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Report of the Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas 7, 8, and 9

Capo, Granitola, Sicily, Italy

14-18 November 2016

ICES International Council for the Exploration of the Sea
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 7, 8, and 9 (previously only for ICES Areas 8 and 9) WGACEGG, met in Capo Granitola, Sicily, Italy, on 14–18 November 2016. The meeting joined WGACEGG and MEDIAS participants with 25 attendees (10 from MEDIAS) from seven countries and representing eight institutes.

Results obtained during the surveys undertaken during the present year were analysed together with one carried out in 2015 (1 anchovy DEPM and 3 spring and 3 autumn acoustic-trawl). There is a decreasing trend in sardine abundance off Atlantic waters of the Iberian Peninsula together with a shrinking process of its distribution area. In northern areas (8ab and 7), sardine shows a more stable situation, due to the strength of the last incoming year classes. On the other hand, anchovy distribution seemed to have been spreading along the surveyed area, occurring in all areas (i.e. north-western Iberian Peninsula and western of the Cornish Peninsula). (see section 5.1 of the report for further details)

A new sardine egg mortality time series from the Iberotlantic DEPM has been presented. The WGACEGG agreed this new estimates has greatly improved the estimation of the sardine spawning stock biomass whose trajectory match better with the acoustic-derived estimation (Annex 4). Besides, in this section, several issues related with fishery-independent data for sardine (e.g. CV from PELAGO and PELACUS surveys or the use of the sardine egg production derived from the mackerel triennial surveys as an indicator of the SSB) has been addressed. The results will be used for evaluating the current data for assessment purposes at the 2017 sardine benchmark.

Acoustic and egg parallel sessions were also done. Improvement for in situ TS estimations together with progress report on new estimates for sardine and anchovy TS/length relationships were discussed. In addition, a new version of EchoR has been tested using data from the Mediterranean acoustic surveys. On egg surveys, improvements on automatic egg counting and staging from CUFES has been presented and methods to derive and egg production from this device have been also discussed.

The Group endorsed the results from the Bay of Biscay anchovy recruitment autumn survey (JUVENA) which were then submitted to the Working Group on Southern Horse Mackerel, Anchovy and Sardine (WGHANSA) for assessment modelling.

The plans for the coordinated 2017 surveys were completed and are present in Annex 7.

The WGACEGG reviewed the ToRs for the next three years and designated the two new chairs for that period.

1 Administrative details

Working Group name

Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas 7, 8, and 9 (WGACEGG)

Year of Appointment within the current cycle

2014

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

3

Chairs

Maria Manuel Angélico, Portugal

Pablo Carrera, Spain

Meeting venues and dates

17–21 November 2014, Vigo, Spain, 27 attendees

16–20 November 2015, Lowestoft, UK, 14 attendees

14–18 November 2016, Capo Granitola, Sicily, Italy, 25 attendees

2 Terms of Reference a) – g)

The terms of reference for 2016 were:

a) Provide echo-integration and DEPM estimates for sardine and anchovy in ICES sub-Areas 7, 8, and 9a, 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

b) Investigate the use of the acoustic survey data to provide indices and/or biological information on other pelagic fish species such as mackerel, horse-mackerel, boar fish and blue whiting by improving survey strategies, acoustic data post-processing and research on target strength

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

d) Develop CUFES as an indicator of anchovy and sardine egg production

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

f) Coordination and standardization of the surveys

Multiannual ToRs

ToR	DESCRIPTION	BACKGROUND	SCIENCE PLAN TOPICS ADDRESSED	DURATION	EXPECTED DELIVERABLES
a	Provide echointegration and DEPM estimates for sardine and anchovy in ICES sub-Areas 7,8, and 9.	Advisory Requirements Requirements from other EGs	1.4, 1.6	1st to 3rd years	Biomass by age group and SSB estimations, distribution area. WGHANSA
a,b	Analyse sardine and anchovy distribution (adults and eggs), aggregation patterns and their habitats in European waters	Science Requirements Requirements from other EGs	1.4, 1.6	1st to 3rd year	Manuscript comparing sardine (and anchovy) population dynamics and habitats among European waters (third year) WGHANSA

	(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	a) Science Requirements	1.6.1, 1.6.2, 3.3.5	1st to 3rd years	Update grid maps Habitat characterization
d	Investigate the use of the acoustic survey data to provide indices and/or biological information on other pelagic fish species such as mackerel, horse mackerel, boar fish and blue whiting by improving survey strategies, acoustic data post-processing and research on	Science Requirements Requirements from other EGs	1.4, 1.6	2nd-3rd years	Biomass by age group estimations, distribution area. Third quarter of the year Updated survey protocols WGWIDE

	target strength				
d	Assess developments in the technologies and data analysis for the application of the Daily Egg production method (on Egg Production or adult parameters)	Science Requirements Advisory Requirements Requirements from other EGs	1.4	1st to 3rd years	Anchovy and Sardine egg production WGHANSA
e	Develop CUFES as an indicator of anchovy and sardine egg production	a. Science Requirements b. Advisory Requirements c. Requirements from other EGs	1.4	2nd-3rd year	Anchovy and Sardine egg production WGHANSA
f	Assess developments in the technologies and data analysis for acoustic data	a. Science Requirements b. Advisory Requirements c. Requirements from other EGs	1.4	1st to 3rd years	List of common possible MSFD indicators, including protocols to monitor them or to complement data from other surveys/monitoring programs Manuscripts describing practical implementation and results

g	Coordination and standardization of the survey	a. Science Requirements b. Advisory Requirements	1.4	1st to 3rd years	Annual plan for coordinated surveys Updated survey protocols

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 Pairovet. Session to analyse the proposed list of MSFD indicators by country (France, Ireland, Portugal, Spain and United Kingdom), 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 Summary of Achievements of the WG during 3-year term

The ACEGG group maintains a database of standard maps covering the European Atlantic area informing on the spatial dynamics of various parameters collected during the surveys coordinated under the auspices of the group (fish acoustic densities, egg/m^2, egg/m^3, surface temperature and salinity, bird and mammals, etc). The rationale for this work is described in ICES, CRR 332. More explicit, main achievements during the last 3 years are:

- Publications:
    - In press: several articles in a special issue in Progress in Oceanography dealing with Integrated Surveys.
- Advisory products:
    - Sardine and anchovy biomass and abundance indices derived from acoustic and DEPM surveys used as input fishery-independent data for analytical assessment purposes in ICES WGHANSA. Surveys involved: PELAGO, PELACUS, PELGAS, JUVENA, BIOMAN ECOCADIZ, SAREVA, PT-DEPM14-PIL, BOCADEVA.
    - Biological information from the same surveys
- Other advisory products:
    - Mackerel, horse mackerel, blue whiting, chub mackerel, boarfish biomass and abundance indices and biological information derived from acoustic surveys used as fishery-independent data in ICES WGWIDE Surveys involved: PELACUS, PELGAS.
    - Sardine, anchovy, mackerel, horse mackerel, blue whiting, chub mackerel, boarfish biomass and abundance indices and biological information derived from acoustic survey used as fishery-independent data in ICES WGWIDE and WGHANSA. Survey involved: PELTIC.
    - Marine birds, mammals, human activities and debris distribution. Surveys involved: PELACUS, PELGAS, BIOMAN, PELTIC.
- Workshops:
    - Two workshops on EchoR
- Methodological developments:
    - New methods for TS in situ measurements on an open pelagic gear using a specific ROV.
    - Sardine and anchovy egg production estimates from CUFES samples.
    - Automated system for identifying and staging sardine and anchovy eggs from CUFES samples.
- Modelling outputs:
    - Improvement on sardine and anchovy target strength modelling using X-ray CT imaging
    - Sardine egg mortality modelling using temperature as covariable.
    - Sardine egg production from specific mackerel triennial surveys.

5 Final report on ToRs, workplan, and Science Implementation Plan

Multiannual Terms of Reference

Those Multi-annual ToR's related with advisory requirements (e.g. ToR's a, b, c, d) have been achieved along this period were achieved. Moreover, ToR g, also related with advisory requirements, but concerning survey coordination has also been achieved. An ICES CRR (No 332) has been submitted for publication, however still pending, where all survey methods, integrated maps and tools for spatial analysis are described. Annual results where submitted as WD to WGHANSA and WIDE. Concerning MSFD indicators (ToR f) a potential list of indicators has been included in the CRR No 332 draft and also in previous WGACEGG reports. However, final list of MSFD indicators will be chosen at country level although implemented in the same maritime region (North-esat Atlantic Ocean, namely Bay of Biscay and Iberian Peninsula).

Specifically related to ToR f, WGACEGG has worked together within Optimising and Enhancing the Integrated Atlantic Ocean Observing Systems EU 2020 project in Task 2.4 (workpackage 2) and ICES (Dataset collections). As main outcome, the EchoR software for fish abundance estimates from acoustic survey has been updated during this period

On egg surveys, a new approach aiming at to split SSB in age groups has been implemented and currently applied to anchovy estimates in the Bay of Biscay. Although no direct comparison has been yet done on total egg production estimated from vertical tows and CUFES records, the estimates from CUFES are currently used as a cross-checking for the acoustic ones fro anchovy in the Bay of Biscay. The implementation of this approach for sardine and for the rest of the surveyed area (Iberian Peninsula) is still pending. On the other hand, discrepancies between DEPM and Echointegration estimates were analysed for the IberoAtlantic sardine; after the implementation of the new model to calculate egg mortality using temperature as covariable and the whole time-series trends for both times-series show now a higher correlation.

From the work plan it should be highlighted the joint sessions with the MEDIAS (Mediterranean acoustic survey on small pelagic) WG. Two meetings (year one and three) were done. During these sessions, two workshops on EchoR. Outcomes from these workshops are accessible in

https://forge.ifremer.fr/docman/?group_id=212&view=listfile&dirid=488

It should be also mentioned the progress report on in situ-TS measurements for anchovy and sardine together with the study of the physical characteristics of the resonance of both species.

6 Cooperation

- **Cooperation with other WG**

WGACEGG is routinely cooperating with the following working groups dealing with SCICOM:

a) WGFAST

b) WGALES

c) WGMEGS

d) WGIPS through WKSCRUT

WGACEGG has also collaborated with WGEAWESS. Preparing a proposal for Interreg (Atlantic Area) called "An applied Ecosystem Assessment for the Atlantic Area". Within this project, WGACEGG team would be mainly involved in WP5 (Spatial Information)

- **Cooperation with Advisory structures**

WGACEGG is cooperating with the following advisory structures

a) ICES Assessment Working groups: HANSA, WIDE, together with related Benchmark WG and Workshops

b) Advice drafting Groups: ADGHANSA

- **Cooperation with other IGOs**

As a part of the planning, every two years ACEGG meets with MEDIAS. (Mediterranean acoustic survey on small pelagic) WG. No other cooperation with ICO's has been established along this period.

7 Summary of Working Group self-evaluation and conclusions

During the last 3 years WGACEGG has made important contributions to science in terms of the knowledge of the pelagic ecosystem in south Atlantic European waters. Most of the pelagic fish species occurring in this area are routinely assessed together with their habitats.

Most of the issues identified in the work plan were properly addressed, although is still pending the final version of the ICES CRR no 332 submitted a couple years ago which describe the bulk of the methodology and analysis done during this period.

The WG recognizes that in order to address challenges for future both in terms of new technologies for data collection and automated data processing devices and software together with new tools for data analysis. This would imply specific in-situ experiences and measurement (eg TS measurements, egg buoyancy and development experiments among other), testing new equipment and also to stablish a systematic plan for i) organize exchanges and workshops to standardize egg staging and POF's reading criteria; ii) standardize post-processing techniques, including as was already done for acoustic, small workshops. This planning should be considered for the next working group period although some difficulties would appear on account the difficulties for finding right periods along the year, given the number of surveys involved (spring, summer and fall surveys).

Taking into account that the science products deliver by this WG is the basis for fishery-independent data for assessment purposes for anchovy, sardine and horse mackerel (WGWIDE and WGHANSA), and its information is used for biological, spatial distribution and dynamics understanding purposes for mackerel, boarfish, blue whiting and chub mackerel routinely assessed in WGWIDE, a new period should be considered. This specific task, which will be improved through the use of new technologies and data analysis, together with the study of possible changes in pelagic communities (from plankton to apical predators) in relation to climate change in the surveyed area would be the short-term tasks.

8 Overview on sardine and anchovy abundance distributions from the DEPM and acoustic surveys in areas 7, 8 and 9

Acoustic surveys carried out in spring and summer are targeted on adults while those performed in fall are focusing on anchovy juveniles. Material and methods of each survey are detailed in Annex 8 (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 (figure 8.1) . 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.

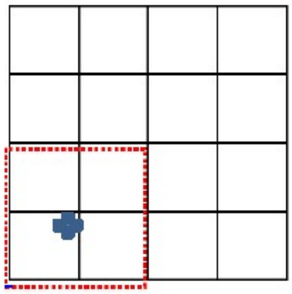


Figure 8.1: Schematic of the standard grid (black: 0.25°x0.25°), the large block (dashed red line) in which the grid origin is randomized. The cross (blue) shows the position at which the origin is randomized. The cross (blue) shows the position at which the origin of the grid is positioned to present 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.

8.1 Spring acoustic surveys 2016

The three coordinate spring acoustic surveys, PELAGO, PELACUS, and PELGAS covered the ICES Divisions 8a,b,c and 9a from 11 March, when PELAGO started, and 1 June, when PELGAS ended.

While PELACUS and PELGAS steamed the surveyed area from the southern part to the northern one, PELAGO, due to adverse weather and some logistics constraints it was not carried out sequentially. This fact should be taken into account when analysing the results, especially those from the oceanographic features.

8.1.1 Oceanographic conditions

Weather conditions were almost similar to those found in the previous year, with less intensity of the NE winds, thus lower upwelling index, being negative in April and May. As in previous years, colder water were found during PELACUS and in general in the NW part of the Iberian Peninsula, and particularly this year, in the northern part of the Portuguese area were the coldest waters were recorded. As the survey period advances, the waters became warmer, with the warmest located in the Gulf of Cadiz (end April) and northern Bay of Biscay (end May). Temperatures ranged from 12 to 18°C. The influence of river plumes led the waters around the coastal areas of the

French shelf (8ab), Rías Baixas (9aN) and North Portugal (9aCN) to low values in salinity (<33.5 ppm). The saltiest waters, as in previous years were located off the NW of the Iberian Peninsula and the southern part of the Gulf of Cadiz (Figure 8.1.1.1**)**.

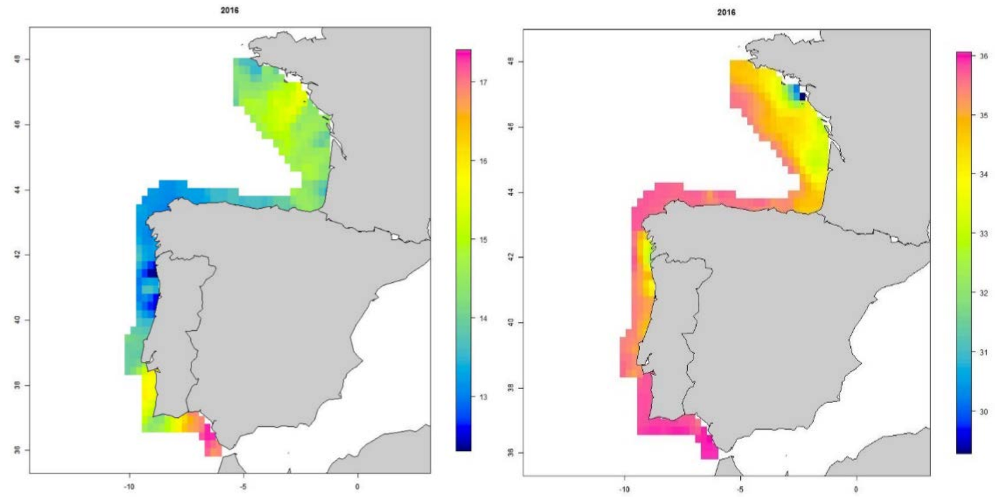


Figure 8.1.1.1: Sea surface temperature (left) and salinity (right) in spring 2016 as recorded by the thermosalinometer during the spring acoustic surveys (*PELAGO, PELACUS* and *PELGAS*)

8.1.2 Trawl species composition

Although fishing hauls are normally conducted to provide ground-truth to the echotraces recorded by the echosounders and also to estimate an age/length spatial distribution by species along the surveyed area, thus done in an opportunistic way, they will reflect the abundance of the main pelagic fish species related to the echotraces. It should be noted that fishing gears are different in each survey, and in the case of the French survey, additional hauls were done by commercial vessels (pair-trawl)

Figure 8.1.2.1 shows the % in number (PELAGO and PELACUS) and in weight (PELGAS) of the fishing stations done during the spring acoustic surveys. The proportion by species and areas obtained this year did not differ from that obtained last year, although this year, anchovy was found in larger proportions in north Portugal and also during PELACUS at the inner part of the Bay of Biscay, where the bulk of the Spanish fleet targeting on this species was also concentrated; in this area sardine proportion was almost negligible.

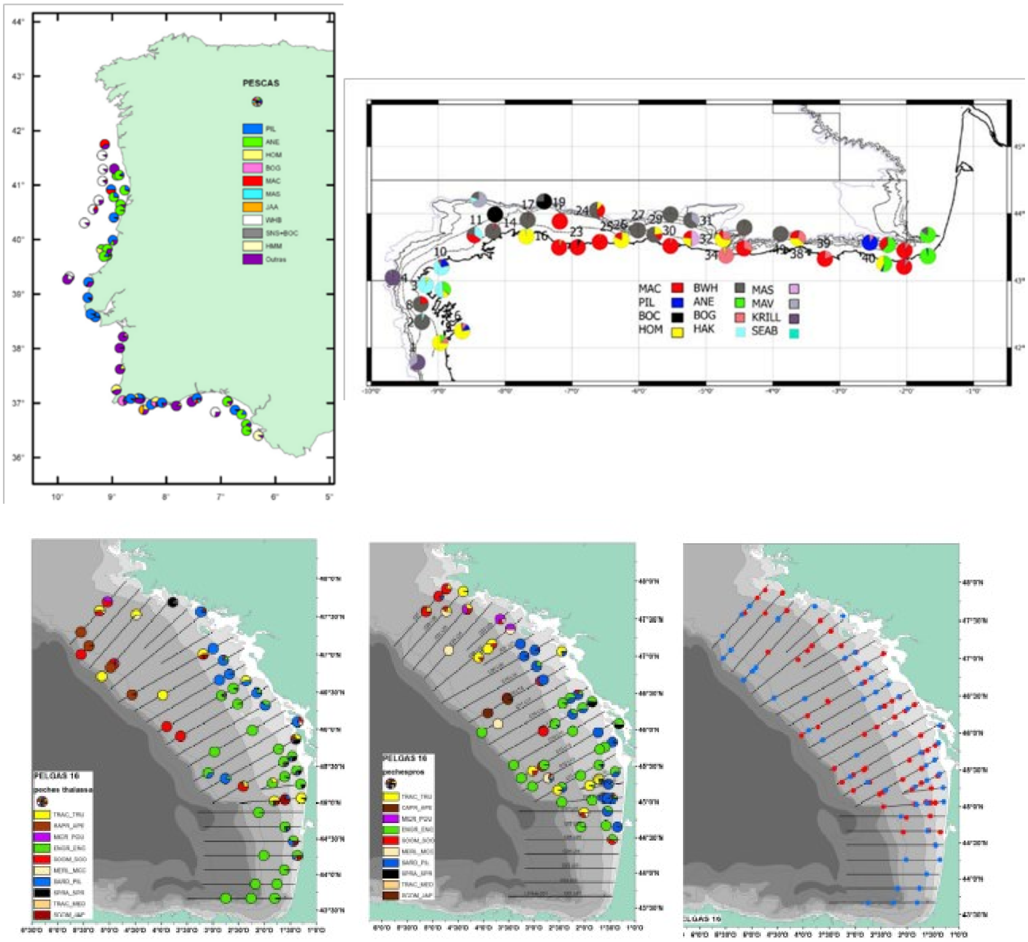


Figure 8.1.2.1. Catch proportion found at the fishing station. Above, during PELAGO (left) and PELACUS (right); below during PELGAS(right panel, catches from RV Thalassa; central one, from the commercial vessels; and right panel the total number of fishing stations –blue dots, RV Thalassa, red one, commercial vessels)

8.1.3 Sardine and anchovy distribution derived from NASC

8.1.3.1 Sardine

Distribution area of sardine, as derived from the NASC values is showing a decreasing trend, shrinking the distribution area towards the sourthern part (9aS and 9a Cadiz) and coastal areas of the French slope. Density was general low and only in few cells mean values are above 1000 m^2 nmi^{-2} (Figure 8.1.3.1.1). No offshore distribution in the French area, as observed in 2015, has been seen this year.

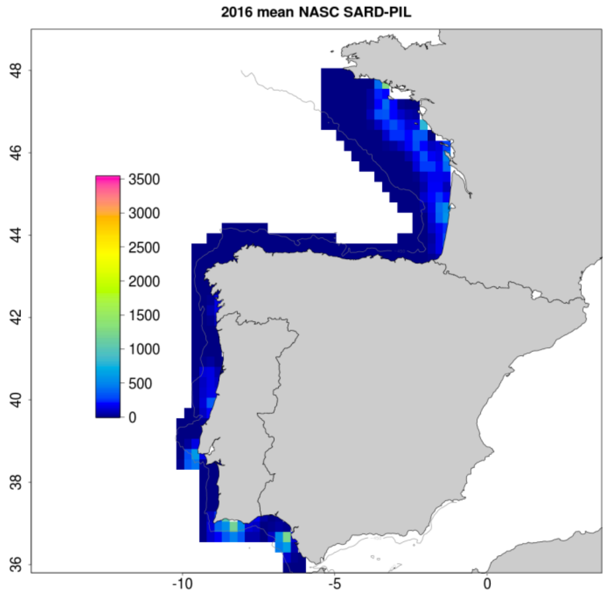


Figure 8.1.3.1.1. Mean backscattering energy (NASC, $m^2 mn^{-2}$) per 0.25°x0.25° square allocated to sardine during the 2016 spring acoustic surveys.

8.1.3.2 Anchovy

It seems the anchovy distribution is spreading along the surveyed area, especially towards northern and southern Portuguese waters and also towards the Spanish easternmost area of the Bay of Biscay (Figure 8.1.3.2.1.). In turn, the density around the Garonne area was lower than that observed last year

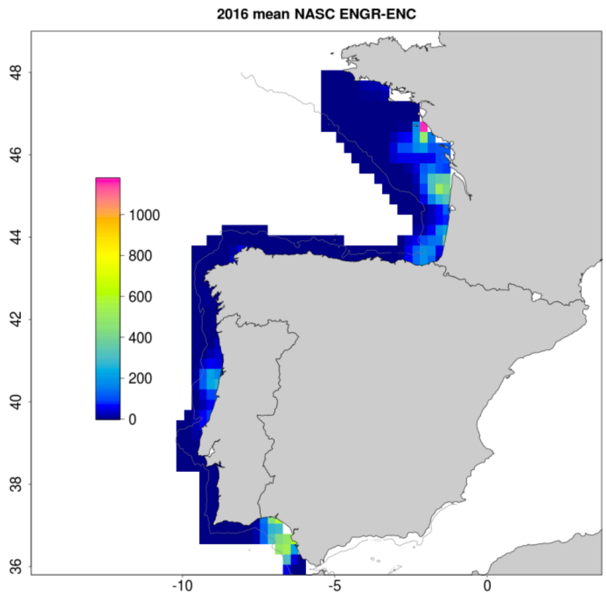


Figure 8.1.3.2.1. Mean backscattering energy (NASC, $m^2 mn^{-2}$) per 0.25°x0.25° square allocated to anchovy during the 2016 spring acoustic surveys.

8.1.4 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 of weight or length calculated for the whole area. During spring 2016, the main differences occurred in weight at age for older sardines, especially from those sardines caught in 8ab compared with those from the southern part (9aS), differences in weight were higher to those observed in size, as shown in figures 8.1.4.1 and 8.1.4.2.

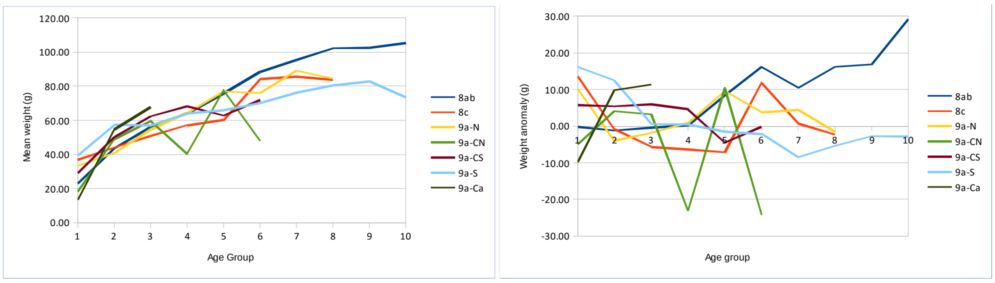


Figure 8.1.4.1: Mean weight-at-age by ICES subdivision and mean weight-at-age anomaly (difference between mean weight-at-age in each ICES subdivision and the weighted mean weight or length-at-age calculated for the whole surveyed area)

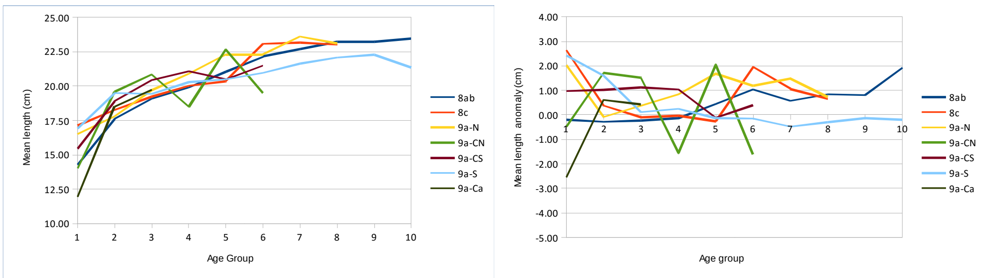


Figure 8.1.4.2: Mean length-at-age by ICES subdivision and mean length-at-age anomaly (difference between each mean length-at-age by ICES subdivision and the weighted mean length for each age)

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 2003–2014. Results are shown in figures 8.1.4.3 and 8.1.4.4. Sardine in 8a,b shown a decreasing trend in mean weight between 2003–2013; since that it seems the mean weight is stable and similar to those of 9a and 8c. In this last case, a sharp decrease is observed since 2012, with mean weight decreasing from 80 gr on average from the period 2003–2012 to less than 46 gr this year. In 2016 mean weight for all divisions are similar. The same trend is also observed in mean length. In 8c and since 2012 mean length has decreased from 22 cm (on average 2003–2012) to only 18.5 cm, evidencing, thus, the lack of bigger sardines in this area in the most recent years. Mean weight for the whole time-series is found at 41.67 gr, corresponding to a mean size of 17.02 cm. Lowest mean weight and length were achieved in 2005, 2013, and 2015 due to the (relative) strength of the incoming year class in both 9a and 8ab.

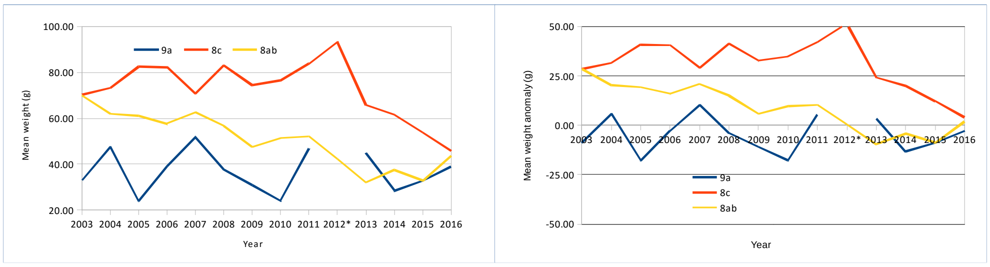


Figure 8.1.4.3: Mean weight by year and ICES subdivision and mean weight anomaly (difference between each mean weight by ICES subdivision and the weighted mean weight for the 2003–2016 time-series). In 2012 no acoustic survey was undertaken by Portugal.

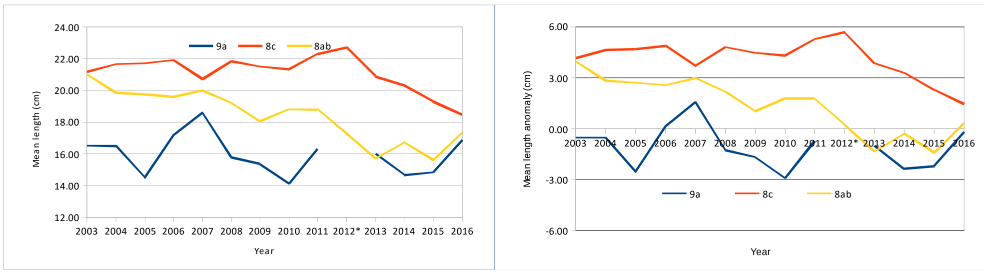


Figure 8.1.4.4: Sardine mean length by year and ICES subdivision and mean length anomaly (difference between each mean length by ICES subdivision and then weighted mean length for the 2003–2016 time-series). In 2012 no acoustic survey was undertaken by Portugal

Table 8.1.4.1: Sardine mean weight by age group and ICES subdivision estimated from 2016 spring surveys

	1	2	3	4	5	6	7	8	9	10	Mean
8ab	22.94	43.64	56.03	63.76	75.71	88.48	95.36	102.21	102.39	105.47	43.60
8c	36.78	43.96	50.79	57.12	60.20	84.12	85.52	83.69			45.73
9a-N	33.30	40.85	54.59	64.40	76.94	76.05	89.21	84.47			40.42
9a-CN	18.24	48.95	59.68	40.52	77.66	48.00					22.69
9a-CS	28.88	50.23	62.39	68.16	62.84	72.02		72.02			38.03
9a-S	39.44	57.37	57.05	64.05	65.84	70.10	76.34	80.61	82.78	73.38	61.42
9a-Ca	13.38	54.69	67.84								15.50
Mean	23.20	44.87	56.47	63.56	67.34	72.26	84.82	86.03	85.50	76.30	41.65

Table 8.1.4.2: Sardine mean length by age group and ICES subdivision estimated from 2016 spring surveys

	1	2	3	4	5	6	7	8	9	10	Mean
8ab	14.29	17.61	19.09	19.91	21.06	22.15	22.70	23.21	23.23	23.45	17.35
8c	17.12	18.26	19.22	20.03	20.36	23.08	23.18	23.02			18.47
9a-N	16.50	17.80	19.70	20.90	22.30	22.30	23.60	23.10			17.60
9a-CN	14.01	19.59	20.84	18.50	22.66	19.50					14.79
9a-CS	15.46	18.90	20.44	21.09	20.50	21.50		21.50			16.87
9a-S	16.91	19.49	19.44	20.30	20.49	20.97	21.64	22.08	22.28	21.34	19.90
9a-Ca	11.93	18.50	19.75								12.25
Mean	14.48	17.88	19.33	20.05	20.62	21.11	22.12	22.37	22.41	21.53	17.17

Table 8.1.4.3: 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**	**2015**	**2016**
Sp-9a	54.13	60.88	23.71	44.25	60.93	68.35	47.62	67.80	50.17		51.01	37.30	54.24	40.42
Pt-9a	32.35	46.84	23.92	38.86	50.94	34.86	30.75	23.15	46.97		44.89	28.45	32.42	38.87
9a	32.95	47.54	23.91	39.10	51.84	37.66	30.83	24.04	47.00		44.94	28.45	32.78	38.88
8c	70.22	73.21	82.52	82.27	70.79	83.01	74.41	76.51	83.90	93.20	65.85	61.55	53.90	45.73
8ab	70.13	61.97	61.00	57.65	62.67	56.67	47.51	51.47	52.04	42.28	32.08	37.50	32.89	43.60
Mean	40.84	57.20	32.99	43.85	54.53	49.73	40.88	38.40	50.99	42.73	34.03	35.19	33.09	41.65
Aver-all	41.67													

Table 8.1.4.4: 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**	**2015**	**2016**
Sp-9a	19.48	20.25	14.43	17.61	19.78	20.48	18.33	20.30	18.80		18.98	17.05	19.08	17.60
Pt-9a	16.42	16.30	14.50	17.16	18.47	15.34	15.34	14.00	16.30		16.00	14.66	14.75	16.85
9a	16.50	16.50	14.50	17.18	18.59	15.77	15.35	14.12	16.32		16.02	14.66	14.82	16.85
8c	21.17	21.66	21.71	21.91	20.72	21.83	21.50	21.32	22.30	22.70	20.88	20.30	19.30	18.47
8ab	20.97	19.85	19.74	19.60	20.01	19.21	18.06	18.80	18.80	17.26	15.70	16.73	15.62	17.35

Mean	17.48	18.66	15.76	17.77	18.92	17.81	16.96	16.54	18.12	17.31	15.76	16.18	15.52	17.17
Aver-all	17.02													

For anchovy, mean weight at age in 8a,b is shown in the following table:

	Age groups					
	1	2	3	4	5	mean
Mean weight	9.37	14.12	30.70	23.97	38.43	5.66

Mean weight at age shows a slight decreasing trend, as that observed for sardine. Whether these decreasing trends in both species in French waters are consequences of and density-dependence effect or the outcome of the good strength of incoming year classes among other explanations are still matter of concern.

8.1.5 Sardine and anchovy biomass and abundance estimation

Figure 8.1.5.1 show the numbers-at-age by ICES subdivision estimated during the 2016 spring acoustic surveys. Age group 1 was the most abundant and mainly occurred in French waters, and North Portugal. Age group 1 is evenly distributed between the French and the Portuguese waters, while age groups 2-4 are mainly found in the French area. Older fish (+5) are mainly found in South Portugal, as observed in previous years.

Table 8.1.5.1: Sardine abundance at age by ICES subdivision estimated during the 2016 spring acoustic surveys. Numbers in millions

Age group	8ab	8c	9a-N	9a-CN	9a-CS	9a-S	9a-Ca	Total
1	1332.98	62.25	12.25	1143.81	862.71	152.34	235.06	3801.39
2	2361.65	148.28	9.18	100.92	287.91	83.49	7.61	2999.03
3	868.04	86.13	2.42	55.54	82.03	289.58	3.80	1387.54
4	481.75	25.05	1.20	6.89	25.09	214.50	0.00	754.48
5	69.19	2.35	0.24	2.72	59.25	218.44	0.00	352.18
6	30.38	0.26	0.03	4.67	2.28	176.54	0.00	214.16
7	48.91	0.70	0.12	0.00	0.00	60.84	0.00	110.56
8	10.11	0.67	0.10	0.00	2.28	23.96	0.00	37.13
9	2.92			0.00	0.00	18.08	0.00	20.99
10	1.09			0.00	0.00	10.87	0.00	11.96
Total	5207.02	325.68	25.54	1314.53	1321.56	1248.62	246.46	9689.42

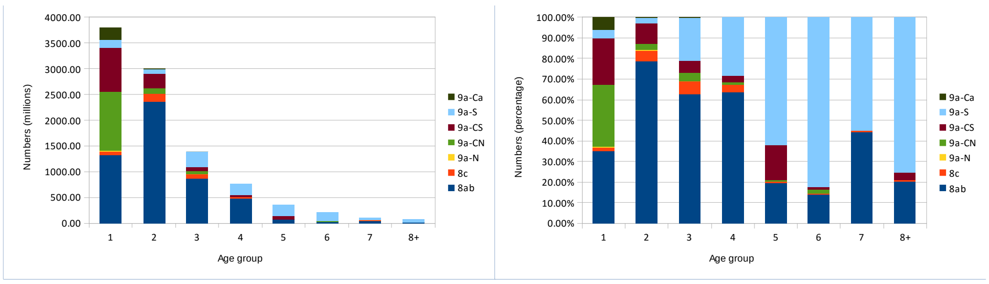


Figure 8.1.5.1: Sardine abundance at age by ICES subdivision estimated during the 2016 spring acoustic surveys. Left panel in absolute numbers (million fish); right panel, relative numbers-at-age.

Table 8.1.5.2: Sardine biomass at age (thousand tonnes) by ICES subdivision estimated during the 2016 spring acoustic surveys.

Age group	8ab	8c	9a-N	9a-CN	9a-CS	9a-S	9a-Ca	Total
1	30.58	2.29	0.41	20.86	24.91	6.01	3.15	88.21
2	103.06	6.52	0.38	4.94	14.46	4.79	0.42	134.56
3	48.64	4.38	0.13	3.31	5.12	16.52	0.26	78.36
4	30.72	1.43	0.08	0.28	1.71	13.74	0.00	47.95
5	5.24	0.14	0.02	0.21	3.72	14.38	0.00	23.71
6	2.69	0.02	0.00	0.22	0.16	12.37	0.00	15.47
7	4.66	0.06	0.01	0.00	0.00	4.64	0.00	9.38
8	1.03	0.06	0.01	0.00	0.16	1.93	0.00	3.19
9	0.30		0.00	0.00	0.00	1.50	0.00	1.80
10	0.11		0.00	0.00	0.00	0.80	0.00	0.91
Total	227.03	14.89	1.03	29.83	50.26	76.69	3.82	403.55

In biomass (Figure 8.1.5.2) age group 2 was also the most abundant, mainly due to the strength of the 2014 year class in French waters, where this cohort accounted up to the 75% of the total biomass. As observed in numbers, older ages are mainly concentrated in the Algarve (South Portugal)

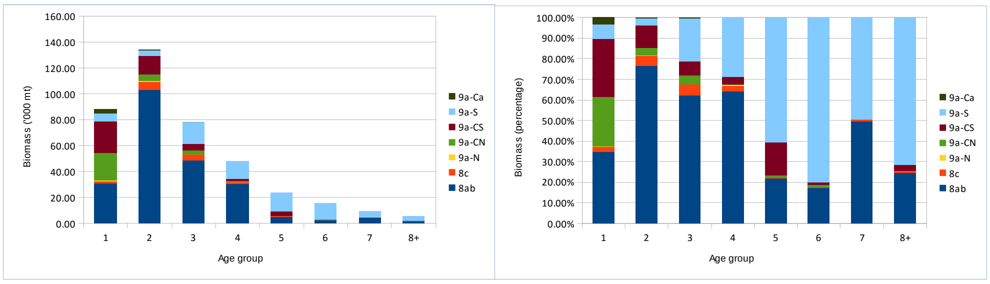


Figure 8.1.5.2: Sardine abundance at age by ICES subdivision estimated during the 2016 spring acoustic surveys. Left panel in absolute biomass (thousand tonnes); right panel, relative biomass at age.

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 8.1.5.3). Nevertheless, this year, in the main nursery areas, an unexpected amount of young of the year were detected in French waters and in the Gulf of Cadiz. These fish, although born at the end of the 2015, belonged to 2016 cohort, as they hatched at the beginning of the spawning season which uses to start at the end of the 3rd quarter and ending at the end of the second one. This phenomenon has been observed in previous year, especially in French and Portuguese waters.

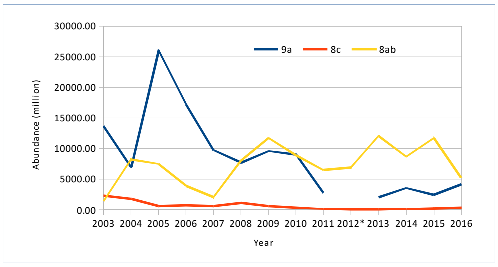


Figure 8.1.5.3: Sardine abundance at age by ICES subdivision estimated during the spring acoustic surveys 2003–2016. Left panel biomass (thousand tonnes); right panel, numbers (millions). In 2012 no acoustic survey was undertaken by Portugal.

Table 8.1.5.3: Sardine abundance (billion fish) by ICES subdivision estimated during the spring acoustic surveys for the period 2003–2016. In 2012 no acoustic survey was undertaken by Portugal.

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Sp-9a	372.32	347.51	905.61	753.10	868.56	643.29	45.15	179.07	26.06		15.93	1.34	40.28	25.54
Pt-9a	13290.32	6623.65	25223.37	16485.11	8872.62	7031.10	9529.80	8861.69	2697.55		2026.22	3561.50	2403.41	4131.18
9a	13662.64	6971.16	26128.98	17238.21	9741.17	7674.39	9574.96	9040.75	2723.61		2042.15	3562.84	2443.69	4156.72
8c	2290.31	1749.31	565.11	730.56	613.82	1118.70	567.52	359.75	123.65	61.02	38.42	145.80	150.32	325.68
8ab	1382.42	8247.98	7465.71	3901.39	2005.77	7983.51	11666.87	8883.33	6479.40	6896.23	12012.27	8722.60	11747.42	5207.02
total	17335.37	16968.45	34159.79	21870.16	12360.77	16776.59	21809.35	18283.83	9326.66	6957.25	14092.84	12431.24	14341.42	9689.42

Table 8.1.5.4: Sardine biomass (thousand tonnes) by ICES subdivision estimated during the spring acoustic surveys for the period 2003–2016. In 2012 no acoustic survey was undertaken by Portugal.

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Sp-9a	20.43	21.16	21.51	33.33	52.94	44.23	2.17	12.14	1.31		0.81	0.05	2.20	1.03
Pt-9a	432.12	309.54	587.41	637.39	451.57	245.18	293.00	205.16	126.71		90.95	101.05	77.92	160.59
9a	452.55	330.71	608.92	670.72	504.51	289.42	295.17	217.30	128.01		91.77	101.10	80.12	161.62
8c	164.47	128.08	46.63	60.10	43.45	93.27	42.43	27.53	10.37	5.69	2.53	8.97	8.18	14.89
8ab	111.23	496.37	435.29	234.13	126.24	460.73	479.68	457.08	338.47	205.63	407.74	339.61	386.34	227.03
total	728.26	955.16	1090.84	964.95	674.20	843.41	817.28	701.91	476.85	211.32	502.04	449.68	474.64	403.55

For anchovy, abundance and biomass by age group in 8a,b are shown in the following table:

	Age groups				
	1	**2**	**3**	**4**	**Total**
Abundance (million fish)	3799.75	3476.60	159.58	5.61	7441.55
Biomass (thousand tonnes)	35.60	49.09	4.90	0.13	125.43

8.1.6 Other fish species

Spring surveys also provide abundance estimates and distribution for other pelagic fish species such as mackerel, horse mackerel, boar fish, bogue, chub mackerel or sprat. However, only data from PELACUS are available, although NASC distribution maps are provided for all surveys. Details are summarized in Table 8.1.6.1

Table 8.1.6.1. Available information (NASC distribution and biomass estimation -thousand tonnes when available-) by ICES Divisions (9a split in northern Spain, Portugal and Gulf of Cadiz) for mackerel (MAC), horse mackerel (HOM), Mediterranean horse mackerel (HMM), Blue whiting (WHB), sprat (SPR), boar fish (BOC), chub mackerel (MAS), lanternfish (MAV), hake (HKE) and bogue (BOG).

	MAC		**HOM**		**WHB**		**MAS**		**BOC**		**MAS**	**MAV**	**HKE**	**BOG**	**SPR**
Area	NASC	Biom.	NASC	Biom.	NASC	Biom.	NASC	Biom.	NASC	Biom.	NASC	NASC	NASC	NASC	NASC
8ab	Y	na	Y	119	Y	18	Y	295	Y	4	-	-	Y	-	Y
8c	Y	497	Y	62	Y	26	Y	na	Y	16	Y	Y	Y	Y	
9a-Sp	Y	0.20	Y	27	Y	3	-	na	-	-	Y	Y	Y	Y	
9a-Pt	-	-	Y	na		-	-	-	-	-	Y	-	-	Y	
9a-GoC	-	-	Y	na		-	-	-	-	-	Y	-	-	Y	

8.1.6.1 Mackerel

Data for mackerel were provided by PELACUS and PELGAS, although the assessment for this species in 8a,b is considered as inconsistent, given the great c.v. Instead, only NASC values area provided. Comparing with previous years, it seems the migration towards the spawning grounds around the Spanish waters took place later than expected; rather than a continuous distribution, mackerel occurred in dense spots.

Figure 8.1.6.1.1 shows the NASC-derived distribution map. Most of the records were located in the western part of 8c and in a coastal patch south Brittany and in the central part of the French shelf either in coastal waters or along the slope. Comparing with the previous year, the Southern component located in Iberian waters had a lower distribution area while the western component located on the French shelf had a wider distribution.

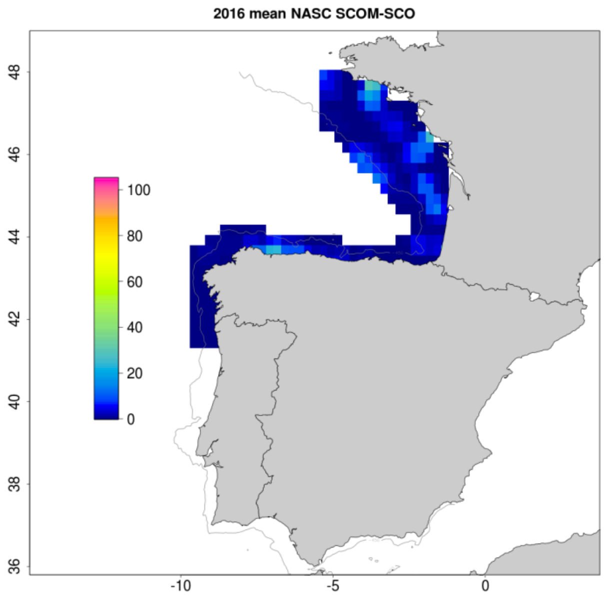


Figure 8.1.6.1.1: Average mackerel abundance and distribution derived from NASC raw values (only for those areas where data were available)

8.1.6.2 Horse mackerel

Horse mackerel shown, as for mackerel, a scarce density in the Cantabrian Sea, reaming more or less at the same level as that recorded last year. In 8a,b, the distribution pattern and density was similar to that observed last year although a high spot occurred in 2016 close to the Arcachon area.

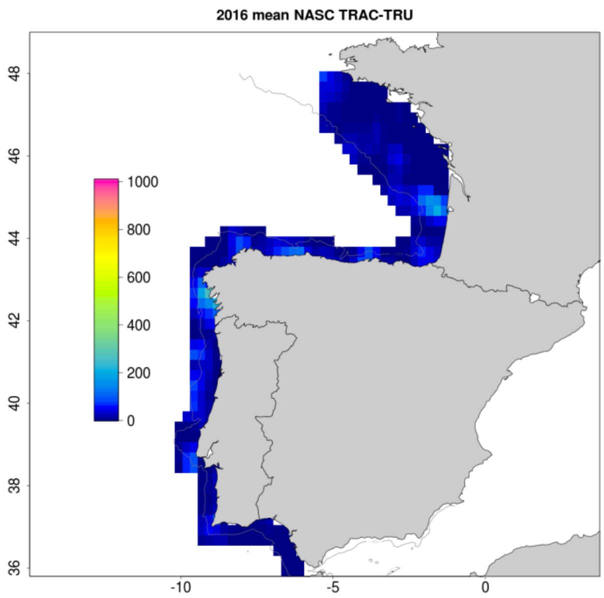


Figure 8.1.6.2.1: Average horse mackerel abundance and distribution derived from NASC raw values (only for those areas where data were available)

8.1.6.3 Blue whiting

Blue whiting was mainly recorded during PELACUS survey. However, the distribution area wouldn't be entirely covered by PELGAS as in this area an offshore extension in pelagic layers is also expected. Main concentration was located in the western part of the Cantabrian, which was similar to that found in 2015. On the French shelf, it the abundance was higher than that observed last year.

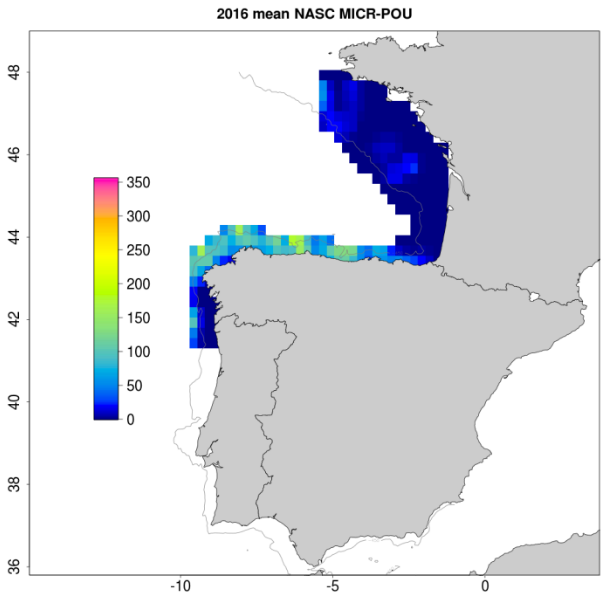


Figure 8.1.6.3.1: Average blue whiting abundance and distribution derived from NASC raw values (only for those areas where data were available)

8.1.6.4 Sprat

NASC data from sprat are only provided by PELGAS where this fish species, as observed in previous years, occurred around the main river plume areas (Garonne and coastal waters of Brittany). Nevertheless, the density was much lower than that recorded in 2015.

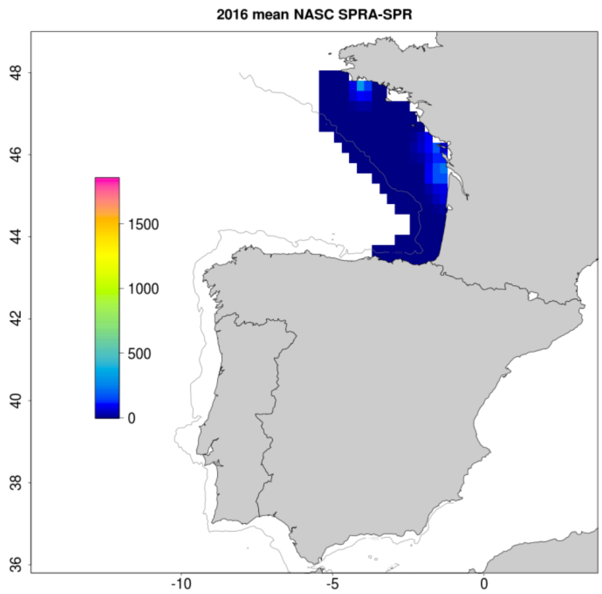


Figure 8.1.6.4.1: Average sprat abundance and distribution derived from NASC raw values (only for those areas where data were available).

8.1.6.5 Boar fish

For boar fish only PELACUS and PELGAS, together with the specific survey BFAS conducted in 7, are providing abundance and spatial distribution. Compared with the previous year, both spatial distribution and abundance have decreased.

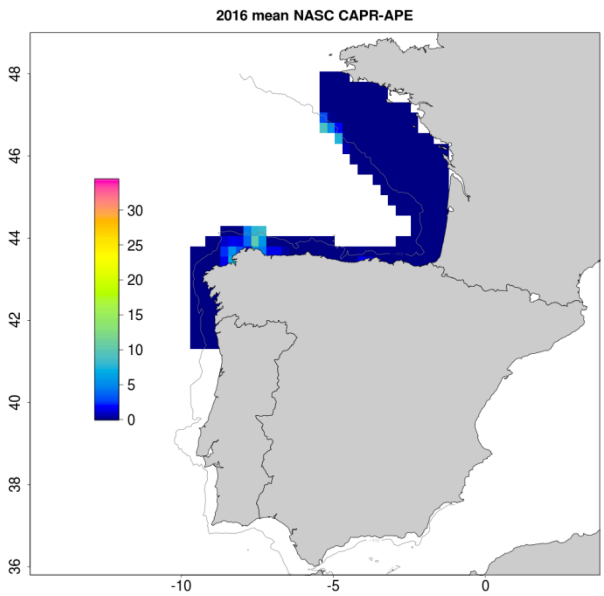


Figure 8.1.6.5.1: Average boar fish abundance and distribution derived from NASC raw values (only for those areas where data were available).

8.1.6.6 Chub mackerel

This year only PELACUS and PELGAS provided data for this species. Density was higher that observed in 2015, especially in France.

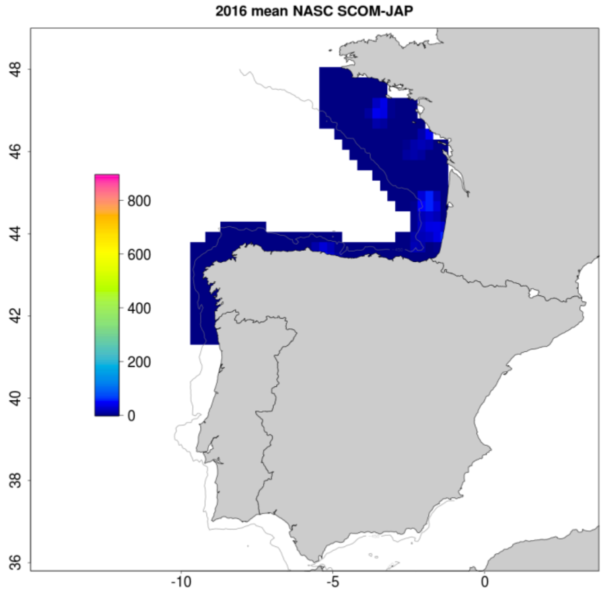


Figure 8.1.6.6.1: Average chub mackerel abundance and distribution derived from NASC raw values.

8.1.6.7 Mediterranean horse mackerel

Mediterranean horse mackerel mainly occurs at the inner part of the Bay of Biscay. Higher density was found close to the Spanish French border, south Arcachon, with another spot located north the Garonne mouth.

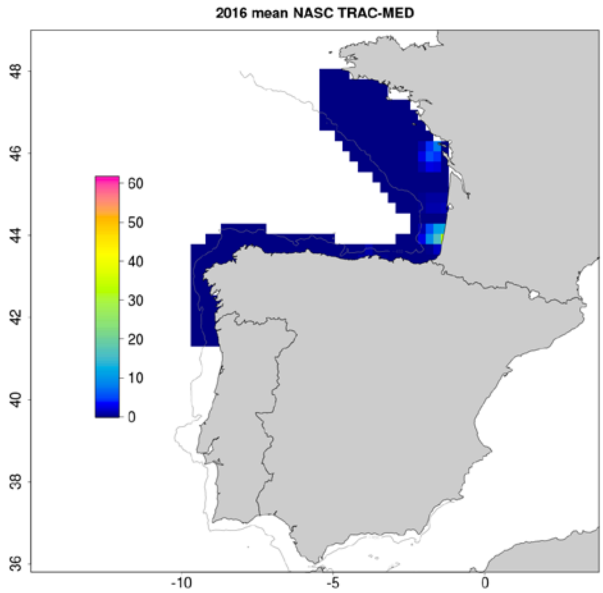


Figure 8.1.6.7.1: Average Mediterranean horse mackerel abundance and distribution derived from NASC raw values (only for those areas where data were available).

8.1.6.8 Bogue

NASC values for bogue were only provided by PELACUS survey, showing similar distribution pattern and density as observed in 2015 (figure 8.1.6.8.1).

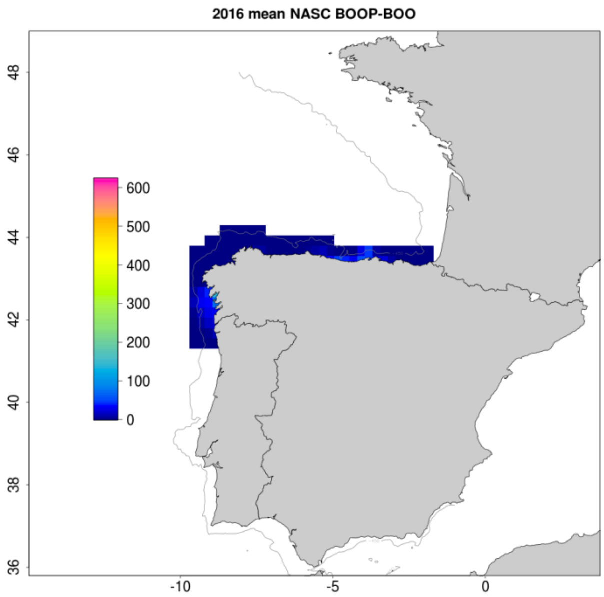


Figure 8.1.6.8.1: Average bogue abundance and distribution derived from NASC raw values (only for those areas where data were available).

8.1.6.9 Hake

NASC values for hake are derived from the fish proportion found at the ground-truthed fishing stations in PELACUS and PELGAS. These were mainly composed by small size (<25 cm) specimen and thus reflecting areas of higher juvenile concentration. In 2016 there was an important increase in both distribution area and density, especially on the French shelf were hake was mainly found at the inner part of the Bay of Biscay and in the north-central part of the continental shelf. Around the Spanish waters, as observed last year, major concentration were recorded in the NW corner. In addition, in this area an important amount of very pelagic young of the years schools were detected (figure 8.1.6.9.1).

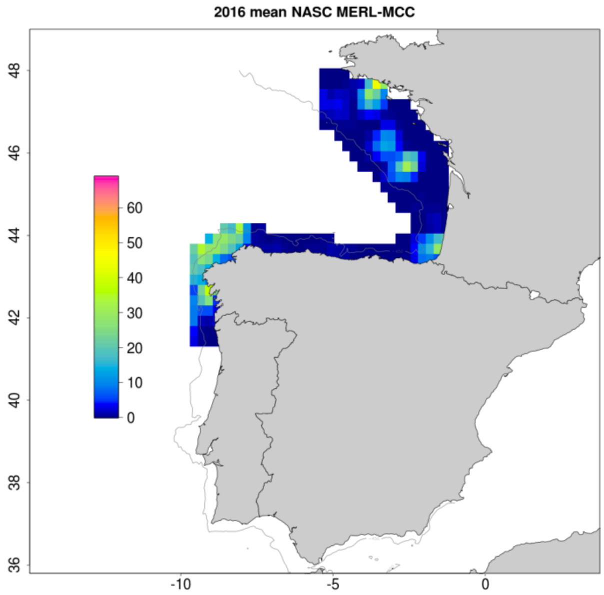


Figure 8.1.6.9.1: Average hake abundance and distribution derived from NASC raw values (only for those areas where data were available).

8.1.6.10 Silver Lightfish

Normally *M. muelleri* occurred offshore, from the slope to deep-sea waters. The main distribution area for this species as recorded by PELACUS is located in the western part and seems to be stable (Figure 8.1.6.10.1).

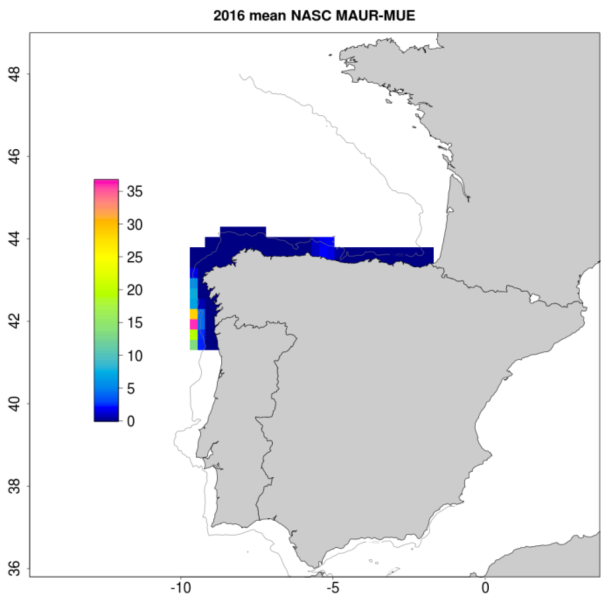


Figure 8.1.6.10.1: Average silver light fish abundance and distribution derived from NASC raw values (only for those areas where data were available).

8.1.7 Other observations

Marine mammals and birds were also recorded, but only data from PELGAS (2122 specimens recorded) and PELACUS (625 specimens) are available. While common dolphin was the most recorded species in the French area (44%), bottlenose dolphin gave the highest records in the Spanish area (42%), most of them in the central part (Cape Peñas), in coincidence with the main distribution area of mackerel. At the inner part of the Bay of Biscay sightings of long-finned pilot whale were also important. Regarding birds, in France (5577 observations) northern gannet was the most common species (55%); in the Spanish area, this species accounted the 30% of the observations, but sea-gulls (*Larus* sp.) accounted in this area up to 66% of the observations.

8.1.8 Sardine and anchovy egg distributions from CUFES sampling

The egg distribution from CUFES sampling is presented in Figure 8.1.8.1. These match quite well with the spatial distribution observed for adults for both species, with the highest concentration of egg located on the central part of the French continental shelf. Egg densities in the Spanish Cantabrian Sea was rather negligible.

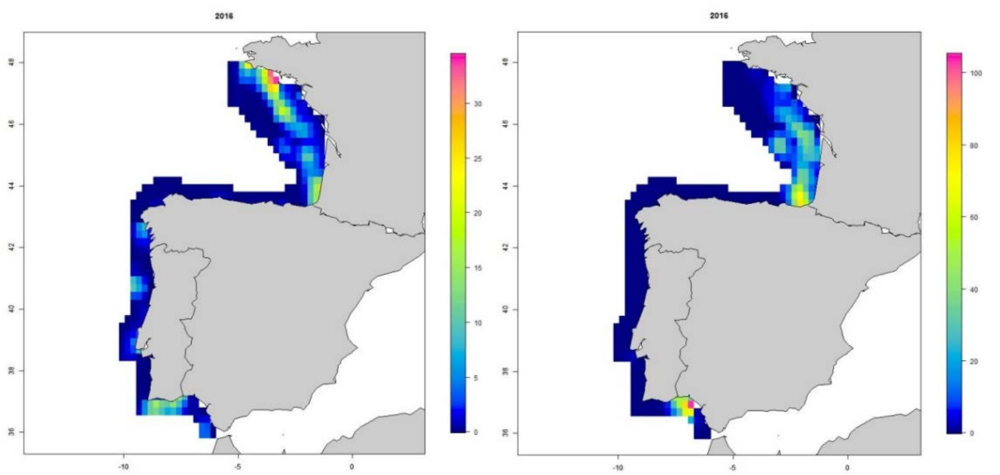


Figure 8.1.8.1: Sardine (left panel) and anchovy (right panel) egg distributions from CUFES (eggs/m^3) sampling during the spring acoustics surveys (IPMA, IEO, Ifremer). Note that due to the data range in the observations the colour scales do not match between left and right panels.

8.2 BIOMAN 2016: Anchovy, sardine and top predators in the Bay of Biscay

8.2.1 Oceanographic conditions (SST, SSS)

The distribution patterns of sea surface temperature (SST) and sea surface salinity (SSS)observed during 2016 daily Egg Production method (DEPM) survey (BIOMAN) in the Bay of Biscay were the typical for the region showing the signature of Garonne River off the French coast. (Figure 8.2.1.1)

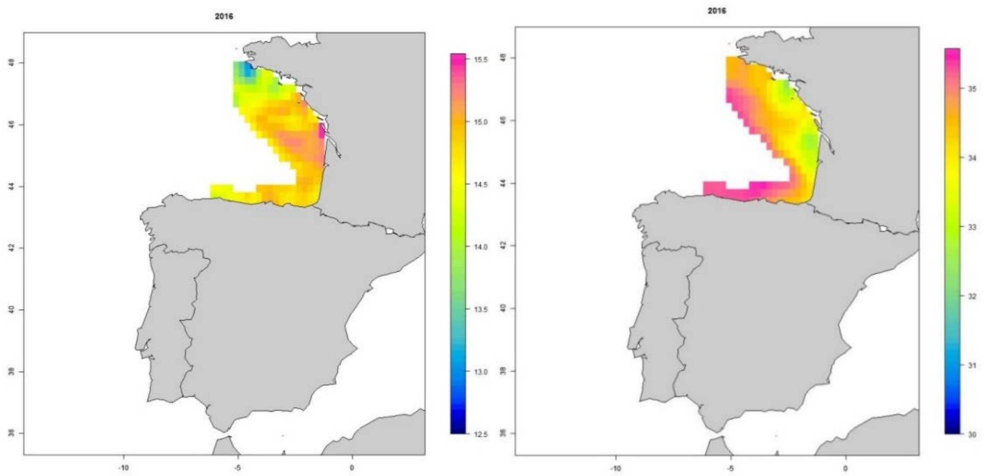


Figure 8.2.1.1. Sea surface temperature (left panel) and salinity (right panel) during May 2016 DEPM survey BIOMAN in the Bay of Biscay.

8.2.2 Anchovy and sardine egg distributions from CUFES and Pairovet observations

This year In the Bay of Biscay during the DEPM survey BIOMAN 2016, the west spawning limit of anchovy eggs was found at 5°17′W at the height of Gijón. In the French platform there were eggs all over the platform until 46°N. From 46°N to 47°23′N the egg were inside the 100 m depth isoline. The northern distribution limit was found at the height of Nantes (47°23′N) (Figure 8.2.2.2). 680 vertical plankton samples were obtained, 69% had anchovy eggs with an average of 550 eggs m^{-2} per station and a maximum of 7530 eggs m^{-2} in a station. Both samplers Pairovet (egg m^{-2}) and CUFES (egg m^{-3}) show the same anchovy egg abundances distribution pattern. For higher spatial resolution in the egg distribution see the detailed maps in Annex 8.9 (WD Santos *et al.,* 2016).

A mean abundance of **sardine eggs**(8.9E+12) in the Bay of Biscay during BIOMAN 2016 were encountered in relation with the historical series, 1.5 times higher than last year; very few eggs were encountered along Cantabrian coast, between 4°20′ and 5°30′ W. In the French platform the eggs were between coast and 100 m depth isoline, all along the coast, from south of France to 48°N, where the north spawning limit was found (Figure 5.1.2.2.3). From the 680 Pairovet samples a total of 266 (39%) had sardine eggs with an average of 290 eggs per m^{-2} per station and a maximum of 6690 eggs m^{-2}. Both samplers Pairovet (egg m^{-2}) and CUFES (egg m^{-3}) show very similar sardine egg abundances distribution pattern.

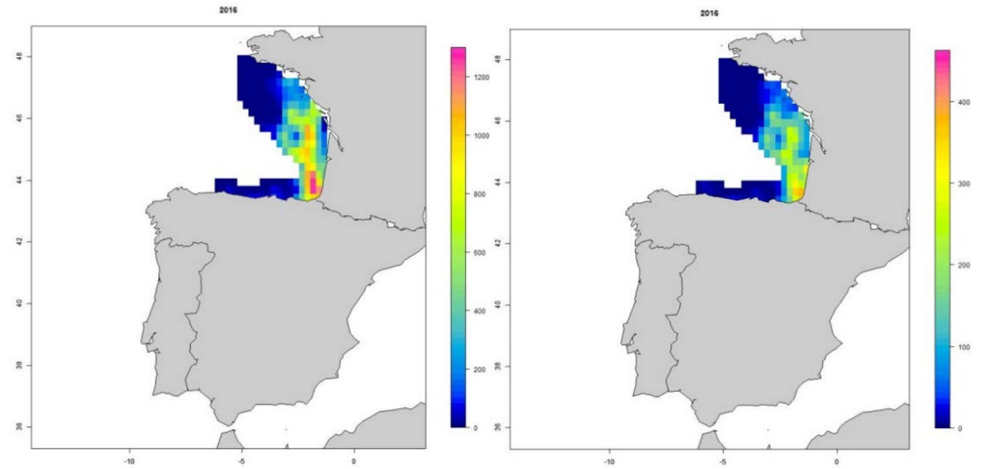


Figure 8.2.2.2. Anchovy egg distributions from Pairovet (left panel; eggs m-2) and CUFES (right panel; eggs m-3) observations collected during the DEPM survey BIOMAN2016.

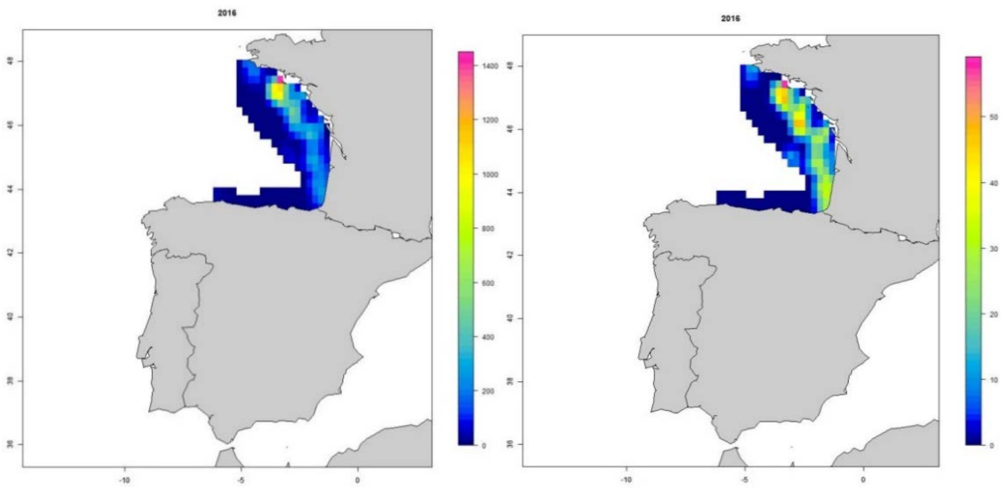


Figure 8.2.2.3. Sardine egg distributions from Pairovet (left panel; eggs m-2) and CUFES (right panel; eggs m-3) observations collected during the DEPM survey BIOMAN2016.

8.2.3 Anchovy egg parameters estimates

In the Bay of Biscay the spawning area for anchovy in 2016 (55 092 km²) was higher than the historical mean (1987–2015) that is 40 901 km². The daily egg production (P_0 = 213 egg m^{-2}) was the highest of the historical series (mean = 82.69). The mortality rate (z = 0.33, this means that 28% of the eggs are dying per day) is higher than the historical series (mean = 0.25, this means 22% of the eggs dying per day). The total daily egg production (P_{tot} = 1.17E+13 eggs) is as well the highest of the historical series (mean = 3.712E+12). (Table 8.2.3.1; Figure 8.2.3.1).

Table 8.2.3.1. Daily egg production (P_0) (eggs m^{-2}), mortality rate (z) and total egg production (P_{tot})(eggs) estimates and their corresponding standard error (s.e.) and coefficient of variation (CV).

Parameter	Value	S.e.	CV
P_0	212.86	21.64	0.1017
z	0.33	0.049	0.1477
Ptot	1.17.E+13	1.2.E+12	0.1017

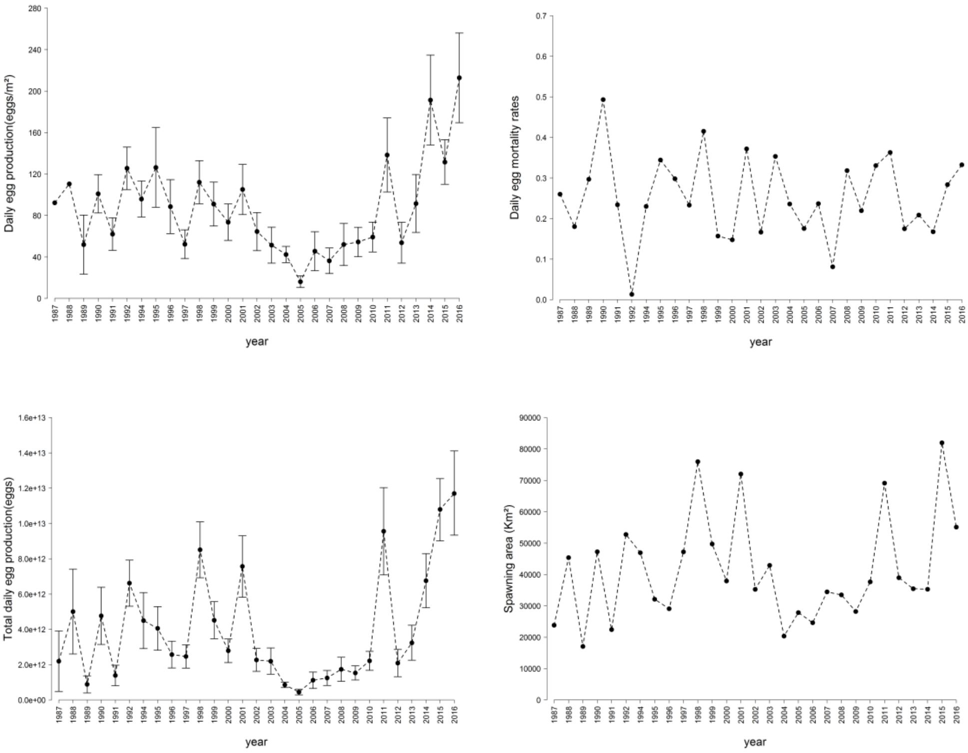


Figure 8.2.3.1. Time-series of DEPM egg parameters and spawning area for anchovy: Daily egg production (P_0) (eggs m^{-2}), mortality rate (z) and total egg production (P_{tot}). Vertical lines indicate 95% confidence intervals (i.e. ±2 standard deviations).

8.2.4 Reproductive parameters and total anchovy biomass estimates

The reproductive parameters for the DEPM in 2016 estimated for Anchovy in the Bay of Biscay in May are showed in Table 8.2.4.1 and Figure 8.2.4.1. Comparing the adult parameters with the corresponding mean historical series (1987–2015) (Figure 5.1.2.4.1), sex ratio (0.53) is at levels of the historical mean (0.54), female mean weight (16.5 g) is the lowest of the historical series (mean = 24.41 g). The batch fecundity this year (6685 eggs per mature female per batch) is the third lowest of the historical series (mean = 11 046 eggs per mature female per batch). The spawning fraction (0.36) is at levels of the historical mean (mean = 38.7) and in consequence the daily fecundity (77.38 egg/g) is lower than the mean historical series (mean = 94.63 egg/g).

Table 8.2.4.1. Reproductive parameters derived from anchovy DEPM survey BIOMAN2016 with their s.e. and CV. Sex ratio (mature females fraction of population by weight),spawning fraction (fraction of mature females spawning per day), batch fecundity (eggs spawned per mature females per batch), female mean weight (g) and daily fecundity (nº of egg per g of biomass) and total biomass (tonnes).

Parameter	estimate	S.e.	CV
R'	0.53	0.005	0.0090
S	0.36	0.014	0.0396
F	6,685	543	0.0812
Wf	16.50	1.091	0.0661
DF	77.38	4.041	0.0522
BIOMASS (Tons)	**152,049**	17,377	0.1143

The Daily Egg Production Method (DEPM) to estimate the anchovy stock biomass in the Bay of Biscay (ICES Subdivision 8abcd) is conducted every year by AZTI (Spain).

The first survey of this series was carried out in 1987. The 2016 anchovy biomass estimate is the second highest of the series (Figure. 5.1.2.4.1; Table 5.1.2.4.2). The high biomass of this year is due to the high total egg production and the low daily fecundity obtained due to the small anchovy encounter this year. Actually, the weight of the anchovy is going down progressively since 2010 and this year was the lowest.

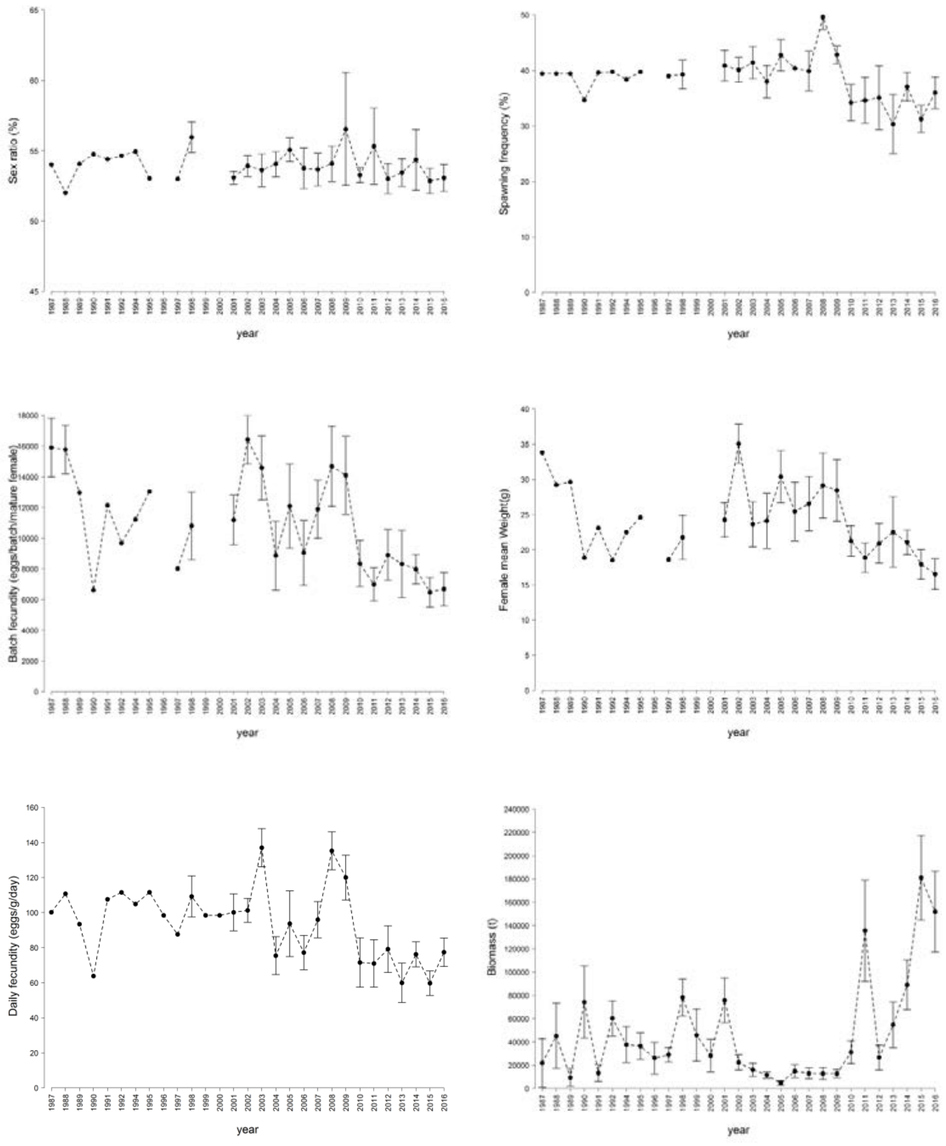


Figure 8.2.4.1. Time-series of anchovy DEPM adult parameters and total biomass. Vertical lines indicate 95% confidence intervals (i.e. ±2 standard deviations). Sex ratio (mature females fraction of population by weight), spawning fraction (fraction of mature females spawning per day), batch fecundity (eggs spawned per mature females per batch), female mean weight (g), daily fecundity (n° of egg per g of biomass) and total biomass (tonnes).

8.2.5 Weight, length, numbers, percentage and biomass-at-age estimates

For the purposes of producing population at age estimates, the age readings based on 2122 otoliths from 31 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. 53% of the population in numbers and 43% in mass corresponded to age 1 (Table 8.2.5.1) and 44% in numbers and 52% in mass corresponded to age 2. This is not a good year of recruitment comparing with the historical series. The weight, length, numbers, percentage and biomass-at-age estimates are showed in Table 8.2.5.1.

Table 8.2.5.1 Anchovy biomass, total mean weight, percentage in numbers, numbers, percentage in mass, biomass, mean weight (g), mean length (mm) at age, from the2016 DEPM survey in the Bay of Biscay with their standard error (s.e.) and Coefficient of variation (CV).

BIOMASS (Tons)	**152,049**	17,377	0.1143
Total mean weight (g)	13.516	1.09	0.0804
Population (millions)	11,264	1609	0.1429
Percentage at age 1	0.530	0.039	0.0731
Percentage at age 2	0.441	0.033	0.0749
Percentage at age 3	0.029	0.008	0.2610
Numbers at age 1	5,981	1,159.2	0.1938
Numbers at age 2	4,961	592.6	0.1194
Numbers at age 3	322	74.4	0.2311
Percent. at age 1 in mass	0.428	0.036	0.0833
Percent. at age 2 in mass	0.515	0.028	0.0540
Percent. at age 3 in mass	0.054	0.012	0.2182
Biomass at age 1 (Tons)	65,312	9,711	0.1487
Biomass at age 2 (Tons)	78,129	9,341	0.1196
Biomass at age 3 (Tons)	8,154	1,986	0.2435
Weight at age 1 (g)	10.92	0.96	0.0883
Weight at age 2 (g)	15.76	0.99	0.0629
Weight at age 3 (g)	26.79	1.33	0.0498
Lenght at age 1 (mm)	120.18	3.54	0.0295
Lenght at age 2 (mm)	134.55	2.85	0.0212
Length at age 3 (mm)	160.92	2.12	0.0132

8.2.6 Sardine total egg abundance

Total egg abundance for sardine was estimate as the sum of the numbers of eggs per m^2 in each station multiply by the area each station represents. This year estimate was 8.56 E+12 eggs, higher than the average in relation with the time-series (5.83 E+12). The historical series of egg abundances is shown in Figure 8.2.2.6. The sardine egg distribution is shown in Figure 8.2.2.3. The eggs in the Cantabrian coast were not account here because does not belong to area 8a,b and the NW were removed in the series present here for the series to be consistent. This egg abundance series was incorporated as an input in the assessment of sardine in 8a,b in June at WGHANSA.

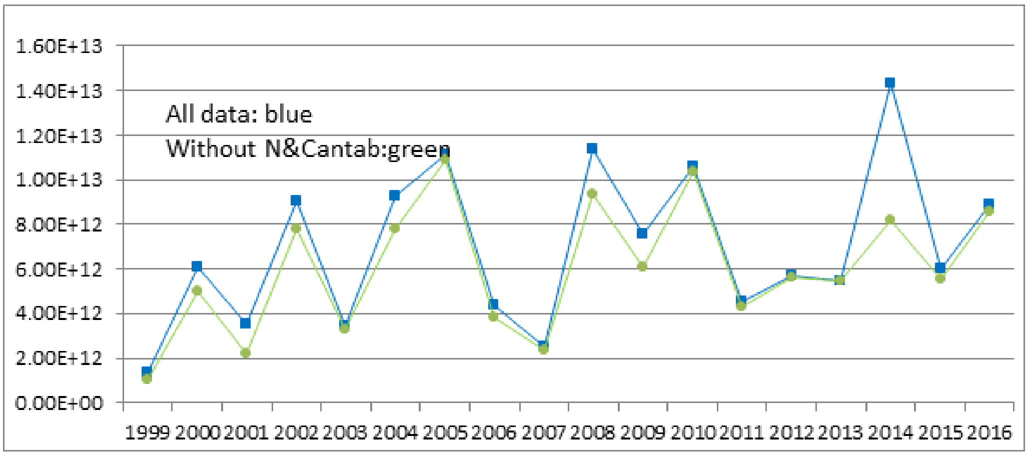


Figure 8.2.2.6: historical series of sardine egg abundances 1999–2016, with all the data (blue line) without the eggs from the Cantabrian coast and NW area (green).

8.2.7 Predators and human activities

Predators and human activities were register for the first time this year. A total of 969 seabirds, 796 cetaceans, 277 of human activities and 33 of land birds were recorded. A complete list is given in Annex 9 (WD Santos *et al.*, 2016).

Regarding **marine mammals**, 4 different species were observed. The spatial distribution of the most abundant species, common dolphin, is showed in Figure 8.2.7.1. Those were mainly concentrated around the area of influence of the Garonne River.

Regarding **seabirds**, 14 different species were observed. Spatial distribution of the most abundant, northern gannet, can be observed in Figure 8.2.7.1. Those were concentrated in the central sector of the study area.

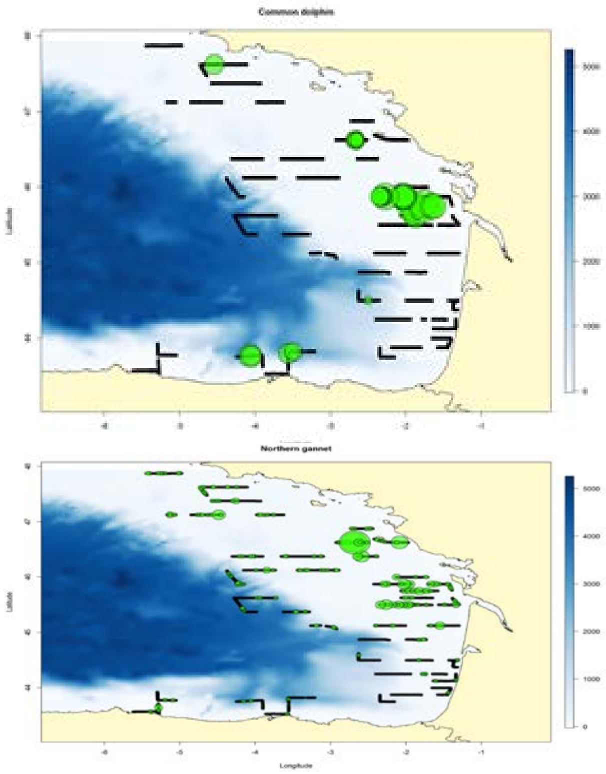


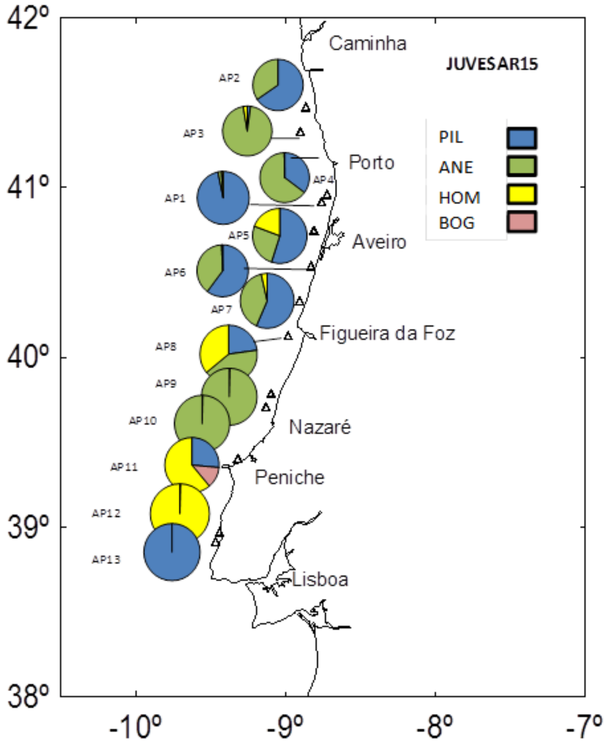
Figure 8.2.7.1. Distribution of the most abundant species of marine mammals: common dolphins(left) and seabirds: northern gannets (right) during BIOMAN 2016.

Regarding **human activities**, 16 different activities-items were observed. The most abundant activities were plastic trashes followed by general trash, fishing buoys, trawlers, and gillnetters. More information in Annex 9 (WD Santos *et al.*, 2016).

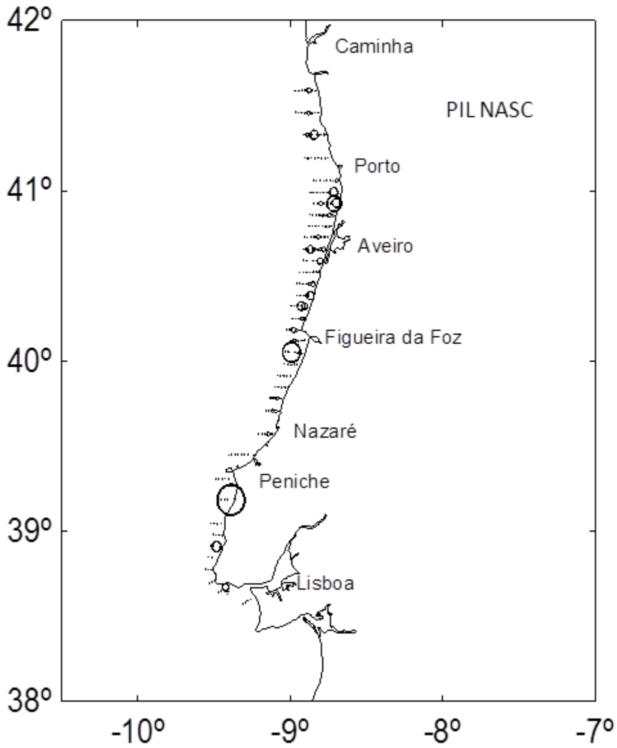
8.3 Autumn JUVESAR15 survey

Juvesar survey was carried out from 5 to 13 December 2015, with RV "Noruega" off the NW coast of Portugal. The main objective was to evaluate the strength of sardine recruitment in the main recruitment area. Anchovy abundance was also estimated in that area.

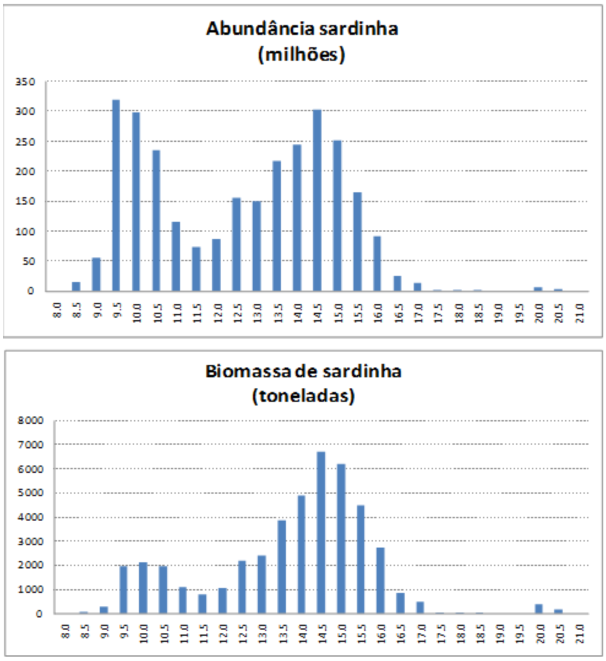
The results point that 98% (in number) of the sardine presented were juveniles, and the abundance estimated was 2831 million, corresponding to 45 thousand tonnes. The length distribution shows two modes at 9.5 cm and 14.5 cm. For anchovy it was estimated 3870 million individuals, corresponding to 30 thousand tonnes, distributed by ages 0 and 1. Data for sea surface temperature, salinity and fluorescence were also received from the CUFES sensors, along the acoustic transects.



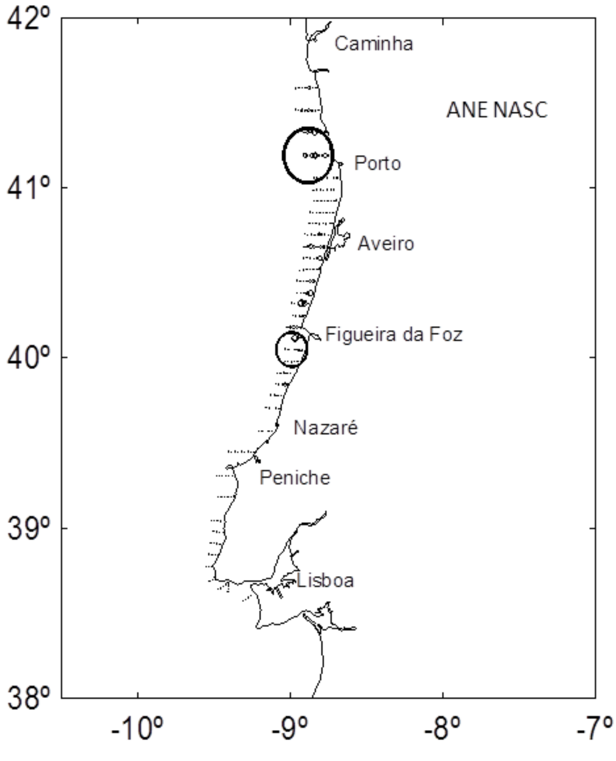
Species proportion in the fishing hauls for sardine, anchovy, horse mackerel, and bogue.



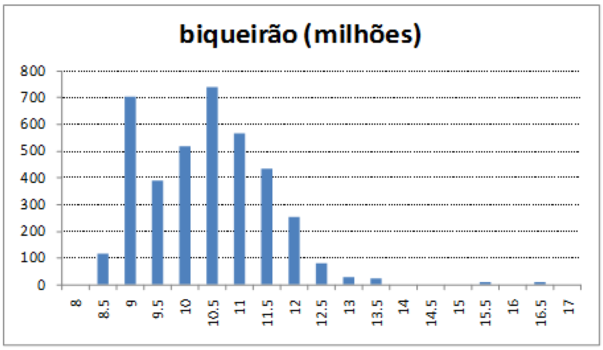
Sardine NASC along the acoustic transects. The major circle corresponds to 8060 m²/mn²



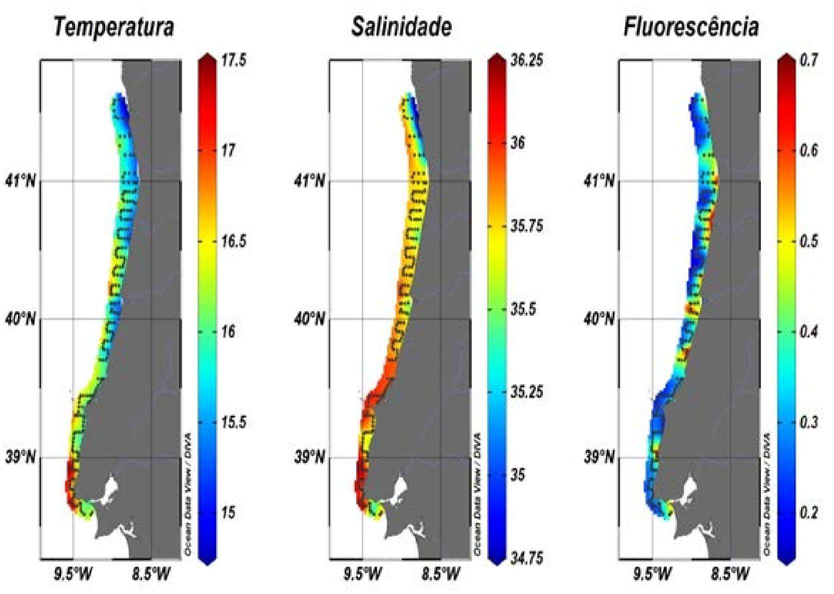
Sardine abundance (million) and biomass (tonnes) by length distribution.



Anchovy NASC distribution. The major circle corresponds to SA = 14 700 m²/mn²



Anchovy abundance and biomass length distribution.



Sea surface temperature, salinity and fluorescence

8.4 Gulf of Cadiz summer survey

Summer survey ECOCADIZ started on 31 July and ended on 12 August, covering the entire Gulf (Spanish and Portuguese waters.

8.4.1 Oceanographic conditions

Sea surface temperature and salinity were within the normal values at this period, with highest temperatures located at the eastern part and the coldest near San Vicente Cap (Figure 8.4.1.1).

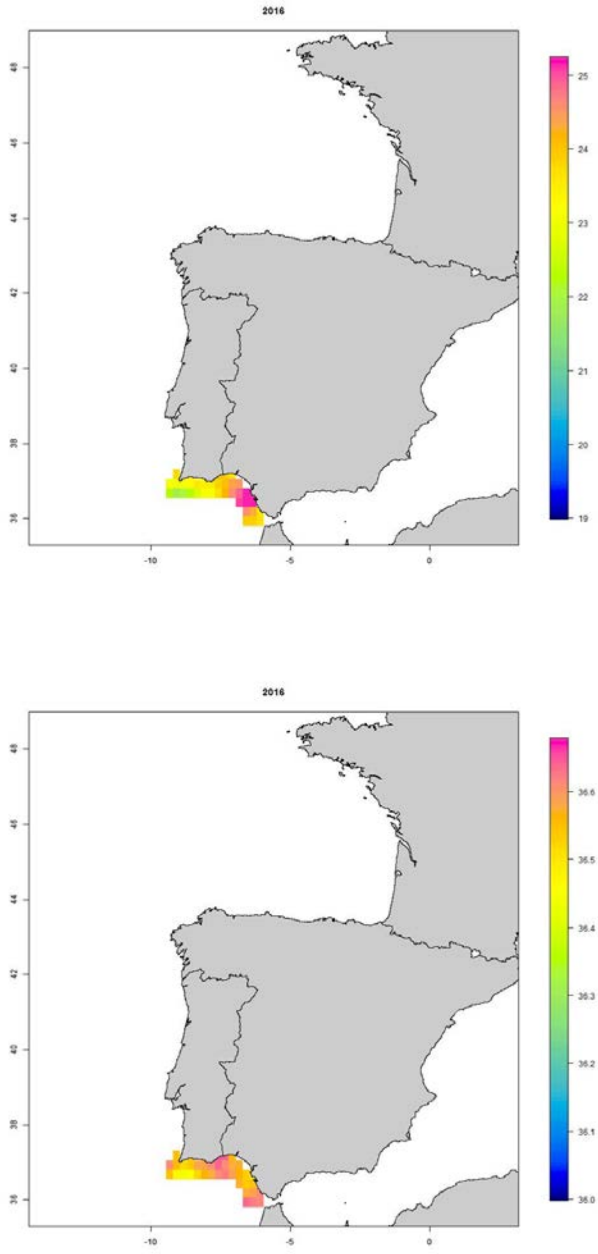


Figure 8.4.1.1. Sea surface temperature (left) and salinity (right) in summer 2016 in the Gulf of Cadiz as recorded by the thermosalinometer during the ECOCADIZ acoustic survey

8.4.2 Sardine and anchovy distribution derived from NASC

8.4.2.1 Sardine

Distribution area of sardine, as derived from the NASC values, is similar to that observed in the previous years, with only few cell with higher values than 300 m^2 nmi^{-2} (Figure 8.4.2.1.1).

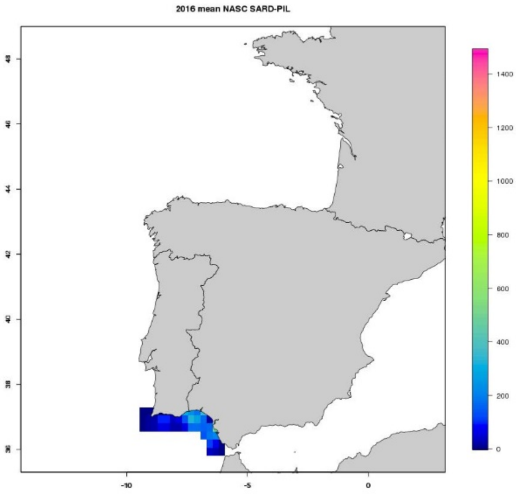


Figure 8.4.2.1.1. Mean backscattering energy (NASC, m²mn⁻²) per 0.25°x0.25° square allocated to sardine during ECOCADIZ summer acoustic survey.

8.4.2.2 Anchovy

Anchovy mainly occurred in the central part, and, as observed for sardine, only few cells got values higher than 300 m^2 nmi^{-2} (Figure 8.4.2.2.1).

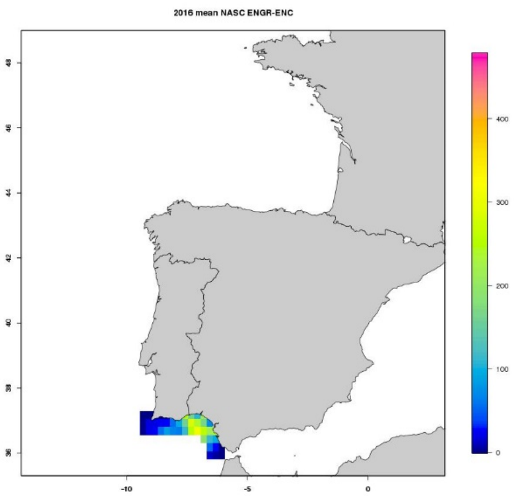


Figure 8.4.2.2.1. Mean backscattering energy (NASC, m^2 mn^{-2}) per 0.25°x0.25° square allocated to anchovy during ECOCADIZ summer acoustic survey.

8.5 Bay of Biscay autumn survey

Autumn survey JUVENA is targeted on juvenile anchovy, covering the whole Bay of Biscay using two research vessels (Ramón Margalef and Emma Bardán) in September.

8.5.1 Sardine and anchovy distribution derived from NASC

8.5.1.1 Sardine

Distribution area of sardine, as derived from the NASC values, showed in general very low density values around the Spanish waters while was higher on the French shelf, mainly at the north of the Garonne mouth (Figure 8.5.1.1.1).

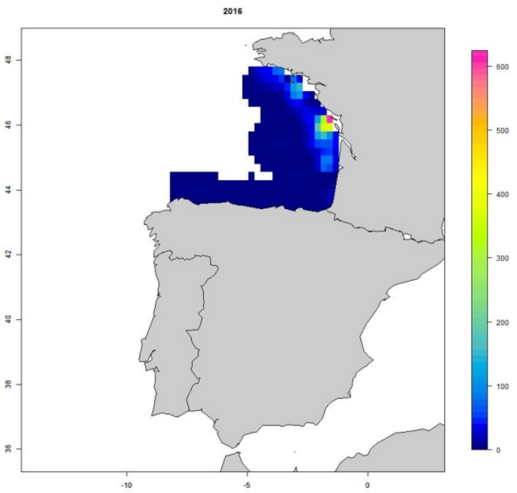


Figure 8.5.1.1.1. Mean backscattering energy (NASC, m^2mn^{-2}) per 0.25°x0.25° square allocated to sardine during JUVENA acoustic survey.

8.5.1.2 Anchovy

Anchovy mainly occurred, as seen for sardine, on the French slope with the higher density spots located in the northern part (Figure 8.5.1.2.1).

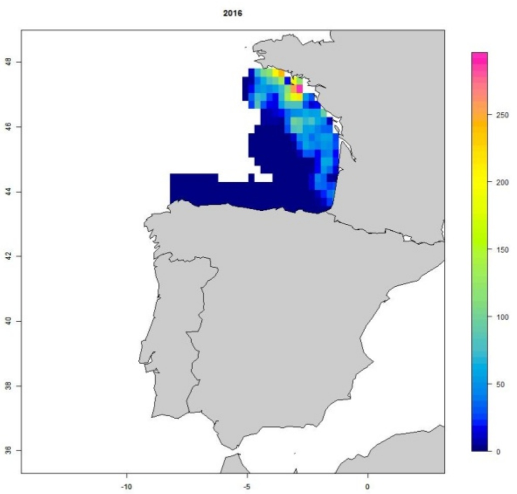


Figure 8.5.1.2.1. Mean backscattering energy (NASC, m^2mn^{-2}) per 0.25°x0.25° square allocated to anchovy adults during JUVENA acoustic survey.

Contrary, juvenile (Young of the Year) were found evenly distributed along the surveyed area, although the higher density, as seen for the adults, were located in the northern part (Figure 8.5.2.2.2).

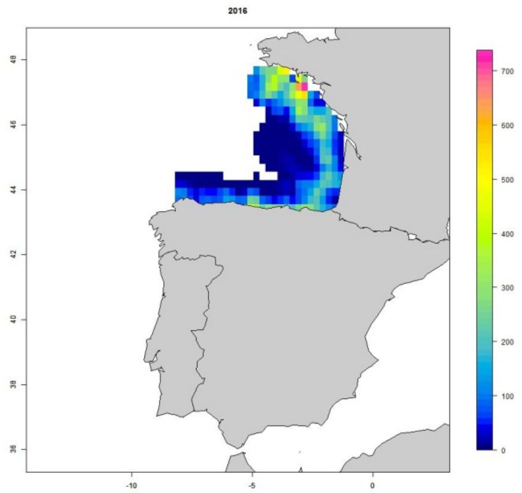


Figure 8.5.1.2.2. Mean backscattering energy (NASC, m²mn⁻²) per 0.25ºx0.25º square allocated to allocated to anchovy juveniles during JUVENA acoustic survey.

8.6 English Channel/Celtic Sea autumn survey

8.6.1 1 Trawl species composition

Figure 8.6.1.1 shows the catch composition from the pelagic trawl. Sardine, sprat, mackerel, and horse mackerel were the most abundant fish species. Jellyfish were also important.

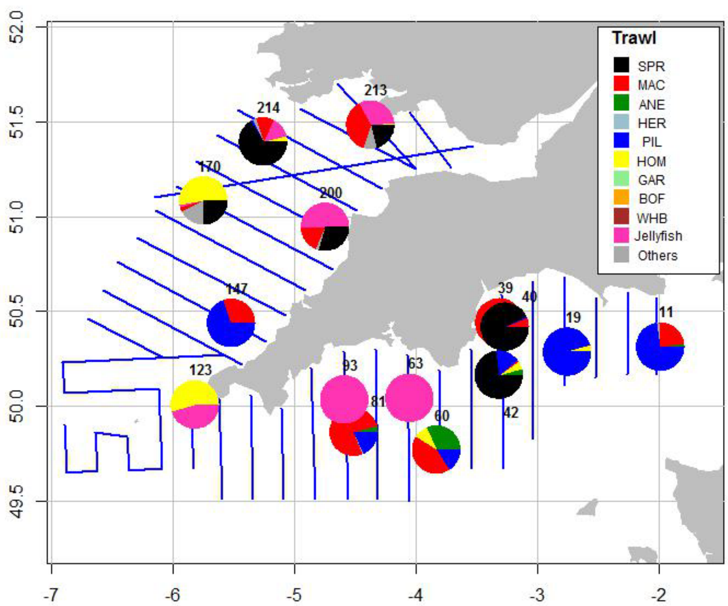


Figure 8.6.1.1. Trawl catches (pies) with relative catch composition by key species. Three letter codes: SPR = sprat, MAC = mackerel, ANE = anchovy, HER = herring, PIL = sardine, HOM = horse mackerel, GAR = garfish, BOF = Boarfish, WHB = Blue whiting.

Preliminary results on the small pelagic fish community suggested that most species were doing well apart from sprat.

Anchovy was found in large numbers in the western English Channel, extending further west as was the case in 2015. Noticeably in this area were the larger number of older specimens than in previous years. Anchovy was also observed in the Bristol Channel, including some larger specimens.

Good sardine numbers were found and their distribution was widespread. They were present in most trawl hauls conducted in the western channel. Distribution here was only limited, it seems, by the cold water pool that was situated south off the western tip of the Cornish Peninsula. In the Bristol Channel sardine appeared to be concentrated to the middle of the transects, between the deeper and very shallowest parts, apparently associated with prevailing frontal systems. Sardine spawning (based on egg distribution) was similar to in 2014 and 2015 both in magnitude and distribution although for the second consecutive year eggs were observed in the Bristol Channel and in good numbers.

Few sprat schools were observed in Lyme Bay and also the offshore schools in deep waters of the Bristol Channel in 2015 were not present in the survey area. As has been observed in previous years, sprat in the western Channel consisted of predominantly adult specimens (age 1–3), compared to in-and offshore sprat in the Bristol Channel which were predominantly age 0 (with a unimodal length distribution around 8 cm).

Mackerel were observed throughout the survey area, both in and offshore, although particular areas contained higher densities, most noticeably around the Celtic Deep. Young of the year made up the majority although older specimens were also found.

Horse mackerel were prevalent in the survey area although they dominated the offshore areas of the western Channel and around the Isles of Scilly. Unlike previously the length data showed unimodal distribution around 9 cm which was generally associated with 0-year old fish.

The oceanographic conditions were similar to those observed in 2014 and represented a relatively warm autumn bloom scenario, in contrast to the more typical 2013 and 2015 condition and the winter conditions encountered in 2012. Primary production was relatively low, and was observed near the strong frontal systems particularly those around a cool water pool off the southwest of Cornwall. One of the most notable observations were seven separate feeding aggregations of bluefin tuna along the coast; the only other time one this species was observed during the 5 year time-series was in the other hot year (2014).

Annex 1: List of participants and agenda

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AGENDA

DATE	TIME	PLENARY/ SESSION 1	SESSION 2
14Nov	9:30	Opening and general issues Adoption of agenda Informations	
	10:00	WGACEGG general business Report structure (assignment of tasks, deadlines) Survey protocols (submission to SGSISPS) Grid maps ToRs and Work Plan revision Chairs election, next meeting, etc.	
	10:45	Coffee	
	11:00	WGACEGG Surveys reporting (ToR a, b, c) DEPM Anchovy BoB – BIOMAN, 2016 Acoustics Spring (9a, 8c,b,a) PELAGO, 2016 PELACUS, 2016 PELGAS, 2016	
	13:30	Lunch	
	14:30	Surveys reporting (ToR a,b, c) Autumn	

		JUVESAR 2015 JUVENA 2016 Acoustics area 7 PELTIC 2016 Other ?
	16:30	Coffee
	16:45	MEDIAS Survey presentations Ionian acoustic survey western Adriatic Sea surveys Eastern Adriatic acoustics DEPM anchovy Aegean Sea 2014 DEPM anchovy Strait of Sicily 2015
	18:30	End Session go to WG dinner
DAY 2		
15Nov	9:30	WKPELA bench mark session (ToR a, b, d, e,) Summary of requests/issues and presentations on results (for topics already finished) PIL P0 estimation using ext mort model (9a+8c) P0 estimations for PIL from HOM/MAC egg surveys (9a+8c) Egg Prod from CUFES (Martin , ANE, PIL, Maria S?) (ToR e) Egg production dif stages AZTI, Maria PIL results/issues from 8 b,a CUFES Gulf of Cadiz (Papi) CVs for PELAGO and PELACUS Comparison of trends from DEPM and Acoustics estimations HOM, MAC echointegration estimates (ToR d) TS influence on acoustic biomass estimates (Mathieu)

		Ecological aspects JUVENA, Guillermo Small pelagic fish habitat in BoB (Mathieu)	
	11:00	Coffee	
	11:30	Session on Acoustics (ToR a, b, d, f, g) Work on bench mark requests and other issues CVs for acoustics …. estimates (AtlantOS) ICES AT database EchoR and Database aspects Standard method for AT biomass target strengths research (Mathieu, et al) (ToR d) acoustic surveys to produce info for more species (e.g.. HOM, WHB, BOC) (ToR d) HOM, MAC echointegration estimates Survey protocols (including WGFAST request) (ToR g)	Session on DEPM (ToR a, b, d, e, f, g) Work on bench mark requests and other issues P0 estimations for PIL from HOM/MAC egg surveys (9a+8c) PIL P0 estimation using ext mort model (9a+8c) PIL results/issues from 8 b,a SSB at age for PIL utilization of mean values for PIL adult parameters in some years/regions…. Survey protocols (ToR g)
	13:00	Lunch	
	14:30	Session on Acoustics continuation EchoR questions/training group work Survey planning 2017 (ToR f)	Session on DEPM continuation group work Survey planning 2017 (ToR f) WGALES plans for spawning frequency study
	16:30	Coffee	
	17:00	Continuation/Group work	Continuation/Group work
	18:30	End of Session /	End of Session /
DAY 3			
16Nov	9:30	Plenary discussion on parallel sessions outputs Report structure/assignments	
	10:30	coffee	
	11:00	Report structure/assignments	
	12:00	Other presentations Developments/ecological aspects Interreg project (AtlantEA)	

		(including data analysis for providing MSFD indicators and survey-base operational products for stakeholders (ToR f)	
	13:00	Lunch	
	14:30	Session on Acoustics continuation group work	Session on DEPM continuation group work
	16:30	Plenary discussion on parallel sessions outputs, list outputs for WKPELA Other ToRs Work Planning and ToRs revision, deliverables	
	18:00	Report structure update	
	18:30	End of Session	
DAY 4			
17Nov	9:30	Plenary session: undergoing work report writing bench mark issues	
	10:00	Group work (subgroups?) Report writing	
	13:00	lunch	
	14:30	Group work (subgroups?) Report writing	
	17:00	Update on Report ToRs, recommendations, Work planning workshops, publications, etc.	
	18:30	End of Session	
DAY 5			
18Nov	9:30	Report ToRs, recommendations, Next meeting Chairs election	
	10:30	Coffee	
	11:00	Report writing	
	12:30	End of meeting	

Annex 2: Recommendations

Recommendation	Adressed to
2 In order to produce an egg abundance index for sardine for the years without a dedicated DEPM, the Group recommends to analyze the feasibility on taking extra samples from: (i) CalVET and/or Bongo nets during HOM and MAC EPMs, either from historical time series or the incoming surevys in 2016; (ii) CUFES (sampler to be included in the HOM and MAC surveys) for the spawning area definition since from Bongo it may not be possible to delineate appropriately the spawning area	WGMEGS

Annex 3: WGACEGG terms of reference (Draft resolution for approval)

The Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas 7, 8 and 9 (WGACEGG), co-chaired by Maria Santos and Mathieu Doray, will meet in Cadiz, from 13–17 November 2017, to:

a) Report DEPM and Acoustics surveys of the year; observations and estimation results, discussion on eventual issues and ways of progressing, including those performed within the frame of MEDIAS surveys (Mediterranean acoustic survey on small pelagic);

b) Research results to advance understanding on sardine and anchovy population ecology: (i) potential habitats and variability of realized habitats; (ii) explore spatial overlaps between species and relationships;

c) Update the common regional "grid database" and maps from the surveys including information on temperature, salinity, top predators abundances, and egg densities, acoustic energy and adults for anchovy and sardine; and with other target species for acoustic energy;

d) Report improvements and results obtained during specific sessions aiming at:

   On acoustic surveys

   i. scrutinize echotraces for a common interpretation

   ii. analyze multifrequency and broadband approach techniques to improve echotrace allocation for both fish and plankton

   iii. present progress in TS experiments

   On egg surveys

   i. Discuss developments on the new approaches for mortality and egg production estimation and adult parameter spatial distribution

   ii. Further explore seasonal and inter-annual variability of sardine reproductive parameters in relation to environmental conditions

b) Review progress in the CUFES index series for anchovy and present developments on an indicator of egg production from CUFES data

c) Report main results and conclusions from a specific session held during the meeting to:

   i. Explore a common possible list of Marine Strategy Framework Directive indicators from the WGACEGG surveys

   ii. Explore potential survey base operational products from the WGACEGG surveys

d) Coordinate and standardize methods for the incoming surveys

Long term ToR:

ToR	Description	Background	Science plan topics addressed	Duration	Expected Deliverables
a)	Provide echo-integration and DEPM estimates for sardine and anchovy in ICES sub-Areas 7, 8 and 9	a) Advisory Requirements b) Requirements from other EGs		1st to 3rd years	Abundance and biomass estimates by age group. Fish spatial distribution and density. WGHANSA
b)	Analyse and update sardine and anchovy (adults and eggs), spatial and temporal distribution patterns and their habitats in European waters	a) Science Requirements b) Requirements from other EGs		3rd year	Manuscript/ICES CRR
c)	Provide information on hydrographical and ecosystem data such as temperature, salinity, plankton diversity, top predators abundances, egg densities and backscattering for sardine, anchovy and other small pelagic fish for ecosystem monitoring (e.g.. MSFD)	a) Science Requirements		1st to 3rd years	Update and provide grid data and maps
d)	Assess developments in the technologies and data analyses for the application of both acoustics and the DEPM	a) Science Requirements b) Advisory Requirements c) Requirements from other EGs		1st to 3rd years	Anchovy and Sardine egg Production and acoustics methods developments WGHANSA

	(on Egg Production or adult parameters)			
e)	Improve and assess the suitability of CUFES data for anchovy and sardine egg production estimates in areas 8 and 9.	a) Science Requirements b) Advisory Requirements c) Requirements from other EGs	1st to 3rd years	Anchovy and Sardine egg Production WGHANSA
f)	Coordination and standardization of the surveys	a) Science Requirements b) Advisory Requirements	1st to 3rd years	Annual plan for coordinated surveys. Updated survey protocols
g)	Development and standardization of data processing methods for DEPM and acoustics for surveys in Atlantic and Mediterranean waters	a) Science Requirements b) Advisory Requirements c) Requirements from other EGs	1st to 3rd years	Updated standardized processing protocols
h)	Provide echo-integration estimates for other species (mainly blue whiting, mackerel, horse mackerel, chub mackerel and boarfish) ICES sub-Areas 8 and 9	a) Advisory Requirements b) Requirements from other EGs	1st to 3rd years	Biomass by age group when available otherwise by length classes and spatial density distribution. WGWIDE WGHANSA

The work plan for the next three years considers general and specific sessions to address the ToRs set and also correspondence work namely to carry on intercalibration exercises for sardine and anchovy egg staging and ovaries histology analyses. The WGACEGG values the participation of colleagues conducting surveys in the Mediterranean to the discussions carried out by the Group and therefore continues to include in its plans a joint meeting with MEDIAS every second year.

Summary of the work plan:

Year 1	General meeting Session for acoustic data analysis and post-processing techniques in relation to ICES Marine Data requirements and for update TS measurements

	Session on automated systems for egg identification and ageing and other DEPM bussiness Proposals for survey-operational products Session to analyse progress on sardine and anchovy egg production estimates from CUFES Work by correspondence with MEDIAS (Mediterranean acoustic survey on small pelagic)
Year 2	General meeting, including joint session with MEDIAS (Mediterranean acousticsurvey on small pelagic). Session for acoustic data analysis and post-processing techniques in relation to ICES Marine Data requirements and for update TS measurements and new acoustic apoproaches (e.g. broadband, mulfifrequency, multibeam) Session on automated systems for egg identification and ageing and other DEPM bussiness Proposals for survey-operational products Session to analyse progress on sardine and anchovy egg production estimates from CUFES
Year 3	General meeting Session for acoustic data analysis and for update TS measurements and new acoustic apoproaches (e.g. broadband, mulfifrequency, multibeam) Session on automated systems for egg identification and ageing and other DEPM bussiness Proposals for survey-operational products

Annex 4: Copy of Working Group self-evaluation

Working Group evaluation

1) **Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas 7, 8 and 9, WGACEGG**

2) **Year of appointment:** 2014

3) **Current Chairs**: María Manel Angelico/Pablo Carrera

4) **Venues, dates and number of participants per meeting:**

- 17–21 November 2014, Vigo, Spain, 27 attendees
- 16–20 November 2015, Lowestoft, UK, 14 attendees
- 14–18 November 2016, Capo Granitola, Sicily, Italy, 25 attendees

WG Evaluation

5) **If applicable, please indicate the research priorities (and sub priorities) of the Science Plan to which the WG make a significant contribution.**

WGACEGG has made contributions to the following research priorities:

- Assess the physical, chemical and biological state of regional seas and investigate the predominant climatic, hydrological and biological features and processes that characterise regional ecosystems
- Identify indicators of ecosystem state and function for use in the assessment and management of ecosystem goods and services
- Provide priorities and specifications for data collection frameworks supporting IEA's.
- Identify monitoring requirements for science and advisory needs in collaboration with data product users, including a description of variable and data products, spatial and temporal resolution needs, and the desired quality of data and estimates
- Identify knowledge and methodological monitoring gaps and develop strategies to fill these gaps
- Promote new technologies and opportunities for observation and monitoring and assess their capabilities in the ICES context
- Allocate and coordinate observation and monitoring requests to appropriate expert groups on fishery dependent surveys and sampling and monitor the quality and delivery of data products.
- Ensure the development of best practice through establishment of guidelines and quality standards for (a) surveys and other sampling and data collection systems; (b) external peer reviews of data collection programmes and © training and capacity building opportunities for monitoring activities

6) **In bullet form, highlight the main outcomes and achievements of the WG since their last evaluation. Outcomes including publications, advisory products, modelling outputs, methodological developments, etc.**

Main outcomes and achievements of the WG were:

- Publications:

- Doray, M., Berger, L., Le Bouffant, N., Coail, J.Y., Vacherot, J.P., de La Bernardie, X., Morinière, P., Lys, E., Schwab, R., Petitgas, P., 2016. A method for controlled target strength measurements of pelagic fish, with application to European anchovy (*Engraulis encrasicolus*). ICES J. Mar. Sci. J. Cons. 73, 1987–1997. doi:10.1093/icesjms/fsw084

- Advisory products:
  - Sardine and anchovy biomass and abundance indices derived from acoustic and DEPM surveys used as input fishery-independent data for analytical assessment purposes in ICES WGHANSA. Surveys involved: PELAGO, PELACUS, PELGAS, JUVENA, BIOMAN ECOCADIZ, SAREVA, PT-DEPM14-PIL, BOCADEVA.
  - Biological information from the same surveys
- Other advisory products:
  - Mackerel, horse mackerel, blue whiting, chub mackerel, boarfish biomass and abundance indices and biological information derived from acoustic surveys used as fishery-independent data in ICES WGWIDE Surveys involved: PELACUS, PELGAS.
  - Sardine, anchovy, mackerel, horse mackerel, blue whiting, chub mackerel, boarfish biomass and abundance indices and biological information derived from acoustic survey used as fishery-independent data in ICES WGWIDE and WGHANSA. Survey involved: PELTIC.
  - Marine birds, mammals, human activities and debris distribution. Surveys involved: PELACUS, PELGAS, BIOMAN, PELTIC.
- Workshops:
  - Two workshops on EchoR
- Methodological developments:
  - New methods for TS in situ measurements on an open pelagic gear using a specific ROV.
  - Sardine and anchovy egg production estimates from CUFES samples.
  - Automated system for identifying and staging sardine and anchovy eggs from CUFES samples.
- Modelling outputs:
  - Improvement on sardine and anchovy target strength modelling using X-ray CT imaging
  - Sardine egg mortality modelling using temperature as covariable.
  - Sardine egg production from specific mackerel triennial surveys.

7) Has the WG contributed to Advisory needs? If so, please list when, to whom, and what was the essence of the advice.

Contributions to Advisory needs: WGACEGG has provided biological data and fish abundance estimates mainly to WGHANSA and WGWIDE and related benchmarks and workshops linked with this working groups. These data are delivered every year in the case of the acoustic surveys and DEPM survey for anchovy in 8abc and on triennial basis for those DEPM targeting in sardine in 8cb and 9a. These consisted in numbers-at-age in the case of sardine and anchovy from acoustic surveys and SSB from DEPM surveys together with biological data (e.g. maturity ogive-at-age, mean length and weight-at-age in the stock for sardine and anchovy and, depending on the survey, for mackerel, horse mackerel, blue whiting or chub mackerel)

8) Please list any specific outreach activities of the WG outside the ICES network (unless listed in question 6). For example, EC projects directly emanating from the WG discussions, representation of the WG in meetings of outside organizations, contributions to other agencies' activities.

WGACEGG has elaborated a product-oriented proposal submitted for an Interreg call in cooperation with WGEAWESS. The proposal has unfortunately not be selected. Besides through its members, WGACEGG, is involved in AtlantOS H2020 project.

9) Please indicate what difficulties, if any, have been encountered in achieving the workplan.

WGACEGG, as a planning group dealing with direct observations at sea needs to address challenges for future both in terms of new technologies for data collection and automated data processing devices and software together with new tools for data analysis. This would imply specific *in-situ* experiences and measurement (eg TS measurements, egg buoyancy and development experiments among other), testing new equipment and also to establish a systematic plan for i) organize exchanges and workshops to standardize egg staging and POF's reading criteria; ii) standardize post-processing techniques, including as was already done for acoustic, small workshops. This planning should be considered for the next working group period although some difficulties would appear on account the difficulties for finding right periods along the year given the number of surveys involved (spring, summer and fall surveys).

Future plans

10) Does the group think that a continuation of the WG beyond its current term is required? (If yes, please list the reasons)

This WG should continue to assess and standardise the methods used to collect the fishery-independent data needed to assess anchovy, sardine and horse mackerel stocks under the auspices of WGHANSA. The group should also assess the information on mackerel, boarfish, blue whiting and chub mackerel biology and spatial distribution submitted to WGWIDE.

11) If you are not requesting an extension, does the group consider that a new WG is required to further develop the science previously addressed by the existing WG.

NA

12) What additional expertise would improve the ability of the new (or in case of renewal, existing) WG to fulfil its ToR?

As it was already noted in point 9), WAGEGG has to compile and review the methodological developments in acoustic and egg data collection, archiving and analysis, to ensure that the fishery independent data provided to assessment groups meet the best standards. The WG could organise specific trainings, e.g. on the new ICES acoustic-trawl database, or spatio-temporal analysis of DEPM data, to help disseminating the best methods and practices.

13) Which conclusions/or knowledge acquired of the WG do you think should be used in the Advisory process, if not already used? (please be specific)

Annex 5: Issues for sardine benchmark in 2017

5.1. Atlanto-Iberian sardine (ICES 9a and 8c) spawning-stock biomass re-analyses for the DEPM dataseries, 1988–2014, considering egg production estimation using a mortality model obtained from aggregated data and with temperature as covariate

Background

In 2011 it was presented at the WGACEGG meeting a revision of the egg production estimates for the Atlanto-Iberian sardine DEPM dataseries (1988–2011) (ICES, 2011). The analyses were undertaken following the traditional approach (e.g. Lasker, 1985) updated with the developments discussed, over the last decade, at the SGSBSA and WGACEGG and in the scientific literature. The review using the traditional method (described in detail in the 2011 report) was for the first time carried out in a standardized manner for the whole historic data. An important discussion raised during the revision was the reliability of the mortality estimates per strata obtained for each survey separately. In some cases (surveys or strata) spurious positive (or almost positive) egg mortality estimates were obtained from the observations taken during the egg production surveys. Bernal *et al.* (2011a) and other before (e.g. Parker, 1980; Stratoudakis *et al.*, 2006) have discussed this issue. Bias mortality estimates can arise from problems with surveying or difficulties in fitting the mortality curve model, in particular related to the lack of observations at both tails of the egg age distribution, very young and very old eggs are often poorly represented in the plankton samples.

To overcome the problems mentioned above and attain statistically significant and biologically plausible mortality estimates the approach described by Bernal *et al.* (2011a and 2011b) was here adopted. Using all data available (1988–2014) the external mortality model developed by Bernal *et al.* (2011a) is updated and used to estimate mortality per strata for all surveys; the average mortality values are then used to obtain P_0 estimates per strata.

In the model egg production and mortality are achieved considering spatial and temporal strata and water temperature. Temperature effects on reproductive capacity, egg development, or other physiological rates have been reported for marine organisms (e.g. as in Ottersen *et al.*, 2001).The effect of temperature on egg mortality for different species including some cupleiforms has been referred in the literature (e.g. Pepin, 1991).

Mortality, egg production and spawning-stock biomass estimates obtained from the traditional method for the 2011 dataseries revision (ICES, 2011) and the results from the Sardine DEPM survey carried out in 2014 are compared to the results achieved using the external mortality model. The implications for SSB estimation and sardine assessment modelling are discussed.

Methodology

Using the approaches by Bernal *et al*. (2007, 2011), three spatial and two temporal strata (1985–1994 and 1995–2014) were used. The geographical strata (Figure 4.1.1) considered were: South: from Gibraltar to Cabo de S.Vicente; West: S.Vicente to the northern Portuguese-Spanish border and North: the Spanish waters from Galicia to the French border. The spatial strata were selected to represent three spawning nuclei using the approaches by Bernal *et al.* (2007, 2011).The two temporal strata represent two periods with different extents of occupancy of the shelf.

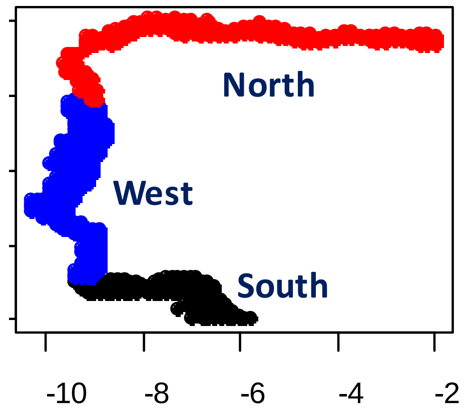

Figure 5.1.1. Strata used in the analysis. South, from the Strait of Gibraltar to Cape St. Vicente (black area), West, from Cape St. Vicente to the northern limit between Portugal and Spain (blue area), and North, between the Portuguese-Spanish border and the Spanish-French Atlantic limit (red area).

Mean surface temperature values by the strata used in the analysis are presented in Figure 5.1.2. Temperature values ranged from 12.6 to 17.2°C. Temperature distribution followed the common patterns; the highest temperature values were observed in the southern area and the lowest values are registered in the Cantabrian Sea. A marked interannual variability by strata is showed for the temperature registered along the DEPM surveys series, higher in southern and western areas than in the northern area.

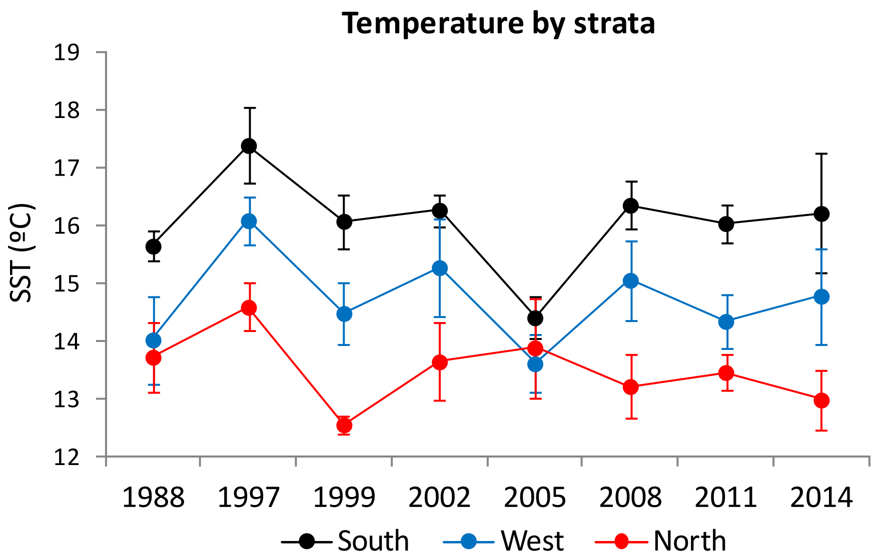

Figure 5.1.2. Mean temperature (SST) estimates for the three strata (South in black, West in blue, North in red) and year. Vertical lines indicate 2 standard-deviations.

The approach described by Bernal *et al.* (2011) is summarized as follow:

1) Estimation of age and cohort abundance
2) Mortality estimation
3) Calculation P_0 with the external mortality

Steps 1 and 2 are based on all available data on egg age and mortality, egg production calculation uses data from DEPM surveys.

Step 1: Egg stage and age are related to temperature with a multinomial model. Peak spawning time is used to define the cohorts, their abundance and mean age. Then the mortality curve is fitted to the abundance-by-cohort estimates.

- Multinomial model of sardine egg development was used to relate egg stage and age for the sampled temperatures. Egg ageing was achieved using the egg development multinomial model presented in Bernal *et al*. (2008) and the Bayesian approach described in Ibaibarriaga *et al.* (2007).
- Assumed peak spawning time (lognormal)was used to define the daily cohorts, cohorts abundance and mean cohort age for all stations
- New data with observed abundance-by-cohort used to fit the mortality curve

The first modification on the traditional application of the DEPM was to consider a lognormal distribution for the daily spawning cycle, usually a normal PDF is assumed (e.g. Lo, 1985). Bernal *et al* (2011a) showed using stage I eggs and running females that the Atlanto-Iberian sardine is a late-evening spawner with a lengthier (non-normal PDF) daily period than previously thought.

Step 2: Establishes a model for the expected number of eggs for a cohort with a given age, resulting from egg production rate and mortality.

$$E[Na] = g^{-1}(\text{offset}(\log(Efarea)) + \log(D0) - ma) \qquad (1)$$

E [Na] = expected number of eggs in a cohort of mean age a
D0 = the rate of egg production
m = the mortality rate
g^{1} = the inverse of the link function that relates the linear predictor and the response, Na

The equation (1) is then reformulated to allow both egg production and mortality to be a function of the spatial and temporal strata and also temperature, as well as their first-order interactions. Terms in which age is involved indicate mortality terms, and the rest of the terms affect egg production. From a general full model:

- Backward stepwise model selection was carried out. At each step, the term with least significance (<5%) was dropped, and this procedure repeated until dropping terms led to no improvement. The models were fitted by an iterative procedure.
- A comparison with Akaike information criterion (AIC) profiles of the model selection procedure was also performed.
- To avoid bias in the mortality model caused for the extremes of the data: lower limit and upper limits were set on the tails of the mortality curve. For the lower tail of the dataset, the first cohort that fell within the spawning period in stations sampled during this period was excluded. At the other end (upper tail) the age limit was considered by stratum, and eggs excluded when 5% of the eggs would already have hatched considering the temperature of the 95% quartile (per stratum).

The process resulting in a model in which mortality is estimated by a general term and an interaction with temperature.

```
glm.nb(formula = cohort ~ offset(log(Efarea)) - 1 + Sstrata +   Tstrata + Temp +
Sstrata:Tstrata + Sstrata:Temp + Tstrata:Temp + age + Temp:age)
```

Step 3: An egg production model that can accommodate mortality estimates external to the estimation procedure is required. The optimized model is expanded to include weights for increased sampling in areas where high egg densities are expected and updated with the data from DEPM carried out in 2011 and 2014.

glm.nb(formula = cohort ~ offset(log(Efarea) - death * age) - 1 + Sstrata, data, weights = Rel.area)

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

Egg Production (P_0) and Spawning-stock biomass (SSB) Estimation

Fitted parameters of the final mortality model updated with 2011 and 2014 in which mortality is estimated by a general term and an interaction with temperature are shown in Table 5.1.1.

Table 5.1.1. Fitted parameters of the final mortality model updated with 2011 and 2014 data.

Variable	Esti-mate	s.e	z-value	Pr(>|z|)
Sstrata1	0.942	1.076	0.876	0.381
Sstrata2	5.980	0.880	6.793	0.000
Sstrata3	-0.817	0.832	-0.982	0.326
Tstrata1	4.570	0.911	5.018	0.000
Temp	0.440	0.060	7.314	0.000
age	0.045	0.015	2.896	0.004
Sstrata2:Tstrata1	-0.238	0.156	-1.528	0.127
Sstrata1:Temp	-0.122	0.076	-1.619	0.105
Sstrata2:Temp	-0.47	0.063	-7.405	0.000
Tstrata1:Temp	-0.351	0.065	-5.371	0.000
Temp:age	-0.005	0.001	-4.271	0.000

The z-value indicates the value of the z-statistics used to test the significance, and Pr(>|z|) the probability of the null hypothesis (H0: parameter does not differ from zero).

The resulting mortality values for the final model with temperature by spatial strata and by year (Table 5.1.2 and Figure 5.1.3) are significantly different from zero and biologically plausible. As it has been shown for other species (e.g. Pepin, 1991) higher egg mortalities were observed at higher water temperatures, in the southern region and decreased in the northward direction. Egg mortality estimates (h^{-1}) obtained with the model described above varied between -0.016, for the northern stratum, and -0.032 for the southern region; variability was higher in the western and southern regions.

Table 5.1.2. Egg mortality (hours^{-1}) estimates by year and spatial strata for the Atlanto-Iberian Peninsula DEPM surveys series. Standard errors are presented in brackets.

Year	South	West	North
1988	-0.026 (0.002)	-0.019 (0.0014)	-0.018 (0.0016)
1997	-0.032 (0.0035)	-0.028 (0.0024)	-0.022 (0.0015)
1999	-0.029 (0.0027)	-0.022 (0.0014)	-0.014 (0.0023)
2002	-0.029 (0.0027)	-0.025 (0.0018)	-0.018 (0.0015)
2005	-0.021 (0.0014)	-0.018 (0.0015)	-0.018 (0.0015)
2008	-0.03 (0.0029)	-0.024 (0.0016)	-0.018 (0.0016)
2011	-0.028 (0.0025)	-0.021 (0.0014)	-0.017 (0.0016)
2014	-0.027 (0.0023)	-0.023 (0.0016)	-0.016 (0.0019)

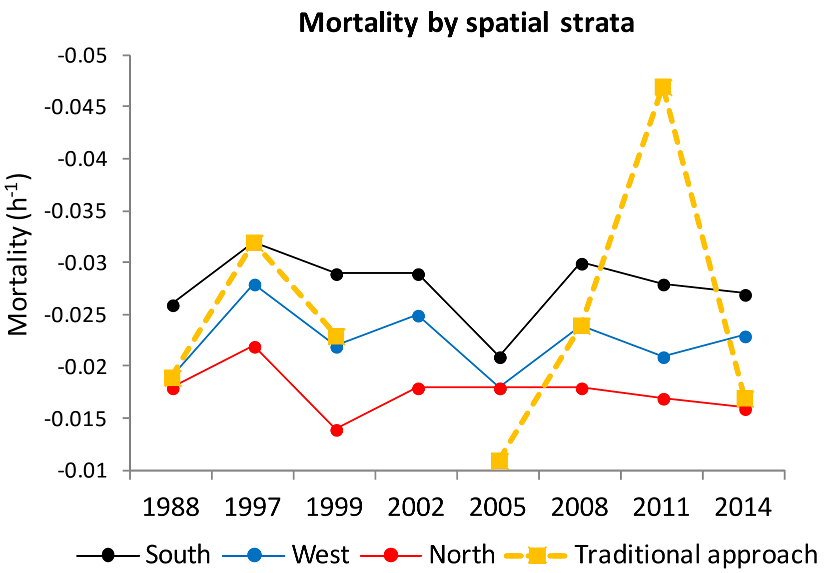

Figure 5.1.3. Egg mortality estimates (h^{-1}) per spatial strata and year, derived from the external model updated with the 2011 and 2014 dataset.

Egg production estimates obtained using the mortality results from the external model (Table 5.1.3 and Figure 5.1.4) were in accord to the results presented by Bernal *et al.* (2011b). Moreover, as discussed by Bernal *et al.* (2011b) the differences between the estimates obtained using their methodology and the results using the traditional approach (with a common mortality for all strata) were considerable for some years. Clearly the differences in the egg production estimates were more noticeable for years or strata for which before no realistic values of mortality were achieved. This is particularly noticeable for the 2002, survey, when no mortality estimation was attained previously, and for 2011, when for the southern and western strata the mortality estimates from the single dataset were quite high, the highest registered (ICES, 2011)

Table 5.1.3.Daily egg production (eggs/m²/day) estimates by year and spatial strata for the Atlanto-Iberian Peninsula DEPM surveys series. Coefficients of variation are presented in brackets.

Year	South	West	North
1988	455.17 (0.26)	129.96 (0.1)	155.77 (0.07)
1997	179.03 (0.16)	236.15 (0.18)	221.77 (0.14)
1999	876.73 (0.19)	435.83 (0.15)	116.9 (0.16)
2002	121.93 (0.18)	188.91 (0.11)	116.89 (0.11)
2005	271.88 (0.16)	203.63 (0.12)	283.09 (0.12)
2008	425.27 (0.14)	200.71 (0.1)	134.95 (0.09)
2011	227.76 (0.16)	82.71 (0.18)	124.44 (0.11)
2014	156.41 (0.16)	115.72 (0.12)	38.55 (0.14)

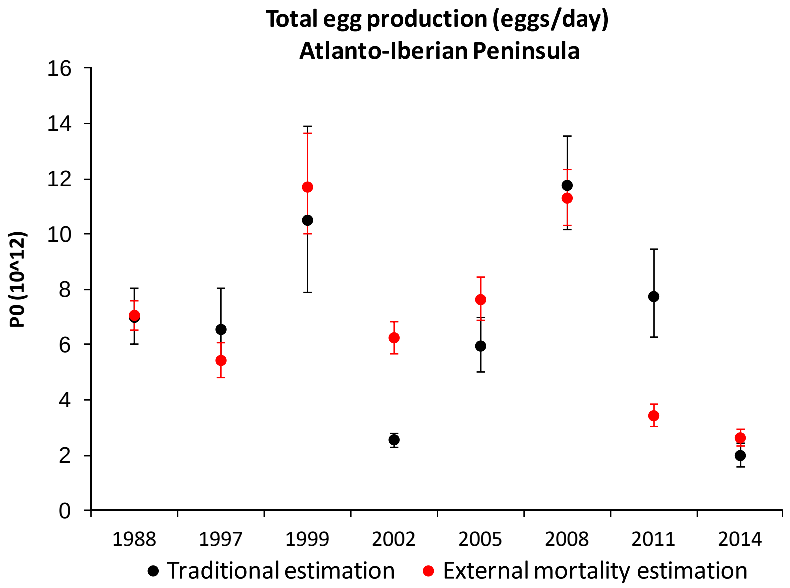

Figure 5.1.4. Total Egg production estimates (eggs/day) for the Atlanto-Iberian Peninsula(South+West+North strata) obtained by the traditional method (black dots) and using the mortalities obtained by the external model (red dots). The bars represent the confidence intervals for the estimates.

Spawning-stock biomass estimates obtained from the traditional method (series revision, ICES 2011) and the results achieved using the external mortality model for egg production are plotted in Figure 5.1.5. As a consequence of the largest differences encountered for the egg production in 2002 and 2011, the SSB estimates for these years suffered also the largest modification compared to the traditional estimates.

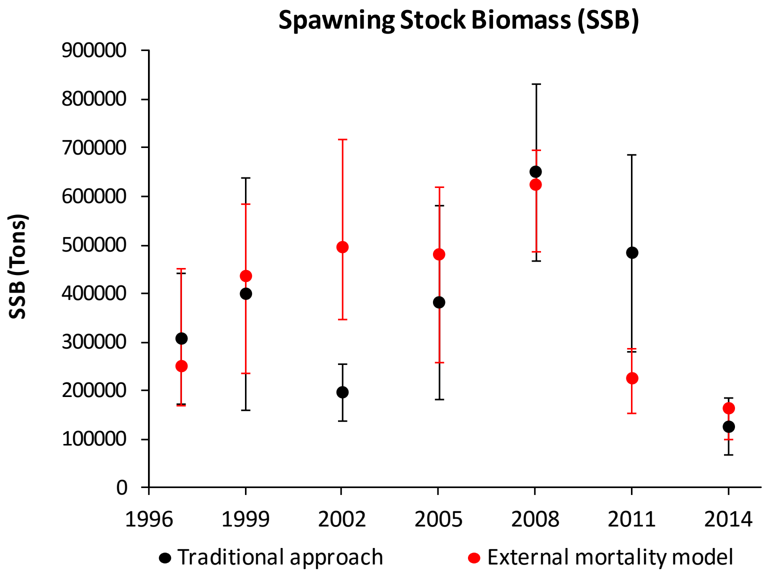

Figure 5.1.5. Spawning-stock biomass (Tons) for the Atlanto-Iberian Peninsula (South+West+North strata) obtained by the traditional method (black dots) and using the mortalities obtained by the external model (red dots). The bars represent the confidence intervals for the estimates.

The revision of the P_0 and SSB estimates for the DEPM dataseries here presented is considered statistically consistent and the results biologically plausible and less influenced by biased and imprecise, single survey, mortality estimates while at the same time allows P_0 and mortality results per stratum. In addition, the current SSB estimates are more in line with the tendencies observed in the biomass calculations obtained along the series of annual acoustics surveys.

The external mortality model showed consistency in the results as few differences in previously estimated mortalities were observed when the model was updated with the datasets from the more recent surveys, in 2011 and 2014. However, in order to avoid changes in the past estimates each time the model is updated to include a new survey, it is considered that only the more recent estimate should be considered. A full revision of the series would be only considered for benchmark reviewing. The WGACEGG has considered that the SSB estimates here presented for the DEPM historic series are the more consistent in light of the current analysis developments.

References

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5.2 Sardine Egg Production Estimation (ICES Areas 9a and 8c) using data from EPM surveys directed at mackerel and horse-mackerel.

Rationale

The IEO and IPMA coordinated surveys for sardine spawning-stock biomass estimation through DEPM have been taken place on a triennial basis since the late 90s. In order to attain higher temporal resolution for the egg production dataseries it was decided within WGACEGG that tests should be run using the egg samples/data available from other egg production surveys conducted in the same geographical areas during a similar period of the year in years without a dedicated sardine DEPM.

All the EPM surveys from which it was thought that information for sardine eggs was obtainable are listed in Table 5.2.1.

Table 5.2.1. Surveys list by year and type (and plankton gear), indicating the egg data availability and/or processing phase, per strata: 1- South, 2- West Pt, 3- North (WGalicia+Cantabric)

Year	Survey type (plankton gear)	Egg data (11 stages)	P0 estimates
1988	regular PIL survey (CalVET)	1 inc, 2, 3	available (1, 2, 3) regular survey
1990	other (CalVET)	3	available
1995	MAC/HOM EPM (Bongo)	?,?, 3	na
1997	regular PIL survey (CalVET)	1, 2, 3	available (1, 2, 3) regular survey
1998	MAC/HOM EPM (Bongo)	?, ?, 3	na
1999	regular PIL survey (CalVET)	1, 2, 3	available (1, 2, 3) regular survey
2001	MAC/HOM EPM (Bongo)	1, ?, 3	na
2002	regular PIL survey (CalVET)	1, 2, 3	available (1, 2, 3) regular survey
2004	MAC/HOM EPM (Bongo)	1, 2, 3 (no stgs)	na
2005	regular PIL survey (CalVET)	1, 2, 3	available (1, 2, 3) regular survey
2007	MAC/HOM EPM (IEO: Bongo,IPMA DEPM, CalVET)	1, 2, 3	1, 2, 3
2008	regular PIL survey(CalVET)	1, 2, 3	available (1, 2, 3) regular survey
2010	MAC/HOM EPM(IEO: Bongo, IPMA DEPM, CalVET)	1, 2, 3	1, 2, 3
2011	regular PIL survey (CalVET)	1, 2, 3	available (1, 2, 3) regular survey
2013	MAC/HOM EPM(IEO: Bongo, IPMA DEPM, CalVET)	1 inc, 2, 3	1, 2, 3

2014	regular PIL survey (CalVET)	1, 2, 3	available (1, 2, 3) regular survey
2016	MAC/HOM EPM (IEO: Bongo, IPMA DEPM, CalVET)	1, 2, 3	1, 2, 3

Methodology

First the survey information was mapped and the spatial grids resolution were assessed. For this phase it was also decided to start the re-analyses from the more recent years backwards. The following step involved revisiting the samples for completing the egg staging process (11 stages). In addition to the laboratorial work, issues such as gear capturability vs. area coverage were also addressed.

At present, data from four surveys (2007, 2010, 2013, and 2016) are available and egg production estimations were calculated. The analyses were carried out using the standard methodology adopted for the 2012 revision (GLM, with a common slope and three intercepts: glm.nb(cohort ~ offset(log(Efarea)) -1 + Stratum+ age, weights=Rel.area , data=aged.data)) and described in ICES (2011, 2012) .

Egg Production

Egg production estimates for sardine were performed for the data from the four more recent mackerel and horse-mackerel egg production surveys which are presented in Figure 5.2.1. IPMA is responsible for surveying the area of the southern stock of horse-mackerel (Gibraltar to Finisterre) while IEO´s campaigns cover Galician and Cantabrian shores. Since 2007 IPMA´s survey adopted the DEPM and the spatial resolution of the plankton sampling was increased while at the same time the CalVET system started to be used instead of the Bongo utilized during the previous AEPM campaigns. The changes introduced in IPMA´s surveys resulted from a compromise between the need to increase the spatial resolution and the sea time available. IEO surveys maintained the AEPM approach and have not introduced alterations in sampling design or gear used. During the period under analysis the spatial coverage of IPMA surveys varied, only in 2010 was the whole area of the horse-mackerel southern stock occupied; in 2007 and 2016 the northern limit of the planned grid was not attained and in 2013 the Bay of Cadiz was not surveyed. In order to fill in these gaps some assumptions were made taking in consideration the estimated spawning areas from other EPMs campaigns, with the highest temporal-proximity, in the regions for which there were some sampling gaps. In 2007 and 2016 the western Galician coast not sampled by IPMA was surveyed during IEO campaign.

To solve questions related to hauls effective area estimation and spawning area delimitation in AEPM surveys carried out by IEO, the values used in different functions to obtain the spawning areas were modified from the standard used for the sardine DEPM revision undertaken in 2012 (ICES, 2011, 2012). The minimum distance in ratio represented by each station was set to 25 km (15 km was set for sardine DEPM surveys) and no maximum and minimum values were fixed. In 2016, the AEPM survey carried out by IEO, used the auxiliary sampler CUFES to delimit the spawning area. Samples were taken every 3 nm throughout the transects and once at the laboratory, sardine eggs were sorted and counted. The spawning area extension is computed as the sum of the area represented by the stations within the spawning area sampled by the CUFES. Despite the advantage of having the CUFES sampling for area definition there are still some issues relating to the area representativeness of each Bongo station for the total spawning area definition that will be further explored in coming analyses.

The egg production estimates obtained for 2007, 2010, 2013, and 2016 are included in the historic series plot presented in Figure 5.2.2. The new results appear coherent within the dataseries, the decline in egg production observed since the 2008 survey is perhaps clear now with the new point for 2010, this tendency is possibly masked by the result in 2011 likely higher due to poor model fitting (see updated estimates using an external model for mortality estimation, previous section in this report). The WGACEGG discussed the analyses here presented and considered that this approach of using the information available from other years in between the dedicated sardine DEPM surveys are useful for completing the dataseries and can assist in describing the sardine biomass temporal trends during stock assessment analyses. The Group considers the extra data gathered in this way very valuable and supports the continuation of the analyses for other, past and future, surveys. In addition, considers that the new data from the four surveys presented should be analysed and included in the series of P_0 (and SSB should adult parameter be available) estimates obtained using the external mortality model approach described in the previous section.

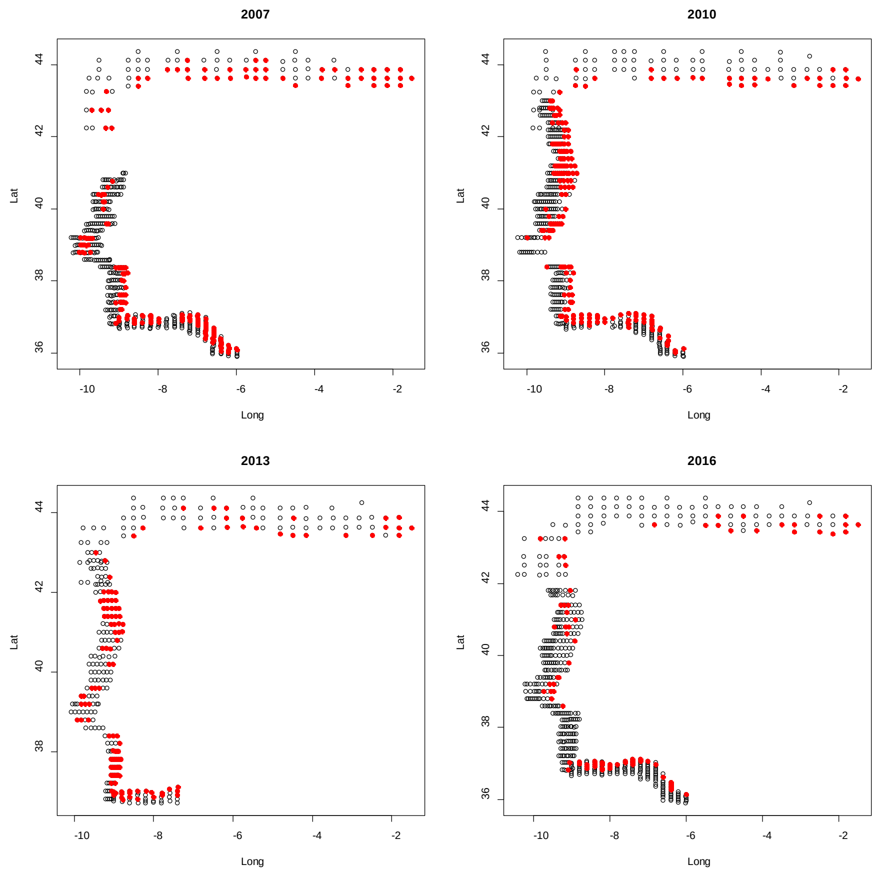

Figure 5.2.1. Plankton sampling coverage (and egg presence, in red) for the 2007, 2010, 2013 and 2016 surveys. Survey periods: 2007 - IPMA: 03/02-02/03; IEO: 15/03-17/04; 2010 - IPMA: 30/01 – 03/03; IEO: 07/03-29/03; 2013 - IPMA: 10/02 – 19/02; IEO: 01-22/04: 2016 - IPMA: 11/03 – 01/05; IEO: 11-25/04

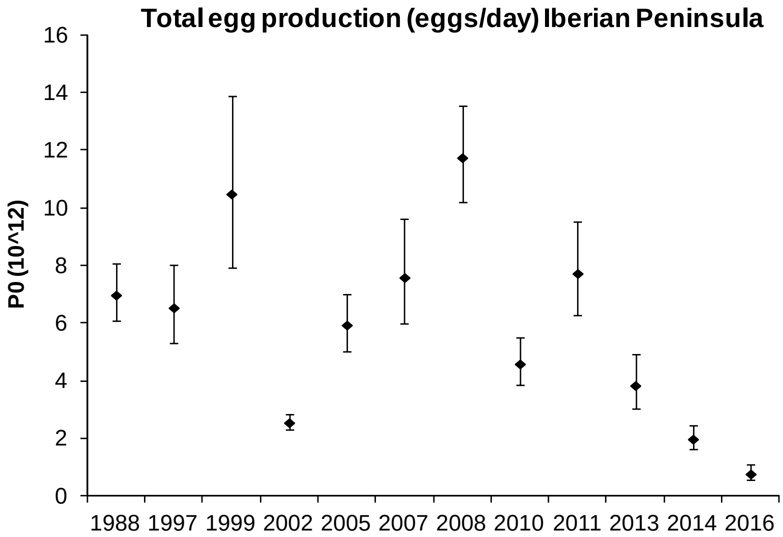

Figure 5.2.2. Total Egg production estimates (eggs/day) for the Atlanto-Iberian Peninsula (9a+8c) obtained by the traditional method (black dots); the new estimates carried out with information from mackerel and horse-mackerel EPM surveys are flagged by pink circles. The bars represent the confidence intervals for the estimates.

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5.3 Estimation of the coefficient of variation from PELAGO and PELACUS

At present, pelagic fish biomass estimates using the echo-integrated method obtained from those acoustic surveys performed in the Iberian Peninsula would be observed as a non direct-independent from the fishery method to estimate fish biomass which accounts the echoes (direct observation), recorded at one (38 kHz in PELAGO case) or different discrete frequencies (PELACUS) on a continuous way, and the species composition obtained at the fishing stations performed in discrete areas along the surveyed area. Is indirect because number or biomass at length groups or at age classes are not derived from the direct observation (echoes) but from the results obtained at the fishing stations. Together with the fish availability related with the fish behaviour (avoidance) of the research vessel (De Robertis and Handergard, 2012), trawl hauls are also subjected to additional sources of variability related with the accessibility, catchability and selectivity of the fishing gear in relation to fish behaviour and fish size (Ona and Godø, 1990).

Apart from the systematic errors described in (Simmonds and McLenan, 2005) the main random sources of variability of an acoustic survey are related with the representativeness of the pelagic fish community in the fishing stations, the method used to allocate the echo-integrated energy to each specific target species and the spatial distribution of this energy along the surveyed area.

In this section is mainly based on the investigations made on the PELACUS time-series in Carrera (2016) and for PELAGO time-series in Zwolinsky (2008).

Representativeness of the pelagic fish community in the fishing stations and methodology to allocate echointegrated energy.

No exhaustive investigations have been carried out on this issue. In PELACUS, three research vessels has been used, although RV Thalassa (TH) and Miguel Oliver (MO) were used since 1997. Both vessels made an intercalibration exercise in 2014 in order to compare the performance of both platform in terms of a) acoustic records; and b) fishing haul results. Methods are described in Carrera (2014). Fishing stations were carried out in parallel, at the same time over the same area. Results on fish proportion and length distributions were analysed.

Fishing stations were located on account the results obtained during the acoustic prospection. In the same way, several hauls have been done over each area in order to check intra-inter ship variability. Both fishing gears and rigging were different in both vessels. On board TH a 76/70 "grandes mailles", with a vertical opening of about 20 m and around 60 m horizontal one, was used whereas on board MO an adaptation of a pelagic gear with a vertical opening similar to that of the TH but with a less horizontal opening (around 35 m). In the same way, doors were also different (semi-pelagic Vertical V morgère type on board TH and pelagic Apollo polyice- in MO). Gear performance was controlled using net sounder. In the former case, a wireless trawl explorer (Marport) was used and in the later a cabled Simrad Sonar 25/20. For the fishing stations the procedure was similar, some of the hauls were done in parallel whereas in other cases one of the vessels leaded the operation as seen in the following figure.

All data were either stored or recorded in order to analyse the performance of each haul. The duration was limited to 30 or 20 minutes depending on the fish availability. Moreover, all trawl hauls were performed close to the seabed, thus excluding those mid or upper waters schools. 11 hauls were done in parallel while in the other 4 one vessel leaded the haul. The special footrope used in the MO gearing this period, a kind of rock-hopper with small dishes which allows it to have a permanent contact with the seabed while preserving the net, makes the demersal species be more available to this vessel. Accordingly the faunistic list obtained by MO was longer (Table 5.3.1). It includes almost the same species caught by the TH (this vessel also caught ten *Trigla lyra* in a single haul).

Table 5.3.1. Faunistic list obtained in PELACUS0414-INTERCALIBRATION by both vessels, including the number of hauls with presence and total specimen caught.

Miguel Oliver			Thalassa		
Species	No hauls	No	Species	No hauls	No
Chelidonichthys cuculus	1	1			
Engraulis encrasicolus	9	244442	*Engraulis encrasicolus*	9	384276
Illex coindetii	1	na	*Illex coindetii*	1	na
Merluccius merluccius	13	380	*Merluccius merluccius*	8	89
Petromyzon marinus	1	1			
Pollachius pollachius	3	6			
Raja spp	1	4			
Sardina pilchardus	8	20211	*Sardina pilchardus*	7	24247
Scomber colias	12	452	*Scomber colias*	9	331
Scomber scombrus	14	18270	*Scomber scombrus*	13	15973
Sprattus sprattus	9	21203	*Sprattus sprattus*	9	24787
Trachinus draco	2	3			
Trachurus trachurus	15	53815	*Trachurus trachurus*	9	15024
			Trigla lyra	1	10
Trisopterus luscus	1	1			
Trisopterus minutus	1	23			
Zeus faber	3	3			

Excluding in the analysis specific areas with isolate thick schools of small horse mackerel or even sardine, the variability intra/intership in both fish proportion and length distributions were of the same order, thus no significant differences between vessels and fishing gears were found and therefore both vessels are expected to get the same representativeness of the pelagic fish community. Nevertheless, single thick schools seem to have a big impact on any result and therefore, this effect should be accounted when the fishing stations are used to typify the pelagic fish community as they could likely to bias this. The same impact was also observed when the trawls are used to obtain demographic information of sardine in PELAGO (Zwolinsky, 2008).

Although multifrequency approach is used in PELACUS to classify echotraces and discriminate among species, fishing station is providing ground-truth (McClatchie *et al.*, 2000) for these direct allocations and also is used to distribute density into numbers at length. On the contrary, on PELAGO, as only one single frequency is used (38 kHz) no multifrequency approach can be used and, therefore, in most of the cases only fishing station are used to discriminate among species.

When fish are likely to occur in mixed situations (schools and/or layers or fish aggregations, i.e. no strict schools but concentrations of fish able to be extracted as an echotrace as defined by Reid *et al.*, (2000), difficult to allocate to a specific fish species) fish proportion by species (and length distributions) obtained at the fishing stations are used to split the NASC ($m^2 nm^{-2}$, s_A). Again, different methods for choosing the best ground-truth fishing station candidates have been explored. Among them, the nearest fishing haul; a manual and/or automatic system which compares echotraces from the acoustic trawl and those obtained at the fishing stations, assigning the fishing station that get a better match between both images; and a third one which, rather to take into account the distance between a particular ESDU from the nearest/better fishing station candidate, is regarding the surveyed area as discrete ecological regions where different pelagic fish communities are expected to be found. This method takes into account the historical time-series of fishing stations which has been analysed in Santos et al. (2013) and Carrera (2016), the main oceanographic regions accounting recurrent hydrographic structures which, in turn, influence the mesozooplankton structure (González-Bueno, 2015); and the potential spawning distribution area of the main pelagic species derived from the CUFES egg counts. For each of these areas, the quality of the hauls for ground-truthing the acoustic data are ranked 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 distribution	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 when no direct allocation is feasible. 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:

$$NASC_l = NASC \cdot \left(\frac{\sigma_{l,\rho}}{\sigma_\rho}\right)$$

where *NASC* is the total backscattering energy to calculate densities by length, $NASC_l$ is the proportion of the total *NASC* which can be attributed to length group l for a particular fish species. $\sigma_{l,p}$ is the backscattering cross section at length l for a particular species at length l multiplied by the proportion of (p_l) of length of this particular species on the overall catch and σ_p is the sum of all $\sigma_{l,p}$ for all species,

$$\sigma_{l,\rho} = \rho_l * \sigma_l$$

$$\sigma_\rho = \sum_l \sigma_{l,\rho}$$

finally σ_l is backscattering cross section (m²) for a fish of length l for a particular species and is computed as follows:

$$\sigma_l = \frac{l^{\left(\frac{m}{10}\right)} * 10^{\left(\frac{b_{20}}{10}\right)}}{4 * \pi}$$

This is computed from the formula TS = 20 $\log L_T$+ b_{20} (Simmonds and MacLennan, 2005), where L_T is the length class. The b_{20} values for the most important species present in the surveyed area are shown in following table.

Table 5.3.2- 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*))

Sp	b_{20}	Ref	Observations	Other b_{20}	Ref.
PIL	-72.6	Degnbol *et al.*, 1985	TS for clupeids	-71.2 -70.4 -74.0 -72.5	ICES ,1982 Patti *et al.*, 2000 Hannachi *et al.*, 2005 Georgakarakos *et al.*, 2011
ANE	-72.6	Degnbol *et al.*, 1985	TS for clupeids	-71.2 -76.1 -71.6 -74.8	ICES 1982 Barange *et al.*, 1996 Zhao *et al.*, 2008 Georgakarakos *et al.*, 2011
HAK	-67.5	Foote *et al.*, 1986; Foote, 1987		-68.5 -68.1	Lillo *et al.*, 1996 Henderson, 2005; Henderson and Horne, 2007
BOG	-67.5	Foote *et al.*, 1986	Adapted from gadoids		
BOC	-66.2	Fässler *et al.*, 2013			
MAC	-84.9	Edwards *et al.*, 1984; ICES, 2002		-86.4 -88.0	Misund and Betelstad, 1996 Clay y Castonguay, 1996
HOM	-68.7	Lillo *et al.*, 1996		-68.15 -66.8 -66.5/-67.0(*)	Gutiérrez and McLennan, 1998 Barange *et al.* (1996) Georgakarakos *et al.*, 2011

MAS	-68.7	Lillo *et al.*, 1996	Adapted from HOM;l (Sawada, com. pers.)	-70.95	Gutiérrez and McLennan, 1998
WHB	-65.2	Pedersen *et al.*, 2011			

*** day and night respect.**

The impact on the final estimation of the variability of the representativeness of the pelagic fish community in both fish proportion or length structure, hasn't been deeply investigated although, accounting the results obtained by Zwolinsky (2008), it would be minor if the issue of the influence of the big schools on the estimates is well addressed.

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:

Table 5.3.3. Main morphological and backscattering energy characteristics used for schools detection.

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

For all school candidates, several of variables were extracted, among them the NASC (s_A, m²/nmi²) 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). Together with this, direct allocation of echotraces to fish species was investigated by multivariate techniques (PCA and Discriminant Function Analysis; Anderson, 1958; Lebart *et al.*, 1995; Cascoullos and Styan, 1973) applied to several echotrace variables (morphologic, energetic and location). Direct allocation consistency was high (>75%) in the analysed surveys (1992–2002). These values were similar to those obtained by Lawson *et al.* (2001) for sardine (*Sardinops sagax*), anchovy (*Engraulis capensis*) and round sardinella (*Etromeus whiteheadi*). As for PELACUS, the use of ancillary variable in this case, namely oceanographic and geographic ones, greatly improved the performance of discriminant analysis. In Our case, the most important ancillary variable for both sardine and anchovy are the egg counts from CUFES; besides, although no quantitative but qualitative, the presence of horse mackerel and mackerel eggs is used to delimitate the potential distribution area and thus used to improve the direct allocation. For the later species, as the survey take places at the same time of the main spring fishery, the presence of the artisanal fleet (mainly short size -10–18 m – provided with automatic jigs) is also used.

According to these results, the effect of the allocation method either directly or using the ground-truth fishing stations may have an impact ranging between 5–15% in the CI of the estimates.

Variability due to the sA spatial distribution

The sources related with specific fish distribution accounting the spatial aggregation pattern and density in PELACUS were explored in Porteiro *et al.* (1996) and Carrera (2016) by means of geostatistics and point-process approaches while in PELAGO has been done by Zwolinsky (2008) using GAM approach. In both cases the skewness of the data, with few high values with a great influence in both mean and variance, made difficult the analysis. As stated by several authors acoustic data are inherently noisy (Petitgas, 1993; Rivoirard *et al.*, 2000; Gimona and Fernandes, 2003). Fitting a model to acoustic data. When the species occur in schools, these are autocorrelated and are distributed in clusters which also shown a spatial correlation. This can be shown either when the data are analysed using point-process technique or geostatistics. In all cases, the distance to the nearest school is far from the random assumption, as shown in Figure 5.3.2.

Figure 5.3.2: Cumulative frequency distribution of the distance to the next school (m) (black dots). Red line is the fitted curve to a Weibull distributions and the blue one the Poisson one obtained from the 1997 acoustic data, the larger distance between the Poisson and the Weibull curves, the greater spatial correlation among schools.

Cluster sizes varied between 1.28 and 2.9 nautical miles while the distance between clusters varied between 1.3 and 3.9 nautical miles. This values agrees with the range of the autocorrelation derived from the variograms, with a first structure located between 2-6 nmi and a second one at 9-26 nautical miles. In the same way, variograms were fitted to the sA values attributed to the main species (sardine, horse mackerel, mackerel and blue whiting). Fitted model showed in some case a nested structure, with the range of the first variogram located between 2–8 nautical miles, with the shorter ones in sardine, and a second model with ranges located between 8-30 nautical miles. In order to investigate the influence of the larger values, sA values were split into 4 categories (0–10; 10–100; 100–500; >500). It was possible to fit the lower values to a specific variogram models. On the contrary, it seems that the high values are randomly distributed as no spatial structure would be derived. Moreover, the lower categories gave larger ranges while the higher categories, when variogram were available, gave very narrow ranges.

As a result, CV derived from the spatial distribution ranged between 23 and 44%, being the higher values from sardine as the values were more skew.

In PELAGO, survey precision was estimated for sardine by fitting s_A values allocated to sardine a two-stage GAM using spatial coordinates and water depth as explanatory variables. The use of a two-stage model assumes that a s_A observation at a given set of predictors is a noisy realization of two processes, the first process controlling the probability of the s_A being a positive value and the second process controlling the mean value conditioned on being a non-zero observation s_A. Confidence intervals (CI) for the GAM-estimates of total sardine backscattering area were obtained by simulation from the posterior distribution of the model parameters. 1000 simulations of the multivariate Gaussian vectors were done. From each simulated vector, the total backscattering area for sardine was obtained by evaluating the model with the new parameters at each grid node and summing across the grid. The resulting 1000 estimates of total backscattering area were used to derive 95% CI for by picking the 0.025 and 0.975 quantiles of the distribution. The sensitivity of the estimate of fish numbers and biomass to the trawl stations was evaluated by a resampling technique similar to jackknife, in which an automated procedure removed one trawl at time while maintaining the positions of the remaining trawl stations fixed. Then, a new length frequency distribution surface was built according to the new nearest neighbour. The abundance of sardine was calculated in each turn by applying the original fitted NASC surface. Finally, a full resampling scheme combining acoustic sampling error and length frequency distribution was built by combining 1000 replicates of the NASC surface with the jackknife realizations of the trawl stations. At every run, numbers and biomass per length class were summed across all nodes creating a matrix from which statistics could be derived, either by length-class or over the whole length distribution. (see Zwolinsky (2008) for further details). In this case, the relative standard error (RSE) varied by regions and years between 6 and 46, most commonly, between 15–25%.

Although, as stated, this analysis was mainly done on sardine estimates using two different approaches, the results were similar, with confidence intervals (CI) of about 15-25%, depending on the spatial distribution. The more restricted distribution, the higher CI. Besides, in both cases the location and the number of fishing station could have an important effect on the confidence intervals on account their representativeness on both the pelagic fish community and the spatial structure of the length (and age) distribution along the surveyed area . Moreover, if the fishing stations are used as NASC allocation method, a fine scrutinisation of the echograms should be done to check differences between the echotraces recorded at each fishing stations with those recorded at the survey track in order to avoid possible bias in biomass estimates due to a bad representation of the true pelagic fish community.

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5.4 Comparison of trends in the sardine SSB estimates (ICES 9a and 8c) obtained from DEPM and acoustics surveys

Several causes have been addressed during WGACEGG related with the differences between sardine DEPM and acoustic estimates. Among them:

- **Effect of time-lag between surveys on population structure and behaviour.**

The surveys are not entirely carried out simultaneously, especially in the Portuguese area. Differences in fish distribution, reproductive phase and interval from recruitment may play a significant role. The phase of the reproductive cycle affects the spatial distribution and aggregation pattern of the fish, and may vary along the surveyed area.

In addition, fish distribution and behaviour are notably modified by the weather conditions (that can vary between surveys); it is not uncommon to observe an appreciable decrease in the fish availability during events of stormy seas.

This may affect both the availability and accessibility of the surveying methods (both acoustics and DEPM) and may lead to results of difficult interpretation.

- **Allocation of acoustic energy to pelagic species**

While the DEPM results derive from direct observations on fish eggs and ovaries, acoustics needs a post-processing phase aiming to scrutinize the echograms and to allocate echo-integrated energy to target species. Several methods are described to perform this task (ICES 2015), but in most of them, an expertise judgement is needed. The use of multifrequency equipment and post-processing programs such as Echoview, LSSS or Movies among others, highly improved the quality of the scrutinization and allowed automated or semi-automated methods to allocate echotraces to fish species be implemented. When this new tools are not available, ground-truth fish samples are used (McClatchie *et al.*, 2000). In this case the total echointegrated energy is split among the different fish species accounting both for the abundance and the specific target strength. This may result in a bias if the fishing gear has different accessibility and catchability to the different fish species and sizes (lengths), giving, thus, a biased representation of the pelagic fish community both in terms of species composition and proportions but also in length structure. However, during a normal acoustic survey, several fishing stations are routinely performed on the same echotypes (i.e. similar echotraces corresponding to a group or single fish species with a given length distribution) in order to ensure the best representation of the pelagic fish community.

- **Estimation of reproductive parameters**

Some DEPM parameters such as spawning fraction, relative fecundity and egg mortality may be more complex to estimate for some particular surveys when sampling is not as comprehensive as desirable due to patchiness of the fish and eggs distribution. Problems related to sardine availability and catchability as described before, may result in a biased sample of sardine and therefore of the adult parameters. Sometimes the samples are not randomly taken, and samples could be only obtained from the high egg density areas, or from particular areas (i.e. offshore or inshore), where there are no restrictions for the fishing operations (i.e. bottom roughness or the presence of other static fishing gears). This is particularly relevant when the data available do not allow estimations stratified by geographical area or population length (age) composition.

- **Differences on age catchability in acoustic surveys**

As explained previously, either because the fishing stations are not randomly or due to a fishing selectivity issues, the length or age structure from the acoustic estimate would result biased in relation to the DEPM one. Moreover, if for both methods the adult sampling intensity is placed accounting, respectively, the egg and the echotrace abundances and if there is a mismatch between both areas, the resulted length or age structure could be different if there is a spatial age or length distribution pattern (i.e. both along the coast or length depth dependent gradient)

Nevertheless, as it can be observed in Figure 5.4.1, trends for both time-series indices are relatively similar, with a correlation of 0.3, and especially after the revision of the mortality estimation method for the DEPM series (WGACEGG 2016, section 1 of this annex). Major disagreement is due to the differences between indices in 2008. Excluding this particular year, correlation improves from 0.3 to 0.7.

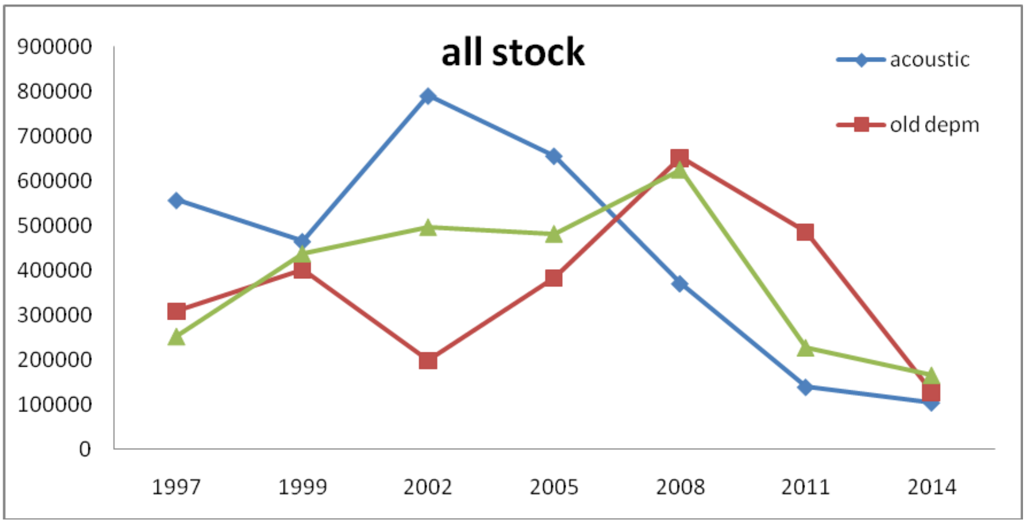


Figure 5.4.1. Sardine biomass estimates (tonnes) from acoustics and DEPM (traditional and using the revised mortality estimates). The DEPM estimates are for SSB while estimations from acoustics are Biomass$_{1+}$.

By strata main differences between surveys are observed in the south (Figure 5.4.2).

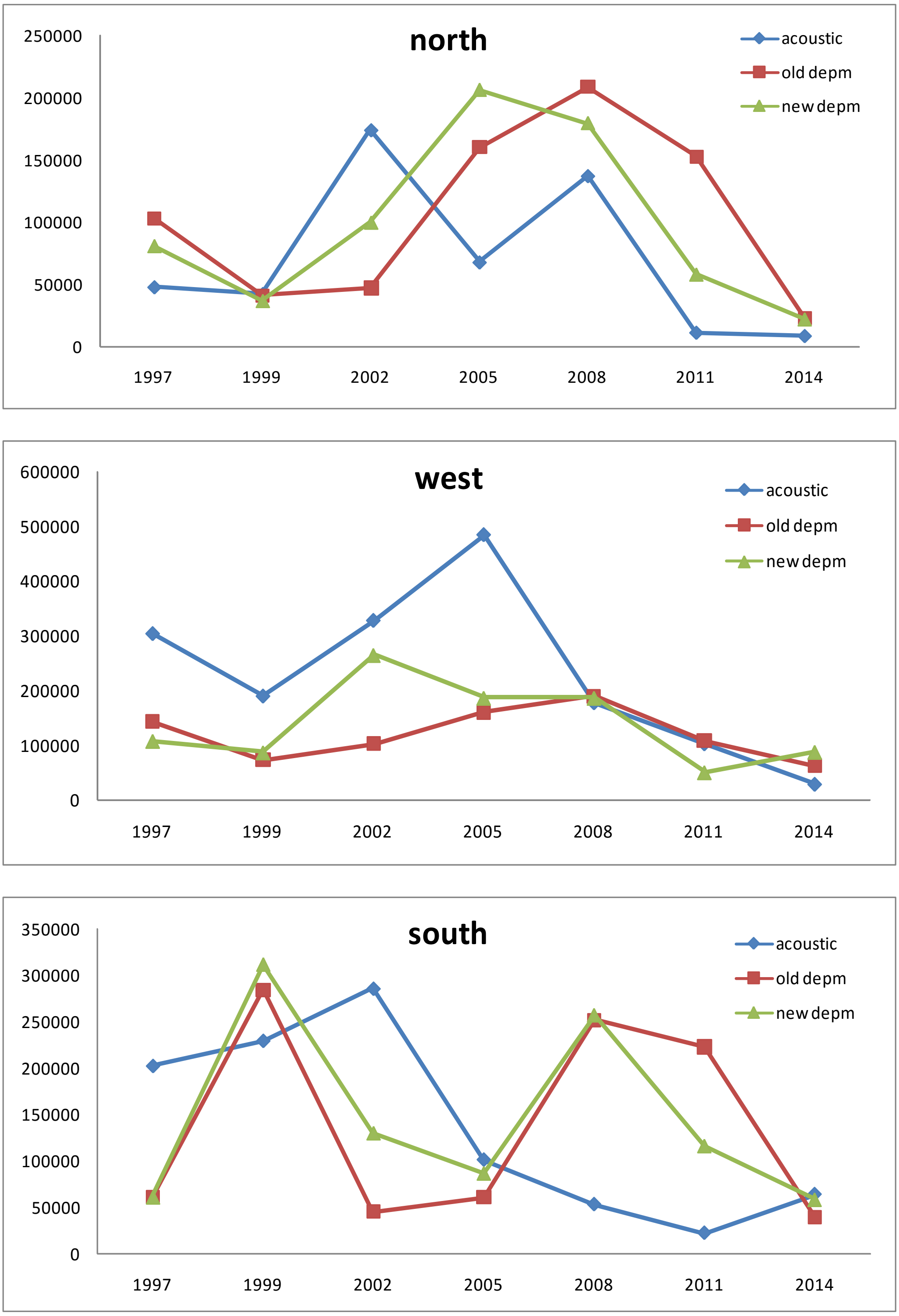


Figure 5.4.2. Sardine biomass estimates (tonnes) from acoustics and DEPM (traditional and using the revised mortality estimates) by strata. The DEPM estimates are for SSB while estimations from acoustics are Biomass$_{1+}$.

Moreover, the WGACEGG has also discussed the methodological aspects of both the DEPM and Acoustics surveys and considers that the surveys are performing well and the work is being carried out complying with the standard agreed methodologies.

The Group is pursuing further studies in order to better understand the differences found in the estimates from acoustics and DEPM, in some years or regions: (i) analyse fish spatial and depth distribution during surveys; (ii) use same regional stratification of the information for both survey types; (iii) calculate biomass estimation by age (length) for sardine; (iv) utilize CUFES data for egg production estimation and comparison to estimations undertaken for CalVET data; (v) discuss standardization of strata definition and (vi) assess bias in energy partition for particular areas.

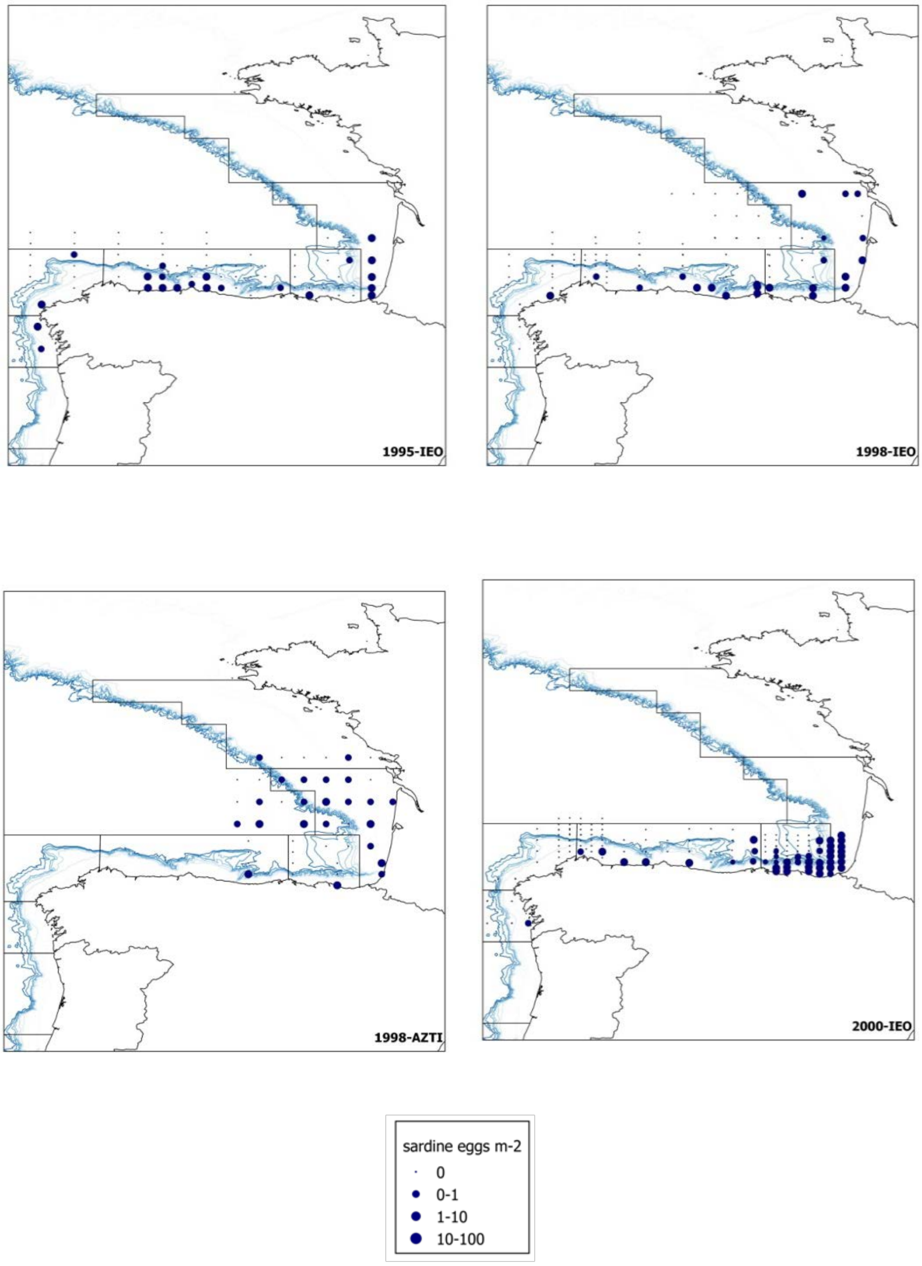
5.5 Sardine egg abundance in IEO and AZTI triennial mackerel and horse mackerel surveys between 1995 and 2016.

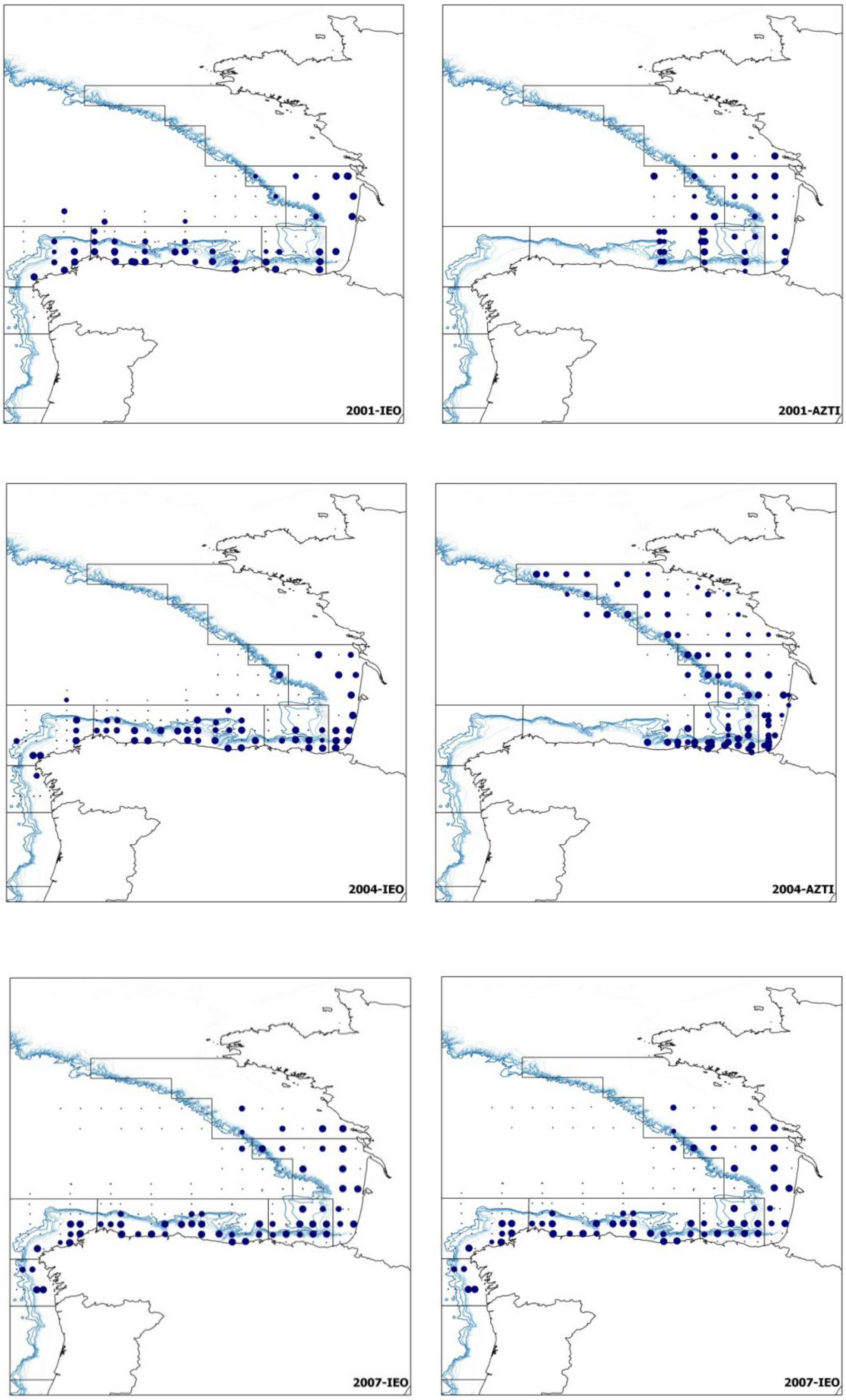
Since 1988, DEPM surveys directed to sardine were performed by IEO (data used in the sardine assessment model since 1997)(mainly in the 8c-9a sardine stock area) and AZTI (since 2011)(mainly in 8abc1), on a triennial basis. Methodology and results are presented and discussed every year in the framework of WGACEGG.

As a request of the WKSAR (Workshop on Atlantic sardine, Lisbon, September 2016), in order to have more information on sardine abundance to include in the assessment model for sardine during the 2017 benchmark (and particularly for the 8abd-7 sardine stock), sardine egg densities from AEPM surveys (triennial from 1995 to 2006) (IEO and AZTI) directed to mackerel and horse mackerel, were presented.

Along the time-series, spring surveys were carried out in 1995, 1998, 2000, 2001, 2004, 2007, 2010, 2013 and 2016 (Figure 5.5.1). In this period, several ships and plankton samplers were used, and depending on the objectives of any given survey, the total area covered was different. Triennial AEPM sardine egg database was uploaded to the WKSAR SharePoint (ices.dk/community/groups/Pages/WKSAR-2016.aspx) in the following format, where **Eggs/m²Sar** are sardine egg densities and **Area** is area represented by each sampling station (km²).

	A	B	C	D	E	F	G	H	I	J	K
1	Year	Survey	Station	Long	Lat	Eggs/m^2 Sar	Eggs Sar	Date	Sampler	Stratum	Area
2	2013	CAREVA0313	1	-4,745	45,751	0	0	07032013	Bongo 40	VIIIb	1829,42984
3	2013	CAREVA0313	2	-4,251	45,751	0	0	07032013	Bongo 40	VIIIb	1716,75089
4	2013	CAREVA0313	3	-3,741	45,747	0	0	07032013	Bongo 40	VIIIb	1718,58306
5	2013	CAREVA0313	4	-3,243	45,744	0	0	08032013	Bongo 40	VIIIb	1727,74396
6	2013	CAREVA0313	5	-2,739	45,751	0	0	08032013	Bongo 40	VIIIb	1703,00955
7	2013	CAREVA0313	6	-2,248	45,751	0	0	08032013	Bongo 40	VIIIb	1722,24742
8	2013	CAREVA0313	7	-1,744	45,749	15,3999793	13	08032013	Bongo 40	VIIIb	1434,59546
9	2013	CAREVA0313	8	-1,435	45,753	0	0	08032013	Bongo 40	VIIIb	1446,50462
10	2013	CAREVA0313	9	-1,328	45,251	0	0	09032013	Bongo 40	VIIIb	1398,86799
11	2013	CAREVA0313	10	-1,762	45,251	372,934212	305	09032013	Bongo 40	VIIIb	1625,14198
12	2013	CAREVA0313	11	-2,251	45,256	0	0	09032013	Bongo 40	VIIIb	1677,35906
13	2013	CAREVA0313	12	-2,737	45,255	0	0	09032013	Bongo 40	VIIIb	1720,41524
14	2013	CAREVA0313	13	-3,243	45,253	0	0	09032013	Bongo 40	VIIIb	1757,05881
15	2013	CAREVA0313	14	-3,749	45,25	0	0	09032013	Bongo 40	VIIIb	1717,66698
16	2013	CAREVA0313	15	-4,251	45,253	0	0	09032013	Bongo 40	VIIIb	1716,75089
17	2013	CAREVA0313	16	-4,738	45,254	0	0	10032013	Bongo 40	VIIIb	1834,92637
18	2013	CAREVA0313	17	-4,754	44,751	0	0	10032013	Bongo 40	IXa N + VIIIc	1841,339
19	2013	CAREVA0313	18	-4,246	44,751	0	0	10032013	Bongo 40	IXa N + VIIIc	1746,06574
20	2013	CAREVA0313	19	-3,743	44,747	0	0	10032013	Bongo 40	VIIIb	1681,9395
21	2013	CAREVA0313	20	-3,244	44,748	0	0	10032013	Bongo 40	VIIIb	1732,3244
22	2013	CAREVA0313	21	-2,744	44,748	0	0	11032013	Bongo 40	VIIIb	1737,82093
23	2013	CAREVA0313	22	-2,243	44,755	0	0	11032013	Bongo 40	VIIIb	1703,00955
24	2013	CAREVA0313	23	-1,767	44,748	174,891979	162	11032013	Bongo 40	VIIIb	1593,99495
25	2013	CAREVA0313	24	-1,35	44,749	0	0	11032013	Bongo 40	VIIIb	1364,0566


1995-IEO
1998-IEO
1998-AZTI
2000-IEO
sardine eggs m-2
0
0-1
1-10
10-100


2001-IEO
2001-AZTI
2004-IEO
2004-AZTI
2007-IEO
2007-IEO

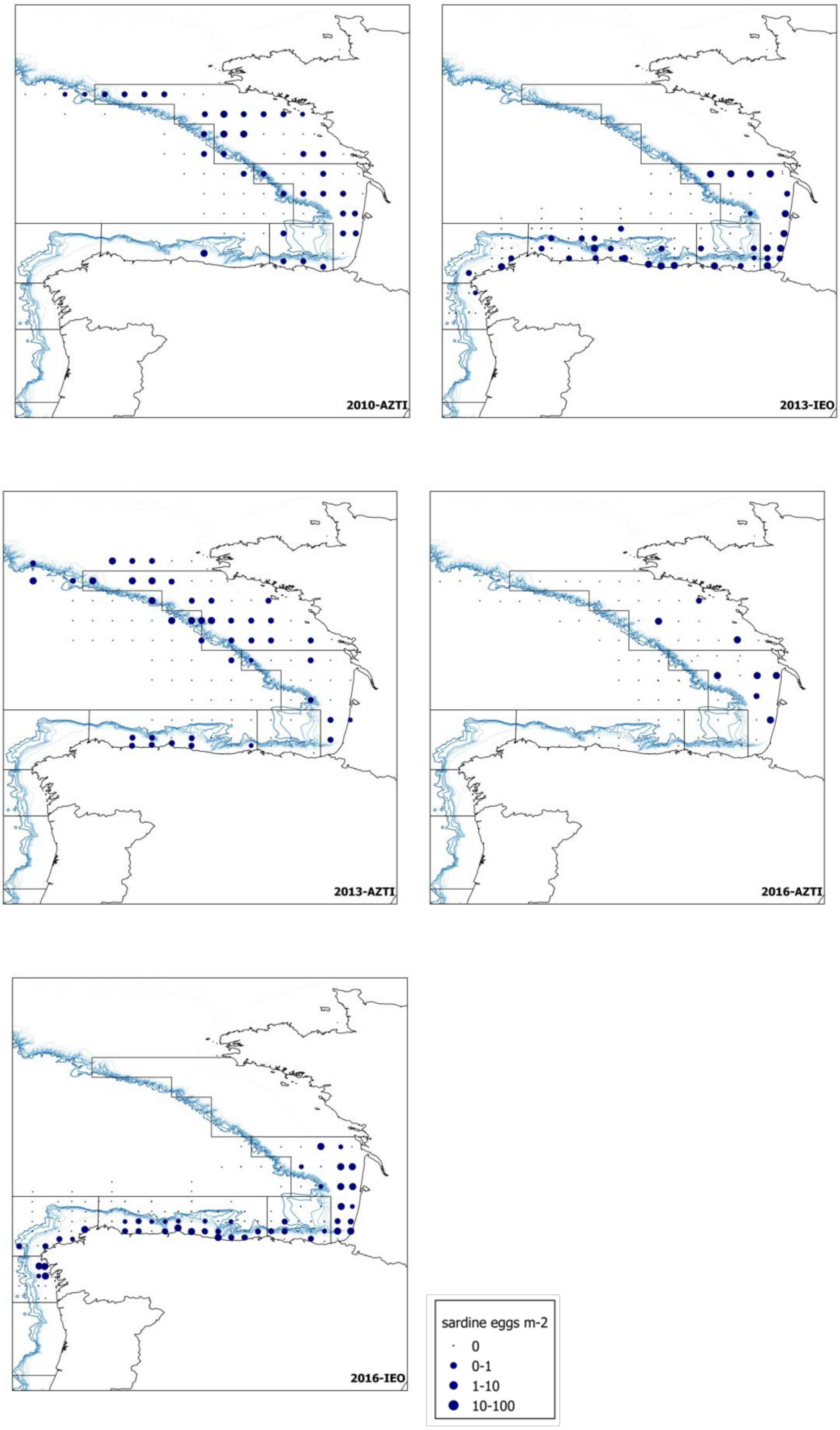


Figure 5.5.1 Sardine egg densities during the different AEPM mackerel and horse mackerel surveys from 1995 to 2016

Annex 6: Developments in Acoustics

6.1. Effect of Target Strength equation selection on PELGAS anchovy and sardine biomass estimates

Mathieu Doray, Ifremer EMH

Knowledge of the acoustic response of single fish (or Target Strength: TS) is of prime importance for acoustic target classification (Barange, 1994; Doray *et al.*, 2006), and abundance estimation (Rose, 1992; Jech and Horne, 2001). TS is hence the scaling factor used to convert acoustic density (NASC) into fish density. TS is classically expressed in dB as a function of total fish length Lcm in cm as:

TS = 20log10(Lcm) – b20 Eq. 1

where b20 is a species-specific parameter.

Ifremer uses b20 = 71.2 (taken from the work of (Edwards *et al.*, 1984) on 7-27 cm herrings), and IEO, AZTI, IPMA use b20 = 72.6 (taken from the work of Degnbol *et al.* (1985) on 19–26 cm herrings and sprats to assess anchovy biomass, . Another classical b20 value was provided by (Foote, 1987 for physostoms: 71.9.

Fish density is classically expressed in fish per square nautical mile as a function of fish TS as:

Fish density = NASC / (10^(TS/10)) Eq. 2

Fish swimbladder produces at least 90% of swimbladdered fish (Foote, 1980). The swimbladder compresses with pressure at depth, which induces a decrease of the fish TS with increasing depth.

The effect of pressure on swimbladder volume and fish TS has been namely investigated by:

i) (Ona, 2003), who proposed an expanded target-strength relationship for herring. (IJMS, 60: 493–499), based on an extensive set of TS measurements on 32 cm Herring, conducted in situ from 40 to 470 m and ex situ from 0 to 100m depth:

TS = 20log10(Lcm) – 65.4 – 2.3log10(1+depth/10) Eq. 3

Ona's work suggest that the swimbladder compression with depth could be less than what would be predicted by Boyle's law for a free balloon model.

ii) (Zhao *et al.*, 2008) measured in situ TS of 6-15cm Japanese anchovy *in situ*, during 1night, between 10 and 45m depth and derived another equation, which is in line with Boyle's law:

TS = 20log10(Lcm) – 67.6 – (23/3)log10(1+depth/10) Eq. 4

The Figure 6.1.1 presents these TS(Lcm) relationships at different depths.

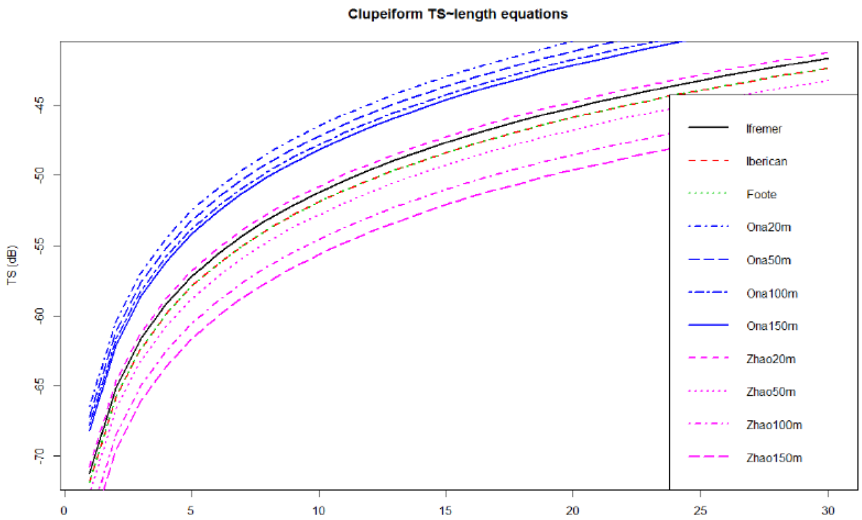


Figure 6.1.1: TS~length equations predictions

Ifremer, Iberian and Foote (1987)'s TS(Lcm) equations predictions are close. Within the depth range sampled by the PELGAS survey (20–150 m), Ona (2003)'s equation predicts higher TS values than Ifremer, Iberian and Foote (1987)'s equations, whereas Zhao (2008)'s equation predicts lower values. The differences between TS predictions mainly stem from differences in the b20 constant, which is inversely proportional to TS. The depth correction term yields lower magnitude TS differences, the TS decreasing with depth.

Acoustic biomass estimates of small pelagic fish provided by WGACEGG are proxies of the real fish biomass, whose interannual variations must be considered in relative terms. Changing the b20 term in the TS equation used to derive such biomass estimates has hence no effect on the biomass trends provided to the stock assessment groups for a given species. It has however been postulated that interannual changes in the depth distribution of Bay of Biscay anchovy might have a significant and non-linear effect on the acoustic biomass estimates, if a depth correction term was included in the TS equation (ICES, 2016).

In this paper, we aim at assessing the respective effects of b20 and depth correction terms on anchovy biomass acoustic estimates derived from the PELGAS survey, in order to evaluate the magnitude of a potential non-linear effect of fish depth on acoustic biomass estimates. The survey data are re-analysed using several TS equations with different b20 values and/or depth correction terms to assess the respective effects of each single term on PELGAS anchovy and sardine biomass estimates.

Material and methods

To investigate the respective effects of depth and b20 on anchovy and sardine Target Strength and biomass estimates, total biomass estimates and proportions at-age were re-computed for PELGAS 2012, 2014, 2015 and 2016 surveys, using either the Ona (2003)'s equation b20 (65.4 dB) without depth correction term, or the full Ona (2003)'s equation. The new sardine and biomass estimates were compared to the results obtained with Ifremer b20s, in order to assess the respective effects of b20 and depth correction terms on the essential population parameters provided to the WGHANSA assessment group (total biomass and age structure).

The surveys that were included in the re-analysis were selected to cover contrasted anchovy spring depth distributions. The anchovy depth distributions were assessed based on: i) the seabed depth at positive anchovy trawl haul locations, ii) the seabed depth at acoustic Elementary Sampling Distance Units (ESDU) locations, weighted by the anchovy acoustic biomass per ESDU, adjusted to take into account the typical anchovy school position in the water column. Anchovy mean depths per survey obtained with the 2 methods were compared.

The mean depth assigned to fish in the surface layer (i.e. in surface hauls and echotypes) was 10 m. The actual depth of clupeiforms closer to the bottom was estimated as the seabed depth minus 20 m, based on the typical altitude of clupeiforms schools in the Bay of Biscay (Villalobos, 2008).

We applied the biomass assessment method per post-stratification region routinely used during the PELGAS surveys, described in details in (Doray *et al.*, 2010).

Results

The depth distributions of anchovy during all PELGAS surveys estimated based on trawl hauls data are presented in Figure 6.1.2. Summary statistics are presented in Table 6.1.1.

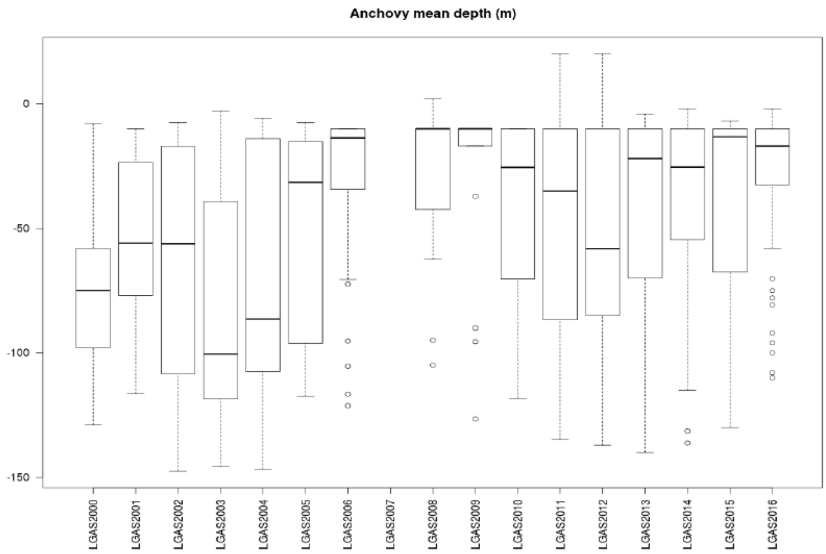


Figure 6.1.2: anchovy depth distribution estimated based on seabed depth at anchovy positive hauls.

Table 6.1.1: Anchovy depth mean, median and SD (m), based on seabed depth at positive haul locations.

Survey	Mean depth (m)	Median depth (m)	SD depth (m)
PELGAS2000	70	75	34
PELGAS2001	53	56	31
PELGAS2002	65	56	47
PELGAS2003	81	101	46
PELGAS2004	73	86	48
PELGAS2005	54	32	41
PELGAS2006	33	14	35
PELGAS2008	25	10	28
PELGAS2009	28	10	36
PELGAS2010	41	26	38
PELGAS2011	50	35	43
PELGAS2012	55	58	43
PELGAS2013	42	22	41
PELGAS2014	40	25	35
PELGAS2015	39	13	40
PELGAS2016	28	17	27
Average	*49*	*40*	*38*
SD	*17*	*29*	*6*

The mean anchovy depths obtained based on seabed depths at the trawl haul and ESDU locations are presented in Figure 6.1.3.

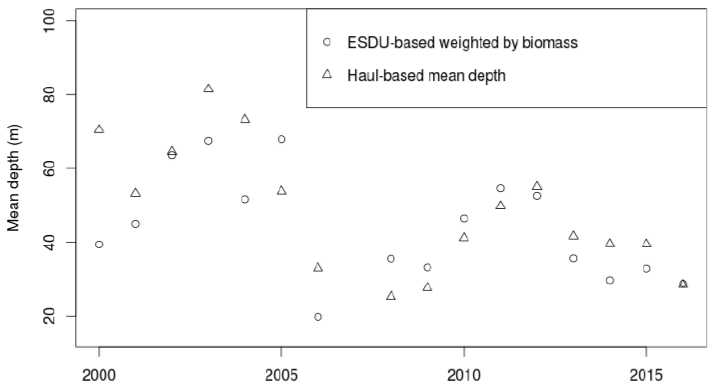


Figure 6.1.3: Mean anchovy depths estimated based on seabed depth at positive hauls locations (triangle) and ESDUs, weighted by anchovy biomass (circle).

The mean anchovy depths estimated with both methods are close, especially after 2007, thanks to the additional trawl hauls performed by commercial fishers since 2007 (Figure 3). The seabed depth at the hauls locations appear to be a good proxy for estimating the anchovy depth.

The anchovy mean depth variations were moderate over the series, ranging from 25 m (2008) to 81 m (2003), around an average value of 49 m (SD = 38 m).

The surveys included in the data re-analysis comprised a year characterized by a relatively deep anchovy distribution (2012, mean depth = 55 m), contrasting to year with below average depth distributions (2014, 2015, 2016).

The anchovy and sardine biomass estimates obtained with the different TS equations are presented in Table 6.1.2. Biomass estimates obtained for all species are presented in Annex 1.

Table 6.1.2. Anchovy and sardine biomass estimates obtained with different TS equations.

Species	Cruise	Biomass (t) b20=71.2	Biomass (t) b20=65.4	Biomass (t) OnaTSzCor	Ifremer/OnaTSzCor biomass difference	Biomass difference induced by b20	Depth correction effect on biomass
ENGR-ENC	*mean*	*28 186*	*33 483*	*33 483*	*-61%*	*-74%*	*13%*
ENGR-ENC	PELGAS2012	187 848	49 460	74 870	-60%	-74%	14%
ENGR-ENC	PELGAS2014	125 427	32 993	46 119	-63%	-74%	10%
ENGR-ENC	PELGAS2015	372 916	98 142	144 144	-61%	-74%	12%
ENGR-ENC	PELGAS2016	89 727	23 602	37 809	-58%	-74%	16%
SARD-PIL	*mean*	*29 636*	*28 857*	*28 941*	*-62%*	*-74%*	*12%*
SARD-PIL	PELGAS2012	206 510	54 387	82 004	-60%	-74%	13%
SARD-PIL	PELGAS2014	339 607	89 418	122 588	-64%	-74%	10%
SARD-PIL	PELGAS2015	416 524	110 073	179 123	-57%	-74%	17%
SARD-PIL	PELGAS2016	229 742	60 638	80 206	-65%	-74%	9%

Using Ona (2003)'s equation leads to a mean decrease of 61% and 62% of the anchovy and sardine and biomass estimates, respectively. Using a 65.4 b20 parameter instead of 71.2 induces a reduction of biomass of 74%.

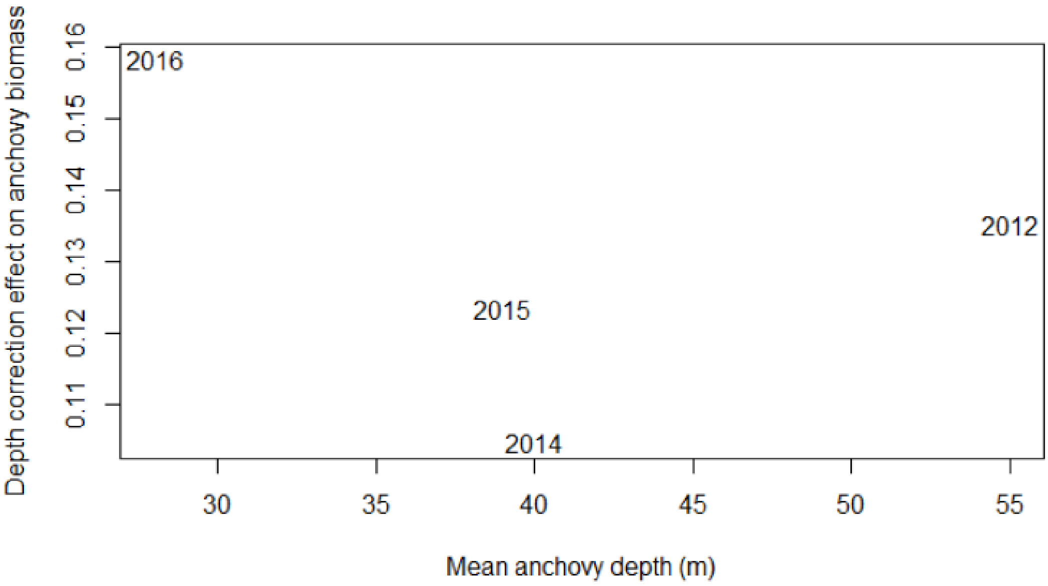


Figure 6.1.4: Depth correction effect on anchovy biomass as a function of anchovy mean depth derived from trawl haul data

Using Ona (2003)'s depth correction induces an increase of 13% (anchovy) and 12% (sardine) biomass on average. The magnitude of the depth correction term effect does not seem to be related to the anchovy depth distribution, as estimated infra (Figure 4). No significant difference in the age structures (Figure 4) or CVs (Annex 1) estimates was found when comparing the results obtained with the different TS equations.

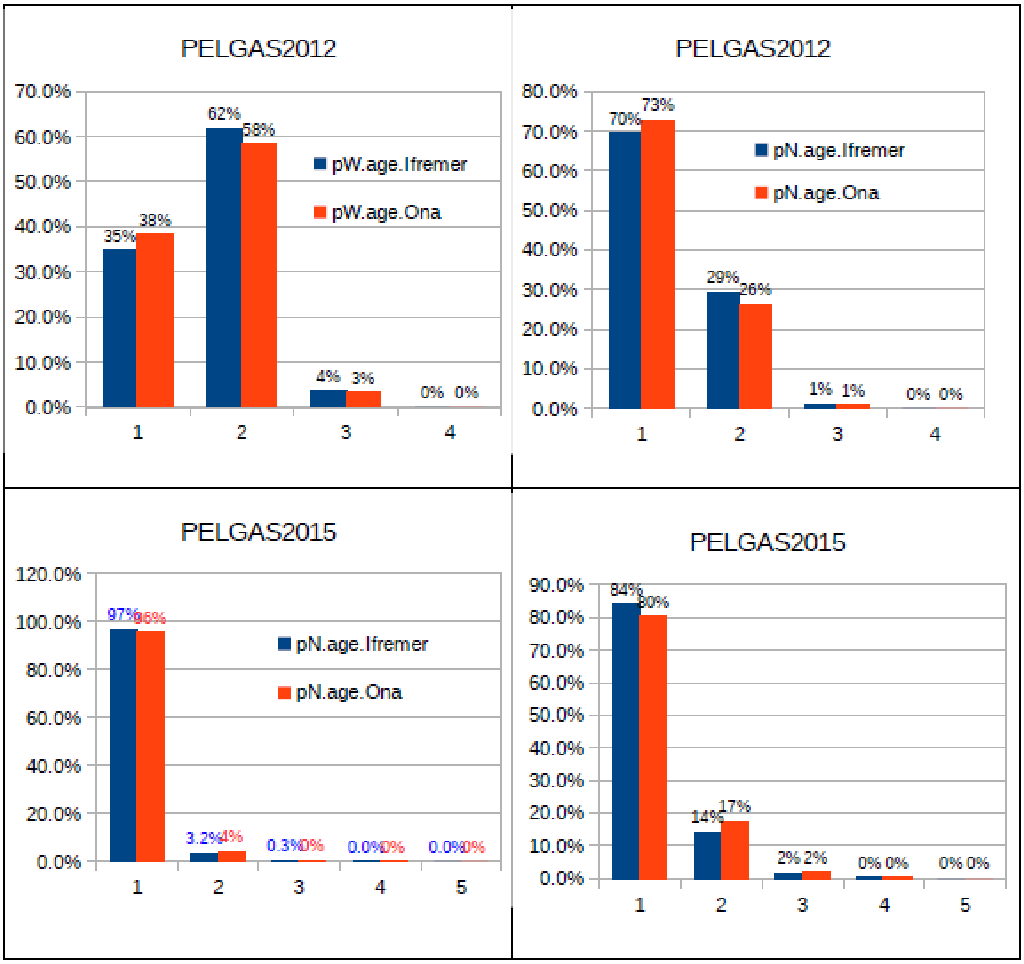


Figure 6.15. Anchovy age structure estimation in numbers (left panels) and weights (right panels) obtained with the Ifremer (blue) and Ona TS equations with PELGAS2012 (upper panels) and PELGAS2015 (lower panels) data.

Discussion and conclusions

No relationship was found between the anchovy TS depth correction effect and their mean depth estimated based on trawl haul data. This is certainly due to the fact that all trawl hauls do not have the same weight or influence in the biomass assessment procedure: i) trawl data are weighted by the fish NASC in the vicinity of the haul, ii) as biomass are estimated within post-stratification regions, trawl hauls in regions with high mean NASC have more influence. The small difference between mean depths estimated based on haul data and on ESDU data, weighted by anchovy biomass, suggest that the segregation of trawl hauls per post stratification regions effect has probably more influence.

These results confirm that the main TS equation parameter influencing the spring Biscay anchovy and sardine biomass estimations is the b20. In comparison, the Ona (2003)'s depth correction term yields marginal and more or less constant changes in the biomass estimates. The hypothesis of a strong and non-linear effect of a depth-correction term in the TS equation used to derive acoustic biomass estimates of anchovy or sardine in the Bay of Biscay is invalidated by these results.

The annual depth distributions of anchovies, as estimated based on PELGAS catch and ESDU data, show moderate variability, which does not seem to be related to biomass fluctuations.

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6.2. WGACEGG2016 EchoR training report, 16 November 2016

Mathieu Doray, Ifremer EMH

A training on the EchoR R package has been given on November 16th 2016 during the WGACEGG joint meeting with MEDIAS group.

A total of 8 scientists from France (Ifremer), Spain (IEO, AZTI), Italy (CNR) and Greece (HCMR) have attended the training.

EchoR new features

The evolutions of the package and tutorials have been presented. EchoR major evolutions include:

- size categories in the catch data can now be defined manually by the user in the "sizecat" function (≥ V1.3.1);
- nearest hauls to ESDUs can now be first searched within a given depth class, or up to a maximum radius in the "nearest.haul" function (≥ V1.3.2);
- implementation of a new biomass estimation per ESDU and size methodology. Biomass-at-size were previously initially computed at the echotype level, which might generates ambiguities in the automatic allocation of subsample hauls to the ESDU: species:size category:depth stratum procedure. Biomass-at-size per ESDU are now initially computed at the echotype:species:size category, which ensures no ambiguity in the subsample hauls automatic allocation (>= V1.3.1)
- gridded maps datafiles and plots can be produced for series of years and species with the EchoR function "gridNplot", see help page for details (≥ V1.2.2);
- implementation of a raster version of gridded maps, based on the "raster" package (≥ V1.3.2).

Updated tutorial scripts will be now provided with the new EchoR versions in the website "files" tab. Tutorials now cover the following topics:

1. Import/check input data: length-weight relationships, rare species handling, catch data correction, missing length/weight/number correction, scrutinised NASC profiles
2. Preprocessing: Xe computation and check, ESDU~echotype~fishing operations linkage
3. Biomass per ESDU
4. Biomass-at-length per ESDU
5. Biomass-at-age per ESDU
6. Biomass per post-stratification region
7. Estimation error per post-stratification region
8. Mapping: bubble maps, gridded maps
9. Population/community indices: Ifremer population/communities indices, spatial indices
10. Data and results export: as text files, as EchoBase input files

Biomass estimation per post-stratification region

A new EchoR feature has been introduced during the training: the biomass estimation per post-stratification region. The methodology can be summarized as follows:

1. Import the “Pechels2” and “ESDUDEVs” EchoR output files from tutorial script 1 into a Geographic Information System (GIS) (e.g. open source QuantumGIS) and display the NASC per echotypes and trawl haul catches spatial distributions on a map.
2. Manually define post-stratification region limits in separate layers, using the GIS polygon tool. Post-stratification region limits should be defined so as to obtain regions as homogeneous as possible in terms of species (and eventually size) and echotype NASC composition. Each region must be saved in a dedicated folder as a polygon shape file (.shp), using the following file naming convention: “cruiseName_regionX_depthStratum”, where “cruiseName” is the cruise name, “depthStratum” the depth stratum (“SURF” for surface layer, “CLAS” for deeper layer or whole water column), and “regionX” the X^{th} region index (1 to N regions, both depth strata included).
3. After running at least the scripts 1 and 2, import the region shape files in EchoR using script 6. Tools are provided to automatically allocate ESDUs and hauls to regions, based on their locations, and check that all ESDUs and hauls belong to post stratification regions.
4. Biomass per region computations are made in script 6. Mean Xe factors per regions are computed as the simple arithmetic average of trawl hauls Xe's or as an average of trawl hauls Xe's weighted by the fish NASC detected within a user defined radius around the haul. Mean Xe factors derived using the simple arithmetic average or the weighted average of trawl hauls Xe's are denoted mXe and wmXe, respectively. Biomass (in tons) and abundance (in thousands of fish) estimates derived using the simple arithmetic average or the weighted average of trawl hauls Xe's are denoted BB and BN, and wBB and wBN, respectively.
5. Estimation errors (expressed as coeffients of variation, CV in %) can be then computed with script 7. The total estimation error denoted CV comprises two additive error components: spatial (CVs) and identification (CVi). CV (in %) of biomass estimates derived using the simple arithmetic average or the weighted average of trawl hauls Xe's are denoted CV and wCV, respectively.

EchoR practicals

The participants have tried the package using the built-in demo data, or their own data. All problems encountered by participants using their own data have been solved by the end of the training, and a new EchoR version (1.3.4) has been released.

Problems mainly came from non-supported input data formats. Namely, the fields “zonesCLAS” and “zonesSURF” now need to be included in the acoustic input data file to allow for further computations, as they provide the ESDU belongings to post-stratification regions.

EchoR training plan

Scientists willing to get trained with EchoR are invited to first experiment with the software and their data, and then to register to the webinar that will be held in early 2017.

Questions or suggestions on the package should preferentially be posted on the EchoR forum. The forum activity will in fact be used to assess the proper timing to run the webinar.

Ifremer releases two fisheries acoustic freewares: Hermes and Movies3D

The Ifremer Hermes and Movies3D softwares (Trenkel *et al.*, 2009) are now available as freewares on the Ifremer website. They can be used to acquire, display and preprocess narrowband or broadband data from monobeam echosounders, or multibeam echosounder or sonar data.

References

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6.3. Review of methodologies for avoiding multiple Target Strength detections, with application to skipjack tuna

G. Boyra, AZTI

One of the most common problems when measuring TS values of *in situ* fish is the occurrence of multiple targets erroneously assigned as single ones by the standard single target detection algorithm, especially in high fish density situations as occurs often with small pelagics as anchovy and sardine. Typically there are several approaches that are used in these cases to filter the multiple targets and reduce the bias of the measured TS values. Several approaches used by the acoustic community to reduce the multiple targets *TS* bias have been reviewed: the single target detection algorithm, fish tracking, multi frequency simultaneity and high fish density filtering. Some methodological changes have been proposed in order to improve their diagnostic use and efficiency. The methodologies were tested on a set of in *situ TS* data of skipjack tuna around FADS but will be tested on historical acoustic data (especially night trawls of anchovy and sardine) of the JUVENA and BIOMAN surveys.

Annex 7: Developments in DEPM

7.1 How does the number of stages affect egg production and mortality estimates?

Traditional estimation of the daily egg production (P_0) and mortality (Z) in the DEPM is based on an 11 egg stage classification system. However, new sampling and estimation methods have led to less detailed egg classification systems with only 3 or 5 stages. This work studies how using a different egg stage classification can affect the daily egg production and mortality estimates of Bay of Biscay anchovy using data collected in the BIOMAN surveys from 2010 to 2016. The standard estimation procedure was repeated using 3, 5 and 11 stage classifications. The egg developed model required for the egg ageing was either from a new fit with fewer stages or from summing the probabilities of the 11 stages fit for the grouped stages. In addition, the effect of cutting or not the older age observations was explored. In general, less egg stages favoured larger Z and P_0 estimates. The effect was larger in Z, for which relative differences could be up to 50%. The apparent larger precision of the estimates in the less stage classification was considered an artefact due to the reduced number of observations. The results confirmed that cutting tails was crucial to avoid positively biased P_0 and Z estimates. The differences between the P_0 and Z estimates obtained from different egg classification systems are smaller when the development model for fewer stages was not refit, but derived from the 11 stage model. However, the results demonstrated that the influence of the number of egg stages considered was non-negligible and larger than initially thought.

7.2 Estimation of total daily egg production for anchovy and sardine from CUFES, and comparison with the traditional methodology

Given the generalized use of the CUFES on board the small pelagics acoustics and DEPM surveys operated in the area from Portugal to the Bay of Biscay, it has been recognized as a general interest to derive egg production estimation from these egg data. ToR e) of the group over the period 2014–2016 is on 'Developing CUFES as an indicator of anchovy and sardine egg production'. The general methodology is not different from deriving egg production from Pairovet, the classical net used within the DEPM, except that the surface egg concentration obtained from CUFES sampling has to be extrapolated over the water column considering the egg vertical distribution that can be variable in space and time.

An estimation over the Bay of Biscay

Petitgas *et al.* (2009) first proposed an estimation of P_0 and P_{tot} from CUFES in the Bay of Biscay for anchovy. Their methodology of deriving P_0 combined a vertical distribution model with the temperature ageing procedure of Lo (1985) and a mortality estimation from age distribution. The number of stages in the egg staging estimation from the CUFES where 3. The procedure was applied at the spatial resolution of blocks, the spatial unit defined in this working group for building maps of several parameters. Then P_0 are cumulated to derive P_{tot}. The egg specific gravity is the most sensitive parameter of the vertical distribution model and was derived from its relationship with sea surface salinity (Goarant *et al.*, 2007).

At the 2016 WGACEGG meeting M. Huret presented an update of the methodology following the new development described in Gatti (2012), and for both anchovy and sardine Pelgas time-series. The new development integrate results of the relationship between egg specific gravity and sea surface density for both species (Huret *et al.*, 2016).

Another improvement is also on the egg ageing that integrates the multinomial model and incubation data detailed in Ibaibarriaga *et al.* (2007) and Bernal *et al.* (2008) for anchovy and sardine, respectively. To give an idea of the effect of the two major steps of the procedure, namely the vertical correction from surface concentration, and the mortality correction to assess P_0, we provide the following metrics. The vertical correction has the effect of multiplying by 15.8 on average (CV = 36% calculated on the 17 years) the CUFES surface concentration. The P_0 estimation from mortality has the effect of multiplying by 1.24 on average (CV = 49% calculated on the 17 years) the total integrated number of eggs. Thus the vertical correction is the most important to consider to get a correct order of magnitude for P_{tot}, but both vertical and mortality corrections imply a relatively large interannual correction and thus variability. Results of the P_0 maps are presented in Figure 1 and time-series of P_{tot} in Figure 7.2.1

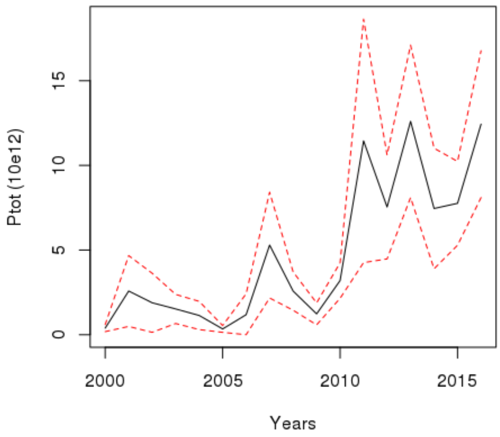

Figure 7.2.1. Maps of P_0 (Number of egg per m^2) by block for anchovy (left) and sardine (right) in 2016 during Pelgas survey based on CUFES data.

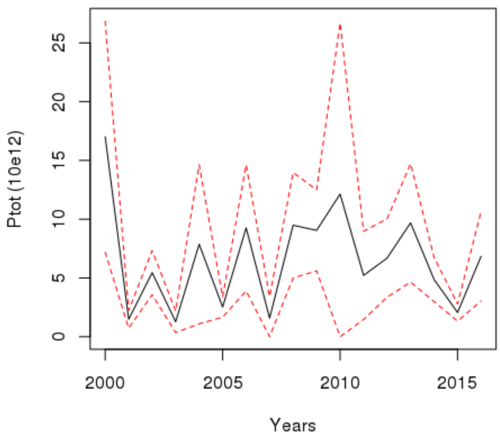

Figure 7.2.2. Time-series of total daily egg production (P_{tot}, Number of eggs) over the Bay of Biscay from CUFES data for anchovy (left) and sardine (right). The red dotted lines represent ±2 s.d. around the mean.

Comparison and assessment of uncertainties

Figure 7.2.3 shows the correlation between the PELGAS CUFES-derived P_{tot} and BIOMAN P_{tot} following the traditional DEPM methodology. The 2 estimations are generally in good agreement ($R^2 = 0.72$), with no bias between the two (slope~1). However 6 among 17 years show strong discrepancies, with 2013 displaying the largest difference with almost 4 times the amount of eggs for CUFES-derived estimation as compared to the BIOMAN P_{tot}.

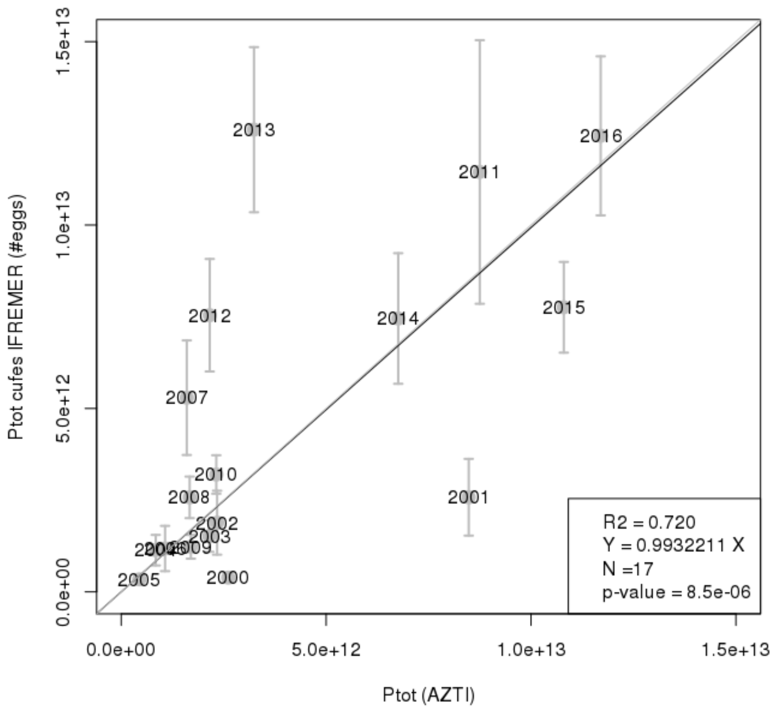

Figure 7.2.3. Correlation between the PELGAS (Ifremer) CUFES-derived P_{tot} and BIOMAN (AZTI) P_{tot} following the traditional DEPM methodology.

In an effort of understanding the sources of discrepancy between the two methodologies, it was decided between AZTI and Ifremer the following steps of comparison:

a) Compare CUFES Egg abundance from Ifremer and AZTI (raw data). This comparison is to be made by blocks for standardization of CUFES sampling resolution between the two surveys.

b) Compare Pairovet P_{tot} standard DEPM estimates with 11 stages and with only 3 or 5 stages in AZTI, to check for the effect of number of stages.

c) Compare CUFES P_{tot} estimates with 3 stages and with 5 stages in Ifremer, to see the effect of number of stages.

d) Compare the CUFES block P_0 estimates with CUFES P_0 as in the standard DEPM (synoptic single area estimate of P_0) by Ifremer.

e) Compare CUFES integrated Egg abundance and Pairovet total Egg abundance in AZTI series to see the effect of the vertical model.

f) Compare CUFES vertically integrated Egg abundance from Ifremer and AZTI to see the effect of sampling time and the environmental condition on the total Egg abundance estimates.

g) Vice-versa, apply the block spatial estimates of Z and P_0 to the Pairovets and compared it with the standard DEPM P_0 of AZTI.

h) Work on spatial variability of mortality

Step a. A first comparison was performed for the years 2015 and 2016 before and during the group. The egg abundances between both surveys is in good agreement but the difference by block seems to increase when the gap in days between sampling dates increases, with large differences when the gap reaches one week. This potentially can explain local differences between CUFES- and Pairovet-derived P0, but could also be due to some change in the vertical distribution of the eggs under the dependence of the wind condition and water column mixing. The comparison has to be extended for the whole time-series.

Step b was assessed by AZTI and was presented during the group, with results presented above.

Step c. A first estimation was made for sardine for the years 2015 and 2016 for which 5 egg stages have been identified. The results tend to show the same trend than step b: lower mortality and P_0 for 5 as compared to 3 stages. Another result is the lower number of blocks with correct estimation of mortality (negative), because of the stage 1 abundance which is often lower than stage 2>3>4>5. Which was not the case with 3 stages because then stage 1 corresponds to stages (I+II+III) of Ahlstrom. This step has to be reconducted when the egg daily cohort analysis is integrated in the mortality estimation of Ifremer's procedure.

The next steps (d to h) will be performed progressively during the following year towards the next group meeting, and should allow in turn a better assessment of the sources of uncertainty in P_{tot} estimation.

Generalization of the approach over the WGACEGG area

There is an interest of valuing the CUFES data available from almost all acoustic and DEPM surveys in the area. Therefore, there will be exchange of knowledge and codes between the different groups to be able to derive the daily production for sardine and anchovy from the CUFES and assess the differences with more traditional methods.

To be consistent with the DEPM P_{tot} estimation, the implementation of the daily cohort allocation to consider spawning synchronicity (Bernal *et al.*, 2011) of eggs from their age estimation has to be performed by Ifremer. Different steps of the sensitive analysis as detailed below can then be made and consistent comparisons performed.

The vertical model can then be run on all CUFES data in different regions, provided that CTD casts are performed during the surveys to retrieve the water column properties necessary for the vertical distribution model. For that purpose and given that oceanography is quite different between regions, all available data on egg vertical distribution should be gathered for the validation of this vertical distribution model. However, given that the relationship between egg specific gravity and sea surface properties seems stable in different environments (e.g. Ospina-Alvarez *et al.*, 2012), there is no real need to conduct density gradient experiments, at least this is not a priority.

Then the sensitivity numerical experiments as detailed above with successive steps could be conducted (at least partly) to compare results of P_{tot} estimations from Pairovet and CUFES.

References.

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Goarant, A., Petitgas, P., Bourriau, P., 2007. Anchovy (Engraulis encrasicolus) egg density measurements in the Bay of Biscay: evidence for the spatial variation in egg density with sea surface salinity. Mar. Biol. 151, 1907–1915.

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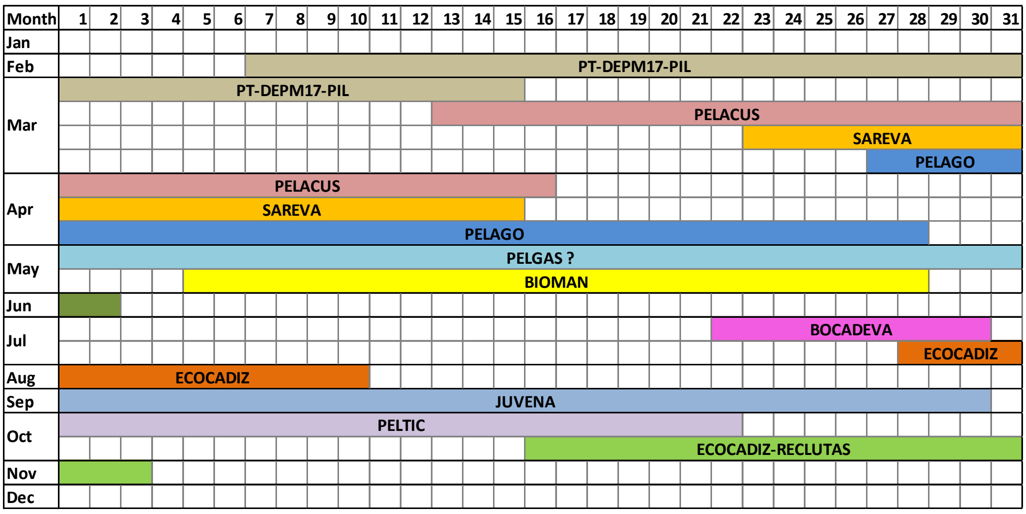
Ibaibarriaga, L., Bernal, M., Motos, L., Uriarte, A., Borchers, D.L., Lonergan, M.E., Wood, S.N., 2007. Characterization of stage-classified biological processes using multinomial models: a case study of anchovy (Engraulis encrasicolus) eggs in the Bay of Biscay. Can. J. Fish. Aquat. Sci. 64, 539–553. doi:10.1139/f07-030

Ospina-Álvarez, A., Palomera, I., Parada, C., 2012. Changes in egg buoyancy during development and its effects on the vertical distribution of anchovy eggs. Fish. Res. 117–118, 86–95. doi:10.1016/j.fishres.2011.01.030

Petitgas, P., Goarant, A., Masse, J., Bourriau, P., 2009. Combining acoustic and CUFES data for the quality control of fish-stock survey estimates. – ICES Journal of Marine Science, 66: 1384–1390.

Annex 8: Planning and coordination of surveys

Survey planning for 2017 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. The usual planned survey's duration of 14 days may possibly be increased in 3-4 additional days in the next year in order to fulfil the MSFD compromises at a national level in relation to the acoustic surveying of the Spanish marine demarcations. Such compromises would include the extension of the acoustic transects and sampling towards more oceanic waters and the realization of the corresponding ground-truthing fishing hauls in such areas, with a special interest in the identification of the mesopelagic ichthyofauna.

In October of 2017, the fifth PELTIC survey will be carried out in area demarcated by the “Mackerel box” off the Southwest of Britain (sections of subarea 7). Multidisciplinary methodologies, coordinated through two relevant survey working groups (WGACEGG and WGIPS), will be implemented as described in the Manual for International Pelagic Surveys (SIPS 9, ICES 2015).

Autumn recruitment surveys

As a result of the compromise of collaboration between AZTI and IEO in 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 (2017), 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 8 and 9

In 2017 the annual anchovy DEPM survey in the Bay of Biscay (BIOMAN) will take-place in May conducted by AZTI on board RV Ramón Margalef to collect the plankton samples and on board the RV Emma Bardán to collect the adult samples. It will cover the usual spawning grounds ranging from 5°W to the French coast for Cantabrian Sea and from there to 48°N for the French area. At the same time, the triennial sardine DEPM survey in the Bay of Biscay will be applied to obtain the sardine spawning biomass in the Bay of Biscay in May.

The next DEPM survey to estimate the SSB of anchovy in the Gulf of Cadiz (triennial survey) will take place by IEO in July 2017, on board RV "Ramón Margalef". The adults samples will be obtain during ECOCADIZ.

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 (48°N). The region from the Gulf of Cadiz to the northern border between Portugal and Spain (PT-DEPM17-PIL) will be surveyed by IPMA;IEO will cover the northwestern Iberian Peninsula and the inner part of the Bay of Biscay until 45°N (SAREVA) and AZTI will survey the North of the Bay of Biscay from 45°N to 48°N (BIOMAN).

All DEPM surveys (both Sardine and Anchovy) 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 CM2010/SSGESST:24).

Annex 9: List of WGACEGG presentations

WGACEGG presentations

BIOMAN survey: Anchovy DEPM, sardine egg abundances and sightings in Bay of Biscay 2016.

Santos, M., Ibaibarriaga, L., Louzao, M. and Uriarte, A.

PELAGO 2016 – RV "Noruega" Acoustics and horse mackerel DEPM.

Marques, V. *et al.*

PELACUS 0316 – Multidisciplinary acoustic-trawl survey.

Carrera, P. *et al.*

PELGAS 2016 acoustic survey – Abundance índices by acoustics in the Bay of Biscay.

Duhamel, E., Doray, M., Huret, M., Sanchez, F., Lespagnol, P., Lemerre, C., Doremus, G.

JUVESAR 2015 – Autumn Portuguese acoustic survey.

Marques, V. *et al.*

JUVENA 2016 – Acoustic surveys for juvenile anchovy in the Bay of Biscay.

Boyra, G.

PELTIC 2016 – Pelagic ecosystem survey in western Channel and eastern Celtic Sea.

Van der Kooij, J.

Effect of Target Strength equation selection on PELGAS anchovy and sardine biomass estimates.

Doray M.

Potential methods to reduce in situ TS bias.

Boyra, G.

Biscay Anchovy controlled *in-situ* target strengths measurements.

Mathieu Doray, Laurent Berger, Naig Le Bouffant, Jean Yves Coail, Jean Philippe Vacherot, Pierre Petitgas

Measuring fish target strength (TS) in the wild is challenging as: i) TS largely varies as a function of physical (tilt angle, depth) or physiological fish attributes, ii) the species and size composition of acoustic targets is difficult to assess in near real time. We propose a methodology for controlled in situ TS measurements based on the joint use of a Remotely Operated Vehicle (ROV) 'EROC' with a pelagic trawl fitted with the 'ENROL' codend opening system. EROC can be moved around the fishing trawl and is equipped with a Simrad EK60 70 kHz split-beam echosounder, and a low-light black and white camera. Pelagic fish are funnelled into the open trawl and their TS is measured with the EROC echosounder in the middle of the net, where the fish swim in small groups towards the trawl mouth, against a strong current. The fish oriented swimming allows for the recording of nearly horizontal fish TS, hence controlling for the large effect of tilt angle on TS variability. Direct optical identification of the fish species composition is conducted with the EROC camera near the open codend. The methodology is used to measure in-situ TS of Biscay *Engraulis encrasicolus* in controlled conditions.

Biscay Anchovy and Sardine target strength modelling

Laurent Berger, Mathieu Doray, Xavier de la Bernardie, Elisabeth Lys, Pierre Morinière, Pierre Petitgas

Adult Biscay Anchovy and Sardine have been scanned by RX tomography to get detailed 3 dimensional shapes of their swimbladder. The real swimbladder shapes dimensions have been used to parameterize cylinder, bent cylinder, deformed cylinder and prolate ellipsoid swimbladder shape acoustic models. Target Strengths (TS) predicted by the different models as a function of fish length, fish tilt angle and acoustic frequency were compared to select the most accurate and computing time efficient model to predict Biscay Anchovy and Sardine TS. TS values averaged over natural fish tilt angle distributions are proposed at several frequencies for Biscay Anchovy and Sardine.

The “zikina”, a surface scattering layer that affects juvenile anchovy distribution.

Boyra, G., Nogueira, E., Martínez, U. and Peña, M.

Spring habitats of small pelagic fish communities in the Bay of Biscay

Mathieu Doray, Camille Hervy, Pierre Petitgas

The spatial distribution of small pelagic fish assessed by the PELGAS surveys from 2000 to 2015 in the Bay of Biscay was analysed using Multiple Factorial Analysis, to: i) define small pelagic fish communities, ii) delineate their characteristic spatial distribution and iii) analyse the temporal variability of fish community spatial distribution. The hydrobiological conditions within the characteristic fish communities distribution areas were analysed in an attempt to define functional habitats of small pelagic fish communities in the Bay of Biscay.

Moving from traditional approach to an external mortality model to estimate egg mortality and egg production for Atlanto-Iberian sardine (1988-2014).

Díaz, P., Angélico, MM., Lago de Lanzós, A., Nunes, C., Henriques, E. and Bernal, M.

How does the number of stages affect egg production and mortality?

Ibaibarriaga, L., Santos, M. and Uriarte. A.

Abundance of anchovy eggs by CUFES: Interannual fluctuations and spatial patterns.

Jiménez, MP, Sánchez-Leal, R., Ramos, F. and González, C.

Data on the abundance of Anchovy eggs in the Gulf of Cadiz as collected by CUFES are explored in the present work in relation to their spatial pattern and interannual fluctuations. These data were gathered in 12 summer surveys, both acoustic (ECOCADIZ series) and DEPM (BOCADEVA series) ones, since 2004 to date (no survey in 2012). A total of 1499 CUFES stations were sampled, which distributed from the strait of Gibraltar, in Spain, to Cape San Vicente, in Portugal (in 2010 to Cape Sta. Maria only). The sampling scheme consisted in a grid of 21 parallel transects, normal to the shoreline and inter-spaced 8 nm, with the samples being collected every 3 nm at a c.a. 600 l/min flow with a 335 µm mesh size net and at a sampling depth of 5 m from the surface. A continuous record of SST and SSS at 5 m (termosalinometer) was coupled to the CUFES sampling. The surveys were carried out in June, July or August depending on the year. Oceanographic variables such as temperature, salinity and chlorophyll, and even the bottom topography of the shelf as well, they all showed significantly different in two regions: to the East and West of the Cape S. Mª. The density of Anchovy eggs presents a high variability between stations showing a very patched distribution. The stations with most eggs are located to the East of Cape Sta. Mª. Egg abundance also showed a very high between-year variability, ranging from 2955 eggs in 2005 to 41941 eggs collected in 2014. Regarding the spatial pattern of egg distribution, the 84.9% of the total egg density (all the surveys pooled) was collected in the area east of the Cape Sta. Mª (37.4 % in 2016), and the 89.8 % of total egg density in stations bellow 100 m depth (47.9 % in 2016). What happened in 2016? The mean temperature registered in 2016 in the Western stratum (22.0ºC) was practically the same that the mean temperature registered from 2004 to 2015 in the Eastern stratum (21.7ºC). The analysis of the centers of gravity of the eggs densitiesvs.longitude and depth show significant trends, but not for latitude, which indicate a displacement towards the West in 2016. However, no trends were found in the centers of gravity of the acoustic energy (NASC) as a proxy of adults. Is then the westward displacement of the spawning in 2016 caused by an advective transport (currents and/or winds) or by other causes? What will be the further effect on recruitment? It would be good to obtain a statistical model in order to explain how the different variables affect the abundance of eggs, including other variables like the wind, tide... The presence of deep canyons crossing the shelf in the East of Cape Sta. Mª indicates that distance to the coast would be a better variable than depth.

Sardine eggs in AEPM surveys.

Riveiro, I.

MEDIAS presentations

Acoustic survey in Eastern Ionian Sea (GSA20) in 2015

Athanassios Machias, Marianna Giannoulaki, Konstantinos Tsagarakis, Maria Myrto Pyrounaki, Zacharias Kapelonis, Stylianos Somarakis

The echosurvey in the Greek waters was carried out in October 2015 in GSA 20 on board the RV "PHILIA". The survey design is made of parallel transects perpendicular to the isobath from 10 m to 200 m depths. The intertransect distance is 10 nm. The EDSU is 1 nm. The average surveying acoustic vessel speed is 7.5 knots. Echotraces were identified based on the catch composition of the pelagic haul. Acoustic recording was performed by daytime. The survey covered the eastern part of Ionian Sea including Patraikos and Amvrakikos gulfs. The survey track involved 30 acoustic transects, that covered an area of 2535 nm^2. In addition, CTD measurements and zooplankton sampling were completed in 56 stations during the survey. The anchovy and sardine biomass were estimated to be 12055 tons and 3456 tons, respectively; and higher concentrations were observed in Amvrakikos gulf for both species.

Estimation of anchovy spawning-stock biomass in the North Aegean Sea (GSA22) in 2014 using the Daily Egg Production Method

Stylianos Somarakis, Eudoxia Schismenou, Apostolos Siapatis, Marianna Giannoulaki, Athanasios Machias

The Daily Egg Production Method (DEPM) for the estimation of anchovy spawning-stock biomass in the North Aegean Sea was conducted in June-July 2014 on board the

RV PHILIA. During the survey, 167 icthyoplankton samples for the estimation of egg production, and 21 adult samples for the estimation of adult parameters (batch fecundity, spawning fraction, sex ratio and average weight of mature female) were collected. A total of 418 female gonads were subjected to histological analysis. Due to spatial differences in topographic and hydrographic features the surveyed area was post-stratified in an eastern (Thracian Sea) and western stratum (Thermaikos Gulf, North Evoikos Gulf) and DEPM parameters and biomass estimation was carried out separately for each stratum. The estimated spawning-stock biomass was 5818 tonnes in the eastern area and 8487 tons in the western area. In total, in the North Aegean Sea the anchovy spawning-stock biomass was estimated at 14305 tons for 2014.

Italian Acoustic survey in Adriatic Sea – MEDIAS western GSA 17 and GSA 18.

Iole Leonori, Andrea De Felice, Ilaria Biagiotti, Giovanni Canduci, Ilaria Costantini, Sara Malavolti, Andrea Miccoli, Gianluca Gabrielli.

The 2016 acoustic survey was carried out in the whole GSA 18 and in western GSA 17 including territorial waters of Slovenia (Dr. Tomaz Modic took part in the cruise in Slovenia waters). Acoustic data were logged over a grid of systematic parallel transects perpendicular to coastline/ bathymetry. In West GSA 17 total nautical miles were 1502 for a total area of 10636 nm^2, in West GSA 18 total nautical miles were 384 for a total area of 2510 nm^2 and in East GSA 18 427 nautical miles for a total area of 2597 nm^2 (survey conducted with the same MEDIAS methodology but under FAO AdriaMed and CNR fundings). All this account for a total of 2313 nautical miles, identifying an area of about 13200 square nautical miles in the western part of Adriatic Sea, that rise up to 15700 nautical miles including the Montenegro and Albania survey. The entire survey in West GSA 17 and 18 plus East GSA 18 took place from 21 May to 27 June, thus ensuring a strong synopticity to the monitoring of such a large area. In particular GSA 18 East took place from 21 May to 1 June; GSA 18 West from 1 to 7 June and GSA 17 West from 7 to 27 June.

In detail, the MEDIAS acoustic survey in western GSA 18 covered 100% of the area; 384 nautical miles were monitored and 10 pelagic trawls were conducted. 58 ichthyoplankton stations to apply Daily Egg Production Method were made, combining CTD and plankton net sampling.

Acoustic survey in western GSA 17 covered 100% of the area; 1502 nautical miles were monitored and 34 pelagic trawls were conducted. 86 CTD stations were made and in 45 stations out of 86 mesozooplankton sampling by means of WP2 net (mesh size 200 μm) was carried out.

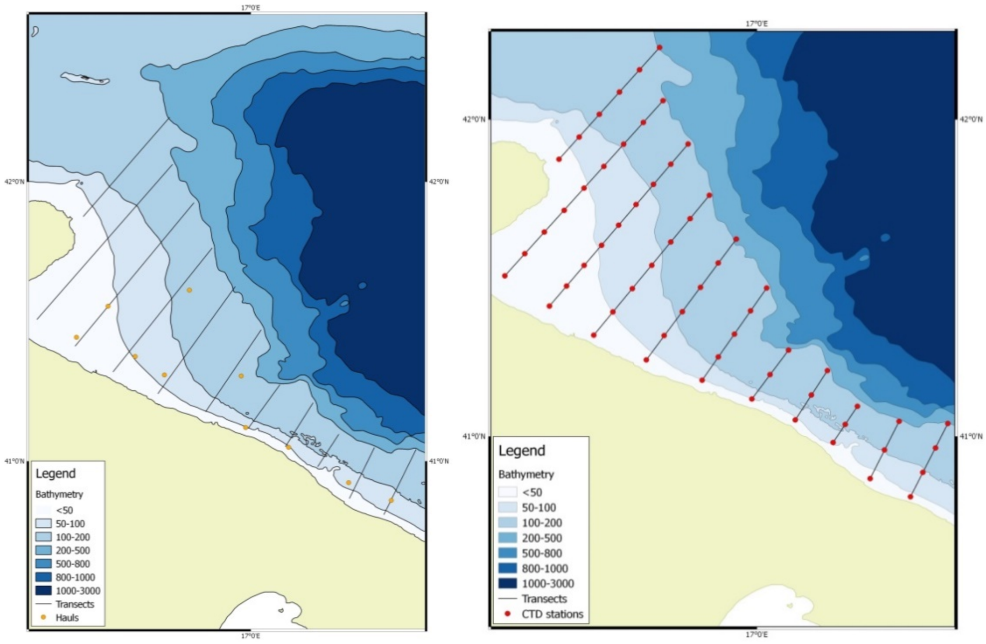


Figure 1. Acoustic survey route plan in western GSA 18. On the left the positions of net samplings are reported; on the right positions of prefixed stations of CTD and plankton sampling are shown.

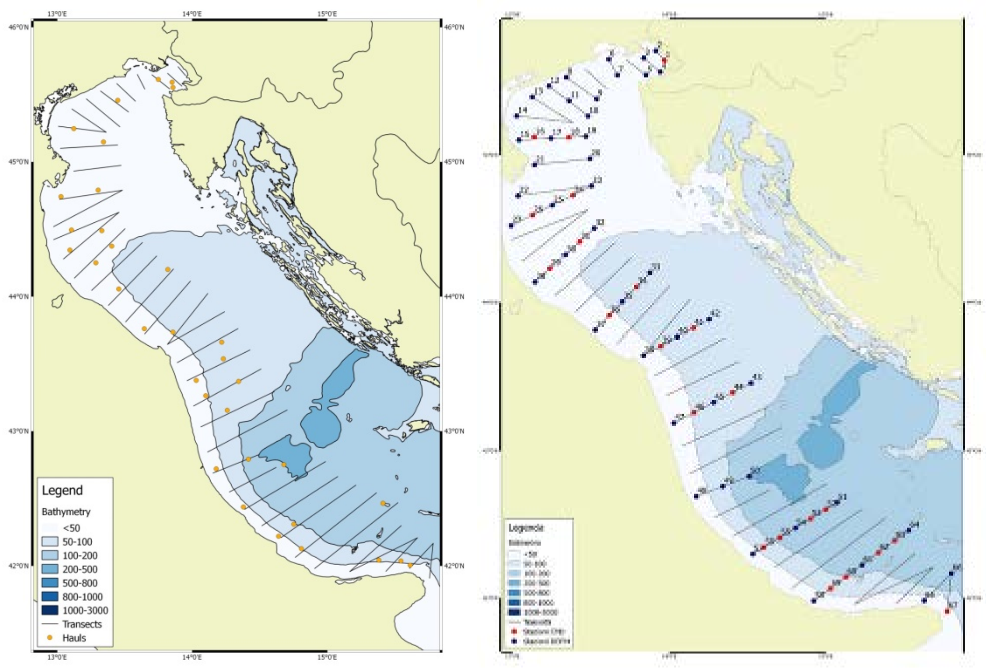


Figure 2. Acoustic survey route plan in western GSA 17. On the left the positions of net samplings are reported; on the right positions of prefixed stations of CTD and plankton sampling are shown (in blue CTD and plankton stations, in red only CTD stations).

Biomass estimations of anchovy (*Engraulis encrasicolus*) and sardine (*Sardina pilchardus*) stocks in western Adriatic Sea until 2015 show a slight decrease in the biomass in the northern part, a weak increase in the central Adriatic and a severe decrease in the southern Adriatic Sea (GSA 18) especially for sardine, that comes back to very low levels.

Due to the joint requests by GFCM and Data Collection Regulation we are asked to produce survey results much earlier than before. In order to fulfil this commitment, in a large area as Adriatic Sea there are not much alternatives to a shift and a fusion of our survey periods.

That is why in 2015 and 2016 we conducted acoustic survey in western GSA 17 in June and the plan for the future surveys is to keep the June-July period to perform acoustic surveys in western GSA 17. GSA 18 now is conducted in June while in the recent past the survey was in July.

A more meaningful statistical analysis of the differences due to the period shift will be performed next year with 3-years data of acoustic survey in June available.

Due to the change in the survey time in GSA 17, a statistical analysis was performed in order to identify if there are significant differences on the length frequency distributions between 2015 and the previous years, but also among all the years to verify if these differences are only between June and September or are present among the September surveys too. Anchovy mean lengths from the surveys 2004-2015 show alternate values over the years with 2015 mean size being the highest, even if the gap with the previous years is little. Sardine mean lengths present a quite evident decreasing trend over the years. Comparing the means in pairs performing pairwise t-tests with Bonferroni correction methodology the results show that not only 2015 means are different in most of the cases with the other years means, but also most of the "September" means are significantly different between them, stating that there is a substantial variability of LFD between years even keeping the month of the survey constant.

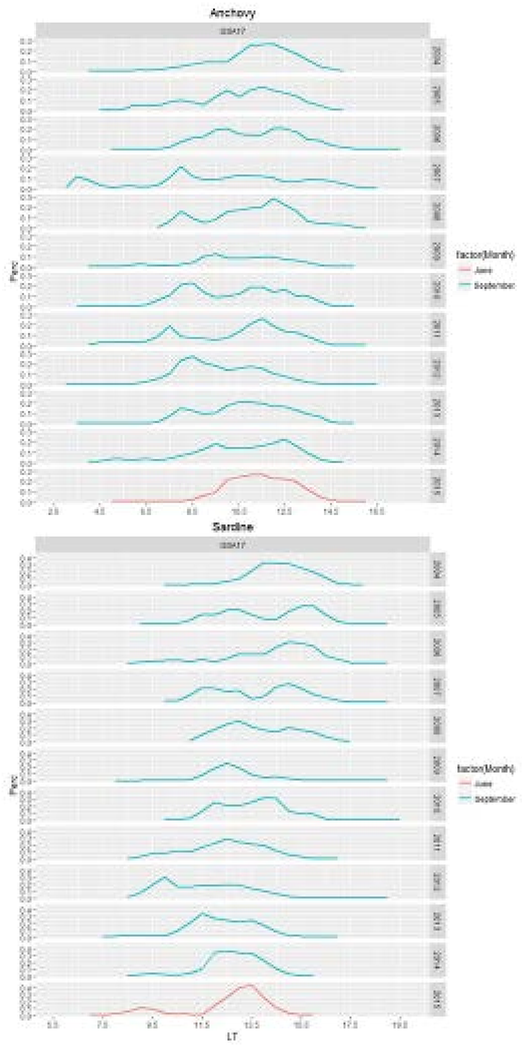


Figure 3. Anchovy and sardine LFD in western GSA 17 from 2004 to 2015.

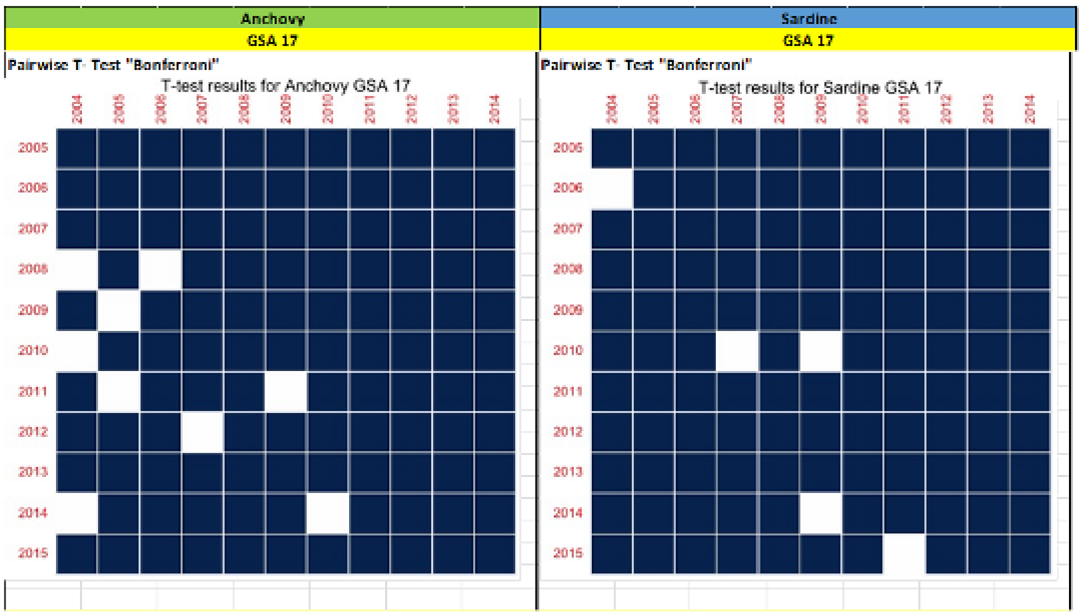


Figure 4. Results of pairwise T- test "Bonferroni" showing in dark the significant differences between couples of mean size values, in white the non-significant differences.

Annex 10: Survey reports

List of survey reports included in this section:

WD 1 – BIOMAN SURVEY

Total anchovy biomass (*Engraulis encrasicolus*, L.) applying the DEPM, sardine (*Sardina pilchardus*) egg abundance and top predators in the Bay of Biscay in 2016

M. Santos1, L. Ibaibarriaga1, M. Louzao1, and A. Uriarte1

AZTI-Tecnalia, Instituto Tecnológico Pesquero y Alimentario, Pasaia, SPAIN.

Working Document to WGACEGG, 14-18 November 2016, Sicily (Italy)

Total anchovy biomass (*Engraulis encrasicolus*, L.) applying the DEPM, sardine (*Sardina pilchardus*) egg abundance and top predators in the Bay of Biscay in 2016

by

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Abstract

The research survey BIOMAN 2016 for the application of the Daily Egg Production Method (DEPM) to the Bay of Biscay anchovy was conducted in May 2016 from the 5th to the 25th 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 98,866 Km^2 and the spawning area was 55,092 Km^2 for anchovy and 31,653 Km^2 for sardine. During the survey 680 vertical plankton samples were obtained, 1,649 CUFES samples and 44 pelagic trawls were performed, from which 34 contained anchovy and 29 of them were selected for the analysis. Moreover, 2 extra samples were obtained from the commercial fleet. In total there were 31 samples for anchovy adult parameters estimates. This is the first year were sights were achieved. One observer using line transect methodology (distance sampling) obtained 215 observations periods (1,341km during 70h (daily average 4.14h and 79km). In those sights marine mammals, seabirds, human activities & debris were recorded.

For anchovy the spawning limit to the West in the Cantabrian coast was found at 5º30'W and in the French platform there were eggs all over the platform up to 200m depth until 46ºN. From 46ºN to 47º23'N the egg were inside the 100m depth isoline. The northern distribution limit was found at the height of Lorient (47º37'N). A mean SST of 14.8ºC and SSS of 34.57 were encountered.

Total egg production (P_{tot}) for anchovy was calculated as the product of spawning area and daily egg production rate (P_0), which was obtained from the exponential decay mortality model fitted as a Generalized Linear Model to the egg daily cohorts.

The adult parameters, sex ratio (*R*), batch fecundity (*F*), spawning frequency (*S*) and weight of mature females (W_f), were estimated based on the adult samples obtained during the survey. Consequently, the Spawning Stock Biomass obtained for anchovy resulted in 152,049 t, the second highest of the series, with a coefficient of variation of 12%. Total egg abundance of sardine was 8.56 E+12 eggs, over the last year estimate (5.52 E+12) and the historical mean (5.83 E+12).

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 and the French fleet rely on this resource (Uriarte *et al*., 1996 and Arregi *et al*., 2004). In order to provide 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 at the end of 2015 a limited TAC of 25,000 t for 2016(January to December). Afterwards in 2016 the TAC was increased to 33,000t. 200t more were added in September

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) (Lasker, 1989; 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*. In case of this anchovy the SSB is equal to the total biomass because at the spawning pick all anchovies are spawning.

Since 1987, AZTI (Marine and Food Technological Centre, Basque country, Spain), has conducted annually specific surveys to obtain anchovy biomass indices (Somarakis *et al*., 2004; Motos *et al*., 2005; Santos *et al.*, 2011; Santos *et al*, 2016). In addition, the anchovy Basque fishery is continuously monitored. This information is submitted annually to ICES, to advice on the exploitation of the fishery.

This survey for the application of the DEPM to estimate the Bay of Biscay anchovy biomass is one of the three surveys which give information about this population. One of those is carried out at the same time in May since 19--, is the acoustic French survey. The other one is carried out in autumn directed to anchovy juveniles since 2003. The biomass indices provided by the acoustic in May, DEPM surveys in May and acoustic in autumn (since 2014), together with the information supplied by the fleet are used as input variables for a two stage biomass model used to assess the Bay of Biscay anchovy population (Ibaibarriaga *et al*., 2008). Since 2014 the assessment of the species is carried out in December of each year, and the advice is from January to December.

Apart from that the DEPM survey in the Bay of Biscay gives information on the distribution and abundance of sardine eggs (since 1999), mammals, birds and litter (since 2016) and environmental conditions due to the collection of different parameters such as sea surface temperature, sea surface salinity, temperature and salinity in the water column, currents and winds.

This working document describes the BIOMAN 2016 survey for the application of the DEPM to the Bay of Biscay anchovy in 2016. First, the data collection, the estimation of the total egg production and the reproductive parameters are described in detail. The daily fecundity was revised from a preliminary one presented in June after histological reading of ovaries from the adults collected during BIOMAN 2016. 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. Distribution and abundance of birds, mammals, litter and human activities are presented. Moreover, historical trajectory of the population is showed. Finally, sardine egg distribution and total abundance is estimate and compare with the historical values.

Material and Methods

Survey description

The BIOMAN2016 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, ichthyoplankton and adult samples were obtained for the estimation of total daily egg production and total daily fecundity respectively for anchovy. The age structure of the population was also estimated. In addition, extra plankton samples with the MIK net were collected for acoustics issues and Bongo samples to collaborate with the triannual mackerel and horse mackerel surveys.

The collection of plankton samples was carried out on board R/V Ramón Margalef from the 5th to the 25th 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 7, at 4º56'W), but as there were found anchovy eggs in this transect two more transects were prospected to the west until 5º37`W. 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 in the eastern part of the Cantabric coast and in the area of influence of the Adour and Garonne rivers.

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 situated at intervals of 3 nm along 15 nm apart transects perpendicular to the Cantabric and French 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 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 nets were washed and the samples obtained were fixed in formaldehyde 4% buffered with sodium tetra borate in sea water, mixing the samples obtained in each of the nets that compound the PairoVET frame. After six hours of fixing, anchovy, sardine and other eggs species were identified, sorted out and counted on board. Afterwards, in the laboratory, a percentage of the samples were checked to assess the quality of the sorting made at sea. Actually, part of the sorting was finished in the laboratory. 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. At some points determinate before the survey, water was filtered from the surface to obtain chlorophyll samples to calibrate the data from the fluorimeter.

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 not to lose eggs. 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, transects were 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.

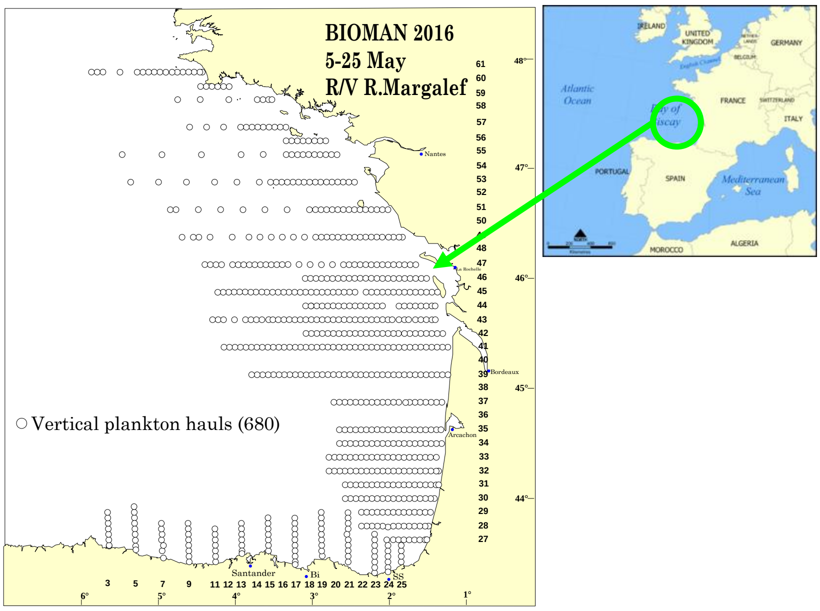


Figure 1: Plankton stations during BIOMAN 2016.

Adult samples were obtained on board R/V Emma Bardán (pelagic trawler) from the 7th to the 27th May coinciding in space and time with the plankton sampling. When the plankton vessel encountered areas with anchovy 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 from all individuals were extracted on-board and read in the laboratory to obtain the age composition per sample. In each haul 100 individuals of each species were measured.

This year 2 additional anchovy adult samples were obtained from the commercial Basque purse seine fleet when the egg sampling was crossing the area of Cape Breton where the purse seiners were operating.

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) $$\log\left(E[N_{i,j}]\right) = \log(R_i) + \log\left(P_0\right) - Z \, a_{i,j} \;,$$

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:

$$(4) \qquad f(age \mid stage, temp) \propto f(stage \mid age, temp)\, f(age)\,.$$

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)*):

$$(5) \qquad f(age) \propto f(spawn = \tau - age)\exp(-Z\ age)\ .$$

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 and total biomass

The daily fecundity (***DF***) is usually estimated as follows:

$$DF = \frac{R \cdot F \cdot S}{W_f} , \qquad (6)$$

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:

$$E[W] = a + b * W_{gf} . \qquad (7)$$

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:

$$E[F] = a + b * W_{gf} \quad . \tag{8}$$

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):

$$y = \frac{\sum_{i=1}^{n} M_i y_i}{\sum_{i=1}^{n} M_i} \quad \text{and} \tag{9}$$

$$Var(y) = \frac{n \sum_{i=1}^{n} M_i^2 (y_i - y)^2}{\left(\frac{\sum_{i=1}^{n} M_i}{n} \right)^2 n(n-1)} \quad , \tag{10}$$

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.

The estimation process of the **spawning frequency (*S*)** was estimate following Uriarte *et al.*, 2012.

The Spawning Stock Biomass (*SSB*) that in the case of anchovy is equal to total biomass at the spawning peak when the survey occurred, 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*).

Numbers at age

To deduce the numbers at age different regions were defined depending on the distribution of the adult samples (size, weight and age) and the distribution of anchovy eggs.

Given that mean length and weight of anchovies change between those regions, proportionality between the amount of samples and a proxy of the total biomass indices by regions was checked. The approximate index of biomass by regions was set equal to egg abundance divided by the daily fecundity (DF) assigned to each region. The DF by regions was approached by the general formula of this parameter ($F*S*R/W_f$) using the unweight mean of the adult parameters of the samples in the region (**Fig.3**).

Predators and human activities

We followed the same methodology implemented in the PELACUS and PELGAS multidisciplinary surveys based on the distance sampling methodology. We performed observations during daylight plankton and acoustic sampling, as well as during certain between-transect navigation while vessel speed and course were constant.

Figure2: Observation platform on-board R/V Ramón Margalef showing an observer activity.

One observer was placed over the bridge of R/V Ramón Margalef, 6 meters high from the sea surface (**Fig. 2**). The observer scanned the water to the front of the boat covering an area of 90º from the trackline to port or starboard (45º to each side), respectively continuously while the vessel was sailing at constant heading and speed during daytime. The temporal observation unit was one minute. The observer 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.

Results

Survey description

This year the West spawning limit in the Cantabrian coast was found at 5º17'W at the height of Gijón. In the French platform there were eggs all over the platform until 46ºN. From 46ºN to 47º23'N the egg were inside the 100m depth isoline. The northern distribution limit was found at the height of Nantes (47º23'N) (**Fig. 3**). The sampling was stopped for 36h hours to refuel. The stern's stay of cufes was broken and was mended but didn't disturb the survey.

The total area covered was 98,866 km² and the spawning area 55,092 km². During the survey 680 vertical plankton samples were obtained, 465 with anchovy eggs (69%) with an average of 550 eggs m^{-2} per station in the positive stations and a maximum of 7,530 eggs m^{-2} in a station. A total of 25,564 anchovy eggs were encountered and classified. 1,648 CUFES samples (horizontal sampling at 3m depth, mesh size net 335) were achieved, 1,050 had anchovy eggs (64%) with an average of 20 eggs m^{-3} per station in the positive stations and a maximum of 225 eggs m^{-3}

A mean abundance of 8.87 E+12 sardine eggs was encountered in all the area surveyed, 1.5 times higher than last year. To be included in the assessment for the sardine in the Viiab the abundance from the cantabric coast and part of the NW was removed obtaining an egg abundance of 8.56 E+12 eggs. Very few eggs were encountered along Cantabrian coast, between 4º20' and 5º30' W. In the French platform the eggs were between coast and 100m depth isoline, all along the coast, from south of France to 48ºN, where the north spawning limit was found (**Fig. 3**). In PairoVET from 680 stations a total of 266 (39%) stations had sardine eggs with an average of 290 eggs per m^{-2} per station in the positive stations and a maximum of 6,690 eggs m^{-2}.

Both samplers PairoVET (eggm^{-2}) and CUFES (eggm^{-3}) show very similar anchovy and sardine egg abundances distribution pattern (**Fig. 3 and 4**).

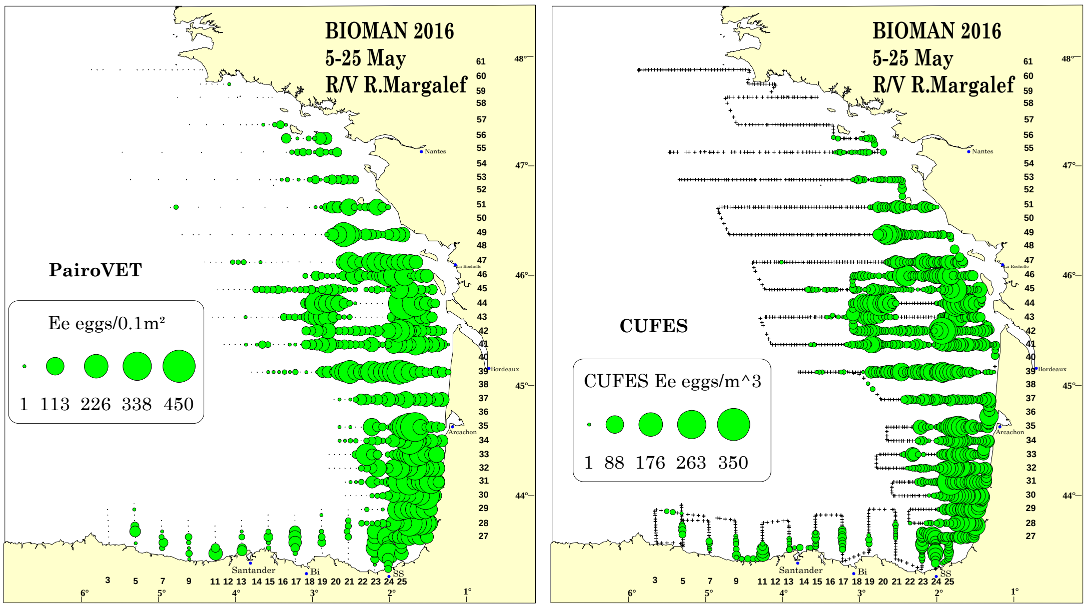


Figure 3: Distribution of anchovy egg abundances obtained with PairoVET (left) (eggs per 0.1m^2) and CUFES (right) (Egg per m^3) from the DEPM survey BIOMAN2016.

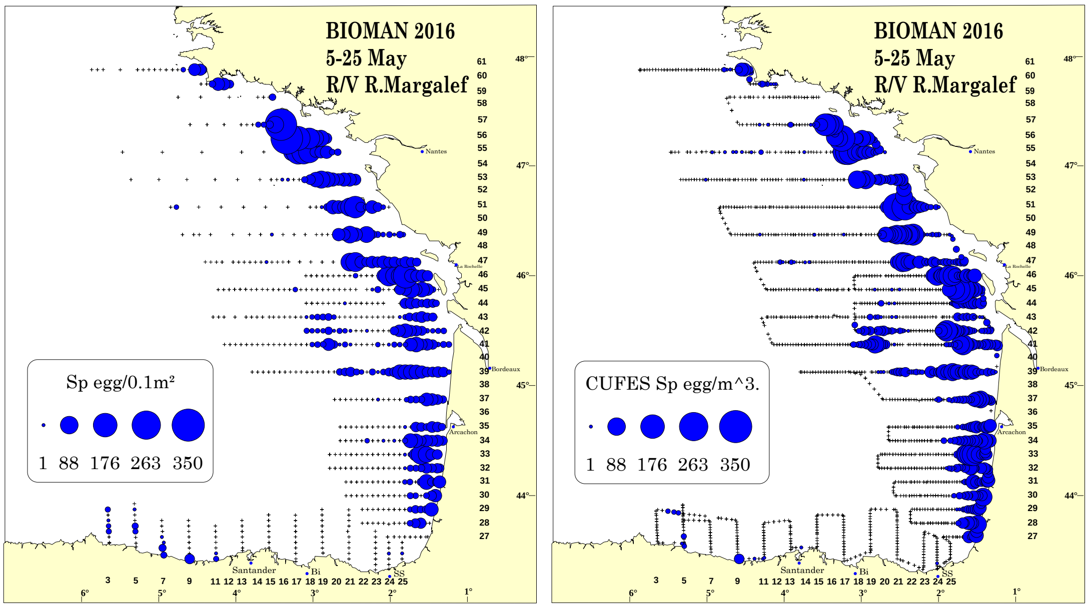


Figure 4: Distribution of sardine egg abundances obtained with PairoVET (left) (eggs per 0.1m^2) and CUFES (right) (Egg per m^3) from the DEPM survey BIOMAN2016.

Figure 5 shows the sea surface temperature (SST) and sea surface salinity (SSS) maps overlapped with the abundance of anchovy eggs as observed during the BIOMAN2016 survey.

This year the mean SST of the survey, 14.8ºC, was at levels of last year (15.1 ºC) and the mean SSS, 34.57 UPS, was as well at levels of last year (34.49 UPS). The distribution patterns of sea surface temperature (SST) and sea surface salinity (SSS) observed were the typical for the region at this season showing the signatures of the Adour and Garonne River off the French coast.

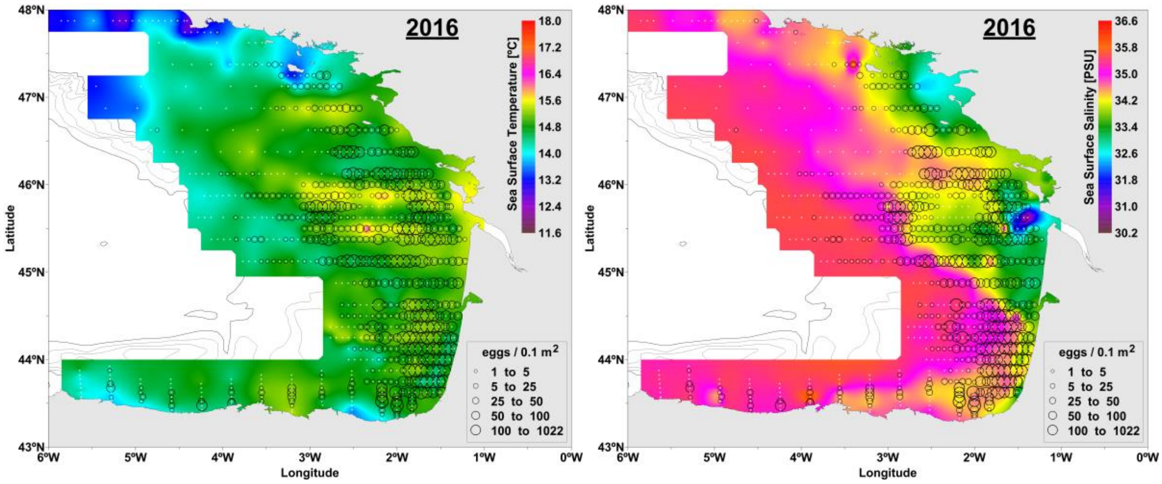


Figure 5: SST and SSS maps (left and right respectively) with anchovy egg distribution 2016.

The adult samples covered adequately the positive spawning area as shown in **Figure 6.** Overall 44 pelagic trawls were performed of these, 36 provide anchovy and 29 were selected for the analysis because the other 7 had a small amount of anchovy. Moreover 2 samples from purse seines were added, in total 31 samples for the analysis.

The most abundant species in the trawls ware: anchovy, sardine, horse mackerel, mackerel, hake and sprat. Anchovy adults were found in the same places where the anchovy eggs were found.

Spatial distribution of mean weight and mine size for anchovy (males and females) are shown in **Figure 7**. As usually, less weight and size individuals were found all along the French coast while heavier and bigger anchovies were found offshore in the French platform and in the cantabric coast. This year the mean weight (males and females) 13.5g was the lower of the historical series. Since 2010 after the reopen of the fishery, the mean weight of the anchovy population in the Bay of Biscay was going down gradually.

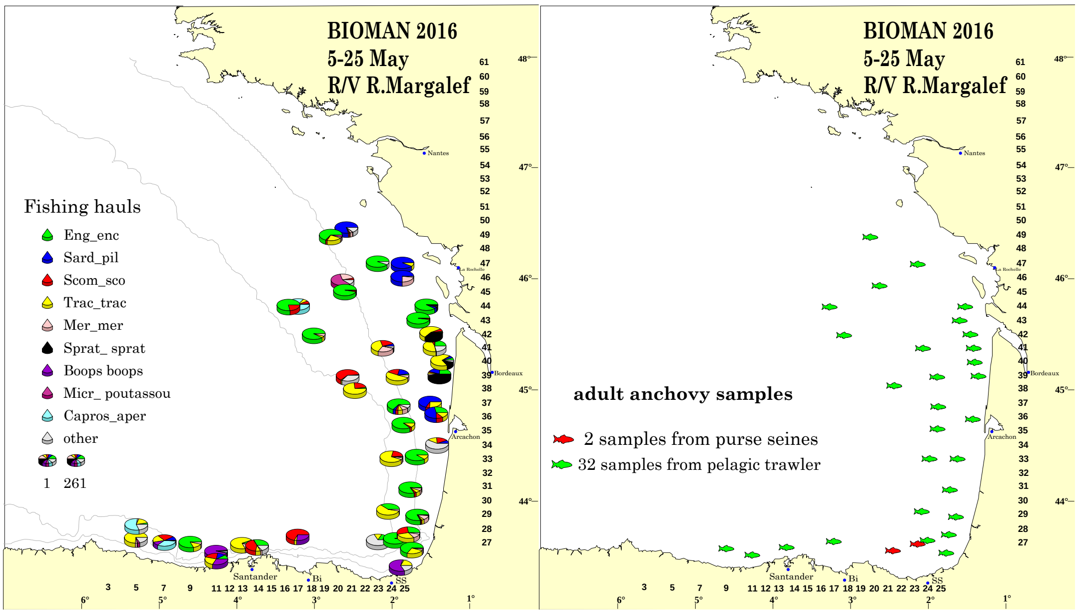


Figure 6: Spatial distribution of fishing hauls from R/V Emma Bardán in 2016. On the left the species composition by haul and on the right the hauls with anchovy selected for the analysis.

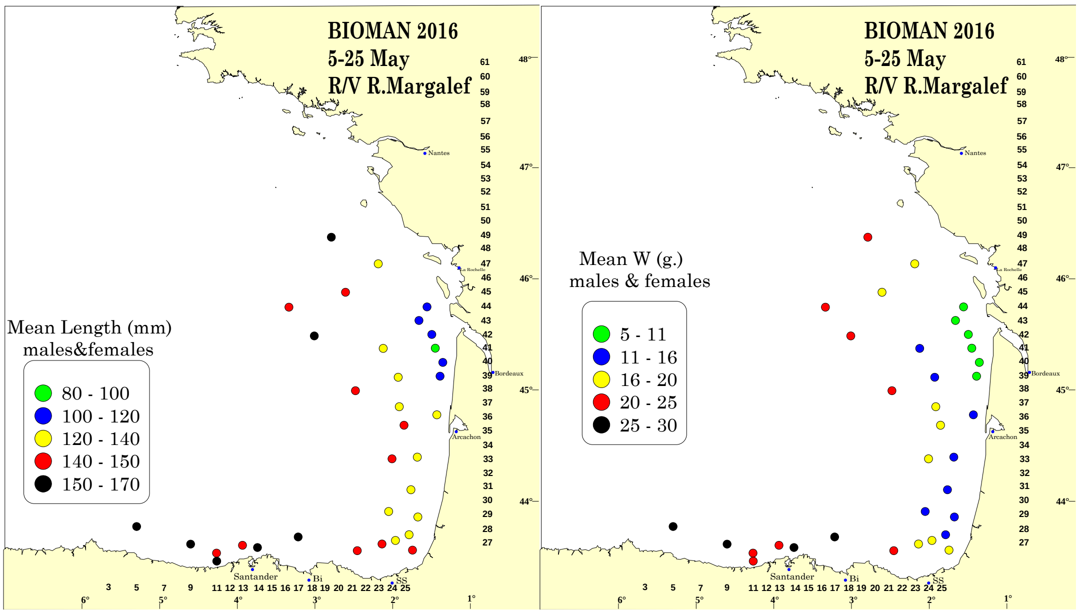


Figure 7: Anchovy (male and female) mean size (left) and mean weight (right) per haul in 2016

In **Figure 8** the size distribution of the anchovy in all the area and in different regions is shown.

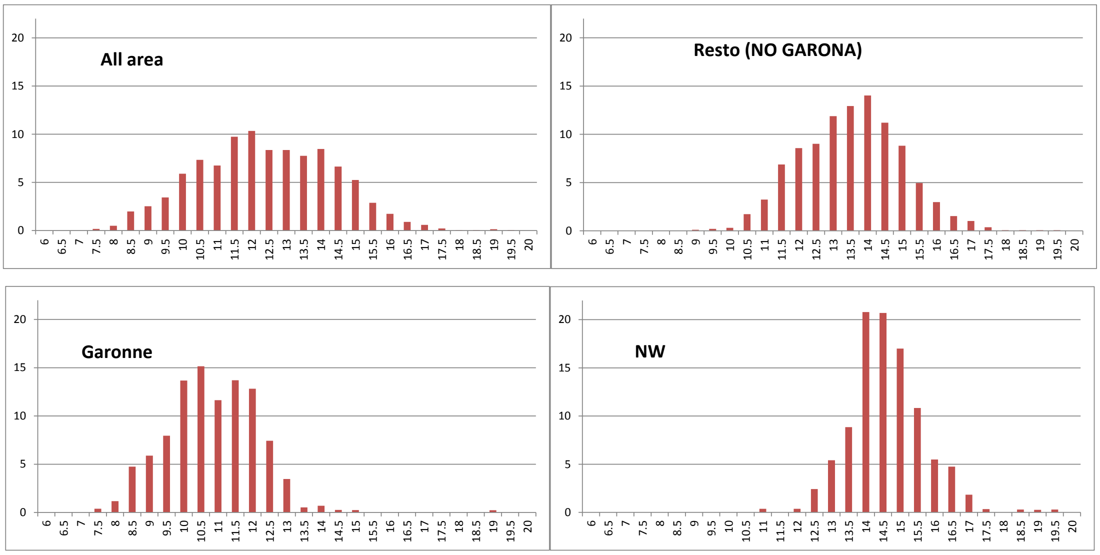


Figure 8: Anchovy (male and female) mean size distribution by region. Top left size distribution of all area; top right all areas except Garonne area, Down-left Garonne and down right NW

Total daily egg production estimates

As a result of the adjusted GLM (**Fig. 9**) the daily egg production (P_0) was 213 egg m^{-2} day $^{-1}$ with a standard error of 21.64 and a CV of 0.10. The daily mortality (z) was 0.33 with a standard error of 0.049 and a CV of 0.15. Then, the total daily egg production (P_{tot}) as the product of spawning area and daily egg production was 1.17E+13 with a standard error of 1.2E+12 and a CV of 0.10

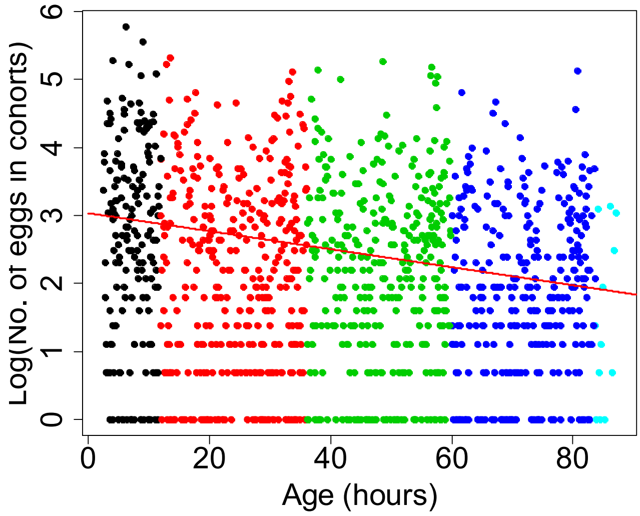


Figure 9: Exponential mortality model adjusted applying a GLM to the data obtained in the ageing, following the Bayesian method, in 2016 (spawning peak 23:00h).The red line is the adjusted line. Data in Log scale. The different colours of the bubbles represented the different cohorts.

Daily fecundity and total biomass

The results of the adjusted linear regression model between gonad-free-weight and total weight fitted to non-hydrated females (hydrated females identified macroscopically as stages 3 and 5 based on the macroscopic maturity scale from WKSPMAT, 2008) are given in **Table 1**. The extra females, not randomly taken, for batch fecundity, were not considered. This correction was not modified for the final estimate for November, because it was considered that the females with a hydrated appearance, even though they have POFs, must remain with the correction. The model fitted the data adequately (**Figure 8**, R^2=99.7%, n= 688). The **female mean weight (*W_f*)** of the population 16.5g was obtained as the weighted mean of the average female weights per sample (Lasker, 1985).

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	-0.2713	0.0360	0
Slope	1.0995	0.0022	0

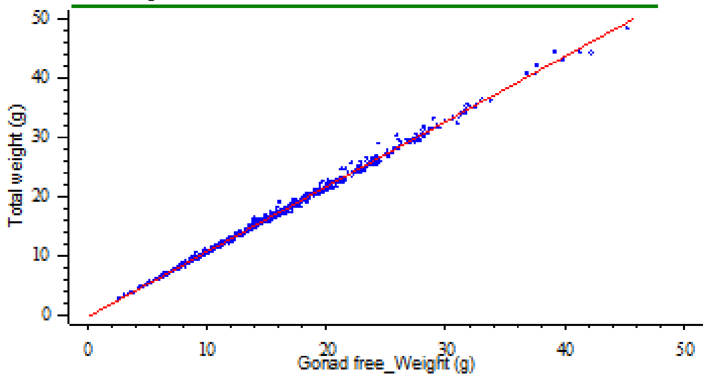


Figure 8: linear regression model between gonad-free-weight and total weight fitted to non-hydrated females.

For the **batch fecundity (*F*)** 83 hydrated females from 14 samples, ranging from 2.9 to 31.2 g gonad free weight were examined. The coefficients of the generalised linear model with Gamma distribution and identity link are given in **Table 2** and the fitted model is shown in **Figure 10**. It was tested whether the model coefficients changed between the 6 strata considered for the numbers at age; no statistically significant differences among the regions at the 95% confidence level were found. Moreover, two strata were considered: the strata Garonne and the rest of the area, instead the six strata, due to the inexistent difference between the 6 strata (**Figure 2**). Statistically significant differences among the two strata at the 95% confidence level were found, so the model fitted to the single region was then used to estimate batch fecundity from the gonad free weight for all the females of all samples. Hence, the overall batch fecundity estimate was obtained as a weighted sample mean of the batch fecundity per sample (Lasker, 1985).

Table 2: Coefficients of the generalised linear model with Gamma distribution and identity link between the number of hydrated oocytes and the female gonad free weight (W_{gf}) for the Gironde and the remainder area

Parameter	estimate	Standard error	t value	Pr(>|t|)
Intercept	911.33	529.93	1.720	0.0894
wgf	313.52	83.46	3.757	0.000328***
remainder	-2395.1	827.92	-2.893	0.00493**
Wgf:remaind	211.25	96.54	2.188	0.031603*

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1 ***

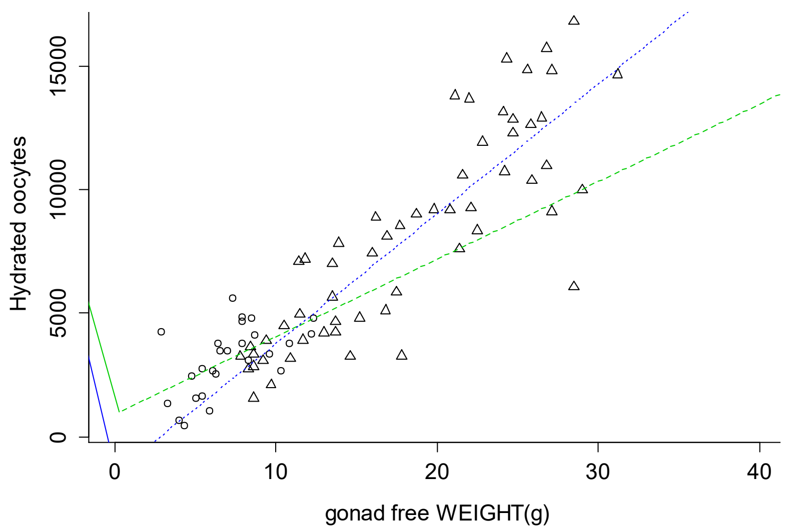


Figure 10: Generalised linear model between gonad-free-weight and hydrated oocytes fitted to hydrate females. The circles are the one from the Gironde and triangles are the ones from the rest of the area. The green line is the fit to the Gironde samples and the blue one the fit to the samples from the remainder area.

For the **spawning frequency (*S*)** the estimate was calculated as describe above in material and methods. After the histological analysis of the gonads was completed, using the new staging (Alday *et al*., 2010) and new ageing (Uriarte *et al*., 2012), the estimate of S obtained was S=0.36 C.V= 4%.

In June (WGHANSA) a mean of the last 6 years for the estimate of DF was adopted, now in November (WGACEGG) a DF of 77.38 cv= 12% was estimated from the parameters obtained through the adult samples from the survey.

Estimates of the female mean weight, total mean weight, batch fecundity, sex ratio, spawning frequency, daily fecundity and SSB with their CVs are given in **table 3**. The anchovy total biomass estimate obtained was 152,049t with a CV of 12%

Table 3: All the parameters to estimate de Spawning Stock Biomass (SSB) using the Daily Egg Production Method (DEPM) for 2016: P_{tot} (total egg production), R (sex ratio), S (Spawning frequency), F (batch fecundity), W_f (female mean weight) and DF (daily fecundity) with correspondent Standard errors (S.e.) and coefficients of variation (CV).

Parameter	estimate	S.e.	CV
Ptot	1.17E+13	1.19E+12	0.1017
R'	0.53057	0.0048	0.0090
S	0.36	0.0142	0.0396
F	6,685	543	0.0812
Wf	16.50	1.09	0.0661
DF	77.38	4.04	0.0522
BIOMASS (Tons)	**152,049**	17,377	0.1143

Numbers at age

For the purposes of producing population at age estimates, the age readings based on 2,122 otoliths from 31 samples were available.

To deduce the numbers at age 6 regions were defined depending on the distribution of the adult samples (size, weight and age) and anchovy eggs (**Figure 11**): South West (SW), South East (SE), Centre (C), Garonne (G), North (N) and North West (NW).

Given that mean length of anchovies change between those regions (**Figure 2**) proportionality between the amount of samples and a proxy of the total biomass indices by regions was checked. The approximate index of biomass by regions was set equal to egg abundance divided by the daily fecundity (DF) assigned to each region (**Table 3**). The DF by regions was approached by the general formula of this parameter ($F*S*R/W_f$) using the unweight mean of the adult parameters of the samples in the region (**Fig.3**).

According to that table, the 31 samples selected cannot be considered to be balanced between those 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 by age and biomass by age, length and weight by age estimates are given in

Table 4 (a&b). 53% of the population in numbers and 43% in mass correspond to age 1. **Figure 12** shows the distribution of anchovy age composition in space.

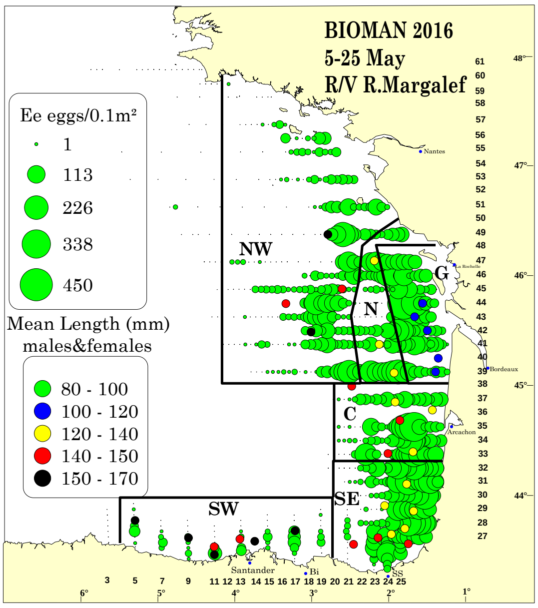


Figure 11: 6 regions defined to estimate the numbers at age. The black lines represent the border of the regions, the green bubbles de abundance of anchovy eggs per 0.1m² in each station and the small colour bubbles represent the mean size (mm) of individuals within each haul.

Table 4: Balance of adult sampling to egg abundance by 6 regions: Garonne-Ga, Coast-Co, Centre-Ce and Offshore-Off in the Bay of Biscay (see **Figure 3**). The 8th row of the table corresponds to the weighting factor for each sample by region to obtain the population structure. Mean weight by regions arise from the 31 adult samples selected for the analysis.

Strata	SW	SE	C	G	N	NW	Addition
Total egg abundance	6.5E+11	6.1E+12	4.4E+12	4.5E+12	4.1E+12	6.0E+12	2.58E+13
% egg abundance	3%	24%	17%	18%	16%	23%	100%
DF	91.69	75.22	77.86	67.73	92.12	75.73	
Proxy of B	7.0E+09	8.1E+10	5.6E+10	6.7E+10	4.5E+10	7.9E+10	3.4E+11
%Proxy Biomass	2%	24%	17%	20%	13%	24%	100%
Nº of adult samples	4	8	5	6	3	5	31
% proxy Biomass/ nº sample	0.005	0.030	0.034	0.033	0.045	0.047	
Proportion of B relative to NW str.	0.11	0.63	0.71	0.70	0.94	1.00	
W. factor proportional to the population	0.11/wi	0.63/wi	0.71/wi	0.70/wi	94/wi	1/wi	
Mean weight of anchovies by region	25.36	15.79	16.39	8.23	13.65	21.42	
Standard Deviation	3.29	3.78	8.30	1.55	6.60	2.08	
CV	13%	24%	51%	19%	48%	10%	

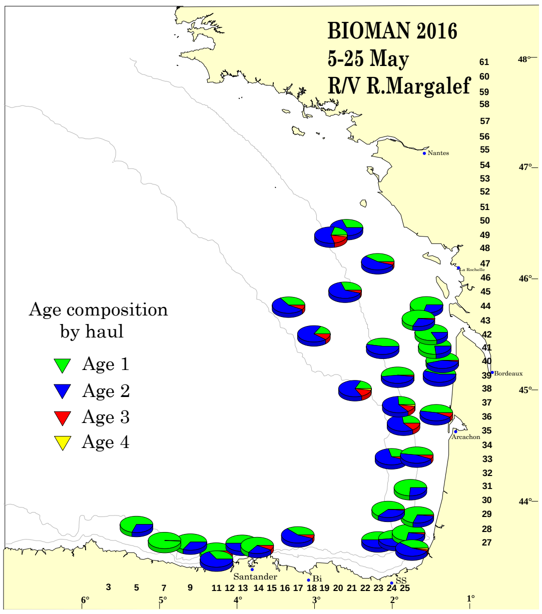


Figure 12: Anchovy age composition in space per haul 2016

Table 5: 2016 anchovy biomass estimates, total mean weight, population in millions and the percentage, numbers, percentage in mass and biomass at age estimates with correspondent standard error (S.e.) and coefficient of variation (CV). And weight and length at age with correspondent standard error (S.e.) and coefficient of variation (CV).

Parameter	estimate	S.e.	CV
BIOMASS (Tons)	**152,049**	17,377	0.1143
Total mean weight (g)	13.516	1.09	0.0804
Population (millions)	11,264	1609	0.1429
Percentage at age 1	0.530	0.039	0.0731
Percentage at age 2	0.441	0.033	0.0749
Percentage at age 3	0.029	0.008	0.2610
Numbers at age 1	5,981	1,159.2	0.1938
Numbers at age 2	4,961	592.6	0.1194
Numbers at age 3	322	74.4	0.2311
Percent. at age 1 in mass	0.428	0.036	0.0833
Percent. at age 2 in mass	0.515	0.028	0.0540
Percent. at age 3 in mass	0.054	0.012	0.2182
Biomass at age 1 (Tons)	65,312	9,711	0.1487
Biomass at age 2 (Tons)	78,129	9,341	0.1196
Biomass at age 3 (Tons)	8,154	1,986	0.2435

Biological Features	estimate	S.e.	CV
Weight at age 1 (g)	10.92	0.96	0.0883
Weight at age 2 (g)	15.76	0.99	0.0629
Weight at age 3 (g)	26.79	1.33	0.0498
Lenght at age 1 (mm)	120.18	3.54	0.0295
Lenght at age 2 (mm)	134.55	2.85	0.0212
Length at age 3 (mm)	160.92	2.12	0.0132

Predators and human activities

A total of 215 observations periods (legs) were performed, travelling a total of 1341 km during 70 hours of observation. We observed an average of 4.14 hours per day (range: 1.2 – 6.5) and travelled an average of 79 km per day (range: 24.4 – 107.1). We recorded a total of 969 seabirds, 796 cetaceans, 277 of human activities and 33 of land birds. A complete list is given in **table 6** at the end of the report.

Regarding **marine mammals**, we observed 4 different species and the spatial distribution of the most abundant species can be observed in **figure 13**. The most abundant species were the common dolphin with 47 sightings (group size = 14.98 ± 12.47, total of 704 individuals), followed by stripped dolphins with 6 sightings (group size = 13.17 ± 16.18, total of 79 individuals). Common dolphins were mainly concentrated around the area of influence of the Garonne River. We also recorded one sighting of minke whale, fin whale and bottlenose dolphin (**Table 6** at the end of the report).

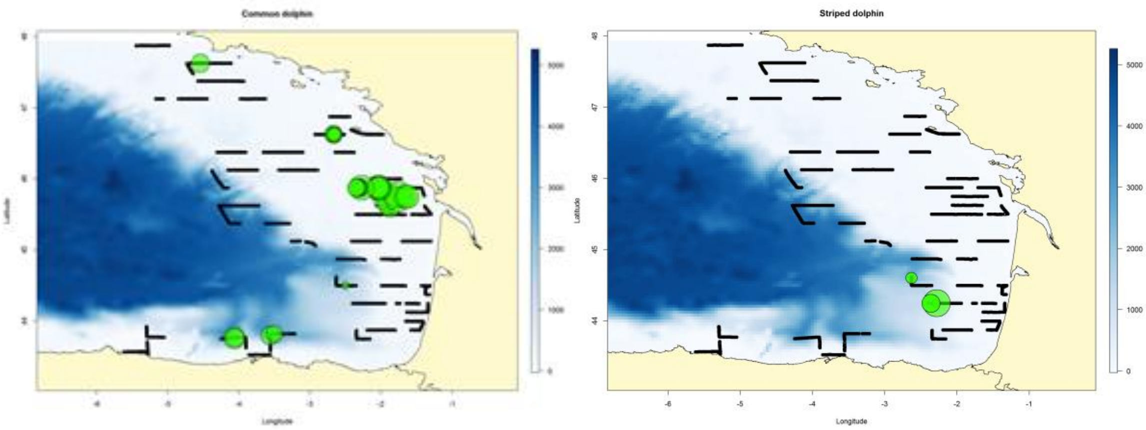
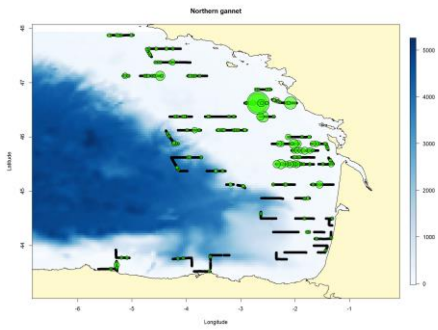


Figure 13: Distribution of the most abundant marine mammal species during BIOMAN 2016, (left) common dolphins and (right) stripped dolphins. Black points represent the effort while the size of the green circles is proportional to observed abundances. Blue background values represent the bathymetry.

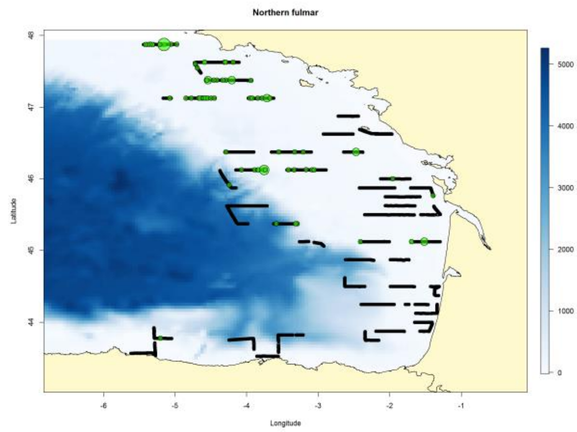
Regarding **seabirds**, 14 different species were observed. Spatial distribution of the most abundant can be observed in **figure 14**. The most abundant species were the northern gannet with 207 sightings (group size = 1.76 ± 4.97, total of 362 individuals), followed by lesser black-backed gull with 81 sightings (group size = 1.8 ± 2.43, total of 146 individuals), northern fulmars with 73 sightings (group size = 1.15 ± 0.57, total of 84), common guillemots with 49 sightings (group size = 3.57 ± 4.14, total of 175) and yellow-legged gulls with 37 sightings (group size = 2.59 ± 3.02, total of 96) (**table 6**). We also observed European storm-petrels, great skuas, Balearic shearwaters, sandwich terns, great black-backed gulls, Manx shearwaters, Cory's shearwaters, black-headed gulls and arctic skuas (**table 6**).

(a)



(b)

(c)

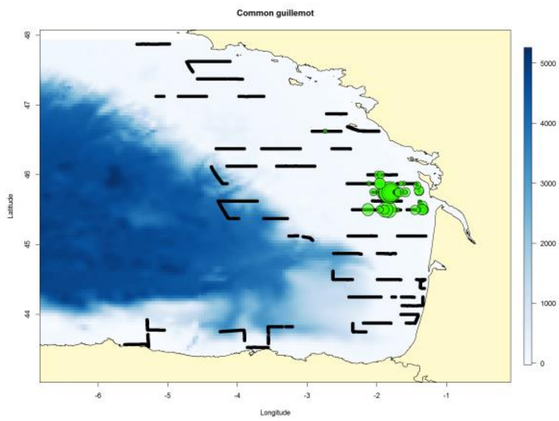


(d)

Figure 14: Distribution of the most abundant seabird species during BIOMAN 2016 such as (a, b) northern gannets and (c, d) northern fulmars. Black points represent the effort while the size of the green circles is proportional to observed abundances. Blue background values represent the bathymetry.

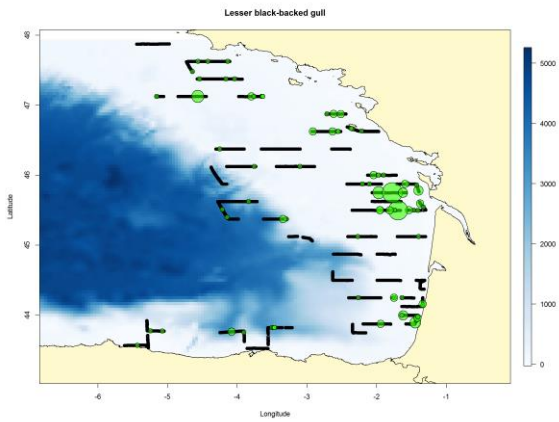
While northern gannets were concentrated in the central sector of the study area, northern fulmars were concentrated in the northern sector. Common guillemots were clearly associated to the area of influence of the Garonne River. The lesser black-baked gull showed a more widespread distribution compared to the yellow-legged gulls which showed a costal restricted distribution. (**Fig.15**)

(a)



(b)

(c)



(d)

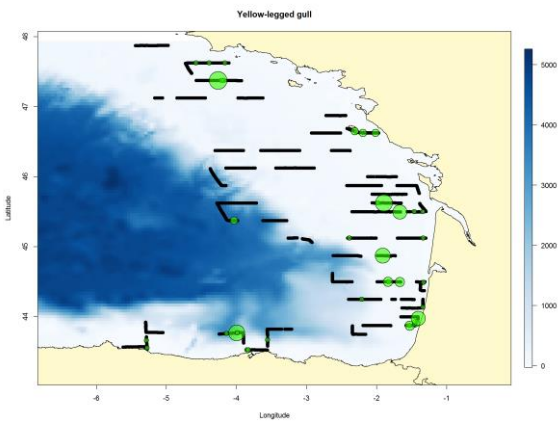


Figure 15: Distribution of the most abundant seabird species during BIOMAN 2016 such as (a,b) common guillemots, (c) lesser black-backed gulls and (d) yellow-legged gulls. Black points represent the effort while size of green circles is proportional to observed abundances. Blue background values represent the bathymetry.

Regarding **human activities**, we observed 16 different activities/items and the spatial distribution of the most abundant can be observed in **figure 16**. The most abundant activities were plastic trashes with 125 sightings (group size= 1.38 ± 1.52, total of 174 items), followed by general trash with 15 sightings (group size = 1.07 ± 0.26, total of 16 items), fishing buoys, trawlers and gill-netters with 14, 11 and 10 sightings, respectively (**table 6**). We also observed pleasure boats, fishing trash, unnatural wood, fishing boats, merchant ships, containerships, planes, long liners, pair trawlers and tankers (**table 6**).

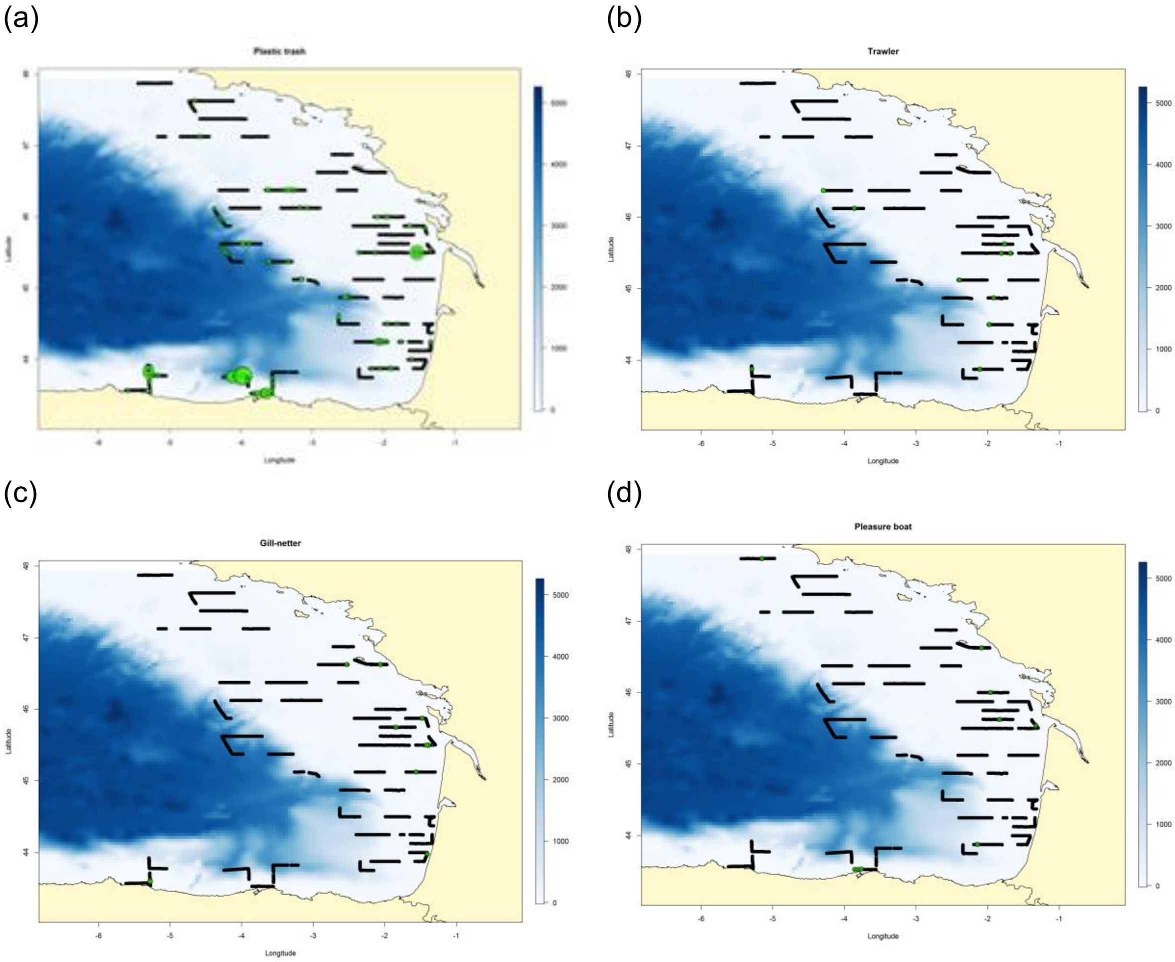


Figure 16: Distribution of the most abundant human activities during BIOMAN 2016 such as (a) plastic trash, (b) trawlers, (c) gillnetters and (d) pleasure boats. Black points represent the effort while the size of the green circles is proportional to observed abundances. Blue background values represent the bathymetry.

Historical perspective

In the Bay of Biscay the spawning area for anchovy in 2016 (55,092 km^2) was higher than the historical mean (1987-2015) that is 40,901km^2 but lower than last year. The daily egg production (P_0= 208egg/m^2) was the highest of the series (mean = 83egg/m^2). The mortality (z=0.33) was higher than the mean historical series (mean = 0.25). The total daily egg production (P_{tot}= 1.17E+13) was highest of the historical series (mean = 3.71E+12). (**Fig.17**)

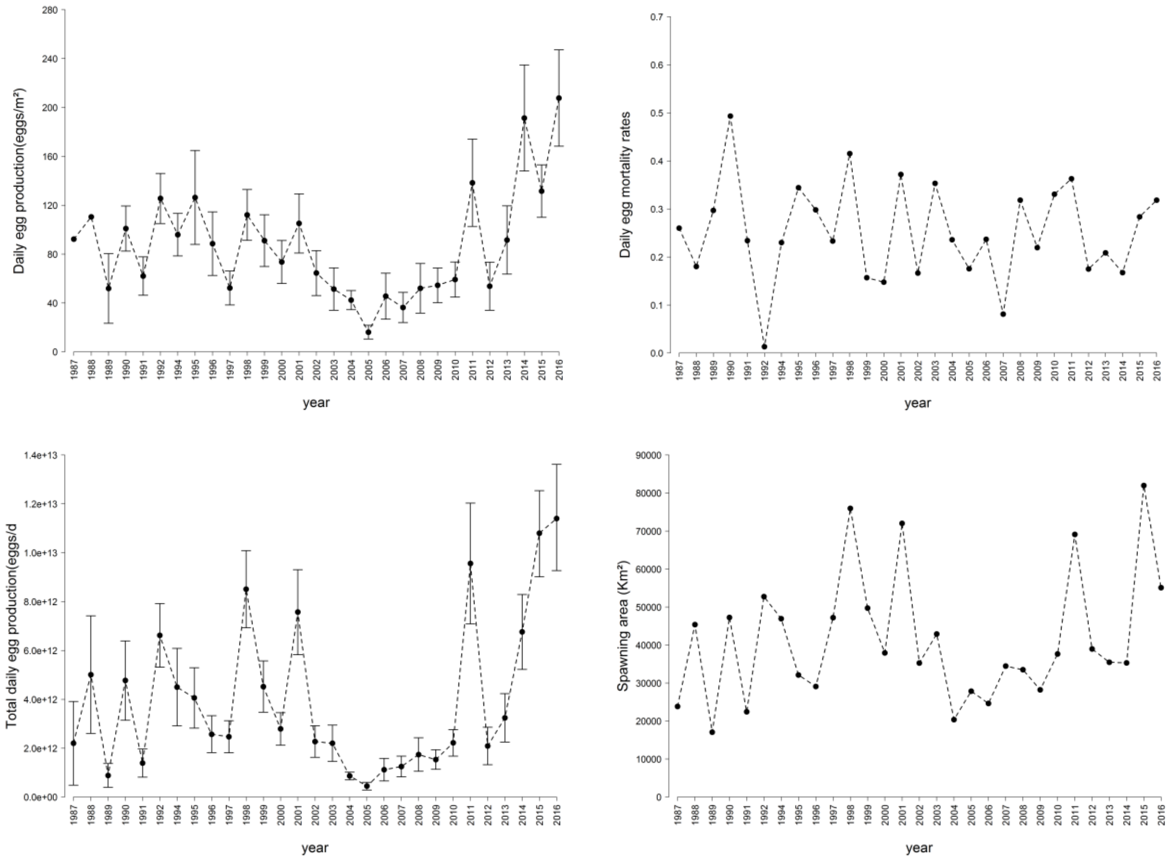


Figure 17: Time series of DEPM egg parameters and spawning area for anchovy: Daily egg production (P_0) ($eggm^{-2}$), Daily egg mortality rates (z), total egg production (P_{tot})($eggsday^{-1}$) and Spawning area(Km^2). Vertical lines indicate 95% confidence intervals (i.e. ± 2 standard deviations).

The historical series of reproductive parameters for the DEPM for Anchovy in the Bay of Biscay in May are showed **figure 18**. Compering the adult parameters estimated in 2016 with the corresponding mean historical series (1987-2015), sex ratio (0.53) is at levels of the historical mean (0.54), female mean weight (16.5g) is the lowest of the historical series (mean = 24.41g); the tendency of the female weight and the total weight have been going down since 2010. The batch fecundity this year (6,685 eggs per mature female per batch) is the second lowest of the historical series (mean = 11,046 eggs per mature female per batch), the tendency of the batch fecundity was going down since 2010. The spawning fraction (0.36) is at levels of the mean (mean = 38.7) and the daily fecundity (77.38 egg/g) is lower than the historical series (mean = 94.63 egg/g).

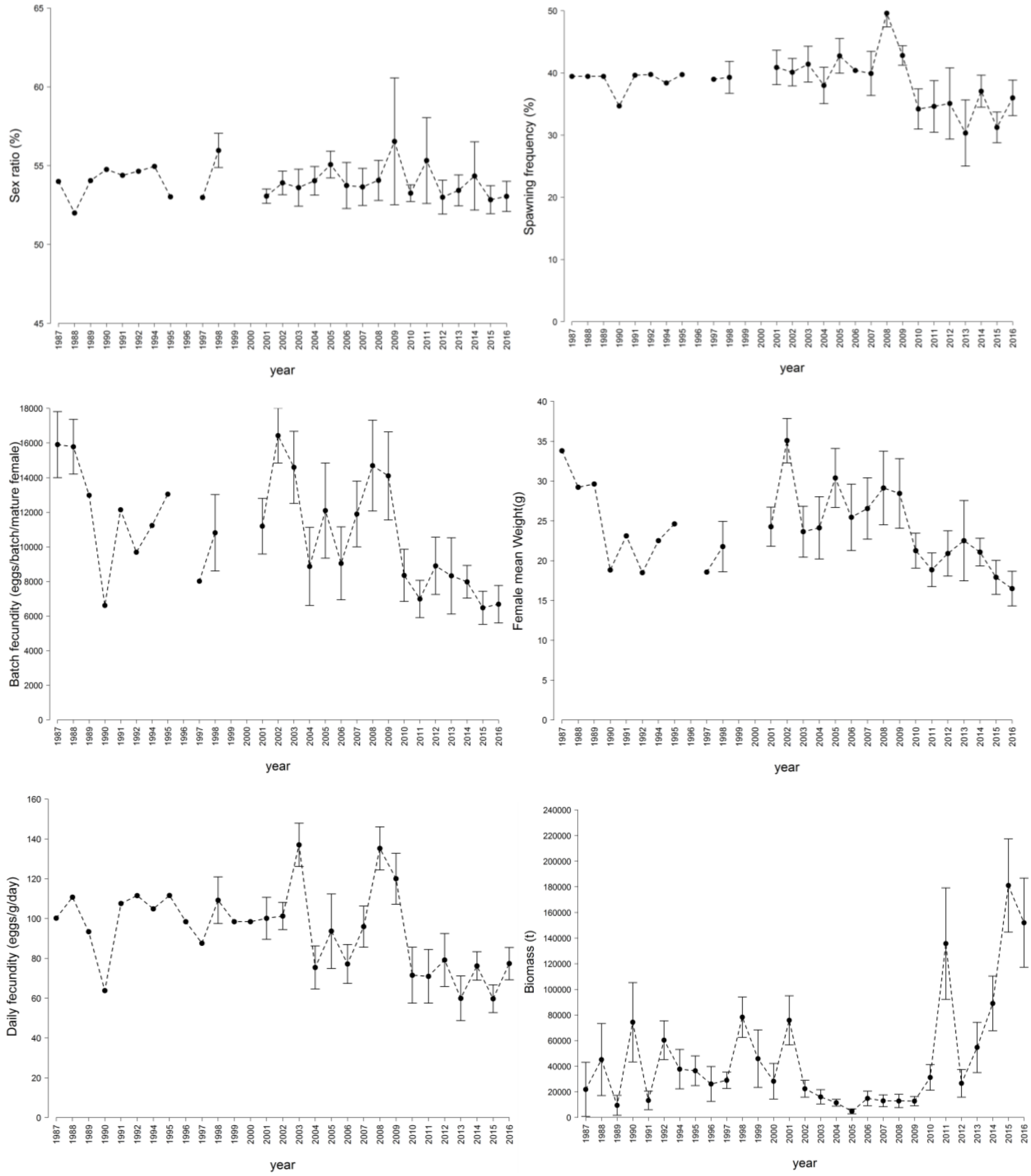


Figure 18: Time series of anchovy DEPM adult parameters and total biomass. Vertical lines indicate 95% confidence intervals (i.e. ± 2 standard deviations). Sex ratio (mature females fraction of population by weight), spawning fraction (fraction of mature females spawning per day), batch fecundity (eggs spawned per mature females per batch), female mean weight (g), daily fecundity (nº of egg per g of biomass) and total biomass (tons).

The historical series of numbers at age in numbers is shown in **figure 19.** This year age two is at levels of age one could be due to the huge recruitment of last year.

Distribution maps of anchovy egg abundances in the last 22 DEPM surveys were compiled (**Fig 20**, at the end of the report)

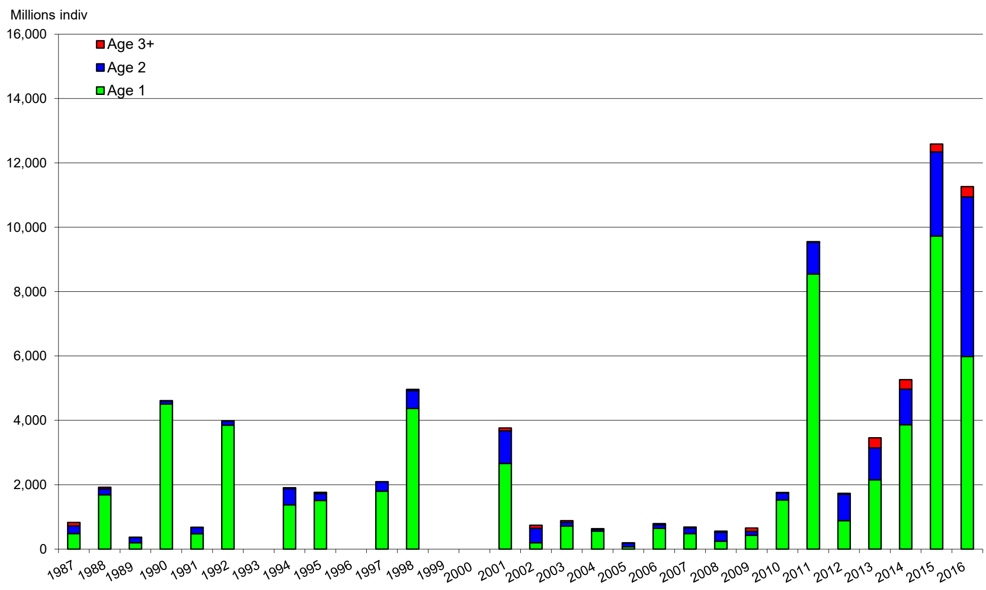


Figure 19: Historical series of numbers at age from 1987 to 2016

Sardine total egg abundance

Total egg abundance for sardine was estimate as the sum of the numbers of eggs per m^2 in each station multiply by the area each station represents. This year estimate was 8.56 E+12 eggs, higher than the average in relation with the time series (5.83 E+12). The historical series of egg abundances is shown in **figure 21, table 7**. The sardine egg distribution is shown in **figure 4**. The eggs in the cantabric coast were not account here because doesn't belong to area VIIIab and the NW were removed in the series present here for the series to be consistent. This egg abundance series was incorporated as an input in the assessment of sardine in VIIIab in June at (WGHANSA).

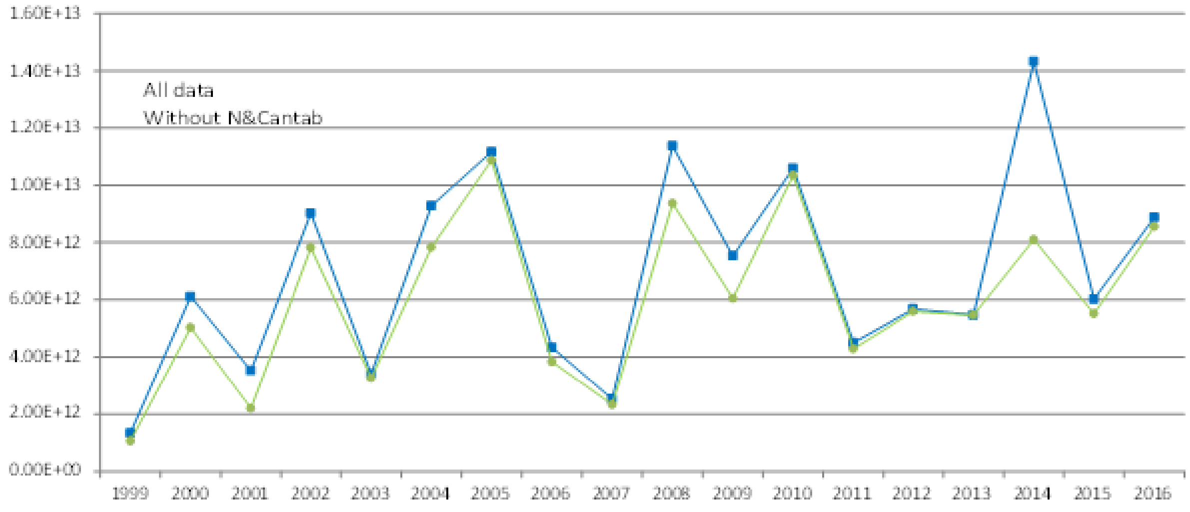


Figure 21: historical series of sardine egg abundances 1999-2016, without the eggs from the cantabric coast and part of the North.

Table 7: historical series of sardine egg abundances without the eggs from the cantabric coast and part of the North

Year	TotAb_whithoutN&Cant
1999	1.06E+12
2000	5.03E+12
2001	2.20E+12
2002	7.82E+12
2003	3.26E+12
2004	7.83E+12
2005	1.09E+13
2006	3.84E+12
2007	2.33E+12
2008	9.37E+12
2009	6.05E+12
2010	1.03E+13
2011	4.29E+12
2012	5.60E+12
2013	5.474E+12
2014	8.209E+12
2015	5.52E+12
2016	8.56E+12

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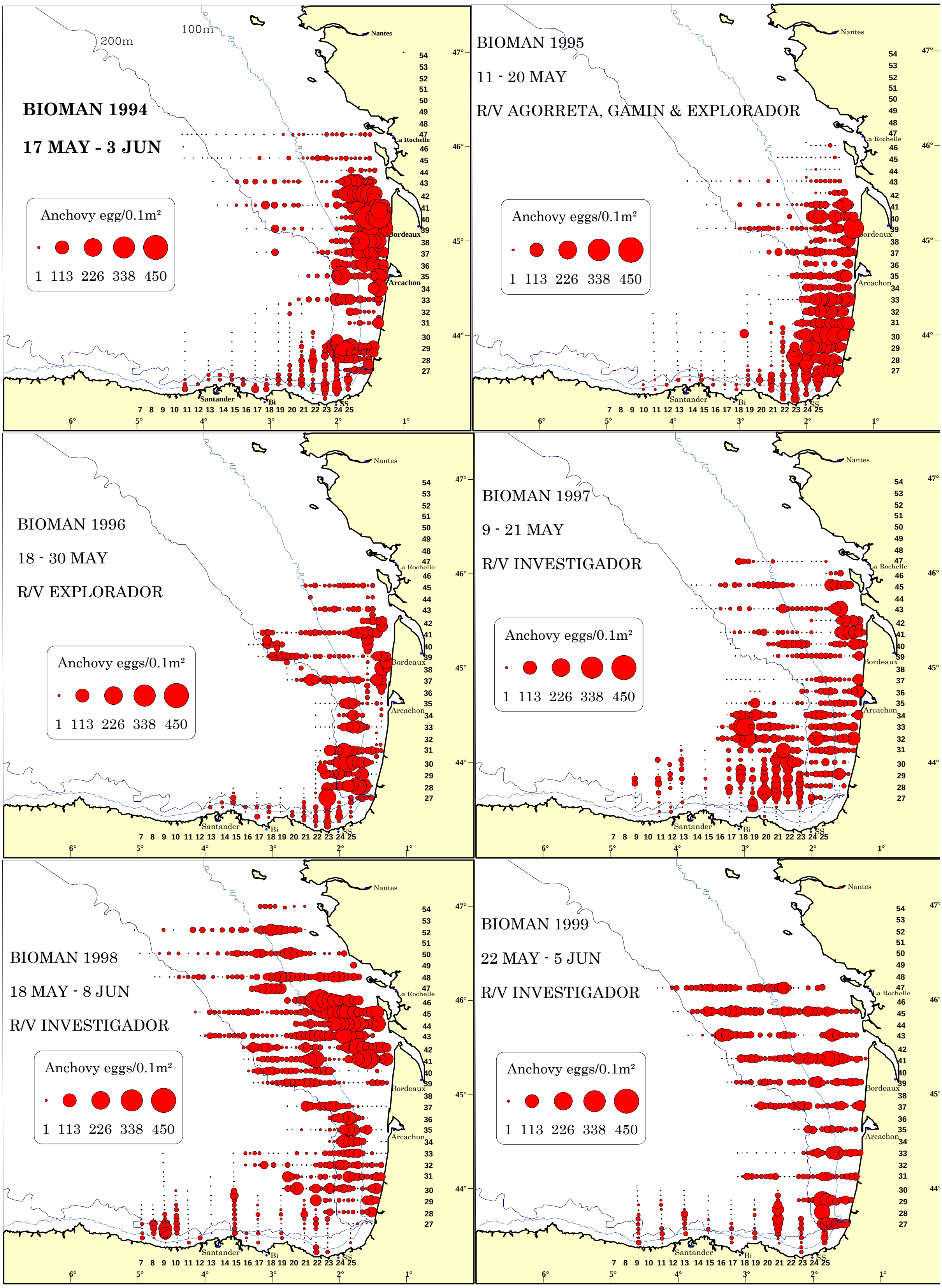
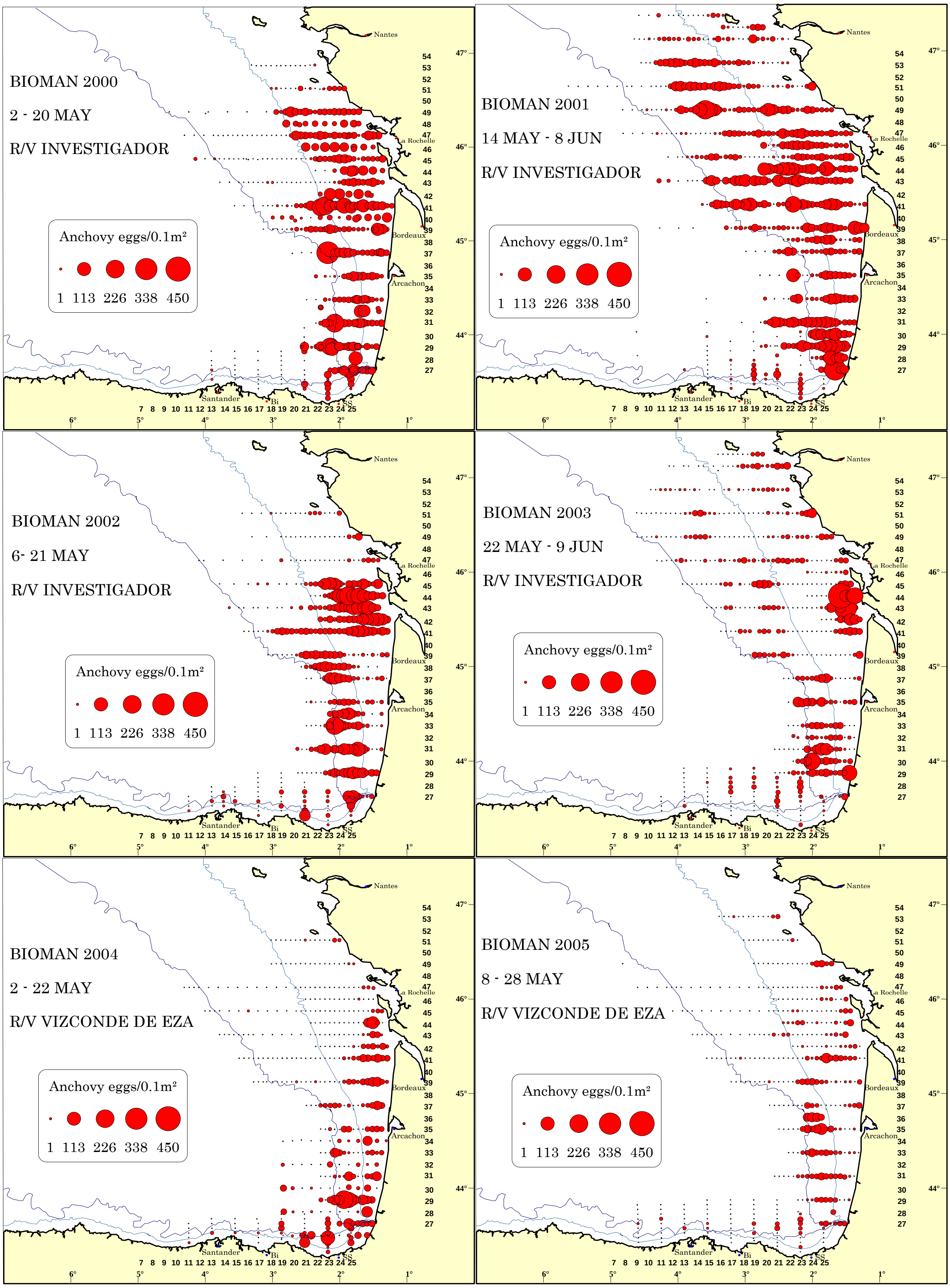
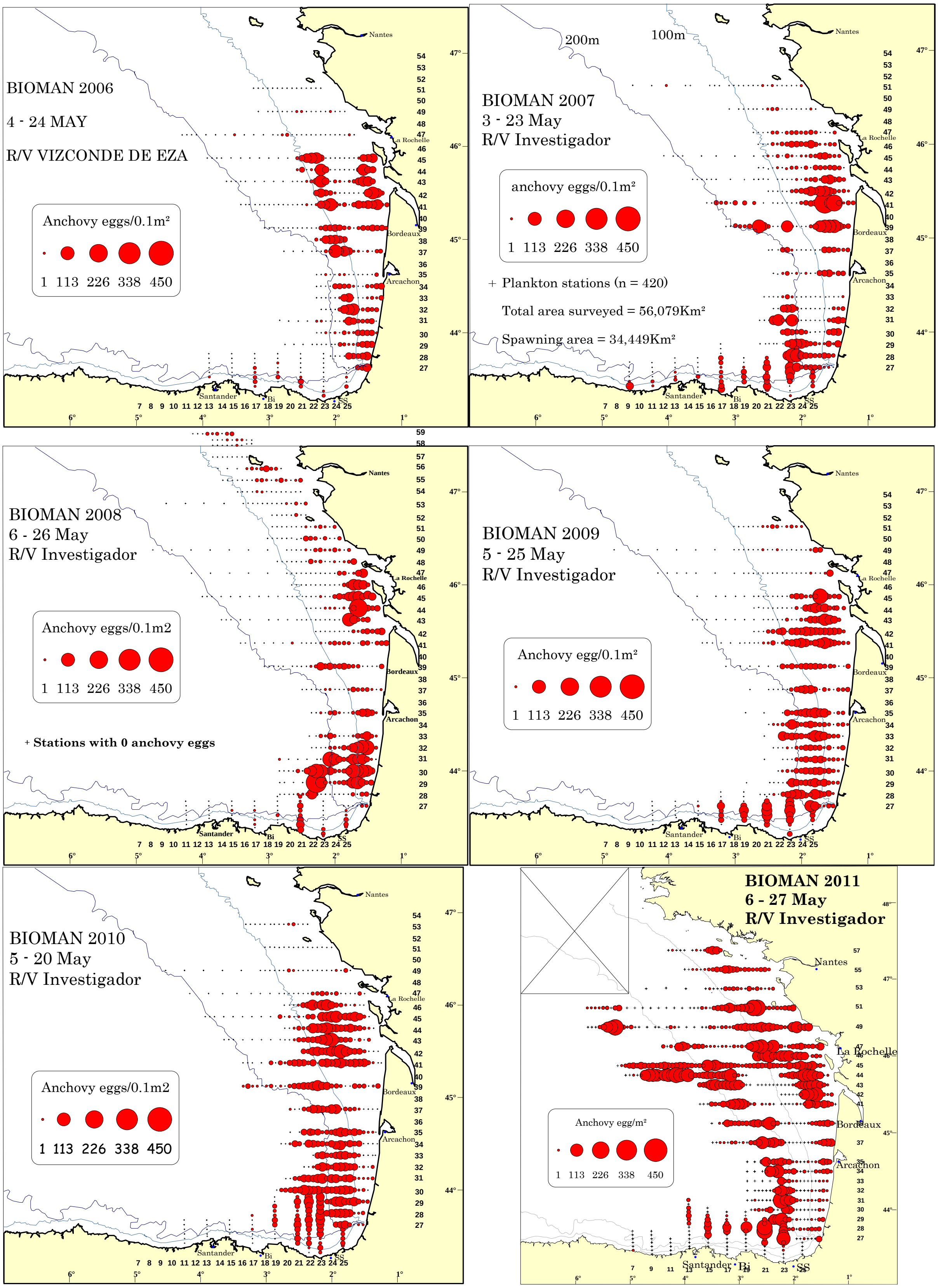

200m
100m
BIOMAN 1994
17 MAY - 3 JUN
Anchovy egg/0.1m²
1 113 226 338 450
BIOMAN 1995
11 - 20 MAY
R/V AGORRETA, GAMIN & EXPLORADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 1996
18 - 30 MAY
R/V EXPLORADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 1997
9 - 21 MAY
R/V INVESTIGADOR
Anchovy eggs/0.1m²
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
47°
46°
45°
44°
6°
5°
4°
3°
2°
1°


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
6° 5° 4° 3° 2° 1°
44° 45° 46° 47°

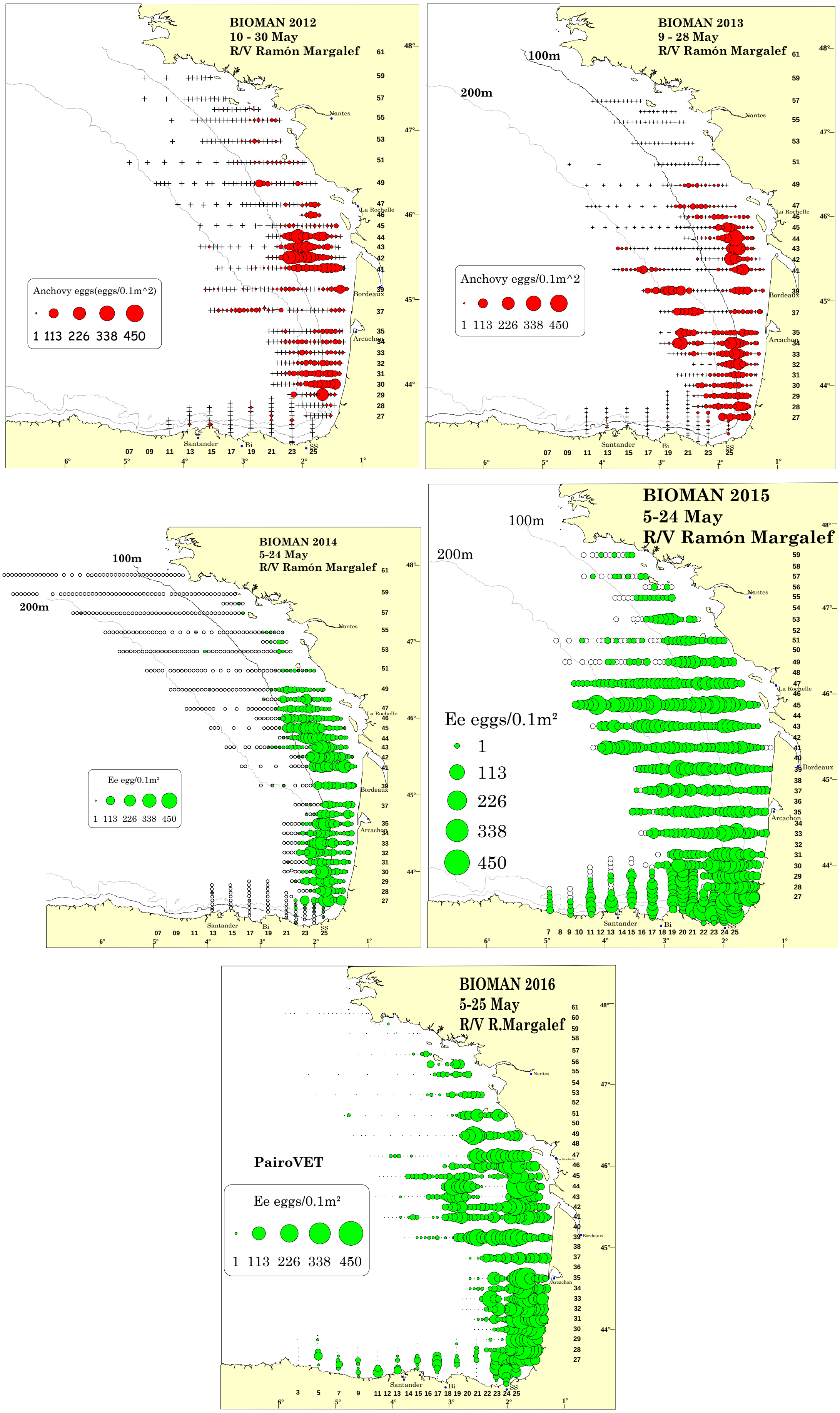
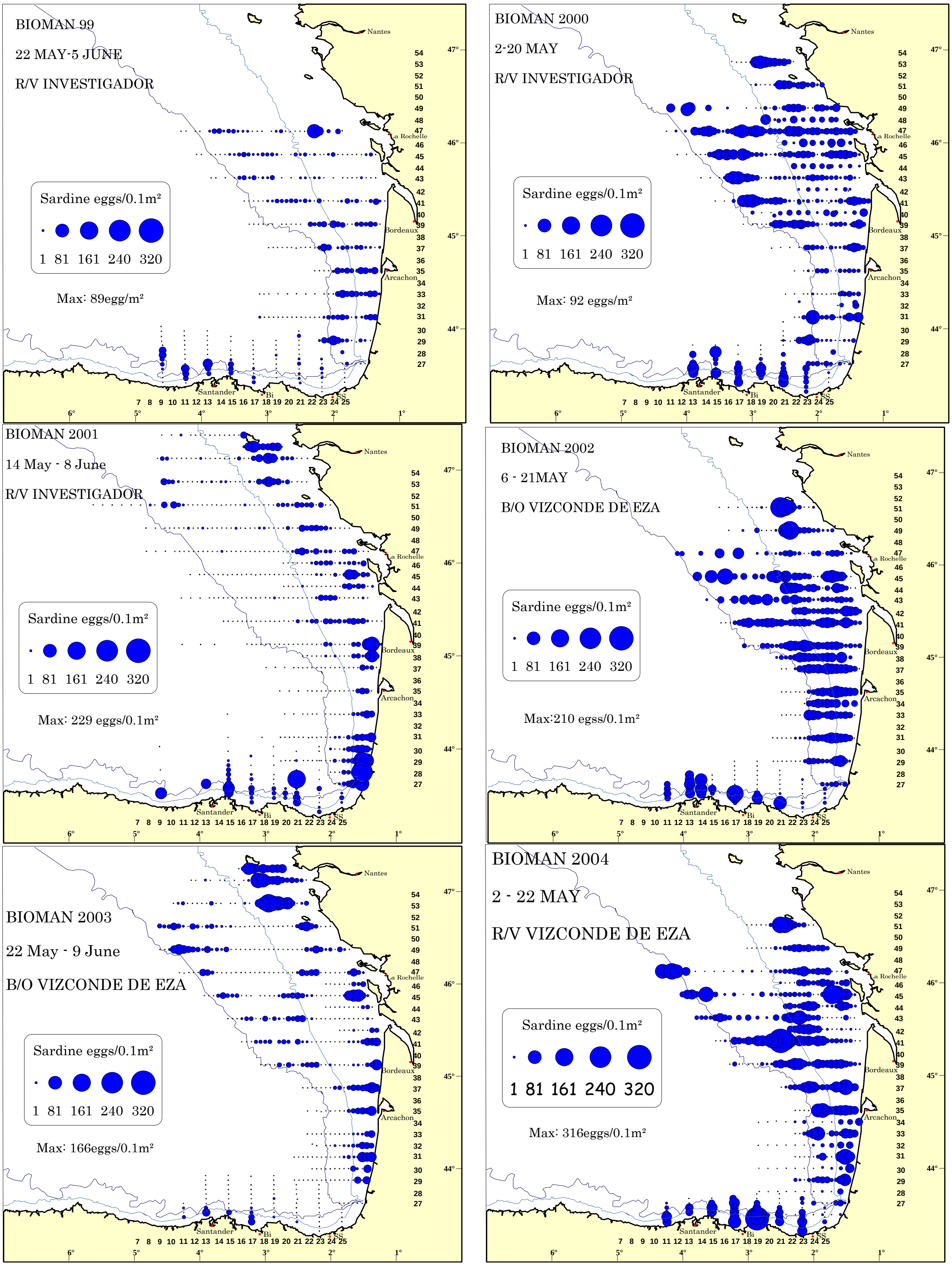
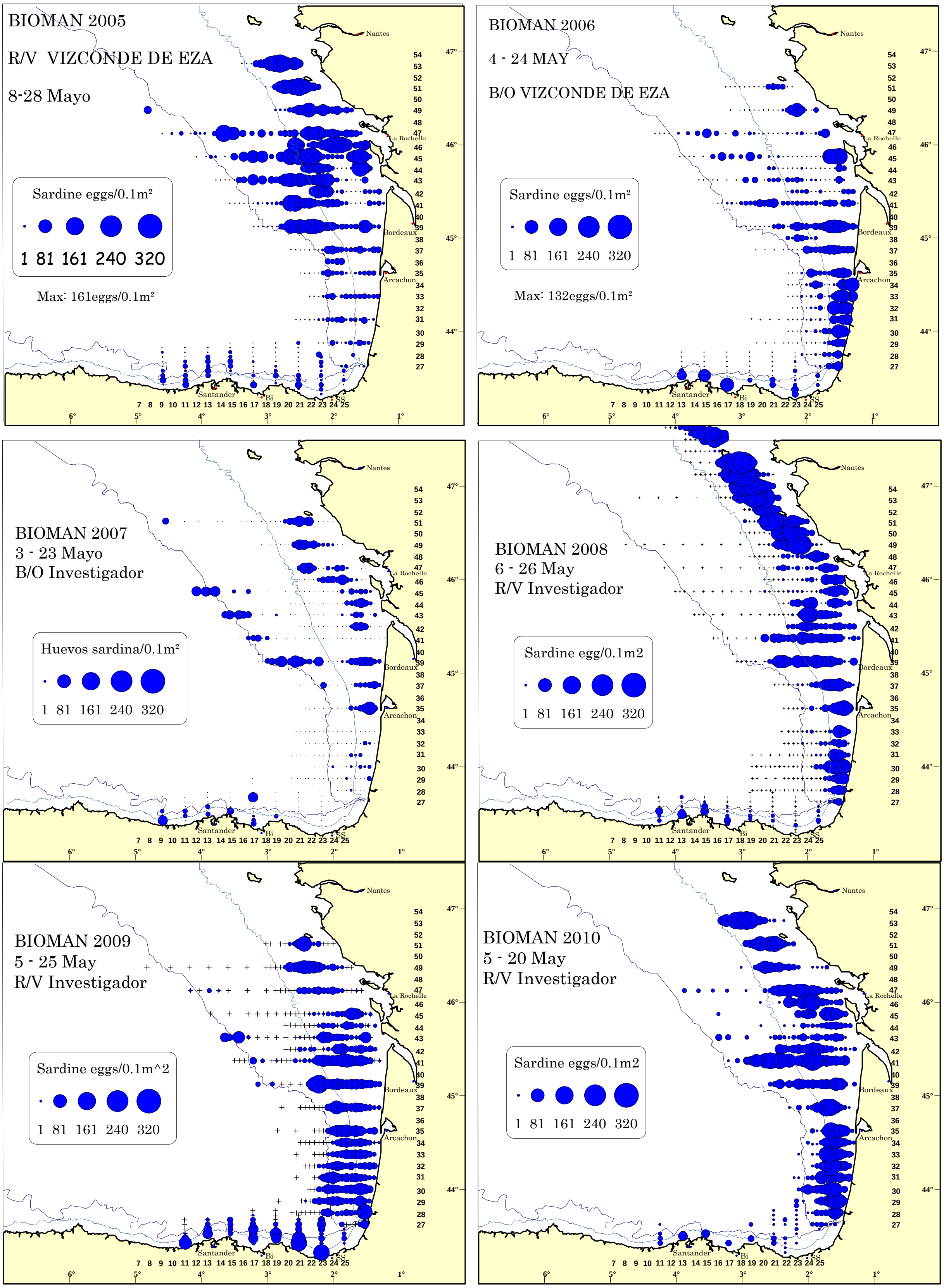


Figure 19: Anchovy egg distribution and abundance from 1994 to 2016.


BIOMAN 99
22 MAY-5 JUNE
R/V INVESTIGADOR
Sardine eggs/0.1m²
1 81 161 240 320
Max: 89egg/m²
BIOMAN 2000
2-20 MAY
R/V INVESTIGADOR
Sardine eggs/0.1m²
1 81 161 240 320
Max: 92 eggs/m²
BIOMAN 2001
14 May - 8 June
R/V INVESTIGADOR
Sardine eggs/0.1m²
1 81 161 240 320
Max: 229 eggs/0.1m²
BIOMAN 2002
6 - 21MAY
B/O VIZCONDE DE EZA
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
Sardine eggs/0.1m²
1 81 161 240 320
Max: 166eggs/0.1m²
BIOMAN 2004
2 - 22 MAY
R/V VIZCONDE DE EZA
Sardine eggs/0.1m²
1 81 161 240 320
Max: 316eggs/0.1m²
Nantes
La Rochelle
Bordeaux
Arcachon
Santander
Bi
SS
47°
46°
45°
44°
6°
5°
4°
3°
2°
1°


BIOMAN 2005
R/V VIZCONDE DE EZA
8-28 Mayo
Sardine eggs/0.1m²
1 81 161 240 320
Max: 161eggs/0.1m²
BIOMAN 2006
4 - 24 MAY
B/O VIZCONDE DE EZA
Sardine eggs/0.1m²
1 81 161 240 320
Max: 132eggs/0.1m²
BIOMAN 2007
3 - 23 Mayo
B/O Investigador
Huevos sardina/0.1m²
1 81 161 240 320
BIOMAN 2008
6 - 26 May
R/V Investigador
Sardine egg/0.1m2
1 81 161 240 320
BIOMAN 2009
5 - 25 May
R/V Investigador
Sardine eggs/0.1m^2
1 81 161 240 320
BIOMAN 2010
5 - 20 May
R/V Investigador
Sardine eggs/0.1m2
1 81 161 240 320
Nantes
La Rochelle
Bordeaux
Arcachon
Santander
Bi
SS
47°
46°
45°
44°
6°
5°
4°
3°
2°
1°

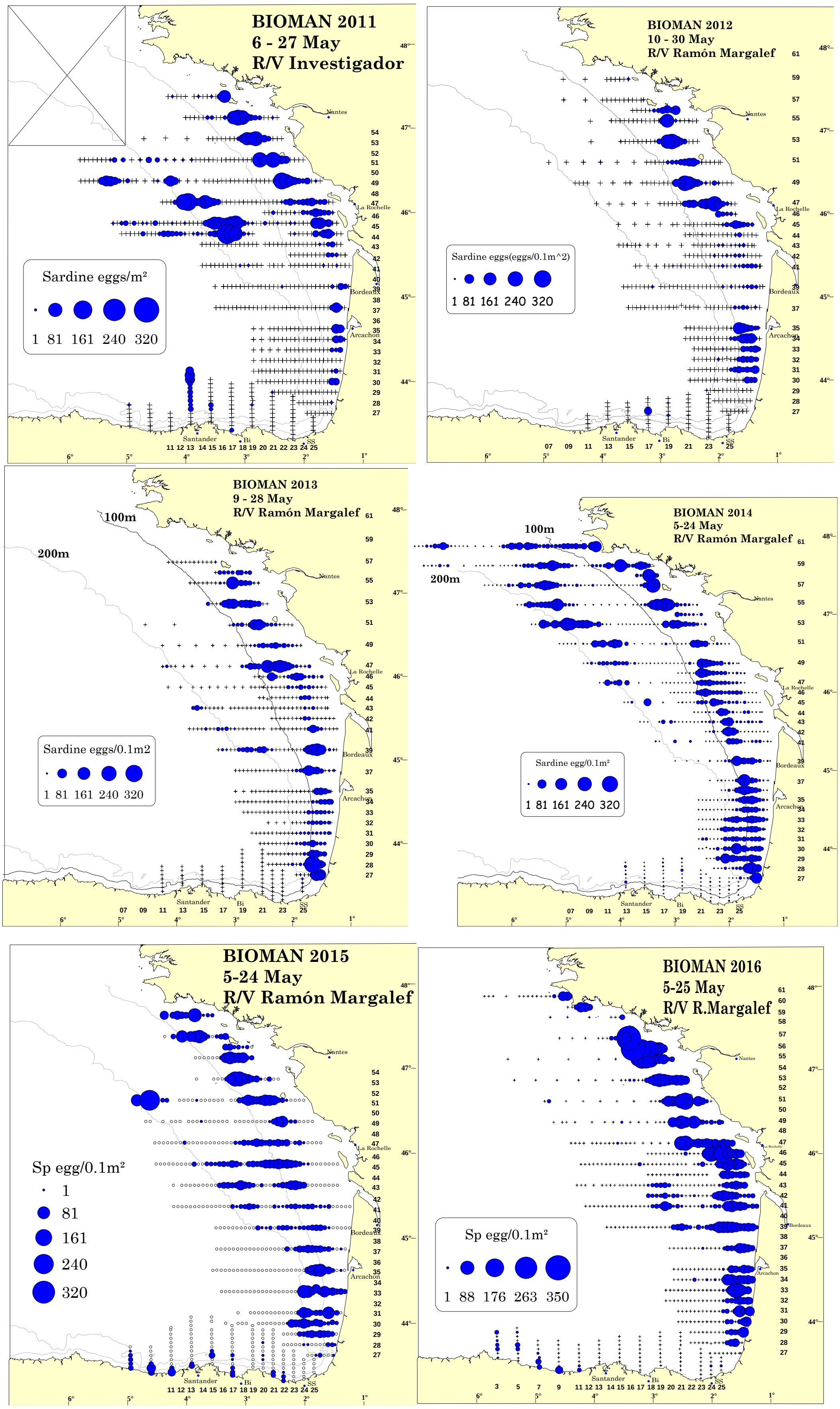


Figure 21: Sardine egg distribution and abundance from 1999 to 2016.

Table 6:.List of taxa observed during BIOMAN 2016.

Group	Common name	Scientific name	Number of sightings	Group_size	Total_sum
Marine mammal	Common dolphin	*Delphinus delphis*	47	14.98 ± 12.47	704
Marine mammal	Striped dolphin	*Stenella coeruleoalba*	6	13.17 ± 16.18	79
Marine mammal	Minke whale	*Balaenoptera acutorostrata*	1		1
Marine mammal	Fin whale	*Balaenoptera physalus*	1		3
Marine mammal	Bottlenose dolphin	*Tursiops truncatus*	1		9
Seabird	Northern gannet	*Morus bassanus*	207	1.76 ± 4.97	362
Seabird	Lesser black-backed gull	*Larus fuscus*	81	1.8 ± 2.43	146
Seabird	Northern fulmar	*Fulmarus glacialis*	73	1.15 ± 0.57	84
Seabird	Common guillemot	*Uria aalge*	49	3.57 ± 4.14	175
Seabird	Yellow-legged gull	*Larus michahellis*	37	2.59 ± 3.02	96
Seabird	European storm-petrel	*Hydrobates pelagicus*	12	1.5 ± 1.17	18
Seabird	Great skua	*Stercorarius skua*	11	1 ± 0	11
Seabird	Balearic shearwater	*Puffinus mauretanicus*	9	1.33 ± 1	12
Seabird	Larid sp	*Laridae spp*	8	5.12 ± 5.49	41
Seabird	Sandwich Tern	*Thalasseus sandvicensis*	7	1.29 ± 0.49	9
Seabird	Great black-backed gull	*Larus marinus*	2	1 ± 0	2
Seabird	Manx shearwater	*Puffinus puffinus*	2	3 ± 2.83	6
Seabird	Cory's shearwater	*Calonectris borealis*	1		1
Seabird	Black-headed gull	*Chroicocephalus ridibundus*	*1*		5
Seabird	Arctic skua	*Stercorarius parasiticus*	1		1
Other Marine Wildlife	Sunfish	*Mola mola*	4	1 ± 0	4
Human activity	Plastic trash		125	1.38 ± 1.52	171
Human activity	Trash (plastic, wood, oil)		15	1.07 ± 0.26	16
Human activity	Fishing buoy, setnet		14	1 ± 0	14
Human activity	Sailing boat		14	1 ± 0	14
Human activity	Trawler		11	1 ± 0	11
Human activity	Gill-netter		10	1 ± 0	10
Human activity	Pleasure boat		9	1 ± 0	9
Human activity	Fishing trash (net part, buoy…)		7	1 ± 0	7

Human activity	Unnatural wood		7	1 ± 0	7
Human activity	Fishing boat (professional)		5	1 ± 0	5
Human activity	Merchant ship (containership, cargo, tanker)		2	1 ± 0	2
Human activity	Containership		2	1 ± 0	2
Human activity	Plane		2	1 ± 0	2
Human activity	Longliner		1		1
Human activity	Pair trawler		1		2
Human activity	*Tanker (oil, gaz, chemical)*		1		1
Land Bird	Barn swallow	*Hirundo rustica*	5	1 ± 0	5
Land Bird		*Phylloscopus spp*	2	1 ± 0	2
Land Bird	Turnstone	*Arenaria interpres*	1		1
Land Bird	Sandpiper sp	*Calidris spp*	1		23
Land Bird		*Charadrius spp*	1		1
Land Bird	Eurasian Collared Dove	*Streptopelia decaocto*	1		1

WD 2 – PELAGO SURVEY

PELAGO16 Spring Acoustics Survey in Atlantic Iberian waters of ICES area 9a (Cabo Trafalgar to River Minho)

Vitor Marques, Maria Manuel Angélico, Ana Moreno, Cristina Nunes, Eduardo Soares, Eva García-Seoane, Andreia Silva, Pedro Amorim, Elisabete Henriques, Paulo Oliveira, Alexandra Silva
IPMA – Instituto Português do Mar e da Atmosfera
R. Alfredo Magalhães Ramalho nº 6 1495-006, Lisboa, Portugal

Working Document to be presented to the WGACEGG, Capo Granitola, 14-19 November 2016

PELAGO16 Spring Acoustics Survey
in Atlantic Iberian waters of ICES area 9a

(Cabo Trafalgar to River Minho)

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R. Alfredo Magalhães Ramalho nº 6 1495-006, Lisboa, Portugal

ABSTRACT

In 2016, the acoustic survey PELAGO16 and the horse-mackerel DEPM survey were carried out simultaneously onboard RV "Noruega", from the 11st of March (beginning of data collection) to the 01st of May. Acoustic surveying was conducted during the day while during the night, plankton samples and CTDF casts were obtained for the DEPM (horse-mackerel and sardine). Fishing hauls were performed taking into account the objectives of the joint surveys. This document presents the acoustics estimations for sardine and anchovy to be addressed to WGHANSA whilst at present the egg distributions and DEPM results are only partially available.

The main objective of the PELAGO16 survey was to describe the sardine and anchovy spatial distributions and to estimate their abundance off the Portuguese and the Spanish Gulf of Cadiz shelves. The estimated sardine biomass was 172 thousand tonnes, representing an important increase in relation to the 2015 survey and reflecting mainly the abundance in a restricted area of the OCS (ICES IXaCS) and Algarve (ICES IXaS) areas. In the Gulf of Cadiz, one of the main recruitment areas of the Iberian sardine stock, there was a marked increase of sardine abundance, mainly of juveniles (99.8%).

Anchovy estimated biomass was very high (103.6 thousand tonnes), above the historical mean, mainly due to the Gulf of Cadiz anchovy biomass estimation (65.4 thousand tonnes). However this value must be regarded with care and be confirmed by the IEO ECOCADIZ survey in July. Off the Portuguese West coast there was also an anchovy "boom" and the resulting estimation (38.3 thousand tonnes) was also above the historical mean.

The survey started at the Portugal-Galicia border and proceeded from there south, but due to adverse weather and some logistics constraints it was not carried out sequentially. Hence the apparent discontinuity in the sea surface distribution. Globally, the surface water temperatures were below the values observed for other years during similar period (~12-18ºC). This was more evident during the

first leg of the survey on the northern shelf, where quite an extended area was occupied by surface waters with temperatures between 12-13ºC.

Preliminary results, from one of the paired CalVET nets, and from CUFES samples, showed sardine eggs distribution overlapping quite well with the main sardine schools identified by acoustics. Egg abundances were however very low, in fact the lowest of the DEPM historic series, even considering 2014, when the survey was also delayed. In addition, the spawning area defined for both the western and the southern shores, using the CalVET observations, were the smallest of the whole data series. Consequently, these results indicate very low egg production estimations for the period of the survey. These observations may be partially explained by the size structure of the population, which included a very large proportion of young sardines, likely first year spawners or even still immature individuals. In the spring of 2016 more eggs of anchovy, particularly in Cadiz, were sampled than sardine eggs.

1. INTRODUCTION

The acoustics surveys, PELAGO series, and DEPM surveys (for sardine and for horse-mackerel) are funded via EU-DCF and national programmes. The Portuguese acoustic survey, takes place each year during spring, covering the shelf waters of Portugal and Cadiz Bay and being coordinated within the ICES –WGACEGG (Working Group on Acoustics and Egg Surveys) with the Spanish and French surveys. The main objectives of the campaign include monitoring the abundance distribution through echo-integration, and the study of several biological parameters for sardine (*Sardina pilchardus*), anchovy (*Engraulis encrasicolus*), chub-mackerel (*Scomber colias*), horse-mackerel (*Trachurus trachurus*) and other small pelagic fishes. Surveying also considers continuous observations of fish egg and larvae along the acoustic transects (CUFES-Continuous Underway Fish Egg Sampler) and hydrological and biological characterization of the water column. Additionally, census of marine birds and mammals are conducted during the survey trajectory.

Surveys directed at the estimation of the spawning stock biomass (SSB) through the Daily Egg Production Method (DEPM) are conducted on a triennial basis and in different years for sardine and for horse-mackerel (and Annual Egg Production method AEPM for mackerel). The survey PT-DEPM16-HOM is coordinated within ICES-WGMEGS (Working Group on Mackerel and Horse-mackerel Egg Surveys) and is part of the international effort that covers the area from Cadiz Bay to the Faroe Islands. The Portuguese survey is scheduled to comprise the area of the horse mackerel southern stock in January-February. The DEPM methodology involves surveying of the target species distribution area for plankton collection (and CTD casts) along a pre-defined grid of stations for spawning area definition and egg density and production estimations. Concurrently fish hauls are performed for adult parameter estimation: female mean weight, sex-ratio, batch fecundity and daily spawning fraction. The DEPM plankton survey design for horse mackerel and sardine are very similar (with an extended area for horse mackerel compared to the sardine stock limits but with a larger distance between transects) and therefore, the samples obtained can be used for egg production estimations for both species. Therefore, in 2016, it was also decided to collect extra fish samples in order to gather ovaries for daily fecundity estimations not only for horse mackerel but also for sardine.

In 2016, operational constraints retarded the horse mackerel DEPM survey. This fact led then to the decision to carry out both surveys, DEPM and acoustics (conducted in spring), concurrently and using the same vessel. Nonetheless, the western Galician coast, part of the southern stock area for horse mackerel, was not surveyed owing to permissions misunderstandings. In addition, due to adverse weather conditions and technical issues, the survey was interrupted several times and the coverage was not synoptic, neither in time nor in space. Despite the fact that the joint survey took 31 working days to be completed there was a time span of nearly eight weeks between the start and the end dates (11st March to 1st May). Table 1 presents the survey summary by geographical area.

2. ACOUSTIC SURVEY

MATERIAL AND METHODS

ACOUSTICS

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 scientific echo sounder 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. An acoustic calibration with a copper sphere was carried out, following the standard procedures (Foote *et al*., 1981). Due to weather constrains the calibration was performed only in the middle of survey, but the sounder gain didn't change since the last December calibration. 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).

ADULT FISH

To collect the biological data, pelagic and a bottom trawls 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 or irregular and rocky bottoms, it was not always possible to make hauls in some areas. Biological sampling of sardine and anchovy was performed in each haul. Ovaries from horse-mackerel, sardine and mackerel were preserved for fecundity estimations. In addition, otoliths were collected for sardine, anchovy, horse-mackerel and mackerel. Otoliths are 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 is estimated from the combination of the ALK and the estimates of abundance at length from the echo-integration in each area.

RESULTS

TRAWL HAULS

During the survey 52 trawl hauls were performed (Figure 2.1), 22 of these hauls had sardine sampled and 19 of them had anchovy sample. Sardine was usually captured together with other pelagic species, being the most abundant bogue (*Boops boops*), chub mackerel (*Scomber colias*) and horse mackerel (*Trachurus trachurus*). Off the south coast, Mediterranean horse mackerel (*Trachurus mediterraneus*) were also found. Anchovy was mainly found off Cadiz Bay, but it was also caught, in the west coast, from Matosinhos to Nazaré. Offshore, near the shelf edge, the more abundant species was blue whiting.

SARDINE

Spatial distribution and abundance

As seen in Figure 2.2, in the Occidental North zone (OCN- Caminha to Nazaré), sardine was mainly distributed from Porto to South of Figueira da Foz. In this area 1315 million sardines were estimated, corresponding to 30 thousand tonnes.

In the Occidental South Zone (OCS – Nazaré to Cabo S. Vicente) sardine was concentrated near Ericeira and Cascais. Sardine in this zone presented an estimated biomass of 50 thousand tonnes, consisting in 1322 million individuals.

In the Algarve area, sardine was mainly found between Lagos and Faro. The abundance result for this area was 1249 million sardines (76.7 thousand tonnes).

In the Gulf of Cadiz, sardine was found between Huelva and Cadiz and it was constituted by very young individuals. It was estimated 5558 million individuals, which corresponds to 15.3 thousand tonnes.

Figure 2.3 shows the sardine abundance evolution, along the time series since 2005, for each zone, Portugal and Total area.

Length and age structure

In the OCN zone, sardine presented a trimodal length structure with modes at 11.5 cm, 15.0 cm and 19.5 cm (Figure 2.4) and was mainly composed of 1 year-old individuals (Figure 2.5).

Sardine length structure in the OCS zone presented 3 modes (Figure 2.4): 13.5 cm, 17.0 cm and 20.5 cm. The age structure was also dominated by age 1 sardines (Figure 2.5).

Off the Algarve, sardine presented a length distribution with a mode around 20.0 cm (Figure 2.4) and 3 and 5 age groups were the strongest (Figure 2.5).

In Cadiz, sardines modal length was 6.5 cm (Figure 2.4) and age group 1 dominated (Figure 2.5).

The sardine age group 1 incorporates a large length range (Figure 2.6).

ANCHOVY

Spatial distribution and abundance

Anchovy was found between Porto and Nazaré, being more abundant than in previous years (Figures 2.7). In the West coast, an estimation of 3198 million anchovies was obtained, corresponding to a biomass of 38.3 thousand tonnes.

In the Cadiz Bay, anchovy was mainly distributed from Huelva to Cadiz, usually inside a dense plankton layer. In this area, the biomass and abundance estimated (65.3 thousand tonnes and 9811 million anchovies, respectively) were one of the highest of the whole series. However, these values should be later corroborated by the IEO ECOCADIZ survey, because the anchovy acoustic energy in this area was masked by the previously referred dense plankton layer.

Anchovy was not found in the OCS zone and in the Algarve.

Length and age structure

The anchovy length structure was unimodal in the OCN zone (mode 12.5 cm-13.0 cm) (Figure 2.8), and bimodal in Cadiz, with the modal lengths 9.0 cm and 11.5 cm (Figure 2.8). The age structure was dominated by age group 1 anchovies in OCN zone and age groups 1 and 2 in Cadiz Bay (Figure 2.9)

OTHER SMALL PELAGIC FISH

Other pelagic species, like chub mackerel (*Scomber colias*) and horse mackerel (*Trachurus trachurus*), were less abundant than usual. Besides sardine and anchovy, only estimates for horse mackerel were done.

HOSE MACKEREL

The Figure 2.10 shows the acoustic energy spatial distribution attributed to horse mackerel. To be notice that the acoustic survey only covers part of the horse mackerel distribution.

Concerning horse mackerel (*Trachurus trachurus*), an abundance of 1047 million was estimated for the OCN zone, corresponding to 44.9 thousand tonnes. In the OCS zone were estimated 288 million individuals weighting 12.4 thousand tonnes. In the Algarve area, only 20.6 million individuals (2.3 thousand tonnes) were estimated. In the Cadiz area the horse mackerel was not abundant, and only 14.4 million individuals, corresponding to 127 tonnes, were estimated.
The horse mackerel length distribution is shown in Figure 2.11.

3. PLANKTON AND ENVIRONMENTAL SURVEYING

MATERIAL AND METHODS

Gear for plankton and hydrology surveying:

- CUFES: mesh size 335 µm, continuous sampling at the surface (~ 3m)
- CalVET: adapted structure (double nets CalVET (40cm mouth opening) + CTDF), mesh size 150 µm, vertical tows through the whole water column
- BONGO: double nets with 60cm mouth opening (mesh size: 200, 500µm), oblique tows through the whole water column
- continuous surface observations of temperature, salinity and fluorescence using onboard sensors associated to the CUFES system
- temperature, salinity and fluorescence (chlorophyll) profiles using a CTDF probe (RBR - Concerto)

During the day the regular surveying, along the acoustic transects, was carried out. Zooplankton samples using the CUFES system and temperature, salinity and fluorescence observations were gathered (Figure 3.1, 3.2, 3.3, 3.4, ...). The data, together with GPS information were compiled using the EDAS software.

DEPM surveying was carried out when acoustics surveying was not running, mainly during the night period. On the pre-defined stations along the DEPM transects CalVET samples (every 3 or 6 nmiles and down to 200m maximum) and CTDF casts were obtained. In addition, CUFES samples were gathered continuously along the path between the vertical plankton tows. To complete the zooplankton surveying, oblique zooplankton tows through the whole water column, were undertaken with Bongo nets at inner and mid shelf locations, alternately, one per transect. CUFES, Bongo and one of the paired CalVET samples, per station, were preserved onboard with buffered formaldeyde solution at 4% in distilled water for further processing in the laboratory. The second of the paired CalVET samples, one per station, were preserved in ethanol to allow genetics analyses for *Trachurus* spp eggs.

RESULTS

Temperature, salinity and fluorescence (chlorophyll$_a$) distributions

In 2016, the joint DEPM and PELAGO survey started on the 11th March off river Minho and ended on the 1st May in front of Lisbon after 31 effective days of work at sea. Due to technical problems and weather constraints the campaign suffered several interruptions which led to temporal and also spatial sampling discontinuities. The temporal and spatial coverage and surveying direction are indicated in table 1 and figure 3.1. Surface temperature, salinity and fluorescence distributions are shown in figure 3.1 while in figure 3.2 selected transects are presented to illustrate the vertical structure for the same water properties. Temperature was lower at the beginning of the survey (12-14ºC), over the NW shelf, where usually the temperature is comparatively lower than in the more southern regions, but below average temperature for early spring was also observed on southern coastal shores (13-17 ºC) (figure 3.1 and 3.2). Overall, the water temperature was lower than during other corresponding periods in previous years, with only restricted areas of the inner Bay of Cadiz showing surface values close to 18ºC. During early spring, fresh water effects were still apparent mainly in the NW coast and due particularly to some rainy events which preceded the campaign (figure 3.1 and 3.2, panel A). Higher fluorescence spots were mostly associated to the colder waters and/or to regions of river influence. Surface (and sub-surficial) chlorophyll maxima were apparent in particular where thermal stratification was setting in.

Egg distribution and production estimation (P0)

Zooplankton samples were collected with CalVET and Bongo nets and the CUFES system, a summary of the information gathered is presented in Table 1. The data available at present include the results from one of the paired CalVET nets and from the CUFES associated with the acoustics transects, for egg abundances, and information on zooplankton volumes from the Bongo nets.

The spatial distribution of plankton volumes derived both from the CUFES (Figure 3.3) and the Bongo nets (figures 3.4) show lower densities in the northwestern shelf than it was observed in previous campaigns which could possibly be related to the sampling period in that region, slightly earlier than usual and about a month before surveying took place in the southern shores.

A total of 393 CalVET samples were collected along the 42 transects of the horse-mackerel DEPM survey grid, from the northern Portugal-Spain border to Cape Trafalgar, in the Cadiz bay. Figure 3.5 shows the preliminary results for sardine egg distribution. Although the observations are restricted to one of the paired CalVET it is clear the low egg abundances, and the patchiness of the distribution, in particular in the NW shore and Cadiz area. In fact, the number of eggs collected by the CalVET systems in the 2016 survey was the lowest of the historic data series and even lower than in 2014 (2653, 1 net, 393 CalVET stations), when the survey took place during a similar period. The highest values in the data set were obtained in 2008, when 11000 eggs were captured in the paired CalVET system (double rings of 25cm diameter). In the spring of 2016 the campaign covered an area of around 32000 km^2 in the west coast, of which only just over 10% were defined as spawning ground, and in the southern region, from the 18000 km^2 surveyed about a quarter was estimated as the positive egg stratum. These spawning areas were the smallest ever, for both strata, west and south. In agreement with the observations, the egg production estimates were very low (P0_tot South: 0.27 x 10^{12} eggs/m2/day; P0_tot West: 0.12 x 10^{12} eggs/m2/day), lower than in 2011 and 2014 and only comparable to the values of 2002 in the southern region. The sardine egg distribution derived from the CUFES samples (figure 3.6) also confirms the patchiness and low abundances observed in 2016, in particular in the northwestern platform. Total egg abundances were there the lowest of the series and with only 23% of the all samples with sardine eggs. About 75% of the sardine eggs collected came from the southern shore and mostly from the Algarve.

The preliminary egg production estimates will be updated when the data from the second paired CalVET net are available. The low egg abundances and egg production estimates can be partially explained by the composition of the sardine population, which evidenced a high proportion of young fish which were first year spawners or even immature individuals (in particular in the NW and Cadiz regions, figure 3.7); however, globally the majority of the fish captured were considered, through macroscopic classification, active spawners. In accordance with the egg density data distribution, the number of spawning active sardines, was higher in the Algarve, where more, larger, fish, were observed. Further analyses are also needed in order to better investigate the regional (and temporal) egg production patterns in relation to the population size composition.

During the 2016 survey more anchovy eggs (41% of the total eggs) were collected than sardine egg (24% of the total eggs) (figure 3.8 and 3.9). Similar observations have occurred before, in the more recent years, when the survey has been taking place later in the season (closer to the anchovy peak spawning period) and also as a result of the increase in the anchovy abundances. Curiously, the higher egg densities were observed in the Cadiz bay, which is usual, but anchovies of the same size range in the west (where the population has been also increasing) were not active and therefore no eggs were there observed. It is however worth nothing that by the time the first leg of the survey was conducted, in early-mid March, in the NW coast, the water temperature was below 14ºC and when the Cadiz area was surveyed (and where SST is always higher), approximately a month later, the temperatures were well above 16ºC.

Figures 3.11 and 3.12 show the distribution of fish eggs of species other than sardine and anchovy and larvae of clupeiforms, respectively. About one third of the egg collected in the studied area were from species other than sardine and anchovy and were distributed over the entire platform but with higher abundances on the coastal waters of the Bay of Cadiz, Algarve and north of Aveiro. Clupleiform larvae (essentially sardine and anchovy) were as frequently more abundant in the inner Bay of Cadiz.

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Table 1. PNAB-IPMA: PT-DEPM16-HOM & PELAGO16. Survey summary, per area.

	OCN (NW)	OCS (SW)	ALG	Cadiz
Research vessel	Noruega	Noruega	Noruega	Noruega
Dates	11-19/03	19-21/03; 1-2/04; 27/04-1/05	9-15/04	21-25/04
Temperature surface (ºC) max/mean/min	14.0/13.2/11.9	16.1/14.7/13.5	16.6/15.2/13.6	17.8/16.9/15.5
SURVEY EGGS & HYDROGRAPHY				
Transects	12	14	9	7
CalVET stations	120	131	70	72
Positive stations PIL	12	11	23	11
Positive stations ANE	0	3	7	22
Tot egg PIL	49	103	757	89
Tot egg ANE	0	11	150	2295
Max egg/m2 PIL	980	2060	15320	1780
Max egg/m2 ANE	0	220	3000	45900
CUFES stations DEPM	178	143	81	76
CUFES stations PELAGO	224	196	86	90
Bongo stations	10	12	9	7
CTDF casts	120	131	70	72
SURVEY ACOUSTICS & FISH				
Number of acoustics transects (nmiles)	17(453)	29(415)	14(166)	11(194)
Number hauls R/V (pelagic/bottom)	13/9	6 /4	8/3	7 /2
Number hauls (comercial vessels): PIL	0	1	0	0
HOM	6	8	7	0
MAC	1	0	0	0
Number RV (+) trawls: PIL	14	4	8	5
HOM	16	7	9	6
MAC	10	1	3	0
ANE	13	2	1	6
Depth range (m) in (pelagic/bottom) R/Vfishing operations	26-84/ 74-157	21-49/ 57-174	22-41/ 75-117	19-85/ 53-165
Period of the day covered by R/V fishing hauls (pelagic/bottom)	8:55-18:55/ 12:12 -17:12	8:32-16:29/ 9:32-18:03	7:51-17:31/ 10:07-17:03	6:31-15:29/ 9:23-15:30
Total number fish sampled: PIL	598	337	503	220
HOM	281	301	435	63
MAC	302	0	0	0
ANE	451	0	0	244
Number ovaries preserved : PIL	152	100	150	36
HOM (RV/CV)	66/177	91/241	168 /214	0/0
MAC	53	0	0	0
Number otoliths collected: PIL	380	179	237	153
HOM	176	161	273	63
MAC	162	0	0	0
ANE	165	0	0	102

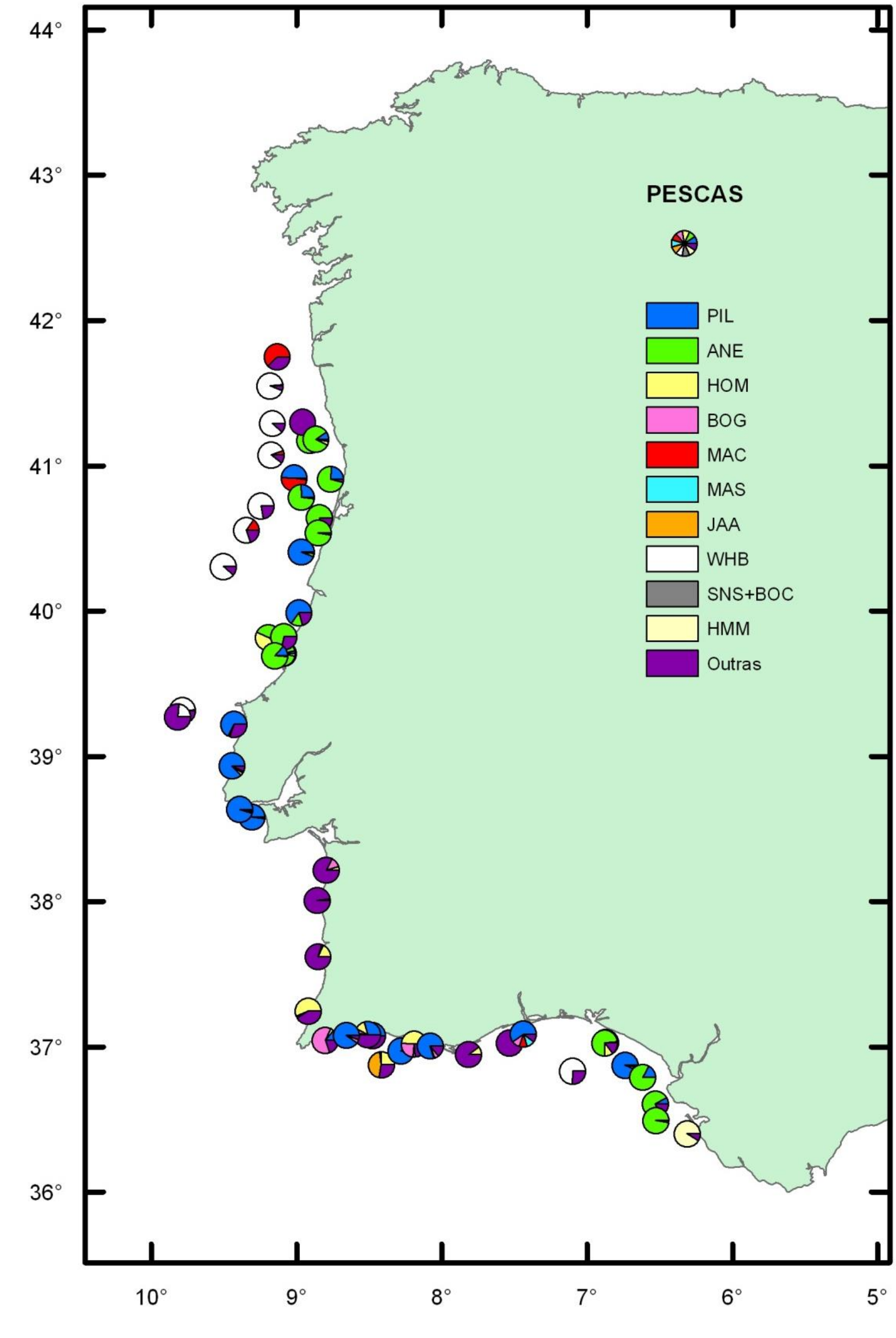


Figure 2.1 – PELAGO16: Fishing trawl location and haul species composition (in number). (PIL-sardine, ANE-anchovy; BOG-bogue, HOM-horse mackerel, MAC-mackerel, MAS-chub mackerel) WHB- blue whiting, JAA- black jack mackerel, HMM- Mediterranean horse mackerel, SNS- snipe fish, BOC- boar fish).

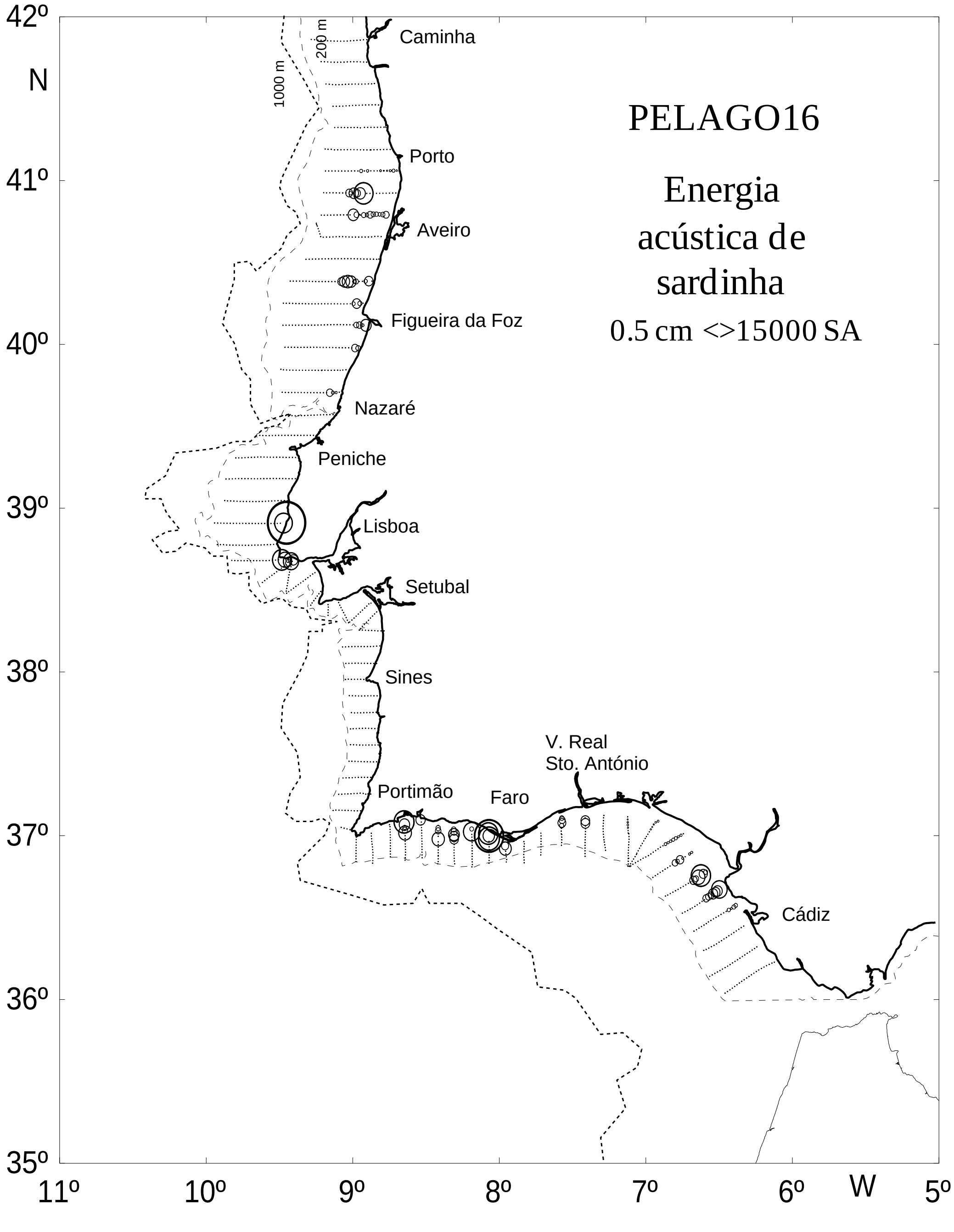


Figure 2.2 – Sardine acoustic energy spatial distribution. Circle area is proportional to the acoustic energy (S_A m^2/nm^2).

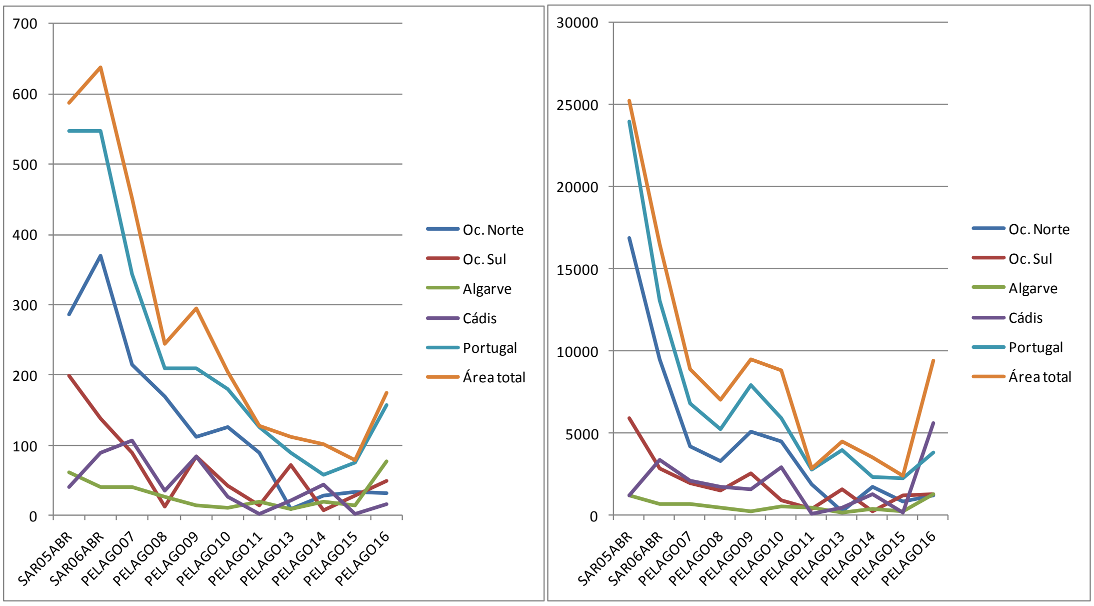


Figure 2.3 – Sardine biomass (thousand tonnes) and abundance (million), in each zone, Portugal and in the total area, along the acoustic survey series since 2005.

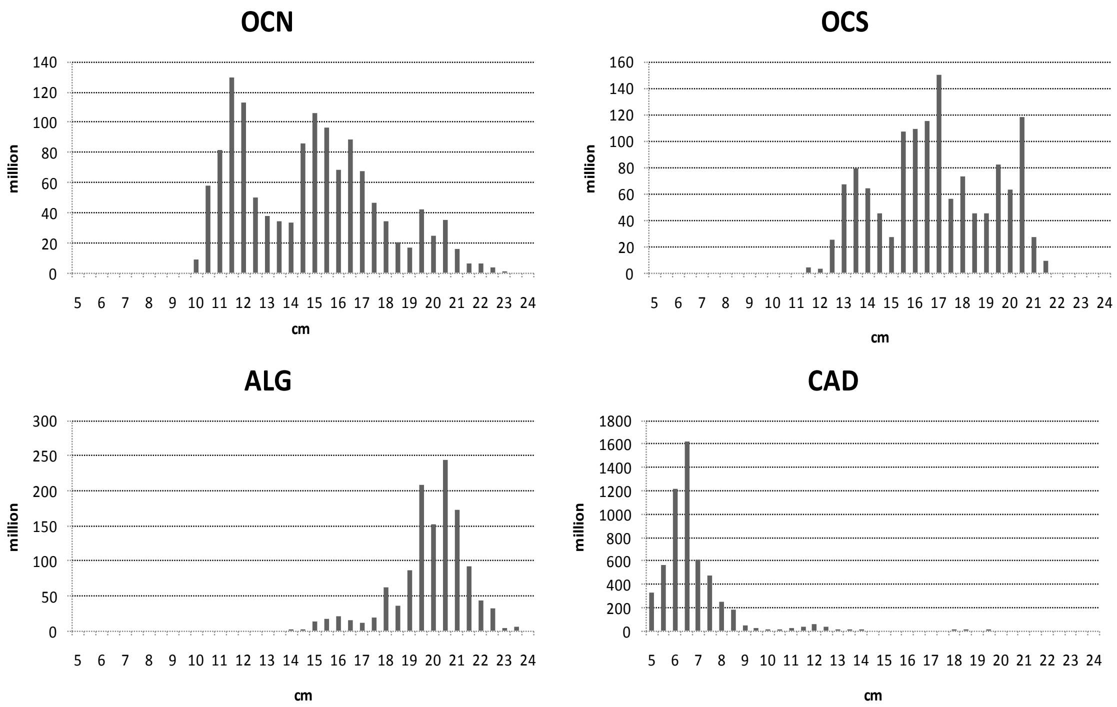


Figure 2.4 – Sardine abundance length distribution, for each zone.

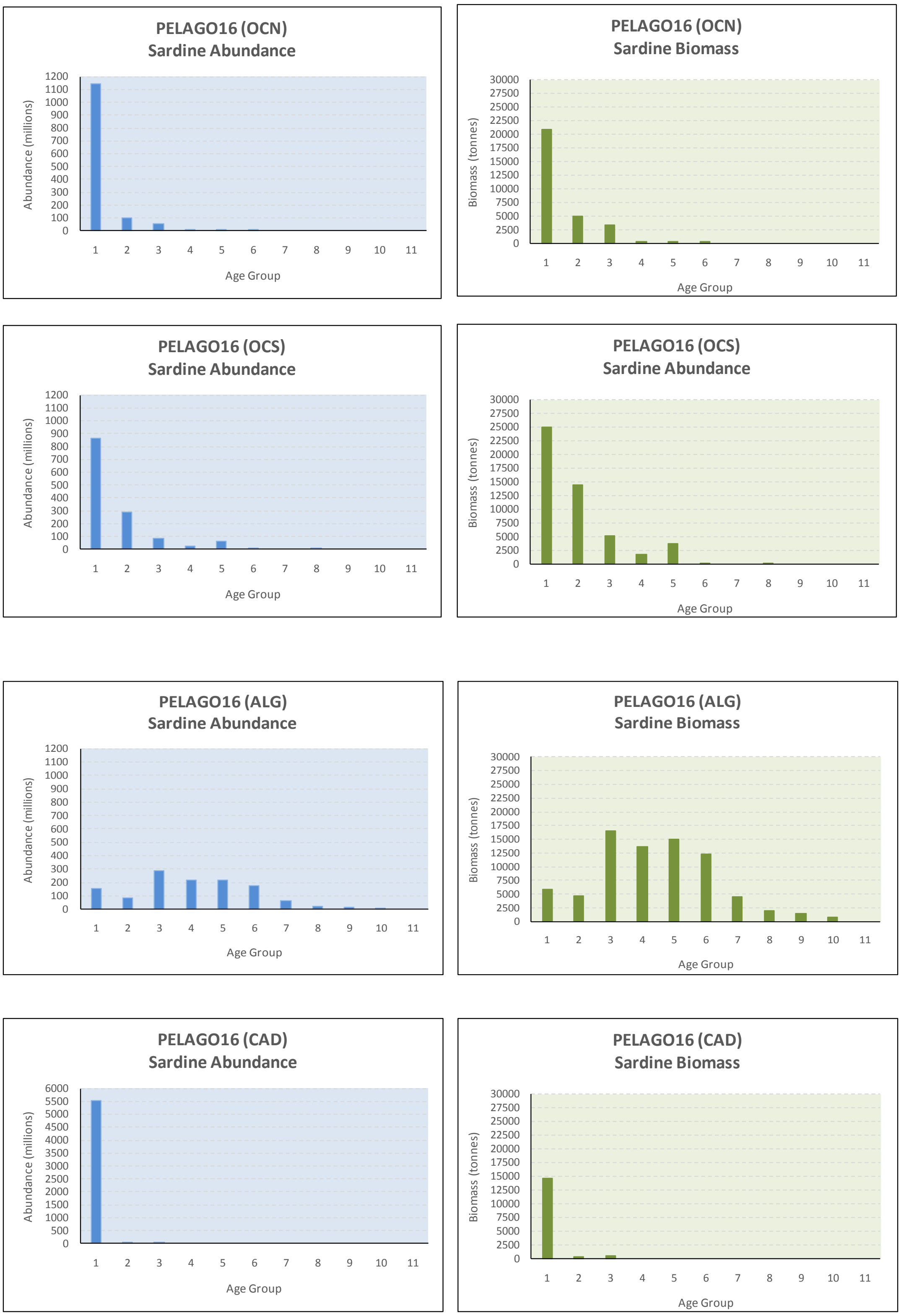


Figure 2.5– PELAGO16: sardine abundance and biomass, by age group, for the considered geographic areas.

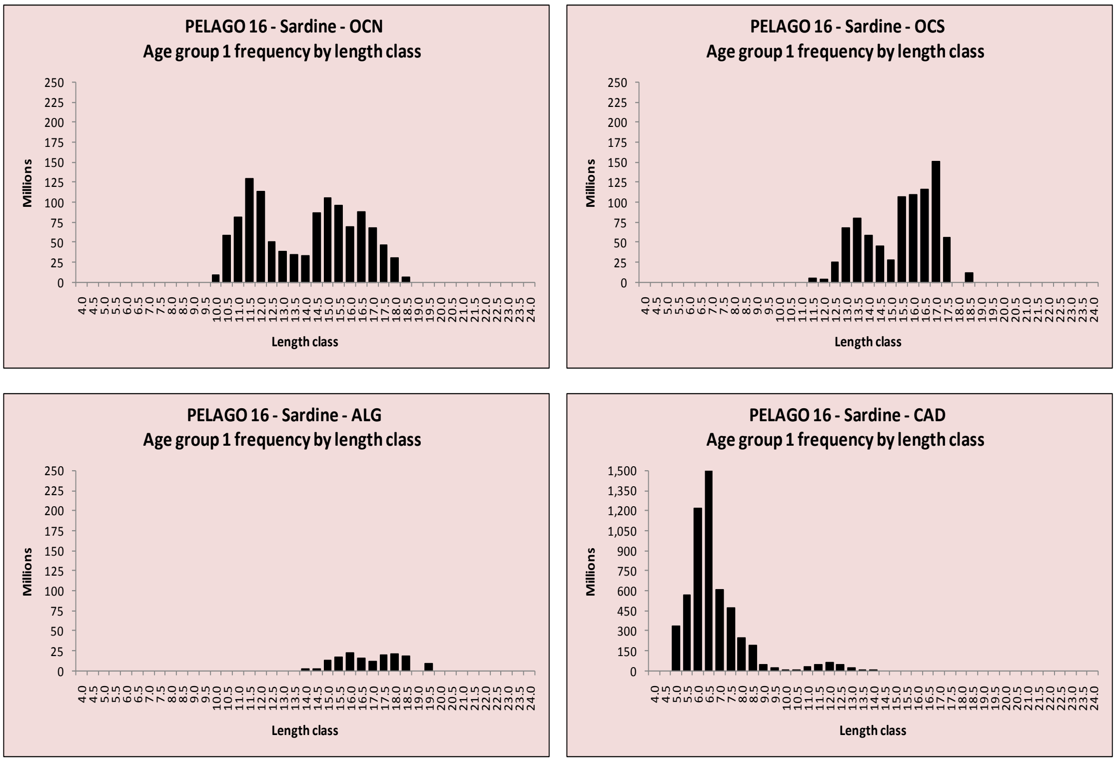


Figure 2.6 - Sardine age group 1 length distribution for each zone.

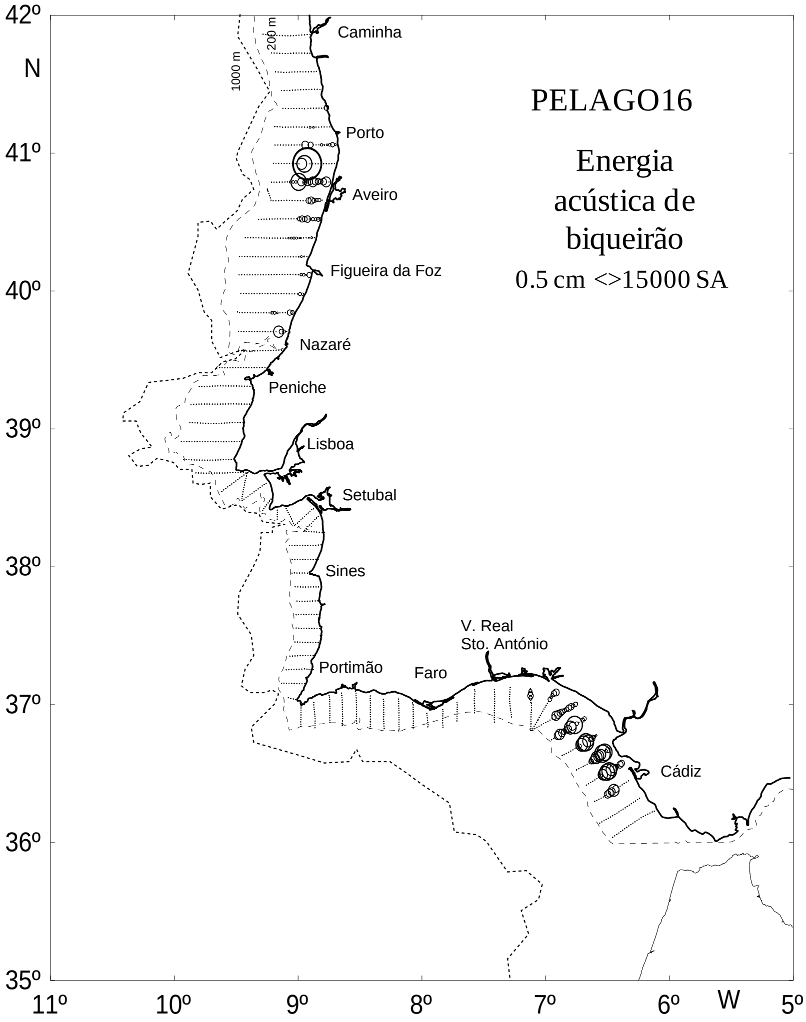


Figure 2.7 – Anchovy acoustic energy spatial distribution. Circle area is proportional to the acoustic energy (S_A m^2/nm^2).

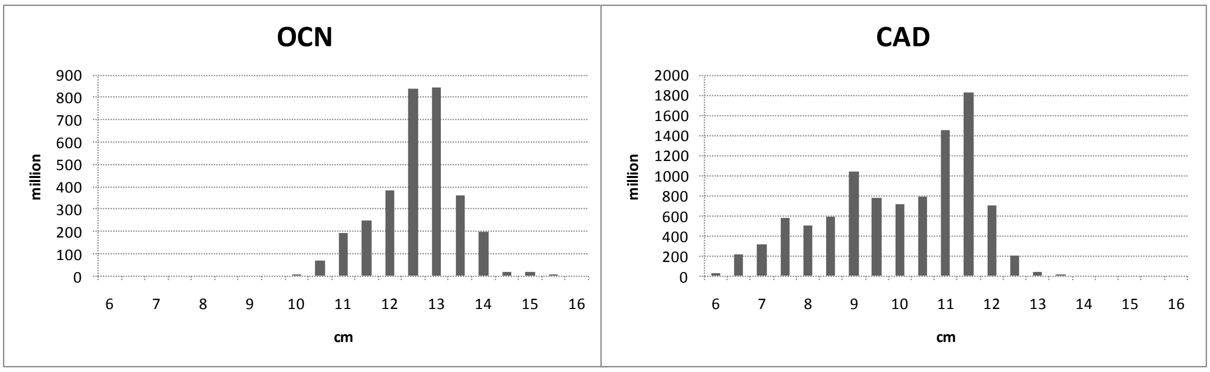


Figure 2.8 – Anchovy abundance length distribution, for each zone.

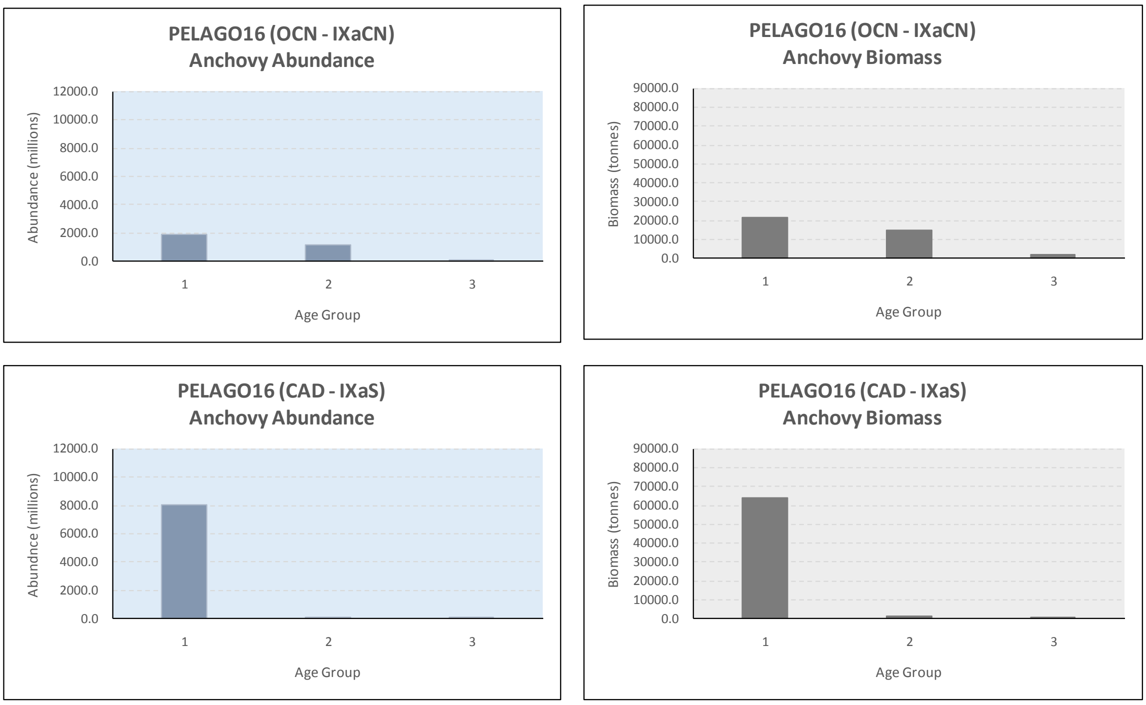


Figure 2.9 – PELAGO16: Anchovy abundance in each age group, for the considered geographic areas.

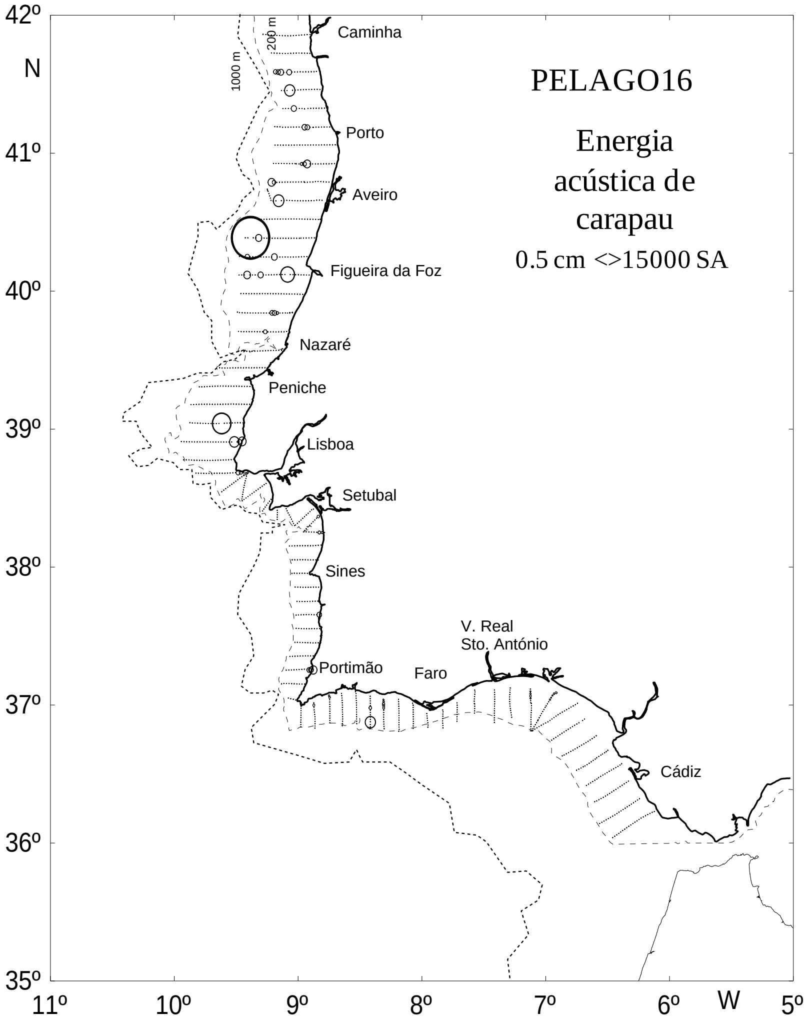


Figure 2.10 – Horse mackerel acoustic energy spatial distribution. Circle area is proportional to the acoustic energy (S_A m^2/nm^2).

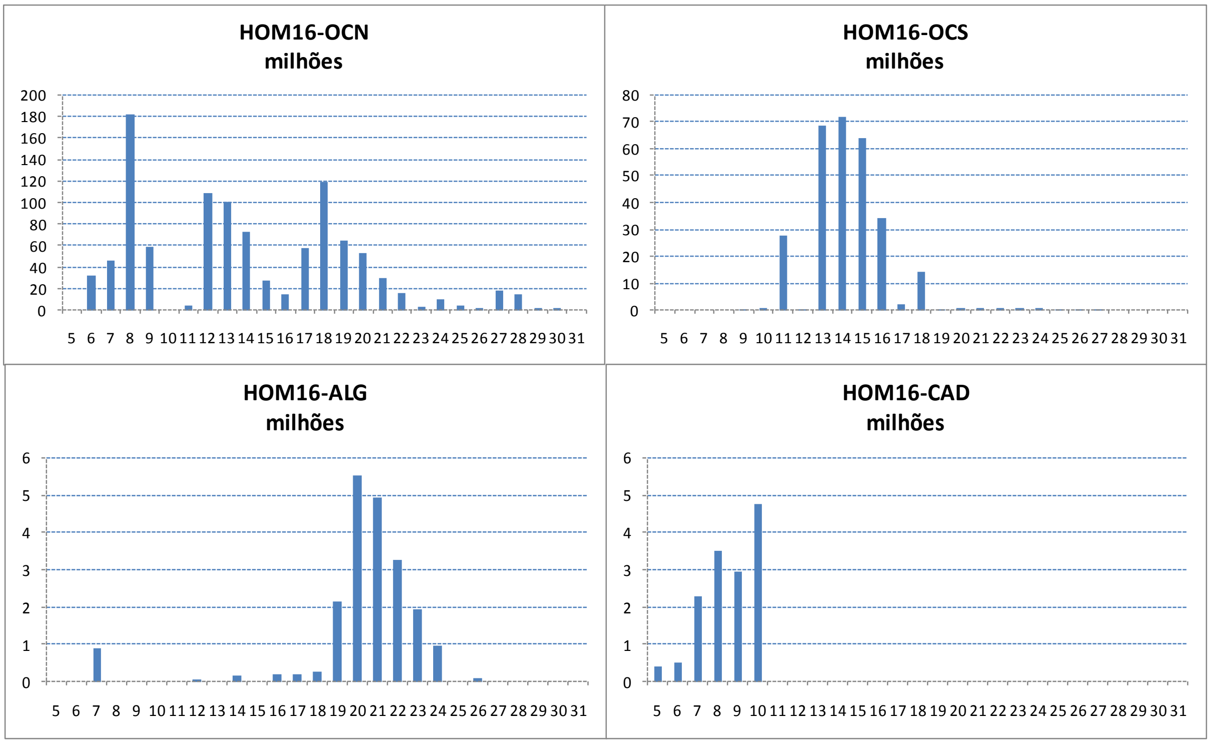


Figure 2.11 – Horse mackerel length distribution, for each zone.

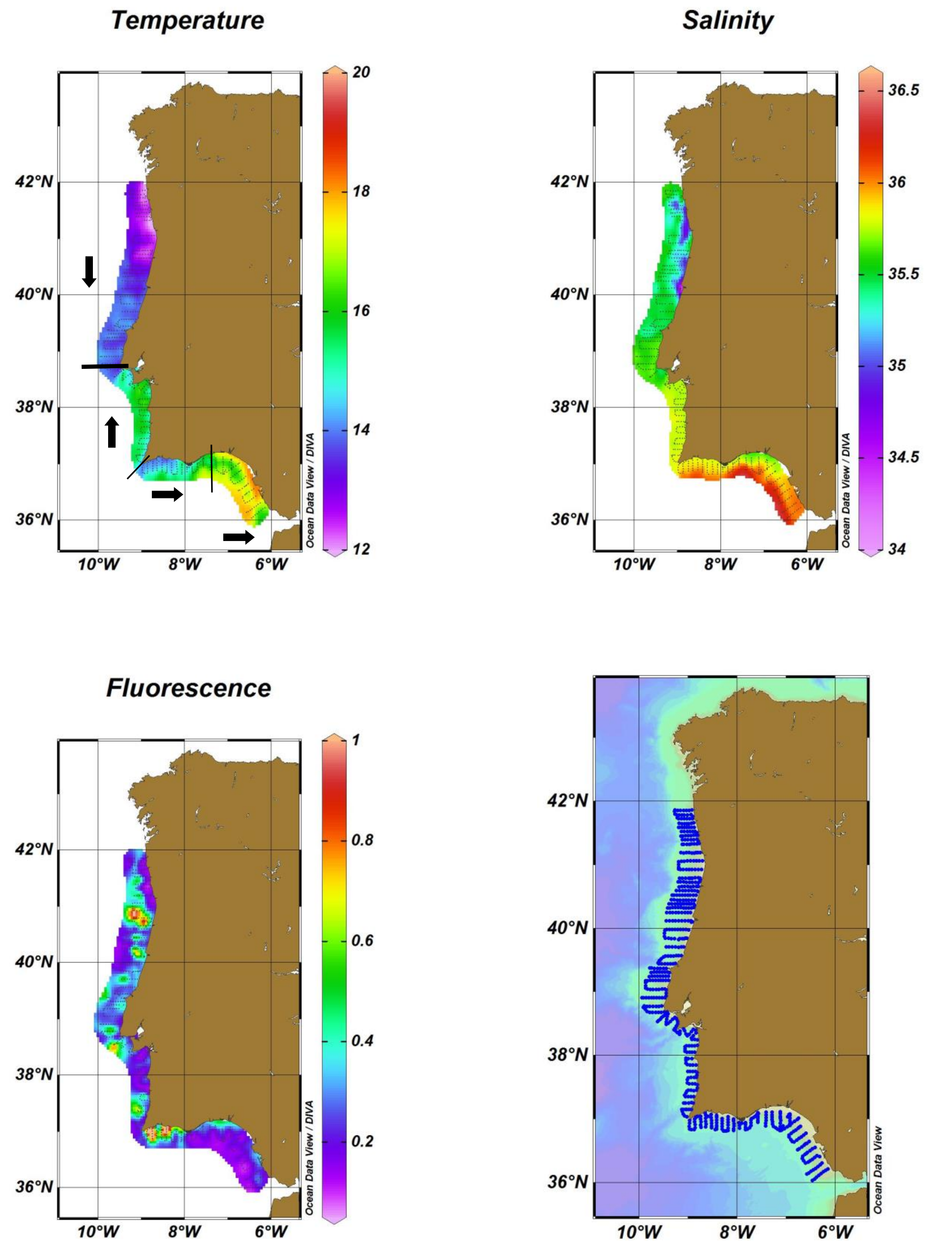
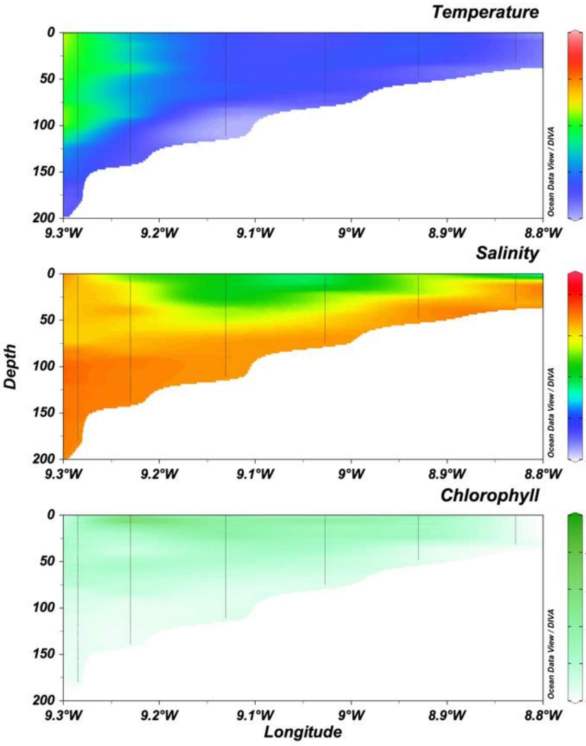
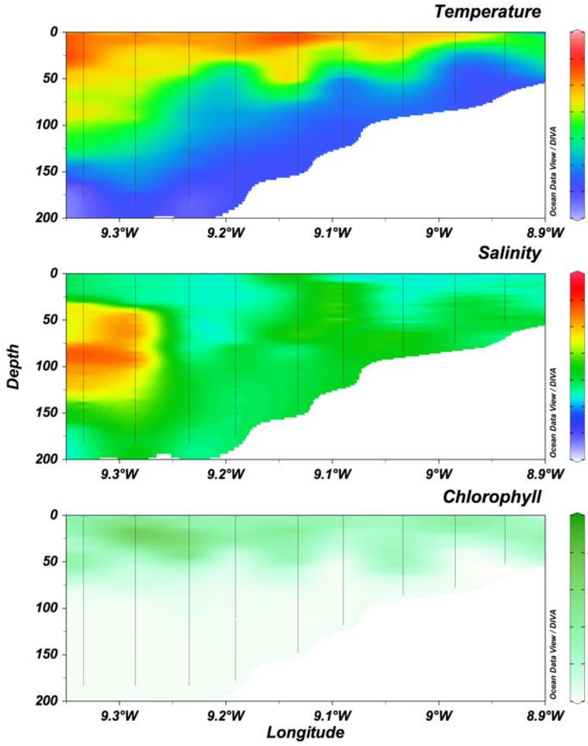


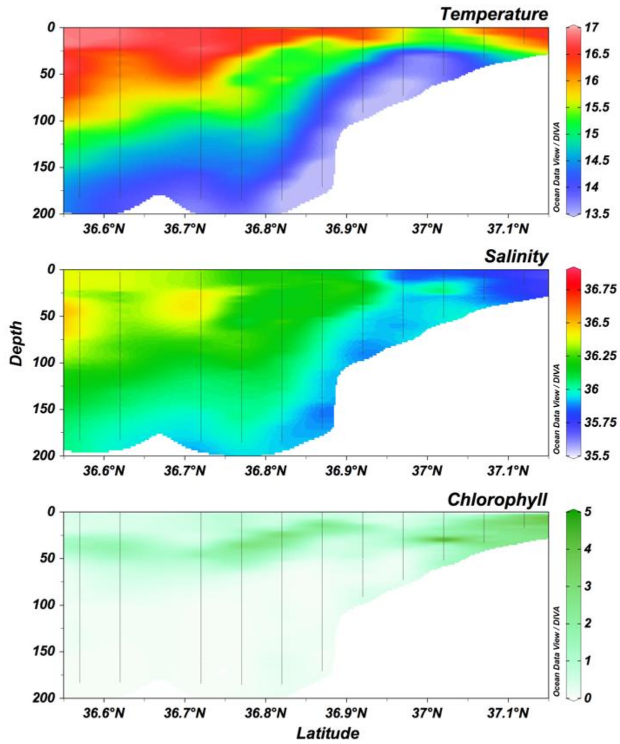
Figure 3.1 – Temperature (ºC) (top left panel), salinity (top right panel) and fluorescence (volt) (bottom left panel) distributions using the data obtained by the sensors associated to the CUFES-EDAS system and location of the CUFES samples (bottom right panel). In the top left panel the black lines indicate the temporal discontinuities in surveying and the black arrows indicate the navigation direction.



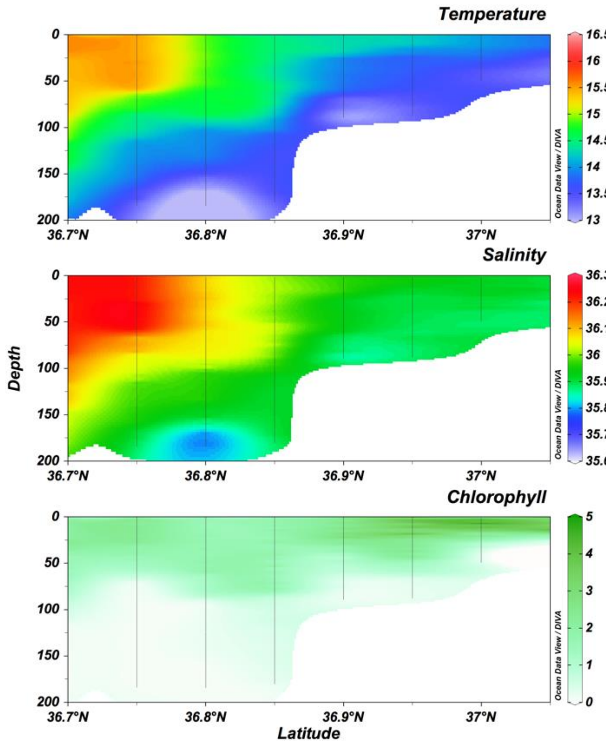
A - 13 Março, 41.2ºN (vicinity of Douro)



B - 27 Abril, 37.2ºN (Alentejo)



C - 21 Abril, 7,2ºW (Algarve)



D - 9 Abril, 8.8ºW (Cadiz Bay)

Figure 3.2 – Sections of temperature, salinity and chlorophyll obtained with the CTD associated with the CalVET. (A) northwestern shelf off Douro river; (B) southwestern shelf off Alentejo; (C) southern shelf off Algarve and (D) southeastern shelf in Cadiz Bay. Note that the colour scales are not the same for all panels.

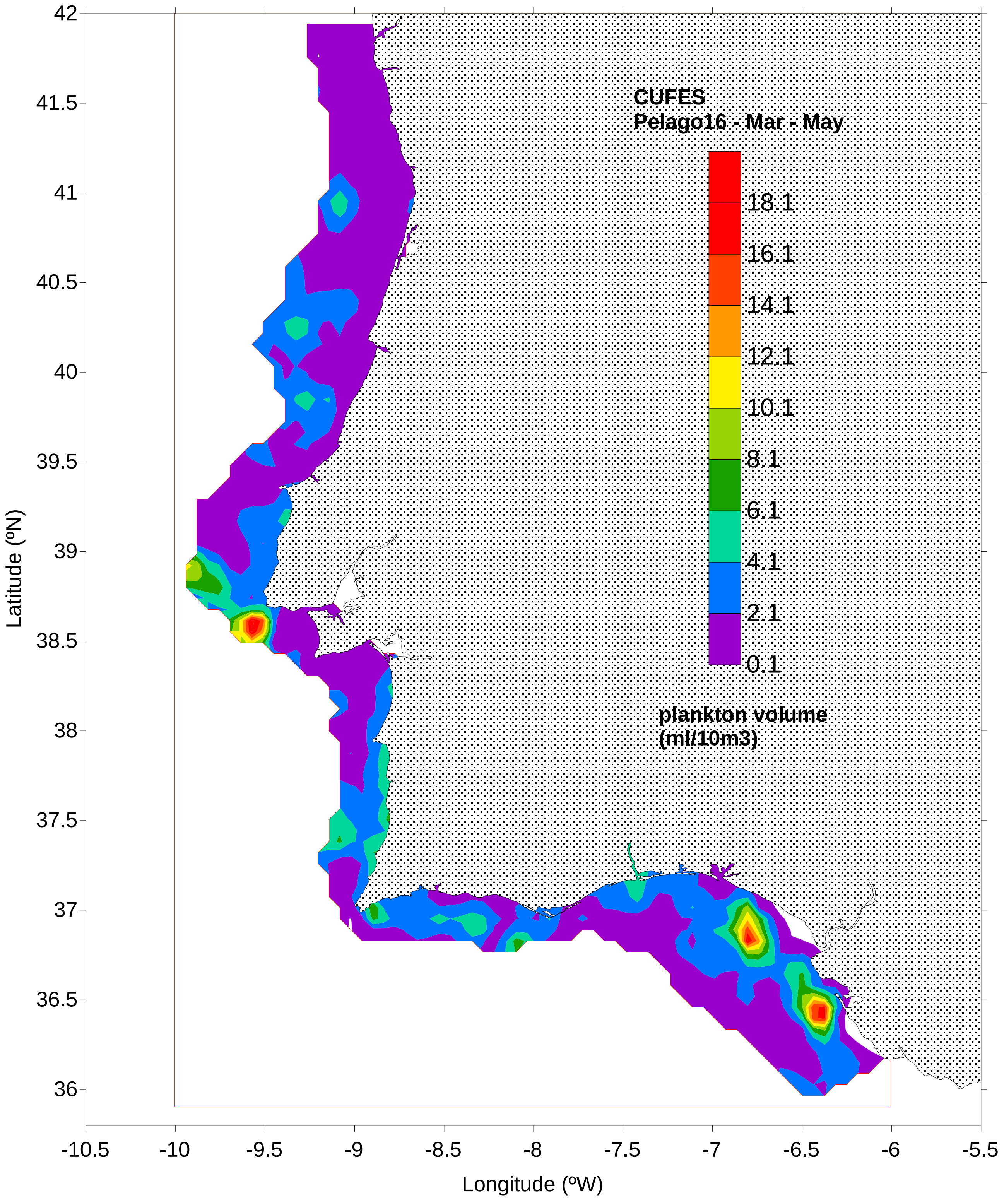


Figure 3.3 – Plankton volumes (ml/10m^3) from CUFES samples using 335µm mesh size net.

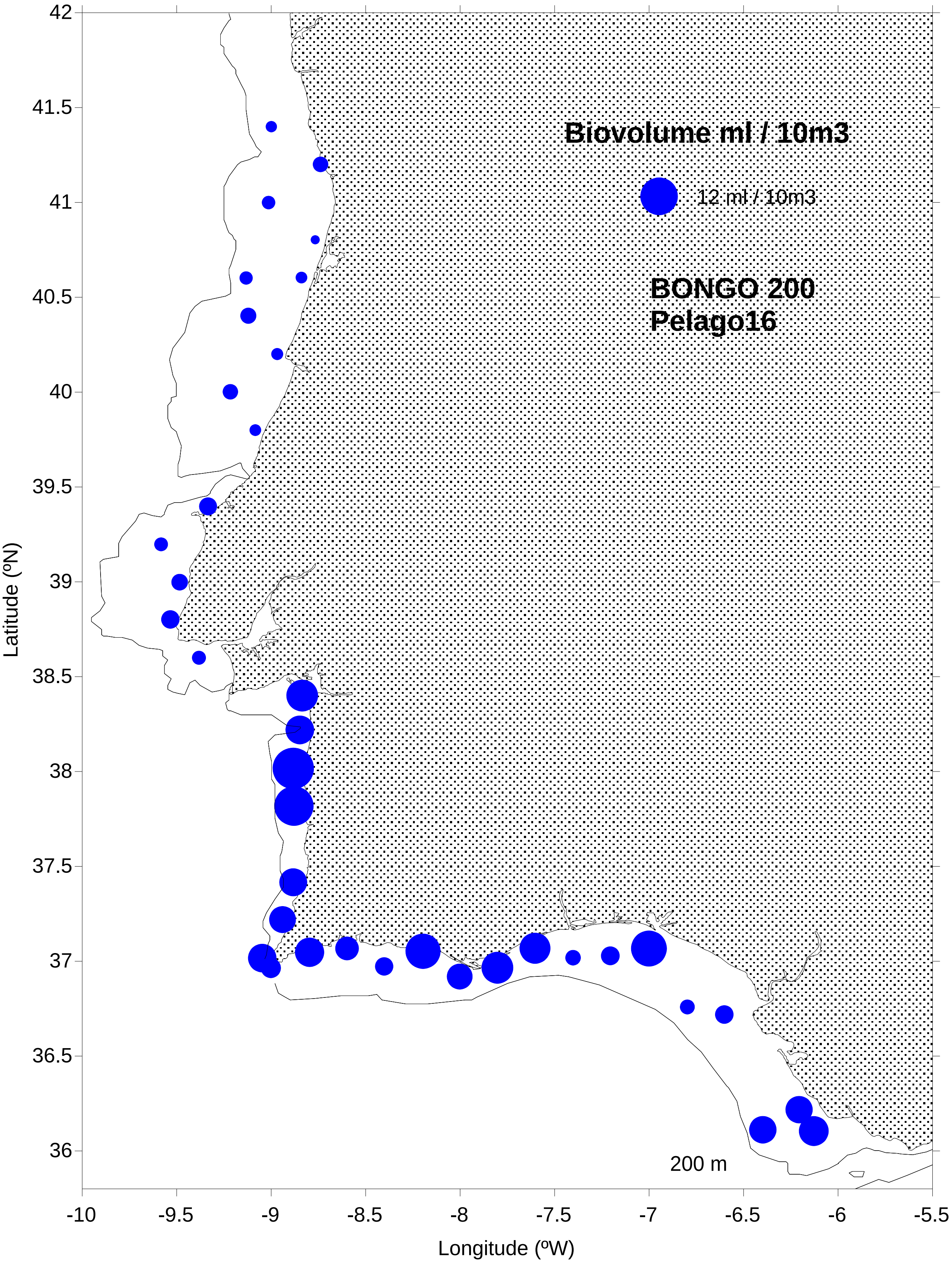


Figure 3.4 (a) – Plankton volumes (ml/10m^3) from oblique towing with a Bongo60 system fitted with 200µm mesh size nets.

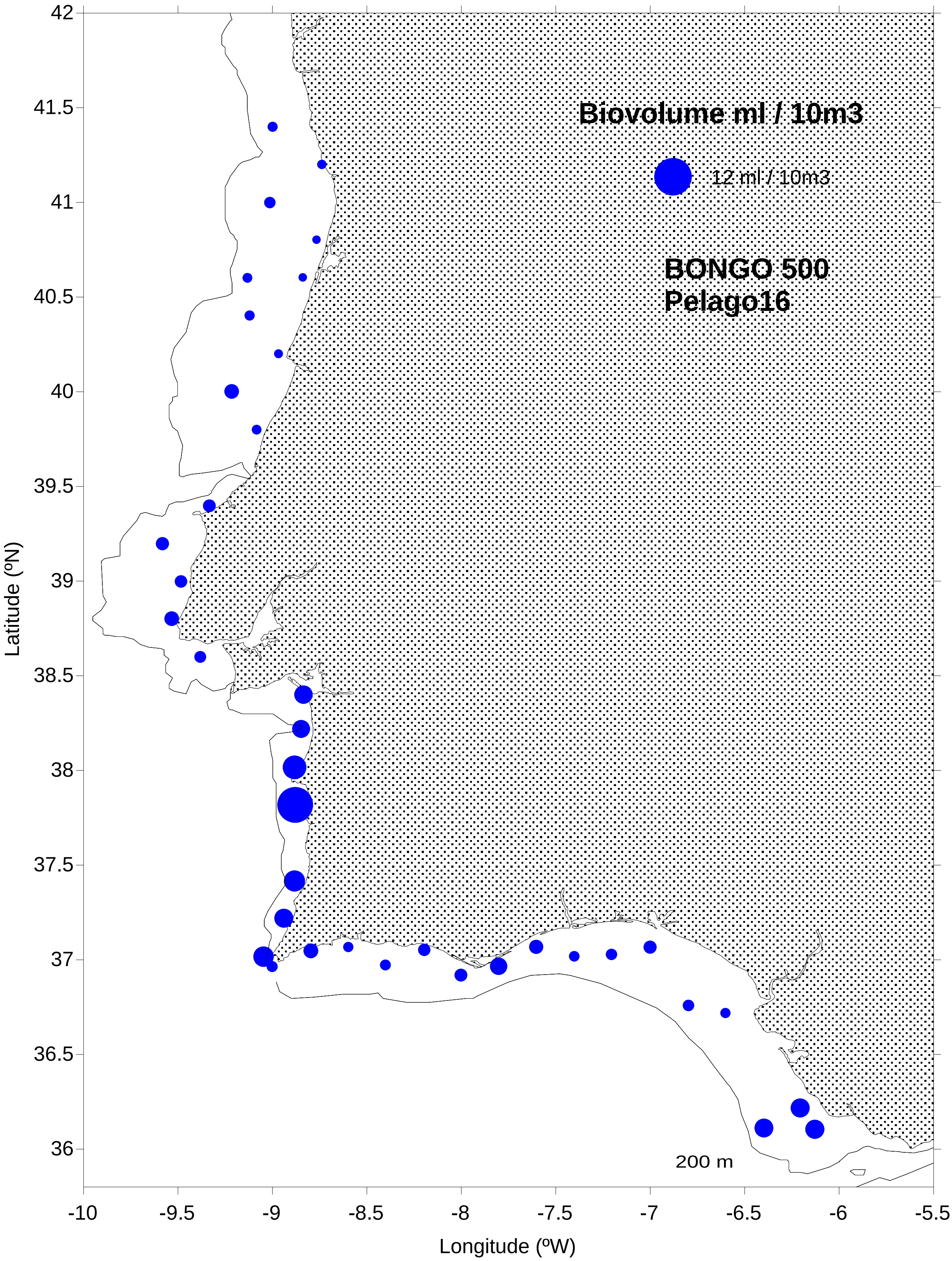


Figure 3.4 (b) – Plankton volumes (ml/10m^3) from oblique towing with a Bongo60 system fitted with 500µm mesh size nets.

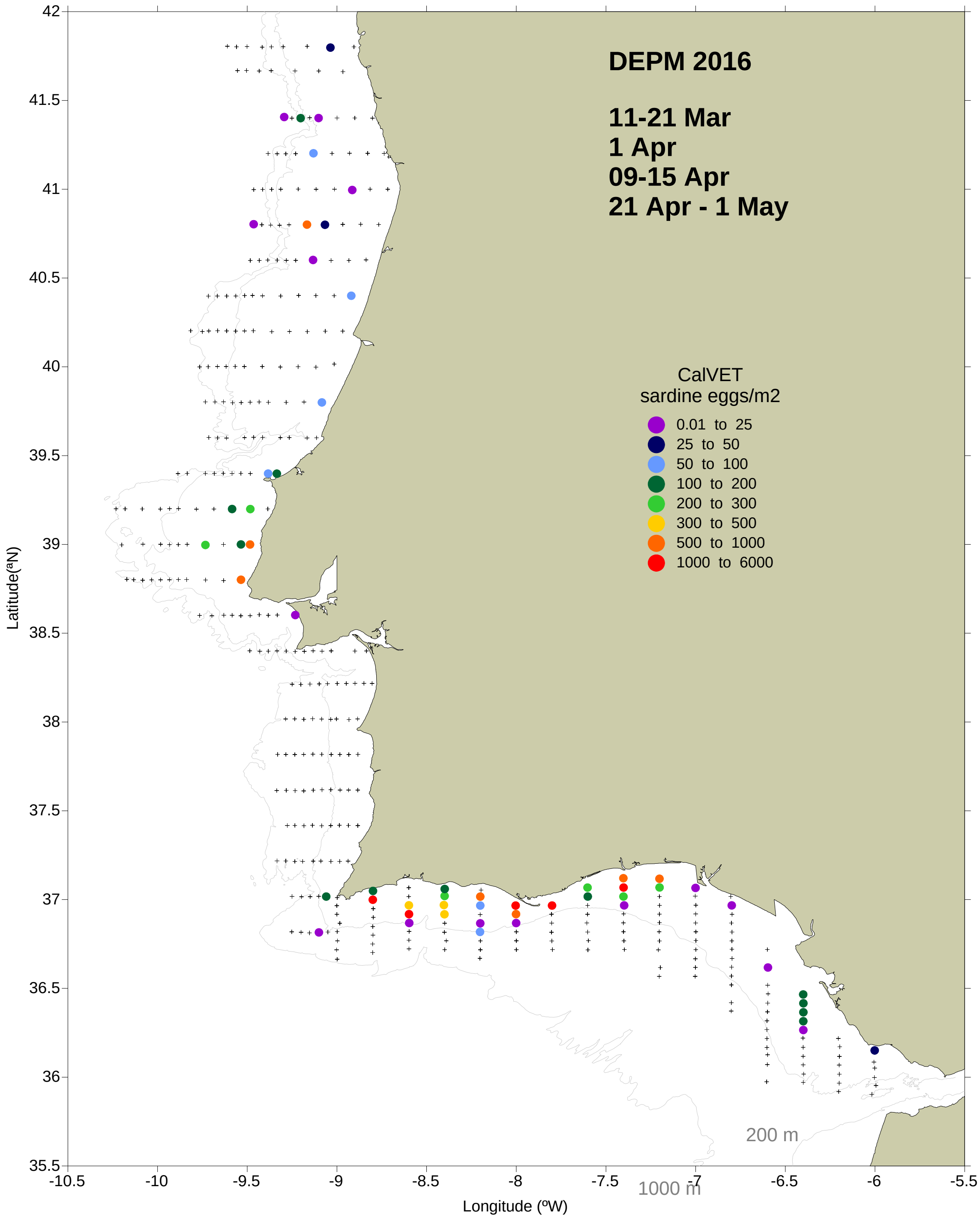


Figure 3.5 – Sardine egg distributions (eggs/m^2). Data from one of the paired CalVET.

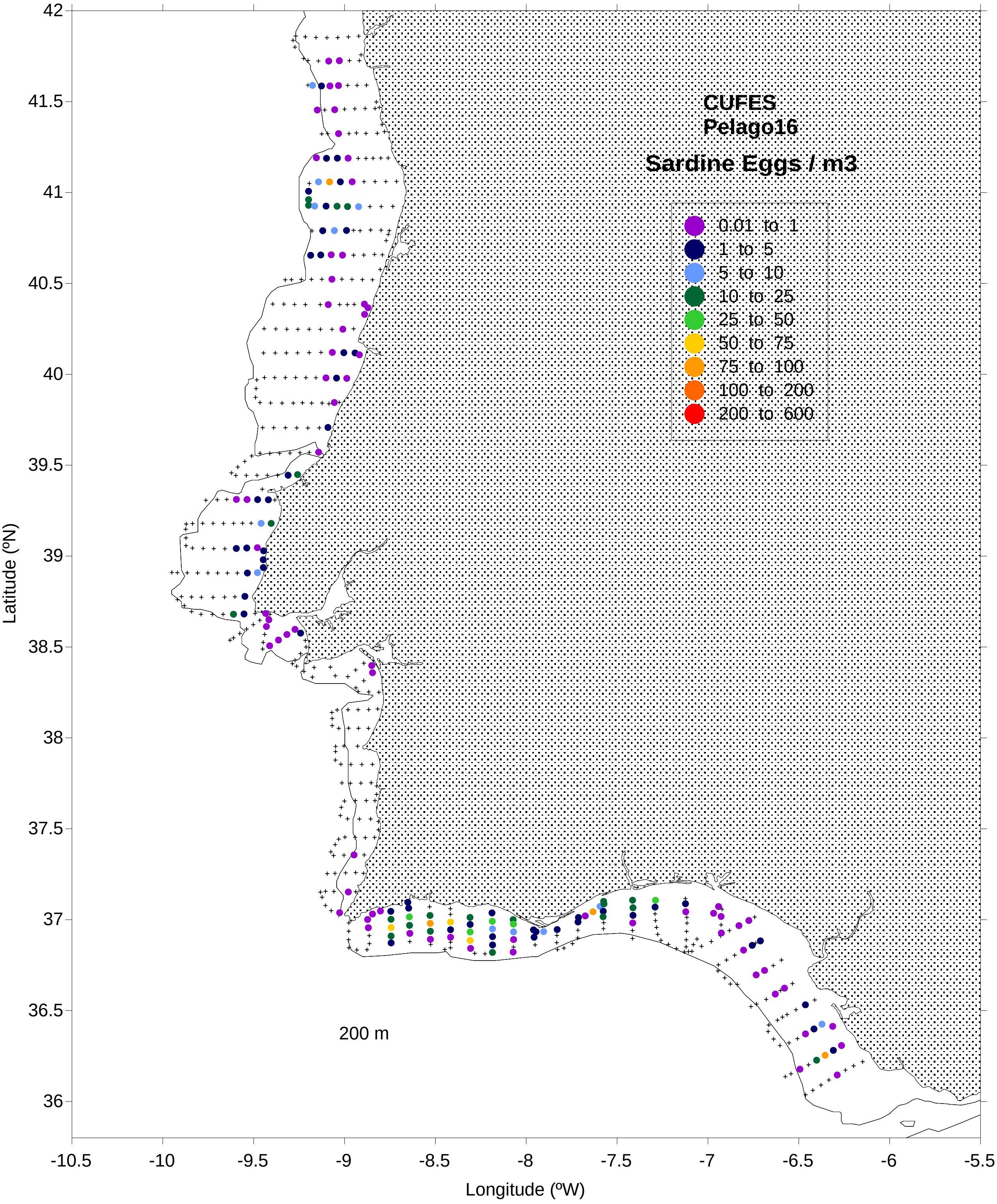


Figure 3.6 – Sardine egg distribution (eggs/m^3) derived from CUFES samples.

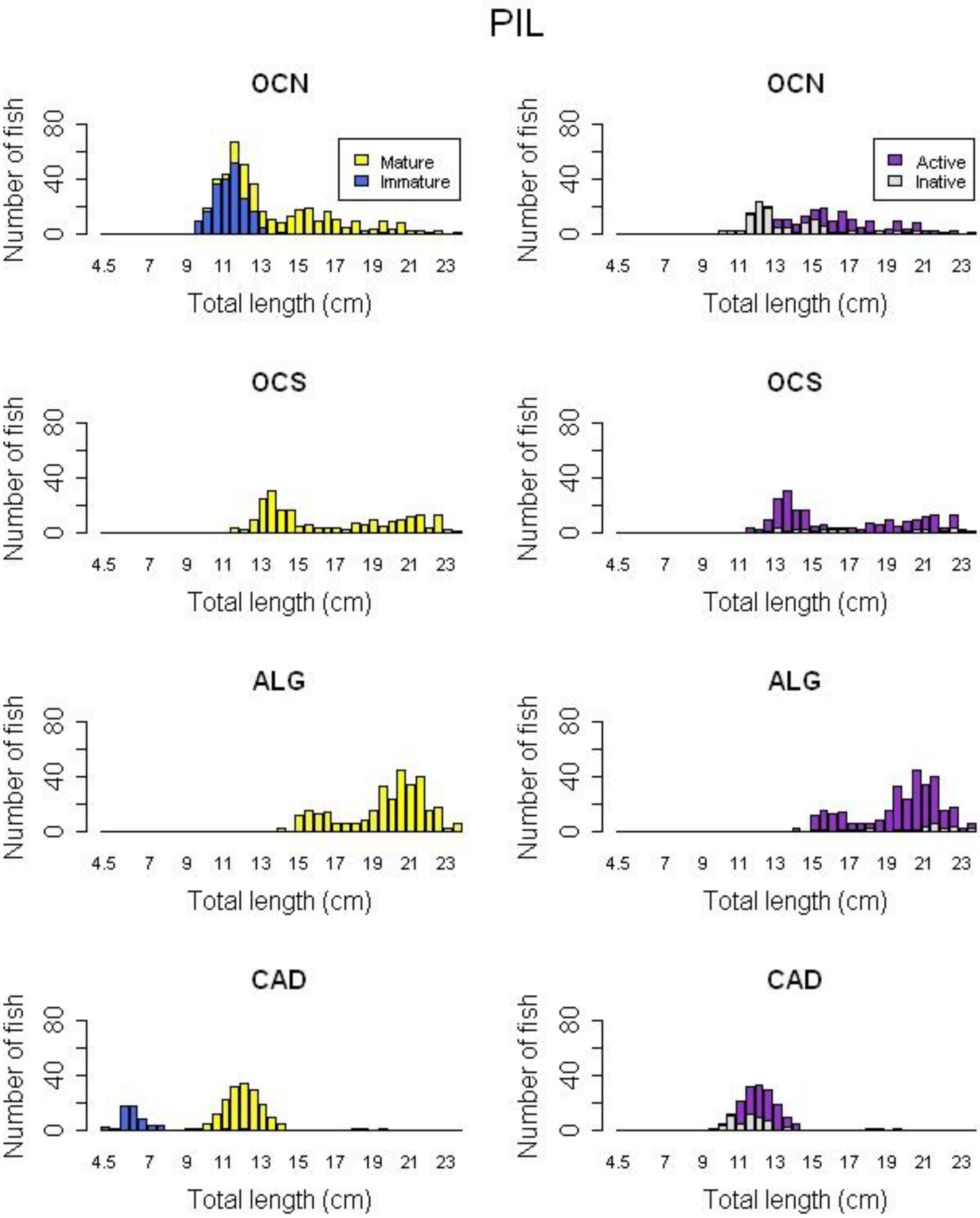


Figure 3.7 – Number of, macroscopically classified, mature vs immature (left panels) and spawning active vs inactive (right panels) sardines, by size distribution in the RV fishing trawls.

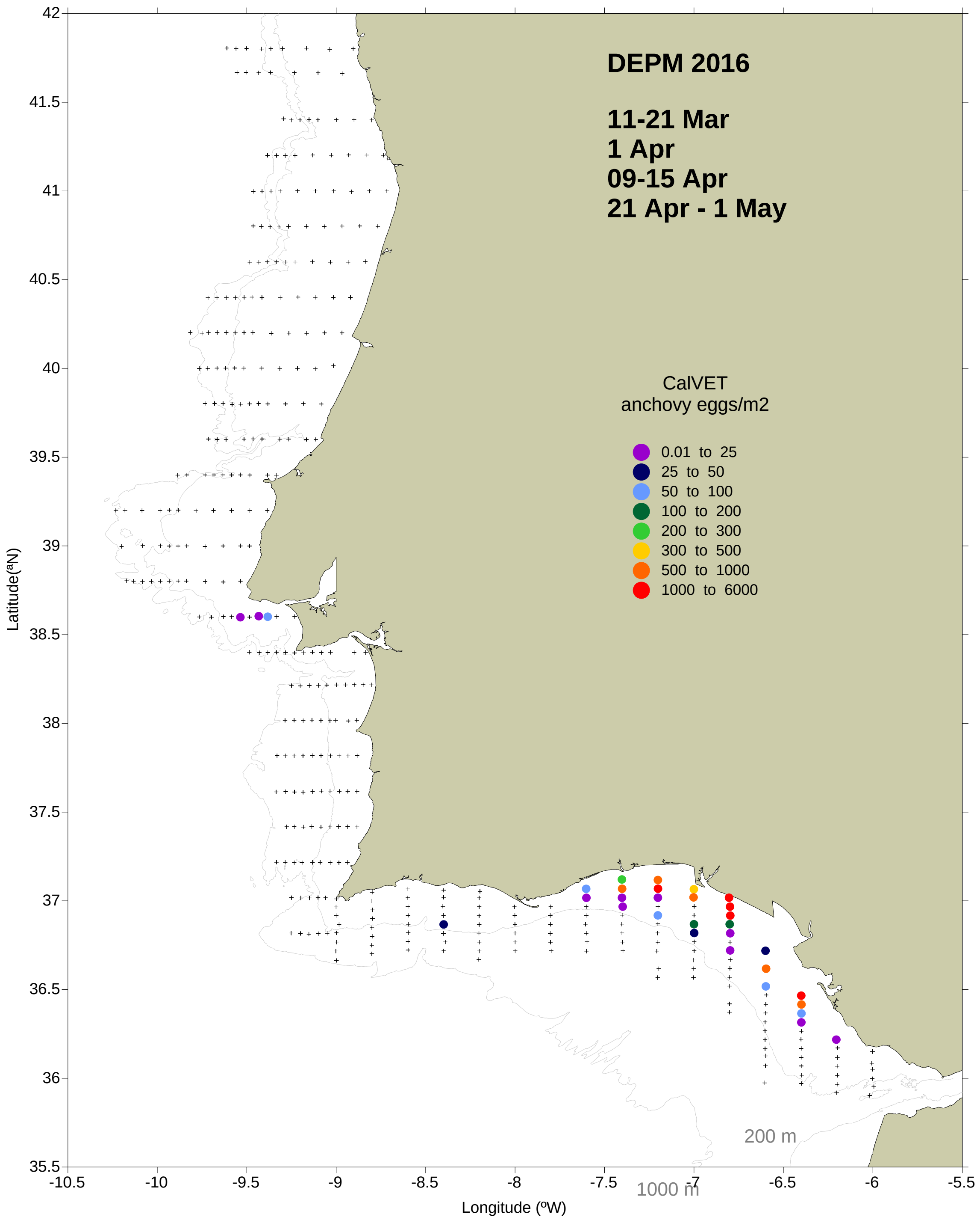


Figure 3.8 – Anchovy egg distributions (eggs/m^2). Data from one of the paired CalVET nets.

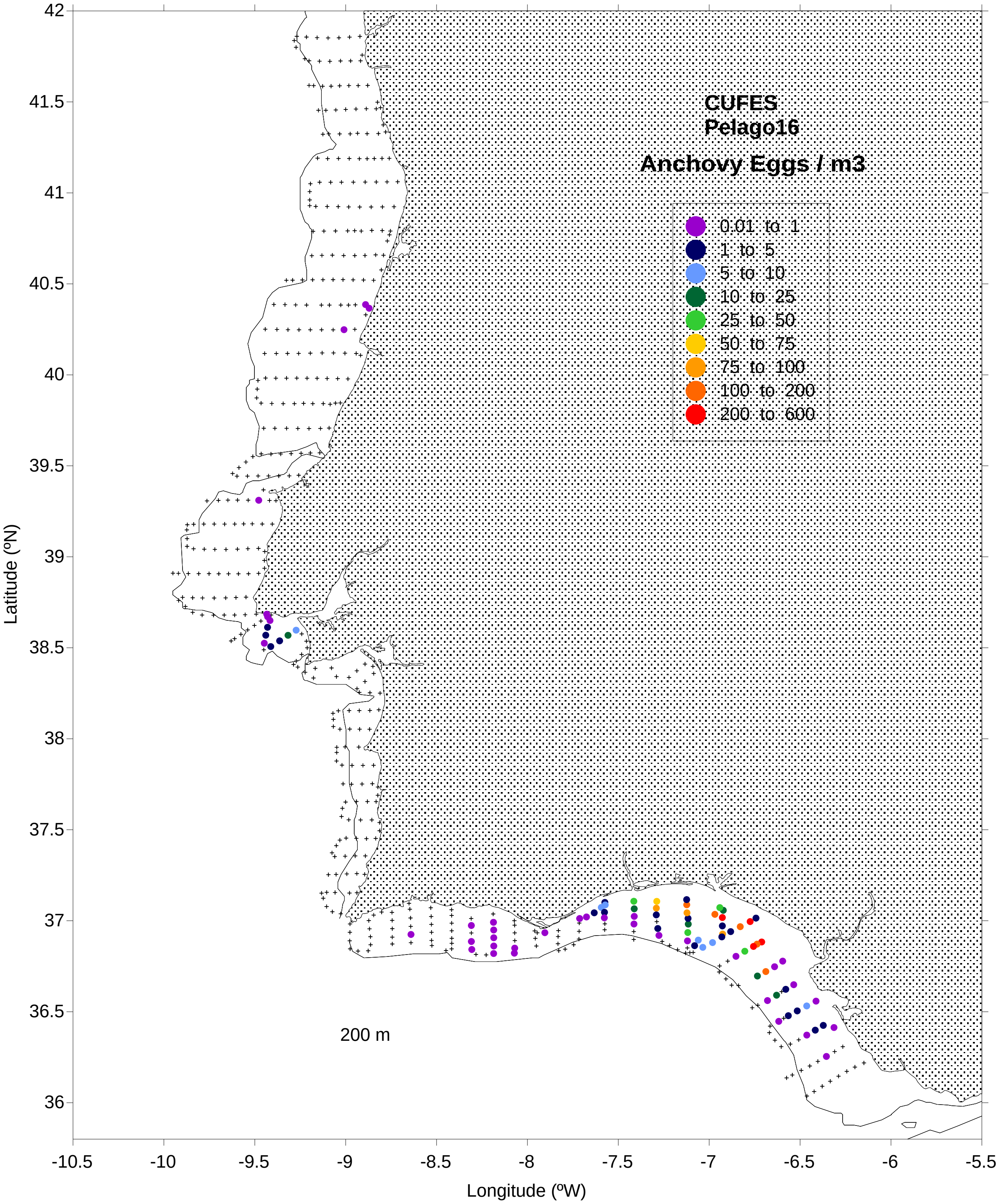


Figure 3.9 – Anchovy egg distribution (eggs/m^3) derived from CUFES samples.

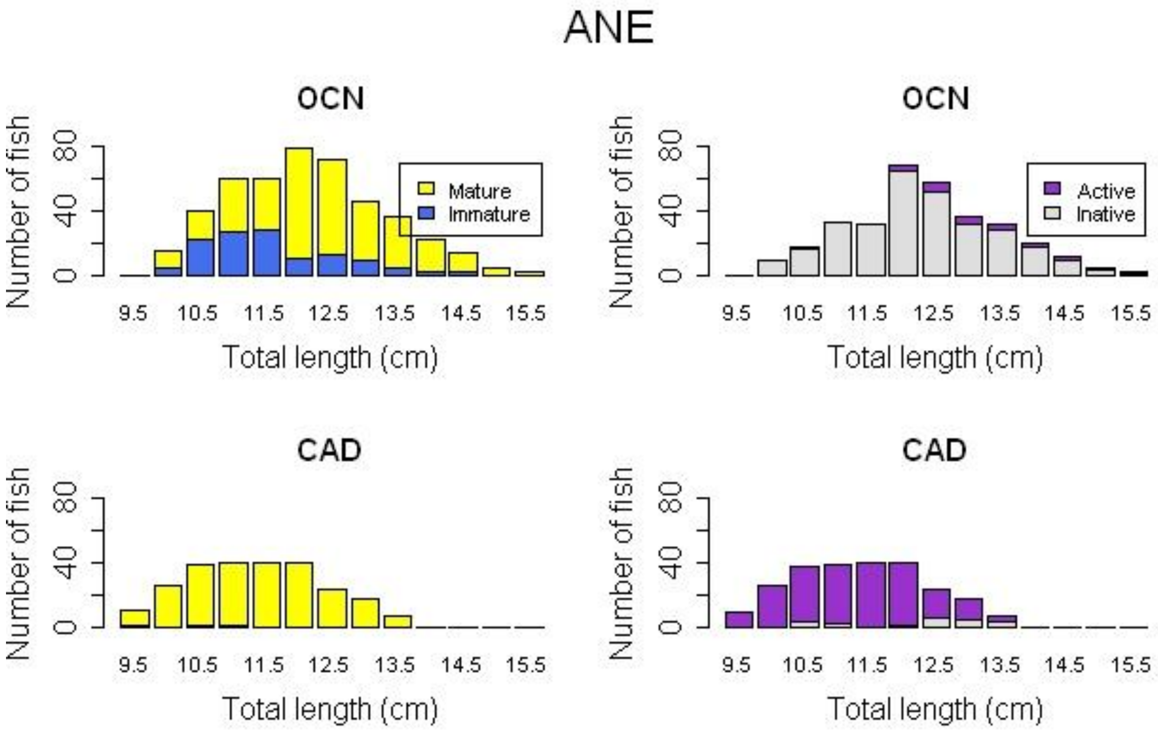


Figure 3.10 – Number of, macroscopically classified, mature vs immature (left panels) and spawning active vs inactive (right panels) anchovies, by size distribution in the RV fishing

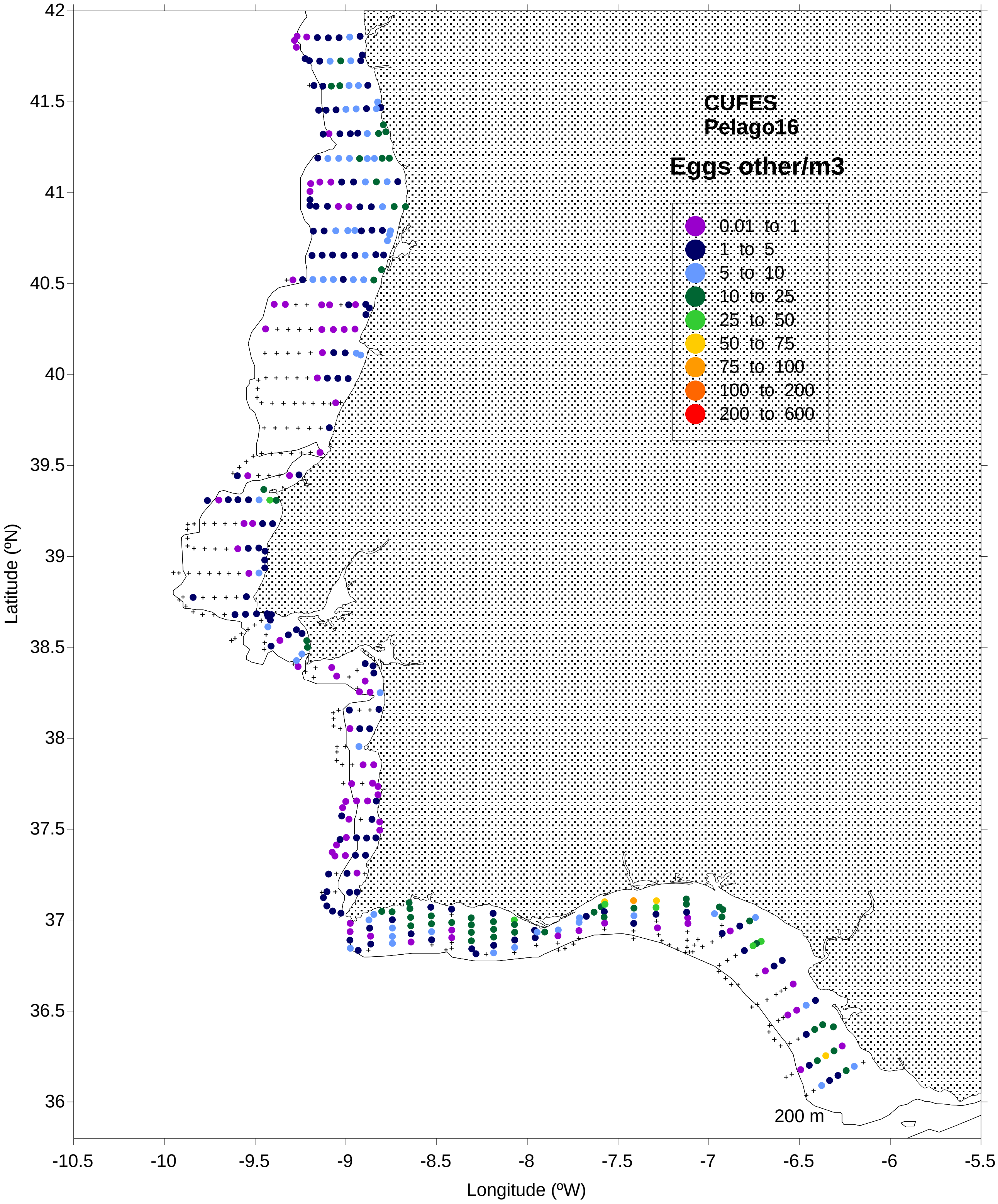


Figure 3.11 – Egg distribution of species other than sardine and anchovy (eggs/m^3) derived from CUFES samples.

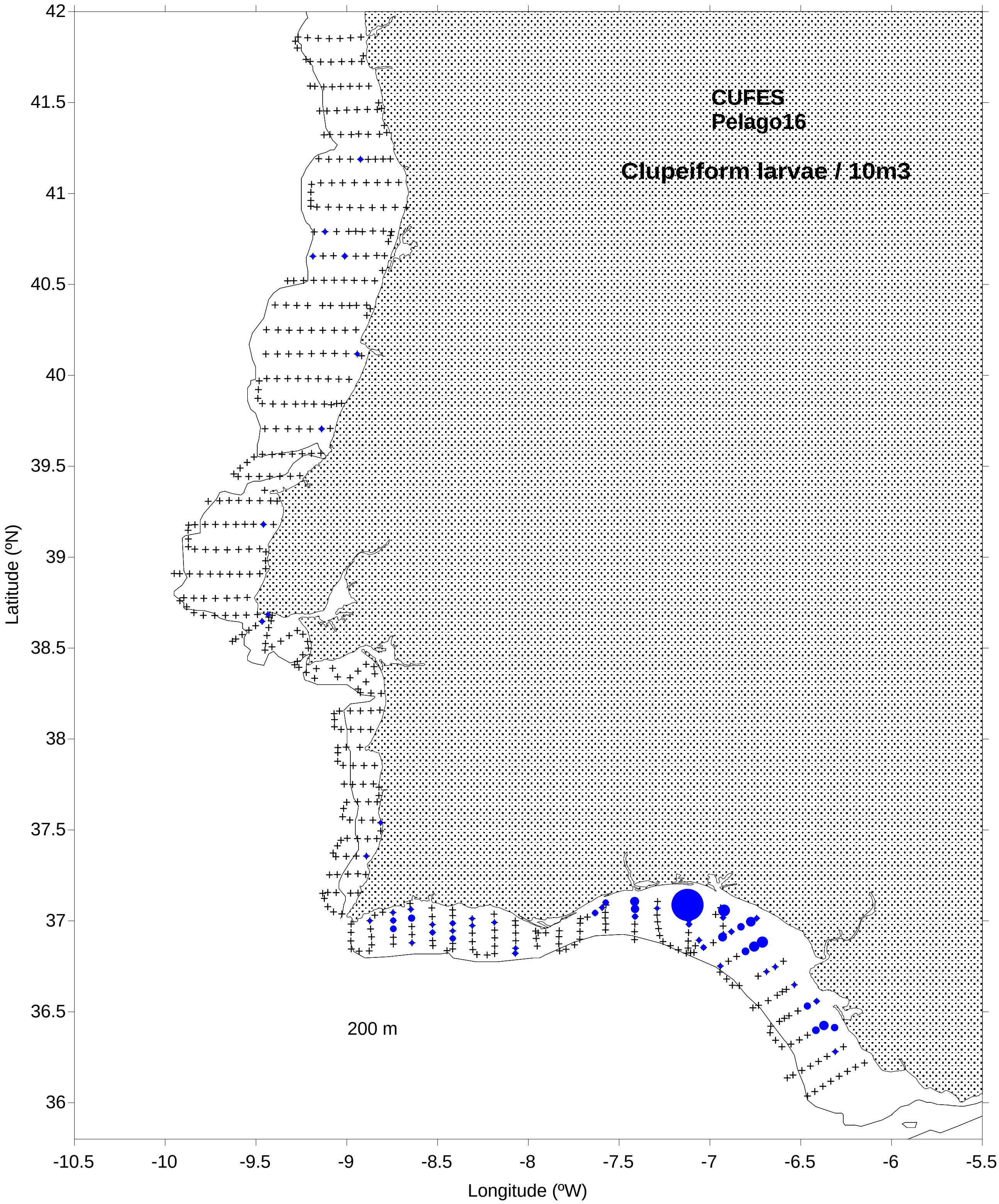


Figure 3.12 –Distribution of clupeiform larvae (eggs/10m^3) (mostly sardine and anchovy but not yet sorted apart) derived from CUFES samples.

WD 3 – PELACUS SURVEY

CRUISE REPORT
PELACUS 0316 - PELAGIC ECOSYSTEM ACOUSTIC-TRAWL SURVEY, RV MIGUEL OLIVER
Coordinated by Pablo Carrera
Instituto Español de Oceanografía

CRUISE REPORT

PELACUS 0316

PELAGIC ECOSYSTEM ACOUSTIC-TRAWL SURVEY
R/V MIGUEL OLIVER

Coordinated by Pablo Carrera
Instituto Español de Oceanografía

Unión Europea
Fondo Europeo Marítimo y de Pesca (FEMP)

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EXECUTIVE SUMMARY

The Spanish acoustic-trawl time series PELACUS 0316 was carried out on board R/V Miguel Oliver from 13th March to 16th 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 3650 nautical miles were steamed, 1248 corresponding to the survey track. Besides 49 fishing stations were performed .

Unexpectedly, weather and oceanographic conditions found during PELACUS 0316 were those of the winter time rather than the incipient spring ones. Together with dominant N-NE at the beginning of the survey, which produced a coastal upwelling in the Galician waters, then consecutive deep W/NW storm fronts have affected the survey plan; five days were lost due to the bad weather conditions. And during the last part of thesuvey either strong south wind (up to 45 knots) or a persistent swell of about 2-4 m height have also made problems to achieve clean echograms (i.e. without bubbles) and good performance at the fishing station. These conditions might have been also affected the availability of the fish. This seems clearer in the southern part (IXaN), where a stronger winter poleward current led the continental self almost empty of plankton and with a very scarce concentration of fish.

Abundance of the main pelagic fish species was lower than that of the previous year. For sardine the abundance was very low, practically below of an acceptable threshold for an acoustic assessment. Moreover, the 75% of the estimated biomass was concentrated in a single large and thick school. Although this school was not caught (i.e. no ground truth) the acoustic and morphological characteristics were similar to those found in other ground-truthed sardine schools. In total the assessed biomass was very low, and excluding this school only 3 thousand tons were estimated, the lowest record in the time series (13 thousand tons including this school but still at a very low level) Horse mackerel showed also an important decrease while anchovy has been mainly detected at the inner part of the Bay of Biscay, although as it was observed for sardine, the presence of thick schools in the western part, presumably being anchovy, had an important impact in the final assessment. Concerning mackerel, it seems the southwards migrations was delayed, and contrary to that found in previous years, adult fish were almost not available in the Cantabrian sea until the end of March. The lack of both eggs and adults observed during the ichthyoplankton-trawl survey CAREVA corroborated this finding. Moreover, fish rather occurred in isolate dense patches than in a continuous way as observed in previous years

TECHNICAL SUMMARY

Institution:	INSTITUTO ESPAÑOL DE OCEANOGRAFÍA
Survey name:	PELACUS 0316
Vessel name:	Miguel Oliver (70 mn length, 2x1000 kW diesel-electric
Dates:	13/03/2015-16/04/2016
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 18-38-70-120-200 kHZ acoustic frequencies. 1248 nmi prospected. Only day time
	CUFES, Intake at 5 m depth, 600 l min^{-1}. 3 nmi/sample, 215 samples (sardine and anchovy eggs)
	Pelagic fishing stations. 49 stations
	Marine mammals and birds observations. 144 legs (115.4 hours)
	Hydrological characterisation. 70 stations (45 CTD with rosette and 27 plankton nets)
Personnel (1st leg)	CARRERA LÓPEZ, PABLO CORDOBA SELLES, PILAR DÍEZ GARCÍA, IRENE PILAR DUEÑAS LIAÑO, CLARA GAGO PIÑEIRO, JESÚS MANUEL GARCÍA BARCELONA, SALVADOR GONZÁLEZ GONZÁLEZ, ISABEL CRISTINA HUERGA VALDUEZA, SOFÍA OCHOA FERNÁNDEZ, VERÓNICA OÑATE GARCIMARTÍN, MARÍA DOLORES OTERO PINZÁS, ROSENDO PEDRAJAS ETXEBARRÍA, ARKAITZ PEREIRO RODRÍGUEZ, DIEGO VALEIRAS MOTA, XULIO
2nd leg	CANSECO RODRÍGUEZ, JOSE ANTONIO CARRERA LÓPEZ, PABLO EIROA, FÁTIMA FERNÁNDEZ LAMAS, ANGEL GARCIA BARÓN, ISABEL GÓMEZ GONZÁLEZ, ANTONIO GONZÁLEZ GONZÁLEZ, ISABEL CRISTINA GUTIÉRREZ MUÑOZ, PAULA HERES GOZÁLBES, PABLO HERNÁNDEZ GONZÁLEZ, ALBERTO JIMENEZ NAVARRO, SEBASTIÁN LOPEZ DÍAZ, EDUARDO MINGUITO FRUTOS, MARIO OÑATE GARCIMARTÍN, MARÍA DOLORES OTERO PINZÁS, ROSENDO PEREIRO RODRÍGUEZ, DIEGO PRECIADO RAMÍREZ, IZASKUN SÁNCHEZ BARBA, MARÍA SOLLA COVELO, ANTONIO JOSÉ SORIANO, Mª MAR
Main report authors	Pablo Carrera Camilo Saavedra
Other collaborators	M. Begoña Santos Xulio Valeiras Isabel Riveiro Isabel García Barón Izaskun Preciado Gonzalo González Bueno

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 behaviour 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, bth 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 had 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 Egg Production Method to both mackerel and horse mackerel.
- 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)

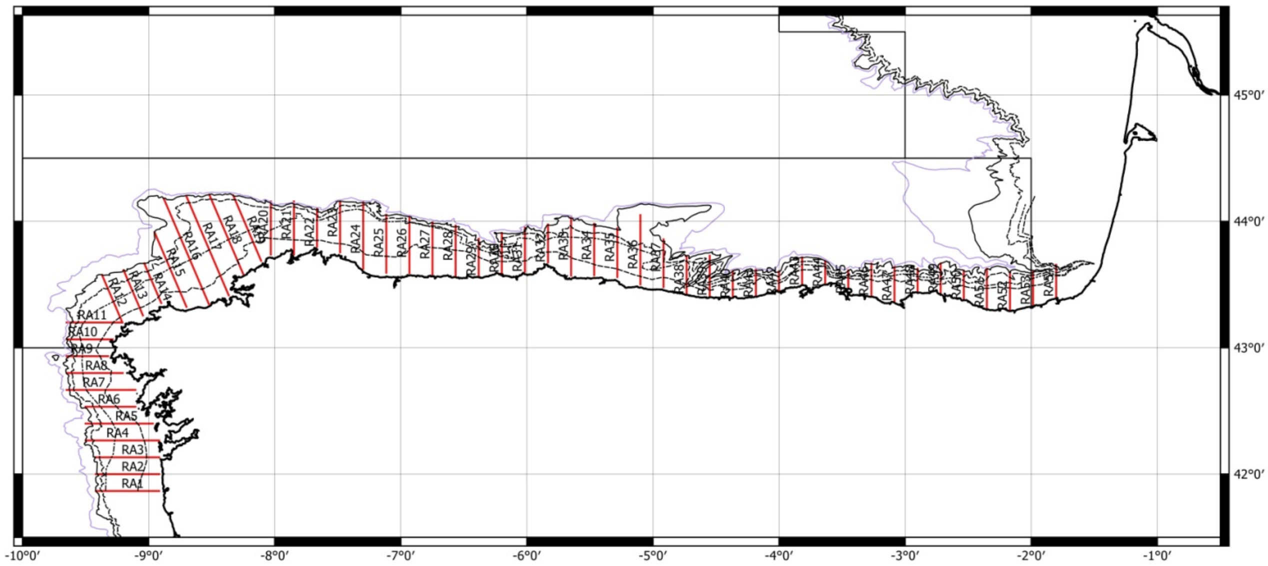


Figure 1 Survey track

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, 70, 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, 70, 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, 70, 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 s_A values (m^2 nm^{-2}) (MacLennan et al., 2002).

Main echosounder settings are shown in table 2

Transducer power	2000/2000/1000/200/90 W for 18/38/70/120/200 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 knots.

Fishing stations

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. 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. Due to a serious damage in this device, a *gloria* 352 has been used. The performance of this fishing gear was also good, although the vertical opening was 5-4 m lower than that of the "grandes mailles".

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 Zoo-Image 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

The methodology is based on the Distance Sampling technique (Buckland et al., 2001). 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. Besides, weather conditions (wind direction and Beaufort value, height and main direction of swells, cloudiness). 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 350µm. 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 on horse mackerel for genetic purposes and also on this specie and mackerel for fecundity purposes, in coordination with the triennial mackerel egg surveys.

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 distribution	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 when no direct allocation is feasible. 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:

$$NASC_l = NASC \cdot \left(\frac{\sigma_{l,\rho}}{\sigma_\rho}\right)$$

where *NASC* is the total backscattering energy to calculate densities by length, $NASC_l$ is the proportion of the total *NASC* which can be attributed to length group l for a particular fish species. $\sigma_{l,p}$ is the backscattering cross-section at length l for a particular species at length l multilpied by the proportion of (p_l) of length of this particular species on the overall catch and σ_p is the sum of all $\sigma_{l,p}$ for all species,

$$\sigma_{l,\rho} = \rho_l * \sigma_l$$

$$\sigma_\rho = \sum_l \sigma_{l,\rho}$$

finally $\sigma_{l,}$ is backscattering cross-section (m^2) for a fish of length l for a particular species and is computed as follows:

$$\sigma_l = \frac{l^{\left(\frac{m}{10}\right)} * 10^{\left(\frac{b_{20}}{10}\right)}}{4 * \pi}$$

This is computed from the formula TS =20 logL_T+ b_{20} (Simmonds and MacLennan, 2005), where L_T is the length class . The b_{20} values for the most important species present in the surveyed area are shown in following table:

Sp	b_{20}	Ref	Observations	Other b_{20}	Ref.
PIL	-72.6	Degnbol et al., 1985	TS for clupeids	-71.2	ICES ,1982
				-70.4	Patti et al., 2000
				-74.0	Hannachi et al., 2005
				-72.5	Georgakarakos et al., 2011
ANE	-72.6	Degnbol et al., 1985	TS for clupeids	-71.2	ICES 1982
				-76.1	Barange et al., 1996
				-71.6	Zhao et al., 2008
				-74.8	Georgakarakos et al., 2011
HAK	-67.5	Foote et al., 1986; Foote, 1987		-68.5	Lillo et al., 1996
				-68.1	Henderson, 2005; Henderson and Horne, 2007
BOG	-67.5	Foote et al., 1986	Adapted from gadoids		
BOC	-66.2	Fässler et al., 2013			
MAC	-84.9	Edwards et al., 1984; ICES, 2002		-86.4	Misund and Betelstad, 1996
				-88.0	Clay y Castonguay, 1996
HOM	-68.7	Lillo et al., 1996		-68.15	Gutiérrez and McLennan, 1998
				-66.8	Barange et al. (1996)
				-66.5/-67.0(*)	Georgakarakos et al., 2011
MAS	-68.7	Lillo et al., 1996	Adapted from HOM;l (Sawada, com. pers.)	-70.95	Gutiérrez and McLennan, 1998
WHB	-65.2	Pedersen et al., 2011			

* day and night respect.

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))

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, 70, 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 (Q-gis). These values, together with the length distributions, are used to calculate the fish abundance in number as described in Nakken and Dommasnes (1975) (see previous section for further details). Estimates for each species 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 using the following formula:

$$\rho_l = \frac{NASC_l}{\sigma_l}$$

$$N_l = \rho_l * A_p$$

where ρ_l is the areal density of fish (numbers per square nautical mile in length group l and the total number for length group l (N_l) within each strata is calculated the product ρ_l of times the total area of the strata (A_p)

Numbers were converted into biomass using the length weight relationships derived from the fish measured on board. 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 the mean latitude.

RESULTS

The survey started on 13th March and ended on 16th April. A total of 3650 nautical miles were steamed, 1248 of them corresponding to the survey track. Weather conditions were in general worse than that found in previous years. The survey was interrupted for 5 days due to the extremely bad weather conditions with NW swell of about 4-6 m height. Besides, strong south wind (up to 55 knots on average) occurred in the inner part of the Bay of Biscay. In addition, no vertical stratification was found (i.e., mixed waters from surface to sea bottom) and it seems the poleward current was stronger than that observed in previous years). All of this features might have been affected the behaviour and the availability of the fish.

Calibration

All frequencies were calibrated on 12th March, with the following results:

		200 kHz	120 kHz	70 kHz	38 kHz	18 kHz
Main	TS	-39.70 dB	-39.51 dB	-41.41 dB	-42.41 dB	-34.40 dB
	Gain	27.00 dB	27.00 dB	27.00 dB	26.50 dB	22.40 dB
	Two way Beam Angle	-20.70 dB	-21.00 dB	-21.00 dB	-20.60 dB	-17.00 dB
	Angles (deg)	7.0 x 7.0	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	1.024 ms
	Power	90 W	200 W	600 W	2000 W	2000 W
	Sample Interval	0.193 m	0.192 m	0.192 m	0.192 m	0.192 m
	Rec. Bandwidth	3.09 kHz	3.03 kHz	2.86 kHz	2.43 kHz	1.57 kHz
	Absorption coeff.	57.9 dB/km	40.6 dB/km	23.5 dB/km	9.5 dB/km	2.5 dB/km
	Sound veloc.	1502.3 m/s	1502.3 m/s	1502.3 m/s	1502.3 m/s	1502.3 m/s
Beam Model Results	Transducer Gain	26.77 dB	26.81 dB	27.20 dB	24.89 dB	22.84 dB
	Sa Corr	-0.31 dB	-0.38 dB	-0.40 dB	-0.57 dB	-0.81 dB
	Athw Beam Angle	6.37 deg	6.30 deg	6.21 deg	6.90 deg	10.97 deg
	Along. Beam Angle	6.42 deg	6.36 deg	6.37 deg	7.17 deg	11.25 deg
	Athw Offset Angle	-0.16 deg	-0.05 deg	-0.04 deg	0.02 deg	0.10 deg
	Along. Offset Angle	0.05 deg	0.03 deg	-0.01 deg	-0.15 deg	-0.06 deg
Data dev from beam model	RMS	0.42 dB	0.31 dB	0.34 dB	0.25 dB	0.27 dB
Data dev polynomial model	RMS	0.38 dB	0.25 dB	0.30 dB	0.24 dB	0.24 dB

Table 5: Acoustic equipment calibration. Main in and outputs for each frequency.

Figure 2 shows the performance of the transducers along the time series. While 18 and 38 kHz frequencies remained more or less stables along this time series, Transducer gain for the higher frequencies is showing and increasing trend.

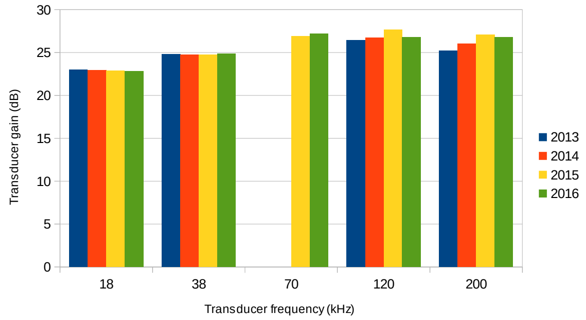


Figure 2: Transducer gain results from the calibrations 2013-16

Main oceanographic conditions

Figure 3 compares the Upwelling index from January to May calculated for the last 4 years. The index for 2016 shows a NE dominant wind regime which forced an upwelling event during February and March. Thus, the situation was rather similar to that found in 2015, although this year the index was higher than that observed 2016, but very different to that observed in both 2013 and 2014 for this period.

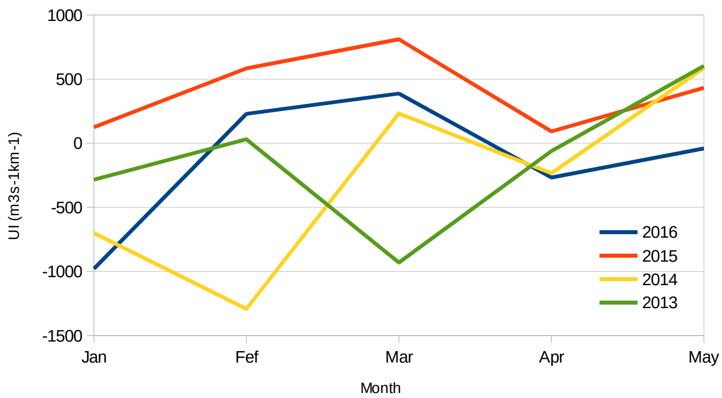


Figure 3: Upwelling index .

In figure 4a-c , the values obtained from the surface continuous records (salinity, temperature and fluorometry) are shown.

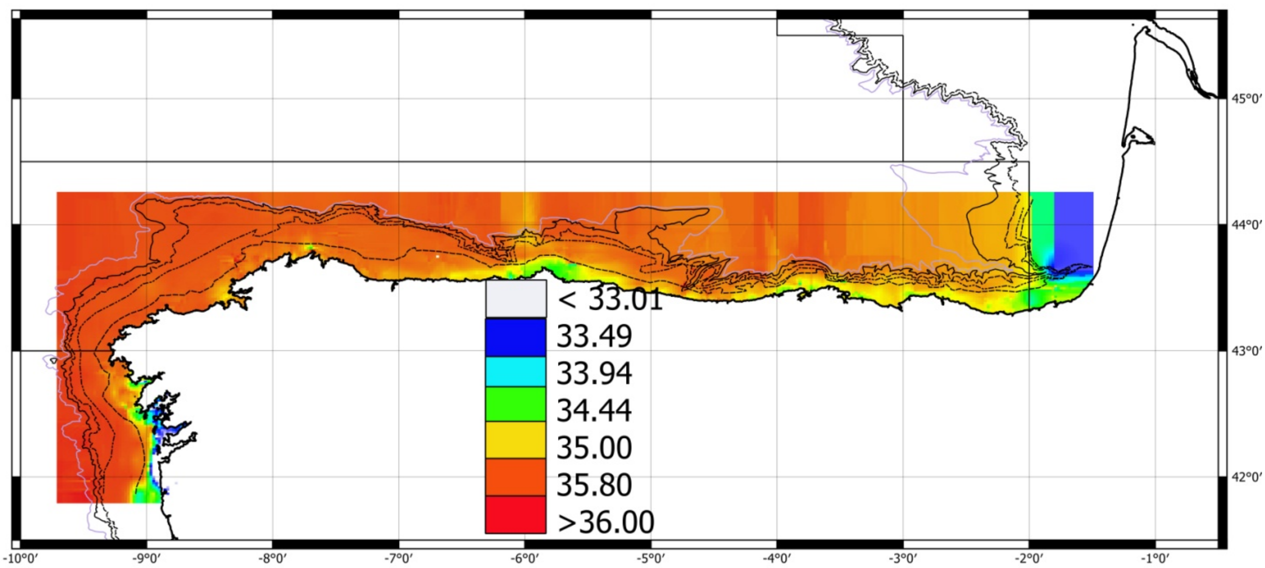


Figure 4a: Sea surface salinity during PELACUS 3016

Coastal waters showed the effect of the run-off of the rivers, which was clearer in the southern area (Rías Baixas), near cape Peñas and also at the inner part of the Bay of Biscay, where salinity was in all cases, below 35‰. On the other hand an intrusion of saltier waters off the southernmost part of the surveyed area is also observed. This water mass is more evident at the SST plot (figure 4b), and corresponds to the poleward current, which seemed to be stronger than in precedent years. Due mainly to the upwelling, the coastal waters of Galicia were below 13.5ºC, with clear extension towards oceanic waters at the north-western corner. Contrary, due to the strong south wind occurred at the en of the survey, waters at the inner part of the Bay of Biscay were warmer, even off-shore.

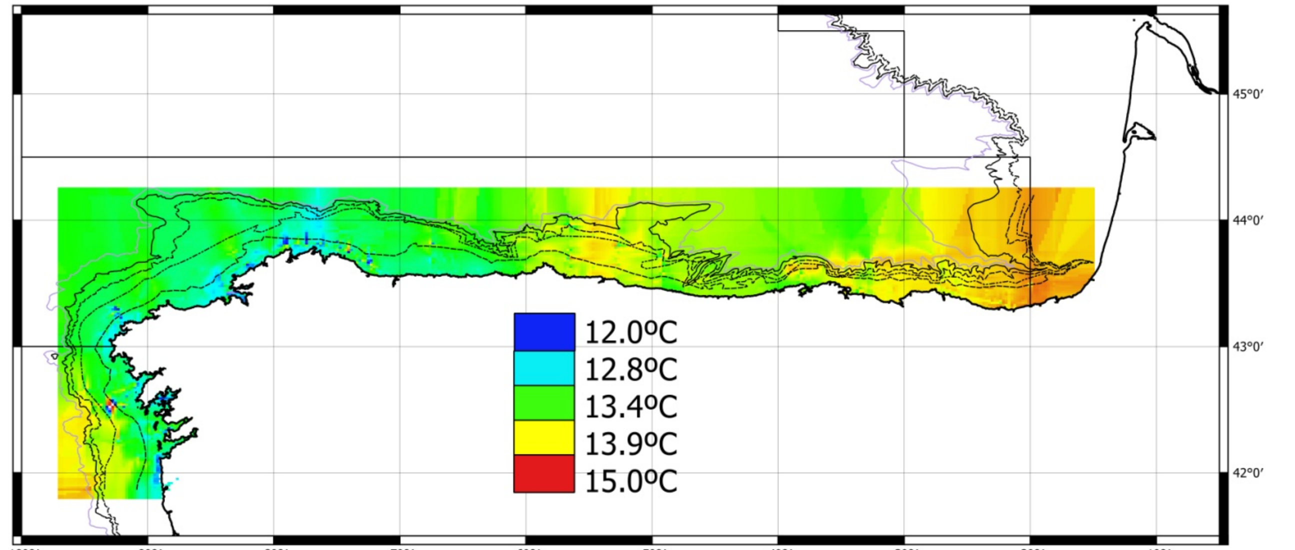


Figure 4b: Sea surface temperature during PELACUS 3016

This situation made strong physical differences along the surveyed area. Main consequence was the high fluorometry concentration of primary production off the north-western corner together with in the coastal waters of the southern part, as shown in figure 4c. Moreover, the high fluorometry in the NW area coincided with an important concentration of earlier hake pre-juveniles.

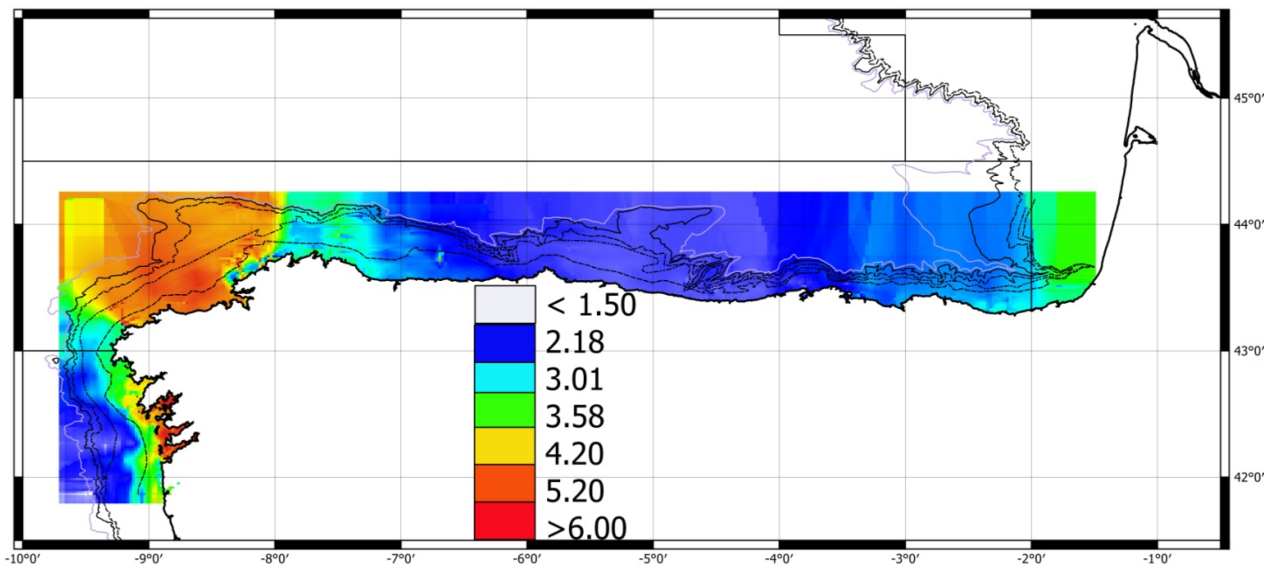


Figure 4c: Sea surface flourometry during PELACUS 3016

Figure 5a-b shows several cuts from the shoreline to the self-break up to 200 m depth in the Cantabrian sea. As seen in the surface maps, flourometry was very low in the central waters of the Cantabrian Sea. In this area, salinity is shown the effect of the off-shore transport of the coastal waters, with less saltier waters located in open waters. This effect can be also observed in the temperature profiles.

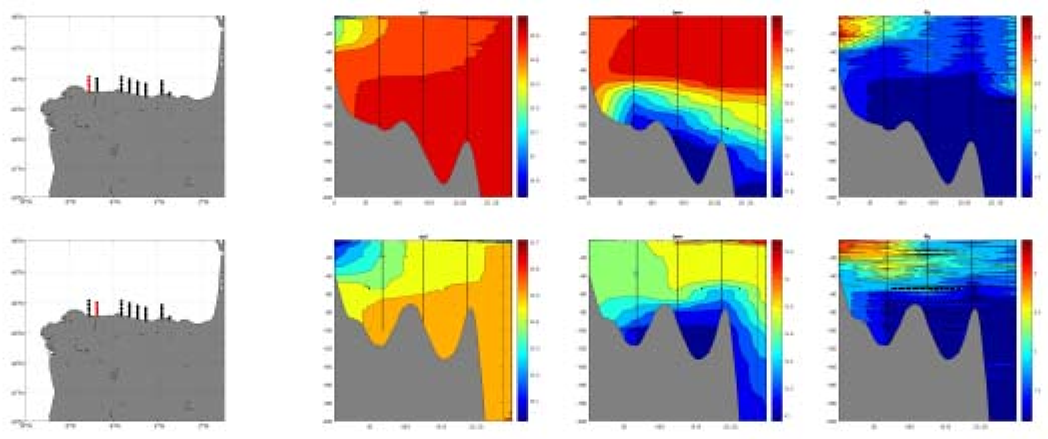


Figure 5a: Vertical profiles of salinity (left pannels) temperature (central pannels) and flourometry (right pannels) from CTD casts obtained at transect normal to the coastline in the Cantabrian Sea. The maps show the location of the transects (note that the scale bars for each plot)

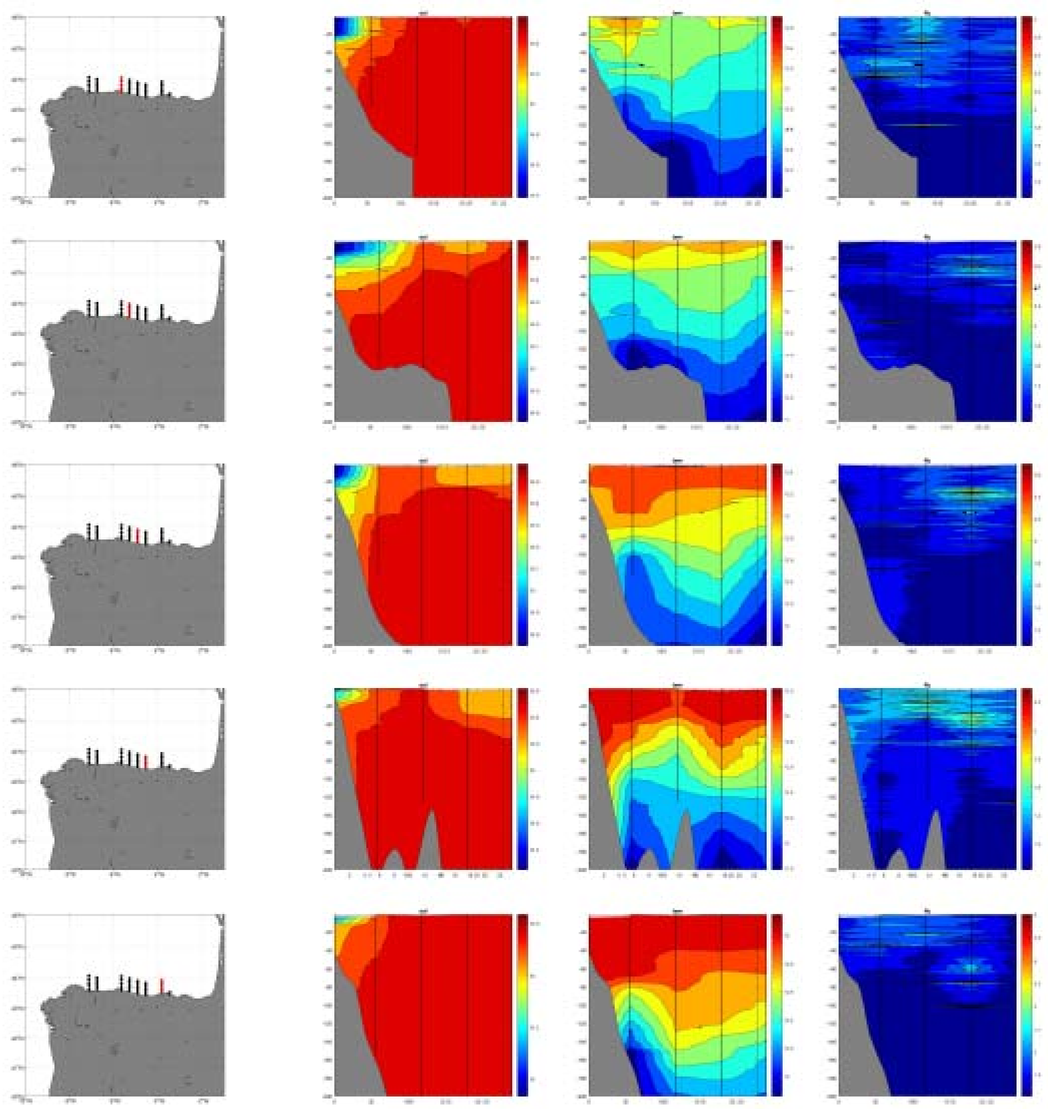


Figure 5b: Cont'd.

Fishing stations

Without including the trawl hauls done at the beginning of the survey for checking and setting up purposes, 49 fishing station were performed, three of them was removed and only 44 were considered valid for assessment purposes. Figure 6 shows the location and the value assigned to each fishing station according to the ground-truth criteria (from 0 to 3).

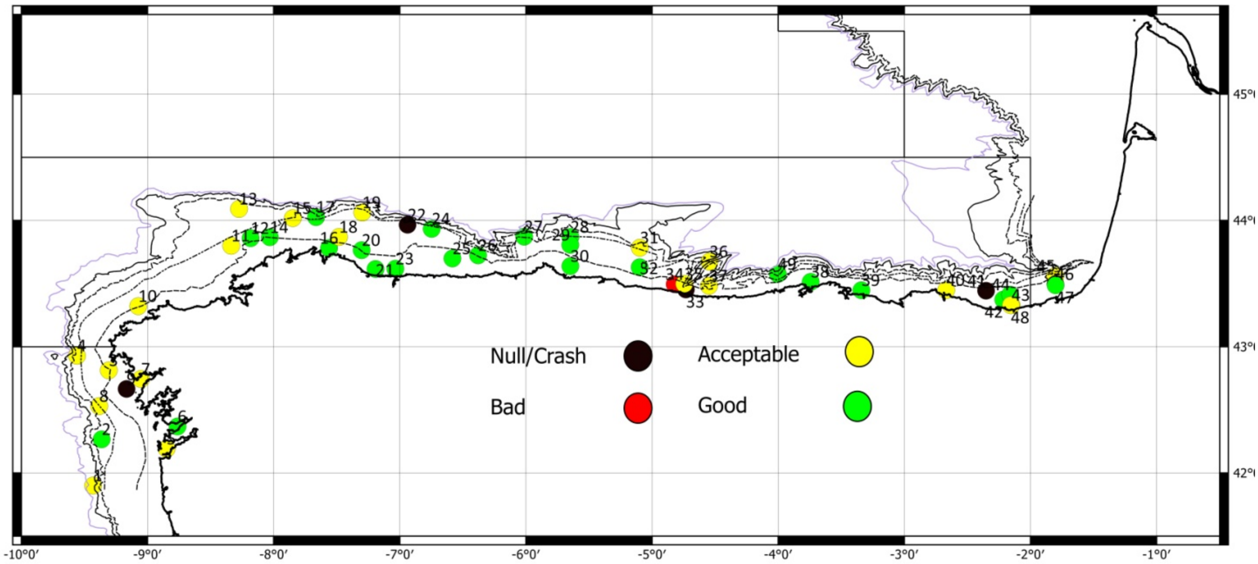


Figure 6: Fishing station and colour system according to ground-truth criteria (red bad; yellow, acceptable; and green good)

As it can be seen, due to either bad weather conditions or even the scarcity of fish, an important amount of the fishing stations were tagged as "acceptable" instead of good, although the performance of the fishing gear was in general good. Unfortunately, the principal gear resulted damaged during a fishing operation and had to be replaced by a smaller one. This gear (a gloria HOD 352 had also a good performance but had a vertical opening of about 4-5 m lesser than the principal. Comparing with the previous year, the number of hauls shows a sharp decrease of a 33%. This was mainly due to the very scarce fish abundance found this year, especially on the self of 9a Subdivision. The reason of this low fish availability could be related with the strong poleward current occurred this year.

A total of 43 mt has been caught corresponding to 247 thousand specimens, 14508 of them being measured. As shown in table 6, mackerel was the most abundant fish species and represented the 84% of the total weight in catches and was present in the 70% of the hauls. Horse mackerel also occurred in most of the hauls (66%) and represented the 4 % of the total catch in weight. Finally, blue whiting and hake accounted for the 25% and 1% respectively of the total catch in number and were present in more than the 50% of the trawl hauls. On the contrary, sardine, which accounted for the 0.96% of the total catch in number, has been only caught in the 25% of the hauls.

	Tot. Catch	No ind.	No F.st.	No meas. Ind.	Mean length	%PRES	% weight	% number
WHB	1943	59964	25	2308	19.64	56.82	4.52	24.27
MAC	36232	119504	31	4071	35.69	70.45	84.31	48.36
HAK	133	1378	35	1300	23.02	79.55	0.31	0.56
HOM	1756	29734	29	2239	20.73	65.91	4.09	12.03
PIL	110	2383	11	859	18.64	25.00	0.26	0.96
JAA	8	32	1	32	30.81	2.27	0.02	0.01
BOG	1582	5583	18	1602	27.55	40.91	3.68	2.26
MAS	218	2392	13	676	24.29	29.55	0.51	0.97
BOC	685	11224	4	439	14.05	9.09	1.59	4.54
Sparidae	9	29	2	29	27.53	4.55	0.02	0.01
ANE	271	14699	9	861	14.70	20.45	0.63	5.95
HMM	26	196	5	92	27.95	11.36	0.06	0.08
Total	***42973***	***247118***		***14508***				

Table 6: Summary of the trawl haul and catches by species, indicating total catch in weight and number, the number of fishing station a particular species has been caught, the total weight and number of measured fish by specie, the overall mean length, the % of presence (number of fishing station with presence/total trawl hauls) and % in weight and number from the total catch in weight and number

Figure 7 shows the backscattering energy proportion allocated to each species on account the fish proportion in number obtained in each trawl haul and the mean TS, calculated from the mean length of each fish species length distribution . Blue whiting accounted for the major proportion of backscattering energy along the self break areas. Bogue and horse mackerel accounted for the major proportion on those fishing stations performed in the middle part of the Catanbrian, while mackerel due to its low TS, was only important when the proportion of this species in the fishing stations was higher than the 90% in number.

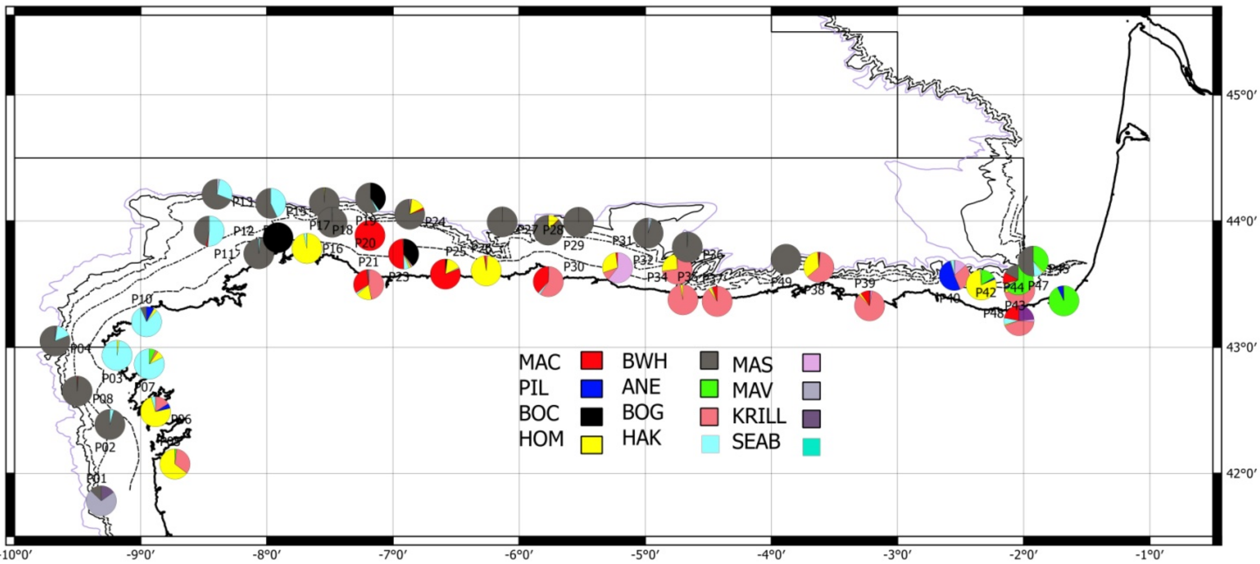


Figure 7: Backscattering energy proportion allocated to each species at each fishing station. (MAC-mackerel; PIL-sardine; BOC-boarfish; HOM- horse mackerel; WHB-blue whiting; ANE- anchovy; BOG-bogue; HAK-hake; MAS-chub mackerel; MAV-M. Muelleri KRILL -M. norvegica; SEAB- Sea breams)

Sardine and anchovy egg distribution CUFES

215 CUFES stations, comprising 3 nautical miles each were taken. This number is considerably lower than last year when 355 were taken, because, due to lack of staff, only alternate transects were sampled during PELACUS in 2016.

The distribution of sardine eggs (obtained from the analysis of 215 CUFES stations) indicates a coastal distribution, agreeing with that observed in previous years (Figure 8). Total number of sardine eggs detected in Spanish waters was 1696, which represents an important decrease from the 2015 value (7588 in 355 CUFES stations), although the number of stations was lower. For this reason, we compared mean egg abundance in 2015 with that obtained this year. While inside the Rias Baixas (coastal waters of IXaN) mean egg abundance, expressed as number of egg/m3, remained quite similar (2.32 in 2015 and 2.5 this year), the highest differences were found in the VIIIc Division where the mean egg abundance decreased from 4.74 to only 1.35 eggs/m3, which is in agreement with the lower fish abundance estimated by echo-integration. Besides, the number of positive stations is still very low (37% in 2016, 45% in 2015, 33% in 2014, 28% in 2013).

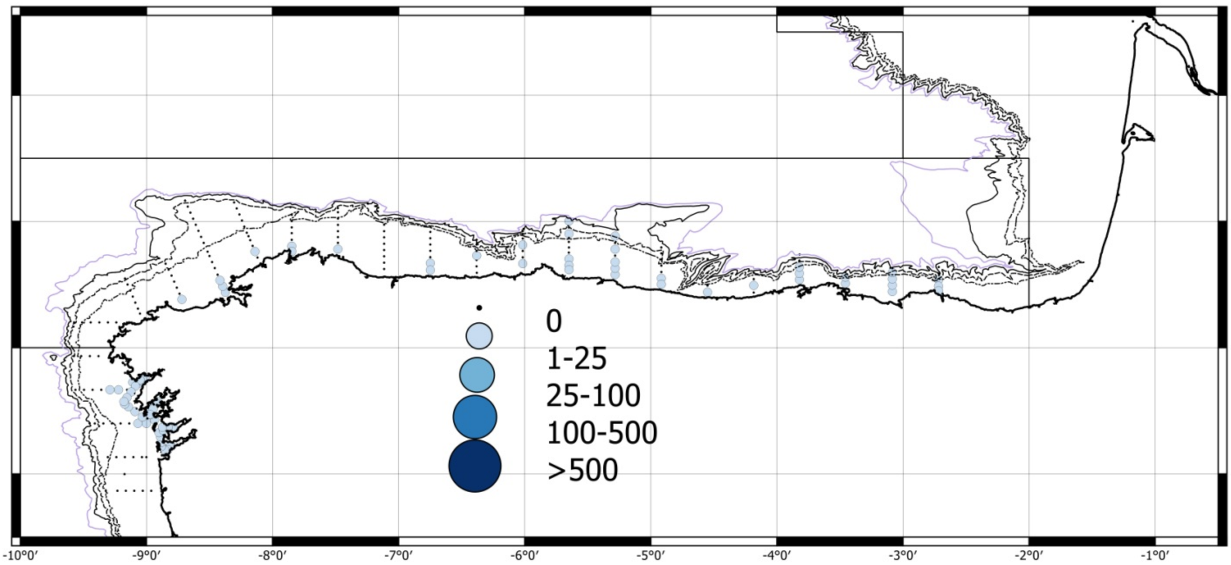


Figure 8. Number of sardine egg collected at the CUFES stations

This year an almost at the same time, the area was also prospected by the CAREVA. This survey, aiming at to estimate the spawning stock biomass of mackerel by the Egg Production Method, was carried out on board R/V Vizconde de Eza which was provided with a CUFES. As show in figure 9, the egg distribution was similar to that found during PELACUS.

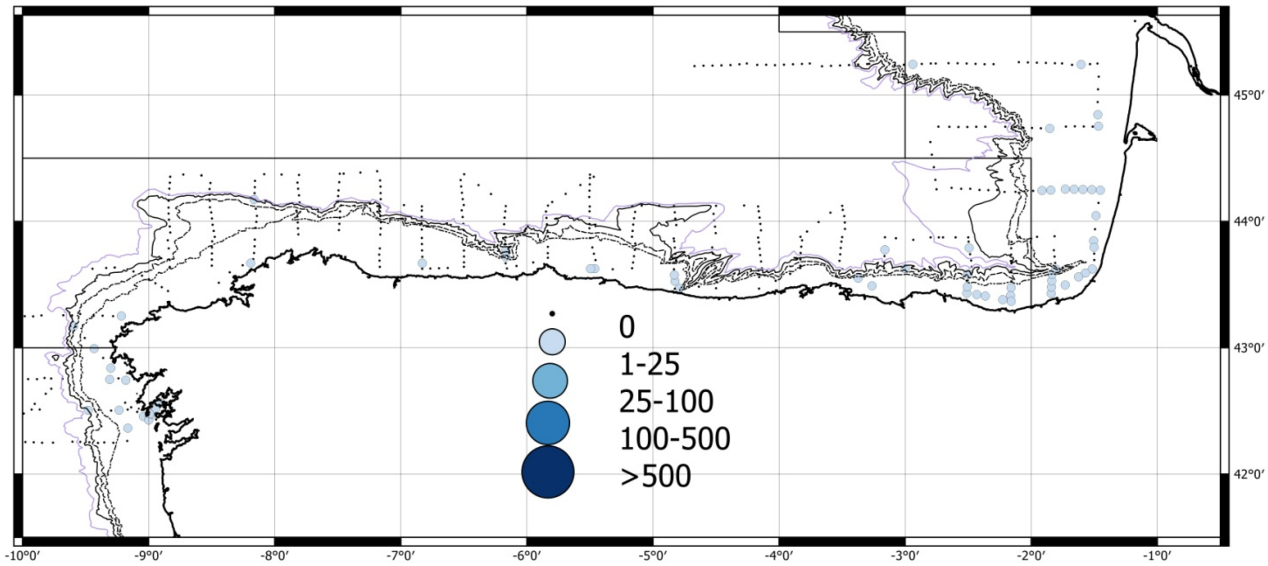


Figure 9. Number of sardine egg collected at the CUFES stations during CAREVA survey

Comparing the results obtained this year with those obtained the previous year, the main differences in egg abundance were found in the Cantabria Sea (8c) where the egg abundance (number egg/m^3) showed a sharp decrease of 75%, as shown in the following table:

Year	ID	POL	AREA	MIN	MAX	MEAN	STDDEV	COUNT
2015	9a	1	277.21672	0	17.32449533	2.315127729	3.5012094937	29
	8c	2	3250.58818	0	98.002496879	4.7359783333	13.267591398	145
Year	ID	Pol	AREA	MIN	MAX	MEAN	STDDEV	COUNT
2016	9a	1	347.24968	0	12.514220705	2.4997614383	3.4656438198	43
	8c	2	3007.9459	0	13.103747022	1.3490912686	2.9967657522	49

Table 7. Results from CUFES sardine egg counts in PELACUS 0315 and 0316., showing the distribution area (nmi^2) and the mean egg per cubic meter. Note that in 2015 only the area inside the rias was covered in Division 9a

Figure 10 shows the anchovy eggs count from CUFES. Although the survey takes place out of the main spawning period (May), eggs are routinely collected in March-beginning April, but in very low density as compared with that of May. Comparing with the previous years, in 2016 the egg distribution was lower than that of 2015, especially in the center part of the Cantabrian Sea, where in 2015 an important amount of anchovy eggs were found. Given the oceanographic conditions found during the survey, more related with winter conditions than those of an incipient spring, the egg production was still lower, far from the spawning activity expected at this period.

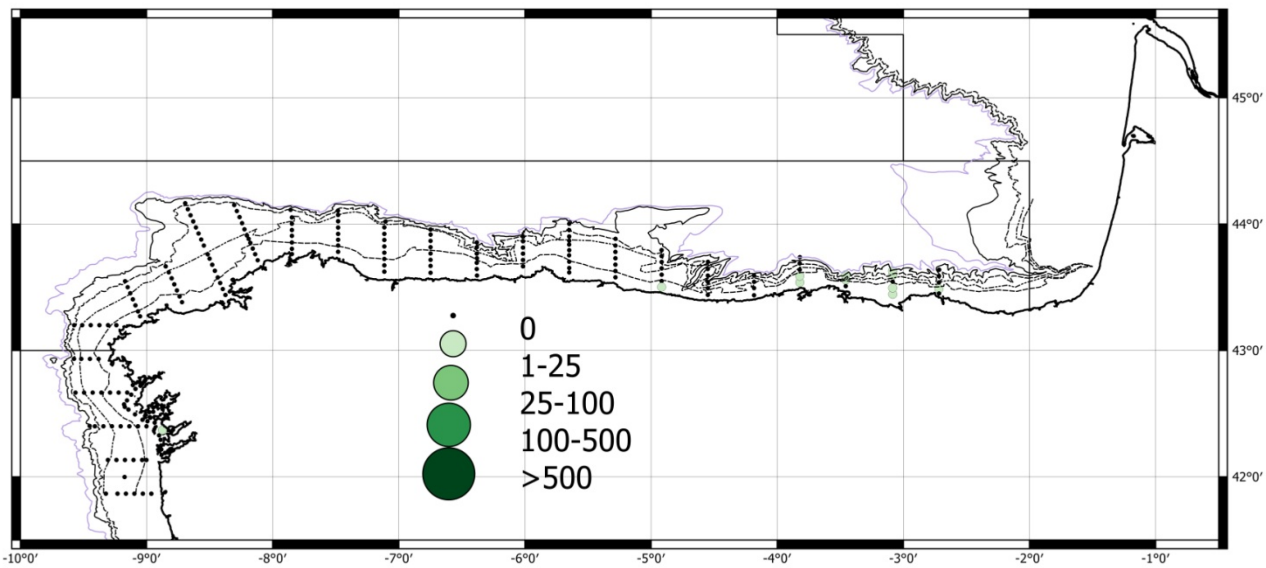


Figure 10. Number of anchovy egg collected at the CUFES stations

Acoustic

A total of 287.615 s_A were attributed to fish species which is little bit higher than that of the previous year when accounted for 254.571 s_A. Table 8 shows the fishing station used to allocate backscattering energy when echotraces were similar to those found around these fishing stations.

Fishing station	**Transects**
P01	RA01, RA03, RA04, RA07, RA08
P01_P02_P04	RA01, RA02, RA03, RA05. RA06, RA07, RA08, RA09, RA10, RA11
P04	RA12, RA13, RA14
P04_P08	RA13
P04_P11_P12	RA15, RA16, RA17, RA18, RA19, RA20
P05	RA08, RA13, RR01, RR02, RR03, RR04, RR05, RR06, RR07, RR08, RR09, RR11
P05_P06	RR12, RR13, RR15, RR16, RR17
P06	RR08, RR09, RR10, RR11
P06_P07	RR19, RR20, RR21, RR22, RR23
P08	RA10, RA12, RA13, RA14
P10	RA11, RA13, RA15, RA16
P11_P12	RA15, RA16, RA17, RA18, RA19, RA20, RA21
P16	RA21
P16_P18	RA24
P18	RA24
P18_P19	RA24
P21	RA26, RA24, RA25
P23	RA27
P24	RA26, RA25, RA27, RA28
P25	RA27, RA28
P26	RA29, RA30, RA31, RA32
P27	RA29, RA30, RA31, RA32
P28	RA32, RA33, RA34
P29	RA32, RA33, RA33, RA34
p30	RA33, RA34
P31	RA35, RA36, RA37
P32	RA35, RA36, RA37, RA38
P35	RA37, RA38, RA39, RA40, RA41, RA42, RA43, RA45
P36	RA38, RA39, RA40, RA41
p37	RA37, RA39, RA40, RA43

P38	RA40, RA41, RA42, RA43, RA44, RA45, RA46, RA47, RA48
P40	RA50, RA51
P42	RA49, RA51, RA53
P43	RA52
P44	RA52, RA53
P44	RA53

Table 8: Fishing station used for backscattering energy allocation and transects

Table 9 shows the backscattering energy distributed by species, 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. This year the occurrence of isolated blue whiting and anchovy schools, ground-truthed by fishing stations increased the amount of direct allocation up to a 33%. For anchovy, 92% of the backscattering energy attributed to this species was directly allocated. In the same way, the majority of the echo-integrated backscattering energy attributed to boarfish was directly asigned (59%). It should be also noticed the direct allocated to sardine. For this species, although the total echointegrated energy was very low, the bulk was concentrated in a single school which accounted for 59% of the total energy (6983 s_A). The implication on the assessment will be further discussed.

	WHB	MAC	HAK	HOM	PIL	JAA	BOG	MAS	BOC	SBR	HMM	ANE	Other	total
Fst	65748	7414	19164	58521	1277	50	17321	13665	536	29	4364	1845	7308	197244
DA	11611	3418	0	34496	10626	0	0	0	784	0	0	20251	9186	90372
Total	77360	10832	19164	93016	11903	50	17321	13665	1320	29	4364	22096	16494	287615
% Fst	84.99	68.44	100	62.91	10.73	100	100	100	40.63	100	100	8.35	44.31	68.58

Table 9: Backscattering energy (s_A) allocated by species, both by direct allocation (DA) and by the fish proportion (Fst) 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; ANE-Anchovy; Other species and- unallocated NASC)

Spatial patterns

Table 10 and figure 11 summarizes the spatial indices of the main fish species.

	BWH	MAC	HAK	HOM	PIL	JAA	BOG	MAS	BOC	SEAB	MAV	ANE	KRILL	HMM	
Total NASC	77357	10832	19164	93016	11903	50	17321	13665	1320	29	4364	22096	7242	84	
Depth	168.38	60.76	81.10	54.77	27.21	100.38	45.46	73.02	68.03	38.58	175.05	34.92	178.22	38.84	
s.d.	369.16	28.61	148.27	122.22	14.18	5.25	52.76	21.36	8.87	1.52	73.77	44.24	75.99	2.68	
ic	44.03	3.41	17.69	14.58	1.69	0.63	6.29	2.55	1.06	0.18	8.80	5.28	9.06	0.32	
Dist 200	5.56	8.81	9.90	5.77	17.94	3.61	8.36	7.58	5.04	5.81	7.04	7.29	8.68	5.45	
s.d.	18.62	7.54	9.85	21.73	8.29	0.27	10.41	4.85	2.58	0.26	2.33	6.17	4.74	0.43	
ic	2.22	0.90	1.18	2.59	0.99	0.03	1.24	0.58	0.31	0.03	0.28	0.74	0.57	0.05	
Dist	218.54	227.40	104.94	186.16	178.49	215.28	246.07	287.44	188.59	367.85	66.65	292.57	97.85	364.23	
s.d.	451.63	57.30	112.85	492.63	159.67	0.90	238.89	25.94	21.40	2.27	45.95	300.10	46.82	3.47	
ic	53.87	6.83	13.46	58.76	19.05	0.11	28.49	3.09	2.55	0.27	5.48	35.80	5.58	0.41	

Table 10: Center of gravity according to the weighting average calculated using Distance from the Origin (Dist, 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; SEAB: Sea breams an other sparidae; MAV-pearlside, ANE-anchovy ; HMM-mediterranean horse mackerel.

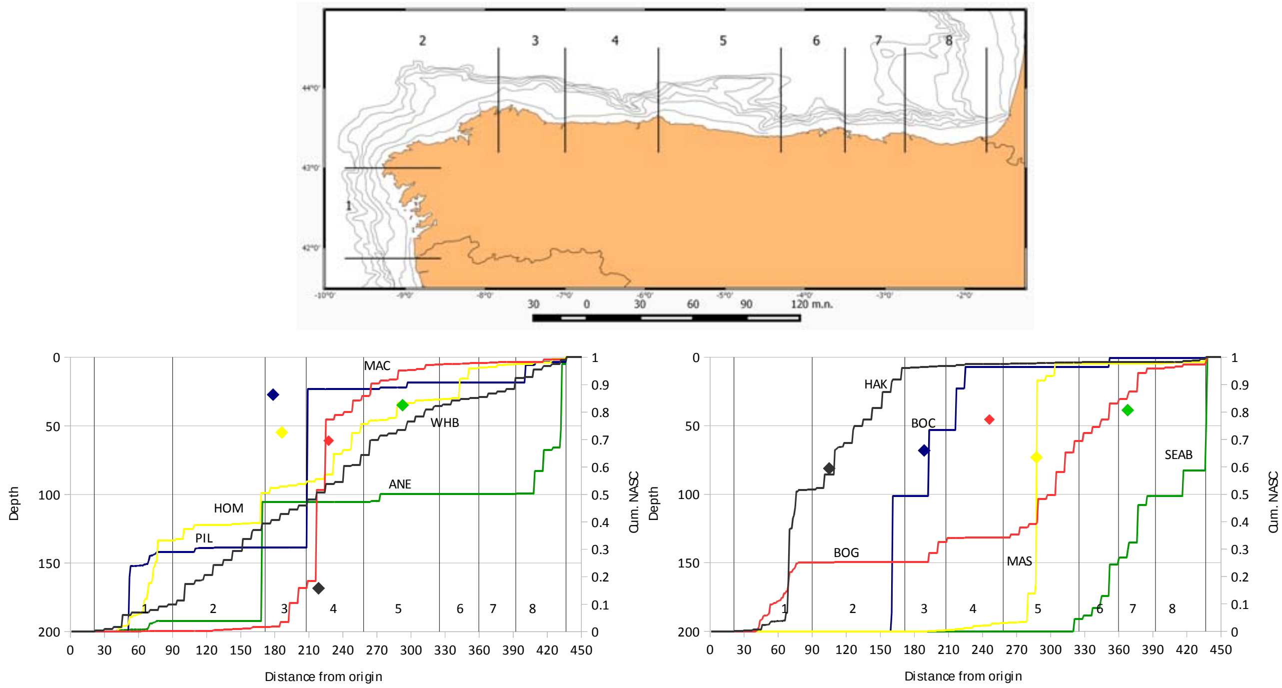


Figure 11: Centre of gravity of NASC distribution for the main fish species and cumulated probability density function along the survey. Surveyed area was divided into geographical zones in order to better understand the plots.

As in previous year, horse mackerel accounted the highest NASC values at 38 kHz, with almost the 32% of the total cumulated backscattering energy. Main distribution areas for this fish specie were located in both IXa N (area 1) and central Cantabrian Sea (areas 3-5; VIIIc-Ew) Mean depth was located close to the coast, at 55 m depth. Blue whiting was evenly distributed and, contrary to that found in the previous year, mean depth was located on the shelf, at 168 m; this could be related with the small amount of off-shore pelagic schools found this year. On the other hand, mackerel was mainly found in the central part of the Cantabrian Sea, round the western part of Cape Peñas, and closer to the coast than that observed in 2015 when the 20% of the total backscattering energy was found in IXaN, and, in general, well spread along the whole continental shelf. The direct allocation of some schools to anchovy and sardine close to Cape Ortegal, changed the perception about the distribution of both species. Excluding those, sardine is showing the same preferential areas, located in Ixa N and VIIIc Ee. In the case of anchovy, although some schools were found in IXa N, the bulk of the distribution was located at the inner part of the Bay of Biscay.

For the other species, it should be noted the high presence of hake, mainly juveniles, in Galicia (IXaN and VIIIcW); for this fish species, an important amount of earlier pre-juveniles were found off NW Galician Waters (VIIIcW), suggesting a good strength of the 2016 recruitment.

Sardine distribution and assessment

Sardine distribution was very scarce in both occupied area and density, as shown in figure 12. Sardine mainly occurred in isolated nuclei. In central Cantabrian Sea, as it has been already observed in previous years, no clear echotrace of sardine schools have been detected, with sardine occurring rather in scatterer echotraces in in-homogeneus agregates an mainly with other fish species. In such circumstances, with sardine observed in a mixed layer with other fish species (mainly mackerel, horse mackerel or bogue) no direct allocation from scrutinization is feasible, being the backscattering energy attributed to sardine derived from the results obtained at the ground-truth fishing stations (length distribution and catch in number). Even in this case, giving its low abundance compared with the other fish species, it is very difficult to get representative samples of sardine; in this case, no length distribution has been got from VIIIc-Ew.

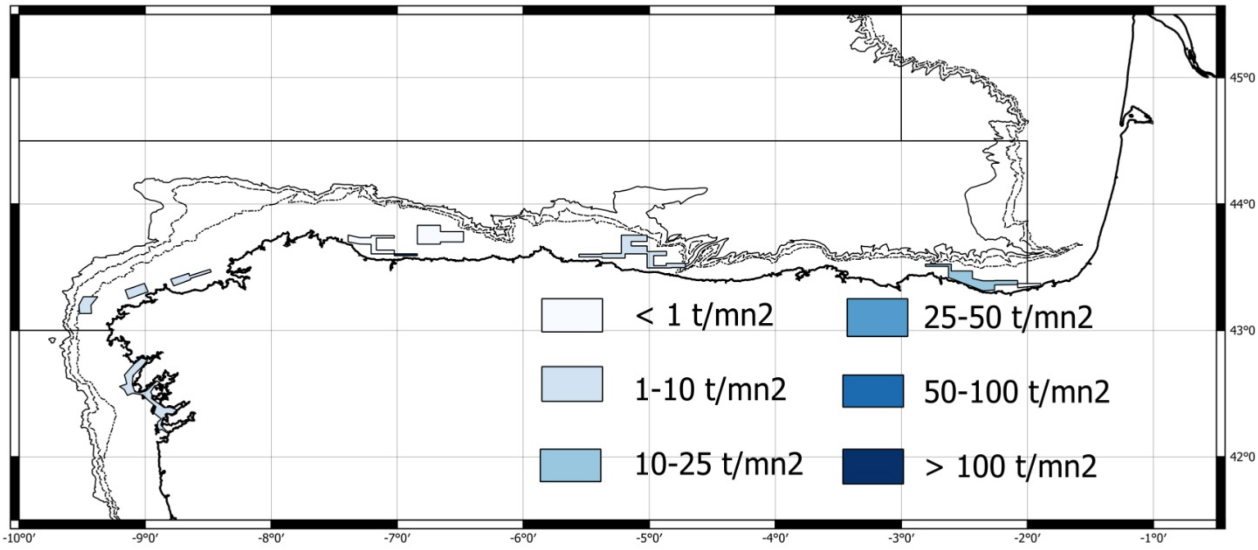


Figure 12. Sardine: spatial distribution of energy allocated to sardine during 2016 PELACUS surveys. Polygons are drawn to encompass the observed echoes, and polygon colour indicates sardine density in t nm^{-2} within each polygon

Nevertheless, at the end of the track number 26, in the coastal area and in very shallower waters, a echotrace corresponding to a school has been detected. This particular school, although not fished, had energetic and morphological characteristics compatible with those of the sardine (sV mean= -30.15 dB, sV max= -18.85 db; length= 23 m length; height=7.6 m; NASC=6982.75 m2/nmi2) (figure 13). This single school accounted the 59% of the total backscattering energy allocated to sardine. For this reason, the assessment has been done accounting and without accounting this possible sardine school in the estimation of the biomass.

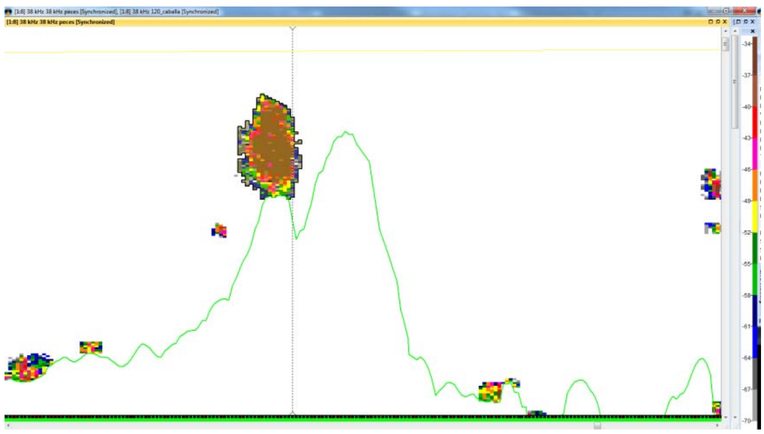


Figure 13. Echotrace attributed to a sardine school. A Mask, to remove other backscatters than those belonging to swimbladder fish and the bottom, has been applied. Total depth is represented as a green line.

A total of 13,960 tons of sardine (308 million fish) were estimated to be present in the surveyed area. That represents a small increase in relation to 2015 abundance and biomass, being still at the lower levels of the time series. If the school attributed to sardine is removed from the estimation, only 3205.5 tonnes, corresponding to 70.3 million fish, were assessed, being, thus, the lowest value ever recorded (table 11).

Zone	Area	No	Mean	Area	Fishing st.	PDF	No (million fish)	Biomass (tonnes)	Density (Tn/nmi-2)
IXa	Rias Baixas	75	46.83	118	P06	S01	26	1032	9
	Total	***75***	***47***	***118***			***26***	***1032***	9
VIIIc-W	Fisterra	4	5.12	35	P10	S02	1	40	1
	Artabro_1	4	38.89	32	P10	S02	4	272	9
	Artabro_2	4	7.05	31	P10	S02	1	49	2
	Total	***12***	***17.02***	***98***			***5***	***362***	4
VIIIc-Ew	Masma	6	0.12	56	P40-P42-P47	S03	0	1	0
	Asturias_oc	15	0.24	110	P40-P42-P47	S03	0	5	0
	Asturias_or	16	18.54	140	P40-P42-P47	S03	11	500	4
	Total	**37**	***8.14***	**307**			***11***	***506***	2
VIIIc-Ee	Euskadi	14	63.92	105	P40-P42-P47	S03	29	1298	12
	Total	**14**	***63.92***	**105**			**29**	**1298**	12
VIIIb	Euskadi	2	3.20	12	P40-P42-P47	S03	0	8	1
	Total	***2***	***3.20***	***12***			***0***	***8***	1
	Total IXa	***75***	***47***	***118***			***26***	***1032***	9
	Total VIIIc	***63***	***22***	***510***			***45***	***2166***	4
	Total VIIIb	***2***	***3***	***12***			***0***	***8***	1
	Total Spain	***140***	***35.13***	***640***			***70***	***3205***	5

Table 11: Sardine acoustic assessment

Length ranged from 14 to 24 cm, with a mode at 18.5 cm (Figure 13) which corresponds to quite large fish. Age 2 was the most abundance (45% in number and 43% in weight), followed by age 3 (25% of the abundance and 28% of the biomass). On the other hand, age 1 only represented the 21% in number (17% of the biomass). Accordingly, no signal of a good recruitment has been observed. (Table 11, Figure 14).

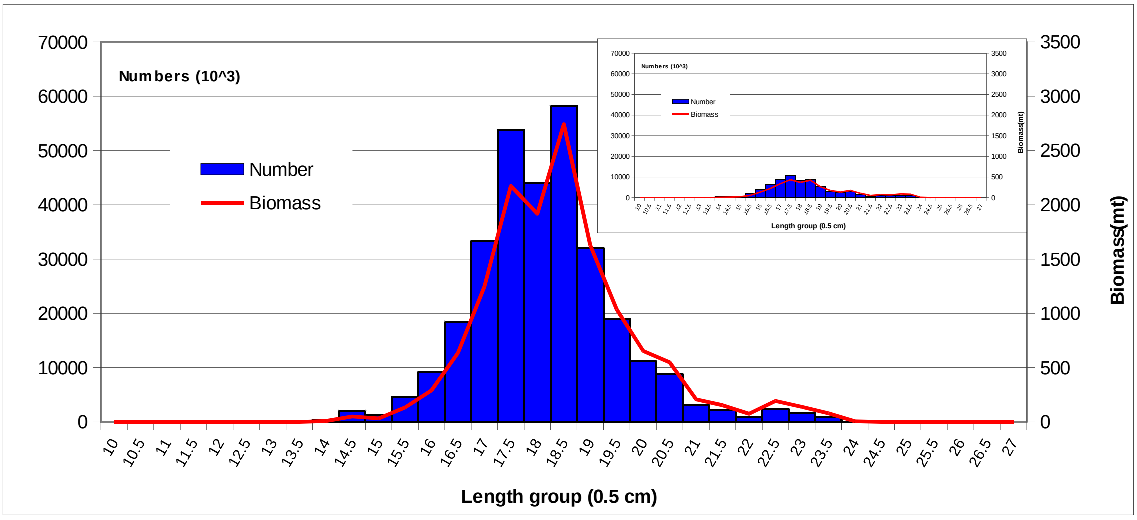


Figure 14: Sardine fish length distribution in biomass and abundance during PELACUS0316 survey (including VIIIb subdivision). In the small chart, the estimates when excluded the school accounted as probably sardine.

By sub-area, VIIIcEast-West subdivision represents 83.2%, VIIIcEast- East 8.2%, IXa North 7.2% and VIIIc West 1.4 of the total abundance. Age group 1 was dominant in IXaN, while it was absent in VIIIcW, were age group 4 was dominant. In VIIIcE, age group 2 was the most abundant (Figure 15).

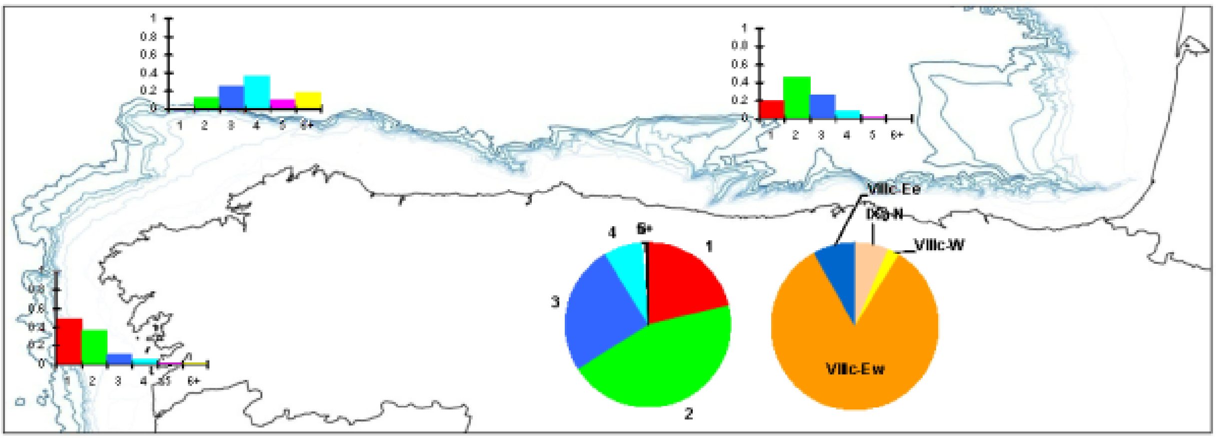


Figure 15. Sardine: relative abundance at age in each sub-area (i.e. the proportion of all age classes within sub-area sum to 1) estimated in the PELACUS0316. The pie chart shows the contribution of each sub-area and each age group to the total stock numbers.

AREA VIIIcE											
AGE	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (Tonnes)	2289	6482	4291	1304	102	7	28	28			14532
% Biomass	15.8	44.6	29.5	9.0	0.7	0.0	0.2	0.2			100
Abundance (N in '0(	62246	147708	84936	23374	1851	79	346	346			320886
% Abundance	19.4	46.0	26.5	7.3	0.6	0.0	0.1	0.1			100
Medium Weight (gr	36.78	43.88	50.52	55.80	55.07	86.01	82.08	82.08			45.29
Medium Length (cm	17.12	18.25	19.19	19.88	19.76	23.25	22.86	22.86			18.42

AREA VIIIcW											
AGE	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (Tonnes)		38	84	126	39	15	31	28			362
% Biomass		10.4	23.2	35.0	10.9	4.2	8.7	7.7			100
Abundance (N in '000)		575	1194	1674	495	183	352	325			4798
% Abundance		12.0	24.9	34.9	10.3	3.8	7.3	6.8			100
Medium Weight (gr)		65.5	70.2	75.6	79.4	83.3	88.9	85.4			75.4
Medium Length (cm)		21.1	21.6	22.1	22.6	23.0	23.5	23.2			22.1

AREA IXaN											
AGE	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (Tonnes)	408	375	132	78	18	2	11	8			1032
% Biomass	39.5	36.3	12.8	7.5	1.8	0.2	1.0	0.8			100
Abundance (N in '0(	12249	9179	2419	1204	240	29	120	100			25540
% Abundance	48.0	35.9	9.5	4.7	0.9	0.1	0.5	0.4			100
Medium Weight (gr	33.30	40.85	54.59	64.40	76.94	76.05	89.21	84.47			40.42
Medium Length (cm	16.5	17.8	19.7	20.9	22.3	22.3	23.6	23.1			17.6

TOTAL SPAIN											
AGE	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (Tonnes)	2697	6894	4507	1508	160	24	70	65			15926
% Biomass	16.94	43.29	28.30	9.47	1.00	0.15	0.44	0.41			100
Abundance (N in '0(	74495	157462	88549	26253	2586	291	818	771			351225
% Abundance	21.21	44.83	25.21	7.47	0.74	0.08	0.23	0.22			100
Medium Weight (gr	36.21	43.78	50.90	57.46	61.75	83.34	86.06	83.79			45.34
Medium Length (cm	17.02	18.23	19.24	20.07	20.53	22.98	23.25	23.02			18.41

Table 12: Sardine acoustic assessment

Mackerel distribution and assessment

Mackerel was the most abundant species, although occurring in a smaller area as compared with that found in previous ones, with only few numbers in the western part (i.e. almost negligible in 9a). Moreover, it seems the availability of mackerel was different to that observed since 2013. At the beginning of March the amount of available mackerel was very scarce. This was corroborated by the egg survey CAREVA, which surveyed the inner part of at the beginning of March, and also by the fishing fleets targeting on mackerel at this period in this area. Also, both the aggregation and the distribution patterns seemed to be different. Once arrived at the Cantabrian Sea, mackerel rather occurred in thick schools and less in an epipelagic layer (round 20-50 m depths); besides, no surface concentrations were observed as seen in previous years. These schools, which were thicker as compared to those found in previous years, had a patchy distribution, giving the perception of different waves of fish moving westwards, trying to occupy the expected normal distribution area.

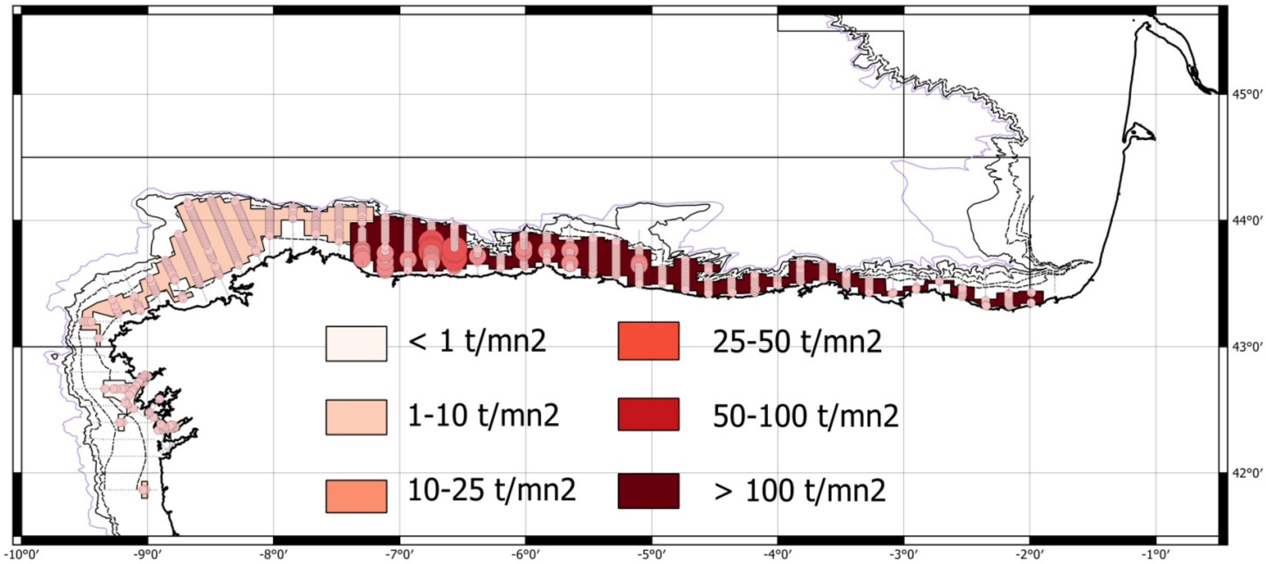


Figure 16. Mackerel: spatial distribution PELACUS0316 cruise. Polygons are drawn to encompass the observed echoes, and polygon colour indicates the mean density expressed as tonnes per squared nautical mile (<1,; 1-10; 10-25; 25-50; 50-100; and >100)

Table 13 shows the mackerel assessment. Round half million tonnes (497.652 mt) have been estimated, corresponding to 1.566 million fish, which is similar to that estimated in 2015 but lower than that of 2014, when mackerel mainly occurred in a continuous thick epipelagic layer.

Zone	Area	No	Mean	Surface	Fishing st.	PDF	No (million fish)	Biomass (tonnes)
Ixa-N	Pontevedra	21	0.14	27	P06	ST01	0	16
	Vigo	2	2.06	17	P08-P11-P12-P18	ST02	1	164
	Muros	47	0.52	152	P08-P11-P12-P18	ST02	0	17
	Total	***70***	***0.45***	***196***			***1***	***197***
VIIIc-W	VIIIc-W	224	1.62	1771	P08-P11-P12-P18	ST02	90	13740
	Total	***224***	***2***	***1771***			***90***	***13740***
VIIIc-E	VIIIc-E	340	30.70	2653	P20-P21-P23-P24-P25-P26-P29-P30-P32-P35-P37-P38-P39-P43-P44-P48	ST03	1475	483715
	Total	***340***	***31***	***2653***			***1475***	***483715***
	Total VIIIc	***564***	***19***	***4424***			***1565***	***497454***
	Total Spain	***634***	***17***	***4620***			***1566***	***497652***

Table 13 Mackerel acoustic assessment

Length distribution estimated for the whole surveyed area remains similar to that observed the last year. The main mode is located on adult fish (37cm; 36 cm in 2015). However, a second small mode on younger small fish was this year located at 28 cm while in 2015 and 2014 it was found at 22 cm (figure 17). The population is dominated by age group 6 followed by ages 7 and 8. Age group 5 was also abundant and age 9 was more abundant than the younger ages (i.e.1-4 age groups) (see table 14). This age composition agrees with the lack of younger fish observed in the previous years (Figure 17).

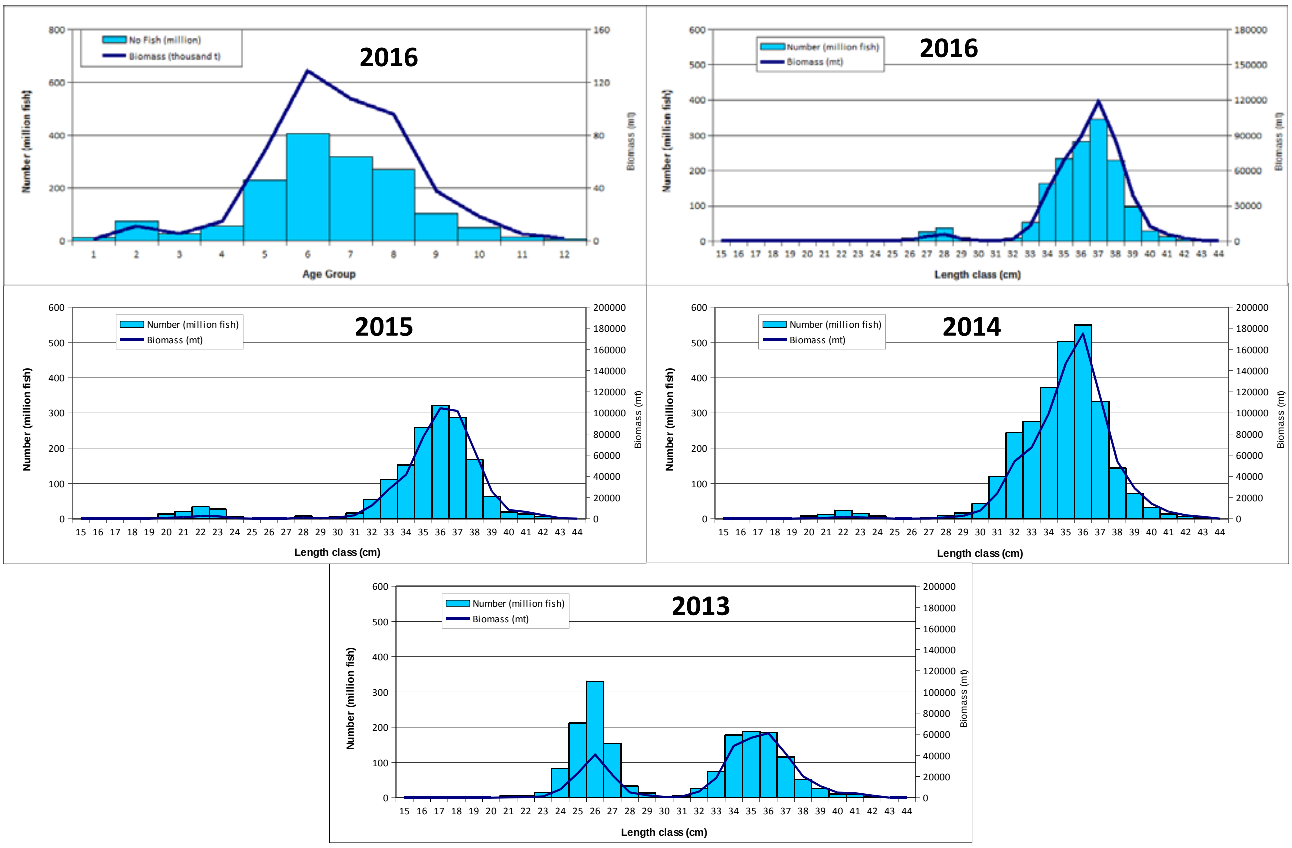


Figure 17. Mackerel age and length distribution in number and biomass estimated in 2016 together with the length distributions estimates in previous years.

Mackerel seems to be able to occur in an epipelagic layer when the weather conditions are good (i.e. no high swells neither strong winds). When this layer is well established, as happened in 2014, mackerel would be more accessible to the acoustic frequencies, as mainly occurred in a dense epipelagic layer and less diffused in the whole water as seen in bad weather conditions. The worse weather conditions found in the rest of years as compared with that of 2014 would be related with the high estimate in that year.

The occupied area remained more stable at around 4500 nmi^2, although, due to the presence in 9a Division, the area in 2015 was much higher. Therefore the density showed a sharper fluctuation that the area, reaching the maximum in 2015, as explained previously.

On the other hand, the lack of a good signal of recruitment at age 1 or 2 since 2013, give an apparently contradictory situation of that observed in summer time during the International Ecosystem Summer Survey in the Northern Seas (IESSNS). This survey, done by 4 vessels during mackerel feeding period (summer time around the Norwegian Sea and beyond) uses a epipelagic gear, covering from near surface up to 30 m depth and estimates the biomass using the Swept Area Method. All fish that undertake feeding migration may be accessible to this survey, being, therefore, a good indicator of the pooled spawning components. Figure 18 shows a comparison between the cumulated biomass and numbers per age group in both surveys. While in the northern areas in summer (main feeding period) the bulk of the population is mainly composed by younger ages, in the Cantabrian Sea in spring (spawning period) older ages are dominant (almost 60% in number of the population belonged to age group 5 or younger at the IESSNS survey, while this percentage during PELACUS was only 25%).

Length	1	2	3	4	5	AGE GROUPS 6	7	8	9	10	11	12	Total	No fish (million)
10														
11														
12														
13														
14														
15														
16														
17														
18	0.02												0.02	0
19	0.06												0.06	1
20	0.22												0.22	4
21	0.09												0.09	1
22	0.00												0.00	0
23	0.15	0.03											0.18	2
24	0.25	0.04											0.29	3
25	0.12	0.13											0.25	2
26	0.09	0.92											1.01	8
27		3.61	0.27										3.88	27
28		5.15	0.98										6.13	38
29		1.26	0.48	0.07									1.81	10
30		0.00	0.41										0.41	2
31		0.04	0.12	0.00	0.04								0.20	1
32		0.00	2.10	0.00	0.08								2.18	10
33			0.95	4.54	6.48	1.30							13.26	54
34			0.02	6.44	14.17	19.32	3.88						43.82	163
35				1.79	16.10	31.01	15.51	3.58	0.60				68.58	235
36				1.31	16.33	30.05	21.56	15.68	3.27	0.65	0.65		89.49	282
37				0.65	9.75	22.10	30.54	34.49	13.00	7.15	0.65	0.65	118.97	346
38					4.54	17.39	23.43	23.43	9.83	5.29	1.51		85.41	230
39					1.40	2.81	9.12	14.73	6.31	3.51	0.70	0.70	39.29	98
40						1.47	1.47	3.44	2.95	1.96	0.98	0.49	12.76	30
41						0.84	1.67	0.84	1.67		0.84		5.86	13
42						2.61							2.61	5
43							0.58					0.29	0.87	2
44														
Biomass (thousand t)	1	11	5	15	69	129	108	96	38	19	5	2	497.65	1566
%	0.20	2.25	1.07	2.97	13.84	25.90	21.65	19.33	7.56	3.73	1.07	0.43		
M. weight	73.97	144.10	193.11	268.23	297.73	315.26	337.27	353.38	365.11	367.85	383.78	398.56	311.66	
No Fish (million)	13	74	27	55	230	406	318	271	103	50	14	5	1566	
%	0.81	4.70	1.70	3.51	14.70	25.95	20.31	17.33	6.56	3.22	0.88	0.34		
M. length	22.36	27.98	30.88	34.49	35.72	36.42	37.26	37.84	38.26	38.36	38.91	39.41	36.28	
s.d.	2.31	0.96	2.06	1.11	1.45	1.60	1.45	1.18	1.28	1.04	1.59	1.80	2.93	

Table 14: Mackerel assessment by length class and age group.

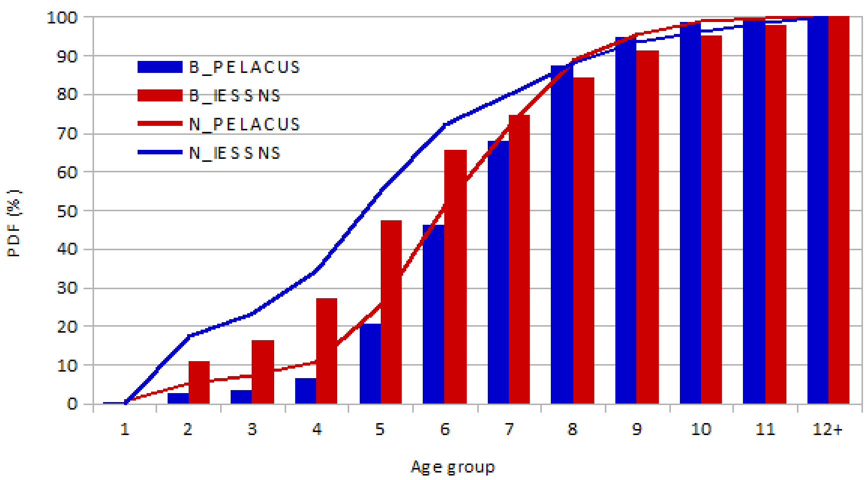


Figure 18: Cumulated age distribution in both number and biomass per age group estimated at PELACUS and IESSNS surveys.

Blue whiting distribution and assessment

As stated previously, main blue whiting distribution area is located around the self-edge. Besides is the closest fish species to the 200 m isobath, occurring with lantern fish (Maurolicus muelleri) and krill (Meganyctiphanes norvegica) in a scattering layer, together with some hake and horse mackerel adults. Sometimes this co-occurrence makes difficult to establish the right quantity of allocated back-scattering energy to each fish specie. In spite of that, the density was still low as compared with the historical records observed in the nineties, although, a small extension of the distribution area towards open waters in pelagic layers has been found. Nevertheless, as observed in the previous years, it seems that the distribution is spreading through the continental shelf, specially in the Cantabrian Sea.

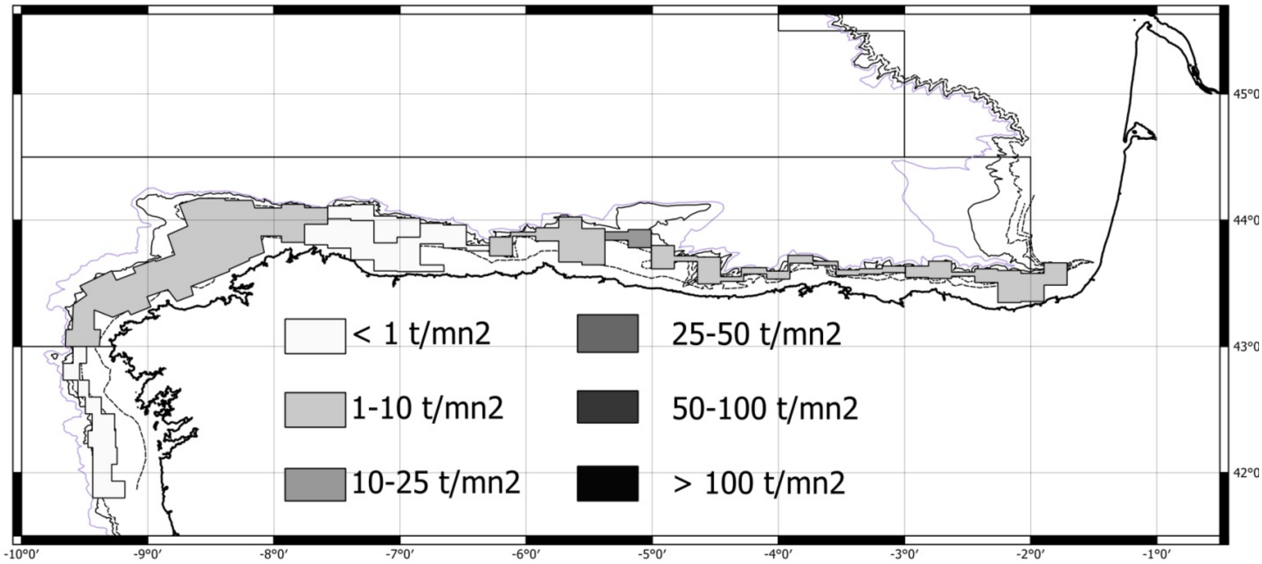


Figure 19. Blue whiting spatial distribution PELACUS0316 cruise. Polygons are drawn to encompass the allocated back-scattering energy, and polygon colour indicates the mean density expressed as tonnes per squared nautical mile (<1,; 1-10; 10-25; 25-50; 50-100; and >100)

Table 15 shows the blue whiting assessment. A total of 24.3 thousand tonnes corresponding to 614 million fish has been estimated. Comparing to previous years, there is an increasing trend since 2013 when only 7146 mt (123 million fish) were assessed. However, there was a slight decrease as compared with the 2015 assessment ($28.8 \cdot 10^3$ mt).

Zone	Area	No	Mean	δ^2	Area	Fishing st.	PDF	No (million fish)	Biomass (tonnes)
IXa	IXa	67	114.43	185.35	516.29	P02-P04-P08-P12-P15-P17	S01	69	2678
	Total	**67**	**114**		**516**			**69**	**2678**
VIIIc-W	North Galicia	100	70.60	155	2088	P02-P04-P08-P12-P15-P17	S02	173.40	6683.44
	Total	***100***	***71***		***2088***			***173***	***6683***
VIIIc-E	Masma	257	92.19	206	787	P19	S03	54	3931
	West Cantabrian	59	225.25	431	282	P28-P24	S04	80	2811
	Penas	38	109.35	120	447	P27-P28-P29-P36-P49		58	2227
	Llanes	51	215.37	250	101	P31		20	1100
	Cantabria	13	116.12	114	407	P29-P36-P49		60	2095
	Euskadi	65	138.44	292	491	P44-P45		100	2817
	Total	***483***	***129.67***		***2514***			***371***	***14981***
Total IXa		***67***	***114***		***516***			***69***	***2678***
Total VIIIc		***583***	***120***		***4602***			***544***	***21665***
Total Spain		***650***	***119.01***		***5119***			***614***	***24343***

Table 15: Blue whiting assessment

Age group 1 was dominant, but the strength of the 2015 seems to be less important than that of of 2014, which is also corroborated by the importance of age group 2 (figure 20). On the other hand, according to the results obtained since 2013, it seems that the density, expressed as number of fish per square nautical mile, remains more or less stable and, therefore, the increases in biomass (number) are related with an expansion of the occupied area (figure 21).

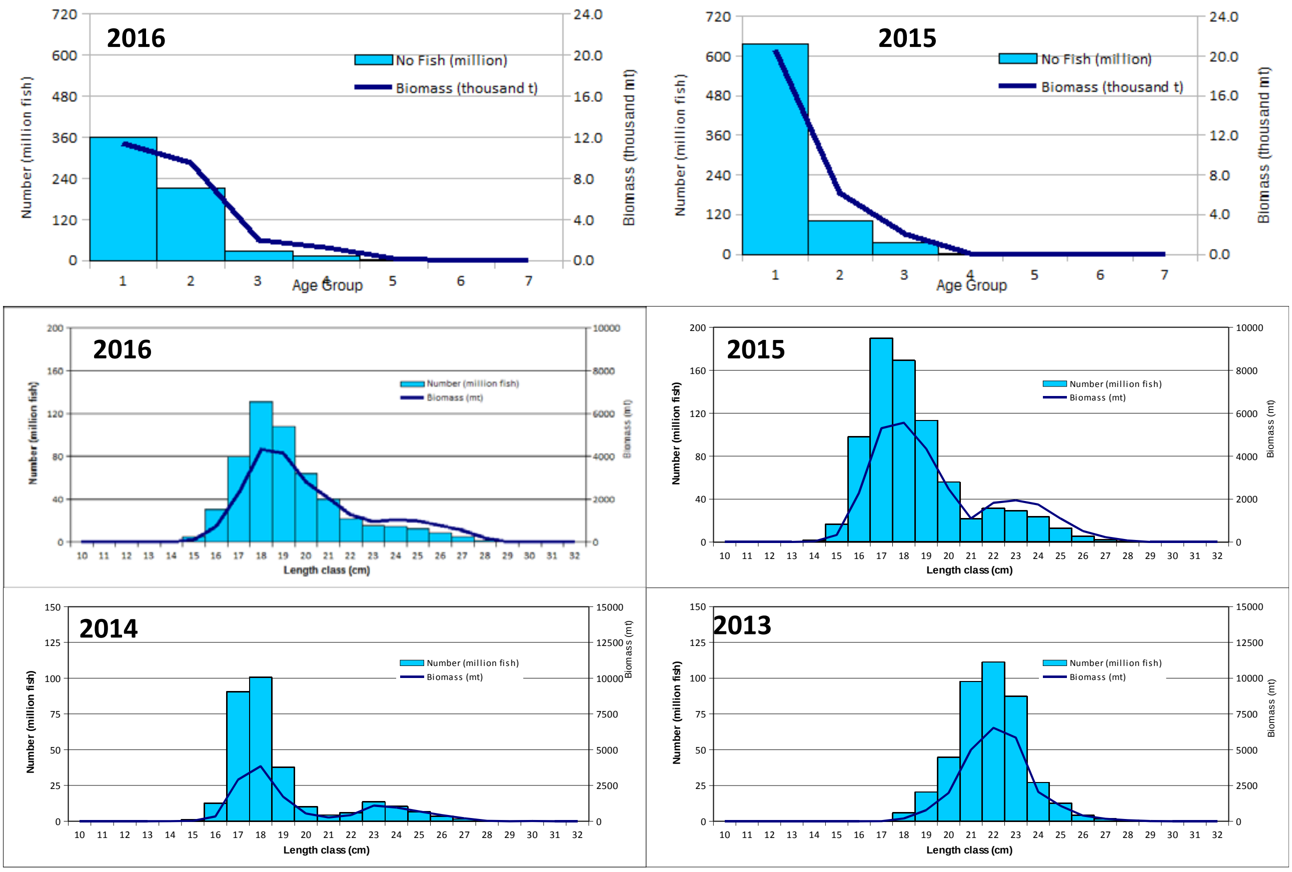


Figure 20. Blue whiting age distribution in both number and biomass during 2016 and 2015 surveys (above) and biomass and abundance estimates by length classes since 2013 survey.

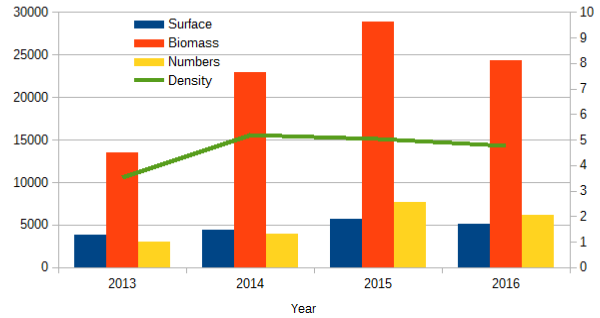


Figure 21. Blue whiting 2013-16 estimates in number and biomass together with the distribution area and mean density.

	AGE GROUPS								
Length	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**	**No fish (million)**
10									
11									
12									
13									
14	0.00							0.00	0
15	0.23							0.23	11
16	1.12	0.10						1.22	51
17	2.77	0.35						3.11	110
18	4.03	0.82						4.86	147
19	2.49	1.58	0.12					4.19	110
20	0.72	2.10						2.82	64
21	0.05	1.96	0.05					2.06	41
22		1.15	0.08	0.04				1.27	22
23		0.73	0.18	0.06				0.97	15
24		0.51	0.36	0.20				1.08	15
25		0.18	0.36	0.36	0.09			0.98	12
26			0.51	0.26				0.77	9
27			0.21	0.28	0.07			0.56	6
28			0.06	0.06	0.06			0.19	2
29				0.00	0.01			0.01	0
30									
Biomass (thousand t)	11.4	9.5	1.9	1.3	0.2	0.0	0.0	24.3	613.7
%	46.90	38.99	7.96	5.20	0.94			100.00	
M. weight	31.44	44.22	72.00	82.46	92.92			38.12	
No Fish (million)	359	210	26	15	2	0	0	614	
%	58.56	34.28	4.28	2.48	0.40			0.00	
M. length	18.16	20.54	24.50	25.74	26.87			19.47	
s.d.	1.16	1.84	2.41	1.44	1.32			2.44	

Table 16: Blue whiting assessment

Horse mackerel distribution and assessment

Horse mackerel density was lower than that found the previous year. In IXaN, only few schools were detected inside the Rias and the distribution was very scarce along the continental self. In the Cantabrian sea (VIIIc-E) was evenly distributed but still in lower density than that occurred in the previous year (figure 22).

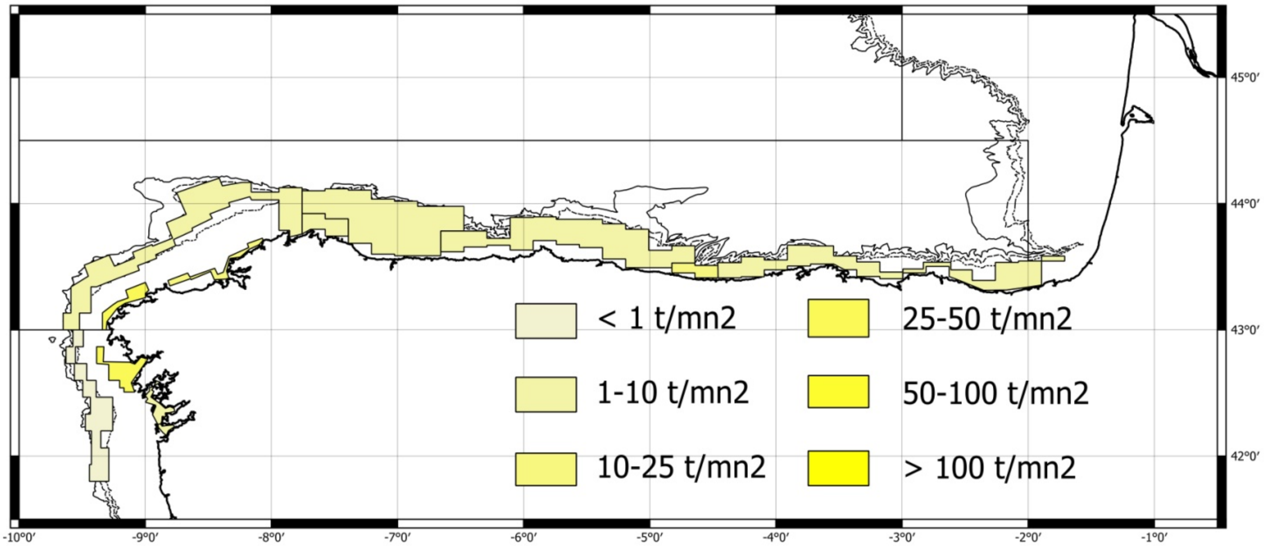


Figure 22. Horse mackerel spatial distribution PELACUS0316 cruise. Polygons are drawn to encompass the observed echoes, and polygon colour indicates the mean density expressed as tonnes per squared nautical miles (<1,; 1-10; 10-25; 25-50; 50-100; and >100

Total biomass was estimated to be 37867 mt (764 million fish, table 17), much lower than that assessed in 2015 (94 thousand tonnes). Main differences were found in 9a, (five times lower -26.9 versus 5.3 thousand tonnes estimated this year-), and in the Cantabrian Sea (22.7 vs 58.6, thousand tonnes estimated last year). In NW Galicia (VIIIc-W) the biomass remained stable. Age group 2 was dominant in both stock (southern and western), although in the southern stock, the length distribution ranged between 14 and 22cm, with a peak at 20 cm (table 18, figure 23 and

Zone	Area	No	Mean	Surface	Fishing st.	PDF	No (million fish)	Biomass (tonnes)
IXa-N	RIA VIGO	19	74.15	15.18	P05	ST01	2	68
	PONTEV-AROUSA	41	126.84	57.43	P06	ST02	15	424
	MUROS	48	509.90	143.17	P07	ST03	106	4782
	IXa-off	52	0.36	399.76	P21-P24	ST04	0	12
	Total	***160***	***194***	***615.53***			***122.54***	***5285.89***
VIIIc-w	COSTA MORTE	10	525.18	84.48	P07	ST03	64	2906
	VIIIc-West	117	87.65	977.33	P21-P24	ST04	83	6680
	ARTABRO	11	59.00	80.43	P16	ST05	6	336
	Total	***138***	***117***	***1142.2***			***153.13***	***9922.67***
VIIIc-E	ESTACA	15	127.08	128.11	P16	ST05	19	1086
	MASMA	141	24.13	1095.17	P21-P24	ST04	21	2035
	ASTURIAS	132	193.81	993.34	P25-P26-P29-P32	ST06	329	11417
	LLANES	11	70.38	85.23	P35	ST07	18	302
	VIIIc-East	102	137.59	781.41	P38-P39-P42-P43	ST08	101	7818
	Total	***401***	***114***	***3083***			***488.25***	***22658.23***
	Total VIIIc	***539***	***115***	***4225***			***641***	***32581***

Table 17: Horse mackerel assessment

22). However, as can be observed in figure 21 and 22, in 8c age and length structures are quite similar to that found in southern waters, with the bulk of the fish belonging to age group 2. In both stocks the signal of the age group 1 was weaker (table 19).

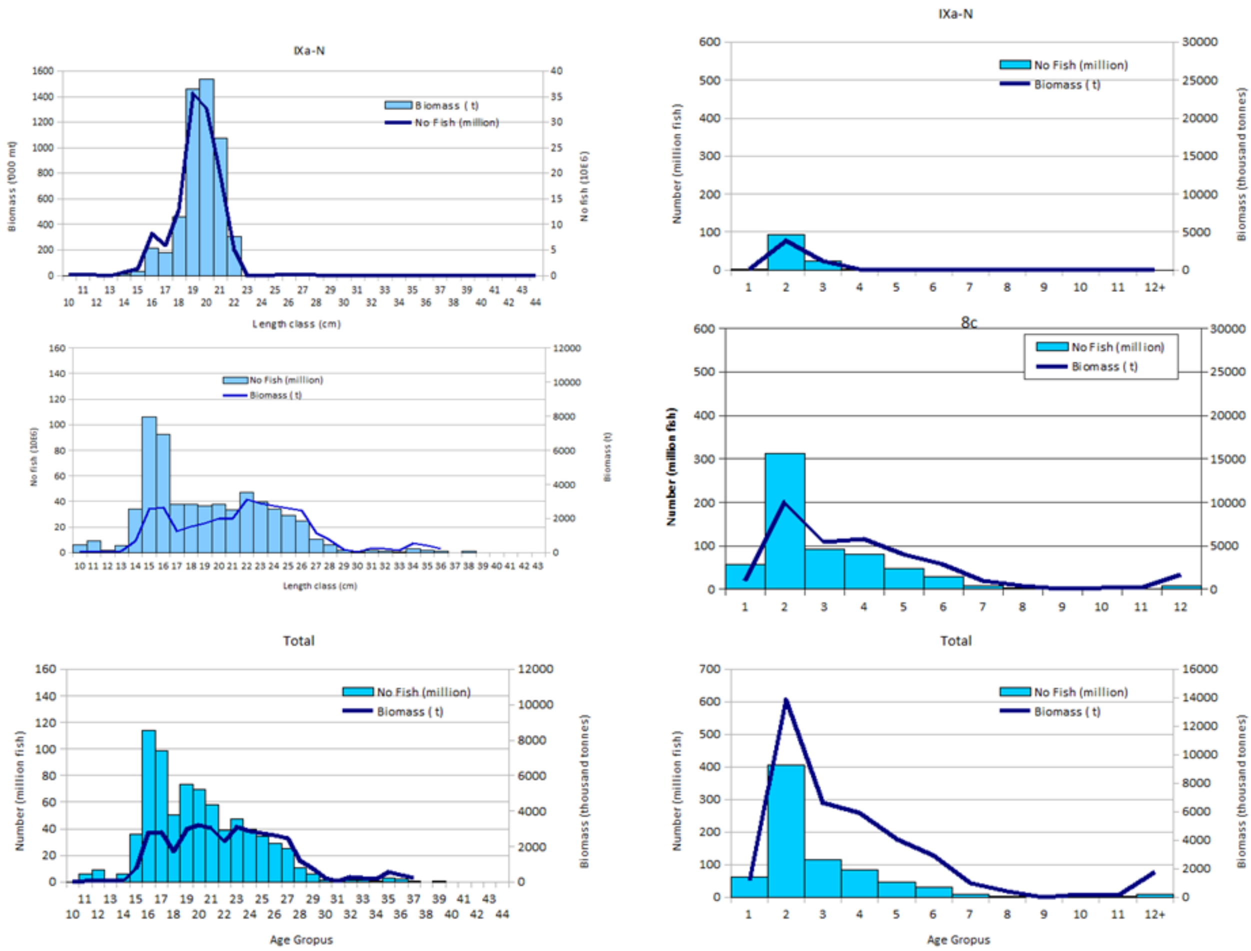


Figure 23: horse mackerel length and age distributions by stocks (above, southern, medium, western) and total during PELACUS0316

Concerning only the western stock, the strength of the 2012 year class, which was important at age 3 during the 2015 survey, has been lost and, in fact, the big differences observed in 2015 between age group 2 and 3, have disappeared in 2016 as even age 3 was more abundant than age 4 in 2016 (figure 24).

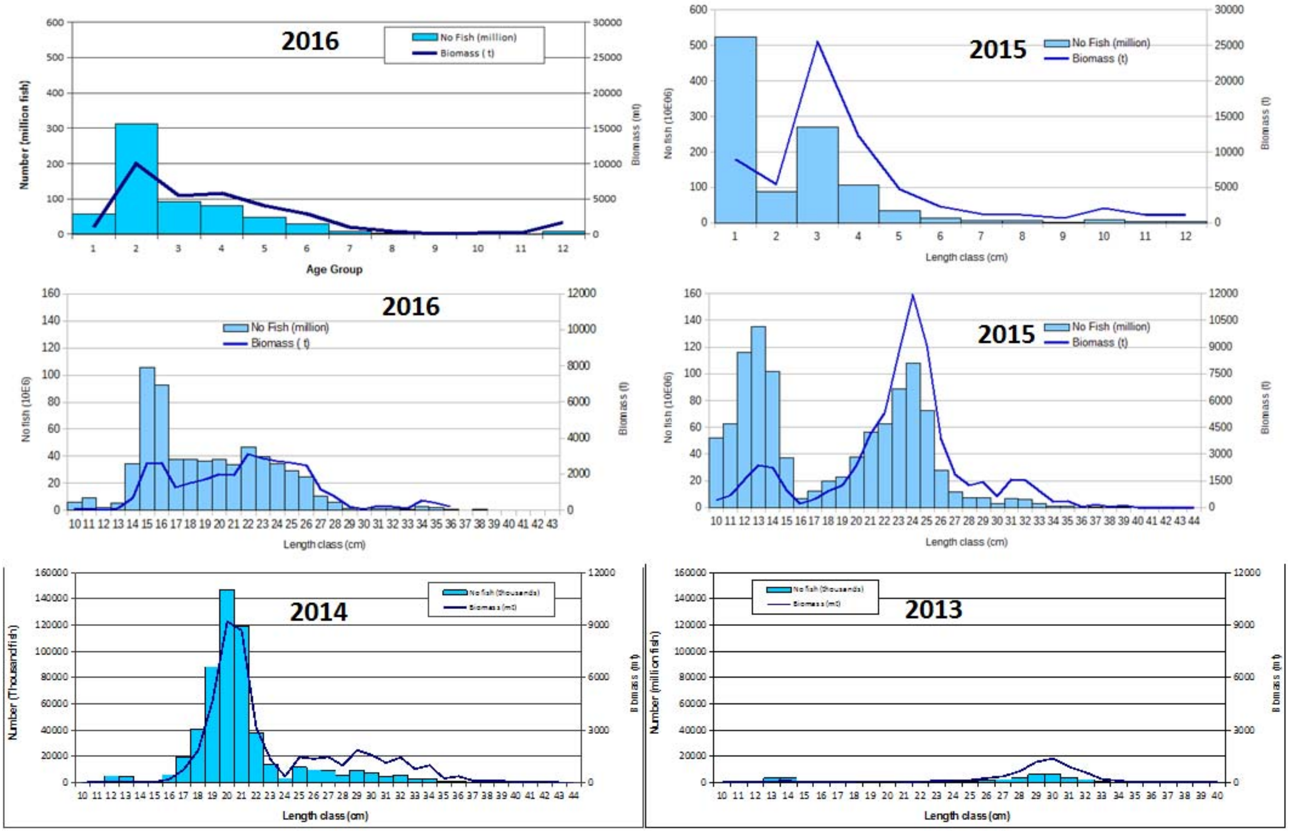


Figure 24: western horse mackerel length since 2013 .

	AGE GROUPS													
Length	1	2	3	4	5	6	7	8	9	10	11	12+	Total	No fish (million)
10	0.21												0.21	0
11	0.27												0.27	0
12	1.36												1.36	0
13													0.00	0
14	11.00												11.00	1
15	20.13	8.81											28.94	1
16	17.16	195.61											212.77	8
17	4.02	176.76											180.77	6
18		457.43											457.43	13
19	36.57	1206.85	219.43										1462.84	36
20		1297.10	211.16	30.17									1538.42	33
21		466.20	609.65										1075.84	20
22		57.12	171.37	76.17									304.66	5
23		0.00	0.08	0.11									0.20	0
24			0.12	0.26	0.11								0.49	0
25			0.09	0.52	0.32								0.94	0
26			0.04	0.42	1.21	0.67							2.34	0
27					1.52	2.06							3.58	0
28					0.08	1.05	0.89	0.08					2.10	0
29						0.11	0.40	0.11					0.63	0
30								0.24		0.08			0.32	0
31										0.25			0.25	0
32								0.07		0.07	0.07		0.22	0
33												0.08	0.08	0
34											0.09	0.09	0.19	0
35													0.00	0
36													0.00	0
37													0.00	0
38													0.00	0
39													0.00	0
40													0.00	0
41													0.00	0
42													0.00	0
43													0.00	0
44													0.00	0
Biomass (t)	90.7	3865.9	1211.9	107.6	3.3	3.9	1.3	0.5	0.0	0.4	0.2	0.2	5285.89	122.5
%	1.72	73.14	22.93	2.04	0.06	0.07	0.02	0.01		0.01	0.00	0.00		
M. weight	24.10	38.27	46.92	52.47	91.99	100.07	112.43	127.51		143.55	171.33	178.25	39.66	
No Fish (million)	3	93	24	2	0	0	0	0	0	0	0	0	123	
%	2.73	75.98	19.65	1.57	0.03	0.03	0.01	0.00		0.00	0.00	0.00		
M. length	16.49	19.50	20.99	21.85	26.78	27.60	28.79	30.13		31.45	33.53	34.02	19.75	
s.d.	2.11	1.39	0.97	1.00	0.87	0.74	0.48	1.33		0.77			1.60	

Table 18 Horse mackerel assessment. Southern stock

Length	1	2	3	4	5	6	7	8	9	10	11	12	Total	No fish (million)
10														
11	53												53	6
12	103												103	9
13	27												27	2
14	95												95	6
15	484	212											696	34
16	206	2351											2557	106
17	58	2566											2625	92
18		1271											1271	38
19		1241	276										1517	38
20		1294	348	50									1693	36
21		734	1247										1981	38
22		204	1225	544									1973	34
23		75	1283	1736									3095	47
24			716	1487	661								2863	39
25			271	1533	947								2750	34
26			47	466	1351	746							2610	29
27					1048	1415							2463	25
28					45	589	498	45					1177	11
29						131	459	131					722	6
30								145		48			193	1
31										45			45	0
32								90		90	90		271	2
33												225	225	1
34											65	65	130	1
35												567	567	3
36												408	408	2
37												219	219	1
38														
39												253	253	1
40														
41														
42														
43														
44														
Biomass (t)	1026	9949	5412	5816	4052	2880	957	412	0	184	155	1737	32580.90	641
%	3.15	30.54	16.61	17.85	12.44	8.84	2.94	1.26		0.56	0.48	5.33		
M. weight	17.39	30.52	56.26	70.02	85.76	98.74	114.20	128.87		146.08	167.52	209.26	44.60	
No Fish (million)	57	313	92	81	47	29	8	3	0	1	1	8	641	
%	8.90	48.85	14.38	12.68	7.31	4.52	1.29	0.49		0.19	0.14	1.24		
M. length	14.66	17.96	22.41	24.26	26.11	27.47	28.95	30.25		31.65	33.26	36.05	20.61	
s.d.	1.71	1.63	1.52	1.19	1.06	0.79	0.50	1.23		0.85	0.97	1.70	4.48	

Table 19 Horse mackerel assessment. Western stock

Boarfish distribution and assessment

Boarfish spatial distribution was smaller than that observed in the previous years. (figure 25), with only few schools found in the NW corner of the Iberian Peninsula and surrounding areas. Only schools were clearly detected in the westernmost area while in the rest, boarfish occurred in thin layers, close to the bottom, and seemed to be associated with other fish species.

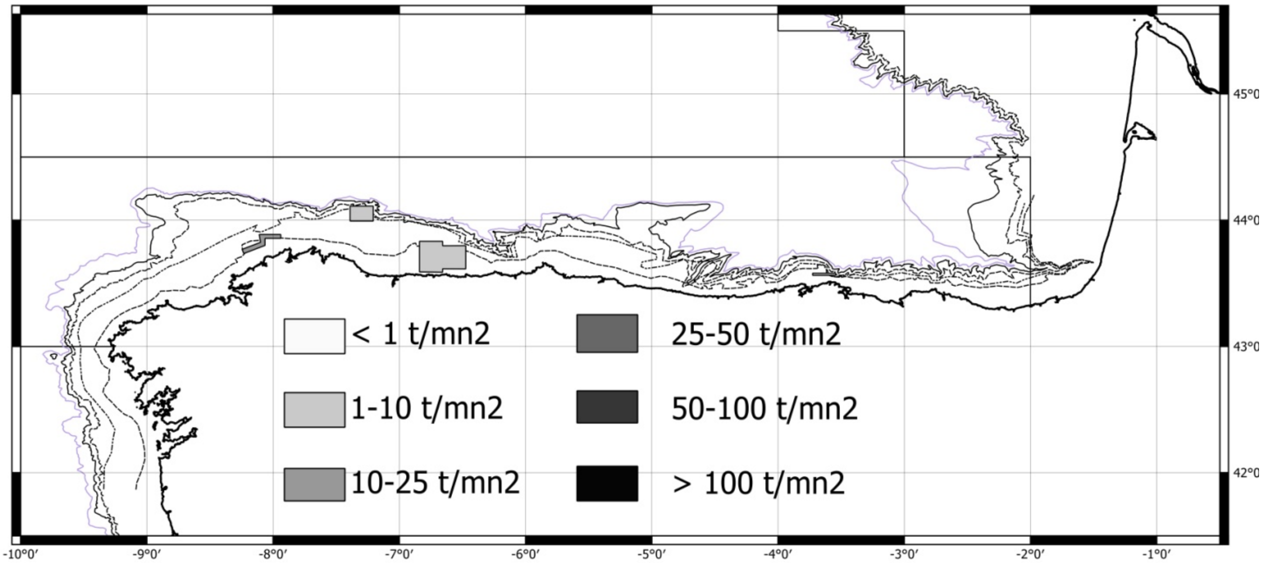


Figure 25. Boarfish spatial distribution PELACUS0316 cruise. Polygons are drawn to encompass the observed echoes, and polygon colour indicates the mean density expressed as tonnes per squared nautical mile (<1,; 1-10; 10-25; 25-50; 50-100; and >100)

Only 1.4 thousand tonnes, corresponding to 23 million fish were assessed, being the lowest value in the time series (table 20). The time series is showing a very sharp decrease, both in number and distribution area (figure 26).

Zone	Area	No	Mean	Area	Fishing st.	PDF	No (million fish)	Biomass (tonnes)
VIIIc-W	Capelada	4	163.35	33.41	P21	S01	9.15	502.34
	Total	*4*	*163*	*33*			*9*	*502*
VIIIc-E	Masma	26	11.72	56.35	P24	S02	1	63
	asturias	8	39.83	204.35	P27	S03	12	775
	Cantabria	1	43.61	8.00	P28	S04	1	33
	Total	*35*	*19.05*	*269*			*14*	*871*
Total VIIIc		*39*	*34*	*302*			*23*	*1374*
Total Spain		*39*	*34*	*302*			*23*	*1374*

Table 20: Boarfish assessment

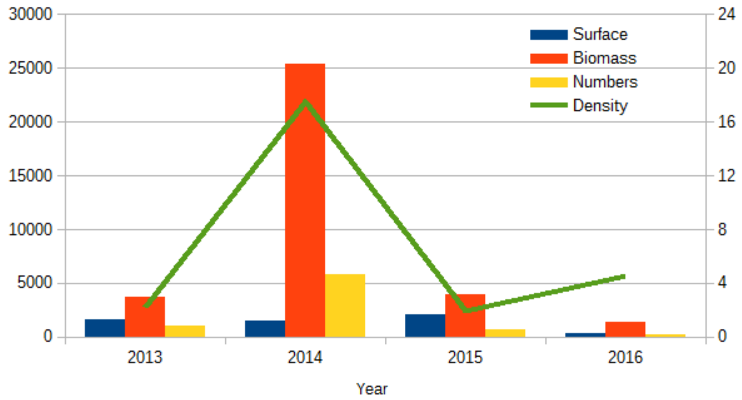
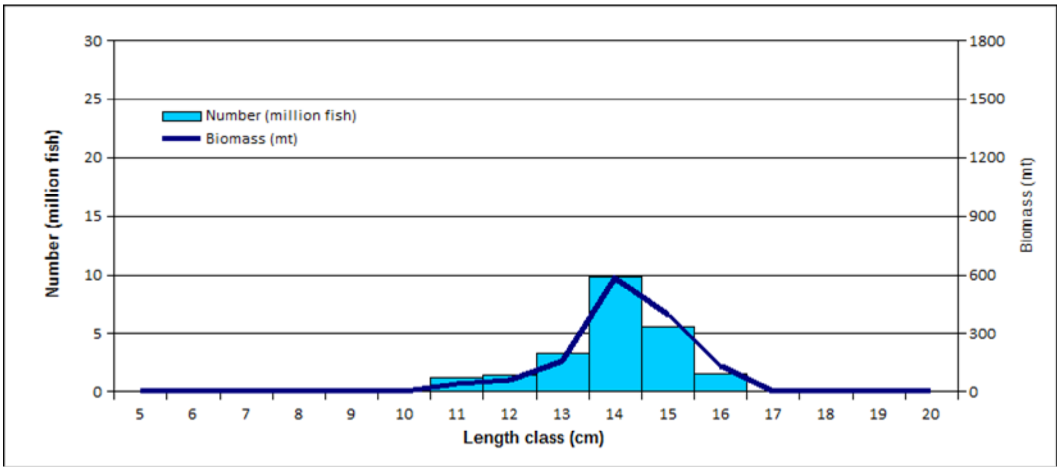


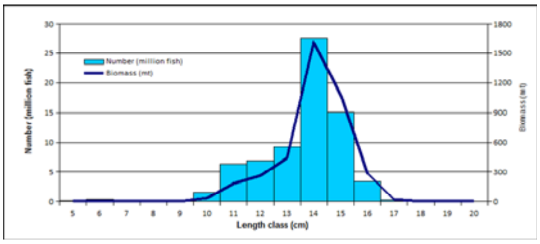
Figure 26: Total boarfish biomass and abundance in number assessed in PELACUS since 2013, together with the occupation area and density.

As has been already observed in the 2015 survey, no signal of recruitment was found also in 2016r. Contrary to that found in 2013 and 2014 only a single mode, located at 14 cm was found (figure 27)

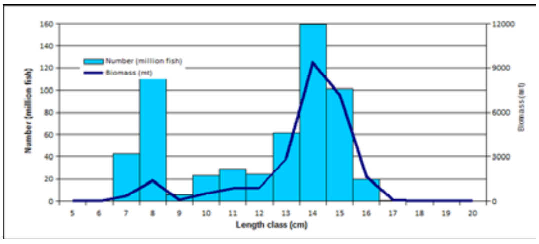


Last years

2015



2014



2013

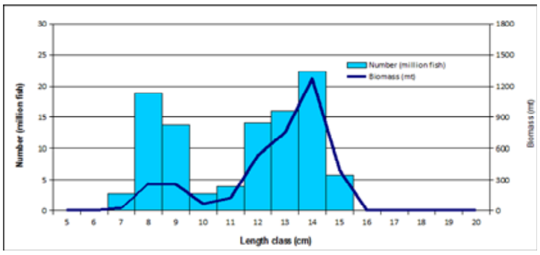


Figure 27. Boarfish length distribution in both number and biomass during the PELACUS0316 (above) and PELACUS 0313-15 (below) .

Anchovy distribution and assessment

Although the amount of pre-recruits anchovies found at the fall survey JUVENA in the Bay of Biscay has shown an important increase in both distribution area an numbers since the last five years, only few adults schools were detected during the spring PELACUS survey. This were mainly concentrated in scarce density in 9a (Rías Baixas), central part of the Cantabrian Sea (around Cape Peñas) and at the inner part of the Bay of Biscay. However, this year, both density and abundance shown an important increase in the whole surveyed area, as show in figure 28. Thick schools were detected in north Galicia, round Cape Peñas and, especially at the inner part of the Bay of Biscay. In this last area, on account the behavior observed in most of the detected schools, it seemed that the distribution area was expanding through the Spanish waters. Close to the Spanish-French border, up to 50-60 Spanish purse seiners were waiting for this arrival, thus confirming our findings.

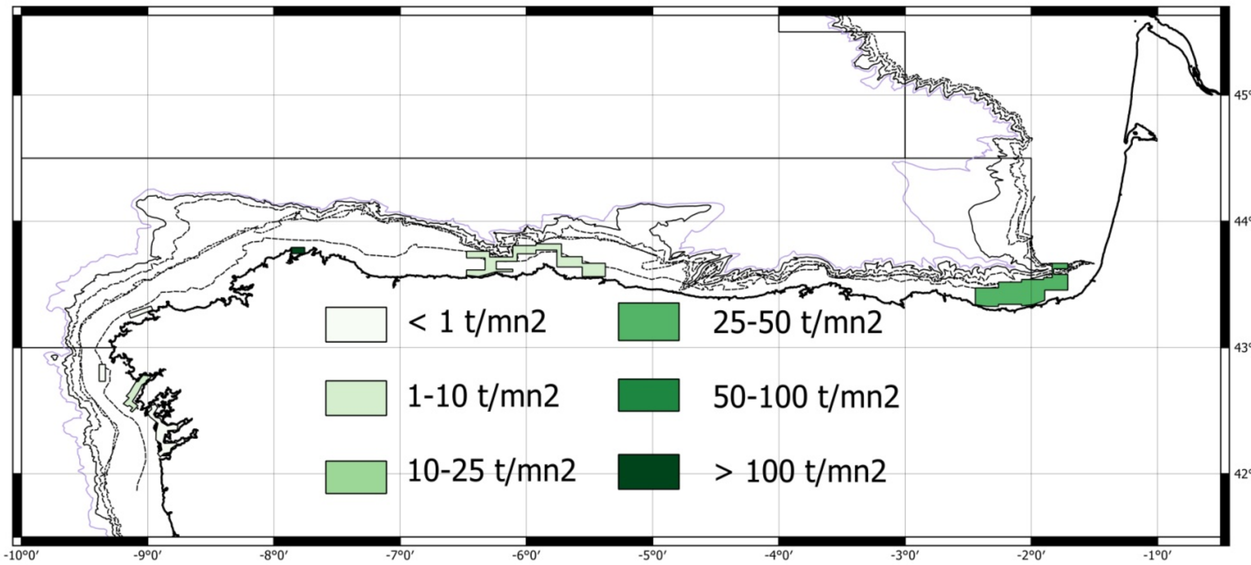


Figure 28. Anchovy spatial distribution. Polygons are drawn to encompass the observed echoes, and polygon colour indicates the mean density expressed as kilograms per squared nautical mile.

A total of 20 thousand tonnes were estimated (table 21). Two main areas were found, inside the Ría of Espasante, where few thick schools were detected. Given the weather conditions and the roughness of the sea bottom no sample was taken, but the schools characteristics (morphological and energy variables) were those of the anchovy, being them directly attributed to this specie.

Zone	Area	No	Mean	Area	Fishing st.	PDF	No (million fish)	Biomass (tonnes)	Density (Tn/nmi-2)
IXa	Rias Baixas	59	2.92	79	P05	S01	3	21	0
	Muros	30	23.78	47	P07	S02	6	184	4
	Total	***89***	***9.95***	***126***			***8***	***205***	2
VIIIc-W	Fisterra	2	1.75	18	P10	S02	0	4	0
	Artabro	2	0.30	17	P10	S02	0	1	0
	Total	***4***	***1.02***	***35***			***0***	***5***	0
VIIIc-Ew	Masma	3	3267.26	17	P40-P42-P47	S03	329	7999	466
	Asturias	28	23.78	252	P40-P42-P47	S03	35	856	3
	Total	**31**	***337.67***	**269**			***364***	***8855***	33
VIIIc-Ee,VIIIb	Euskadi	45	237.81	318	P40-P42-P47	S03	444	10804	34
	Total	**45**	***237.81***	**318**			**444**	**10804**	34
	Total IXa	***89***	***10***	***126***			***8***	***205***	2
	Total VIIIbc	***80***	***265***	***623***			***809***	***19665***	32

Table 21: Anchovy acoustic assessment

as can be observed in figure 29

Figure 29. Echotraces attributed to anchovy schools. A mask, to remove other backscatters than those belonging to swimbladder fish, has been applied

In this small area (only 17 nmi^2) given the patchiness and the amount of thick schools observed, a total of 8 thousand tonnes were estimated. Around Cape Peñas the density was scarce and only at the inner part of the Bay of Biscay, the density increased again. On the other hand, the distribution found in PELACUS match quite well with the anchovy egg distribution recorded with CUFES at the simultaneous survey CAREVA. (figure 30).

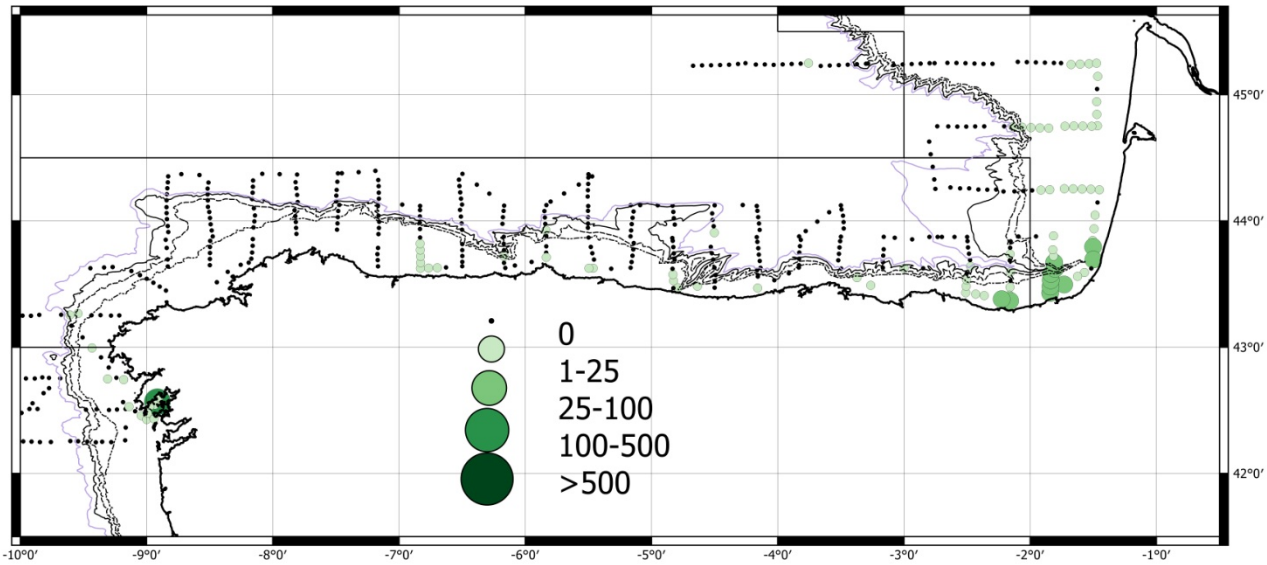


Figure 30. Anchovy egg count from CUFES recorded at the CAREVA survey.

The most noticeable in 9a, within the rias and especially in the Vigo Bay, was the presence of a very small anchovies of about 3-4 cm, which is unusual (figure 31).

Figure 31: size of the anchovies caught at the Ría de Vigo

Given the mesh size of the pelagic gear, the amount of this pre-recruit anchovy was difficult to determine.

Table 22 and figure 32 show the anchovy assessment in 9a ICES Division. Length distribution showed three modes, which roughly correspond to 3 age groups. The most abundant was the age group 3, with a mean size of 17.83 cm.

Length	1	2	3	4	Total	No fish (thousands)
10	2				1.92	356
10.5	4				4.10	644
11	6				6.08	813
11.5	3				3.25	373
12	1				0.85	85
12.5	1				1.02	88
13	1	1			2.14	161
13.5	3	3			5.70	377
14						
14.5	1	2			3.07	158
15	1	3	0		3.45	158
15.5	0	4	0		4.27	175
16	0	4	0		4.85	178
16.5		18	6		23.30	770
17		20	20		39.71	1184
17.5		15	45		59.86	1615
18			24		24.20	592
18.5			10		9.67	215
19			8		7.96	161
19.5						
20						
20.5						
Biomass (mt)	23	69	113	0	205.40	8105
%	11.32	33.77	54.90			
M. weight	8.13	28.23	37.64		24.93	
No Fish (thousands)	2728	2397	2981	0	8105	
%	33.65	29.57	36.78			
M. length	11.52	16.43	17.83		15.29	
s.d.	1.16	1.27	0.62		2.93	

Table 22: Anchovy assessment in 9a

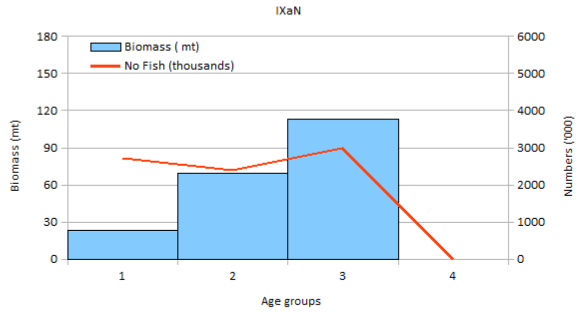


Figure 32 Anchovy abundance and biomass by age group estimated in 9a Division during PELACUS 0316

In the same way, table 23 and figure 33 show the assessment in 8c. The distribution is clearly dominated by age group 2, accounting for more than the 75% of the total biomass and abundance.

Length	1	2	3	4	Total	No fish (thousands)
10						
10.5						
11						
11.5						
12						
12.5	20				19.93	1717
13						
13.5	52	52			103.59	6848
14	340	170			510.41	29765
14.5	474	1423			1897.02	98014
15	1026	3763	171		4959.85	227958
15.5	379	4297	126		4802.53	197093
16	175	3493	349		4017.50	147743
16.5		954	298		1252.77	41421
17		518	518		1035.75	30886
17.5		176	529		704.93	19014
18			208		207.94	5088
18.5			152		152.43	3392
19						
19.5						
20						
Biomass (mt)	2466	14846	2352	0	19664.64	808939
%	12.54	75.50	11.96			
M. weight	20.63	23.90	31.37		24.10	
No Fish (thousands)	118636	616363	73940	0	808939	
%	14.67	76.19	9.14			
M. length	15.02	15.66	16.93		15.68	
s.d.	0.64	0.66	0.95		0.82	

Table 23: Anchovy assessment in 8c

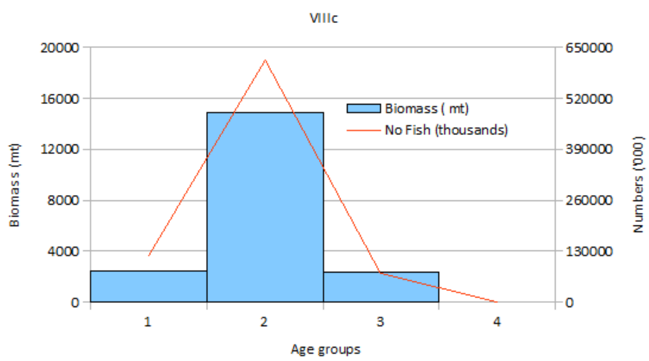


Figure 33 Anchovy abundance and biomass by age group estimated in 8c Division during PELACUS 0316

Other fish species

Bogue (Boops boops)

Was one of the most important species in the pelagic community. It was mainly recorded in the 9a, within the rias with a mean length of 20 cm, and throughout the Cantabrian Sea with a mean length of 28 cm (figure 34)

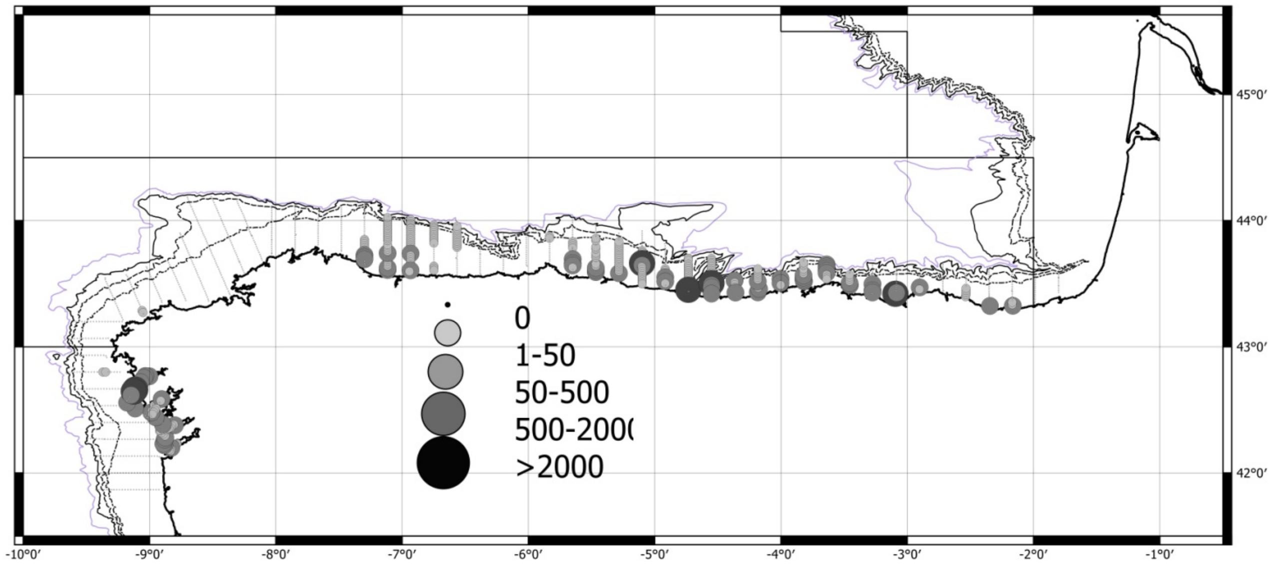


Figure 34. Bogue density distribution (NASC)

Chub mackerel (Scomber colias)

As usually chub mackerel is mainly located in the Cantabrian Sea. Those located at the central part, around Cape Peñas mainly had 20 cm, but close to the shoreline (between 50-80 m) the mean size was higher, reaching 31 cm. These were mainly distributed in the eastern part (figure 35).

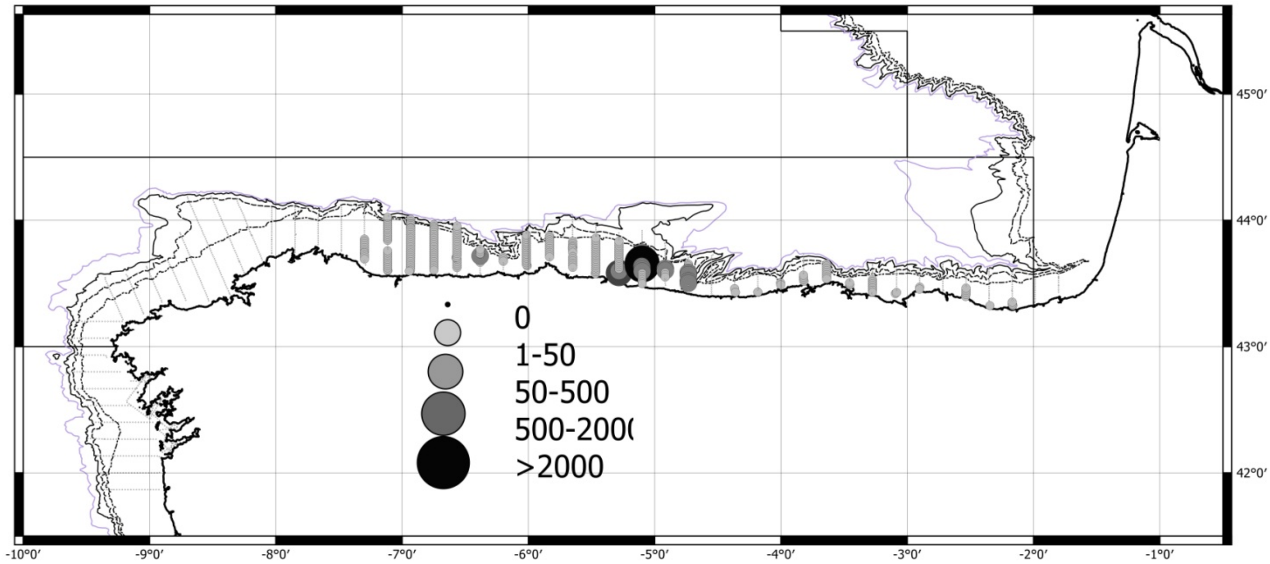


Figure 35. Chub mackerel density distribution (NASC)

Hake (Merluccius merluccius)

Hake was widely distributed around the surveyed area, although the main concentrations were recorded in the western part. However, it seems only the younger fraction of this species is accessible to the pelagic gear and therefore, able to be assessed by acoustic. Mean length is quite stable along the surveyed area, at around 20-22 cm(figure 37).

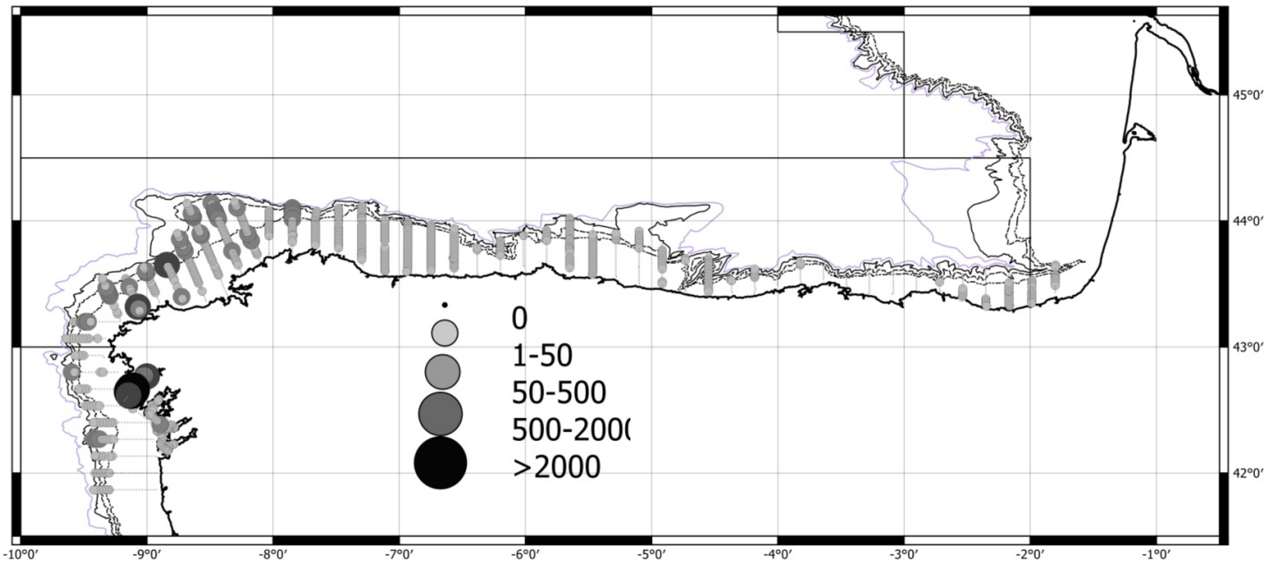


Figure 36. Hake density distribution (NASC)

Hake larvae (Merluccius merluccius)

This year, for first time an important amount of hake larvae of 2.5 cm (2-4 cm range) were detected in the NW corner of the Iberian peninsula. They were located off-shore and at 40-60 m depth.

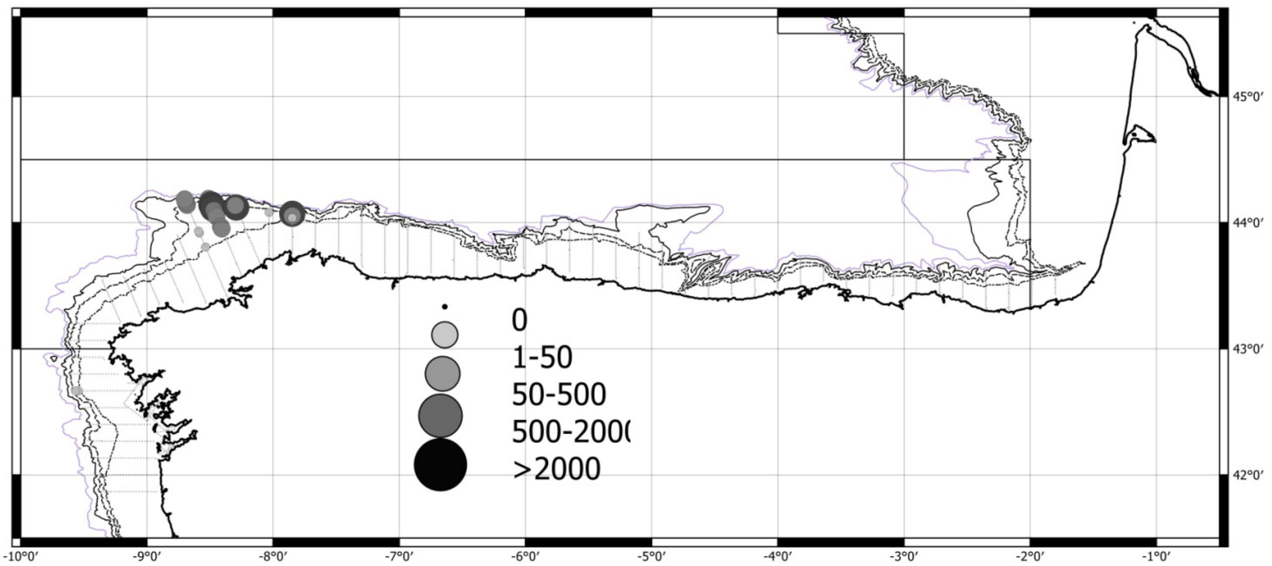


Figure 37. Hake larvae density distribution (NASC)

Mediterranean horse mackerel (T. mediterraneus)

This species was only caught in few fishing station and, therefore, the density is scarce, as shown in figure 38, and, as expected located at the eastern part of the surveyed area

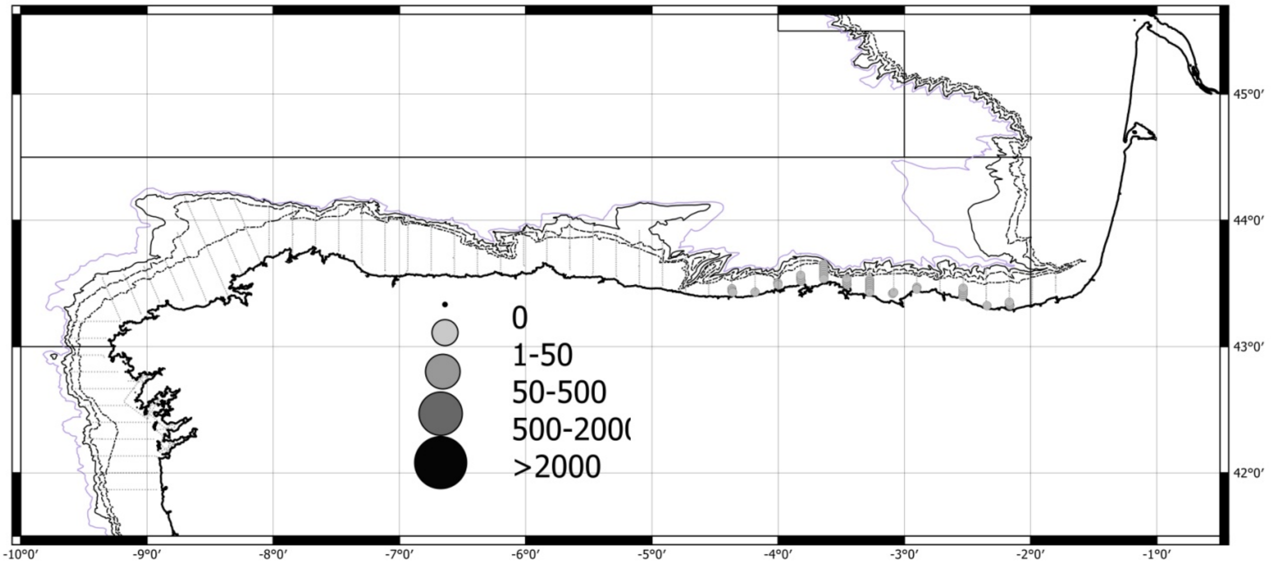


Figure 38. Mediterranean horse mackerel density distribution (NASC)

Top predators

A total of 144 legs were done corresponding to 1806 km prospected during 115.4 hours (4.6 hours/day on average and round 38.8 nmi per day. Overall 625 marine mammals, 8073 marine birds, 984 human activities (268 plastic debris and 537 vessels), 197 inland and coastal birds, 26 pelagic organisms (sunfish among them) were recorded.

Marine birds:

A total of 27 taxa of sea, coastal and terrestrial birds were recorded. Gannet (*Morus bassanus*), yellow legged gull (*Larus michahellis*) and lesser black-backed gull (*Larus fuscus*) were the most abundant species (table 24). Higher concentrations were located in the NW area. The yellow legged gull (*Larus michahellis*) was observed in more coastal waters than lesse black-backed (*Larus fuscus*). In addition, gannets (*Morus bassanus*) were also mainly sighted in coastal waters, although those specimen undertaking a northward migration were also observed offshore (figures 39 and 40)

Name	Number
Larus sp	2579
Morus bassanus	2398
Larus michahellis	1306
Larus fuscus	745
Laridae spp	653
Stercorarius skua	125
Melanitta nigra	59
Phalacrocorax carbo	45
Alcidae spp	40
Thalasseus sandvicensis	21
Phalacrocorax aristotelis	18
Alca torda	16
Ichthyaetus melanocephalus	15
Chroicocephalus ridibundus	11
Passeriformes	8
Puffinus puffinus	6
Phylloscopus spp	4
Puffinus griseus	4
Puffinus mauretanicus	4
Uria aalge	4
Sterna hirundo	3
Fratercula arctica	2
Hirundo spp	2
Sterna spp	2
Alauda spp	1
Larus marinus	1
Sylvia atricapilla	1

Table 24 Marine birds observations during PELACUS 0316.

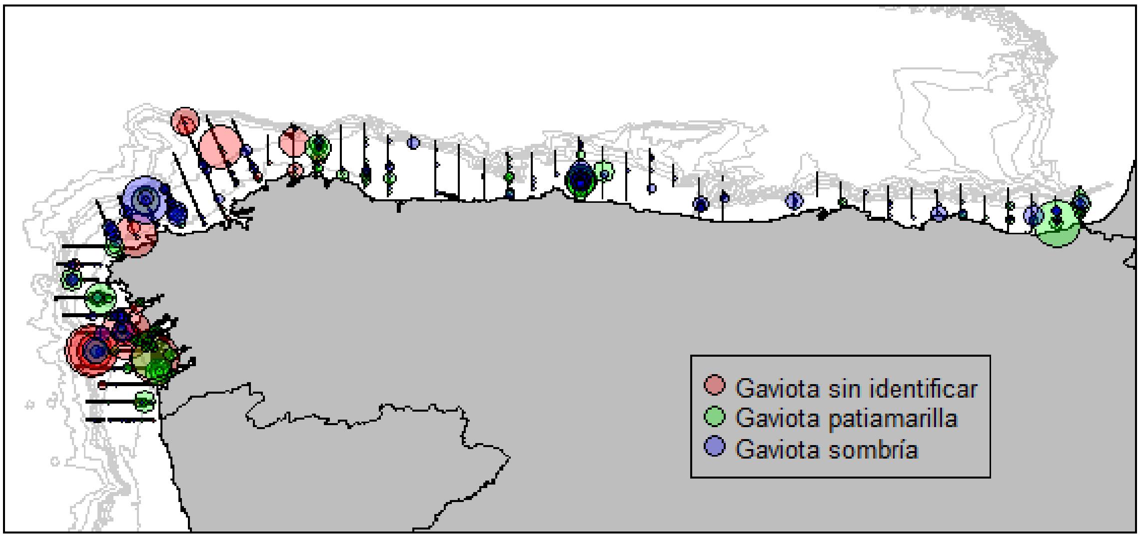


Figure 39 Observations of birds during PELACUS 0316. Yellow legged gull (green), lesser black-backed gull (blue) and Larus spp (red).

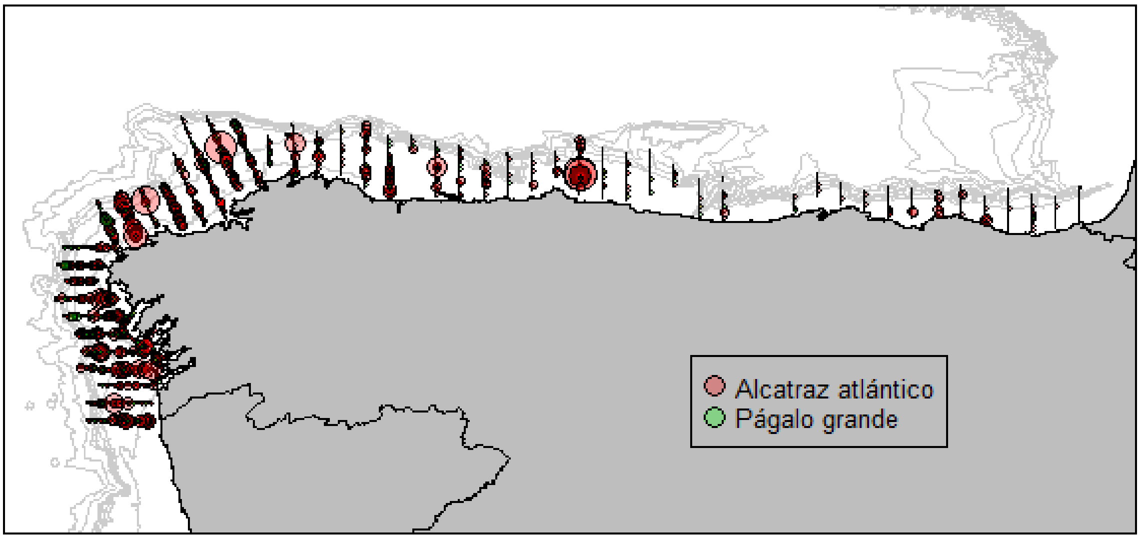


Figure 40 Observations of gannet (red) and skua (green) during PELACUS 0316.

Marine mammals:

A total of 7 different species were observed, as shown in table 25. Bottlenose dolphin (*Tursiops truncatus*) was the most sighted species (282 individuals observed), followed by Common dolphin (*Delphnus delphis*) (263), 57 long-finned pilot whale (*Globicephala melas*), 6 members of the family Ziphiidae and 4 big whales. Most of sightings of bottlenose dolphin and long-finned pilot whale; on the contrary, common dolphin mainly occurred in the west of Galicia (figure 41)

Name	Number
Tursiops truncatus	282
Delphinus delphis	263
Globicephala melas	57
Delphinidae	13
Ziphiidae	6
Balaenoptera physalus	3
Balaenoptera acutorostrata	1

Table 25 Marine mammals' sightings during PELACUS 0316.

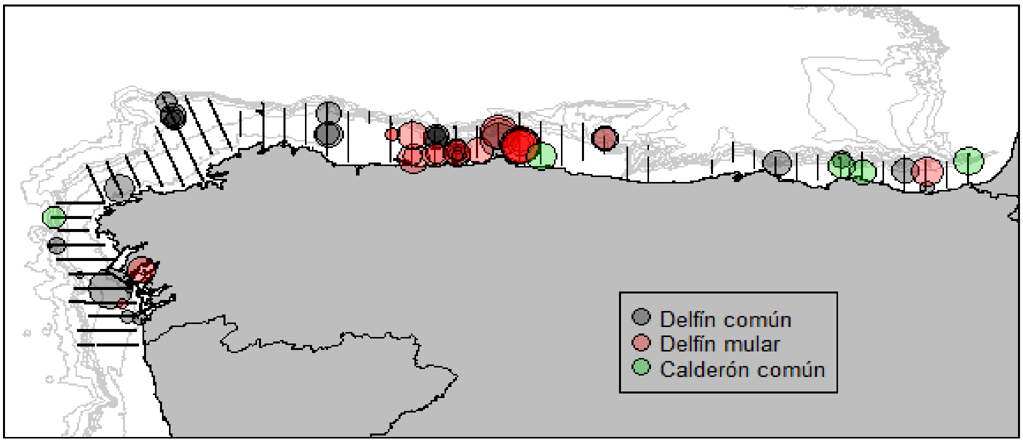


Figure 41 Sightings distribution during PELACUS 0316. Common dolphin (grey), bottlenose dolphin (red) and long-finned pilot whale (green).

CONCLUSIONS

PELACUS 0316 has been carried out between 13th March and 16th April, covering the north Spanish continental self between the Miño river (Spanish/Portuguese border) and the Bidasoa one (Spanish/French border). Unexpectedly, weather and oceanographic conditions found were those of the winter time rather than the incipient spring ones. Consecutive deep W/NW storm fronts have affected the survey plan; five days were lost due to the bad weather conditions and even during part of the survey either strong south wind (up to 45 knots) or a persistent swell of about 2-4 m height have also made problems to achieve clean echograms (i.e. without bubbles) and good performance at the fishing station. These conditions might have been also affected the availability of the fish. This seems clearer in the southern part (9aN), where a stronger winter poleward current led the continental self almost empty of plankton and with a very scarce concentration of fish.

The mackerel distribution and behaviour was different to that observed in previous years, with a later arrival and a more patchier and denser distribution. This change, which could be linked with a change in the migration pattern, has also been observed in northern areas (Fernandes, pers. communication). In other to verify the magnitude of this change, for the 2017 survey, a special effort will be done. On the other hand, the movement detected in the anchovy schools towards the Spanish waters could be considered as normal. When the Bay of Biscay anchovy stock is in good condition, a spawning migration from the French shelf to the Spanish one was historically recorded, being the start of the fishing season for this specie, which normally started at the inner part of the Bay of Biscay and continued westward until Galicia.

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PELACUS is included in the Spanish Data Collection Framework project. This project has been funded by the EU through the European Maritime and Fisheries Fund (EMFF) within the National Program of collection, management and use of data in the fisheries sector and support for scientific advice regarding the Common Fisheries Policy.

Unión Europea

Fondo Europeo Marítimo y de Pesca (FEMP)

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WD4 – PELGAS SURVEY

Direct assessment of small pelagic fish by the PELGAS16 acoustic survey

Erwan Duhamel, Mathieu Doray, Martin Huret, Florence Sanchez,
Patrick Lespagnol, Ghislain Doremus and Charlotte Lemerre

Working Document for ***WGHANSA***
(Lorient, 24-29 June.2016)

Direct assessment of small pelagic fish by the PELGAS16 acoustic survey

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1. Material and method

1.1. PELGAS survey on board Thalassa

An acoustic survey (PELGAS) is carried out every year in the Bay of Biscay in spring onboard the French research vessel Thalassa. The objective of PELGAS survey 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.

This survey is 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. This survey 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:

- Continuous acquisition of acoustic data from six different frequencies, pumping sea-water under the surface in order to evaluate the number of fish eggs using a CUFES system (Continuous Under-water Fish Eggs Sampler) and 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.
- 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.

The strategy this year was the identical to previous surveys (2000 to 2015). The survey protocols are described *in Doray M, Badts V, Masse J, Duhamel E, Huret M, Doremus G, Petitgas P (2014).* ***Manual of fisheries survey protocols. PELGAS surveys (PELagiques GAScogne)***. http://dx.doi.org/10.13155/30259:

- 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.

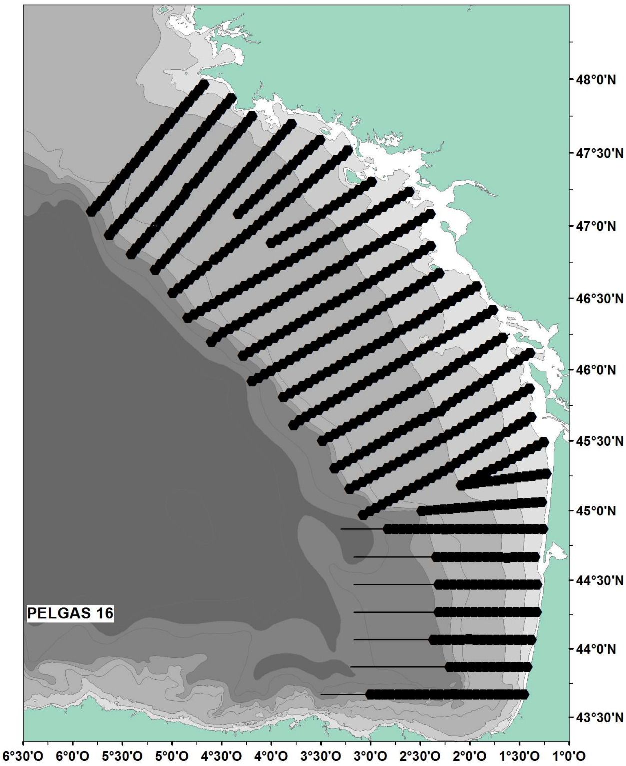


Fig. 1.1.1 - Transects prospected during PELGAS16 by Thalassa.

In 2016, 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 (21 2 to 7°beams, from 70 to 120 kHz) used essentially for visualisation and observing 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 near Brest, in the West of Brittany, in optimal meteorological conditions at the beginning of the survey.

Acoustic data were collected by R/V Thalassa along a total amount of 5220 nautical miles from which 1876 nautical miles on one way transect were used for assessment. A total of 28 859 fishes were measured (including 7 433 anchovies and 4 702 sardines) and 2857 otoliths were collected for age determination (1621 of anchovy and 1236 of sardine).

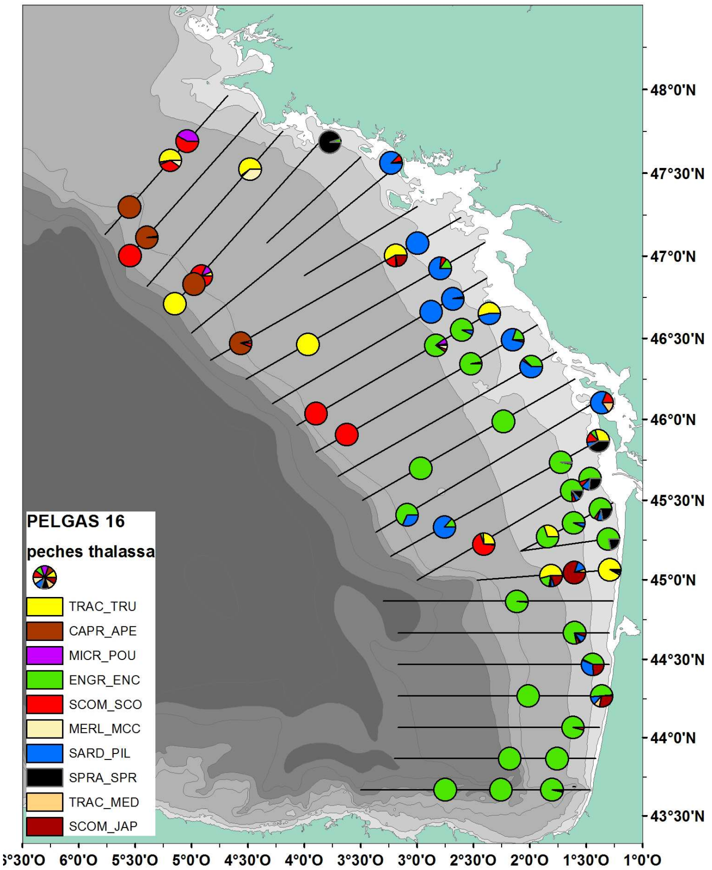


Fig. 1.1.2: Species distribution according to Thalassa identification hauls.

1.2. The consort survey

A consort survey is routinely organised since 2007 with French commercial vessels during 19 days. This approach is in identical to last year's surveys, using the commercial vessel's hauls were for echoes identification and biological parameters to complement hauls made by the R/V Thalassa.

Four commercial vessels (two pairs of pelagic trawlers) participated to PELGAS16 survey:

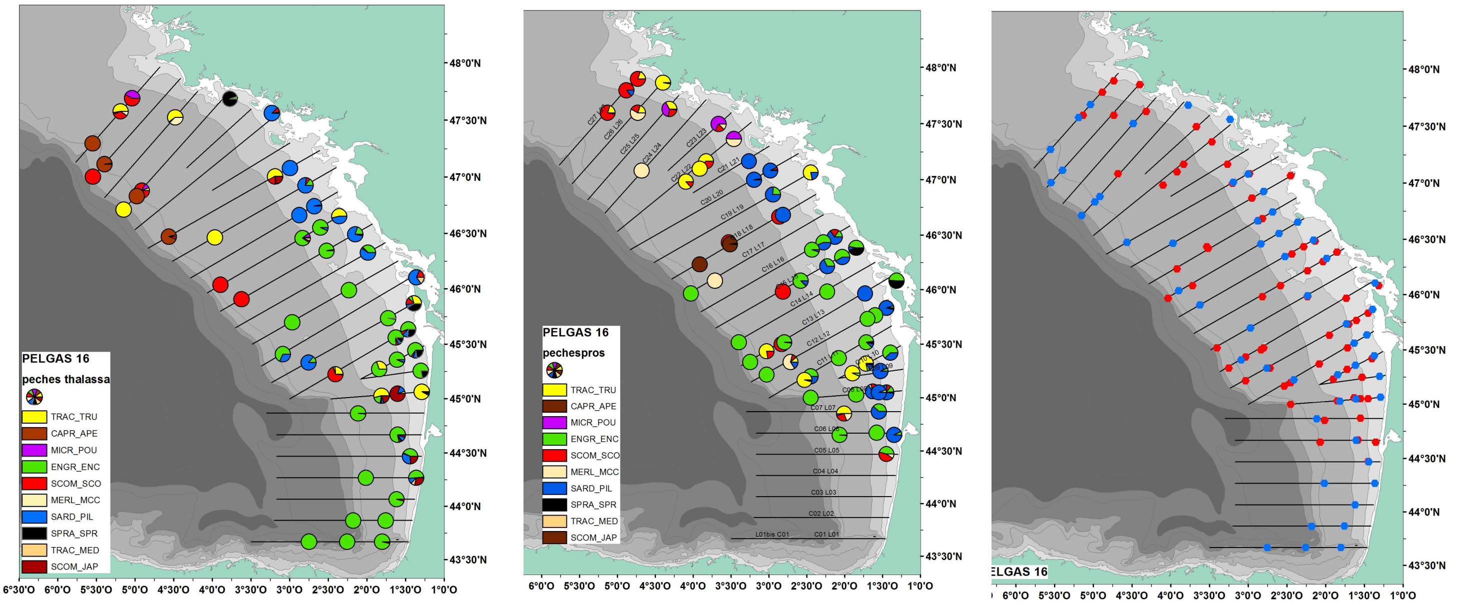
Vessel	Gear	Period	Days at sea
Carla-Eglantine / El Amanecer	Pelagic pair trawl	04/05 to 12/05/2015	9
Papi Paul / Joker	Pelagic pair trawl	12/05 to 21/05/2015	10

The regular transects network agreed for several years for Thalassa is 12 miles separated in 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 up to 25 m vertical opening and the mesh of their codend was similar to the on uses by the R/V Thalassa (12 mm).

A scientific observer was on board the commercial vessel to control every fishing 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, these fishing operation were used 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 the commercial vessels to Thalassa to improve otoliths collection and sexual maturity (240 otoliths of anchovy, 200 of sardine). A total of 7743 fishes were measured onboard commercial vessels, including 3118 anchovies and 1772 sardines.

Catches and biological data were used to complement the sampling made on boar the R/V Thalassa.

A total of 136 hauls were carried out during the consort survey including 73 hauls by the R/V Thalassa and 63 hauls by commercial vessels.



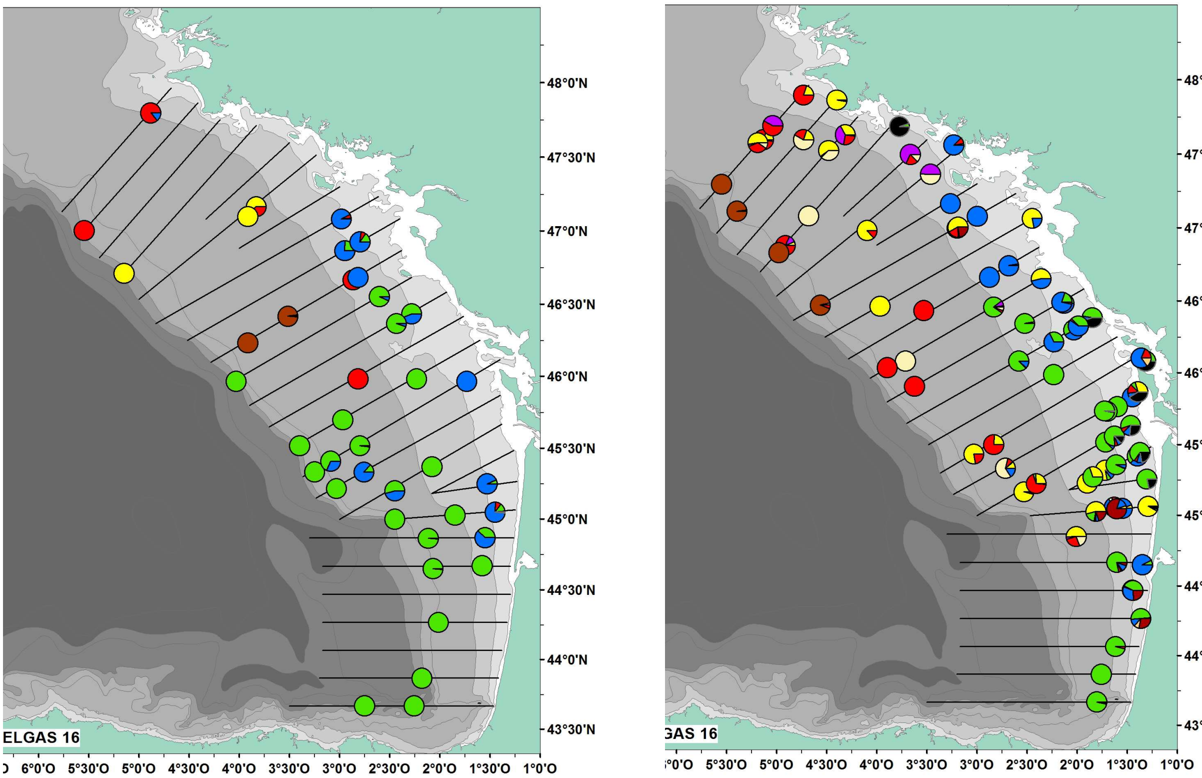
a) Thalassa (nb :54) *b) Commercial vessels (nb : 65)* *c) all fishing hauls (nb :119) thalassa in Blue and commercial in red*

Figure 1.2.2 : fishing operations carried out by Thalassa and commercial vessels during consort survey PELGAS16

The collaboration between Thalassa and commercial vessels was excellent. It was once more a very good opportunity to 1)explain our methodology to the fishermen and 2) check consistency between scientists and fishermen echo-trace's observation and interpretations. Some fishing operations were done in parallel by Thalassa and commercial vessel in order to check catches' similarity (in proportion of species and, most of the time, in quantity as well - taking the vertical and horizontal opening into account). As last year, commercial vessels' fishing operations were only carried out at 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.

Table 1.2.3. : Number of fishing operations carried out by Thalassa and commercial vessels during consort survey PELGAS16

	thalassa	commercial	total
surface hauls	12	27	39
classic hauls	42	35	77
null	0	3	3
total	54	65	119



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 and species composition during survey PELGAS16

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, and 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 and sometimes more offshore areas.

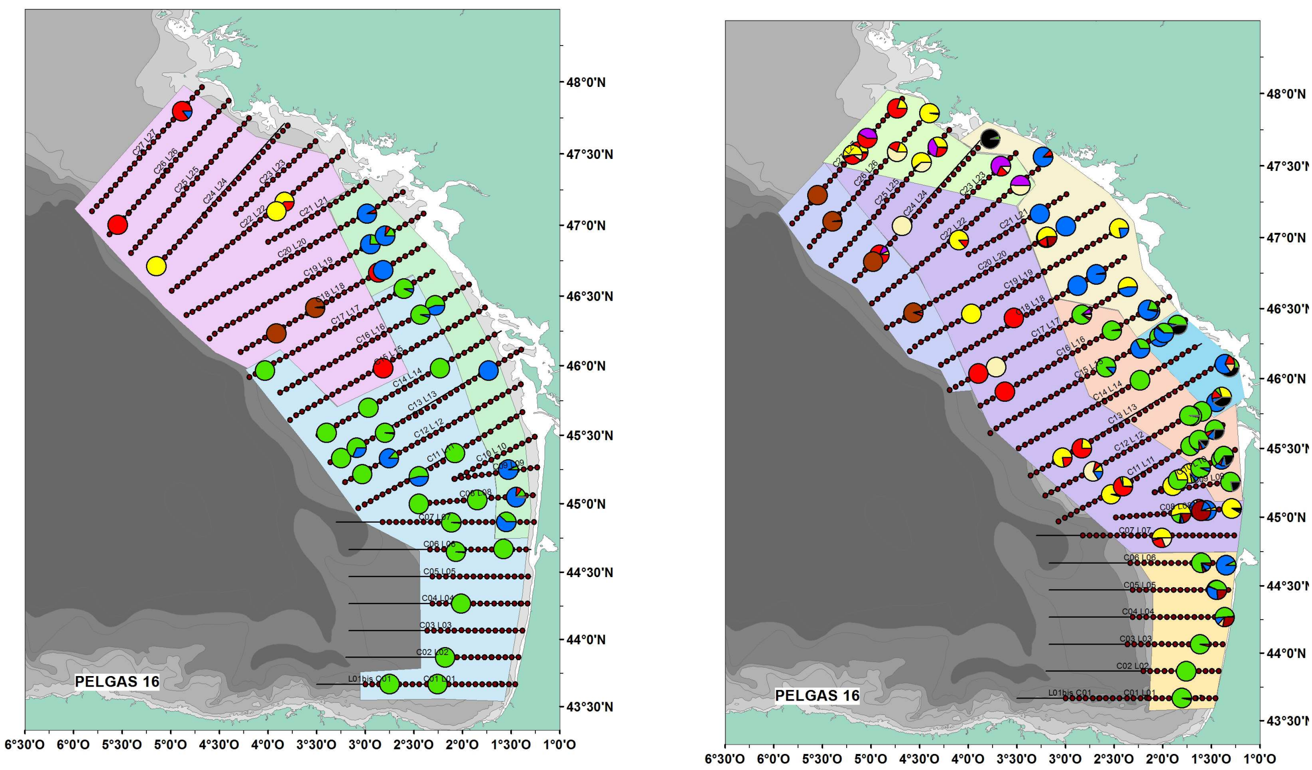
D3 – energies attributed to scattered detection corresponding to blue whiting, myctophids, boarfish, mackerel and horse mackerel.

D4 – energies attributed to sardine, mackerel and anchovy corresponding to echoes very close to the surface. This year, horse mackerel was also allocated in this category

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 different species assemblages. Figure 2.2 shows the strata considered to evaluate biomass of each species. For each stratum, energies where converted into biomass by applying catch ratio, length distributions and weighted by abundance of fish in the haul surrounded area.



Coherent surface strata

Coherent classic 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 PELGAS16 survey.

2.3. Biomass estimates

The fishing strategy has been followed all along the survey in order to benefit of each vessel's efficiency and maximise the number of samples (in term of identification and biological parameters). Therefore, the commercial vessels carried out mostly surface hauls when Thalassa fished preferably in the bottom layer. According to previous strata (Figure 2.2), using both Thalassa and consort fishing operations, biomass estimates were calculated for each main pelagic species in the surveyed area.

Biomass indices are presented in tables 2.3.1 and 2.3.2 and in figure 2.3.1. No estimate is 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 were much less abundant than last year and their abundance was estimated this year at a medium level compared to the historical time series (around 90 000 tonnes). Soft densities were observed in the Gironde area. It must be noticed that we observed anchovy on the first transect along the Spanish coast in relatively high densities, mainly close to the surface.

Sardine were also less present this year compared to 2015, almost exclusively in coastal waters from the South until the Loire river, and they were rather absent in surface along the shelfbreak.

About other species, another characteristic of this year was that horse mackerel showed a small increase of the biomass for another year in a raw, and reached now a medium level, after 10 years of low biomass at this period of the year in this area.

Mackerel appeared much dispersed all over the area and seemed to be relatively well present this year, particularly offshore, close to the bottom, and sometimes near the surface.

Table 2.3.1. Acoustic biomass index for the main species by strata during PELGAS16

	classic	surface	total
anchovy	71 168	18 558	89 727
sardine	228 308	1 435	229 742
blue whiting	17 934	162	18 096
horse mackerel	115 840	3 390	119 230
sprat	36 593	0	36 593
chub mackerel	111 197	183 452	294 649
hake	16 780	0	16 780
boarfish	4 475	0	4 475

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

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
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**	**372 916**	**89 727**
CV anchovy	*0.064*	*0.141*	*0.113*	*0.132*	*0.167*	*0.171*	*0.136*	*0.100*	*0.162*	*0.112*	*0.147*	*0.0774*	*0.04665*	*0.1282*	*0.062928*	0.0735509	0.13
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**	**416 524**	**229 742**
CV sardine	*0.083*	*0.117*	*0.088*	*0.241*	*0.121*	*0.135*	*0.117*	*0.159*	*0.139*	*0.098*	*0.091*	*0.0699*	*0.07668*	*0.0738*	*0.065212*	0.1023153	0.08
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**	**91 248**	**36 593**
CV sprat	*0.098*	*0.155*	*0.120*	*0.198*	*0.178*	*0.228*	*0.162*	*0.132*	*0.268*	*0.108*	*0.108*			*0.1992*	*0.241009*	0.1953397	0.44
Horse mackere	**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**	**77 142**	**119 230**
CV HM	*0.079*	*0.204*	*0.156*	*0.137*	*0.287*	*0.160*	*0.316*	*0.065*	*0.455*	*0.09*	*0.188*			*0.3007*	*0.227089*	0.1549802	0.3
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**	**8 684**	**11 852**
CV BW	-	-	*0.386*	*0.131*	*0.202*	*0.593*	*0.210*	*0.147*	*0.253*	*0.219*	*0.074*			*0.1542*	*0.337606*	*0.2234791*	*0.15*

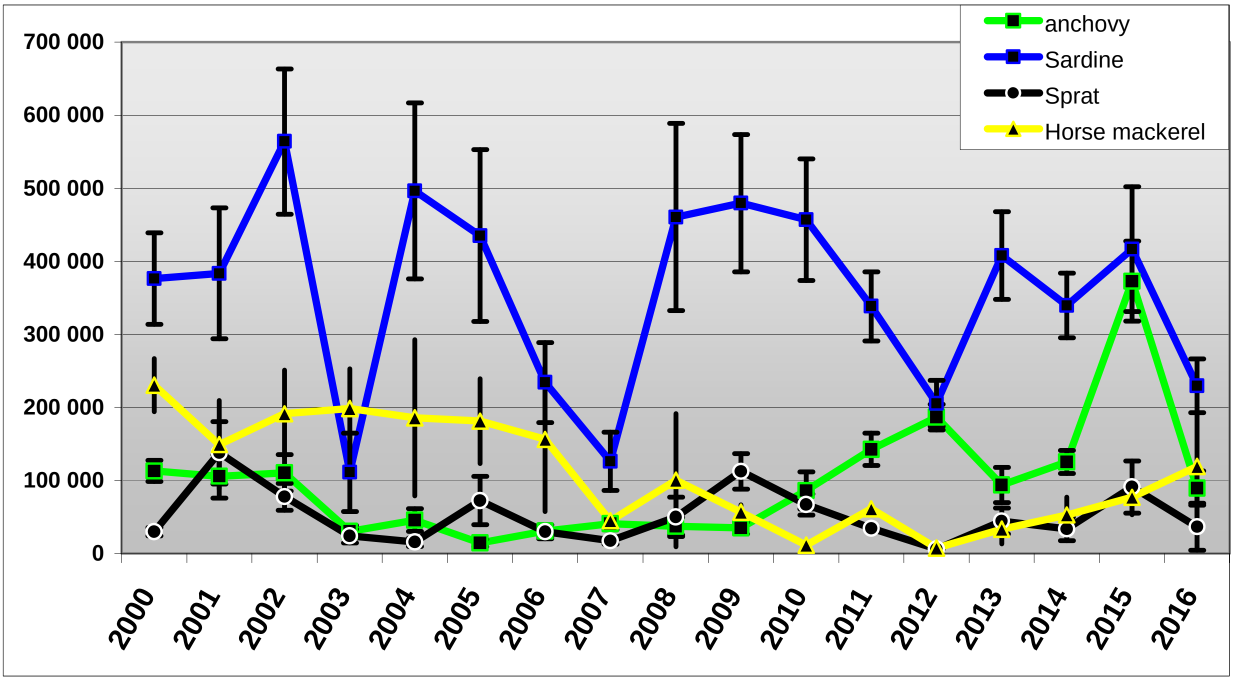


figure 2.3.3. – biomass estimate using Thalassa acoustic data along transects and all the consort identification fishing operations (Thalassa + commercial vessels) and associated coefficients of variation.

3. ANCHOVY DATA

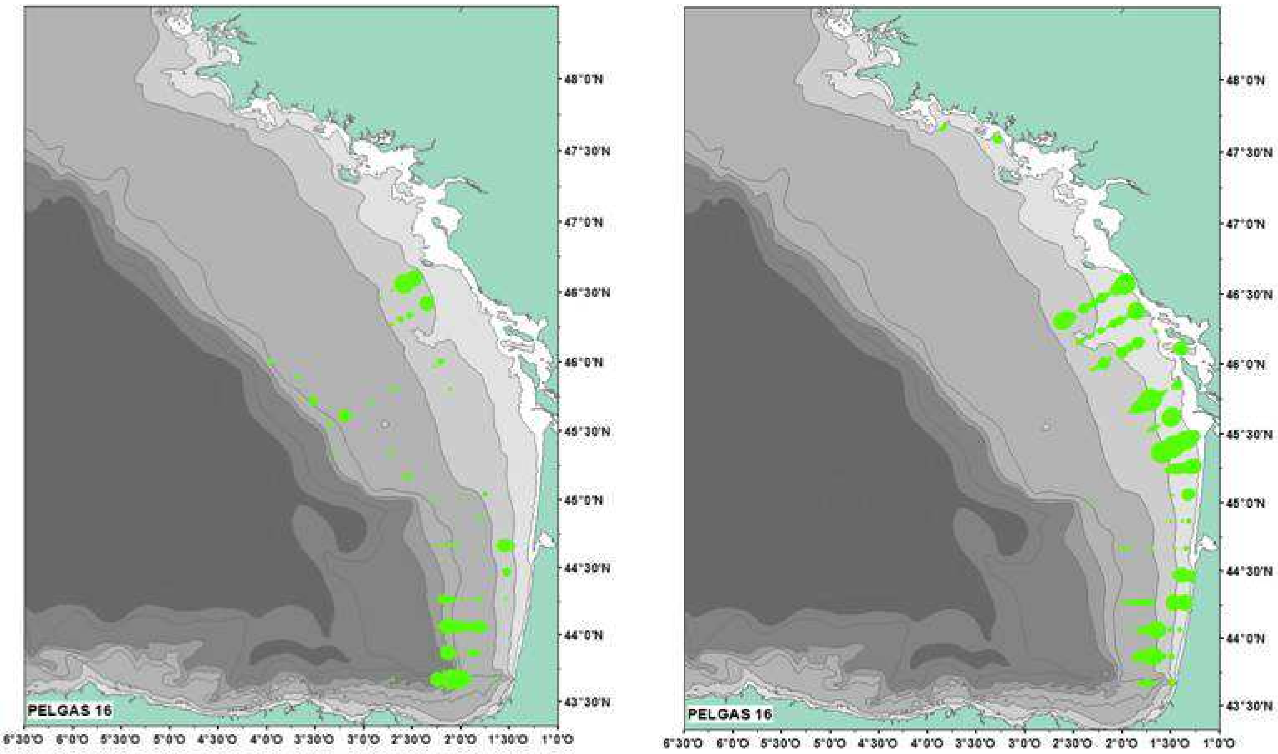
3.1. anchovy biomass

The biomass estimate of anchovy observed during PELGAS2016 is **89 727** tons. (table 2.3.2.), which seems to be a medium biomass compared to previous year's, comparable to 2010 and far away from the 2015 biomass.

In the Gironde area, the configuration was unusual in terms of energy compared to what was observed last years, with a low energy attributed to anchovy, far away from the huge abundance calculated in 2015 in this area. Nevertheless, anchovy was predominant in this area.

The one year old anchovies were mostly present around the Gironde plume (in terms of energy and, as well, biomass) but they were still well present on the platform, in the southern part of the Bay of Biscay. The most part of the age 1 anchovy was there. The average size of one old fish was comparable the average size (two years really differed from the average: 2012 and particularly 2015 where fishes were much smaller).

Figure 3.1 shows the vertical distribution of anchovy. Offshore, anchovies were so closed to the surface that their abundance was probably underestimated in that area, given to the quantity of eggs counted (for more detail, see chapter 3.7 "Coherence between CUFES and Acoustic survey indices").



Surface distribution

Near-seabed distribution, between the bottom and 40m above

Figure 3.1. – Anchovy distribution according to PELGAS16 survey.

3.2. Anchovy length structure and maturity

Length distribution in the trawl hauls were estimated from random samples. The population length distributions (figures 3.2) were 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.

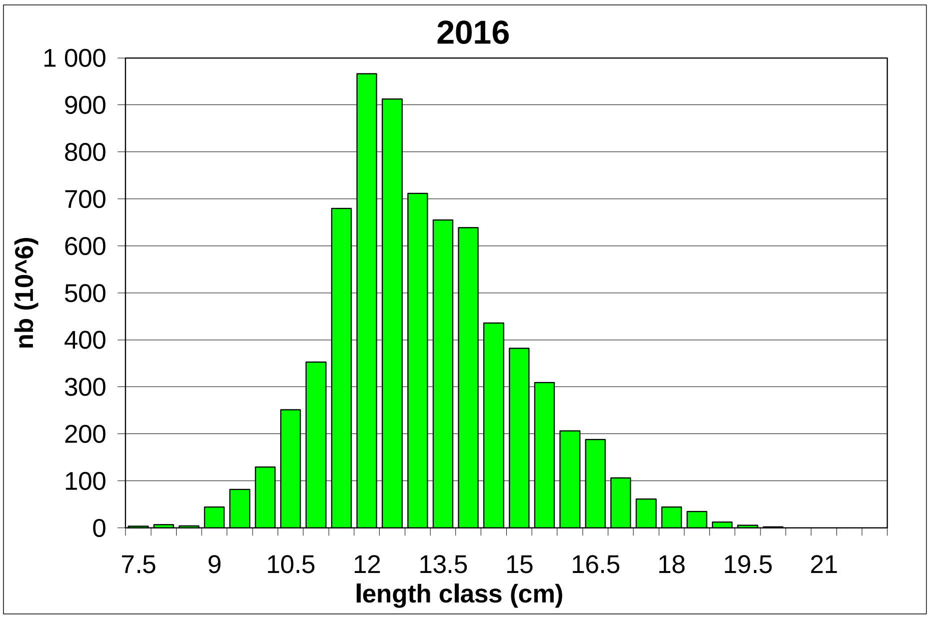


Figure 3.2: length distribution of global anchovy as observed during PELGAS16 survey

Globally we observe that length structure shows an unimodal distribution, with a mode around 12 centimetres (constituted by age 1 and Age 2 fishes). It must be noticed that even if some individuals were small (less than 10centimeters), almost all fishes were mature and in their spawning period. This observation on maturity contrasted with last year observation where a large proportion of the population was not spawning at the period of the survey.

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 given number of fishes per length class (4 to 6 / half-cm), for a total amount of around 50 fishes per haul. As there was a lot of fishing operations where anchovy was present (as previous surveys), the number of otoliths taken during the survey was still important (1587 otoliths of anchovy taken and 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.

Table 3.3.1. PELGAS2016 anchovy Age/Length key.

Nombre de Age	Age				
Taille	1	2	3	4	Total
7	100.00%	0.00%	0.00%	0.00%	100.00%
7.5	100.00%	0.00%	0.00%	0.00%	100.00%
8	100.00%	0.00%	0.00%	0.00%	100.00%
8.5	100.00%	0.00%	0.00%	0.00%	100.00%
9	100.00%	0.00%	0.00%	0.00%	100.00%
9.5	96.67%	3.33%	0.00%	0.00%	100.00%
10	70.45%	29.55%	0.00%	0.00%	100.00%
10.5	69.23%	30.77%	0.00%	0.00%	100.00%
11	67.44%	32.56%	0.00%	0.00%	100.00%
11.5	54.74%	45.26%	0.00%	0.00%	100.00%
12	62.86%	37.14%	0.00%	0.00%	100.00%
12.5	45.19%	54.81%	0.00%	0.00%	100.00%
13	33.61%	66.39%	0.00%	0.00%	100.00%
13.5	36.11%	63.89%	0.00%	0.00%	100.00%
14	28.46%	69.11%	1.63%	0.81%	100.00%
14.5	15.63%	80.47%	3.91%	0.00%	100.00%
15	10.83%	87.50%	1.67%	0.00%	100.00%
15.5	2.73%	86.36%	10.91%	0.00%	100.00%
16	4.95%	67.33%	26.73%	0.99%	100.00%
16.5	1.47%	58.82%	39.71%	0.00%	100.00%
17	0.00%	46.67%	50.00%	3.33%	100.00%
17.5	0.00%	35.00%	65.00%	0.00%	100.00%
18	0.00%	18.18%	81.82%	0.00%	100.00%
18.5	0.00%	22.22%	77.78%	0.00%	100.00%
19	0.00%	0.00%	100.00%	0.00%	100.00%
19.5	0.00%	0.00%	100.00%	0.00%	100.00%
Total	33.14%	56.40%	10.21%	0.25%	100.00%

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 2016 are shown in figure 3.3.3.

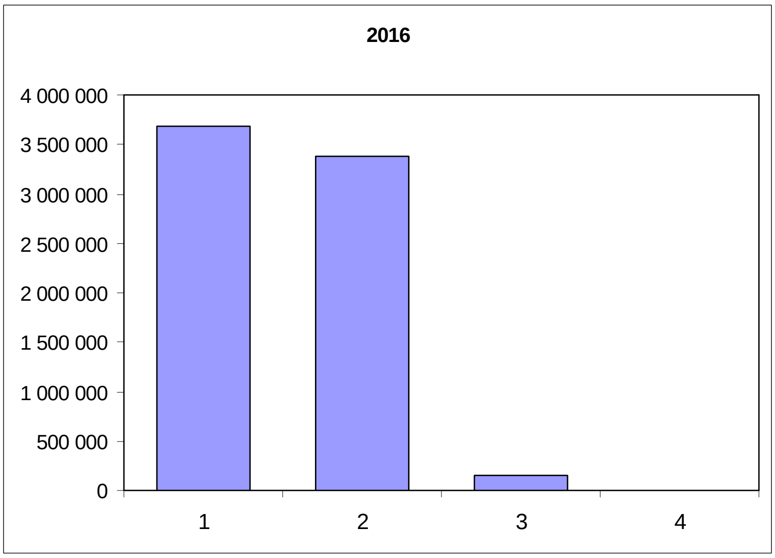


Figure 3.3.2– global age composition (numbers) of anchovy as observed during PELGAS16.

Looking at the numbers at age since 2000 (fig 3.3.3.), the number of 1 year old anchovies this year seemed equivalent to 2010 or 2013, far away from the very best recruitment observed last year. As it is described in chapter 3.7, we probably underestimated the number of age 2 & 3 this year, as they were present very closed to the surface offshore in the middle part of the bay of Biscay, in the blind layer of vertical echosounders but observed by the lateral echosounder. The lateral echosounder is not used for assessment purpose.

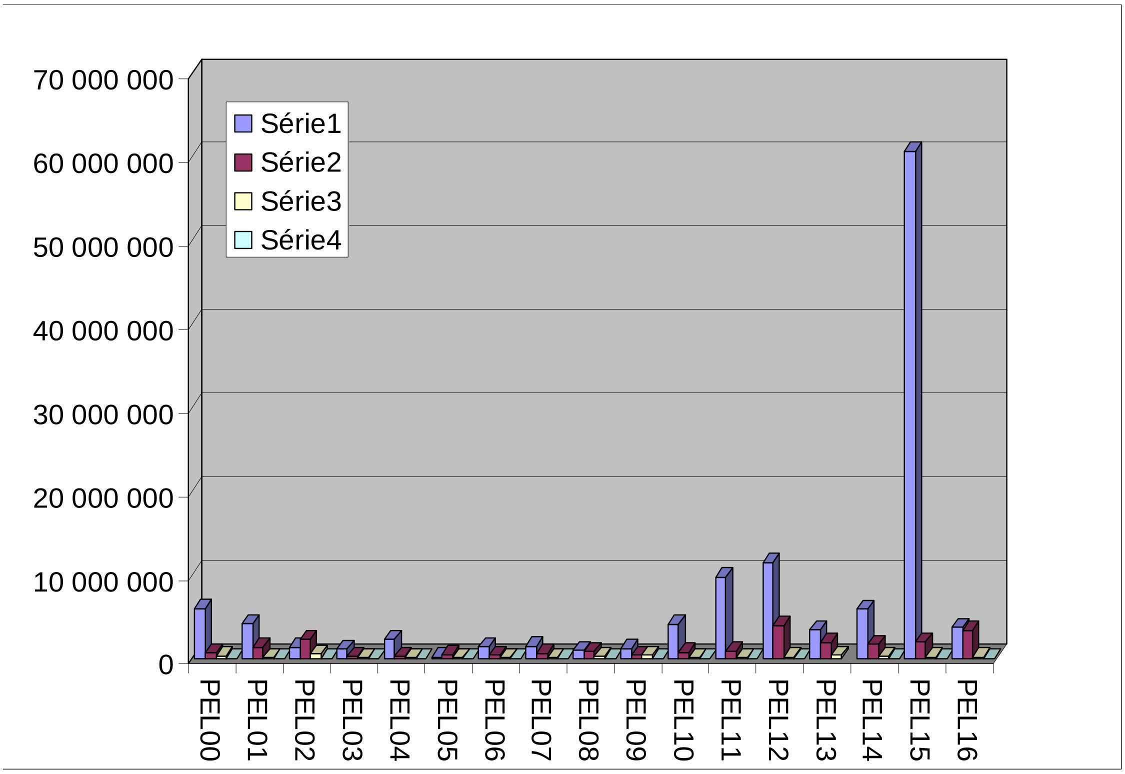


Figure 3.3.3 Anchovy numbers at age as observed during PELGAS surveys since 2000

The huge 2015 age class last year is not fully followed in a high abundance of age 2 this year (see before and in chapter 3.7).

In 2016, the number of age 1 and 2 seemed to be equivalent in numbers.

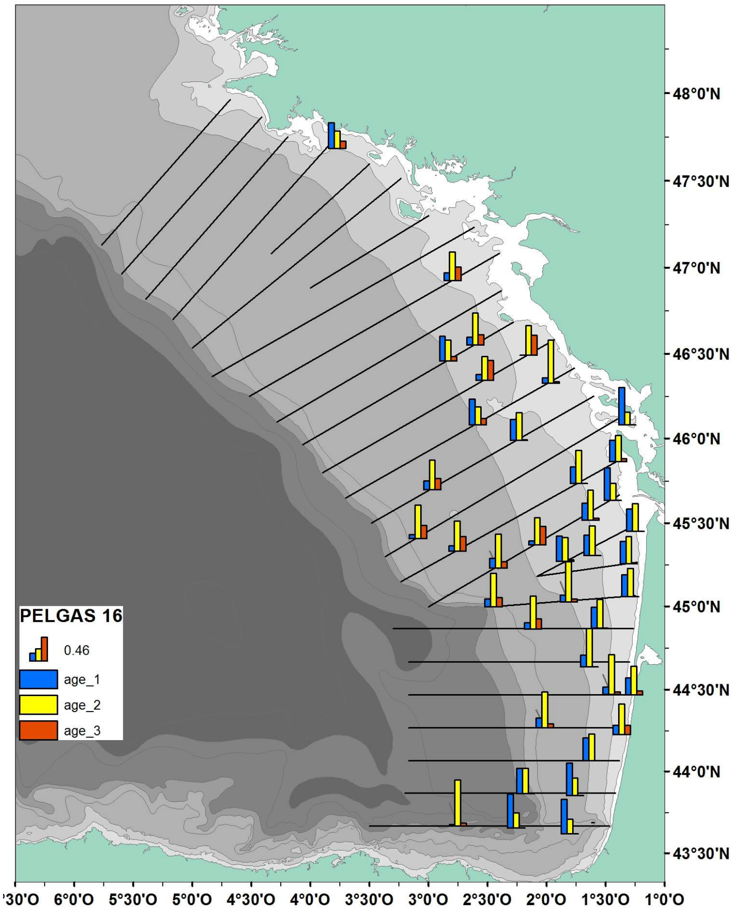


Figure 3.3.4 Anchovy proportion at age in each haul as observed during PELGAS16 survey (blue = age 1, yellow = age 2).

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 in 2014, as age2 were present all over the area where anchovy was present, even in the Gironde area where usually age 1 is almost pure. Offshore and closed to the surface, older fishes (age 2 and 3) were detected and caught

	PEL16 - % - N
age 1	51.06%
age 2	46.71%
age 3	2.14%
age 4	0.08%

	Pel16 - % - W
age 1	39.68%
age 2	54.71%
age 3	5.46%
age 4	0.15%

Figure 3.3.5 percentage by age of the Anchovy population observed during PELGAS16 in numbers (left) and biomass (right).

3.4. Weight/Length key

Based on 1781 weights of individual fishes, the following weight/length key was established (figure 4.5.):

$W= 0.004L^{3.199}$ with R2 = 0.9697 *(with W in grams and L in mm)*

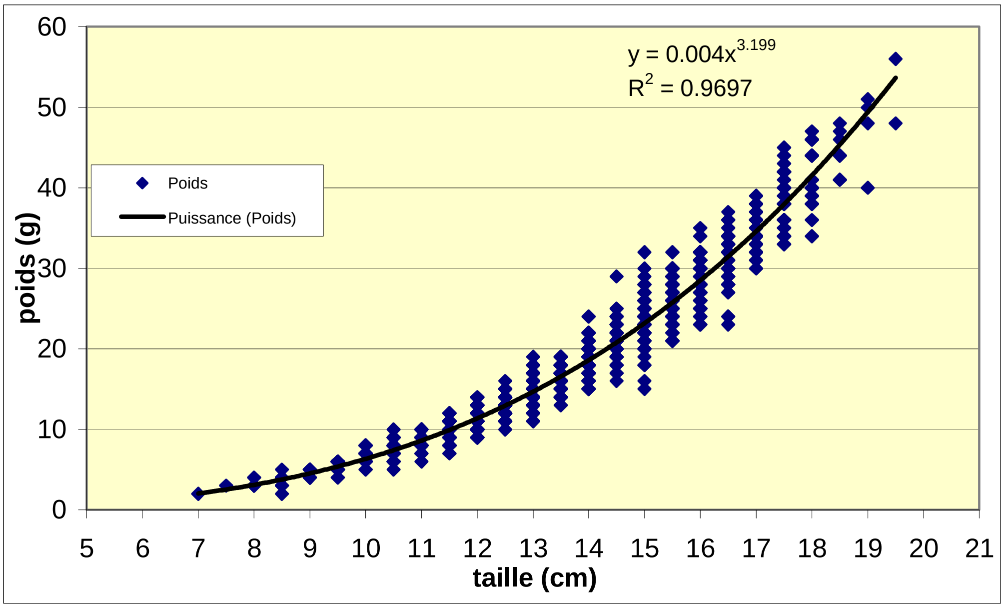


Fig. 3.4 – Weight/length key of anchovy established during PELGAS16

3.5. Mean Weight at age

mean weigth at age (g)	AGE				
survey	1	2	3	4	5
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	50.52
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	
PEL15	5.13	20.43	19.94	19.63	38.43
PEL16	9.37	14.12	30.70	23.97	

Fig. 3.5. – mean weight at age (g) of anchovy for each PELGAS survey

As previous years, we observe that globally the trend of the mean weight at age is a decrease. This trend is the same for sardine in the bay of Biscay. Further investigates should be done and, if we have some hypothesis (maybe an effect of density-dependance), we do not have real explanation for the time being.

3.6. Eggs

During this survey, in addition of acoustic transects and pelagic trawl hauls, 538 CUFES samples were collected and counted, 82 vertical plankton hauls and 114 vertical profiles with CTD were carried out. Eggs were sorted and counted during the survey.

2016, as from 2011, was marked by a large quantity of collected and counted anchovy eggs (Fig 3.6.2).Their spatial pattern of distribution was quite usual, with major part of the abundance South of 46°N. However, eggs are also abundant on 2 more transects than usual North of the Gironde estuary, with a connection all over the shelf between the classical inshore and slope distributions. This may be related to the large extension of the Gironde plume to the North-West, as well as the large adult abundance spreading larger than usual. South of the Gironde eggs are mostly located in the mid-shelf, with extension off-shelf on some of the transects. Small amount of eggs are again found in front of the Loire mouth and along the southern coast of Brittany.

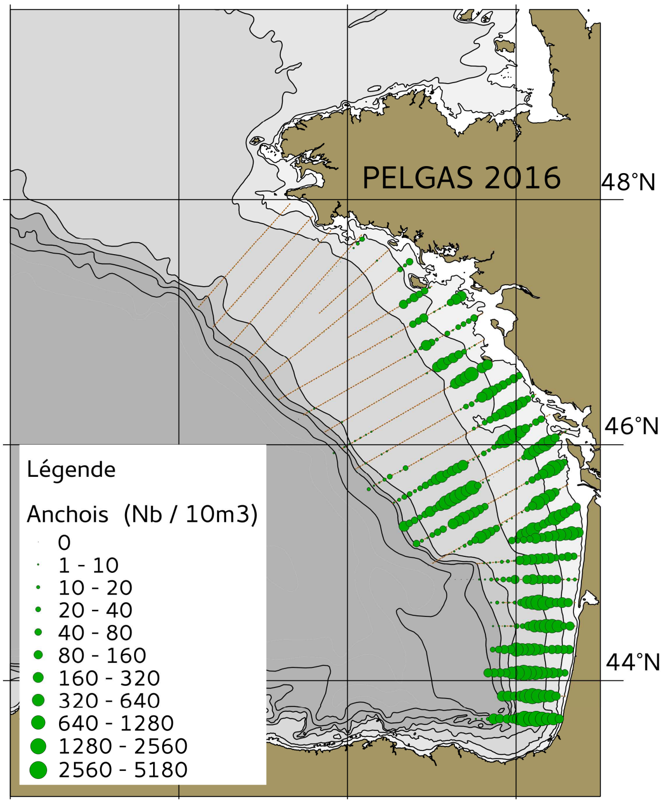


Figure 3.6.1 – Distribution of anchovy eggs observed with CUFES during PELGAS16.

Figure 3.6.2 – Number of eggs observed during PELGAS surveys from 2000 to 2016

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 gram 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 series is shown on figure 3.7.1.

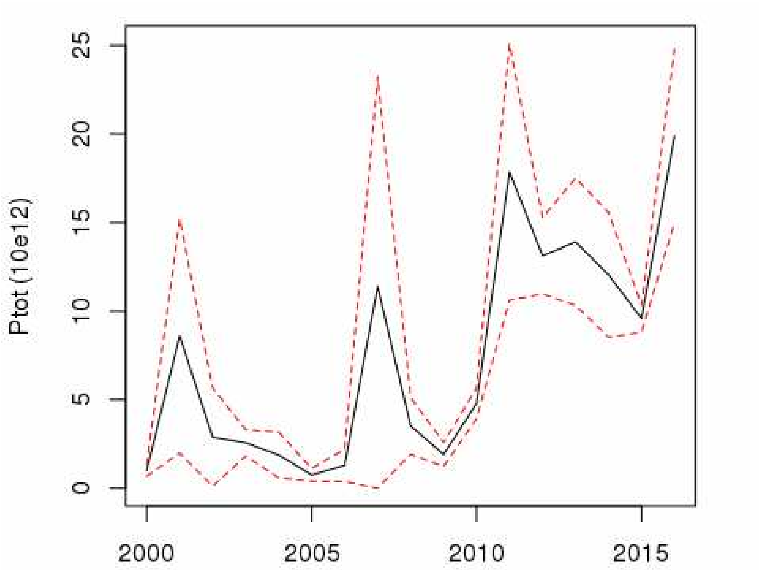


Figure 3.7.1 – Ptot serie from the CUFES index

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 3.7.2.). 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 some years.

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.

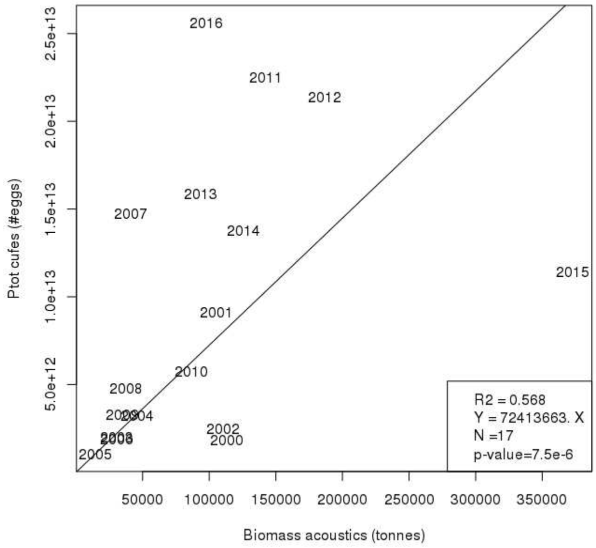


Figure 3.7.2 – Coherence between CUFES and Acoustic PELGAS survey indices

It must be noticed that with such a high acoustic biomass in 2015, this year's point drives the linear regression. It must be simply explained by the fact that a high proportion of in 2015 were not spawning at the time of the survey (see chapter 3.2). In near future, we'll correct this biomass with the real spawning one to adapt the regression between eggs and spawning biomass. Once again, if the biomass this year in slightly underestimated according to the presence of large anchovies in the blind layer of vertical echosounder, the point should be closer to the slope.

An other important thing is that this year is the second year when the eggs count is realised by the zoocam system, tested, improved and validated during previous surveys in quality and in quantity of eggs as well.

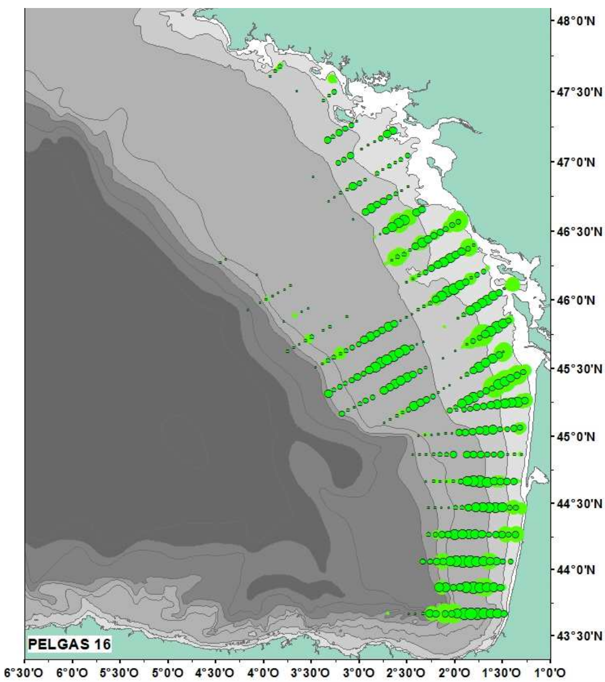


Figure 3.7.3 – Coherence between spatial distribution of adults and eggs. circled point = eggs, without circle = biomass of adults per ESDU

We can see that globally the spatial distribution of eggs match with the adult's one. but in the center of the bay, a lot of eggs were counted despite a low abundance of adults. In this area particularly, anchovy was very closed to the surface, in the blind layer of vertical echosounders. This lead a probable underestimation of adults biomass in this area.

4. SARDINE DATA

4.1. Adults

The biomass estimate of sardine observed during PELGAS15 is **229 742** tons (table 2.3.), which is is at a low average level of the PELGAS series, and constituting a real decrease of the biomass compared to the 4 last years. It must be enhance that this survey doesn't cover the total area of potential presence of sardine, and 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. It seems to be the case along the coast of Brittany this year where eggs were counted along the coast but without real energy attributed to sardine.

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. Sardine was present, often mixed with anchovy and sometimes with sprat, from the Gironde to the South coast of Brittany. Sardine appeared rather absent offshore, close to the surface, along the shelf break, contrary to previous years when sardine was well present along the shelfbreak.

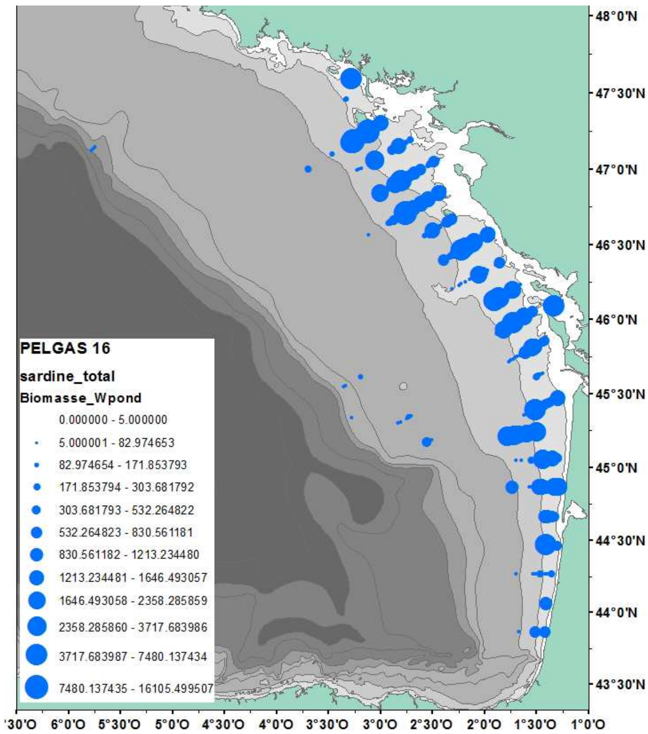


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Figure 4.1.1 – distribution of sardine observed by acoustics during PELGAS16

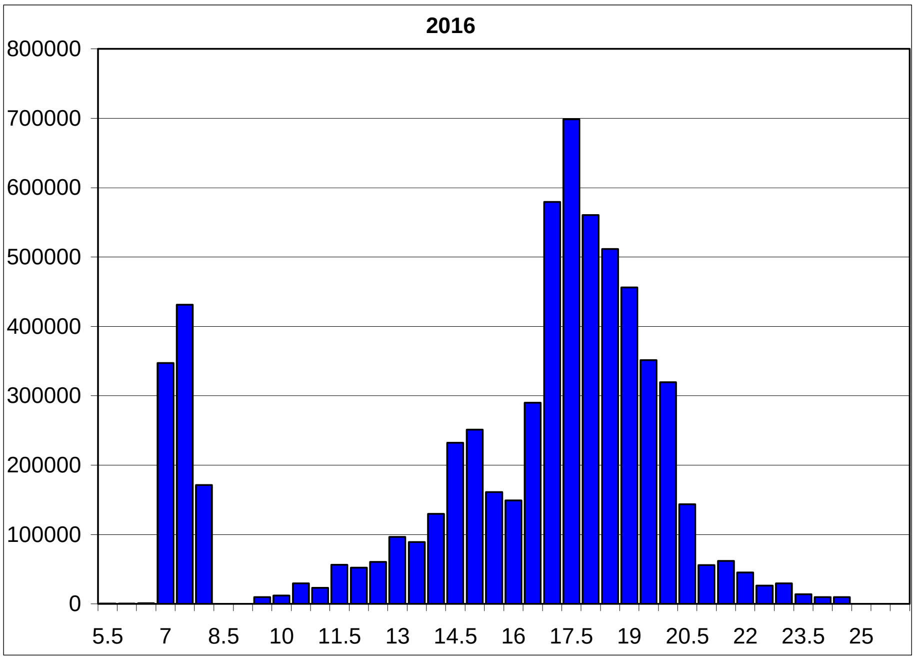

Figure 4.1.2. – length distribution of sardine as observed during PELGAS16

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 the acoustic biomass estimated in the post-stratification regions comprising each trawl haul. The global length distribution of sardine is shown on figure 4.1.2.

This year, sardine shows a trimodal length distribution, the first one (about 7 cm), corresponding to the age 0, and present for the first time this year at this period front of the Gironde and in the extrem south of the bay of Biscay). The second , about 14cm, corresponds to age 1 and the third, about 18cm, is mainly constituted by the 2 and 3 years old (still present a bit more offshore than the 1 year class, mainly between depths 60 and 80 m. The older individuals (age 5 and more) seems to be rather absent of the bay of Biscay this year.

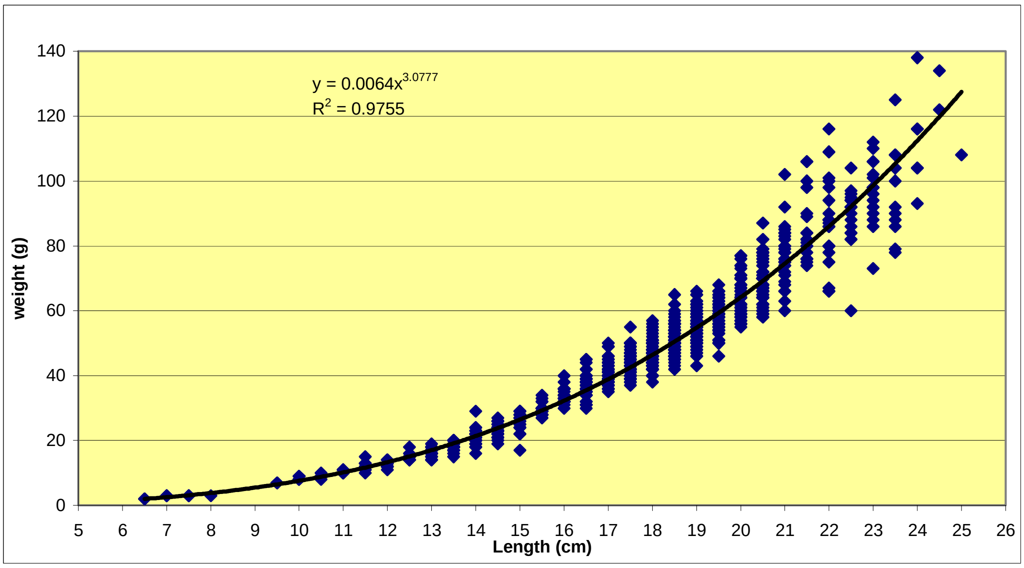

Figure 4.1.3 – Weight/length key of sardine established during PELGAS16

Nombre de Age	Age											
Taille	0	1	2	3	4	5	6	7	8	9	10	Total
6.5	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
7	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
7.5	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
8	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
9.5	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
10	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
10.5	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
11	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
11.5	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
12	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
12.5	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
13	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
13.5	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
14	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
14.5	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
15	0.00%	94.74%	5.26%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
15.5	0.00%	95.24%	4.76%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
16	0.00%	44.44%	55.56%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
16.5	0.00%	23.64%	76.36%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
17	0.00%	8.51%	89.36%	2.13%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
17.5	0.00%	6.48%	87.04%	4.63%	1.85%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
18	0.00%	0.00%	83.04%	16.07%	0.89%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
18.5	0.00%	0.00%	58.77%	34.21%	7.02%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
19	0.00%	0.00%	41.46%	42.28%	16.26%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
19.5	0.00%	0.00%	20.59%	55.88%	23.53%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
20	0.00%	0.00%	6.33%	46.84%	37.97%	6.33%	2.53%	0.00%	0.00%	0.00%	0.00%	100.00%
20.5	0.00%	0.00%	2.00%	28.00%	62.00%	6.00%	0.00%	2.00%	0.00%	0.00%	0.00%	100.00%
21	0.00%	0.00%	0.00%	31.25%	34.38%	28.13%	0.00%	6.25%	0.00%	0.00%	0.00%	100.00%
21.5	0.00%	0.00%	0.00%	15.79%	57.89%	15.79%	0.00%	10.53%	0.00%	0.00%	0.00%	100.00%
22	0.00%	0.00%	0.00%	4.55%	54.55%	13.64%	4.55%	18.18%	4.55%	0.00%	0.00%	100.00%
22.5	0.00%	0.00%	0.00%	5.56%	27.78%	33.33%	16.67%	11.11%	0.00%	5.56%	0.00%	100.00%
23	0.00%	0.00%	0.00%	0.00%	6.67%	13.33%	40.00%	33.33%	6.67%	0.00%	0.00%	100.00%
23.5	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	41.67%	25.00%	25.00%	0.00%	8.33%	100.00%
24	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	50.00%	33.33%	16.67%	0.00%	100.00%
24.5	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	100.00%
25	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%
Total	0.82%	21.39%	38.78%	19.51%	12.73%	2.53%	1.39%	1.96%	0.57%	0.16%	0.16%	100.00%

Table 4.1.4 : sardine age/length key from PELGAS16 samples (based on 1225 otoliths)

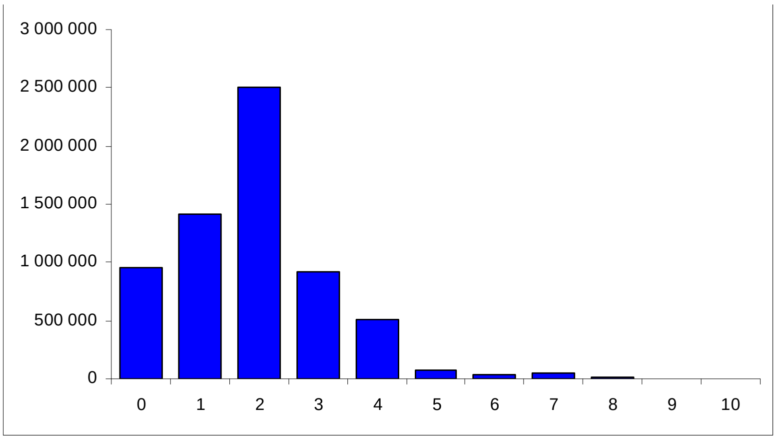

Figure 4.1.5.- Global age composition (nb) of sardine as observed during PELGAS 16

	pel16 - % - N
age 0	14.70%
age 1	21.85%
age 2	38.68%
age 3	14.22%
age 4	7.89%
age 5	1.13%
age 6	0.50%
age 7	0.80%
age 8	0.16%
age 9	0.05%
age 10	0.02%

	PEL16 - W - %
age 0	1.18%
age 1	13.31%
age 2	44.86%
age 3	21.17%
age 4	13.37%
age 5	2.28%
age 6	1.17%
age 7	2.03%
age 8	0.45%
age 9	0.13%
age 10	0.05%

Figure 4.1.6 percentage by age of the sardine population observed during PELGAS16 in numbers (left) and biomass (right).

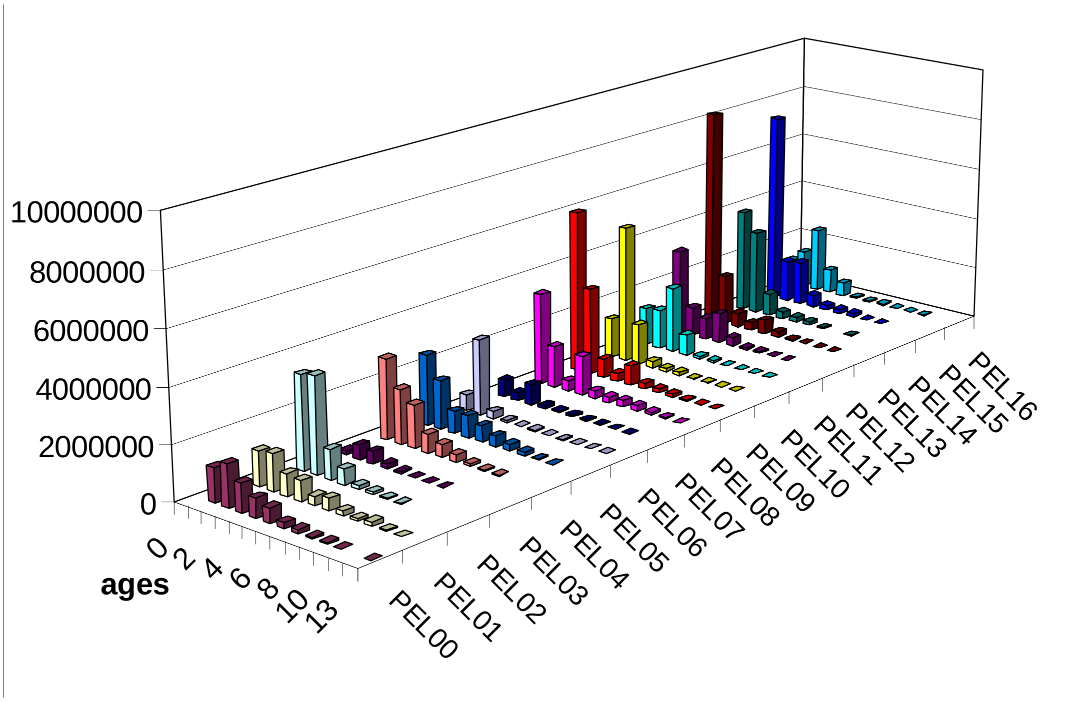

Figure 4.1.7- Age composition of sardine as estimated by acoustics since 2000

PELGAS serie of sardine abundances at age (2000-2016) is shown in Figure 4.1.7. Cohorts can be visually tracked on the graph particularly in the past : the respectively very low and very high 2005 and 2008 cohorts denote atypical years in terms of environmental conditions, and therefore fish (and particularly sardine) distributions. this is less true in recent years, with the good recruitment in 2013 which doesn't profit to incoming years.

The 2016 recruitment at age 1 seems to be low. But the real new event is that juveniles appearance particularly front of the Gironde. Otoliths were extracted and read and they show a full opaque pattern, without any winter ring. So it was decided to attribute age 0 to these fish.

	age										
survey	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
PEL 2000	-	35.05	54.74	69.15	76.46	84.82	89.93	98.83	110.18	105.04	112.87
PEL 2001	-	41.28	58.85	76.83	83.84	93.68	96.92	103.41	105.35	112.71	120.97
PEL 2002	-	40.48	60.2	74.94	81.7	92.31	99.42	106.68	118.05		
PEL 2003	-	53.35	68.04	73.15	78.11	86.04	93.33	88.74	96.09		
PEL 2004	-	35.94	64.73	76.54	84.39	95.87	98.83	104.34	109.19	106.15	
PEL 2005	-	34.44	63.45	73.29	79.62	84.88	88.96	90.04	105.42	109.45	98.35
PEL 2006	-	39.17	58.37	70.78	81.18	86.37	82.48	91.25	97.22	107.02	112.02
PEL 2007	-	37.55	65.96	71.77	79.05	84.02	94.45	100.37	96.93	101.27	114.86
PEL 2008	-	33.44	60.33	71.1	75.18	83.82	92.84	90.45	95.67	99.48	101.41
PEL 2009	-	29.51	57.13	73.62	81.28	83.26	88.35	95.67	91.44	96.50	106.67
PEL 2010	-	30.33	50.55	64.04	73.05	78.43	87.58	93.16	105.88	106.96	116.01
PEL 2011	-	27.37	50.13	58.69	69.84	78.35	83.00	84.28	108.17	105.38	108.33
PEL 2012	-	22.88	44.66	57.40	65.45	78.42	87.83	95.26	92.27	99.83	
PEL 2013	-	21.16	44.33	55.82	68.30	77.42	84.27	89.28	99.10	113.27	89.17
PEL 2014	-	23.02	44.53	55.93	62.07	69.35	76.11	78.46		86.50	
PEL 2015	-	18.75	44.73	56.98	67.22	78.86	87.07	94.81	95.23	90.01	
PEL 2016	3.01	22.94	43.64	56.03	63.76	75.71	88.48	95.36	102.21	102.39	105.47

Figure 4.1.8- mean Weight at age (g) of sardine for each PELGAS survey

The PELGAS sardine mean weights at age series (Table 4.1.8) shows a clear decreasing trend, whose biological determinant is still poorly understood.

4.2. Eggs

The spatial pattern of sardine eggs overlaps with the one of anchovy, with a further north distribution along the coast though, and a lack of eggs along the slope in the North, which was the case only one year in the past in 2010.

For sardine, egg abundances are at a mean level with regard to the whole Pelgas time-series.

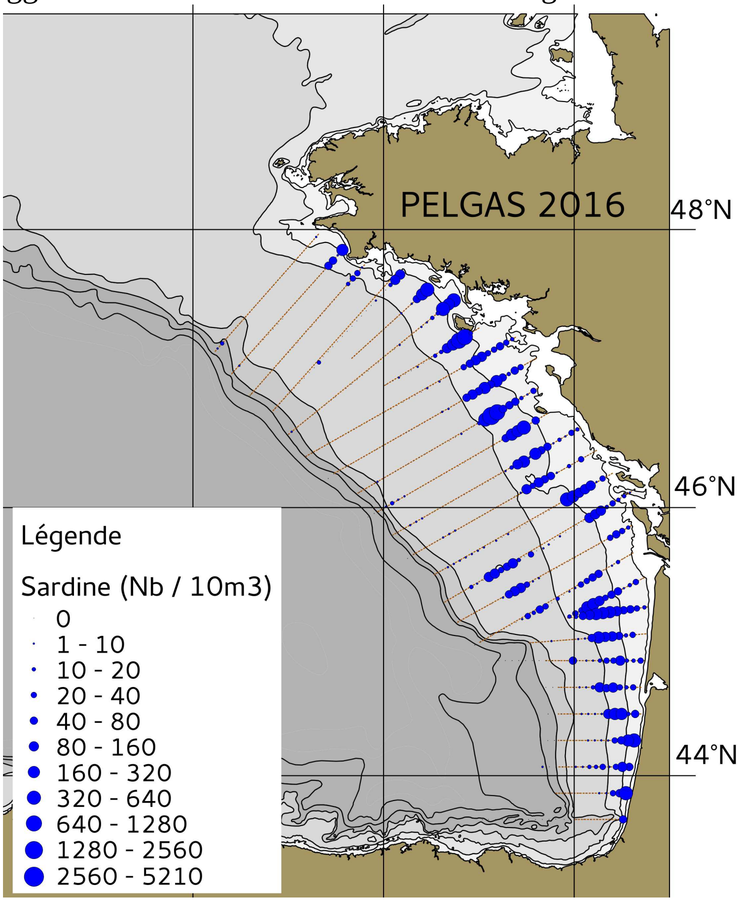

Figure 4.2.1. Distribution of sardine eggs observed with CUFES during PELGAS16.

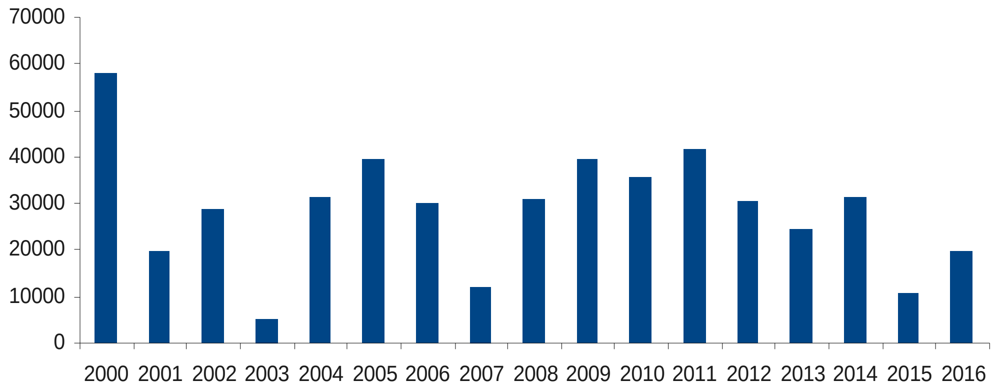

Figure 4.2.2. Number of eggs observed during PELGAS surveys from 2000 to 2016

2016 was marked by a medium abundance of sardine eggs as compared to the PELGAS time-series. It must be noticed that this year almost all sardines were mature and in spawning period, compared to 2015 when the small sardine at age 1 were not spawning at the period of the survey.

5. Top predators

For the thirteenth consecutive year, monitoring program to record marine top predator sightings (marine birds and cetaceans) has been carried out , during the whole coverage of the transects network (from the 2nd of May to the 1st of June 2015).

A total of 236 hours of sighting effort were performed for 31 days (Figure 5.1.), with an average of 7.6 hours of sighting effort per day. Weather conditions were generally good with a majority of the effort deployed in Beaufort conditions 2 or 3.

During the survey, 2,240 sightings of animals or objects were recorded. Seabirds constitute the majority of sightings (70%). Other most frequent sightings concern either litter drifting at sea (12%), fishing ships (6%) and buoys (5%). Cetaceans only account for less than 2% of sightings.

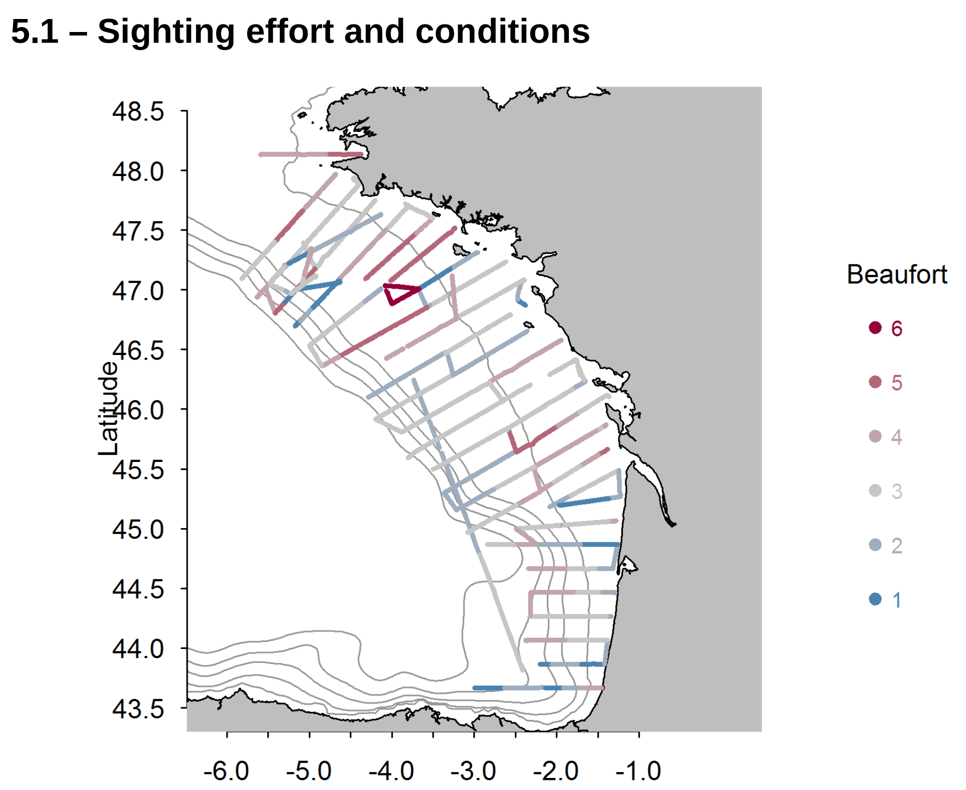

Figure 5.1. Sighting effort and conditions

The better conditions were met in the central part of the bay of Biscay, and the worst in the North. Globally conditions of sightings were considered as "good", 8% as medium and 31 % as bad, due to wind or fog

5.2 – Birds

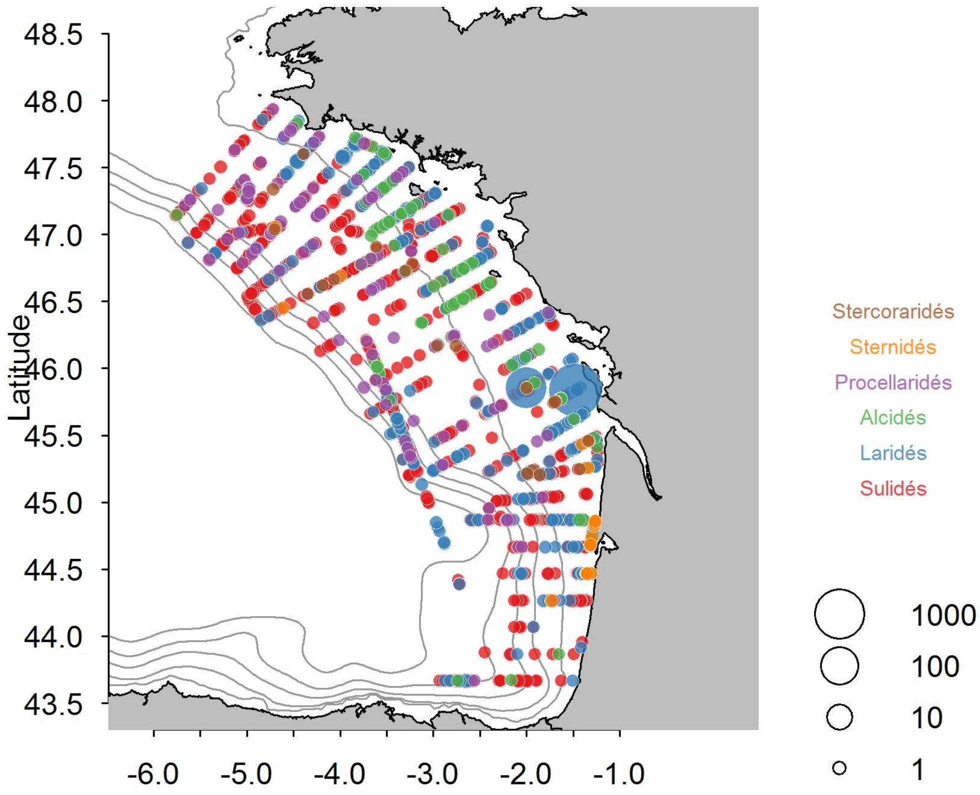

Figure 5.2. Distribution of birds observed during the PELGAS16 survey

Birds constitute the vast majority of sightings. Shorebirds and passerines accounted for less than 4% of bird sightings. 1,505 sightings of seabirds were found all over the Bay of Biscay (Figure 5.2), divided into 22 identified species and a raw estimate of 5577 individuals.

Northern gannets accounted for 55% of all seabird sightings: its distribution is homogeneous across the Bay of Biscay.

An other group of species was also well met : the larids, including the sea gulls and Black-legged Kittiwake (4 species observed this year in this family). They represent the most important number of individuals observed during the survey, with a total of 4805 birds. Some groups are really huge in terms of numbers of fish, with a strong maximum this year of almost 500 individuals, observed in the Gironde area.

Alcids (guillemot, razorbill) are softly present this year, with only 5% of the observations concerning this group.

5.2 – Mammals

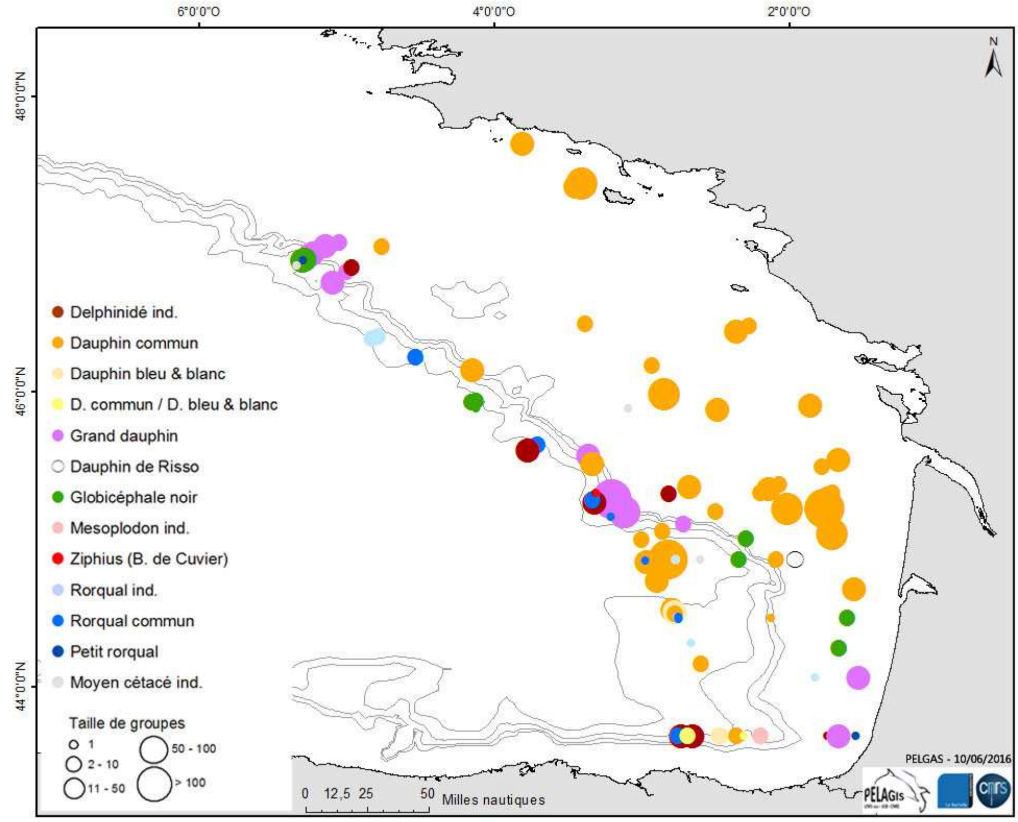

Figure 5.2. Distribution of mammals during the PELGAS16 survey.

A total of 109 sightings were recorded corresponding to a raw estimate of 2122 individuals and 8 species of cetaceans clearly identified (Figure 2). The greatest diversity of marine mammals was observed in the central part of the Bay of Biscay. The overall distribution pattern is similar to that of previous PELGAS spring surveys.

Common dolphin is the most recorded species (44% of total observations, 1375 individuals). Common dolphins were present on the continental shelf, with a maximum front of the Gironde, with large groups someone (until 200 individuals). Striped and Risso's dolphins were sighted this year, but as usual in lower quantities than Bottlenose dolphins. However, some long-finned pilot whales were sighted on the continental slope in the central part of the Bay of Biscay.

Two observations of minke whales were reported after the slope, in the extreme South and the extreme North of the bay of Biscay. Compared to previous years, fin whales were well present in 2016 all along the shelfbreak, with 11 observations reported.

6. Hydrological conditions

The conditions were very similar than 2015, with a well established stratification despite relatively low temperature at surface, around 14°C over the whole bay. The calm but cold weather in April (before the start of the survey) explain these conditions. Thermal stratification was even more favoured by the river runoffs quite strong during the winter generating a haline stratification over a large part of the continental shelf.

The early spring phytoplankton blooms were important from early March on the shelf. Offshore the typical northward progression of high chlorophyll surface concentration occured during April.

At the start of the survey, stratification is then well established, with a thermocline well marked around a depth of 40m, but surface temperature remain relatively cold just above 14°C. The fresh weather conditions, even if no real wind event occurred during the survey, maintain this temperature between 14°C and 15°C during the whole survey, with not much evolution of the structure of the surface mixed layer.

The surface primary production remain high along the coast in the plumes. More offshore, the chlorophyll maxima are well marked around the thermocline.

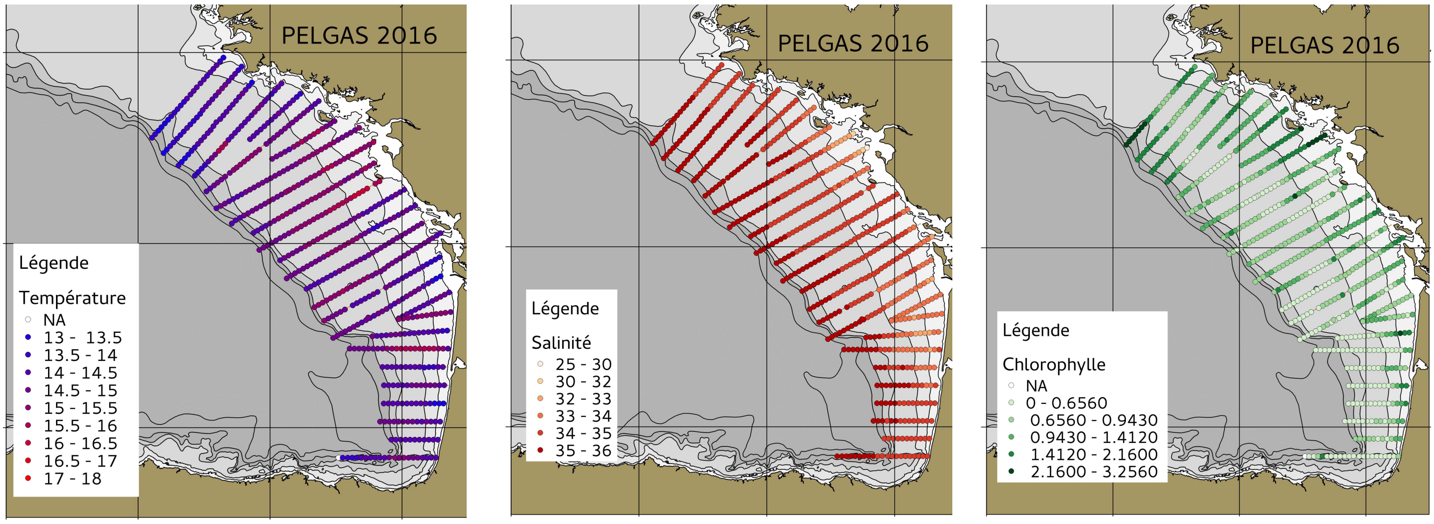

Figure 6.1. – Surface temperature, salinity and fluorescence observed during PELGAS16.

7. CONCLUSION

The Pelgas16 acoustic survey has been carried out with very good weather conditions (regular low wind, medium 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 120 valid identification hauls instead of about 60 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 PELGAS16 were close to the average of the serie, with a surface temperature still relatively cold (just above 14°C) maintained by low atmospheric temperature and an absence of real wind event during the survey and some time before.

Affected by relative good weather conditions before and during the survey, the water column was well stratified , with a surface temperature around the average of the serie (14°C). Surface phytoplanktonic production remained high along the coast under the influence of the river discharges. More offshore, the chlorophyll maxima are well marked around the thermocline.

The PELGAS16 survey observed a medium level of anchovy biomass (**89 727 tons**), which seems to be a medium biomass compared to previous year's, comparable to 2010 and far away from the 2015 biomass. Offshore, anchovies were so closed to the surface that we probably underestimate the abundance in that area, according to the quantity of eggs counted. As previous years, we observe that globally the trend of the mean weight at age is a decrease. This trend is the same for sardine in the bay of Biscay. Further investigates should be done and, if we have some hypothesis (maybe an effect of density-dependance), we do not have real explanation for the time being.

The biomass estimate of sardine observed during PELGAS16 is **229 742 tons**, which constitutes a decrease of the last years level of biomass. It confirms that this specie shows a variable abundance in the bay of Biscay at this period. Last years showed a high level of biomass, and the current year a medium one, taken into account the probable light underestimate along the coast in the Northern part. Effectively, eggs were present along the coast without any energy attributed to sardine in this area. It must be explained by fish in very shallow waters, where Thalassa is not allowed to do acoustic acquisition, and then, to fish.

The proportion of age 1 (22% in number, and 13 % in mass) seems to be low compared to high recruitments observed during last 3 years. the relative high proportion of age 2 (39% in number and 44 % in mass) confirms the last year's good recruitment. 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. But it must be noticed that global weights and lengths at age are regularly decreasing in the bay of Biscay, maybe due to an effect of density-dependence or other reasons not well known at this time. Old individuals (>5 years old) seems to be less an less present in the bay of Biscay, year after year.

Concerning the other species, mackerel was relatively well present this year compared to recent surveys, while horse mackerel seems to be one more time a bit more abundant for the fourth consecutive year, this index of biomass now reaching a medium level of biomass.

WD5 – JUVENA SURVEY

Acoustic surveying of anchovy Juveniles in the Bay of Biscay: JUVENA 2016 Survey Report

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Working Document to WGACEGG meeting 14-18 November 2016 at Capo Granitola, Italy

Acoustic surveying of anchovy Juveniles in the Bay of Biscay:

JUVENA 2016 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. 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 2016 is around 370,000 tonnes, which represents the fourth highest biomass value of the temporal series, well above the average. This result foreseen a high recruitment value for the next year 2016.

2. Materials and Methods

2.1 Data acquisition

The survey JUVENA 2016 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 18, 38, 70, 120, 200 and 333 kHz transducers were installed looking vertically downwards, 3 m deep, at the end of a tube attached to the side of the boat, whereas at the R/V Emma Bardan the 38, 120 and 200 kHz transducers were installed at the hull. For acoustic data processing the IFREMER Movies+ software was used.

The water column was sampled to depths of 400 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 7º32’ W and 47º45’ 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:

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

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 the September 13th along a 80 nautical miles long transect over a pure juvenile distribution. The intercalibration analysis of the data registered by EB and RM showed no substantial collection bias. Therefore, the recorded acoustic data was not corrected.

Sampling coverage

The survey JUVENA 2016 took place between the 31st of August and 3th of October (see Table 2). The survey sampled around 3000 n.mi. that provided a coverage of about 45,000 n.mi.2 along the continental shelf and shelf break of the Bay of Biscay, from the 7º32' W in the Cantabrian area up to 47º 45' N at the French coast (Figure 1). Seventy eight hauls were done during the survey to identify the species detected by the acoustic equipment, 54 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 and a mixed juvenile-adult stratum (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 both on and off the shelf, from 7º30' W to 1º40' W (Figure 4). Mean sizes ranged between 4 and 10 cm in this area (Figure 3). The vertical distribution of juvenile anchovy extended from 5 to 50 m depth.
    - **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 7 and 11 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 13 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 (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, spratt 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 2016 is 371,563 tones (Table 7). This value, is the fourth maximum biomass of the JUVENA series, well above the average (Figure 6). The area of distribution of juvenile anchovy this year was also among the highest in the temporal series, (Figure 6, Table 8). The mean size of anchovy was slightly less than 7 cm long (Figure 3). As usual, most 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.

The biomass estimated foresees a high recruitment of anchovy for next year (Figure 7). The index of juvenile anchovy provided by JUVENA will be used to update the assessment of anchovy in the Bay of Biscay based on the CBBM (ICES, 2015).

Predators observation in JUVENA 2016

By Isabel García-Barón, Jose Antonio Vázquez, Ruairí Gallagher, Mikel Basterretxea and Maite Louzao

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 (Spanish Institute of Oceanography) and PELGAS (Ifremer) 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, 6 meters high from the sea surface. Observers scanned the water to the front of the boat covering an area of 90° 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 202 observations periods (legs) were performed, travelling a total of 2286 km during 136 hours of observation. We observed an average of 5.21 hours per day (range: 0.5 – 9.75) and travelled an average of 88 km per day (range: 9.9 - 165). We recorded a total of 3875 seabirds, 1121 cetaceans, 557 human activities and 63 land birds. A complete list is given in the Tables 10-14.

- **Marine mammals:** Regarding marine mammals, we observed 10 different species and the spatial distribution of the most abundant species can be observed in Figure 9. The most abundant species where the common dolphin (*Delphinus delphis*) with 82 sightings (group size = 7.51 ± 6.92, total of 616 individuals), followed by fin whales (*Balaenoptera physalus*) with 56 sightings (group size = 1.38 ± 0.65, total of 77 individuals) and stripped dolphins (*Stenella coeruleoalba*) with 27 sightings (group size = 9.74 ± 14.07, total of 263 individuals). We also observed long-finned pilot whales, bottlenose dolphins and minke whales (Table 10).

- **Seabirds:** Regarding seabirds, we observed 31 different species and the spatial distribution of the most abundant species can be observed in Figure 10. The most abundant species where the northern gannet *(Morus bassanus*) with 368 sightings (group size = 1.58 ± 1.96, total of 538 individuals), followed by the great shearwater (*Puffinus gravis*) with 300 sightings (group size = 2.85 ± 6.96, total of 854 individuals), yellow-legged gull (*Larus michahellis*) with 150 sightings (group size = 1.99 ± 3.11, total of 297 individuals) and lesser black-backed gull *(Larus fuscus*) with 114 sightings (group size = 1.4 ± 1.29, total of 160 individuals). We also observed sooty shearwaters (*Puffinus griseus*) with 82 sightings (group size = 1.73 ± 1.9, total of 142 individuals), Cory's shearwater (*Calonectris diomedea*) with 60 sightings (group size = 2.13 ± 3.06, total of 128 individuals), great skuas (*Catharacta skua*) with 51 sightings (group size = 1.08 ± 0.34, total of 55 individuals), Sabine's gulls (*Larus sabini*) with 41 sightings (group size = 6.2 ± 6.86, total of 254 individuals). We also observed Manx shearwater (*Puffinus puffinus*), sandwich tern (*Sterna sandvicensis*), balearic shearwater (*Puffinus mauretanicus*), parasitic jaeger (*Stercorarius parasiticus*), european storm petrel (*Hydrobates pelagicus*), european shag (*Phalacrocorax aristotelis), red phalarope (Phalaropus fulicarius), great cormorant (Phalacrocorax carbo), black*-headed gull (*Chroicocephalus ridibundus*), great black-backed gull (*Larus marinus*), mediterranean gull (*Ichthyaetus melanocephalus*), black tern (Chlidonias niger) (Table 11).

- **Opportunistic sightings:** Furthermore, we have collected opportunistic predator sightings onboard the R/V Emma Bardán that complements the observations gathered from systematic oceanographic survey onboard R/V Ramón Margalef. Opportunistic observations can help test distribution models developed with observations from systematic surveys. It is therefore interesting to gather information on the presence of marine mammals, tunas, turtles, sharks and sunfish. In the case of seabirds, we recorded the presence of less abundant species and aggregations / associations (e.g., associations of seabirds feeding with tuna and marine mammals) or unusual behaviour of the most abundant species (see Tables 10-14).

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 biomass estimate of this year (371,563 tonnes) is the fourth maximum of the JUVENA series, well above the average.
- Since the 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.

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

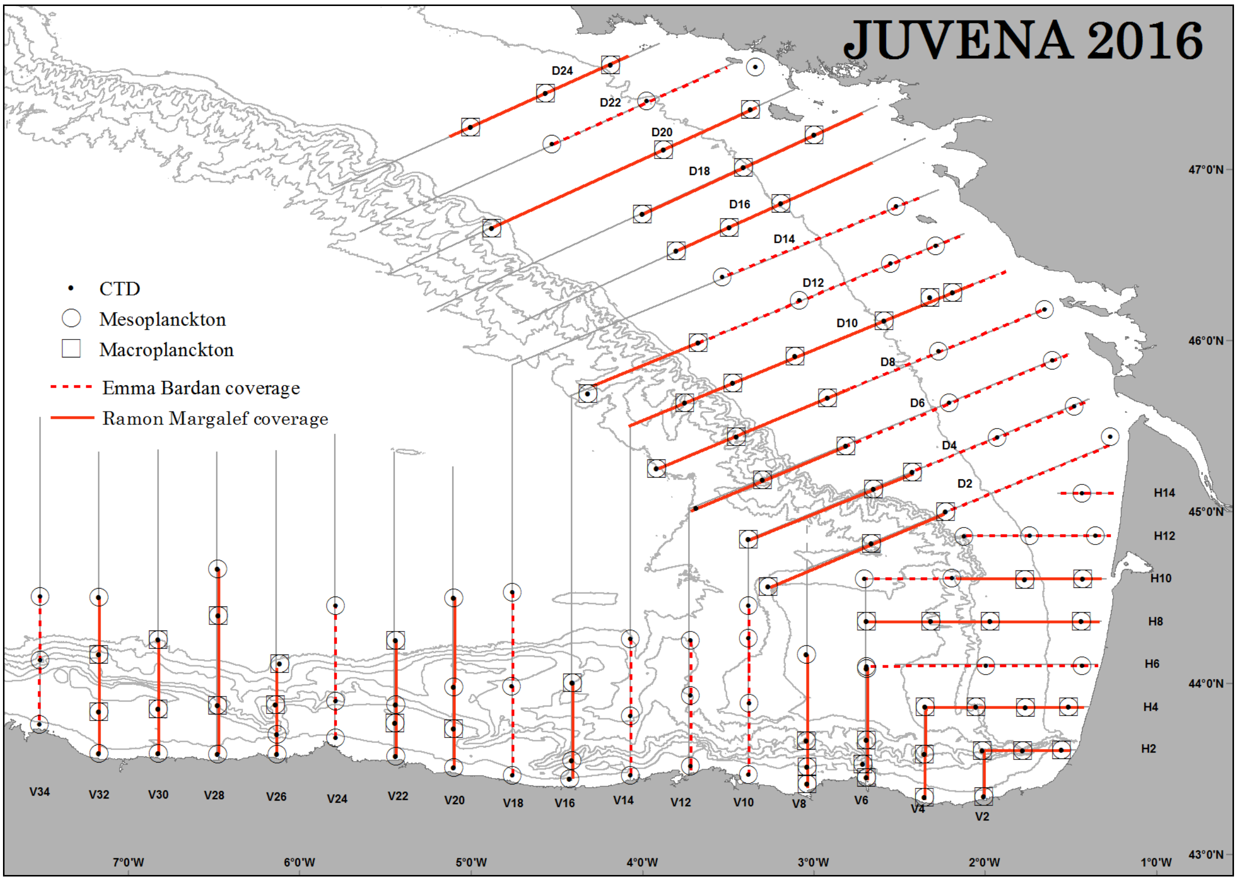

Figure 1. Visited transects (red solid line for the RM and dashed line for the EB) and stations of hydrography / plankton by the R/V Ramon Margalef and R/V Enma Bardán.

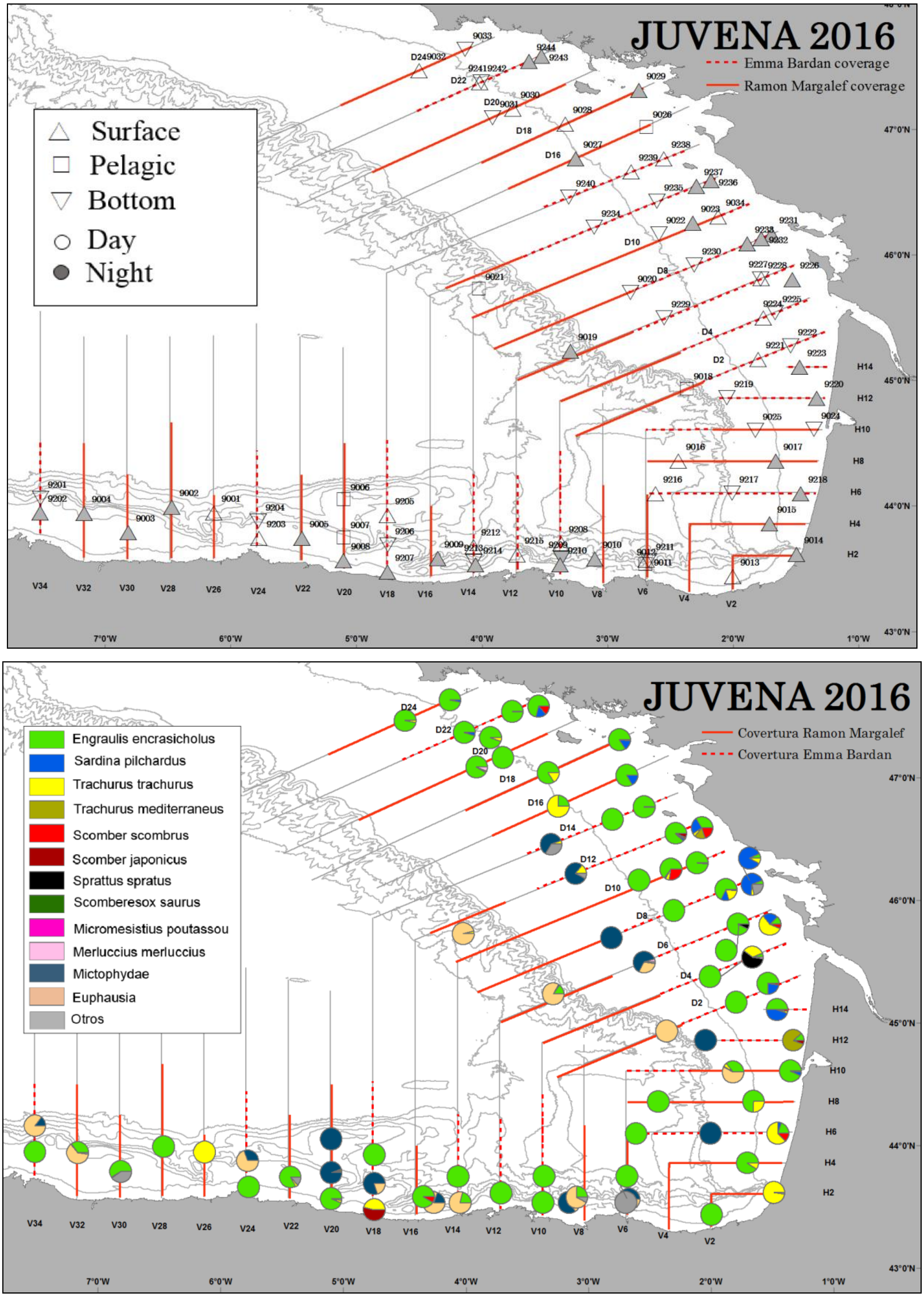

Figure 2. Top panel: position of the fishing stations. Hauls performed by RM are numbered from 9001 to 9034 and the transects are marked with dashed lines; hauls performed in the EB are numbered from 9201 to 9244 and the transects are marked with solid lines. Bottom panel: Species composition of the hauls.

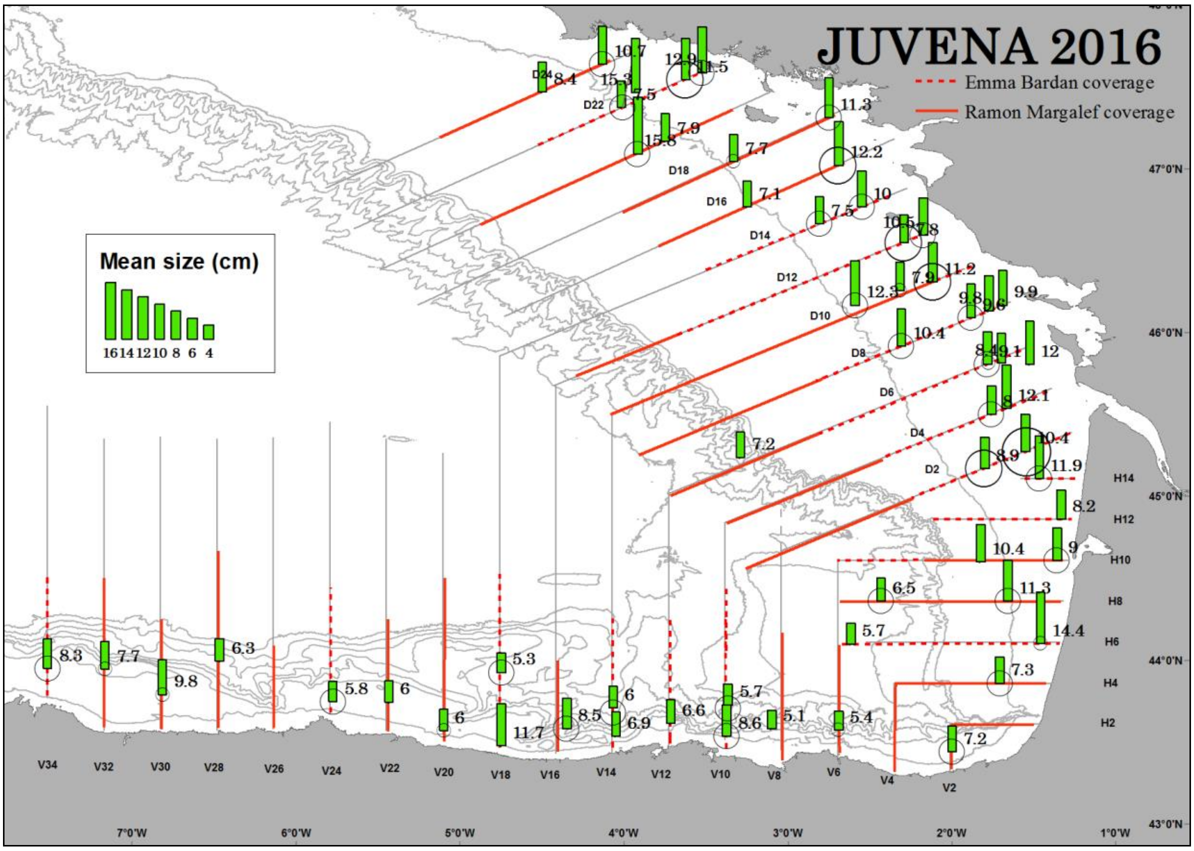

Figure 3: Top panel: Size of anchovy in the positive anchovy hauls. The length of the bars is proportional to the mode of the size (Standard length) of the captured anchovy.

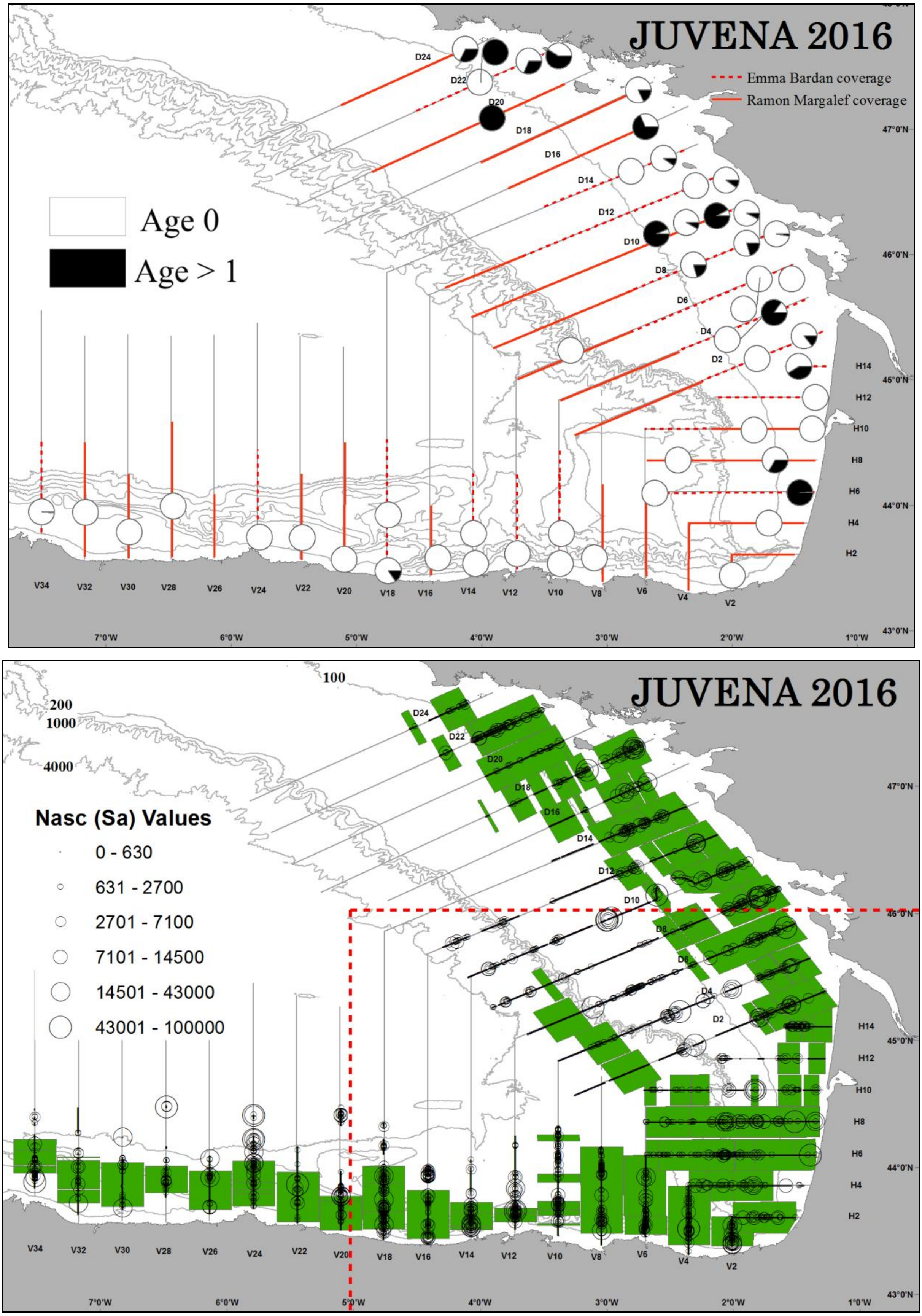

Figure 4: Top: positive area of distribution of anchovy. The pie charts show the percentage of juveniles (white) and adults (black) in the fishing hauls. Bottom: total acoustic energy (NASC) of all the identified species.

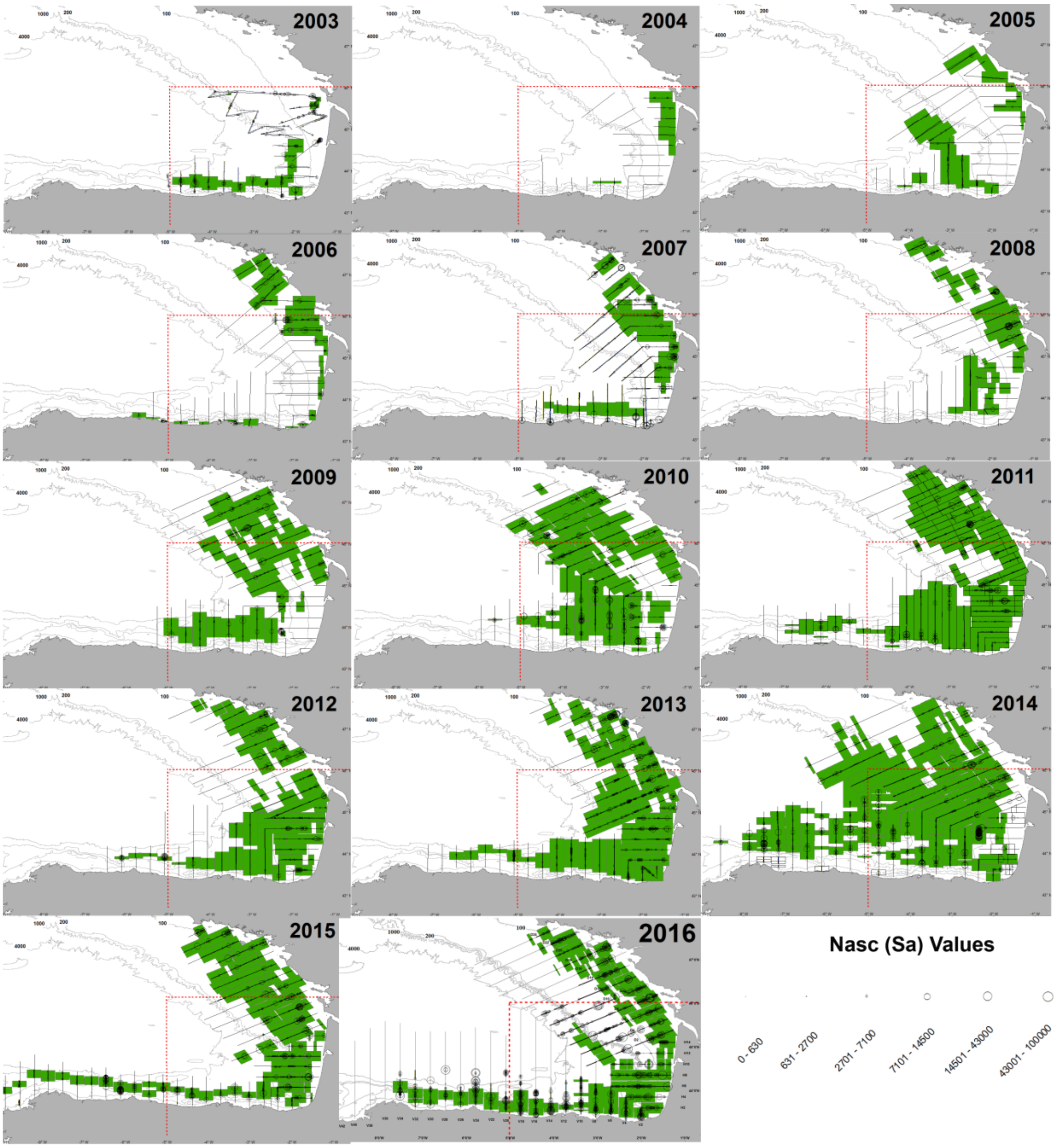

Figure 5: Positive area of presence of anchovy and total acoustic energy echo-integrated (from all the species) for the eight years of surveys. The area delimited by the dashed line is the minimum or standard area used for inter annual comparison.

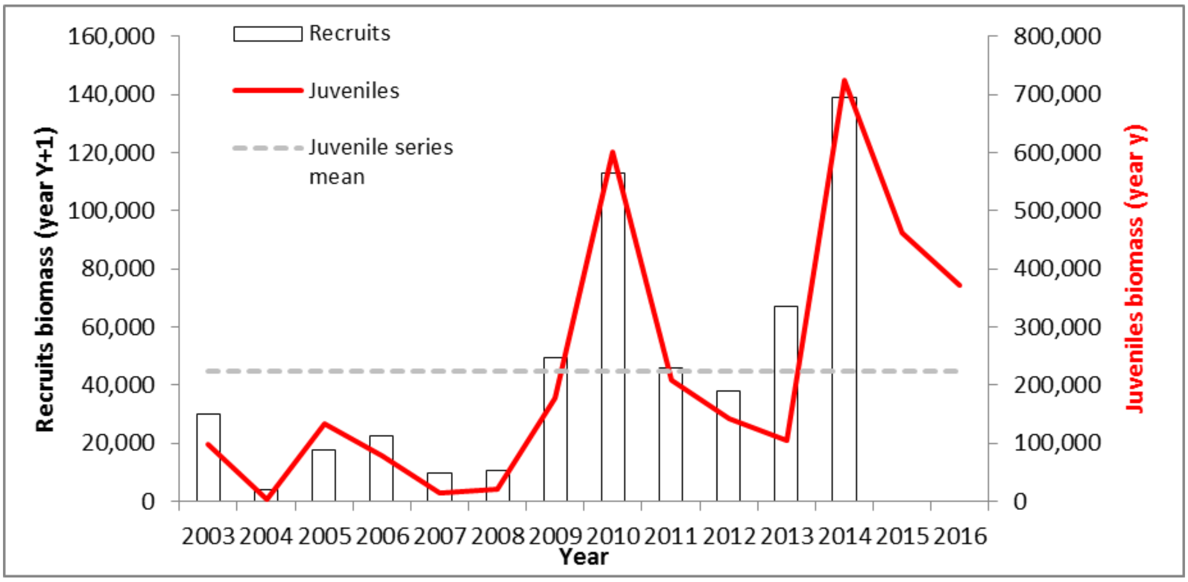

Figure 6: Temporal series of the estimated abundances of anchovy juveniles (blue) against the CBBM synthetic estimated abundances of age 1 anchovy next spring (red), based on PELGAS and BIOMAN surveys plus the catches.

Figure 7: Observation platform onboard R/V Ramón Margalef showing observer activities when they measure the distance and angle to an object or animal.

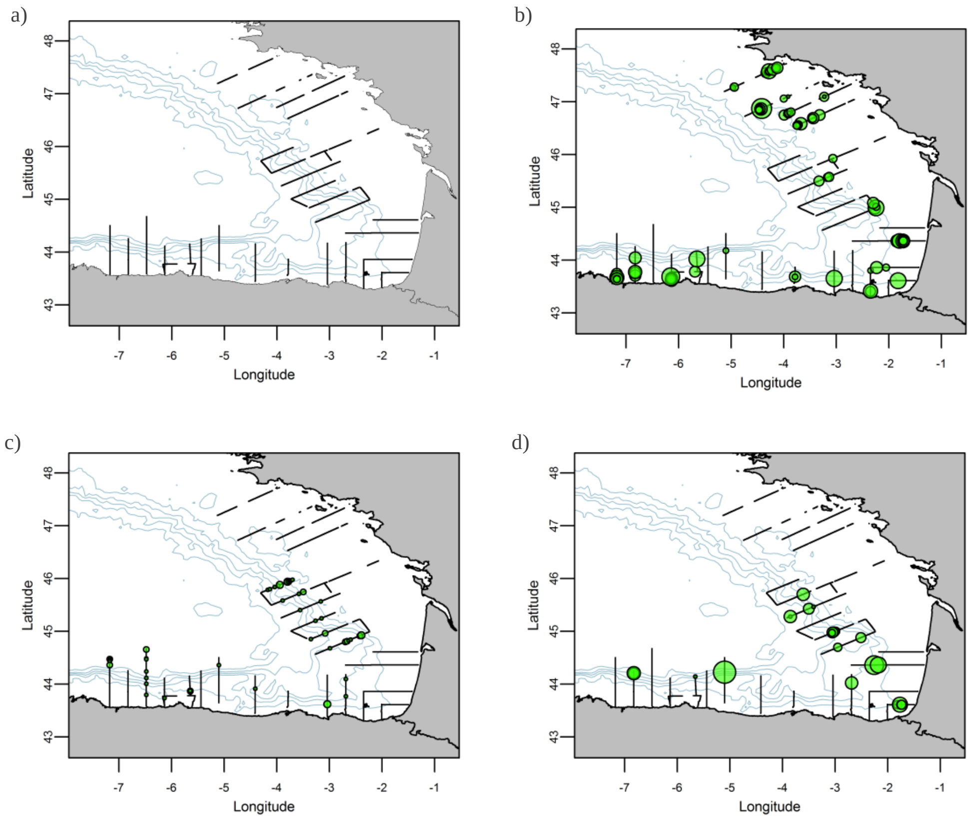

Figure 8: Line transects and distribution of the most abundant marine mammal species during JUVENA 2016, a) line transects performed during the survey, b) Distribution of sightings of common dolphin, c) Distribution of sightings of fin whale and d) Distribution of sightings of stripped dolphins. Black points represent the effort while the size of the green circles is proportional to observed abundances.

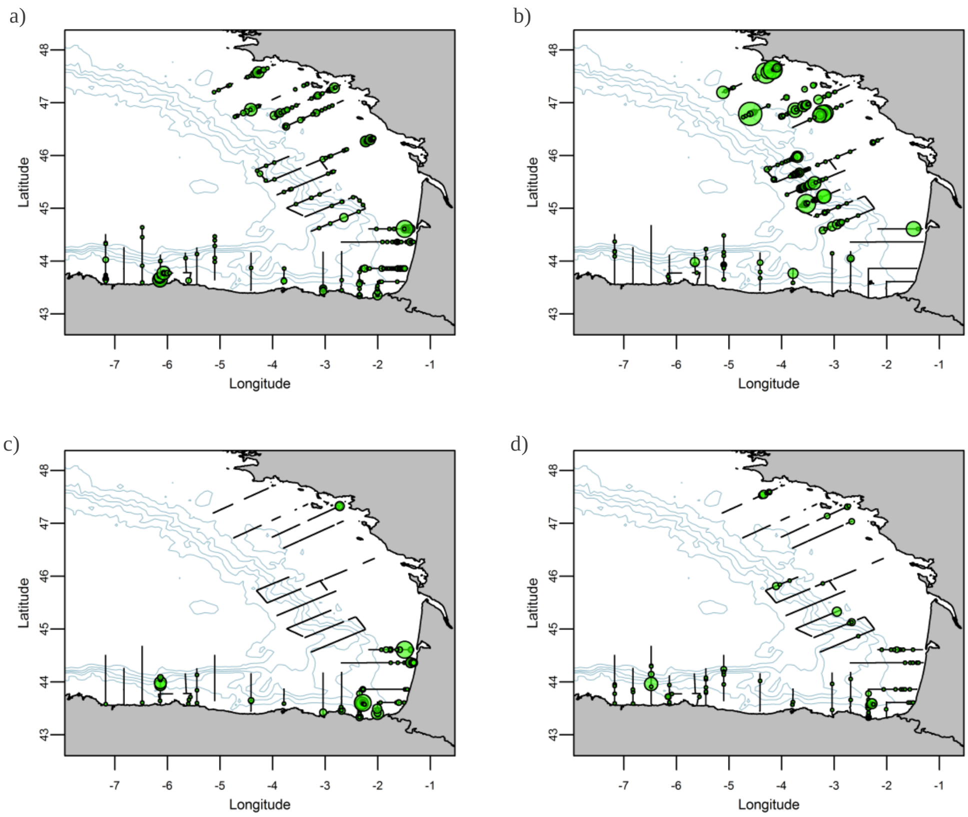

Figure 9: Distribution of the most abundant sea birds species during JUVENA 2016, a) Distribution of northern gannets, b) Distribution of sightings of great shearwaters, c) Distribution of sightings of yellow-legged gulls and d) Distribution of sightings of lesser black-backed gulls. Black points represent the effort while the size of the green circles is proportional to observed abundances.

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	**Harbor**	**Date**	**Notes**
Instalation RM	Santander	29 August	
Setup RM	Santander	30 August	Equipment testing. Calibration.
Setup EB	Vigo	31 August / 1 September	Calibration / Gear testing.
Start survey RM		31 August	
Start survey EB		3 September	
Escale EB	Santurce	8-9 September	
Escale RM	Pasaia	9-10 September	
Escale EB	Pasaia	13-20 September	Crane repairs and Bad weather
Escale RM	Pasaia	14-16 September	Bad weather
RCAN RM (Radiales del Cantábrico)		17-19 September	
Escale RM	Gijón	19 September	
Escale EB	Pasaia	24-26 September	Bad weather. Gasoil
Escale EB	Pasaia	3 October	Download of material
End of survey RM	Pasaia	3 October	Download of material
End of survey EB		6 October	

Table 3:
Relation of fishing catches performed by Ramon Margalef

ST.	DATE (yyyymmdd)	TIME	LAT (Minutes Hex.)	LONG (Minutes Hex.W)	ESTIMATED CATCH (kg)	DEPTH (m)
9001	20160831	18:26	43º56'845	6º08'000	0.4	2000
9002	20160901	22:05	43º59'555	6º28'000	8.9	2000
9003	20160902	21:59	43º04'737	6º49'000	80.6	
9004	20160903	21:51	43º56'660	7º10'000	105.6	
9005	20160904	21:46	43º44'665	5º26'000	7.7	
9006	20160905	13:20	44º03'295	5º00'001	1.0	650
9007	20160905	18:21	43º45'075	5º00'001	26.6	300
9008	20160905	22:37	43º00'341	5º00'001	28.5	130
9009	20160906	21:27	43º34'995	4º00'021	114.0	500
9010	20160907	22:35	43º03'483	3º00'001	1.9	500
9011	20160908	9:56	43º34'360	2º41'500	46.2	500
9012	20160908	13:19	43º32'260	2º00'004	0.0	350
9013	20160910	14:30	43º26'380	2º00'001	112.9	129
9014	20160910	21:28	43º37'070	1º29'500	415.9	29
9015	20160911	22:44	43º00'052	1º42'500	116.3	115
9016	20160912	10:18	44º21'615	2º26'000	62.4	1000
9017	20160912	23:02	44º21'735	1º39'500	81.3	115
9018	20160920	14:36	44º56'120	2º22'000	13.9	500
9019	20160921	23:41	45º14'305	3º17'500	12.1	
9020	20160922	14:21	45º41'825	2º49'000	1.3	130
9021	20160923	9:12	45º43'825	4º00'015	5.8	500
9022	20160924	13:30	46º10'035	2º35'500	261.3	95
9023	20160924	21:44	46º15'395	2º19'000	57.3	58
9024	20160926	9:40	44º36'590	1º21'500	174.2	45
9025	20160926	14:05	44º36'070	1º00'495	3.4	125
9026	20160927	9:25	47º01'245	2º41'500	1608.9	
9027	20160927	21:31	46º46'120	3º00'015	59.4	112
9028	20160928	12:47	47º02'595	3º20'000	26.5	103
9029	20160928	19:50	47º18'685	2º00'045	162.6	
9030	20160929	10:27	47º09'970	3º00'045	2.9	109
9031	20160929	13:06	47º05'480	3º55'000	234.2	121
9032	20160930	12:45	47º28'130	4º00'003	14.2	114
9033	20160930	17:24	47º38'205	4º08'000	78.2	97
9034	20161001	9:22	46º18'465	2º07'000	267.1	40

Table 4:
Relation of fishing catches performed by Emma Bardan

ST.	DATE (yyyymmdd)	TIME	LAT (Minutes Hex.)	LONG (Minutes Hex.W)	ESTIMATED CATCH (kg)	DEPTH (m)
9201	20160903	15:56	44º03'620	7º31'000	10.6	220
9202	20160903	20:00	43º56'990	7º31'000	200	166
9203	20160904	10:11	43º44'715	5º00'465	150	130
9204	20160904	14:14	43º52'635	5º47'000	100	200
9205	20160905	14:03	43º55'540	4º00'045	300	1000
9206	20160905	18:22	43º00'413	4º00'045	25	250
9207	20160905	22:15	43º28'720	4º00'045	300	70
9208	20160906	14:00	43º42'290	3º22'000	300	2200
9209	20160906	20:00	43º34'820	3º22'000	20	200
9210	20160906	21:57	43º32'180	3º00'225	100	115
9211	20160907	14:35	43º33'835	2º00'405	10	220
9212	20160910	14:12	43º40'720	4º04'000	254	1000
9213	20160910	17:38	43º33'290	4º04'000	60	180
9214	20160910	22:15	43º32'085	4º00'003	30	120
9215	20160911	9:37	43º36'890	3º43'000	10	140
9216	20160912	9:05	44º05'955	2º37'000	5	2000
9217	20160912	14:30	44º06'045	2º00'500	1	150
9218	20160912	22:28	44º06'050	1º27'500	108.1	60
9219	20160920	14:08	44º51'595	2º00'003	16.2	135
9220	20160920	22:19	44º51'605	1º20'000	90.15	30
9221	20160921	11:12	45º10'155	1º00'005	450	80
9222	20160921	14:30	45º16'520	1º32'500	1500	53
9223	20160921	22:46	45º06'575	1º28'000	300	50
9224	20160922	12:30	45º29'995	1º45'500	65	60
9225	20160922	14:51	45º32'255	1º40'000	38.75	50
9226	20160922	21:38	45º48'370	1º00'315	110	35
9227	20160923	9:08	45º48'785	1º00'465	42.2	57
9228	20160923	11:08	45º48'405	1º47'000	170	60
9229	20160923	17:55	45º29'890	2º00'033	215	118
9230	20160927	16:11	45º00'551	2º18'500	150	90
9231	20160927	21:48	46º09'985	1º41'500	44.4	28
9232	20160927	22:45	46º07'965	1º00'465	150	38
9233	20160927	0:01	46º00'543	1º53'000	160	47
9234	20160928	11:52	46º13'255	3º06'500	40	120
9235	20160928	17:07	46º25'550	2º36'500	0	80
9236	20160928	21:44	46º35'695	2º00'105	215	32
9237	20160928	23:04	46º00'329	2º17'500	480	44
9238	20160929	9:50	46º45'980	2º00'033	180	45
9239	20160929	12:50	46º39'845	2º48'500	150	80
9240	20160929	17:44	46º27'595	3º18'500	2.5	118
9241	20160930	12:09	47º02'259	4º00'500	144	106
9242	20160930	14:16	47º22'415	4º01'000	3.15	105
9243	20160930	21:32	47º35'180	3º00'315	300	63
9244	20160930	22:56	47º32'625	3º00'375	400	77

Table 5:
Species composition of the fishing performed by Ramon Margalef**.**

STATION	BOARDING WEIGHT (kg)	BOARDING WEIGHT/ SPECIES (kg)	*SPECIES*	Fao
9001	0.4	0.35	Trachurus trachurus	HOM
9002	8.9	8.80	Engraulis encrasicholus	ANE
		0.01	Trachurus trachurus	HOM
		0.01	Loligo vulgaris	SQR
		0.07	Myctophidae	LXX
		0.003	Euphasiacea	KRX
9003	80.6	47.00	Engraulis encrasicholus	ANE
		0.85	Trachurus trachurus	HOM
		0.01	Scomber scombrus	MAC
		0.04	Loligo vulgaris	SQR
		1.20	Dicentrarchus labrax	BSS
		31.20	Mola mola	MOX
		0.28	Rhopilema spp	JEL
9004	105.6	36.49	Engraulis encrasicholus	ANE
		1.51	Trachurus trachurus	HOM
		2.45	Loligo vulgaris	SQR
		64.29	Euphasiacea	KRX
		0.84	Rhopilema spp	JEL
9005	7.7	6.42	Engraulis encrasicholus	ANE
		0.28	Trachurus trachurus	HOM
		1.00	Loligo vulgaris	SQR
9006	1.0	0.95	Myctophidae	LXX
9007	26.6	0.00	Engraulis encrasicholus	ANE
		0.65	Trachurus trachurus	HOM
		0.50	Scomber scombrus	MAC
		0.35	Merluccius merluccius	HKE
		25.10	Myctophidae	LXX
9008	28.5	26.60	Engraulis encrasicholus	ANE
		1.22	Trachurus trachurus	HOM
		0.05	Scomber scombrus	MAC
		0.65	Loligo vulgaris	SQR
		0.03	Others	
9009	114.0	104.50	Engraulis encrasicholus	ANE
		9.50	Scomber scombrus	MAC
		0.05	Euphasiacea	KRX
9010	1.9	0.45	Engraulis encrasicholus	ANE
		0.15	Loligo vulgaris	SQR
		1.25	Euphasiacea	KRX
		0.04	Others	
9011	46.2	46.20	Engraulis encrasicholus	ANE
9012	0.0	0.00	Engraulis encrasicholus	ANE
		0.02	Loligo vulgaris	SQR
		0.01	Myctophidae	LXX
9013	112.9	112.85	Engraulis encrasicholus	ANE

STATION	BOARDING WEIGHT (kg)	BOARDING WEIGHT/ SPECIES (kg)	*SPECIES*	Fao
9014	415.9	2.05	Sardina pilchardus	PIL
		398.50	Trachurus trachurus	HOM
		0.45	Scomber scombrus	MAC
		0.04	Micromesistius poutassou	WHB
		1.25	Trachinus draco	WEG
		0.70	Mugil sp.	MGS
		0.45	Loligo vulgaris	SQR
		2.80	Merluccius merluccius	HKE
		7.40	Boops boops	BOG
		2.21	Others	
9015	116.3	104.74	Engraulis encrasicholus	ANE
		10.80	Trachurus trachurus	HOM
		0.74	Others	
9016	62.4	62.35	Engraulis encrasicholus	ANE
9017	81.3	60.35	Engraulis encrasicholus	ANE
		20.45	Trachurus trachurus	HOM
		0.25	Scomber scombrus	MAC
		0.25	Others	
9018	13.9	13.85	Euphasiacea	KRX
9019	12.1	1.82	Engraulis encrasicholus	ANE
		0.16	Myctophidae	LXX
		10.12	Euphasiacea	KRX
9020	1.3	1.30	Myctophidae	LXX
9021	5.8	0.23	Trachurus trachurus	HOM
		5.05	Euphasiacea	KRX
		0.49	Rhopilema spp	JEL
9022	261.3	258.70	Engraulis encrasicholus	ANE
		0.19	Trachurus trachurus	HOM
		0.41	Merluccius merluccius	HKE
		1.60	Zeus faber	JOD
		0.40	Rhopilema spp	JEL
9023	57.3	36.80	Engraulis encrasicholus	ANE
		1.40	Sardina pilchardus	PIL
		3.20	Trachurus trachurus	HOM
		15.65	Scomber scombrus	MAC
		0.20	Scomber Japonicus	MAS
		0.06	Rhopilema spp	JEL
9024	174.2	161.70	Engraulis encrasicholus	ANE
		9.90	Sardina pilchardus	PIL
		2.00	Trachurus trachurus	HOM
		0.06	Scomber scombrus	MAC
		0.14	Trachinus draco	WEG
		0.35	Loligo vulgaris	SQR
		0.07	Boops boops	BOG

STATION	BOARDING WEIGHT (kg)	BOARDING WEIGHT/ SPECIES (kg)	*SPECIES*	Fao
9025	3.4	1.05	Engraulis encrasicholus	ANE
		0.15	Trachurus trachurus	HOM
		0.04	Merluccius merluccius	HKE
		0.01	Myctophidae	LXX
		1.70	Euphasiacea	KRX
		0.48	Others	
9026	1608.9	345.00	Engraulis encrasicholus	ANE
		66.75	Sardina pilchardus	PIL
		1.95	Scomber scombrus	MAC
		1195.18	Others	
9027	59.4	0.65	Engraulis encrasicholus	ANE
		1.90	Trachurus trachurus	HOM
		0.01	Scomber scombrus	MAC
		0.01	Merluccius merluccius	HKE
		0.13	Rhopilema spp	JEL
		56.75	Others	
9028	26.5	20.98	Engraulis encrasicholus	ANE
		3.90	Trachurus trachurus	HOM
		0.00	Capros aper	BOC
		1.56	Rhopilema spp	JEL
9029	300.7	253.03	Engraulis encrasicholus	ANE
		43.86	Sardina pilchardus	PIL
		3.48	Scomber scombrus	MAC
		0.33	Sprattus spratus	SPR
9030	2.9	2.85	Engraulis encrasicholus	ANE
9031	234.2	214.55	Engraulis encrasicholus	ANE
		5.30	Trachurus trachurus	HOM
		0.05	Scomber scombrus	MAC
		14.25	Merluccius merluccius	HKE
		0.00	Capros aper	BOC
		0.00	Myctophidae	LXX
		0.02	Rhopilema spp	JEL
9032	14.2	12.97	Engraulis encrasicholus	ANE
		0.33	Trachurus trachurus	HOM
		0.01	Capros aper	BOC
		0.01	Thalia democratica	SPX
		0.83	Rhopilema spp	JEL
9033	191.0	183.99	Engraulis encrasicholus	ANE
		5.08	Sardina pilchardus	PIL
		0.14	Trachurus trachurus	HOM
		0.59	Scomber scombrus	MAC
		0.04	Sprattus spratus	SPR
		0.00	Capros aper	BOC
		1.09	Thalia democratica	SPX
		0.03	Others	
9034	365.3	360.75	Engraulis encrasicholus	ANE
		4.28	Sardina pilchardus	PIL
		0.05	Trachurus trachurus	HOM
		0.25	Scomber scombrus	MAC

Table 6:
Species composition of the fishing performed by Emma Bardan**.**

STATION	BOARDING WEIGHT (kg)	BOARDING WEIGHT/ SPECIES (kg)	*SPECIES*	Fao
9201	10.6	1.51	Myctophidae	LXX
		9.09	Euphasiacea	KRX
9202	200.0	200.00	Engraulis encrasicholus	ANE
9203	150.0	150.00	Engraulis encrasicholus	ANE
9204	100.0	30.00	Myctophidae	LXX
		70.00	Euphasiacea	KRX
9205	300.0	300.00	Engraulis encrasicholus	ANE
9206	25.0	5.00	Myctophidae	LXX
		20.00	Euphasiacea	KRX
9207	200.0	0.60	Engraulis encrasicholus	ANE
		91.87	Trachurus trachurus	HOM
		107.53	Scomber Japonicus	MAS
9208	300.0	300.00	Engraulis encrasicholus	ANE
9209	20.0	17.00	Myctophidae	LXX
		3.00	Euphasiacea	KRX
9210	100.0	100.00	Engraulis encrasicholus	ANE
9211	10.0	8.48	Myctophidae	LXX
		1.52	Euphasiacea	KRX
9212	254.0	254.00	Engraulis encrasicholus	ANE
9213	60.0	11.71	Myctophidae	LXX
		48.29	Euphasiacea	KRX
9214	30.2	6.30	Engraulis encrasicholus	ANE
		0.12	Trachurus trachurus	HOM
		0.11	Scomber Japonicus	MAS
		0.08	Micromesistius poutassou	WHB
		23.60	Euphasiacea	KRX
9215	10.0	10.00	Engraulis encrasicholus	ANE
9216	5.0	5.00	Engraulis encrasicholus	ANE
9217	1.0	1.00	Myctophidae	LXX
9218	108.1	21.60	Engraulis encrasicholus	ANE
		5.35	Sardina pilchardus	PIL
		67.06	Trachurus trachurus	HOM
		14.10	Scomber scombrus	MAC
9219	16.2	16.20	Myctophidae	LXX
9220	90.2	10.20	Engraulis encrasicholus	ANE
		0.55	Sardina pilchardus	PIL
		73.55	Trachurus mediterraneus	HMM
		0.85	Scomber scombrus	MAC
		5.00	Scomber Japonicus	MAS
9221	450.0	450.00	Engraulis encrasicholus	ANE
9222	1500.0	1135.57	Engraulis encrasicholus	ANE
		324.45	Sardina pilchardus	PIL
		1.14	Trachurus trachurus	HOM
		34.27	Scomber scombrus	MAC
		4.57	Sprattus spratus	SPR

STATION	BOARDING WEIGHT (kg)	BOARDING WEIGHT/ SPECIES (kg)	*SPECIES*	Fao
9223	300.0	148.30	Engraulis encrasicholus	ANE
		136.42	Sardina pilchardus	PIL
		9.91	Trachurus trachurus	HOM
		5.38	Scomber scombrus	MAC
9224	65.0	65.00	Engraulis encrasicholus	ANE
9225	38.8	2.60	Engraulis encrasicholus	ANE
		0.10	Sardina pilchardus	PIL
		12.40	Trachurus trachurus	HOM
		0.25	Scomber scombrus	MAC
		22.65	Sprattus spratus	SPR
		0.75	Merluccius merluccius	HKE
9226	110.0	13.83	Engraulis encrasicholus	ANE
		25.54	Sardina pilchardus	PIL
		63.74	Trachurus trachurus	HOM
		6.80	Scomber scombrus	MAC
		0.09	Merluccius merluccius	HKE
9227	42.2	42.20	Engraulis encrasicholus	ANE
9228	170.0	156.87	Engraulis encrasicholus	ANE
		11.75	Sprattus spratus	SPR
		1.38	Merluccius merluccius	HKE
9229	215.0	10.00	Merluccius merluccius	HKE
		5.00	Zeus faber	JOD
		135.00	Myctophidae	LXX
		65.00	Euphasiacea	KRX
9230	150.0	150.00	Engraulis encrasicholus	ANE
9231	44.4	2.95	Engraulis encrasicholus	ANE
		37.74	Sardina pilchardus	PIL
		3.50	Trachurus trachurus	HOM
		0.20	Scomber scombrus	MAC
9232	150.0	9.02	Engraulis encrasicholus	ANE
		101.00	Sardina pilchardus	PIL
		6.91	Trachurus trachurus	HOM
		0.60	Scomber scombrus	MAC
		5.41	sarda sarda	BON
		27.05	Merluccius merluccius	HKE
9233	160.0	107.95	Engraulis encrasicholus	ANE
		17.99	Sardina pilchardus	PIL
		29.88	Trachurus trachurus	HOM
		0.64	Scomber scombrus	MAC
		2.57	Loligo vulgaris	SQR
		0.96	Merluccius merluccius	HKE
9234	40.0	5.81	Trachurus trachurus	HOM
		2.90	Loligo vulgaris	SQR
		31.29	Myctophidae	LXX
9236	215.0	73.63	Engraulis encrasicholus	ANE
		53.50	Sardina pilchardus	PIL
		10.80	Trachurus trachurus	HOM
		33.87	Trachurus mediterraneus	HMM
		43.20	Scomber scombrus	MAC

STATION	BOARDING WEIGHT (kg)	BOARDING WEIGHT/ SPECIES (kg)	*SPECIES*	Fao
9237	480.0	421.22	Engraulis encrasicholus	ANE
		13.71	Sardina pilchardus	PIL
		5.88	Trachurus trachurus	HOM
		10.78	Scomber scombrus	MAC
		28.41	Scomber Japonicus	MAS
9238	180.0	177.84	Engraulis encrasicholus	ANE
		2.16	Sardina pilchardus	PIL
9239	150.0	150.00	Engraulis encrasicholus	ANE
9240	2.5	0.16	Trachurus trachurus	HOM
		0.78	Capros aper	BOC
		1.56	Myctophidae	LXX
9241	144.0	136.26	Engraulis encrasicholus	ANE
		7.74	Trachurus trachurus	HOM
9242	3.0	3.00	Engraulis encrasicholus	ANE
		0.02	Trachurus trachurus	HOM
9243	300.0	212.68	Engraulis encrasicholus	ANE
		48.59	Sardina pilchardus	PIL
		1.41	Trachurus trachurus	HOM
		37.32	Scomber scombrus	MAC
9244	400.0	394.52	Engraulis encrasicholus	ANE
		0.78	Trachurus trachurus	HOM
		4.70	Scomber scombrus	MAC

Table 7:
Synthesis of the abundance estimation (acoustic index of biomass) for Juvena 2016 by main strata

	Area (n.m.2)	Talla media (cm)	Biomasa (t)
Pure juve	10875	6.9	252,769
Mixed	4660	9.7	110,656
Garonne	1398	10.4	8,138
Total	16933	7.3	371,563

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	139,062
2015	32,763	21,867	6.8	462,340	
2016	45,000	16,933	7.3	371,563	

Table 10

List of marine mammal taxa observed during JUVENA 2016

Common name	Scientific name	Number of sightings	Group size	Total of individuals
Minke whale	*Balaenoptera acutorostrata*	1	1	1
Fin whale	*Balaenoptera physalus*	56	1.38 ± 0.65	77
Balaenopterid sp.	*Balaenopteridae* sp.	5	1 ± 0	5
Cetacean sp.	*Cetacea* sp.	1	1	1
Common dolphin	*Delphinus delphis / capensis*	82	7.51 ± 6.92	616
Delphinid sp.	*Delphinidae* sp.	19	6.05 ± 4.21	115
Long-finned pilot whale	*Globicephala melas*	4	2.75 ± 1.5	11
Small delphininae	*Small delphininae*	2	2	2
Striped dolphin	*Stenella coeruleoalba*	27	9.74 ± 14.07	263
Bottlenose dolphin	*Tursiops truncatus*	4	7.5 ± 8.74	30

Table 11
List of sea birds taxa observed during JUVENA 2016

Common name	Scientific name	Number of sightings	Group size	Total of individuals
Auk sp	*Alcidae* sp.	2	1 ± 0	2
Unidentified Bird		6	1.67 ± 0.82	10
Cory's shearwater	*Calonectris diomedea*	60	2.13 ± 3.06	128
Skua	*Catharacta skua*	51	1.08 ± 0.34	55
Black Tern	*Chlidonias niger*	1	2	2
Cormorant / shag sp	*Phalacrocorax* sp.	1	16	16
European storm-petrel	*Hydrobates pelagicus*	15	3.93 ± 4.62	59
Lesser black-backed gull	*Larus fuscus*	114	1.4 ± 1.29	160
Gull sp	*Larus* sp.	77	6.94 ± 20.62	534
Great black-backed gull	*Larus marinus*	1	1	1
Mediterranean gull	*Ichthyaetus melanocephalus*	1	1	1
Yellow-legged gull	*Larus michahellis*	150	1.99 ± 3.11	297
Black-headed gull	*Chroicocephalus ridibundus*	1	3	3
Sabine's gull	*Larus sabini*	41	6.2 ± 6.86	254
Larid sp	*Laridae* sp.	5	1 ± 0	5
Storm-petrels sp.	*Hydrobates / Oceanites / Oceanodroma*	18	3.61 ± 4.77	65
European shag	*Phalacrocorax aristotelis*	3	1.67 ± 0.58	5
Great cormorant	*Phalacrocorax carbo*	1	6	6
Grey Phalarope	*Phalaropus fulicarius*	2	1 ± 0	2
Great shearwater	*Puffinus gravis*	300	2.85 ± 6.96	854
Sooty shearwater	*Puffinus griseus*	82	1.73 ± 1.9	142
Mediterranean shearwater	*Puffinus mauretanicus*	20	5.95 ± 9.47	119
Manx shearwater	*Puffinus puffinus*	39	7.72 ± 27.01	301
Shearwater sp.	*Puffinus* sp.	35	1.51 ± 1.04	53
Small gull sp	*Larus* sp.	2	4.5 ± 3.54	9
Common Tern	*Sterna hirundo*	5	2.4 ± 1.67	12
Parasitic jaeger	*Stercorarius parasiticus*	17	1.06 ± 0.24	18

Jaeger sp.	*Stercorarius* sp.	1	1	1
Sandwich Tern	*Sterna sandvicensis*	22	5.36 ± 7.88	118
Tern sp.	*Sterna* sp.	16	3.75 ± 4.17	60
Northern Gannet	*Morus bassanus*	368	1.58 ± 1.96	583

Table 12
List of other marine wildlife taxa observed during JUVENA 2016

Common name	Scientific name	Number of sightings	Group size	Total of individuals
Fish sp	*Ostéichiens*	10	7.67 ± 16.29	69
Sunfish	*Mola mola*	128	1.23 ± 1.12	157
Shark sp	*Selachimorpha*	8	1 ± 0	8
Albacore tuna	*Thunnus alalunga*	4	21 ± 15.56	42
Tuna / Bonito	*Thunnus* sp. / *Sarda* sp.	84	13.53 ± 17.46	988

Table 13

List of human activities observed during JUVENA 2016.

Common name	Scientific name	Number of sightings	Group size	Total of individuals
Administrative boat (navy, custom, coast guard)	*Administrative boat (navy, custom, coast guard)*	1	1	1
Non identified ship	*Non identified ship*	1	1	1
Fishing buoy, setnet	*Fishing buoy, setnet*	45	1.05 ± 0.21	46
Merchant ship (containership, cargo, tanker)	*Merchant ship (containership, cargo, tanker)*	13	1 ± 0	13
Ferry	*Ferry*	2	1 ± 0	2
Fishing boat (professional)	*Fishing boat (professional)*	24	1.21 ± 0.59	29
Fishing trash (net part, buoy…)	*Fishing trash (net part, buoy…)*	37	1.05 ± 0.23	39
Longliner	*Longliner*	9	1 ± 0	9
Small motor boat	*Small motor boat*	4	2.25 ± 2.5	9
Oil slick	*Oil slick*	1	1	1
Pair trawler	*Pair trawler*	4	1 ± 0	4
Plastic trash	*Plastic trash*	282	1.09 ± 0.39	307
Pleasure boat	*Pleasure boat*	15	1 ± 0	15
Sailing boat	*Sailing boat*	13	1 ± 0	13
Seiner	*Seiner*	1	1	1
Tanker (oil, gaz, chemical)	*Tanker (oil, gaz, chemical)*	4	1 ± 0	4
Trash (plastic, wood, oil)	*Trash (plastic, wood, oil)*	31	1 ± 0	31
Trawler	*Trawler*	19	1.21 ± 0.71	23
Unnatural wood	*Unnatural wood*	9	1 ± 0	9

Table 14

List of land bird taxa observed during JUVENA 2016

Common name	Scientific name	Number of sightings	Group size	Total of individuals
Swallows and swifts	*Apus* sp.	1	1	1
Grey heron	*Ardea cinerea*	1	1	1
Sanderling	*Calidris alba*	1	1	1
European robin	*Erithacus rubecula*	1	1	1
Waders	*Limicole* sp.	1	13	13
Wagtail sp.	*Motacilla* sp.	2	2.5 ± 2.12	5
Passerine bird	*Passeriformes*	19	2.16 ± 3.45	41

WD6 – PELTIC SURVEY

PELTIC16: Small pelagic fish in the coastal waters of the western Channel and Celtic Sea (Draft Survey report CEND22_16)

Jeroen van der Kooij, Elisa Capuzzo, Joana Silva, Mike Bailey, Sophie Pitois and Paul Bouch

DRAFT Survey report CEND22_16

PELTIC16: Small pelagic fish in the coastal waters of the western Channel and Celtic Sea

Jeroen van der Kooij, Elisa Capuzzo, Joana Silva, Mike Bailey, Sophie Pitois and Paul Bouch

Survey report CEND22_16

PELTIC16: Small pelagic fish in the coastal waters of the western Channel and Celtic Sea

Jeroen van der Kooij, Elisa Capuzzo, Joana Silva, Mike Bailey

1. Outline of the survey

STAFF:
1. Jeroen van der Kooij (SIC)
2. Elisa Capuzzo (2IC)
3. Joana Silva (2IC)
4. Marc Whybrow
5. Richard Humphreys
6. Matt Eade
7. Paul Bouch
8. James Pettigrew
9. Sophie Pitois
10. Tom Hull
11. Julian Tilbury (Plymouth University)
12. Mike Bailey (Observer)
13. Sean Minns (Observer)
14. Peter Howlett (Observer)

1.2. **Duration**: 3rd – 19st of October

1.3 Location

Western Channel and Celtic Sea coastal zone (embarking in Portland and disembarking in Swansea)

1.4 Objectives

1. To carry out the fifth and final of five annual multidisciplinary pelagic surveys of the Western Channel and Celtic Sea waters as part of project Poseidon, to estimate the biomass of-, and gain insight into the population of the small pelagic fish community (sprat, sardine, mackerel, anchovy, horse mackerel, herring).
   a. To carry out a fisheries acoustic survey during daylight only using four operating frequencies (38, 120, 200 and 333 kHz) to investigate:
      - distribution of small pelagic species
      - abundance of small pelagic species
      - distribution of the pelagic species in relation to their environment
   b. To trawl for small pelagic species using a 20x40m herring (mid-water) trawl (taking the Cosmos Fotø and Engels 800 as back up) in order to obtain information on:
      - Species- and size composition of acoustic marks
      - Age-composition and distribution, from all small pelagic species
      - Length weight and maturity information on pelagic species
      - Stomach contents (see also 11)
2. To collect plankton samples using 2 different mesh ringnets (80 µm, and 270 µm mesh) at fixed stations along the acoustic transects (marked in red in below map) at night by vertical haul. Samples will be processed onboard:

a. Ichtyoplankton (eggs and larvae, 270 µm) of pelagic species will be identified, counted and (in case of clupeids) measured onboard and combined with information from maturity to identify spawning areas.
b. Zooplankton samples (from ringnet with 80 µm mesh) will be stored for further analysis back in the lab.

3. Water column sampling. At fixed stations along the acoustic transect, marked in yellow on below map, an ESM2 will be deployed to obtain a vertical profile of the water column. Water column profiles and water samples will provide information on chlorophyll concentration, dissolved oxygen concentration, salinity, temperature, inorganic nutrients concentration and the relevant QAQC samples for calibration of the equipment. Water samples will be collected and fixed on board for analysis post-hoc.
4. Seabirds and Marine Mammals. Locations, species, numbers and activities observed will be recorded continuously during daylight hours by three Marinelife observers from bridge.
5. Additional high resolution ESAS observations will be conducted on critically endangered Balearic shearwaters and other seabirds as part of a collaborative Defra funded project between MarineLife, Natural England and Cefas.
6. Ferrybox Continuous CTD/Thermo-salinigraph/pCO2. Continuously collect oceanographic data at the sea surface (4 m depth) during steaming.
7. To conduct further experiments with the online flow-cytometer to obtain continuous data on phytoplankton functional groups in collaboration with project JERICO NEXT.
8. To collect discrete samples of phytoplankton and micro-zooplankton at predetermined 18 primary stations for further analysis back to the lab (species composition, abundance, biomass and size distribution).
9. To test an automatic continuous zooplankton camera in collaboration with PML (Julian Tilbury).
10. To collect juvenile mackerel for AZTI (Paula Alvarez) in support of genetic study.
11. To collect jellyfish for PhD student Katie St John Glew in support of isotope study

1.5 Narrative

Staff from Cefas, MarineLife and Plymouth University joined the RV Cefas Endeavour in the afternoon of Sunday the 2nd of October from 16:00 BST. After initial gear-check and -set up in the afternoon and early evening, plus a safety induction for the relevant staff, the vessel left Portland at 06:00 on the 3rd of October, steaming straight to the calibration site off West Bay, west of Portland Bill. Whilst steaming staff were run through relevant dynamic risk assessments. A weighted parachute line was guided round the hull before the anchor was dropped. First the new rosette was deployed to ensure some recent alterations were successful and to train the oceanographic staff in its use. After successful deployment Tom Hull disembarked by searider and was dropped off on land (in West Bay) as planned. At the same time, at approximately 9:00 BST the plankton ringnets plus SAIV mini CTD were tested and the calibration of the echosounders commenced. Although the calibration spheres were briefly detected on the echosounder, the spring tides proved too strong to keep the targets in the beam. Despite further attempts during three slack tide periods, the spheres were not detected again and the calibration exercise was postponed, particularly as the weather conditions were picking up. During this period a toolbox talk was conducted. At ~19:00 BST we came off station and started sampling the primary stations (using Rosette and Plankton ringnets), which continued throughout the night.

On Monday morning the 4th of October the survey started proper, commencing first with the eastern most transects of the western English Channel. Similar to the previous two years' surveys, fisheries acoustic transects, trawling and bird and mammal observations were conducted during daylight hours, and CTD- and plankton stations were covered during the night. The exception was a number of inshore stations located in areas with static gear which were sampled during daylight, to maximise visibility. On a few occasions acoustic data acquisition continued after dusk to complete remainders of transects. During ~40 of the zooplankton stations the CALPS system (Cefas' Automatic Litter and Plankton Sampler) was switched on to collect surface zooplankton

It was decided to use the first targeted trawl as a shake-down tow, taking extra time for all involved to get used to gear. As it turned out, the whole process went very smoothly. For the duration of the survey, when appropriate, the pelagic trawl was deployed to ascertain the species- and length composition of acoustic targets, or 'marks'. In total 15 successful trawls were conducted. On a few occasions no trawl could be conducted despite the presence of targets on the echogram. The main reasons were adverse weather and swell conditions (~ 3 days), presence of static gear and schools close to hard seabed substrate in areas of string relief.

During the 5th of October, acoustic data acquisition was stopped around mid-day as the data quality deteriorated due to the bad weather. Work was resumed on the 6th of October and continued throughout the rest of the survey. During a deployment of the trawl on the 8th of October the starboard G-link came off the pennant, delaying the deployment. During this trawl, several of the floats were removed around the Marport bag to improve its tilt angle for better communication with the dropkeel based transducer. This had the desired effect. On the morning of the 9th of October one of the three engines had to be switched off to enable repairs. The acoustic transect was able to be continued at 10 knots due to favourable swell and tide conditions, but no trawling operation could be conducted during this period. This was resolved in the afternoon and after completion of transects the RV sailed to some fish aggregations spotted earlier in the day to shoot the trawl. From the 16th late morning through to the 18th of October, survey conditions inside the Bristol Channel deteriorated due to gradual westward shift of winds which, in periods, compromised the acoustic data quality although it was not sufficiently bad to stop data acquisition.

The last of the night-time prime stations (Rosette and plankton) were completed on the 16th of October, which enabled the night shift to be moved back to day shifts to acclimatise before docking. Despite the fact that the survey programme had been adapted to accommodate for the reduced survey duration and as a result the acoustic transects around the Isles of Scilly were dropped, the primary stations of this area were successfully completed providing information on the physical oceanography and sardine eggs and larvae. The final acoustic transects of the regular survey design were completed on the 18th of October. On the morning of the 19th a final trawl was conducted on some fish aggregations observed the day before after which transect 39 was run from an approximate halfway point to the inner Bristol Channel. The vessel steamed to meet the pilot and docked in Swansea at approximately 19:45.

2. Material and Methods

2.1. Study area

The survey was conducted according to the PELTIC survey grid (Fig 1) established in 2012. Acoustic transects, plankton and water sampling were undertaken along the predefined transects, undertaken in a generally east to west direction for the first half of the survey, then a south-west to north east direction for the second half of the survey. Trawls were undertaken opportunistically, depending on the presence and type of acoustic marks observed. Acoustic data acquisition, trawling operation and marine mammal and bird observations were conducted during daylight hours, whereas the primary stations (plankton and water sampling) were conducted during the night. Due to the (planned) reduction in survey duration by two days it was decided to drop the acoustic transects around the Isles of Scilly. However, the primary stations were all completed, including those around the Isles of Scilly.

2.2 Fisheries acoustics

2.2.1. Acquisition

Fisheries acoustics were recorded along the pre-designed transects (Fig. 1) at the four operating frequencies (38, 120, 200 and 333 kHz). The transducers were mounted on a drop keel which was lowered to 3.0 m below the hull, 8.3 m below the sea surface. Pulse duration was set to 0.512 ms for the 38-200 kHz frequencies and to 1.024 for the 333 kHz frequency (as better results were obtained) and the ping rate was set to 0.5 pings s^{-1}. During the first 10 days, fairly persistent easterly winds caused occasional interference although the 38kHz echogram remained of good quality. During the last week, winds turned westerly and caused further periods of poor data quality largely due to surface aeration. At all times on-transect live acoustic data were monitored and when unidentified acoustic marks appeared the trawl was shot where possible to identify these marks.

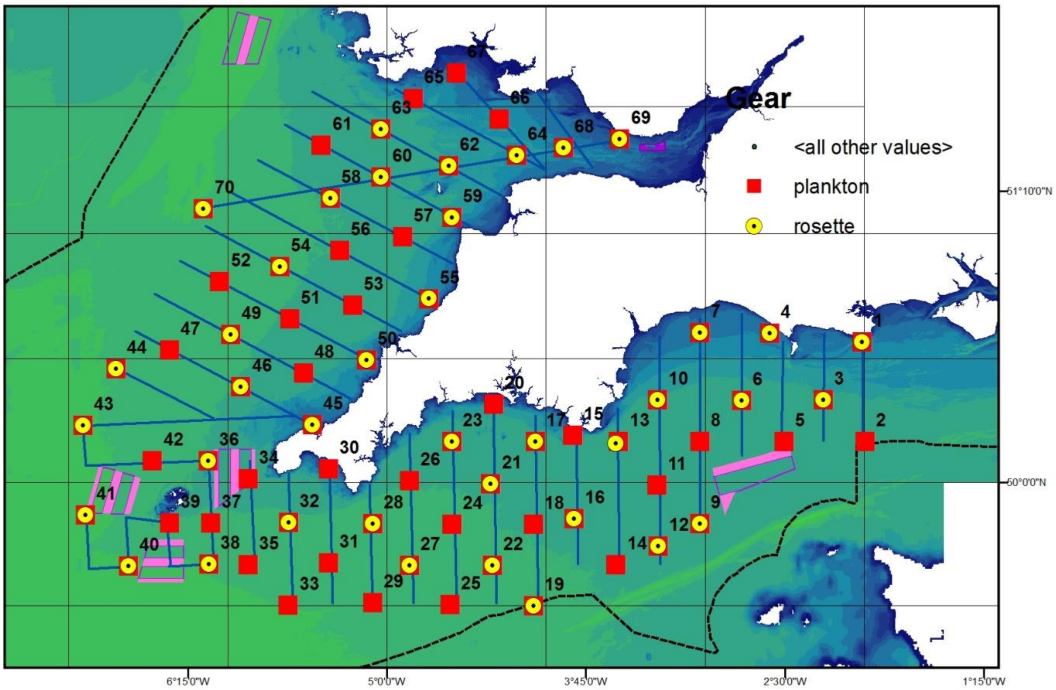

Figure 1. Overview of the survey area, with the acoustic transect (blue lines), plankton stations (red squares) and hydrographic stations (Yellow circles).

2.2.2. Processing

Acoustic data were cleaned, which included removal of data collected during fishing operations. Both the on-transect data and those collected during the steam between transects were retained. Only the former was used for further biomass estimates but the inter-transect data was retained and cleaned for future studies on spatial distribution of predators and prey. A surface exclusion line was set at 13 m and acoustic data below 1 m above the seabed were also removed to exclude the strong signals from the seabed. Large amounts of plankton were present throughout the survey, often represented in layers on all three acoustic frequencies (although at different strengths depending on the organisms). Fish schools and plankton were often mixed and a simple extraction of fish echoes was not possible. Therefore, to distinguish between organisms with different acoustic properties (echotypes) a multi-frequency algorithm developed in 2012 was refined to separate echograms for each of the echotypes (Fig. 2). The echogram with only the echoes from fish with swimbladders was then scrutinised and attributed to individual species based on expertise and the nearest relevant trawls, using imagery of sonar and netsonde collected during the trawling process to assess the sampling performance in relation to the acoustic marks.

In the case of mackerel a separate algorithm was used (following Korneliussen 2010). An additional bad weather filter was developed which removed “empty” pings as a result of adverse weather conditions. This was applied only on files which were affected by bad weather.

2.3 Fishing and catch sampling

A heavy duty ‘herring’ trawl (20 x 40m v d K Herring trawl, KT nets) was used to sample the pelagic community for the purpose of validating acoustic marks and collecting biological samples. A wireless 50 kHz Marport net-sonde was mounted on the head-rope of the trawl at the mouth of the net, which allowed for live monitoring of the trawling performance. Trawling operations went very well with no gear damage.

Fish were sorted to species and size categories before the total catch was weighed and measured using the Cefas Electronic Data Collection (EDC) system. In the case of very large catches, subsamples were taken before weighing and measuring. The sex and maturity of the pelagic species in each trawl was assessed (up to 5 per length class of mackerel, sprat, sardine, anchovy, horse mackerel, garfish, herring), and their otoliths and stomachs were dissected out and removed for later analysis. For the stomachs a total of up to 25 stomachs were taken across the various length categories per species per catch.

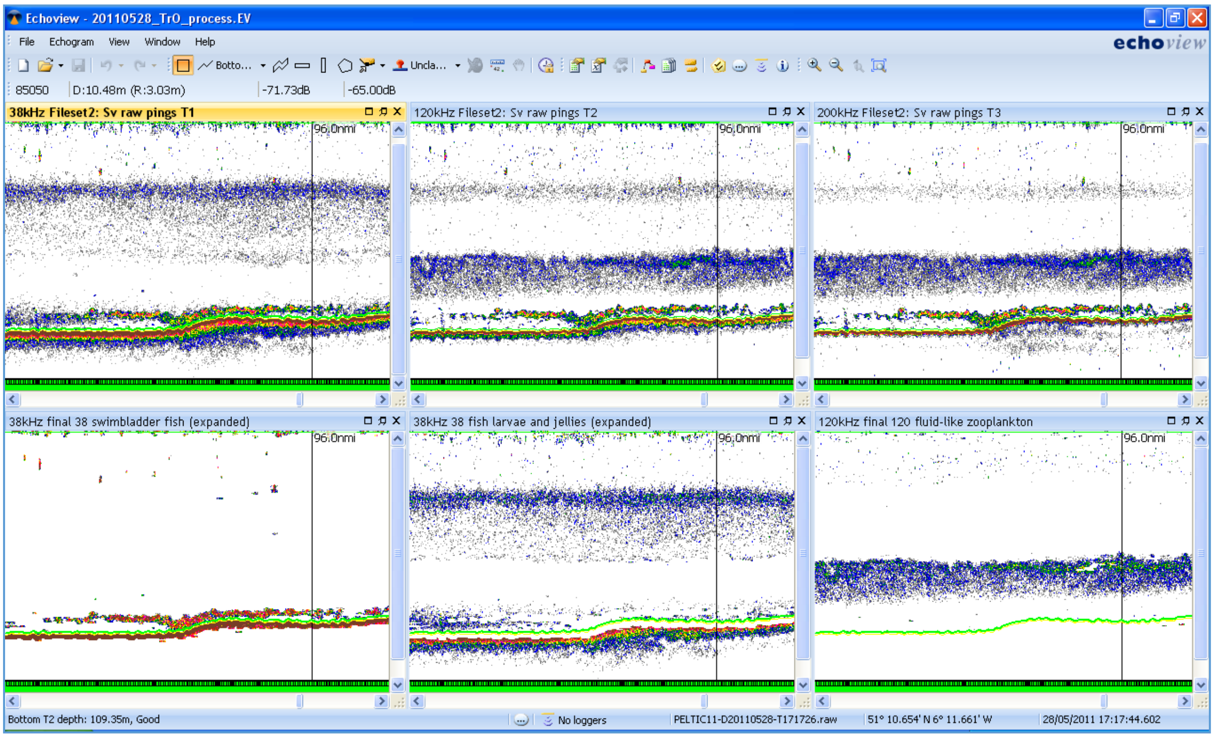

Figure 2. Dataflow of algorithm (top) used to divide the acoustic data by echotype. Screen-shot example (bottom) with raw echograms of 38, 120 and 200 kHz (top panels) and three examples of extracted echotypes (bottom panel from left to righ): fish with swimbladder (sardine schools at surface and myctophids layer near seabed), fish larvae/ jellyfish and zooplankton (dense krill layer).

2.4 Zooplankton

2.4.1. Ringnets

The various planktonic size components were sampled at 71 fixed plankton stations along the various transects using two ringnets of different mesh: 270 µm (ichtyoplankton and macro-zooplankton) and 80 µm (zooplankton). The two ringnets were fixed to a frame which enabled them to be deployed simultaneously. Both nets had flowmeters (General Oceanics mechanical flowmeters with standard rotor, model 2030R) mounted in the centre of the aperture of the net and a mini-CTD (SAIV) was attached to the bridle. Position, date, time, seabed depth, sampled depth (from CTD attached to net) and flowmeter reading were recorded. Nets were washed down on hauling and samples were transferred from the terminal mesh grid. When possible, samples from the 270 µm mesh were transferred into jars and immediately analysed under a binocular microscope before the full sample was preserved in 4% buffered formaldehyde. If immediate analysis was not possible, samples were transferred into 1 lb glass jars and preserved before analysis on a later day during the survey. Ichthyoplankton (eggs and larvae) and macrozooplankton from the 270 µm samples were counted, aged and, in the case of clupeid larvae, measured and raised using flow meter derived sample volumes. Samples from the 80 µm mesh were transferred into jars and preserved with 4% buffered formaldehyde for later analysis using a zooscan in the lab.

2.4.2. Microzooplankton

At a subset of 18 prime stations two water sample were taken and fixed on lugol, one for phytoplankton analysis back in the lab and one for micro-zooplankton analysis.

2.4.3. CALPS

At 40 ringnet stations additional surface samples of zooplankton were taken using the CALPS (Cefas Autonomous Litter and Plankton Sampler). For an hour at each of these stations a sample was taken using an 80 µm mesh net to be compared with the vertical casts, starting ~20 mins before arriving at the station, running during the station and continuing until ~20 mins after the station.

2.4.4. Plankton Image Analyser

A Plankton Image Analyser (PIA) system was trialled during the Peltic survey. PIA is a real-time high speed instrument developed by Phil Culverhouse (University of Plymouth) that continuously takes samples from a water inlet (the same one used by the CALPS) whilst underway. As the pumped water passes through a flow-cell, the PIA takes images of the passing particles. Those images will be sent to a recognition software which will classify them into categories corresponding to zooplankton taxonomic groups. The PIA was ran for the entire duration of the cruise, collecting over 10 million images of zooplankton throughout the sea trip.

2.5 Oceanography

A Ferrybox system provided continuous subsurface measurements in real time of various environmental variables (e.g. temperature, salinity, fluorescence and dissolved oxygen) during steaming. In addition, weekly maps of sea surface temperature, frontal systems, and chlorophyll concentration were obtained from Neodaas (www.neodaas.ac.uk). The Ferrybox was connected to a flow cytometer, which performed hourly measurements of the size and abundance of pico- and nano-phytoplankton populations in the water.

Vertical profiles of temperature, salinity, fluorescence, optical backscatter, dissolved oxygen and Photosynthetically Available Radiation (PAR) were collected at 38 sampling stations using a Rosette sampler equipped with a SeaBird CTD, in calm and moderate sea states. An ESM2 profiler was used instead in rough sea conditions.

At 18 of these 38 sampling stations, surface water samples for analysis and calibration of salinity, inorganic nutrients, dissolved oxygen, and phytoplankton pigments were collected using the Rosette sampler, or, when not in use (during periods of adverse weather), from the continuous water pump that supplies the Ferrybox. At the same 18 stations further surface samples for analysis of phytoplankton and microzooplankton communities were collected; at one of these stations, prime station 27, samples were also collected at depth, due to the presence of a Deep Chlorophyll Maximum.

Samples for analysis of dissolved oxygen concentration, salinity and phytoplankton pigments will be used for calibrating the sensors of the SeaBird CTD, of the ESM2 profiler and of the Ferrybox. A summary of the samples collected, and of the CTD profiles carried out during the survey, is given in Table 1.

Table 1. Samples collected during the survey and number of profiles carried out.

Salinity	19
Dissolved oxygen	8 (x3)
Chlorophyll/Pigments analysis	40
Inorganic nutrients	20
Phytoplankton	19
Microzooplankton	19
CTD profiles with Rosette SeaBird	28
CTD profiles with ESM2	10

2.6 Top predators

For the second year running, two different but complimentary approaches were taken to record birds and marine mammals. On the Bridge wing of one side of the vessel (selected as appropriate to minimise sun glare), two experienced JNCC-accredited European Seabirds At Sea (ESAS) surveyors (Mike Bailey and Sean Minns) employed an effort-based distance sampling straight-line transect survey following strict ESAS methodology, whilst on the other Bridge wing, a single experienced volunteer MARINElife surveyor (Peter Howlett) employed an adapted and slightly simplified version of this methodology. As a result, a 90° bow-to-beam scan area was surveyed by the ESAS team along transect lines during daylight hours, and with the additional coverage provided by the MARINElife surveyor, a 180° scan area was surveyed along every transect line. During transits between transects, both teams maintained incidental observations whenever possible, logging significant species only. Furthermore, observations were regularly conducted during the net-retrieval stage of many trawls to identify species of birds associated with the fishing activity of the survey vessel but only significant species were logged as incidental records. All species of birds (both seabirds and terrestrial migrants) were recorded, along with all sightings of marine mammals.

ESAS methodology aims to achieve an assessment of the numbers and distribution of animals in a designated quantifiable area by employing a sampling method so that numbers can be extrapolated into the entirety of the study zone. ESAS methodology is an internationally recognised sampling method conforming to internationally accepted standards enabling data to be compared with surveys elsewhere.

It is recommended that ESAS surveys only occur in sea state 4 or less, although the effects of environmental conditions on surveyability are very vessel dependent. Frustratingly, the weather conditions during this 2016 Peltic survey regularly exceeded sea state 4 (reaching sea state 8 on one day) meaning that some of the data will be unusable using the usual ESAS analysis methods.

The single MARINElife surveyor adopted a transect on the opposite side of the vessel to the side used by ESAS observers (and was therefore frequently affected by sunglare). Priority was given to detecting marine mammals, often at significant distance, so the use of binoculars was far more frequent, and this undoubtedly affects the detectability and reliability of recording each bird within transect. In addition to cetaceans, specific effort was made to detect Balearic Shearwater (Puffinus mauretanicus), and any other birds. Communication between the two teams was maintained throughout via two-way PMR446 radio to ensure that any unusual or significant sightings were corroborated, although in reality this was sometimes impossible to do when large aggregations were encountered and when the vessel's bulkhead prevented viewing across to the opposite transect. Otherwise, all data recorded by the two teams was kept separate to ensure independence when detecting animals.

During the deployment of the fishing net, both teams paused effort. However, during the net-retrieval phase, incidental records of significant species was logged (e.g. Balearic Shearwater, Sooty Shearwater, cetaceans) whenever time permitted. Observations were conducted from the rear of the Bridge to cover a 180° arc, aft of the vessel. Whilst this data was not part of the standard transect data it provided an opportunity to observe behaviour and associations with a fishing vessel and could provide useful comparisons with future surveys in these waters.

3. Preliminary results

3.1. Pelagic Ichthyofauna

After removing the off-transect data a total of ~1200 nautical miles of acoustic sampling units were collected for further analysis (Fig. 3). A total of 15 successful trawls were made (Fig. 3). The trawls were evenly spread across the survey area, providing a suitable source of species and length data to partition the acoustic data.

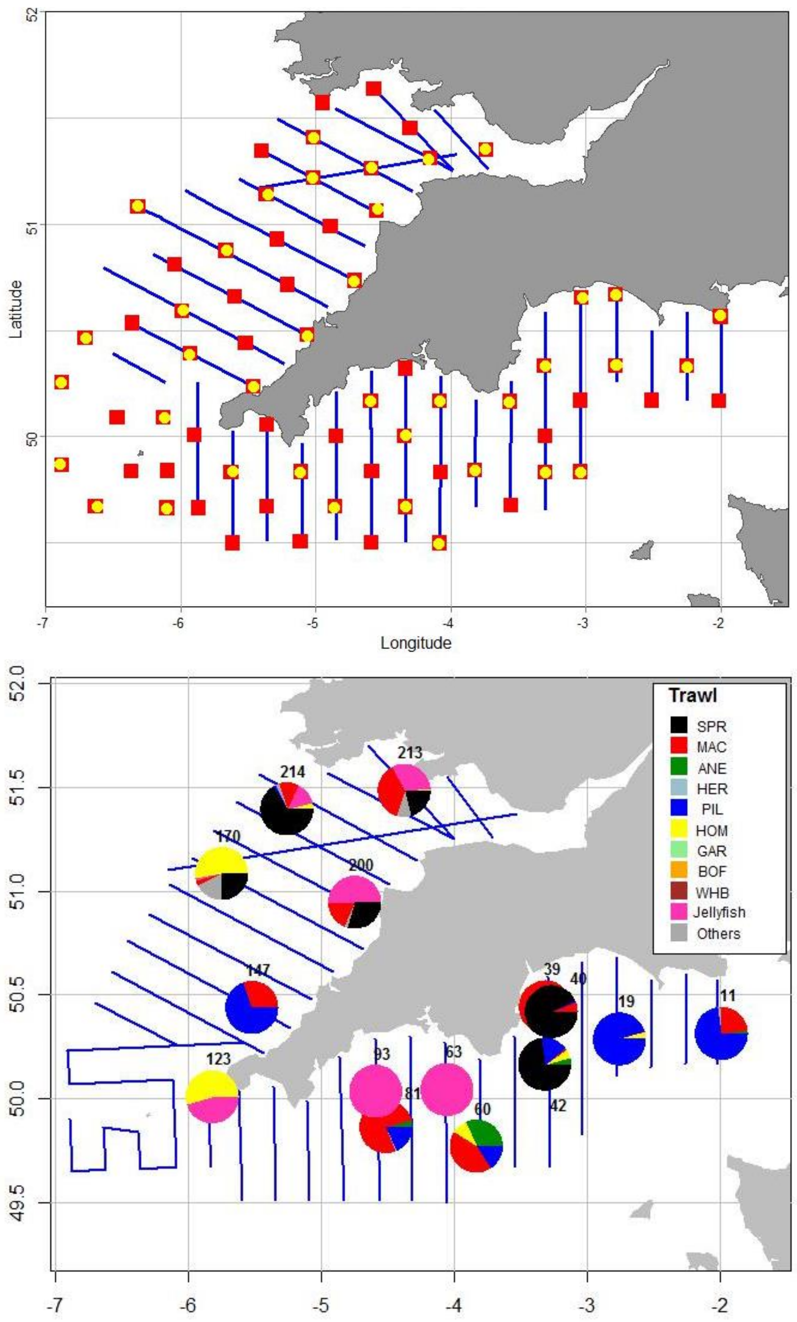

Figure 3. Overview map and detail of the survey area. Top: Acoustic transects (blue lines) and prime stations completed during PELTIC16. Bottom: Trawl catches (pies) with relative catch composition by key species. Three letter codes: SPR=sprat, MAC=mackerel, ANE=anchovy, HER=herring, PIL=sardine, HOM= horse mackerel, GAR=garfish, BOF=Boarfish, WHB=Blue whiting.

Species distribution in 2016 was comparable to those observed in previous years. Sprat dominated in western Lyme Bay and in the coastal waters of the Bristol Channel. As in previous years, sprat in the Bristol Channel consisted nearly entirely of juvenile specimens, whereas those from the Lyme Bay area were more mature although maximum size was relatively low at 14 cm (fig. 4) compared to previous years.

Sardines (*Sardina pilchardus*) were widespread as in 2015 and specimens were found in most hauls (fig. 3). As was the case in 2015, the size of specimens collected in the Bristol Channel included larger adults fish of around 19 cm although the dominant large numbers of fish of around 15cm were also found this year (Fig 4). Similar length frequency distribution was obtained from the English

Channel trawl stations. Maximum sardine size exceeded 22 cm (Fig 4) which is larger than 2015 (20) but smaller than 2014 (25 cm).

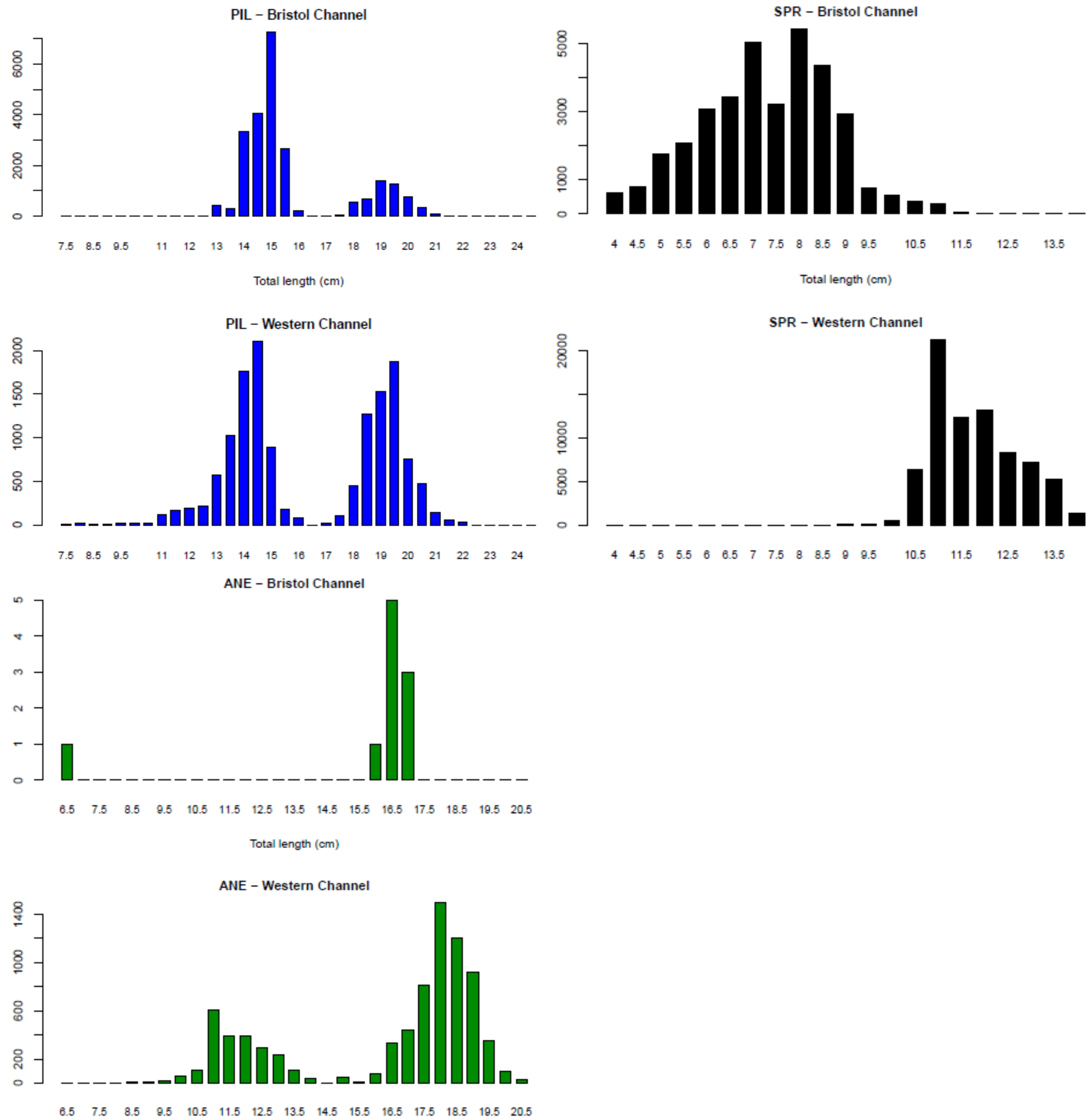

Figure 4. Trawl-caught numbers by length of sardine (*Sardina pilchardus*) (PIL, top left) sprat (*Sprattus sprattus*) (SPR, top right) and anchovy (*Engraulis encrasicolus*) by subarea. Please note that these numbers are not raised by the acoustic data.

Anchovy (*Engraulis encrasicolus*) was found in good numbers and more widespread in the Bristol Channel area. Mackerel (*Scomber scombrus*) and horse mackerel (*Trachurus trachurus*) were found widespread throughout the survey area dominated by juvenile specimens (Fig 5). Some large and relatively dense mackerel aggregations were apparent near the Celtic Deep.

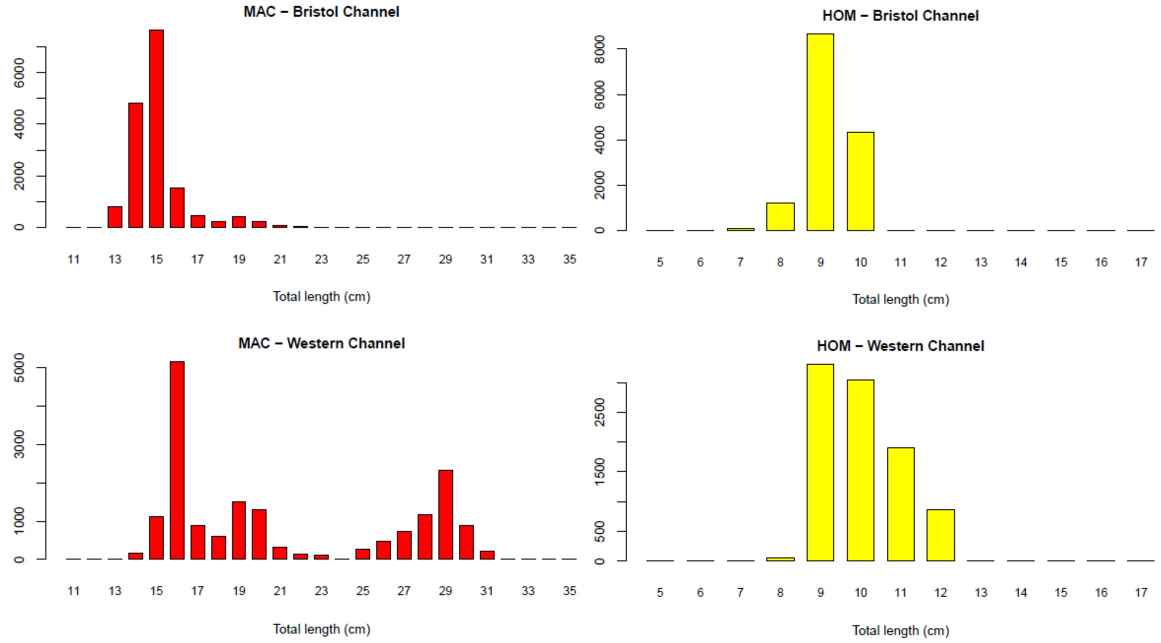

Figure 5. Trawl caught numbers by length of mackerel (MAC, left) and horse mackerel (HOM, right) in the Bristol Channel (top) and English Channel (bottom).

3.2. Plankton

3.2.1. Ichthyoplankton

Good numbers of sardine egg were found, with the highest densities in the Eddystone Bay, western Channel. As in previous years, sardine larvae were slightly more widely distributed although the highest densities were also found in Eddystone Bay. Prior to 2015, no sardine eggs had been found north of the Cornish Peninsula. In 2015 two stations contained small numbers of eggs. This year however, eggs were found at five station in the Bristol Channel and at one station in larger numbers. Sardine larvae, normally found in low numbers in the Bristol Channel, were particularly abundant on one of the offshore Bristol Channel stations (Fig 6).

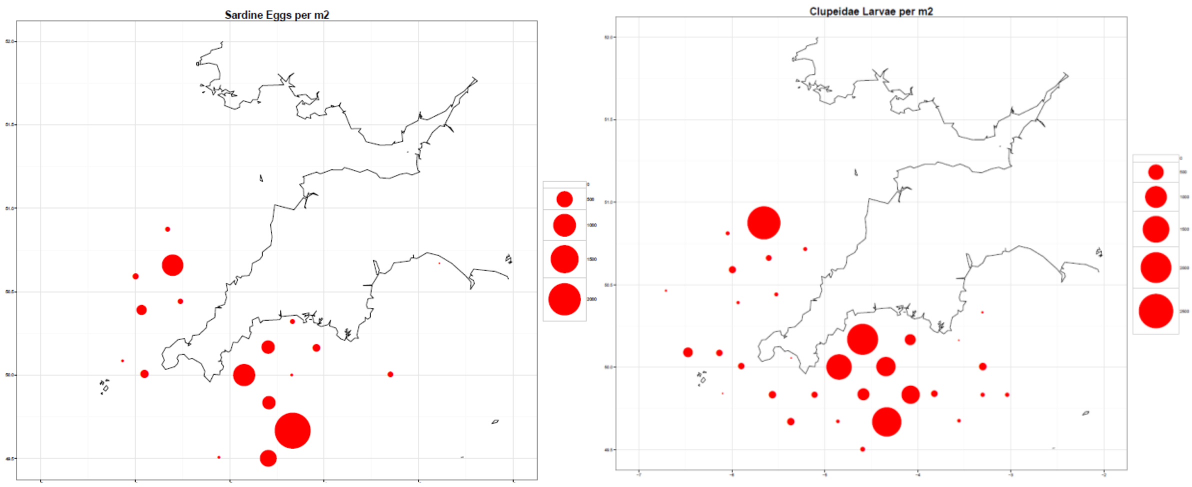

Figure 6. Sardine egg densities in m2 (left) and larvae (right) as sampled during the 2016 Peltic survey.

3.2.2. Plankton Image Analyser

PIA was successfully deployed throughout the survey, collecting over 10 million images of zooplankton throughout the sea trip. Despite the significant swell and wind conditions the system operated consistently and reliably, collecting good quality images (Fig 7 for some examples). These will be further processed and categorised back in the lab and compared with the zooscan results from the 70 Ringnet samples and from 40 CALPS stations.

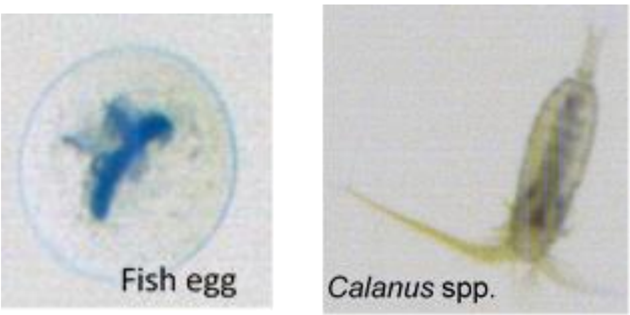

Figure 7. Examples of two images recorded during the PELTIC16 survey using the Plankton Image Analyser system.

3.3. Oceanographic data

3.3.1. Temperature and salinity

Surface waters of the Western English Channel were warmer than waters of the Celtic and Irish Seas with temperatures up to 17.13°C (from the SAIV MiniCTD; Figs 8 and 9). The maximum temperature recorded during the survey in 2016 was higher than maximum temperatures during surveys in 2013 and 2015 (approximately 16°C), but it was 1°C lower than maximum temperature recorded in 2014. Temperatures near the bottom were highest at stations in the Western English Channel and lowest at offshore stations in the Celtic Sea (down to 10.15°C; Figure 8).

Salinity was similar between the sampling stations, except at the inner stations in the Bristol Channel, which had lower salinity (33.48), as result of freshwater inputs from the River Severn. The salinity range (33.48-35.13) was comparable with ranges measured during surveys in the previous years.

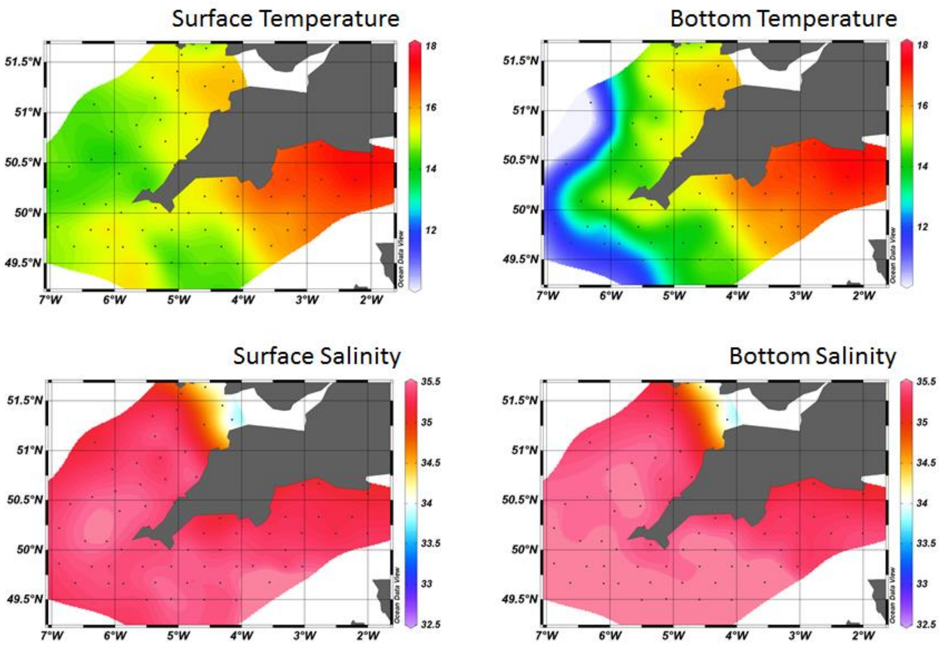

Figure 8. Temperature (°C) and salinity at the subsurface (1-2 m depth) and above the bottom measured by the SAIV MiniCTD at the 69 sampling stations between 3rd October and 19th October 2016. Maps prepared with Ocean Data View (ODW).

The patch of slightly cooler water, located south of Eddystone Bay, was clearly visible in satellite remote sensing images (Fig 9a). In comparison with images from previous years, the patch was smaller and located further south, near the France coast (compare Fig 9a and 9b). During the course of the survey the patch extended northwards, towards the Cornish coast.

The boundary layer where the patch cooler waters meet the warmer waters of the English Channel and the Celtic Sea was marked by a series of frontal systems (Fig 9a); in 2016, the fronts were located further south and appeared to be weaker than the previous year (compared Fig 9a and 9b).

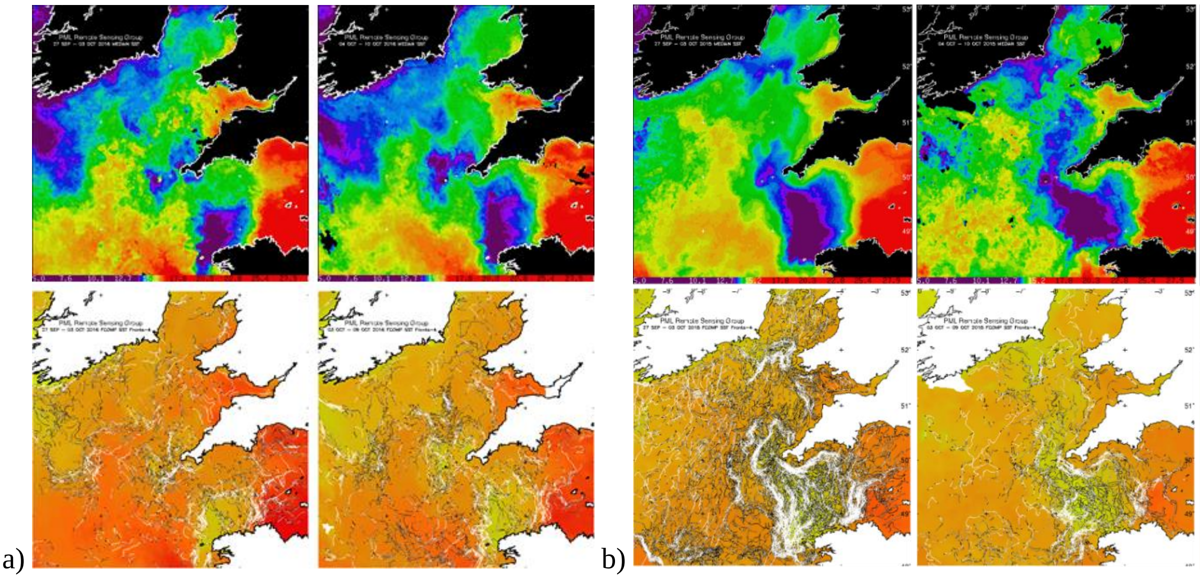

Figure 9. Composite surface maps for the periods 27 September - 3 October, 4 – 10 October 2016 (a) and 2015 (b) of temperature (upper row of images) and thermal frontal systems (lower row) from Neodaas.co.uk (PML).

The majority of stations near the Isles of Scilly, the most westerly stations of the Western English Channel and the offshore stations of the Bristol Channel area, were thermally stratified ($\Delta T > 0.5°C$), with difference in temperature between surface and bottom of up to 4.35°C (Fig 10). Distribution of the mixed/stratified areas in 2016 was similar to distribution in 2013 and 2015 (Fig 10).

Differences in surface and bottom salinity were small, suggesting that the vertical stratification of the water column was mainly driven by changes in temperature rather than salinity.

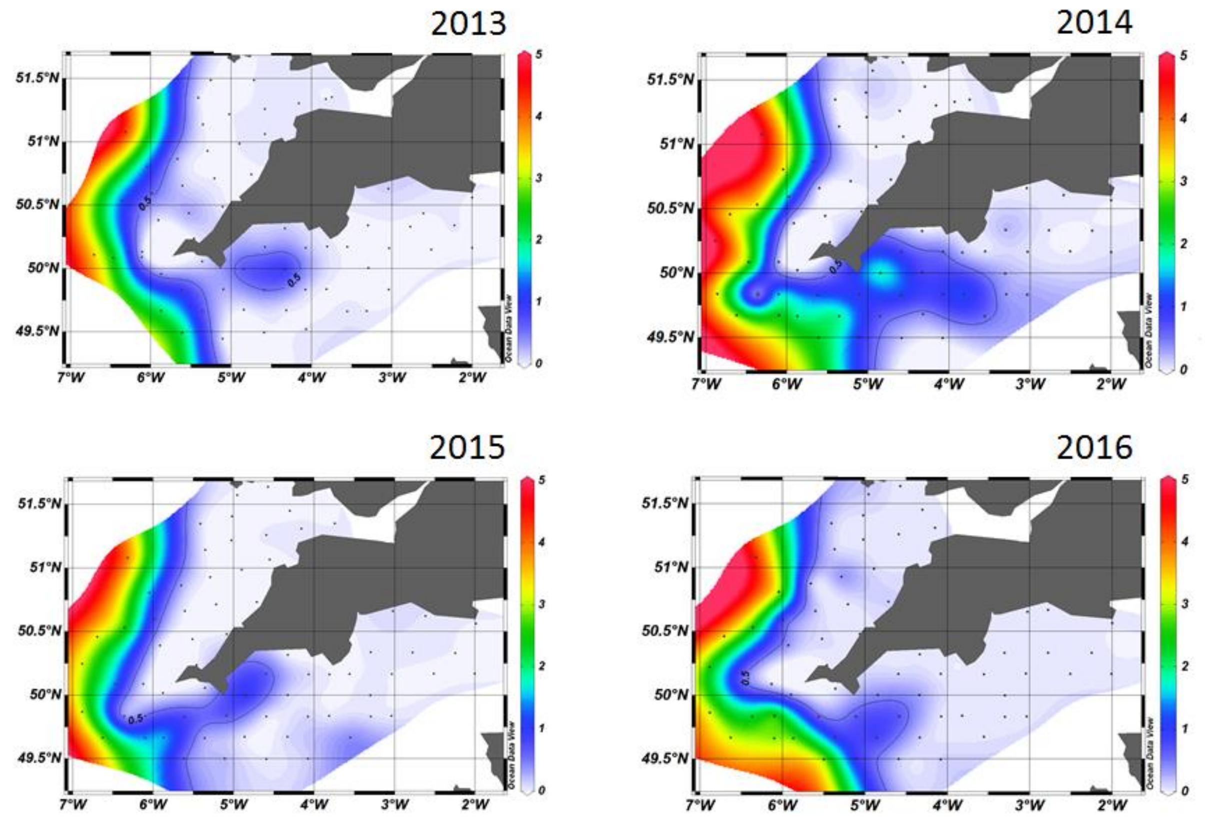

Figure 10. Values of ΔT (surface temperature – bottom temperature; °C) at the 69 sampling stations, as measured by the SAIV MiniCTD, in 2013, 2014, 2015 and 2016. The water column is considered stratified when ΔT > 0.5 (°C); ΔT = 0.5 °C is marked by the continuous black line. Maps prepared with Ocean Data View (ODW).

Differences in vertical structure of the water column between the three main areas of the Western English Channel (WEC), Isles of Scilly (SI) and Bristol Channel (BC) were observed (Fig 11, based on measurements by the Rosette SeaBird CTD). WEC and BC had the highest temperatures and were fully mixed; BC had the lowest salinity and the highest turbidity (Fig 11). Offshore stations showed thermal stratification, with cooler water near the bottom, except at station prime 27 (indicated with a '*' in Fig 11) where the cooler water reached the mid-water column. Interestingly, this latter station also presented a Deep Chlorophyll Maximum (Fig 11 – Fluorescence Seapoint).

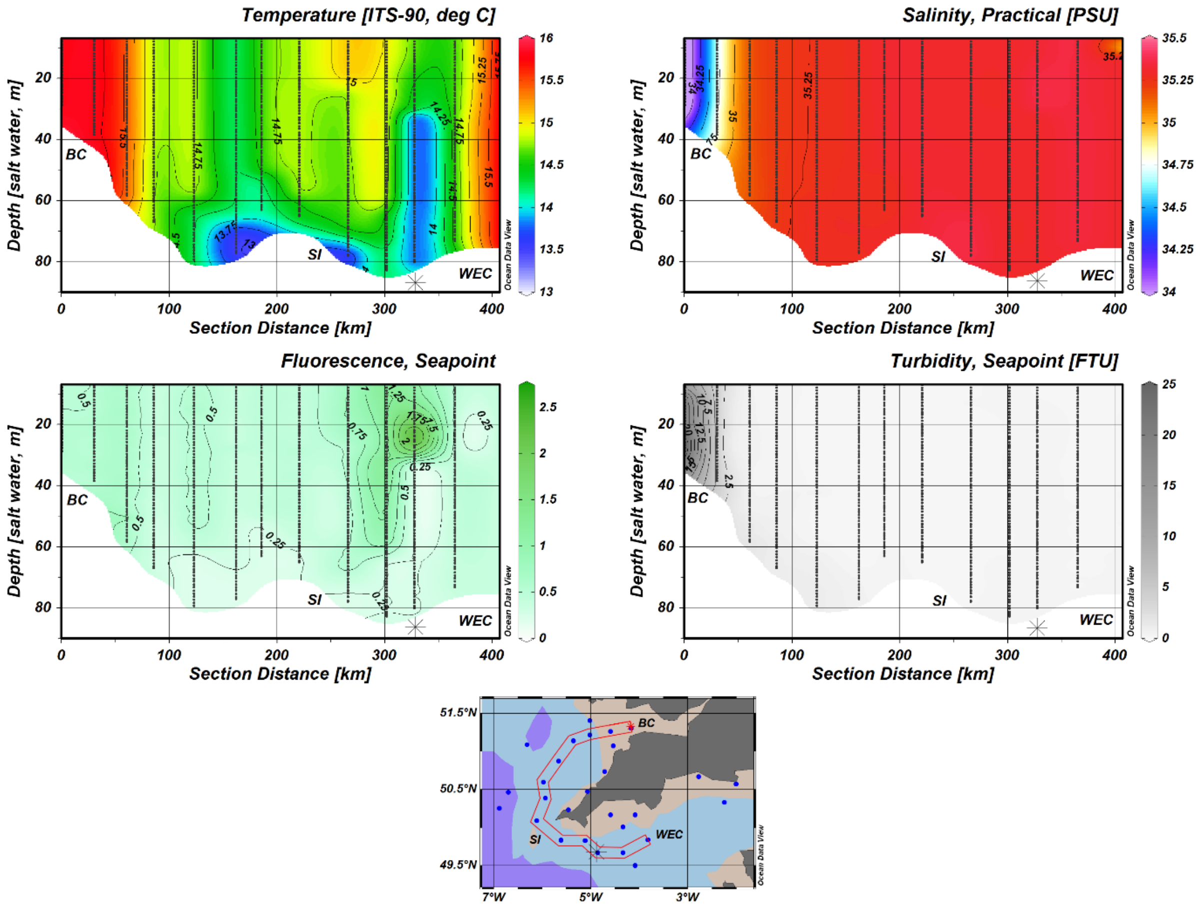

Figure 11. Section from Western English Channel (WEC), to the Bristol Channel (BC), passing through the Scilly Isles (SI), prepared combining temperature, salinity, fluorescence and turbidity profiles collected with the SeaBird on the Rosette sampler. Prime station 27, characterised by a Deep Chlorophyll Maximum (DCM) is indicated with a star '*'. Maps prepared with Ocean Data View (ODW).

3.3.2. Fluorescence and chlorophyll concentration

Remote sensing techniques showed that surface chlorophyll concentration at the end of September were highest south of the Cornish coast (in the middle of the Western English Channel) and offshore near the Isles Scilly (Fig 12). In situ measurements of surface fluorescence showed that higher levels of chlorophyll were observed south of Lizard Point (Fig 13, from Ferrybox measurements).

Furthermore, the satellite images of surface chlorophyll (Fig 12) also suggested high level of chlorophyll concentration in the Bristol Channel; this observation was not supported by the Ferrybox and SeaBird CTD fluorescence measurements which were generally low in the Bristol Channel area (Fig 11 and 13). This could be explained by the higher level of suspended solids in the inner Bristol Channel (see Fig 11 – Turbidity Seapoint [FTU] transect) affecting the reliability of the remote sensing algorithm for calculating chlorophyll concentration.

Chlorophyll concentration (expressed as fluorescence) at the 18 sampling stations was generally constant throughout the surface mixed layer, with exception of prime station 27 (in yellow in Fig 14), which showed the presence of a Deep Chlorophyll Maximum (DCM) at around 20 m depth. DCM are normally observed in seasonally stratified water column during summer. In the summer months the surface mixed layer is nutrient depleted while nutrients are 'locked' below the thermocline in the bottom layer. As the light level is low below the thermocline, phytoplankton is not able to utilize the available nutrients. However, just above the thermocline the light level is sufficient for phytoplankton to utilize the dissolved nutrients, resulting in a maximum of chlorophyll at depth. During the autumn, with the breaking of the vertical stratification, the inorganic nutrients are released throughout the water column, potentially leading to an autumn bloom.

Analysis in the laboratory of phytoplankton samples will provide details of the pico-, nano- and micro-phytoplankton community as well as their abundance and pigment composition.

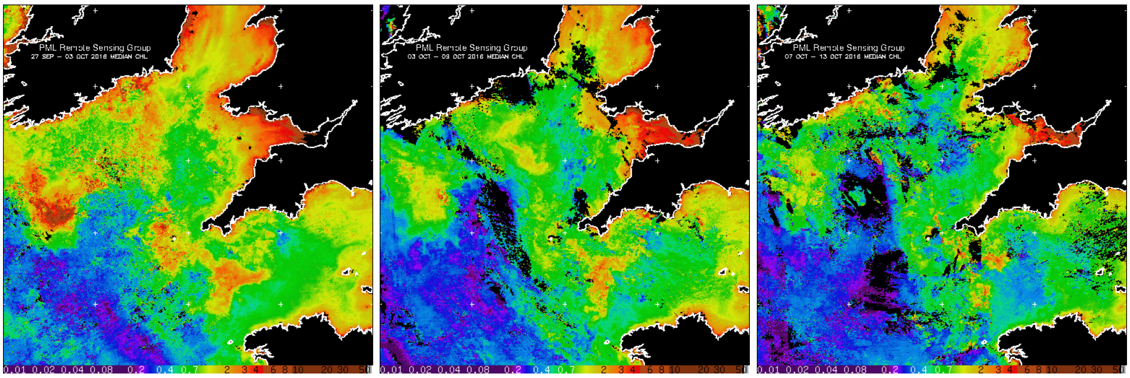

Figure 12. Composite surface maps of chlorophyll, OC3 algorithm, for periods 27 September - 3 October, 4 – 10 October, 7 – 13 October (left to right), from Neodaas.co.uk (PML).

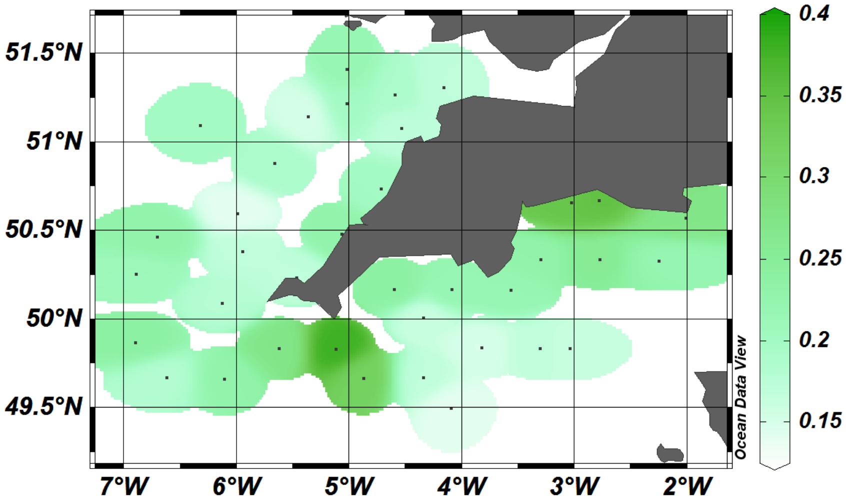

Figure 13. Fluorescence values at 4 m depth, at 18 sampling stations, as recorded by the Ferrybox. Maps prepared with Ocean Data View (ODW).

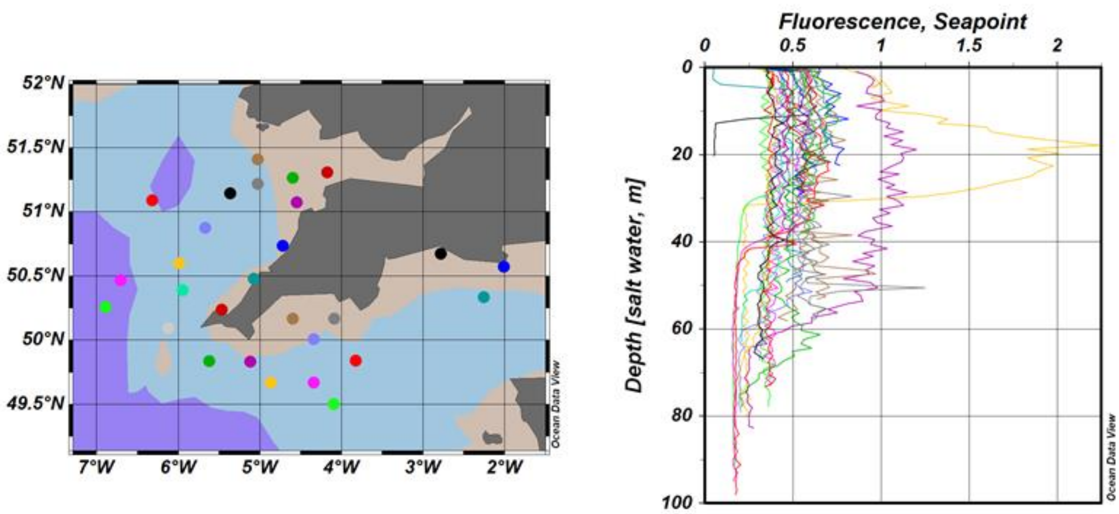

Figure 14. Fluorescence profiles at 18 sampling stations, as recorded by the SeaBird CTD mounted on the Rosette sampler. Maps prepared with Ocean Data View (ODW).

3.4. Marine Mammals and birds

Whilst a full analysis of the data has not yet been conducted, a superficial summary of species recorded by the two teams follows. Please note that due to the different methodologies used and the different times during which incidental records were logged, these totals from the two teams are not comparable. Some of the birds included in these totals may have been recorded by both teams simultaneously whilst others may not.

Bird species recorded (58 species in total):
Of significant note, the total number of Balearic Shearwater *Puffinus mauretanicus* seen was a minimum of 99 (subject to analysis of the two data sets recorded), with notable concentrations to the west of Lundy island, Devon. Behaviours noted include shallow plunge diving, surface pecking and active searching, particularly around the RV Endeavour's wake during one notable net retrieval. Numbers of Fulmar *Fulmarus galcialis* were very low this year.

Some evidence of visible migration was noted, particularly along the Dorset coast, with a steady stream of Meadow Pipits *Anthus pratensis* and Barn Swallow *Hirundo rustica* overhead. Additionally, a small variety of species were observed on board or attempting to land on board the survey vessel. Perhaps surprisingly, considering the challenging weather conditions, none of these required rehabilitation this year and all left the vessel of their own accord. The Long-tailed Skua *Stercorarius longicaudus* was arguably the highlight, but a migrating ring-tailed Hen Harrier *Circus cyaneus* and Hawfinch *Coccothraustes coccothraustes* also stand out as most unexpected species recorded. No rare vagrants were seen this year most likely due to the position of the weather systems.

Cetacean species recorded:
Animals were only recorded in transect by each team if they entered the respective transect. Any animals seen outside of this were recorded as out of transect. There were fewer sightings this year compared to last, arguably due to the poor sea state and weather. Most noticeably this affected the number of Harbour Porpoise *Phocoena phocoena* detected with only 6 animals seen. The Long-finned Pilot Whale *Globicephala melas* were found south of Plymouth and the Fin Whale *Balaenoptera physalus* were located to the north west of the Cornwall and Devon coasts, although they were a little further into the Celtic Deep than last year. No White-beaked Dolphin *Lagenorhynchus albirostris* were seen this year.

Fish species recorded:
Atlantic Bluefin Tuna *Thunnus thynnus* were seen by the ESAS observers at 6 different locations, scattered around the Dorset, Devon and Cornwall waters. Frustratingly however the fish never remained active after first detection so no photographs were taken. A further 7th separate observation was made by the MarineLife observer.

The most unusual species recorded was a Gem moth *Nycterosea obstipata* found in the garage area of the vessel by one of the fish scientists, having landed onboard overnight on 10 October. This is a rare migrant moth but several were found by lepidopterists along the south coast during this week so it is far from unprecedented.

4. Summary

The fifth in the series of Pelagic Ecosystem Surveys in the western English Channel and Eastern Celtic Sea took place between the 3rd and 19th of October 2016. The oceanographic conditions were similar to those observed in 2014 and represented a relatively warm autumn bloom scenario, in contrast to the more typical 2013 and 2015 condition and the winter conditions encountered in 2012. Primary production was relatively low, and was observed near the strong frontal systems particularly those around a cool water pool off the southwest of Cornwall.

Preliminary results on the small pelagic fish community suggested that most species were doing well apart from sprat. Few sprat schools were observed in Lyme Bay and also the offshore schools in deep waters of the Bristol Channel in 2015 were no present in the survey area. As has been observed in previous years, sprat in the western Channel consisted of predominantly adult specimens (age 1-3), compared to in-and offshore sprat in the Bristol Channel which were predominantly age 0 (with a unimodal length distribution around 8 cm).

Anchovy was found in large numbers in the western English Channel, extending further west as was the case in 2015. Noticeably in this area were the larger number of older specimens than in previous years. Anchovy was also observed in the Bristol Channel, including some larger specimens.

Good sardine numbers were found and their distribution was widespread. They were present in most trawl hauls conducted in the western channel. Distribution here was only limited, it seems, by the cold water pool that was situated south off the western tip of the Cornish Peninsula. In the Bristol Channel sardine appeared to be concentrated to the middle of the transects, between the deeper and very shallowest parts, apparently associated with prevailing frontal systems. Sardine spawning (based on egg distribution) was similar to in 2014 and 2015 both in terms of magnitude and distribution although for the second consecutive year eggs were observed in the Bristol Channel and in good numbers.

Mackerel were observed throughout the survey area, both in and offshore, although particular areas contained higher densities, most noticeably around the Celtic Deep. Young of the year made up the majority although older specimens were also found. Horse mackerel were prevalent in the survey area although they dominated the offshore areas of the western Channel and around the Isles of Scilly. Unlike previously the length data showed unimodal distribution around 9 cm which was generally associated with 0-year old fish.

One of the most notable observations were the seven separate feeding aggregations of blue fin tuna along the coast; the only other time one this species was observed during the 5 year time series was in the other hot year (2014).