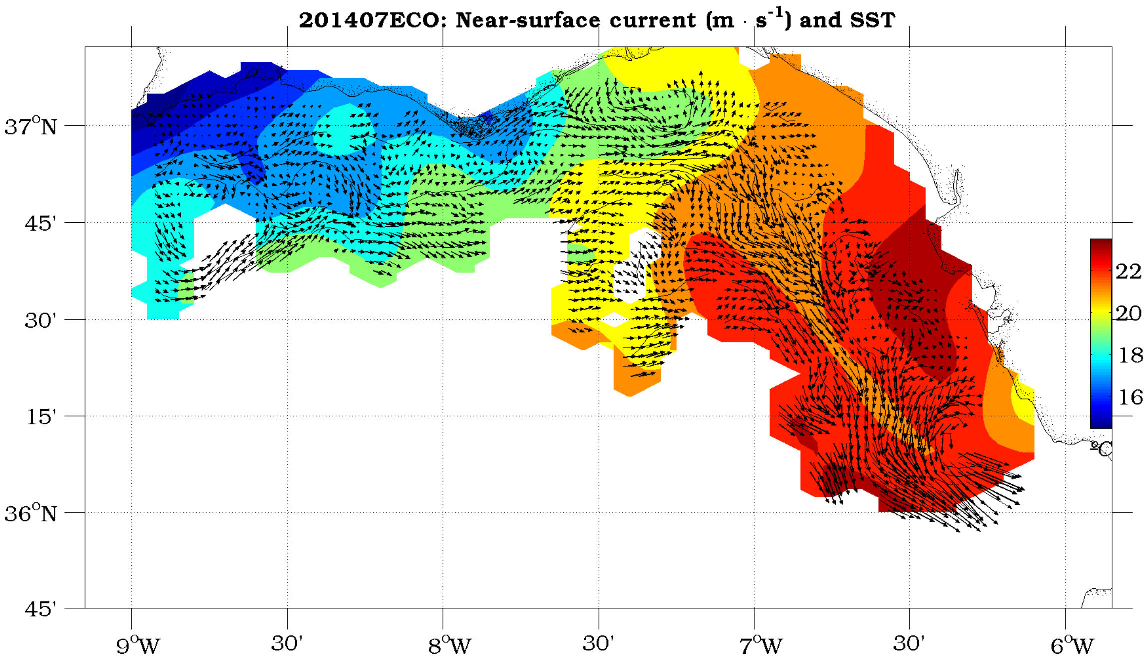
Figure 5: *In situ* horizontal fields at 5 m.

5 In situ ADCP data

The surface current pattern showed resemblance with the SST distribution. The disrupting effect of the Strait of Gibraltar was noted as velocity vectors aligned parallel to the bathymetry and exibited vigorous accelerations to attain values greater than 0.6 m/s towards the Mediterranean Basin to form the Atlantic Surface Jet. This component was formed both by relatively cold waters drained along the 100-200 m isobaths, and warmer offshore waters conveyed into the Strait to feed the Atlantic Jet.



(a) Near-surface ADCP velocity vectors



(b) Near-surface ADCP velocity vectors over temperature at 5 m

Figure 6: *In situ* Near-surface ADCP currents

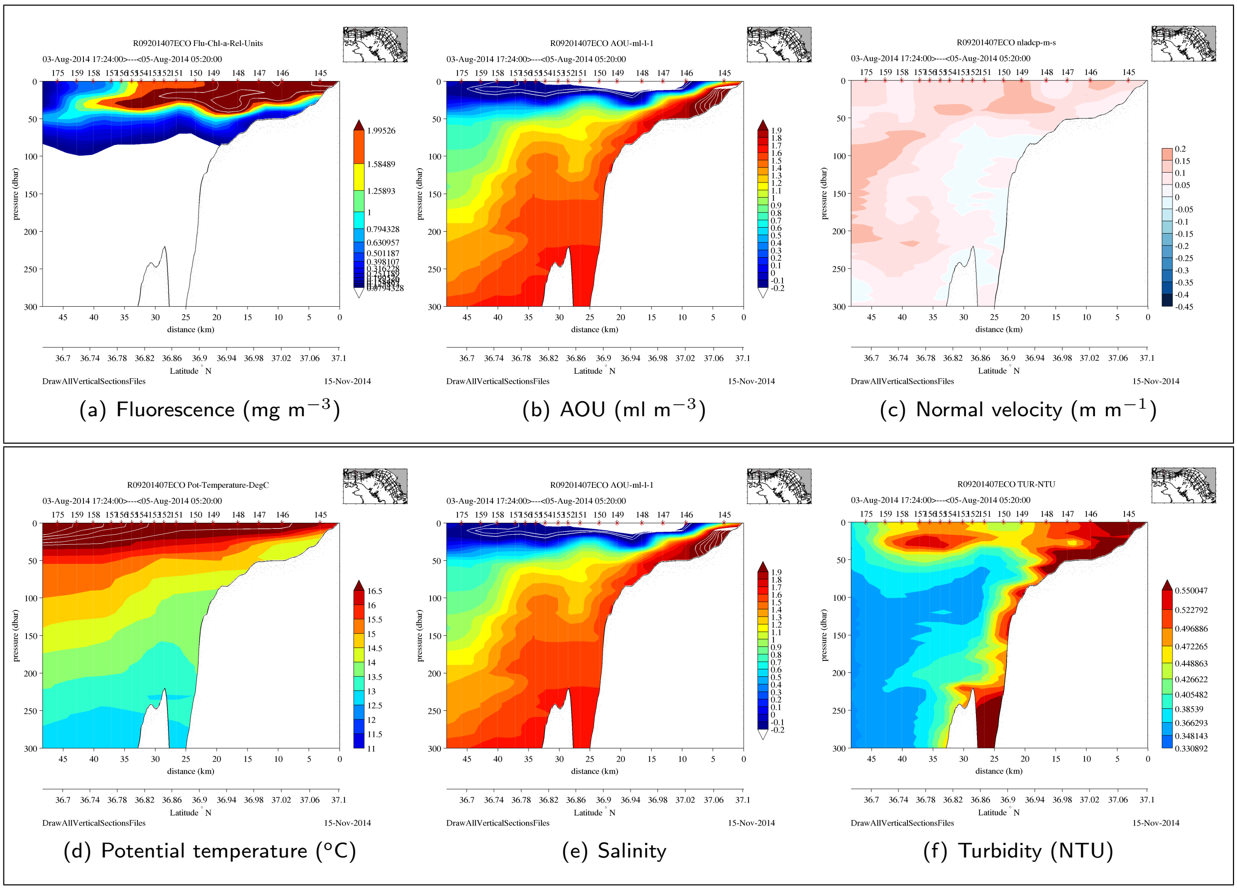
The Cape St. Maria upwelling filament was noted as near-surface velocities formed a coherent jet from the cape to the Strait of Gibraltar. Inshore, rather sluggish velocities were ubiquous, what suggests the retentive character of the inner shelf east of the cape.

Due to the strong intensity of the coastal upwelling and the relatively offshore location of the upwelling fornt, no coherent jet was observed in our data to the west of the cape. However, parts of this eastward circulation is inferred as some transects extended far beyond the continental shelf, such as for instance south of Cape St. Vicente. This jet advances towards the Strait of Gibraltar and it is hypothesized that part of the inflow in the Strait of Gibraltar must be partly composed of this water coming from the Portuguese upwelling.

Whereas the eastern shelf was split in two by the Cape St. Maria filament, the western shelf seemed relatively homogeneous. Smaller scale meanders did not split the upwelling zone west of Cape St. Maria. In both cases the circulation in the inshore part of the continental shelf was relatively tranquil, exhibing recirculatory patterns what led to favourable conditions for plankton retention.

6 Vertical cross sections

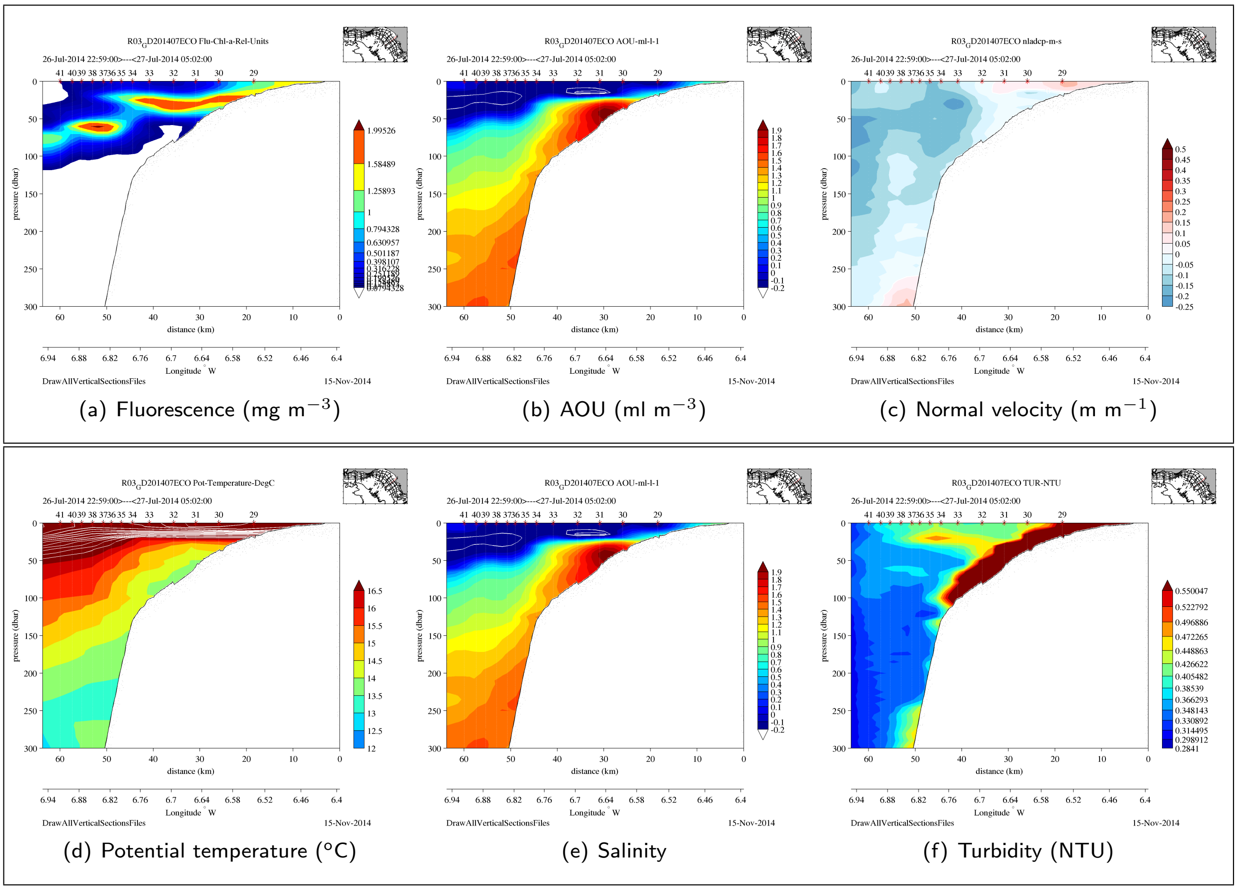
This picture can be observed along two sections conducted across each of the zones: one off the Guadalquivir river mouth (characteristic of the eastern shelf) and another off Portimao (characteristic of the western shelf). The chl-a fluorescence shows that the western shelf was actively being upwelled at the time of the cruise, as no DFM (deep fluorescence maxima) were noted. On the other hand, in the eastern part two different DFM were observed. A relatively weaker, inshore one was physically connected with the coast and shared features compatible with typical DFM of temperate oceans. A stronger, deeper offshore DFM was laid along the upwelling jet that conveyed the Cape St Maria upwelling, what suggest the connection with the Portuguese upwelling.



(a) Fluorescence (mg m^{-3}) (b) AOU (ml m^{-3}) (c) Normal velocity (m m^{-1})

(d) Potential temperature (°C) (e) Salinity (f) Turbidity (NTU)

Figure 7: ECOCADIZ 201407 section 09: off Portimao



(a) Fluorescence (mg m^{-3}) (b) AOU (ml m^{-3}) (c) Normal velocity (m m^{-1})

(d) Potential temperature (°C) (e) Salinity (f) Turbidity (NTU)

Figure 8: ECOCADIZ 201407 section 03: Off the Guadalquivir river mouth

Acknowledgements

We thank the Captain and crew of R/V Miguel Oliver and Ramón margalef as well as the IEO staff responsible for the data acquisition. Horizontal fields were interpolated with Data Interpolation Variational Analysis (DIVA, http://modb.oce.ulg.ac.be/mediawiki/index.php/DIVA). We are grateful to projects ICTIO-EVA. PELCOSAT-3 and INGRES-3 (CTM2010_21229-02).

Annex 8.11: WGACEGG presentations

List of presentations by members of WGAAEGG on survey reports or other issues. Survey reports also have specific WDs in Annex 8.10

1. PELTIC14 - Pelagic ecosystem survey in western Channel and eastern Celtic Sea

Jeroen van der Kooij

2. PELTIC – Multi-frequency processing on PELTIC surveys

Jeroen van der Kooij

The five-year PELTIC survey series, part of the UK government funded project Poseidon, explores the distribution and abundance of the small pelagic fish community and its role in the coastal ecosystem of the southwest of the British Isles. Seven pelagic fish species are commonly found in these waters during the autumn in large yet varying numbers and it is therefore important that the conversion from acoustic backscatter to species biomass is conducted in an appropriate and where possible objective manner. So far three surveys are completed and the information gathered has contributed to the current operating procedures. First, the details of data acquisition were presented and these generally adhered to the Korneliussen *et al.*, 2009 recommendations for multifrequency acoustic data collection. Second, details of the cleaning process were provided which included creation of exclusion lines, application of TVG noise removal on the 200 kHz and where necessary a bad weather mask which removes empty pings. In the next step a series of algorithms are applied to the raw multifrequency data which ultimately results in four different virtual echograms, each retaining the backscatter associated with a specific echotype only: fish with swimbladder, fish without swimbladder, fluid-like zooplankton and juvenile fish and jellyfish aggregations. More recently the fish without swimbladder category has been replaced by a more advanced mackerel detection algorithm which eventually provides mackerel backscatter at 200 kHz. The fish with swimbladder category is then further partitioned by dividing the echogram into up to 8 categories including for example “single species mid water schools”, or “mixed aggregations above seabed” using scrutiny and trawl data to divide into species. A new 333 kHz frequency will be incorporated in future algorithms and may contribute to resolving some further species separation. With every survey the database of acoustic schools and corresponding catch data grows and with it hopefully the chance of identifying the distinguishing features to robustly separate some of the swimbladdered species from each other.

3. Boarfish Acoustic Survey 2014 (10–31 July 2014)

C. O’Donnell

4. Celtic Sea Herring Acoustic Survey (6–26 October 2014)

C. O’Donnell

5. Direct assessment of small pelagic fish by the PELGAS14 acoustic survey. PELGAS14

E. Duhamel, M. Doray, M. Huret, M. Authier, T. Gestin

Abstract: An acoustic survey was carried out in the Bay of Biscay from April 24st to June 5th on board the French research vessel Thalassa. The objective of PELGAS14 survey was to study the abundance and distribution of pelagic fish in the Bay of Biscay. The target species were mainly anchovy and sardine and were considered in a multi-specific context. To assess an optimum horizontal and vertical description of the area, two types of actions were combined: i) Continuous acquisition by storing acoustic data from five different frequencies and counting the number of fish eggs using CUFES system, and discrete sampling at stations. Commercial vessels were accompanying Thalassa during 18 days, such as to improve the number of identifications hauls and increase the reliability of identification of echoes. This WD reports acoustic assessments and length distributions of main species, age distribution for anchovy and sardine and some environmental data. Anchovy was present this year as an abundance index a bit above the average on the series, 125 427 tonnes. The biomass estimate of sardine observed during PELGAS14 is 339 607 tons, which constitutes a small decrease of the last year level of biomass, but this species is still at a high level of abundance in the bay of Biscay.

6. Spatial structure of the Bay of Biscay pelagic ecosystem in spring as revealed by the survey series PELGAS

P. Petitgas, M. Doray, M. Huret, C. Dupuy, O. van Canneyt, G. Dorémus

Abstract. Since year 2000, the acoustic fisheries survey Pelgas that covers the French shelf of the Bay of Biscay is used as a platform to monitor all compartments of the pelagic ecosystem. Measurements span from hydrology to plankton, fish and top predators and are collected either on route along the ship sailing track or at stations. The paper presents a procedure to assemble all data and summarize their major horizontal structural features thus providing a synoptic ecosystem overview. The data comprise hydrological parameters, chlorophyll and zooplankton biomass by size classes, egg counts of anchovy and sardine, pelagic fish concentration by species and length classes and marine mammal and seabird counts. The data are block-averaged on the same grid, resulting in a large collection of raster files for all parameters and years. The multidimensional raster data are then analysed using a multi-table principal components analysis to characterize common structures across ecosystem compartments and interannual variability. Results show that the ecosystem compartments are organized following similar spatial patterns, which structure the ecosystem into a mosaic of defined habitats.

7. Analysis and comparison of the demographic structures of sardine and anchovy of the Bay of Biscay, based on spring and autumn surveys

E. Despois, E. Duhamel

Abstract: This preliminary study explores the possibility to have and abundance and/or recruitment index for anchovy and sardine of the Bay of Biscay based on the EVHOE bottom-trawl survey series. Is there any possibility with a survey targeting demersal and benthic species to have some information about the global trend on catches of recruitment? the first approach, to study if it’s possible to tracks cohorts for these species is clearly negative.

The second one, if this kind of survey can show a similar trend of catches as the biomasses calculated by spring acoustic (PELGAS) and DEPM (BIOMAN) surveys, is also clearly negative for both species.

The global trend of catch-at-age 0 (recruitment) during autumn bottom-trawl survey(EVHOE) might maybe be correlated with Juvena and with recruitment-at-age 1 as observed during spring except two years of strong discrepancies. It might be useful to complete the series to observe what will happened in near future.

8. Multi-frequency characterization of the 3-dimensional, mesoscale spatial distribution of Biscay sound scattering layers (SSLs) (poster)

Barbara REMOND, Mathieu DORAY, Pierre PETITGAS, Laurent BERGER

9. Bay of Biscay dense sound scattering layers composition

Barbara REMOND, Mathieu DORAY, Anne LEBOURGES-DHAUSSY, Laurent BERGER, Pierre PETITGAS

Oral communication presented at the 2014 ICES Annual Scientific Conference

10. In-situ measurements of the individual acoustic backscatter of European anchovy and sardine, with concurrent optical observations.

Mathieu Doray, Laurent Berger, Jean Yves Coail, Jean Philippe Vacherot, Gérard Bavouzet, Pierre Petitgas

11. X-ray microTomography for Fish Target Strength Modelling

Ifremer

12. ZOOCAM: a new on-board optical instrument to count and classify eggs and mesozooplancton

Huret M., Bourriau P., Colas F., Danielou M.M., Doray M., Le Mestre S., Lunven M., Perchoc J., Petitgas P., Tardivel M.

13. Assessment of Bay of Biscay anchovy following new stock annex approved in October 2013 and recent changes in management

Uriarte

14. Anchovy and Sardine DEPM in Bay of Biscay 2014 and Sardine egg abundance

M. Santos, L. Ibaibarriaga and A. Uriarte

15. Consistency of relative changes in Biomass and P1 in Anchovy Surveys: First approach - Food for thought

Uriarte A.

16. JUVENA 2014 survey report

G. Boyra and M. Louzao

17. Multidisciplinary acoustic survey PELACUS 0314

P. Carrera

18. INTERPELACUS 0414 - Calibration between RV Miguel Oliver and RV Thalassa

P. Carrera

19. Seasonal drop in total fecundity does not imply determinacy for the southern stock of horse mackerel (*Trachurus trachurus*) in the Northeast Atlantic

Ganias Kostas, Mouchlianitis Foivos-Alexandros, Cristina Nunes, Ana-Maria Costa, Maria-Manuel Angelico

Abstract: The objective of this work was to study the seasonal pattern of fecundity of horse mackerel, *Trachurus trachurus*, in N.E. Atlantic using innovative methods (particle analysis and stereology in digital images of ovarian tissue). It was observed that total relative fecundity, RFt, shows a significant drop during the spawning period as opposed to relative batch fecundity, RFb, which remained constant at 264 oocytes/g. Although the seasonal reduction in RFt consists one of the standard criteria of 'determinate fecundity' we show that horse mackerel follows the 'indeterminate fecundity' type. Specifically, the rate of decrease of RFt (~10 oocytes/gram/day) is much smaller than the daily egg production rate per unit biomass (26–79 oocytes/gram/day). This result is explained by the fact that parallel with egg laying, spawning females produce de-novo oocytes, which suggests indeterminate fecundity.

20. 2014 Sardine DEPM survey - Iberian Peninsula and VIIIb (PT-DEPM14-PIL/SA-REVA-0414)

Paz Díaz, A. Lago de Lanzós, C. Franco, J. R. Pérez, P. Cubero, L. Iglesias, A. Silva, V. Marques, E. Henriques, C. Nunes, M.M. Angélico

21. PELAGO 14 – RV "Noruega"

Vítor Marques, Maria Manuel Angélico, Alexandra Silva, Eduardo Soares Cristina Nunes and Paulo Oliveira

22. Sardine assessment -WGHANSA, June 2014

Isabel Riveiro, Alexandra Silva, etc.

23. JUVESAR13 survey - Portugal

S. Rodríguez-Climent, Domínguez R., Silva A., Marques V. , Santos A.M.P. , dos Santos A. , Barra J. , Bento T. , Silva A.V. , Guerreiro M. , Malta T., Matos A. , Pereira A. , Santos C.

24. Identifying essential habitat for juvenile sardine (*Sardina pilchardus* (Walbaum, 1972)) along the Portuguese coast and Gulf of Cadiz

Rodríguez-Climent Sílvia, Marques Vitor, Angélico M. Manuel, Silva Alexandra

Poster presented at the "Johan Hjort Symposium on Recruitment Dynamics and Stock Variability"

Abstract: Understanding fish distribution, including juvenile fish distribution, is essential to sustainable fisheries management, where the protection of the juveniles (i.e. assuring first spawn) is required. The distribution of juvenile sardine (*Sardina pilchardus*; Walbaum, 1972) was mapped along the Portuguese coast and Gulf of Cadiz for the springs of the years 2005–2010 using data obtained during the acoustic surveys. The abundance of juveniles was then related with six environmental variables: sea surface temperature, salinity, fluorescence, zooplankton volume and depth, using Generalized Additive Models. Our results highlighted three key locations for the residence of juveniles: the Northern Portuguese shelf (centred off Aveiro), the coastal region in the vicinity of the Tagus Estuary and the Eastern Gulf of Cadiz. Enriched by the river run-off during the winter, these areas are characterized by higher productivity in spring and lower salinities, factors cited to be crucial to the presence of juvenile stages. Moreover the combination of mesoscale and submesoscale physical processes and features occurring in these waters, have been reported to promote retention mechanizms for early life stages.

25. BOCADEVA 0714 - Gulf of Cadiz Anchovy Egg Survey. 2014 SSB preliminary estimates

Paz Jiménez , Jorge Tornero and Ricardo Sánchez-Leal

26. Acoustic assessment and distribution of the main pelagic fish species in the ICES Subdivision IX a South during the ECOCADIZ 0813 Spanish survey (August 2013)

Fernando Ramos, Magdalena Iglesias, Paz Jiménez, Joan Miquel, Dolors Oñate, Jorge Tornero, Ana Ventero and Nuria Díaz

Abstract. The present presentation summarizes the main results from the Spanish (pelagic ecosystem-) acoustic survey conducted by IEO between 2nd and 13th August 2013 in the Portuguese and Spanish shelf waters (20–200 m isobaths) off the Gulf of Cadiz onboard the RV Cornide de Saavedra. The survey dates were somewhat delayed in relation to the usual ones and to the anchovy (*Engraulis encrasicolus*) peak spawning as well. 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. The bulk of the anchovy population was concentrated in the Spanish shelf, with a residual nucleus to the west of Cape Santa Maria. A delay of the usual survey dates may be the reason of a higher relative importance of smaller anchovies in the population as a probable consequence of the incorporation of the first waves of recently recruited juveniles to the adult population. The total biomass estimated for anchovy was 8.5 thousand tonnes (609 million fish), the lowest estimate in its series. Sardine showed a distribution pattern almost complementary to that described for anchovy, with higher densities occurring over the

inner-middle shelf of both extremes of the surveyed area, mainly west to Cape Santa Maria, and in shallower waters than anchovy. Sardine yielded a total of 9.7 thousand tonnes (232 million fish). The 2013 sardine estimate was also the lowest one in its series and corroborates a clear recent decline in the population, which has also been corroborated by the PELAGO surveys. Chub mackerel was present all over the surveyed area although showed a more "oceanic" distribution in the westernmost waters. The species was the most important in terms of assessed biomass, rendering estimates of 31.3 thousand tonnes (333 million fish). 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 in the study area during the survey.

27. ECOCADIZ (July) and ECOCADIZ-RECLUTAS (October) surveys in 2014. A short presentation

Fernando Ramos, Jorge Tornero, Paz Jiménez and Ricardo Sánchez-Leal

Abstract. This presentation introduces the methods adopted in the summer and autumn acoustic surveys conducted by the IEO in the Gulf of Cadiz in 2014 (ECOCADIZ and ECOCADIZ-RECLUTAS series, respectively) and provides the main results from the echotraces ground-truthing hauls from the summer survey. The acoustic assessment of the set of species usually assessed within these two series is still in progress for both surveys. The presentation also includes results from the distribution pattern of Gulf of Cadiz anchovy eggs as sampled by CUFES during the BOCADEVA 0714 egg survey, conducted at the same time than the summer acoustic one, which is discussed in the context of the main oceanographic features prevailing during the survey season. The abovementioned information (also including the results from the fishing hauls from the autumn survey) is described in detail in Ramos and Tornero WD 2014a,b, Jiménez *et al.* WD 2014 and Sánchez-Leal *et al.* WD 2014 and provided to this WG.

Annex 8.12: Medias presentations (list with abstracts)

List of presentations at the WGACEGG meeting by MEDIAS members

1. Spanish Mediterranean Acoustic Survey MEDIAS 2013

Magdalena Iglesias, Ana Ventero, Joan Miquel, Dolores Oñate, Nuria Díaz

Abstract. The MEDIAS 2013 acoustic survey was carried out in the Mediterranean Spanish waters from 29th June to 31th July 2013 on board the RV "Cornide de Saavedra" (67 m long). Acoustic data were collected over 1292 nautical miles, corresponding to 128 tracks (GSA06 and GSA01 areas) and 58 pelagic trawls were used to scrutinize the echograms. Moreover, 90 CTD stations were performed and 429 CUFES (Continuous Underway Fish Egg Sampler) stations were analysed. The most abundant species in the pelagic trawls were sardine (*Sardina pilchardus*), anchovy (*Engraulis encrasicolus*) and horse mackerel (*Trachurus trachurus*), but other important pelagic species were sprat (*Sprattus sprattus*), Mediterranean horse mackerel (*Trachurus mediterraneus*), bogue (*Boops boops*) and blue horse mackerel (*Trachurus picturatus*). Biomass and abundance of sardine and anchovy were estimated.

In GSA06 it was detected in 2013 the best recruitment for sardine for the MEDIAS series (2009–2013).

2. Echosurveys MEDIAS 2013 - Small pelagics biomass estimation in GSAs 15 and 16

IAMC-MCFS

3. Overview of the Mediterranean International Acoustic Survey (MEDIAS)

HCMR, Ifremer, IEO, ISMAR-CNR, FRIS, IAMC-CNR, IOF, MSDEC-DFA

4. Assessment of small pelagic fish biomass by means of acoustic methods in the western Adriatic Sea Year 2013–2014

Iole Leonori, Andrea De Felice, Ilaria Biagiotti, Fabio Campanella, Giovanni Canduci, Claudio Vasapollo, Sara Malavolti, Rocco De Marco, and Ilaria Costantini

In 2014, acoustic surveys in western Adriatic Sea have been carried out in July in GSA 18 and in August–September in GSA 17 in the framework of the MEDIAS project. Acoustic data were logged over a grid of systematic parallel transects perpendicular to coastline/bathymetry for a total of around 2500 nautical miles, identifying an area of about 15700 square nautical miles in the western part and southeastern part of Adriatic Sea. The acoustic survey in western GSA 18 (21 – 28 July 2014) was carried out along 450 nautical miles; the area coverage was 100%, with 15 pelagic hauls for the determination of pelagic biomass in species and sizes and 58 CTD and plankton net stations for the application of Daily Egg Production Method on anchovy. Similarly on the eastern side of GSA 18 an acoustic survey, as extension of the MEDIAS project in the framework of the FAO AdriaMed project, was carried out in cooperation with IBM of Kotor (Montenegro) and the University of Tirana (Albania; 29 July – 6 August 2014) along

472 nautical miles with 62 CTD and plankton net stations. Western GSA 17 was monitored by acoustic survey from 25th of August until 17th of September 2014. Survey included Slovenian waters in cooperation with Fishery Research Institute of Slovenia. Total nautical miles covered were 1518 (100% of the area coverage) with 38 pelagic hauls and 96 CTD stations, 45 of them had also a net sampling on mesozooplankton. This last activity was done in cooperation with OGS of Trieste (Italy). The trend of anchovy biomass in all western Adriatic sea (1976–2013 in the Northwestern Adriatic, 1987–2013 in the Middle and Southwestern Adriatic) is similar, showing medium levels in these last years with the tendency to decline, while sardine biomass, after years of low level of biomass shows a good degree of recovery even if apparently not stable.