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

16–20 November 2015

Lowestoft, UK

ICES International Council for the Exploration of the Sea

CIEM Conseil International pour l'Exploration de la Mer

International Council for the Exploration of the Sea
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Executive summary

The Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VII, VIII and IX (previously ICES Areas VIII and IX), met in Lowestoft, United Kingdom, on 16-20 November 2015. The meeting was attended by 14 participants from four countries (representing five institutes). After opening of the meeting and general Group business day 1 and part of day 2 were spend on survey presentations. During the remainder of the week, the Group discussed general WGACEGG business and specific Daily Egg Production Method (DEPM) or acoustics issues either in plenary or parallel sessions.

Nine surveys (one update to 2014, Sardine DEPM, and eight from 2015) were reported to the Group. The highlights from 2015 surveying showed:

- The Iberoatlantic stock of sardine, distributed along 8c and 9a, is still showing a decreasing trend, with the lowest biomass level since 2003.
- Contrasting to the low sardine abundance recorded in 8c and 9a, in 8ab sardine is still showing an increasing trend in numbers. However, as observed for anchovy, mean weight is decreasing since 2003. A trend also observed in 8c.
- During the spring acoustic surveys, more than the 70% of each year class of sardine, either in number or in biomass, were observed in the French area of the Bay of Biscay.
- In northern areas (7e and 7h), both sardine and anchovy have been found in large numbers, mostly belonging in both cases but specially in the case of anchovy to older age classes.
- PELGAS survey accounted for the highest anchovy estimate in number in Bay of Biscay, thus, with the lowest mean size ever recorded.
- No clear explanation would be hypothesized on the decreasing trend in size observed in both species in the French area

Addressing DEPM developments (Annex 8.5) the Group discussed the preliminary results on the utilization of aggregated survey data and inclusion of geographical and environmental (temperature) factors for the Gulf of Cadiz anchovy mortality modelling. Following a plan from last year, aiming at analysing the sardine reproductive activity during the 2014 DEPM surveys and contextualize it within the 2013–2014 reproductive season, the institutes involved in the sardine DEPM surveys (IPMA, IEO, AZTI) presented compiled biological data collected monthly at national fishing ports. The information gathered helped in describing the seasonal (and interannual) variability of the reproductive parameters which assist in the interpretation of the DEPM estimations with regard to the population structure and environmental forcing. The Group decided that such type of analyses should be considered during each survey season. Since the sardine DEPM does not produce annual estimates, contrasting to the acoustics results which are available yearly, and the Working Group on Southern Horse Mackerel, Anchovy and Sardine (WGHANSA) modelling approach performs better when both sources of data are equally frequent, a trial was undertaken to explore the utilization of egg data collected during mackerel and horse-mackerel egg production survey years (which occur in between sardine DEPM years). The results presented encourage further exploration of the data, which will be finalized for the next sardine benchmark meeting. Further contributions to this meeting will include SSB estimation

by age (length) and analyses on the DEPM parameters interannual, seasonal and spatial fluctuations.

During the session dedicated to acoustics issues a promising exercise on the anchovy TS-depth dependent, has been carried out in order to give a plausible explanation to the discrepancy in biomass estimates found between echointegration and daily egg production methods.

The Group endorsed the results from the Bay of Biscay anchovy recruitment autumn survey (JUVENA), which were then submitted to WGHANSA for assessment modelling.

The plans for the coordinated 2016 surveys were completed and are present in Annex 8.7.

The Group agreed on some main subjects to be investigated for collaborative work targeting joint publications. The themes to be initially addressed include: (i) comparison of acoustics and DEPM abundance estimates, cross-validation of methods and ways of overcoming apparent contradictions (ii) extending sardine DEPM estimates to SSB by age (or length) (iii) development of egg production CUFES indices for sardine and anchovy (iv) temporal and spatial variability of the BoB anchovy, recolonization of the Cantabrian Sea.

1 Administrative details

Working Group name

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

Year of Appointment

2005 (with the current designation since 2013)

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

2

Chair(s)

Maria Manuel Angélico, Portugal

Pablo Carrera, Spain

Meeting venue

Lowestoft, UK

Meeting dates

16–20 November 2015

2 Terms of Reference a) – z)

The terms of reference for 2015 were:

a) Provide echo integration and DEPM estimates for sardine and anchovy in ICES Sub-areas 7, 8, and 9;

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

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

d) 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

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

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

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

g) Coordination and standardization of the surveys

Multiannual ToRs

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	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 (Atlantic and Mediterranean waters)	a) Science Requirements b) 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
c	Provide information on hydrographical and ecosystem indicators such as	a) Science Requirements	1.6.1, 1.6.2, 3.3.5	1st to 3rd years	Update grid maps Habitat characterization

	temperature, salinity, plankton characteristics, top predators abundances, egg densities for sardine and anchovy and backscattering acoustic energy from pelagic fish				
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 target strength	a) Science Requirements b) 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
d	Asses developments in the technologies and data analysis for the application of the Daily Egg production method (on Egg Production or adult parameters)	a) Science Requirements b) Advisory Requirements c) 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
	Asses developments in the technologies and data analysis for acoustic data				
f	Asses developments in technologies and data analysis for providing MSFD indicators and survey-base	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

	operational products for stakeholders				surveys/monitoring programs Manuscripts describing practical implementation and results
g	Coordination and standardization of the surveys	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 Pairovets.
	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 List of Outcomes and Achievements of the WG in 2015

The following outcomes and achievements were obtained during 2015 by WGACEGG:

- Sardine and anchovy biomass indices derived from acoustic and DEPM surveys used as input fishery-independent data for analytical assessment purposes in ICES WGHANSA:
  - Anchovy total biomass estimated by PELGAS acoustic survey in 8ab;
  - Anchovy proportion of the biomass at age 1 estimated by PELGAS acoustic survey in 8ab;
  - Anchovy total biomass estimated by BIOMAN DEPM survey in 8abc;
  - Anchovy proportion of the biomass at age 1 estimated by BIOMAN DEPM survey in 8abc;
  - Anchovy juvenile abundance index estimated by JUVENA acoustic survey in 8abc;
  - Anchovy total biomass estimated by PELAGO and ECOCADIZ acoustic surveys in 9a;
  - Anchovy total biomass estimated by ECOCADIZ-Recruit acoustic survey in 9a;
  - Sardine population in numbers-at-age in 8c and 9a from PELAGO and PELACUS acoustic surveys;
  - Sardine total Biomass in 8c and 9a from PELAGO and PELACUS acoustic surveys;
  - Sardine total biomass estimated by PELGAS acoustic survey in 8ab;
  - Sardine proportion of the biomass and populations at age estimated by PELGAS acoustic survey in 8ab;
  - Sardine egg abundance from BIOMAN DEPM survey in 8abc;
  - Spawning-stock biomass index for sardine in 8c and 9a from PT-DEPM14-PIL and SAREVA DEPM surveys in 2014, update.

- Other indices used as biological information at the WGHANSA:
  - Horse mackerel distribution and numbers-at-age estimated by PELAGO and PELACUS acoustic surveys in 9a;
  - Numbers-at-age for sardine and anchovy in 8ab from PELGAS acoustic survey;
  - Numbers-at-age for anchovy in 8abc from BIOMAN DEPM survey.

- Other biological information used at the WGHANSA:
  - Maturity ogives from the sardine DEPM (SAREVA, PT-DEPM14-PIL) and acoustic-trawl surveys (PELAGO and PELACUS);
  - Mean weight and length-at-age of anchovy in BIOMAN and PELGAS surveys in ICES Subarea 8;
  - Mean weight and length-at-age of sardine in PELGAS surveys in ICES Subarea 8abd;
  - Mean weight and length-at-age of sardine in 8c and 9a from PELAGO and PELACUS acoustic.

- Other biological information not explicitly used for the assessment at WGHANSA but of relevance as biological indicators and contributing to the direct SSB inputs:
  - Daily Fecundity of anchovy (and associated parameters W; F; S; R) in Subarea 8 from BIOMAN survey
  - Daily Fecundity of sardine (and associated parameters W; F; S; R) in Subarea 9a, and 8c from PT-DEPM14-PIL and SAREVA DEPM surveys.

- Other acoustic indices used as biological information at the WGWIDE:
  - Horse mackerel, boar fish, mackerel, and blue whiting distribution and numbers-at-age estimated by PELACUS acoustic trawl surveys in 9a and 8c;
  - Horse mackerel, boar fish, mackerel, and blue whiting distributions, qualitative indices from PELGAS (8a,b)

- Other survey-derived operational products:
  - Sardine, anchovy and sprat distribution and numbers-at-age estimated by PELTIC acoustic trawl survey in 7;
  - Sardine and anchovy egg counts from CUFES from acoustics surveys ECOCADIZ, PELAGO, PELACUS, PELGAS;
  - Sardine and anchovy egg counts from CUFES from DEPM-BIOMAN;
  - SSS, SST and SSF from spring acoustics surveys PELGAS, PELACUS, PELAGO;
  - SSS, SST and SSF from summer/autumn acoustics surveys ECOCADIZ, PELTIC, JUVENA;
  - SSS, SST and SSF from DEPM survey BIOMAN;
  - Marine birds and mammals distribution and counts obtained during spring acoustics surveys PELGAS, PELACUS, PELAGO;
  - Marine birds and mammals distribution and counts obtained during summer/autumn acoustics surveys ECOCADIZ, PELTIC, JUVENA;
  - Sea surface microplastic distribution obtained during PELACUS and PELGAS surveys.

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

5 Progress report on ToRs and workplan

5.1 General report on ToRs

The multi-annual Terms of Reference (section 2) were addressed as programmed.

The Echointegration and DEPM estimates for sardine and anchovy in ICES Subareas 7, 8 and 9 (ToR a) were provided and made available for assessment. Nine surveys (one update to 2014, Sardine DEPM, and eight from 2015) were reported. Two surveys from the Gulf of Cadiz (ECOCADIZ and ECOCADIZ Reclutas) were not presented during the meeting, however their reports were submitted during the process of compilation of the Group report. Final results from BOCADEVA 2014 were not available for this year report. The information from the 2015 surveys highlighted the trend, which has been observed in recent years with changes in the sardine distribution patterns with the Bay of Biscay nuclei being more relevant than the more southern, Iberian cores. The anchovy population in 9a has been fairly stable, with even an increase in the western part (i.e. North Portugal) and in the Bay of Biscay, although discrepancies between sources, the species biomass has been close to the series peaks, with signal of strong incoming year class. Preliminary results on the small pelagic fish community in the Western English Channel and Eastern Celtic Sea suggested that most species had increased in both abundance and distribution. The Group discussed further the distribution of sardine and anchovy and their interannual fluctuations and spatial patterns (ToR a, b).

The Group continued the compilation of the survey data in the gridding format (see maps in section 5.2) which has been described in previous reports and planned collaborative studies to explore the information jointly (ToR c). Acoustics data on other small pelagic fish, e.g. mackerel and horse mackerel, are being processed with the aim of providing information to assessment (ToR d). Several aspects were discussed during the DEPM session, including developments on mortality estimation for the Gulf of Cadiz anchovy, utilization of egg data from other sources to produce abundance indices (and egg production), and the importance of analysing information on the species reproductive cycle off the period of the surveys (data from commercial fleets) (ToR d,e).

The WGACEGG 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 counts, surface temperature and salinity, bird and mammals, etc.). These standard maps can be used to compute global indices describing the state of the European Atlantic pelagic ecosystem in spring and autumn. The standard maps and indices could be used within the Marine Strategic Framework Directive (MSFD) to compute ecological state indicators (multi-annual ToR f). For a list of variables gathered during WGACEGG surveys check Annex 8.7 of the 2014 Group Report. The Group will continue to compile the data and will explore its utilization in collaborative studies.

During the Acoustics and DEPM sessions, the coordination of the surveys was undertaken and updates on the standard survey manuals were discussed to be included in the ICES SISP series (ToR g). For 2016, eight surveys are planned (table in annex 8.7).

No changes in the ToR or WorkPlan were proposed.

5.2 General overview on sardine and anchovy abundance distributions from the DEPM and acoustic surveys in ICES Areas 8 and 9

Acoustic surveys carried out in spring and summer target adults, while those performed in fall focus on anchovy juveniles. Material and methods of each survey are detailed in Annex 8.8 (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. The grid mesh is 0.25° x 0.25°, the lower left corner of the grid is positioned at 10.2°W and 35.8°N (Figure 5.2.1).

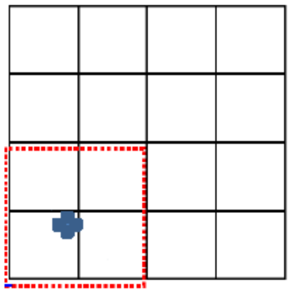


Figure 5.2.1. Schematic of the standard grid (black: 0.25° x 0.25°), the large block (dashed red line) in which the grid origin is randomized. The cross (blue) shows the position at which the origin is randomized. The cross (blue) shows the position at which the origin of the grid is positioned to present mesh is 0.25° x 0.25°, 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.

5.2.1 Spring acoustic surveys 2015

5.2.1.1 Oceanographic conditions

The survey area was characterized by a big temperature contrast, with cold waters in the Northwestern corner of the Iberian Peninsula as outcome from a relatively intense upwelling-favourable westerly winds, and warmer waters in both Portuguese and French areas. The pattern is similar to that found in 2014, which could be mainly driven by the survey period: PELACUS is normally undertaking one month earlier than PELGAS and PELAGO. However 2015 was colder than 2014, especially in the French area. The warmest waters were located in the Gulf of Cadiz while the French waters, where the survey took place one month later than that of the Spanish waters, SST ranged from 12.5 to 17.5°C. On the other hand, surface salinity maps highlighted the influence of the strength of the river flows in North Portugal (Douro river), South France (Adour river) and Central France (Garonne and Loire rivers) achieving in this last area the lowest values in salinity (i.e. < 31 ppm) (Figure 5.2.1.1.1).

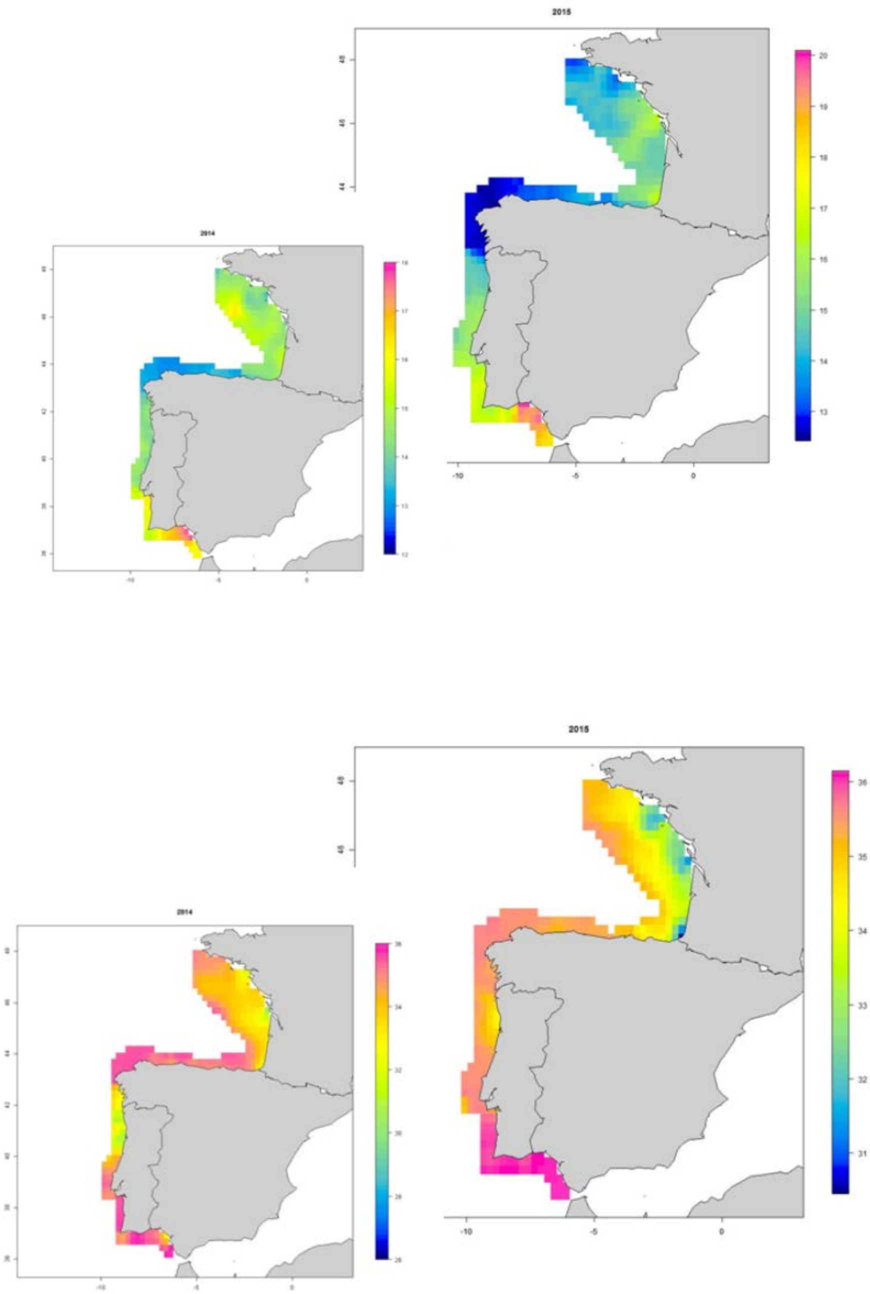


Figure 5.2.1.1.1. Sea surface temperature (above) and salinity (below) in spring 2015 (in the higher right hand maps) and 2014 (in the smaller left small maps) as recorded by the thermosalinometer during the spring acoustic surveys (*PELAGO*, *PELACUS* and *PELGAS*). Note that the colour scales are different for each year

5.2.1.2 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.

Figure 5.2.1.2.1 shows the percentage in weight of the fishing stations done during the spring acoustic surveys. Mackerel, together with horse mackerel, are clearly the most dominant species on the Spanish continental shelf. Complementary, blue whiting are also abundant on those hauls performed over the slope. Horse mackerel was also abundant in SW Portugal and in the outer part of the northern French continental shelf. Along the Portuguese coast, although the bulk of the fishing stations have been taken close to the coast, anchovy was noticeable in the northern part as well as in the Gulf of Cadiz, and seems to alternate with the spatial distribution of sardine which was abundant close to the Tagus mouth and in the SW part (Algarve). In French waters the same patterns would also inferred with anchovy being for the most present around the Garonne mouth (together with sprat) and along the southern part of the continental shelf while sardine occurrence was higher in the coastal waters and close to the slope in the north western part.

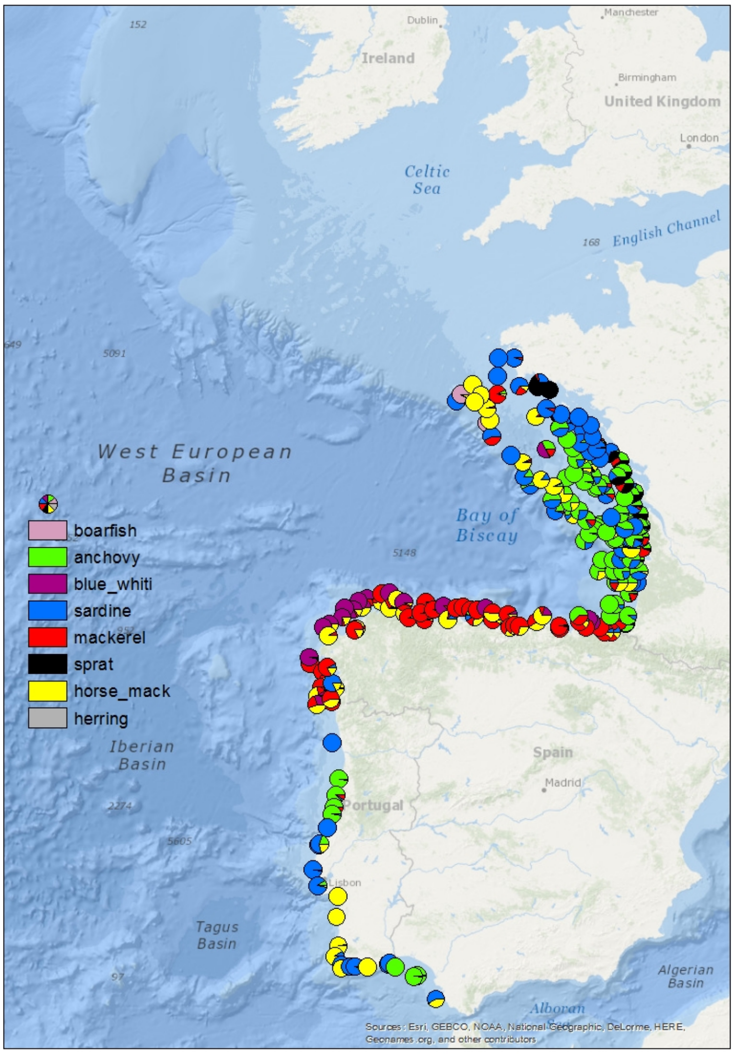


Figure 5.2.1.2.1. Sea surface temperature (above) and salinity (below) in spring 2015 (in the higher right hand maps)

5.2.1.3 Sardine and anchovy distribution derived from NASC

5.2.1.3.1 Sardine

During the 2015 spring surveys, sardine mainly occurred around the influence of the main river areas of the French coast (Loire, Garonne, and Adour rivers). Apart from these areas, as shown in Figure 5.2.1.3.1.1, sardine was also abundant close to the continental shelf break located in NW of the French area. Off Iberian Peninsula, sardine was scarce. Along the Portuguese coast sardine occurrence was also scarce, and only small spots located around the Douro and Tagus mouths and in the southwest part, near San Vicente cap, far in mean backscattering energy from those located on the French continental shelf, could be noticed.

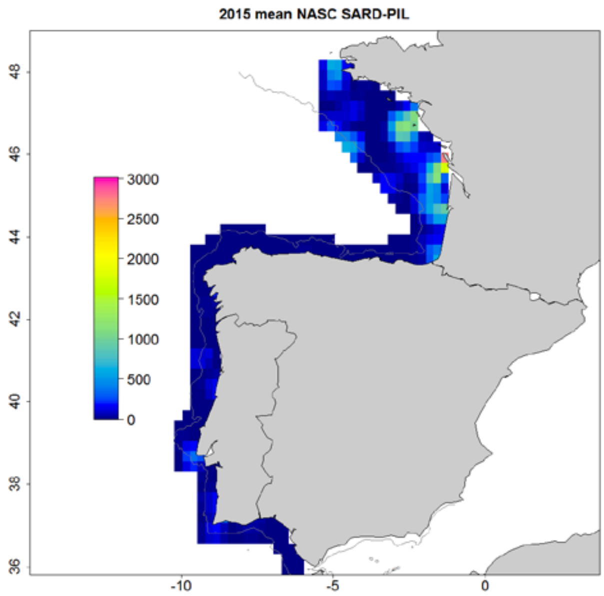


Figure 5.2.1.3.1.1. Mean backscattering energy (NASC, m^2 mn^{-2}) per 0.25° x 0.25° square allocated to sardine during the 2015 spring acoustic surveys.

5.2.1.3.2 Anchovy

The bulk of the anchovy population was concentrated, as usual, around the Garonne mouth and, as shown in the trawl composition, in Portugal, at the northern part of the Tagus mouth, and in the Gulf of Cadiz (Figure 5.2.1.3.2.1.). On the contrary, only few schools of anchovy were recorded in North Spanish waters

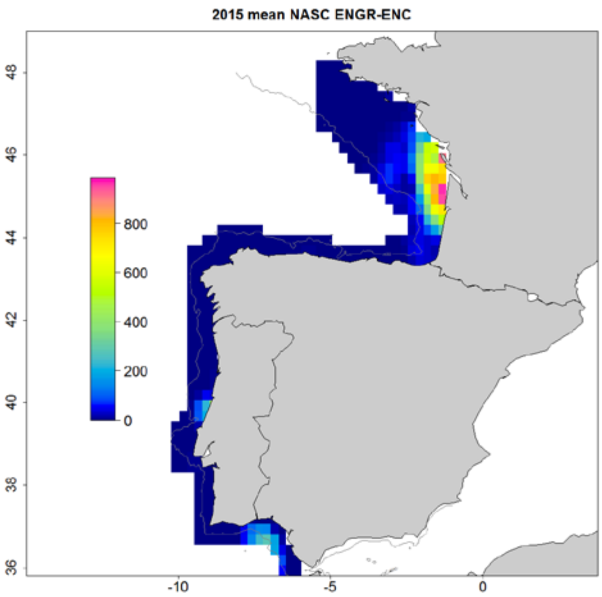


Figure 5.2.1.3.2.1. Mean backscattering energy (NASC, m² mn⁻²) per 0.25° x 0.25° square allocated to sardine during the 2015 spring acoustic surveys.

5.2.1.4 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 2015, the biggest sardines at age older than 1 occurred in north Spanish and in south Portuguese waters, as shown in Figures 5.2.1.4.1 and 5.2.1.4.2. On the contrary, the smallest were located off north Portugal and France.

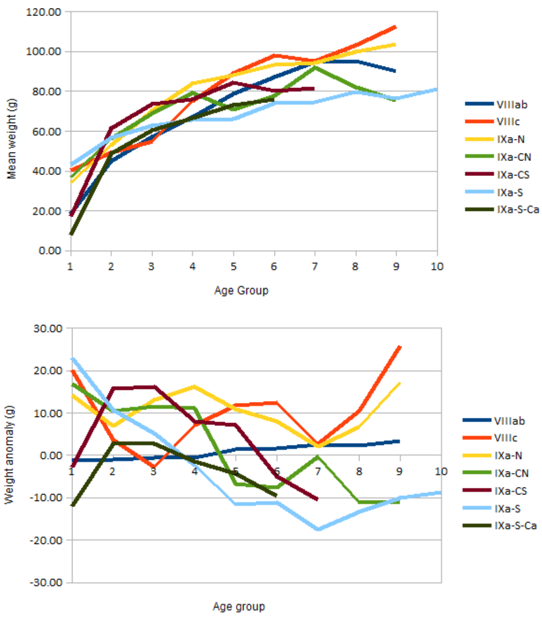


Figure 5.2.1.4.1. Mean weight-at-age by ICES subdivision and mean weight-at-age anomaly (difference between mean weight-at-age in each ICES subdivision and the weighted mean weight or length-at-age calculated for the whole surveyed area).

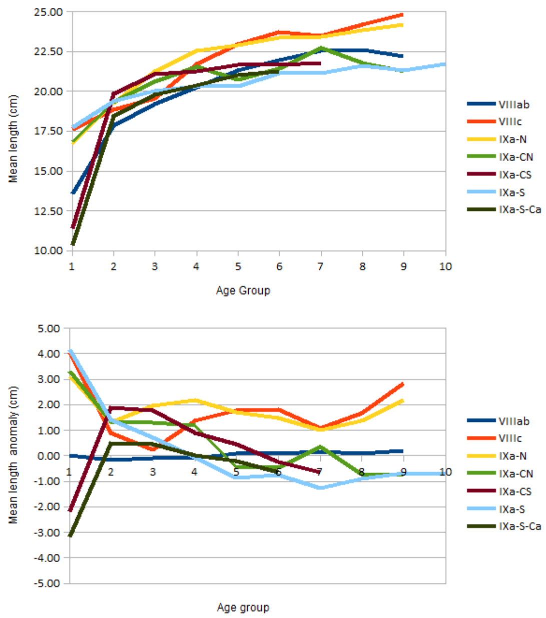


Figure 5.2.1.4.2. Mean length-at-age by ICES subdivision and mean length-at-age anomaly (difference between each mean length-at-age by ICES subdivision and the weighted mean length for each age).

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 5.2.1.4.3 and 5.2.1.4.4.

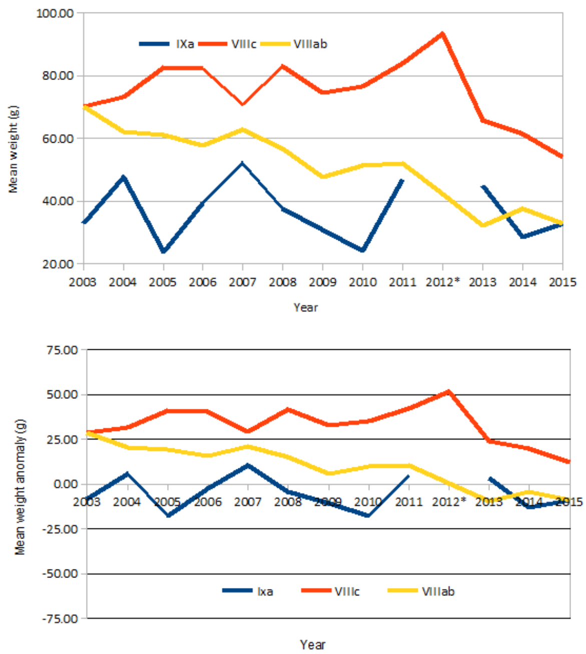


Figure 5.2.1.4.3. Mean weight by year and ICES subdivision and mean weight anomaly (difference between each mean weight by ICES subdivision and the weighted mean weight for the 2003-2015 time-series). In 2012, no acoustic survey was undertaken by Portugal.

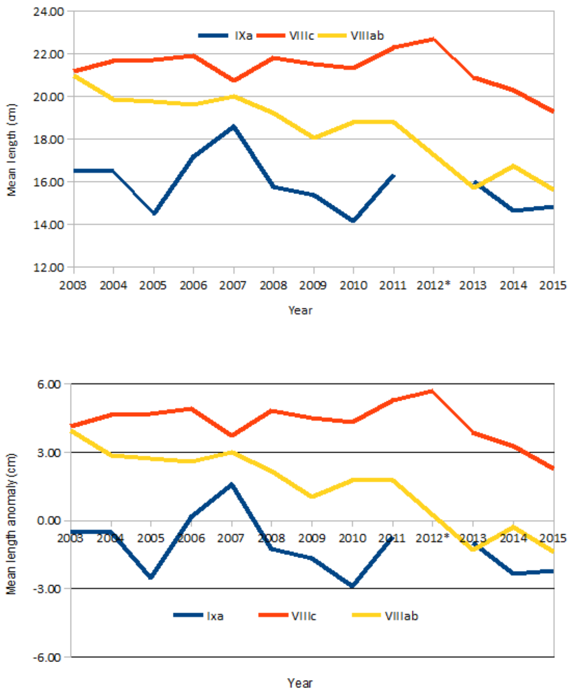


Figure 5.2.1.4.4. Sardine mean length by year and ICES subdivision and mean length anomaly (difference between each mean length by ICES subdivision and then weighted mean length for the 2003–2014 time-series). In 2012, no acoustic survey was undertaken by Portugal.

Table 5.2.4.1.1: Sardine mean weight by age group and ICES subdivision estimated from 2015 spring surveys

	1	2	3	4	5	6	7	8	9	10	MEAN
8b	18.75	44.73	56.98	67.22	78.86	87.07	94.81	95.23	90.01		32.89
8c	40.16	49.33	54.83	75.12	89.08	97.81	95.04	103.41	112.52		53.90
9a-N	34.05	52.70	70.50	84.08	88.36	93.45	94.33	99.68	103.89		54.24
9a-CN	36.77	56.31	69.11	79.10	70.66	77.73	91.79	81.87	75.54		39.71
9a-CS	17.28	61.61	73.72	75.84	84.46	80.29	81.79			93.78	24.22
9a-S	42.95	56.56	62.69	65.64	65.85	74.25	74.63	79.60	76.64	81.29	63.25
9a-S-Ca	7.94	48.47	60.28	66.43	73.07	75.78					10.06
Mean	19.96	45.81	57.51	67.89	77.41	85.36	92.21	93.03	86.66	90.05	33.09

Table 5.2.4.1.2: Sardine mean length by age group and ICES subdivision estimated from 2015 spring surveys.

	1	2	3	4	5	6	7	8	9	10	Mean
8b	13.56	17.82	19.23	20.25	21.29	21.96	22.56	22.59	22.19		15.62
8c	17.60	18.86	19.54	21.71	22.98	23.71	23.49	24.16	24.85		19.30
9a-N	16.66	19.28	21.25	22.54	22.92	23.36	23.43	23.87	24.20		19.08
9a-CN	16.87	19.31	20.62	21.55	20.75	21.43	22.75	21.80	21.25		17.22
9a-CS	11.36	19.86	21.07	21.26	21.65	21.65	21.77			22.75	12.53
9a-S	17.71	19.36	20.01	20.30	20.33	21.11	21.14	21.60	21.32	21.75	20.02
9a-S-Ca	10.36	18.45	19.77	20.38	21.00	21.25					10.73
Mean	**13.55**	**17.97**	**19.30**	**20.35**	**21.20**	**21.88**	**22.41**	**22.50**	**22.00**	**22.45**	**15.52**

Table 5.2.4.1.3: 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
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
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
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
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
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
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**

Table 5.2.4.1.4: 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
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
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
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
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
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
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**

While in the Iberian Peninsula mean weight or length remained more or less stable until 2012, when a decreasing trends is also observed reaching the lowest value of the time-series in 2015, in 8ab the decreasing trend is much significant with a net decrease between 2003 and 2015 of 37.25 g and 5.36 cm per sardine. This decrease in mean length would be a consequence of the strength of the incoming recruitments since 2011.

For anchovy, mean weight at each in 8ab is shown in the following table:

	Age groups					
	1	2	3	4	5	mean
Mean weight	5.13	20.43	19.94	19.63	38.43	5.66

Either the big amount of age group 1 (96.5% of the total assessed abundance belonged to this age group) or the small mean size of those exemplars left the mean weight in 2015 as the lowest of the total time-series (2000-2015). Besides, as observed for sardine, mean length and weight show a decreasing trend. 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.

5.2.1.5 Sardine and anchovy biomass and abundance estimation

Figure 5.2.1.5.1 shows the numbers-at-age by ICES subdivision estimated during the 2015 spring acoustic surveys. Age group 1 was the most abundant and mainly occurred in French waters, and South Portugal. The bulk of the sardines were found in French waters. Up to seven 7 years old, more than the 50% of the sardines (more than 80% for ages 2 and 3) are located in this area. The oldest ones, although negligible in number, occurred in the Algarve Area.

Table 5.2.1.5.1. Sardine abundance at age by ICES subdivision estimated during the 2015 spring acoustic surveys. Numbers in millions.

	8ab	8c	9a-N	9a-CN	9a-CS	9a-S	9a-S-Ca
1	7 424.06	34.59	21.08	723.31	1 041.43	20.93	155.76
2	1 611.84	48.95	4.15	65.72	26.06	39.92	1.25
3	1 699.91	46.91	5.09	19.42	27.67	54.69	2.11
4	483.19	7.86	3.52	4.16	30.67	33.03	2.77
5	193.72	4.20	2.68	5.63	28.30	44.94	0.21
6	159.71	2.97	1.55	1.79	16.29	20.24	0.11
7	141.24	3.60	1.58	0.02	10.14	15.73	0.00
8	23.82	1.02	0.51	0.83	0.00	4.26	0.00
9	9.93	0.22	0.11	0.70	0.00	3.31	0.00
10		0.00	0.00	0.00	1.44	0.61	
Total	11 747.42	150.32	40.28	821.57	1 181.99	237.64	162.20

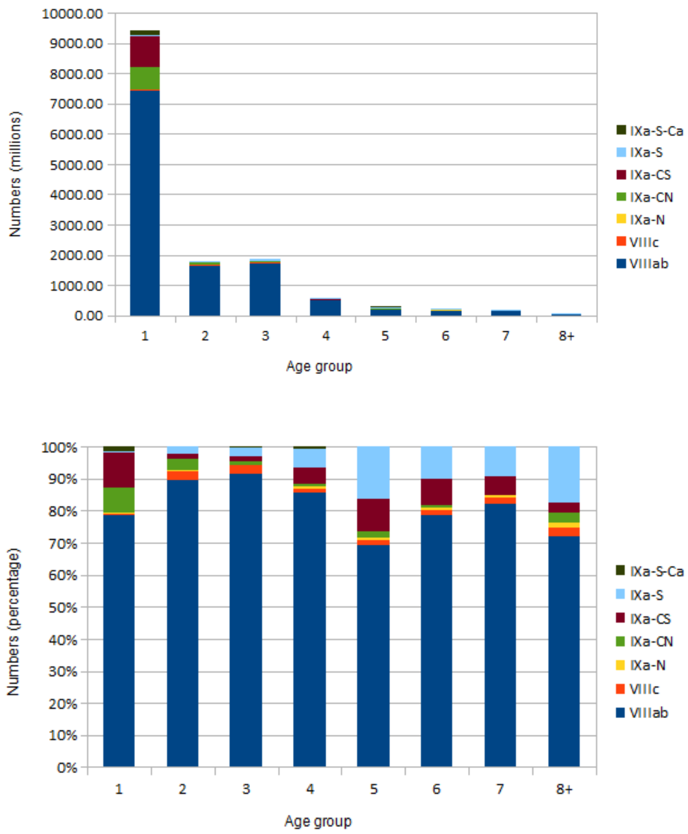


Figure 5.2.1.5.1. Sardine abundance at age by ICES Subdivision estimated during the 2015 spring acoustic surveys. Left panel in absolute numbers (million fish); right panel, relative numbers-at-age.

Table 5.2.1.5.2. Sardine biomass at age (thousand tonnes) by ICES subdivision estimated during the 2014 spring acoustic surveys.

	8AB	8C	9A-N	9A-CN	9A-CS	9A-S	9A-S-CA
1	139.17	1.40	0.72	26.60	18.00	0.90	1.24
2	72.10	2.44	0.22	3.70	1.61	2.26	0.06
3	96.85	2.60	0.37	1.34	2.04	3.43	0.13
4	32.48	0.60	0.30	0.33	2.33	2.17	0.18
5	15.28	0.38	0.24	0.40	2.39	2.96	0.02
6	13.91	0.29	0.14	0.14	1.31	1.50	0.01
7	13.39	0.34	0.15	0.00	0.83	1.17	0.00
8	2.27	0.11	0.05	0.07	0.00	0.34	0.00
9	0.89	0.02	0.01	0.05	0.00	0.25	0.00
10		0.00	0.00	0.00	0.14	0.05	
Total	386.34	8.18	2.20	32.63	28.63	15.03	1.63

In biomass (Figure 5.2.1.5.2), age group 1 was also the most abundant, mainly concentrated in French waters. On the contrary, the Spanish water only accounted, and only a small portion has been found in the Gulf of Cadiz (< 10%)

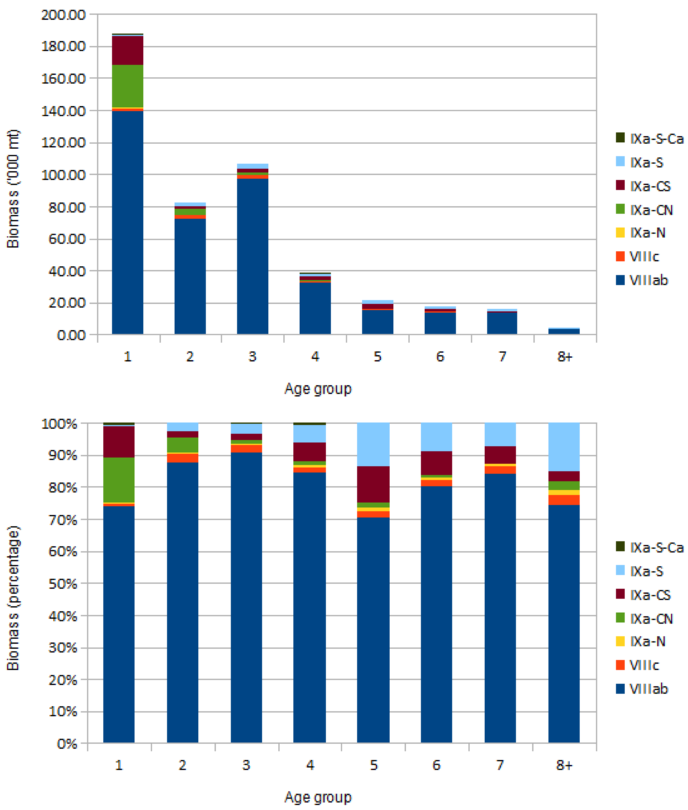


Figure 5.2.1.5.2. Sardine abundance at age by ICES subdivision estimated during the 2015 spring acoustic surveys. Left panel in absolute biomass (thousand tonnes); right panel, relative biomass at age.

Since 2003 both biomass and abundance show a declining trend in the Iberian peninsula while 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 5.2.1.5.3)

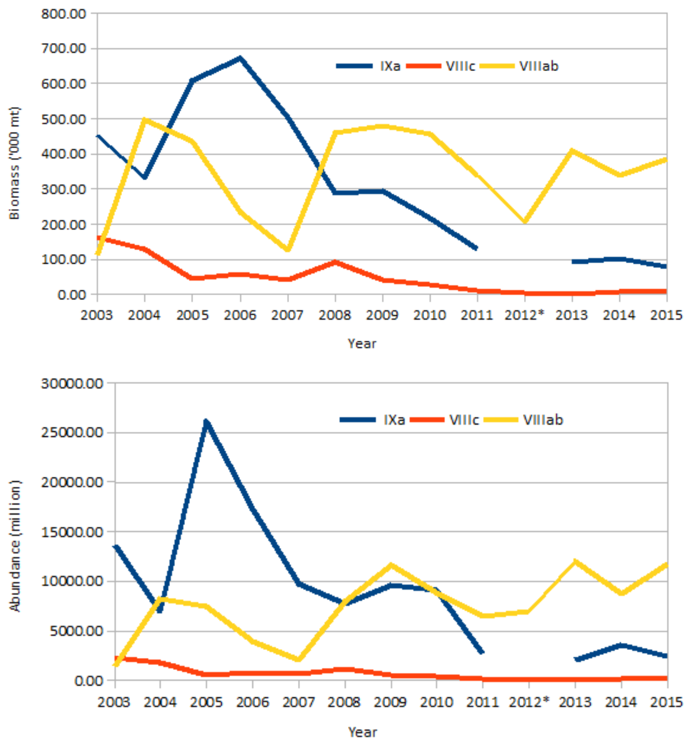


Figure 5.2.1.5.3. Sardine abundance at age by ICES subdivision estimated during the spring acoustic surveys 2003-2015. Left panel biomass (thousand tonnes); right panel, numbers (millions). In 2012, no acoustic survey was undertaken by Portugal.

Table 5.2.1.5.3. Sardine abundance (million fish) by ICES subdivision estimated during the spring acoustic surveys for the period 2003-2015. In 2012, no acoustic survey was undertaken by Portugal.

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Sp-9 a	372.32	347.51	905.61	753.10	868.56	643.29	45.15	179.07	26.06		15.93	1.34	40.28
Pt-9 a	13 290.32	6 623.65	25 223.37	16 485.11	8 872.62	7 031.10	9 529.80	8 861.69	2 697.55		2 026.22	3 561.50	2 403.41
9 a	13 662.64	6 971.16	26 128.98	17 238.21	9 741.17	7 674.39	9 574.96	9 040.75	2 723.61		2 042.15	3 562.84	2 443.69
8c	2 290.31	1 749.31	565.11	730.56	613.82	1 118.70	567.52	359.75	123.65	61.02	38.42	145.80	150.32
8ab	1 382.42	8 247.98	7 465.71	3 901.39	2 005.77	7 983.51	11 666.87	8 883.33	6 479.40	6 896.23	12 012.27	8 722.60	11 747.42
Total	17 335.37	16 968.45	34 159.79	21 870.16	12 360.77	16 776.59	21 809.35	18 283.83	9 326.66	6 957.25	14 092.84	12 431.24	14 341.42

Table 5.2.1.5.4. Sardine biomass (thousand tonnes) by ICES subdivision estimated during the spring acoustic surveys for the period 2003-2015. In 2012, no acoustic survey was undertaken by Portugal.

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Sp-9 a	20.43	21.16	21.51	33.33	52.94	44.23	2.17	12.14	1.31		0.81	0.05	2.20
Pt-9 a	432.12	309.54	587.41	637.39	451.57	245.18	293.00	205.16	126.71		90.95	101.05	77.92
9 a	452.55	330.71	608.92	670.72	504.51	289.42	295.17	217.30	128.01		91.77	101.10	80.12
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
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
Total	728.26	955.16	1 090.84	964.95	674.20	843.41	817.28	701.91	476.85	211.32	502.04	449.68	474.64

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

	AGE GROUPS				
	1	2	3	4	Total
Abundance (million fish)	5 955.72	1 711.87	262.75	31.85	7 962.20
Biomass (thousand tonnes)	86.67	32.23	5.64	0.88	125.43

5.2.1.6 Other fish species

Spring surveys also provide abundance estimates and distribution for other pelagic fish species such as mackerel, horse mackerel, boarfish, bogue, chub mackerel or sprat. However, only data from PELACUS and PELGAS are available, although NASC distribution maps are provided for all surveys. Details are summarized in Table 5.2.1.6.1.

Table 5.2.1.6.1. 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), boarfish (BOC), chub mackerel (MAS), lanternfish (MAV), hake (HKE), and bogue (BOG).

	MAC		HOM		HMM	WHB		SPR		BOC		MAS	MAV	HKE	BOG
Area	NASC	Biom.	NASC	Biom.	NASC	NASC	Biom.	NASC	Biom.	NASC	Biom.	NASC	NASC	NASC	NASC
8ab	Y	243	Y	77	Y	Y	9	Y	91	-	-	-	-	Y	-
8c	Y	269	Y	62	Y	Y	26	-	-	Y	16	Y	Y	Y	Y
9a-Sp	Y	27	Y	27	Y	Y	3	-	-	-	-	Y	Y	Y	Y
9a-Pt	-	-	Y	na	-		-	-	-	-	-	Y	-	-	Y
9a-GoC	-	-	Y	na	-		-	-	-	-	-	Y	-	-	

5.2.1.6.1 Mackerel

Data for mackerel were provided by PELACUS. Contrary to that observed the previous year, adult mackerel also occurred in 9a. However, this is a nursery area, only few specimens < 30 cm were observed. Besides, weather conditions, with rather strong NE winds, would affect the normal behaviour and thus the spatial distribution, characterized by a non-homogeneous layer located at around 50–75 m depth with some dense schools going down towards the ground or rising from the bottom. The bulk of the population belonged to age groups 5 to 7.

Figure 5.2.1.6.1.1 shows the NASC-derived distribution map. Most of the record were located in 8c and 9a, with two small patches located on the French coast, near Oléron and Ré islands, and close to the slope at 45°N.

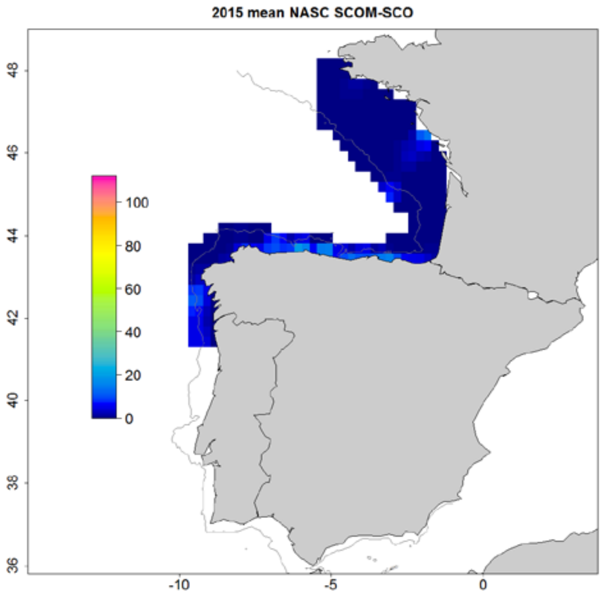


Figure 5.2.1.6.1.1. Average mackerel abundance and distribution derived from NASC raw values (only for areas where data were available).

5.2.1.6.2 Horse mackerel

Horse mackerel shows more or less the same distribution pattern than observed for mackerel. In 9a N there was a clear mode at 23 cm while in 8c length distribution had two at 13 and 23 cm.

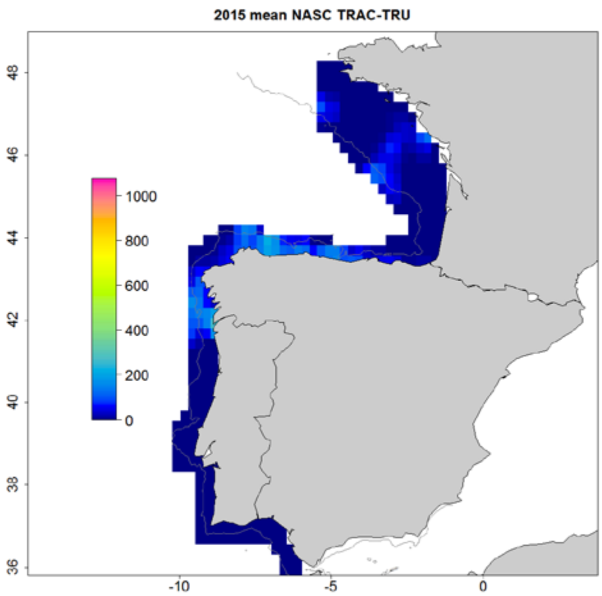


Figure 5.2.1.6.2.1. Average horse mackerel abundance and distribution derived from NASC raw values (only for areas where data were available).

5.2.1.6.3 Blue whiting

Blue whiting was mainly recorded during PELACUS survey. However, the distribution area would not be entirely covered by PELGAS as in this area an offshore extension in pelagic layers is also expected.

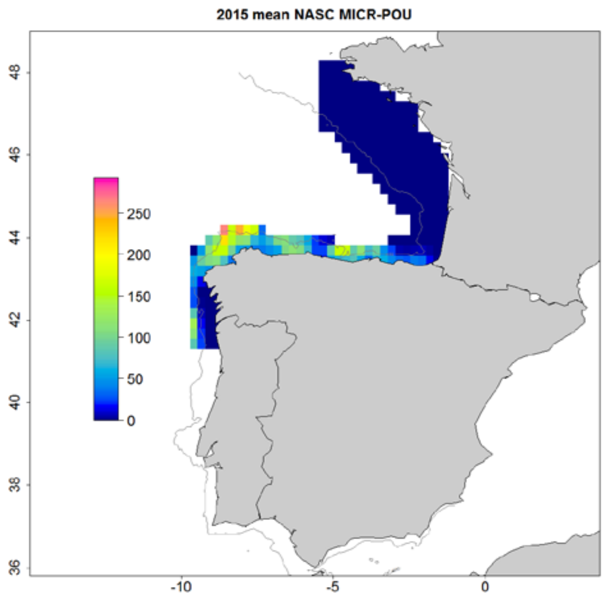


Figure 5.2.1.6.3.1. Average blue whiting abundance and distribution derived from NASC raw values (only for areas where data were available)

5.2.1.6.4 Sprat

NASC data from sprat are only provided by PELGAS where this fish species, as in 2014, occurred around the main river plume areas (Garonne and coastal waters of Brittany).

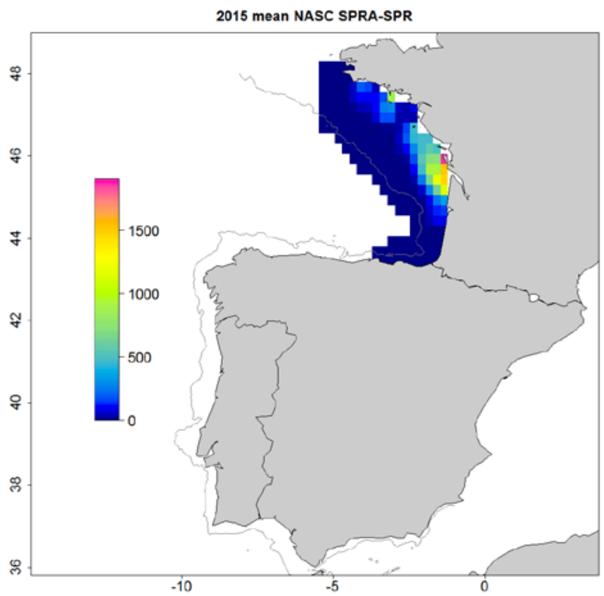


Figure 5.2.1.6.4.1. Average sprat abundance and distribution derived from NASC raw values (only for areas where data were available).

5.2.1.6.5 Boarfish

For boarfish only PELACUS, together with the specific survey BFAS conducted in 7, is providing abundance, although this time-series and also PELGAS are both providing fish spatial distribution. Compared with the previous year, both spatial distribution and abundance have decreased.

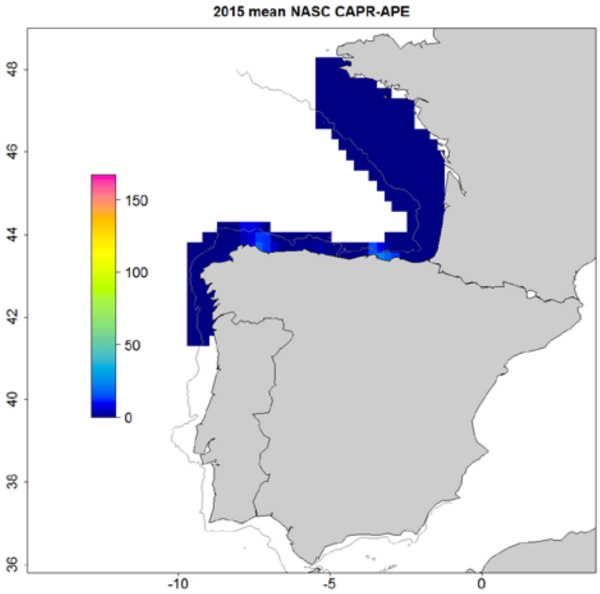


Figure 5.2.1.6.5.1. Average boarfish abundance and distribution derived from NASC raw values (only for areas where data were available).

5.2.1.6.6 Chub mackerel

Although chub mackerel is distributed throughout the surveyed area, but this year the density was very low without.

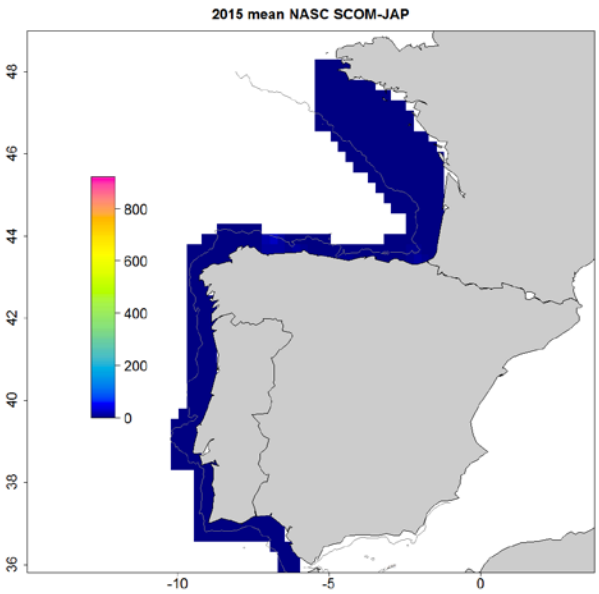


Figure 5.2.1.6.6.1. Average chub mackerel abundance and distribution derived from NASC raw values.

5.2.1.6.7 Mediterranean horse mackerel

As in the case of chub mackerel, the abundance of Mediterranean horse mackerel was scarce and without noticeable spots along the surveyed area.

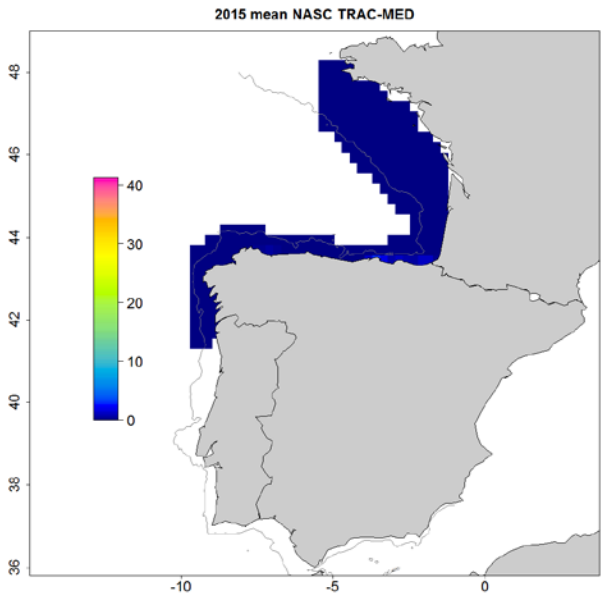


Figure 5.2.1.6.7.1. Average Mediterranean horse mackerel abundance and distribution derived from NASC raw values (only for those areas where data were available).

5.2.1.6.8 Bogue

NASC values for bogue are provided by PELAGO and PELACUS survey. Together with a patch located within the Rias Baixas area (NW Spanish 9a), the bulk of the distribution is located around Cape Ajo area, at the inner part of the Bay of Biscay.

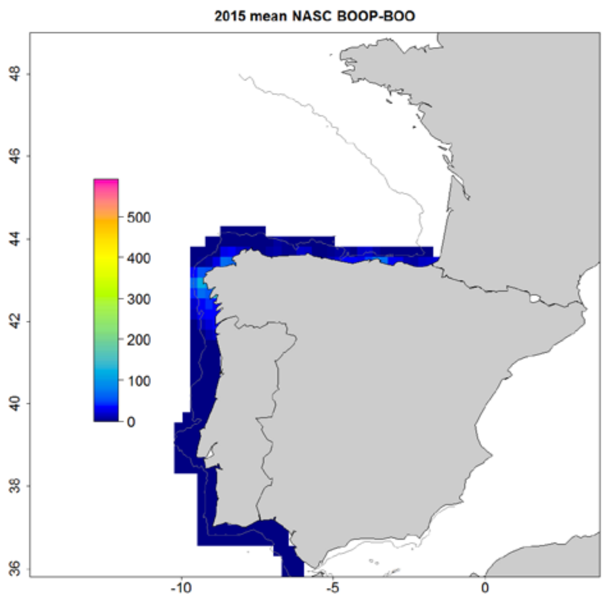


Figure 5.2.1.6.8.1. Average bogue abundance and distribution derived from NASC raw values (only for areas where data were available).

5.2.1.6.9 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. These mainly occurred in the western part (Atlantic waters), with two additional areas, one located at the inner part of the Bay of Biscay and around Cape Ortegal (NW Iberian area).

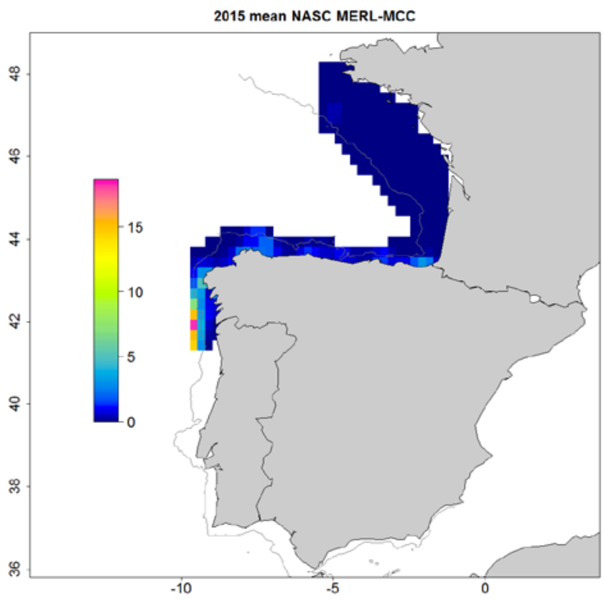


Figure 5.2.4.6.9.1. Average hake abundance and distribution derived from NASC raw values (only for areas where data were available).

5.2.1.6.10 Silver Lightfish

Normally M. *muelleri* occurred offshore, from the slope to deep-sea waters. However, as in 2014, it was found over the continental shelf, in the northwestern area of the Spanish waters and also at the inner part of the Bay of Biscay.

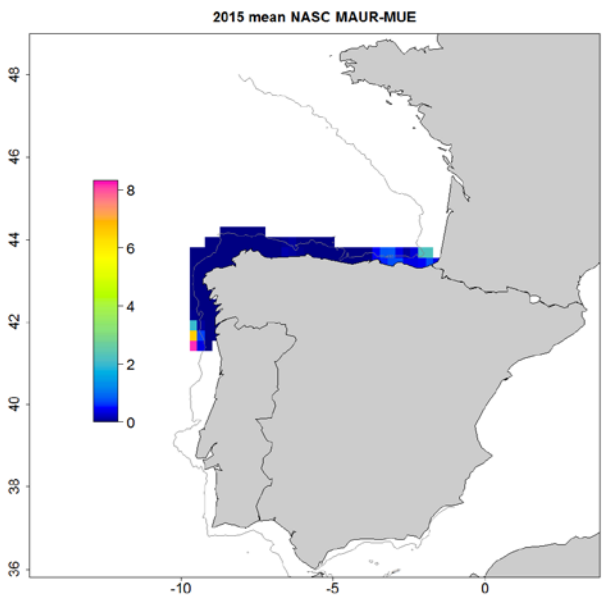


Figure 5.2.1.6.10.1. Average silver light fish abundance and distribution derived from NASC raw values (only for areas where data were available).

5.2.1.7 Other observations

Marine mammals and birds were also recorded, but only data from PELGAS and PELACUS are available. Common dolphin was the most abundant mammals sighted being mostly distributed in 9a N and in close to the northern French coast. Bottlenose dolphin has been mostly sighted in the Cantabrian Sea, area in which long-finned pilot whale was also observed as well as on the continental slope in the central part of the Bay of Biscay. Regarding birds, overall northern gannet was the most common species, being also important seagull (*Larus* sp.) and northern fulmar.

5.2.1.8 Sardine and anchovy egg distributions from CUFES sampling

The egg distribution from CUFES sampling is presented in Figure 5.2.1.8.1. 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.

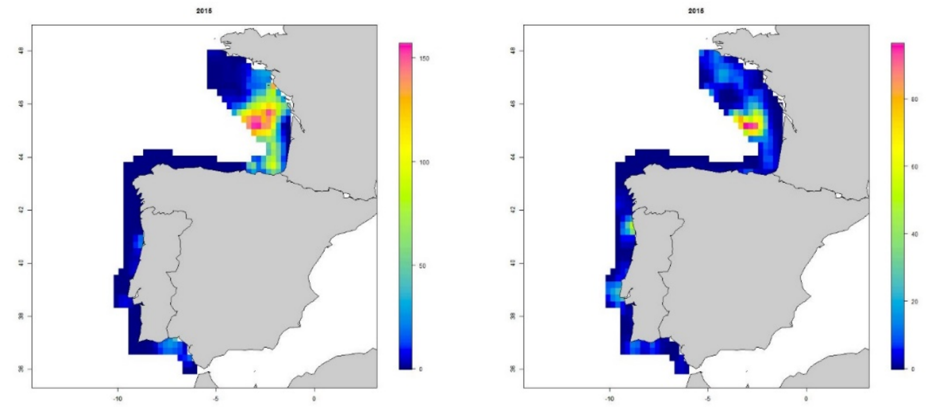


Figure 5.2.1.8.1. Sardine (left panel) and anchovy (right panel) egg distributions from CUFES (eggs/m^3) sampling during the spring acoustics surveys (IPMA, IEO, Ifremer). Note that due to the data range in the observations the colour scales do not match between left and right panels.

5.2.2 DEPM surveys (2014 and 2015

Table 5.2.2.1. General information on the DEPM surveys undertaken in ICES Areas 8 and 9. Temperature in °C (including min/mean/max values), Pairovet tows (total number, positives and total number of egg), CUFES samples (total number, positives and total number of egg) and Fishing hauls (RV hauls, positive hauls and + commercial).

Survey Institute	Area	Dates	Vessel	Temp	PairoVET	CUFES	Fishing hauls	Total fish sampled	Females histology Hydrated females
PT-DEPM14-PIL * IPMA	9a-S	**2014** 15-26/04	Noruega	14.5/16.3/ 19.1	134 (62) 2019	146 (60) 2695	13 (12) + 4[1]	938	444 70
	9a-W	**2014** 15-21/03; 4-15/04	Noruega	12.8/14.9/ 18.5	265 (101) 2164	313 (116) 12709	31 (17) + 16[1]	1 635	705 21
SAREVA IEO *	9a- N, 8c	**2014** 29/03-09/04 16/04-21/04	Vizconde de Eza	12.3/13.0/ 14.9	394 (66) 313	339 (112) 2186	57[2](15)	755	262 119
	8b	**2014** 09/04-16/04	Vizconde de Eza	12.3/13.2/ 14.5	128(77) 1449	122(98) 12067	13(3)	324	148 51
BIOMAN2014 PIL AZTI	8ab	**2014** 05/05-23/05	Ramón Margalef	12.3/14.8/ 16.6	767 (445) 11666	1702 (874) 20682	51(25)	1 131	373 59
BIOMAN2014 ANE AZTI	8ab	**2014** 05/05-23/05	Ramón Margalef	12.3/14.8/ 16.6	767 (349) 22310	1702 (730) 88707	51(42)+6[1]	2 762	1 263 1 192
BIOMAN2015 PIL AZTI	8abc	**2015** 05/05-24/05	Ramón Margalef	12.5/15.1/ 17.2	629 (267) 3505	1390 (646) 8584	0	0	0
BIOMAN ANE AZTI	8abc	**2015** 05/05-24/05	Ramón Margalef	12.5/15.1/ 17.2	629 (542) 18,834	1390 (1166) 115559	46(39) + 6[1] +2[3]	3 069	1 338 1 312

Remarks:

*** 2014 Survey - updated estimates on adults and SSB presented during WGACEG 2015**

[1] Samples obtained from commercial vessels

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

[3] Samples obtained during the acoustic survey carried out by RV Thalassa

5.2.2.1 Sardine 2014 DEPM surveys

During the previous WGACEGG meeting in November 2014, the adult information collected in the Western and Southern areas was still not fully processed and the results from the Atlanto-Iberian sardine 2014 DEPM surveys submitted to the WGACEGG were preliminary. This section represents an update to these results, those corresponding to oceanographic conditions, spawning area and egg parameters being exactly the same as the ones included in the 2014 WGACEGG report.

Oceanographic conditions (SST, SSS)

The distribution patterns of sea surface temperature (SST) and sea surface salinity (SSS) observed during the 2014 surveys were the typical for the region with temperature and salinity decreasing from south to north along the Iberian shores and then showing an increase over the wider platform of the Bay of Biscay by the time spring conditions were already in place (Figure 5.2.2.1.1). Despite the fact that the Portuguese survey started later than usual the river plumes in NW Portugal, and also in W Galicia, were very clear as a consequence of rainy and stormy periods which occurred towards the end of the winter. The signatures of the Adour and Garonne River off the French coast were also evident. By the time the Gulf of Cadiz DEPM survey for anchovy was conducted in summer, the maximum temperature (not shown) had raised by about 3°C compared to the maps presented.

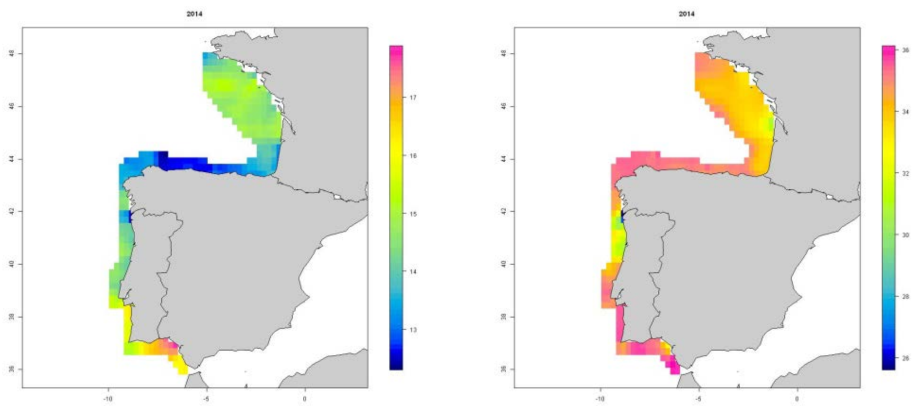


Figure 5.2.2.1.1. Sea surface temperature (left panel) and salinity (right panel) during the period March-May 2014 during the DEPM surveys for sardine (IPMA, IEO) and anchovy in the Bay of Biscay north of 45°N (AZTI). For dates of coverage in each region, see table 5.2.2.1.

Egg distributions from CUFES and PairoVET observations

Sardine egg distributions patterns derived from CUFES and PairoVET observations during winter/spring 2014 DEPM surveys looked alike with higher abundances in the southern and southwestern Iberian coasts and in the mid shelf of the Bay of Biscay. Sardine egg abundances were very low in the Cantabrian Sea where the numbers observed were the lowest of the time-series (Figure 5.2.2.1.2.). As it has been noted in recent years, the sardine egg abundances in western Iberia and Bay of Biscay are similar or even higher in the more northern region where an increase in the sardine population has been observed. Figure 5.2.2.1.3 shows the distribution of eggs during the anchovy DEPM surveys that took place in late spring in the Bay of Biscay (in part repeated with Figure 5.2.2.1.2.) and during summer in the Gulf of Cadiz. Accordingly, because the DEPM survey for the Gulf of Cadiz anchovy is conducted in summer, off spawning season for sardine, the observations of sardine eggs are residual as expected. The gridded egg density maximum in 2014 derived from CUFES sampling was considerably higher than the average of the historic series (2003-2011) while it was within the average for the PairoVET observations. For higher spatial resolution in the egg distributions see the detailed maps in the survey reports in Annex 8.8.

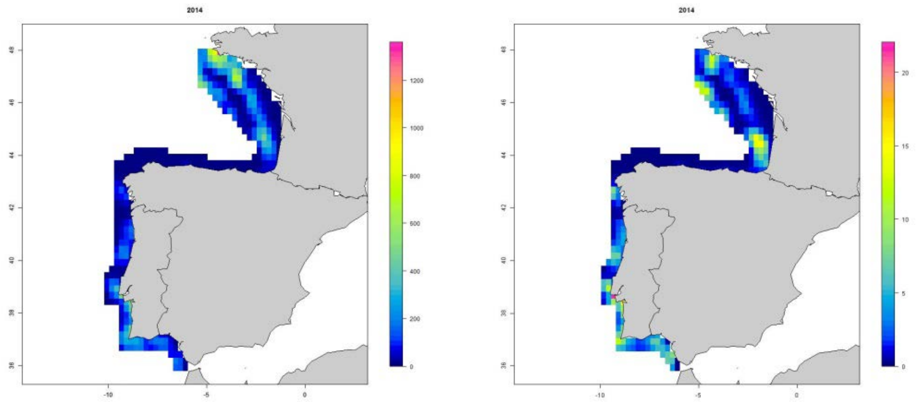


Figure 5.2.2.1.2.Sardine egg distributions from PairoVET (left panel; eggs/m^2) and CUFES (right panel; eggs/m^3) observations collected during the DEPM surveys for sardine (IPMA, IEO) and anchovy in the Bay of Biscay north of 45°N (AZTI). For dates of coverage in each region, see table 5.2.2.1. Note that due to the data range in the observations the colour scales do not match between figures.

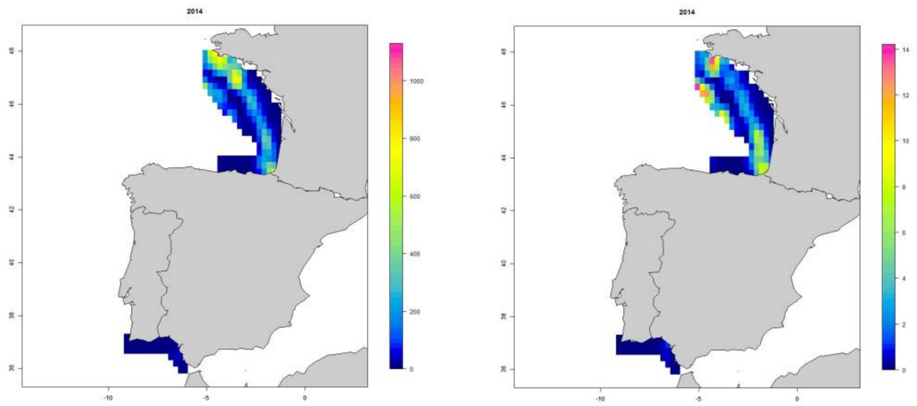


Figure 5.2.2.1.3. Sardine Egg distributions from PairoVET (left panel; eggs/m^2) and CUFES (right panel; eggs/m^3) observations collected during the DEPM surveys for anchovy in the Bay of Biscay (AZTI) and Gulf of Cadiz (IEO). For dates of coverage in each region, see Table 5.2.2.1. Note that due to the data range in the observations the colour scales do not match between figures.

Mean weight and length-at-age and reproductive parameters

During the 2014 survey the availability of adult sardine for trawling was limited in the whole area; nevertheless, 55 samples were obtained, 12 in the south, 17 in the west and 15 in the north, 3 in the 8b area up to 45°N and 8 in the 8ab area (45-48°N). Extra samples (20) from purse-seiners were collected in Portugal (Table 5.2.2.1.). Despite the fact that sardine schools were less available than during other surveys the number of hydrated females (indicating spawning activity) collected was higher than in 2011 for all the areas sampled.

Table 5.2.2.1.1 Sardine mean weight (g) at age and mean length (mm) at age for individuals randomly sampled by areas covered for sardine DEPM surveys (IPMA, IEO, AZTI).

MEAN WEIGHT (G)	IPMA	IPMA	IEO	IEO	AZTI
	9a South	9a West	9a N and 8c	8b (up to 45°N)	8ab (45-48°N)
Age 1	35.2	27.0	32.7	43.8	28.8
Age 2	50.9	50.2	52.6	46.3	46.9
Age 3	58.5	62.0	65.2	60.5	58.7
Age 4	58.9	73.6	72.7	79.0	70.1
Age 5	68.6	76.3	87.9	85.2	74.7
Age 6	69.2	80.2	86.4	91.1	92.4
Age 7	69.9	81.5	94.6	97.6	103.8
Age 8	71.1	82.5		97.3	103.8
Age 9	71.4	88.3			
Age 10	62.0	98.0			

MEAN LENGTH (MM)	IPMA	IPMA	IEO	IEO	AZTI
	9a South	9a West	9a N and 8c	8b (up to 45°N)	8ab (45-48°N)
Age 1	164	152	160	181	155
Age 2	188	183	194	186	181
Age 3	198	194	209	203	194
Age 4	200	215	216	221	206
Age 5	211	215	231	228	209
Age 6	213	224	231	233	224
Age 7	215	215	236	241	233
Age 8	216	221		243	233
Age 9	218	233			
Age 10	208	232			

One not anticipated result was that for the first time, mean female weight and batch fecundity were lower for the northern than for the western and southern strata, and were the lowest observed off the Spanish coast in the whole series, indicating a structure of the population unusual for that area (Table 5.2.2.1.1). In fact, the mode of individual age distribution off the northern Spanish coast was 1 year old, these fish representing about half of the individuals for which otoliths were sampled. On the west coast, the majority of individuals for which age data are available were also aged as 1 year old. On the contrary, sardine age distribution off the south coasts was widespread with fish aged from 1 to 7, with no clear modal ages. Mean female weight obtained for the Spanish coast was much lower (48.7) than values reported from the whole historical series, which ranged between 70.1 g in 1997 and 85.8 g in 2011, whereas in the South coast mean weight estimate was the highest (60.7 g) observed since 1997 (values ranging between 38.8 g in 2002 and 56.3 g in 2008).

Batch fecundity doubled in the western area and increased slightly in the south compared with 2011; for the north the lowest values were observed which were similar to the estimates for west and south in previous years. Spawning fraction estimates were very similar between strata, and moreover almost identical with the values obtained in 2008 throughout all the stock area. Spawning fraction for the north strata in 2014 was lower than for the 2011 survey but similar to estimations of other years; as for the west and south coasts the comparison with 2011 is not feasible as the estimates obtained that year were unrealistic.

For the 8b (up to 45°N) area, the estimates obtained for the adult parameters are close to those obtained for the whole time-series. Values of mean female weight and batch fecundity are higher for the southern French area than those obtained in the adjacent areas (northern Iberian Peninsula and French shores surveyed during the AZTI campaign).

For the 8ab (from 45°N to 48°N) all the adult parameters are in the range of the adult parameters from the other areas surveyed but the weight is more similar to that in the west Cantabrian Sea. The area passed the shelf break at 47°N could not be sampled by this survey but the survey PELGAS (Ifremer) covered it (pers.com.) and the weight of the sardines at this oceanic area was similar to that in 8b up to 45°N, so it is possible that these individuals moved from the corner of the Bay of Biscay to the northwest in the oceanic part, outside the platform. For similar female mean weights, batch fecundity was nevertheless higher for the 8ab (northern to 45°N) than in the Cantabrian Sea (9a N and 8c). The spawning fraction estimates obtained were relatively homogeneous in the whole area covered by the different DEPM surveys, which in 2014 were more coincident in time in relation to sardine spawning season (March-May) due to the delayed realization of IPMA's survey.

Table 5.2.2.1.2. Reproductive parameters derived from sardine DEPM surveys (IPMA, IEO, AZTI) with corresponding CV (%) in brackets by institution and area. Females mean weight (g), Batch fecundity (number of eggs spawned per mature females per batch), Sex ratio (fraction of population that are mature females by weight), Spawning fraction (fraction of mature females spawning), Daily specific fecundity (numbers of eggs per g of biomass) and Spawning-stock biomass (tonnes).

Reproductive parameters Sardine DEPM	IPMA	IPMA	IEO	IEO	AZTI
	9a South	9a West	9a N and 8c	8b (up to 45°N)	8ab (45-48°N)
Female Weight	60.72 (5)	52.63 (14)	48.70 (11)	65.51 (22)	48.46 (5)
Batch Fecundity	22 673 (7)	21 322 (16)	17 118 (12)	25 545 (24)	21 056 (12)
Sex Ratio	0.602 (8)	0.505 (6)	0.397 (15)	0.59 (12)	0.482 (18)
Spawning Fraction	0.080 (15)	0.075 (19)	0.093 (34)	0.084 (25)	0.089 (23)
Daily Specific Fecundity	18.0 (19)	15.3 (30)	13.0 (41)	19.3 (43)	18.6 (32)
Spawning Biomass	39 482	63 216	23 887 (49)	86 624 (51)	322 974 (35)

Egg parameters

The spawning area in 2014 as a whole for area 9a and 8c was slightly reduced compared to 2011 and the smallest of the historic series; this was particularly evident for the Cantabrian Sea where less than half of the area was positive for eggs compared to the previous survey. The egg distribution was patchy and very low sardine eggs were observed off the Spanish shores. In western Portugal, the spawning area increased to more than double. Daily egg production per m^2 (eggs/m^2/day) was higher for the southern stratum, intermediate in the west coast and lower in the north; for all strata daily egg production per m^2 was much lower than in recent surveys

The sum of total egg production for the 3 strata of divisions 9a and 8c in 2014 were much lower than in 2011, in particular in the northern and southern regions, and similar in the west. The mortality value (single mortality for whole area) was one of the lowest of the series but with high CV.

Further north in French waters the egg densities were higher than in the more southern regions however not as high as previously observed and the spawning area was reduced compared to past surveys. The daily egg production per m^2 and total egg production (eggs/day) in area 8b up to 45°N was much higher than in the adjacent stratum, in Cantabrian waters and also higher than further north, north of 45°N. This was possibly related to the structure of the sardine population observed in the inner corner of the Bay of Biscay where the larger (more fecund) individuals of all the 2014 surveys were collected.

Table 5.2.2.1.3. Eggs parameters derived from sardine DEPM surveys with their CV (%) in brackets. Final egg production model for the Iberian Peninsula include individual egg production estimates for each strata (9a South, 9a West and 9a North-8c) and a common mortality for the whole area. Significant mortality values (hour^{-1}) are shown. ** Significance at $p < 0.01$ and * Significance at $p < 0.001$.**

EGGS PARAMETERS SARDINE DEPM	IPMA	IPMA	IEO	IEO	AZTI
	9a South	9a West	9a N and 8c	8b (up to 45°N)	8ab (45-48°N)
Survey area (km^2)	14 559	27 357	38 914	13 480	69 944
Positive area (km^2)	6 825	11 001	7 494	7 914	46 512
Z (hour^{-1})	-0.017 ** (36)			-0.021*** (29)	-0.013***(30)
Z (daily^{-1})	-0.41**(36)			-0.50***(29)	-0.31***(30)
P0 (eggs/m^2/day)	104 (27)	89 (23)	40 (26)	214 (28)	129 (15)
P0 tot (eggs/day)	0.71 (27)	0.97 (23)	0.31 (26)	1.70 (28)	6.02 (15)

Biomass estimates

The SSB estimates for the south, west and north strata (39 482, 63 216 and 23 887 tonnes, respectively) and for the whole Atlanto Iberian stock (126 584 tonnes) are the lowest of the whole series, and represent a substantial decrease of the biomass, compared to 2011 (74% for the whole stock). Despite the fact that the Portuguese survey was conducted later than usual the population was actively spawning and the results obtained for all parameters estimated were consistent.

The SSB estimate for the area 8b covered by IEO was around 40% lower than in 2011. This reduction is mostly a consequence of the decrease in total egg production, from 2.7 (eggs/day) in 2011 to 1.7 (eggs/day) in 2014. The biomass estimate in the 8ab this year was the highest, compared with the rest of the areas surveyed.

Figure 5.2.2.1.4. Time-series of the sardine DEPM based SSB estimates by areas. Vertical lines indicate SSB approximate 95% confidence intervals (i.e. ± 2 standard-deviations). Sardine DEPM in area 8ab (45-48°N) was first considered in 2011.

5.2.2.2 Anchovy in the Bay of Biscay (BIOMAN 2015)

Oceanographic conditions (SST, SSS)

The distribution patterns of sea surface temperature (SST) and sea surface salinity (SSS) observed during 2015 daily Egg Production method (DEPM) survey in the Bay of Biscay were the typical for the region showing the signatures of the Adour and Garonne River off the French coast. (Figure 5.2.2.2.1)

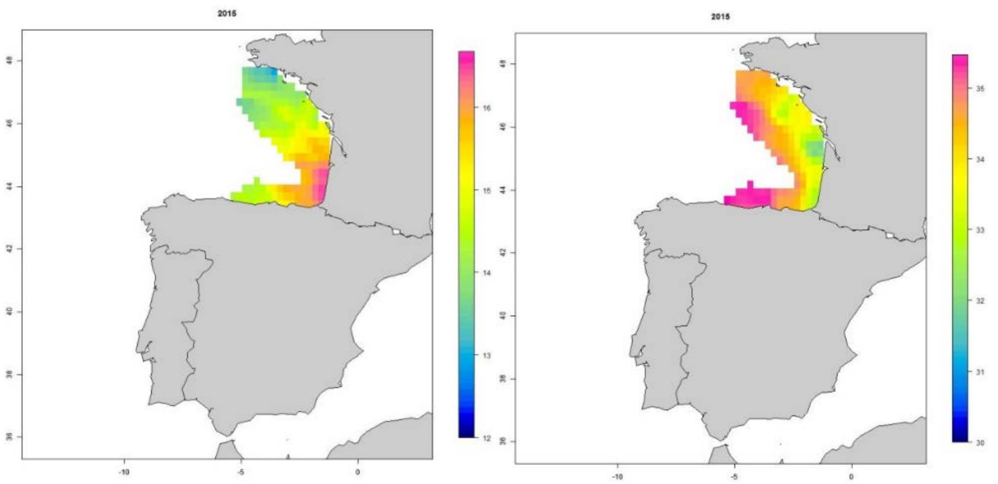


Figure 5.2.2.2.1. Sea surface temperature (left panel) and salinity (right panel) during May 2015 DEPM survey BIOMAN in the Bay of Biscay.

Egg distributions from CUFES and PairoVET observations

In the Bay of Biscay during the DEPM survey BIOMAN 2015 **anchovy eggs** were found in the Cantabrian Coast after 15 years without eggs in this area. The spawning area started in the Cantabrian coast at 5°W to the French coast and in the French platform the northern limit was found at 47°37'N. The eggs in the French platform where encountered all over the platform well passed the 200 m depth (Figure 5.2.2.2.2). 629 vertical plankton samples were obtained, 86% had anchovy eggs with an average of 300 eggs m^{-2} per station and a maximum of 2870 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.*, 2015).

A mean abundance of **sardine eggs** in the Bay of Biscay during BIOMAN 2015 were encountered in relation with the historical series; very few eggs were encountered along Cantabrian coast, close to it. In the French platform the eggs were between coast and 100 m until Arcachon and between 80 m and 200 m between Arcachon and Gironde estuary. From there to 48°N, were from 100 m to the coast, but as well some sardine eggs were encountered in 48°30'N at 200 m depth (Figure 5.2.2.2.3). The north limit of the spawning was not delimited properly due to the lack of time. From the PairoVET samples a total of 213 (43%) had sardine eggs with an average of 80 eggs per m^{-2} per station and a maximum of 3010 eggs m^{-2}. Both samplers PairoVET (egg m^{-2}) and CUFES (egg m^{-3}) show very similar sardine egg abundances distribution pattern.

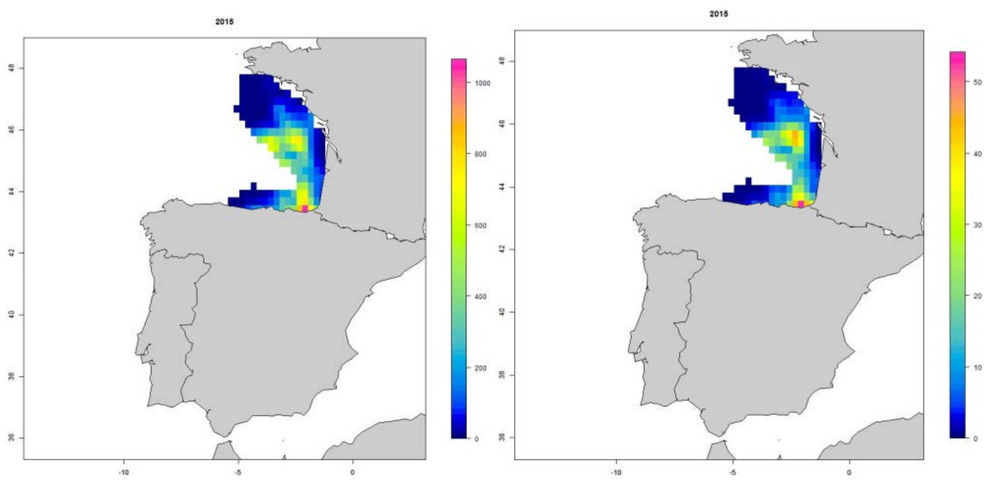


Figure 5.2.2.2.2. Anchovy egg distributions from PairoVET (left panel; eggs m^{-2}) and CUFES (right panel; eggs m^{-3}) observations collected during the DEPM survey BIOMAN2015.

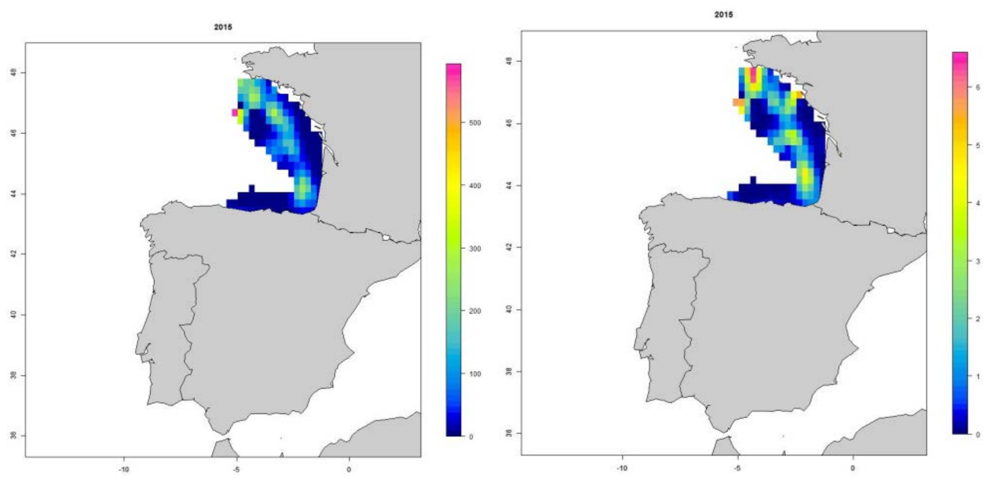


Figure 5.2.2.2.3. Sardine egg distributions from PairoVET (left panel; eggs m^{-2}) and CUFES (right panel; eggs m^{-3}) observations collected during the DEPM survey BIOMAN2015.

Egg parameters

In the Bay of Biscay the spawning area for anchovy in 2015 (81 956 km^2) was more than double of the mean historical series (1987-2015) that is 40 901km^2. The daily egg production (P_0) is the third highest of the series (mean = 82.69). The mortality (z) is about the mean historical series (mean = 0.25). The total daily egg production (P_{tot}) is almost three times the mean historical series (mean = 3.712E+12). (Table 5.2.2.2.1; Figure. 5.2.2.2.4).

Table 5.2.2.2.1 Daily egg production (P_0) (eggs /m^2), mortality (z) and total egg production (P_{tot}) estimates and their corresponding standard error (s.e.) and coefficient of variation (CV).

Parameter	Value	S.e.	CV
P_0	131.53	10.75	0.0817
z	0.28	0.043	0.1519
Ptot	1.08.E+13	8.8.E+11	0.0817

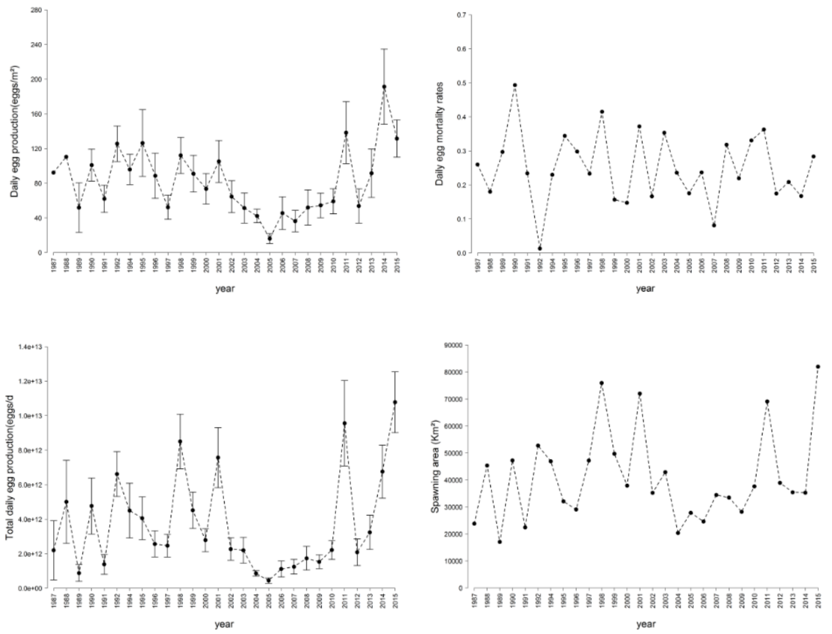


Figure 5.2.2.2.4. Time-series of DEPM egg parameters and spawning area for anchovy: Daily egg production (P_0) (eggsm^{-2}), mortality (z) and total egg production (P_{tot}). Vertical lines indicate 95% confidence intervals (i.e. ± 2 standard deviations).

Weight, length, numbers, percentage, biomass-at-age and reproductive parameters

For the purposes of producing population at age estimates, the age readings based on 2422 otoliths from 47 samples were available. Estimates of anchovy mean weights and proportions at age in the population were the average of proportions at age in the samples, weighted by the population each sample represents. 77% of the population in numbers and 63% in mass correspond to age 1 (Table 5.2.2.2.2). This is the year with the best recruitment of the historical series.

The reproductive parameters for the DEPM in 2015 estimated for Anchovy in the BoB in May are showed in Table 5.2.2.2.3 and Figure 5.2.2.2.5. Compering the adult parameters with the corresponding mean historical series (1987-2015) (Figure 5.2.2.2.5), sex ratio (0.53) is at levels of the historical mean (0.54), female mean weight (17.91g) is the lowest of the historical series (mean = 24.41g). The batch fecundity this year (6479 eggs per mature female per batch) is the lowest of the historical series (mean = 11046 eggs per mature female per batch). The spawning fraction (0.31) is the second lowest of the series (mean = 38.7) and in consequence the daily fecundity (59.74 egg/g) is the lowest of the historical series (mean = 94.63 egg/g).

Table 5.2.2.2.2 Anchovy biomass, total mean weight, percentage in numbers, numbers, percentage in mass, biomass, mean weight (g), mean length (mm) at age, from the 2015 DEPM survey in the Bay of Biscay with their standard error (Se) and Coefficient of variation (CV).

Parameter	estimate	S.e.	CV
BIOMASS (Tons)	**181,063**	18,202	0.1005
Wt	14.43	1.00	0.0695
Population (millions)	12,589	1701	0.1351
Percentage at age 1	0.77	0.031	0.0406
Percentage at age 2	0.21	0.029	0.1378
Percentage at age 3	0.02	0.004	0.1860
Numbers at age 1	9,727	1,587.3	0.1632
Numbers at age 2	2,615	314.0	0.1201
Numbers at age 3	246	45.2	0.1832
Percent. at age 1 in mass	0.63	0.04	0.0639
Percent. at age 2 in mass	0.34	0.04	0.1065
Percent. at age 3in mass	0.03	0.01	0.2043
B at age 1 (Tons)	113,677	14,472	0.1273
B at age 2 (Tons)	61,339	8,192	0.1335
B at age 3 (Tons)	6,086	1,371	0.2252
Weight at age 1 (g)	11.73	0.83	0.0708
Weight at age 2 (g)	23.42	0.96	0.0411
Weight at age 3 (g)	24.70	2.10	0.0850
Lenght at age 1 (mm)	120.98	3.10	0.0256
Lenght at age 2 (mm)	151.10	1.77	0.0117
Length at age 3 (mm)	153.17	3.55	0.0231

Table 5.2.2.2.3 Reproductive parameters derived from anchovy DEPM survey BIOMAN2015 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 (number of eggs per g of biomass).

Parameter	estimate	S.e.	CV
R'	0.53	0.0044	0.0084
S	0.31	0.0123	0.0395
F	6,479	478	0.0738
Wf	17.91	1.07	0.0597
DF	59.74	3.50	0.0586

Total biomass estimate

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 2015 anchovy biomass estimate is the highest of the series (Figure 5.2.2.2.5; Table 5.2.2.2.2). 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.

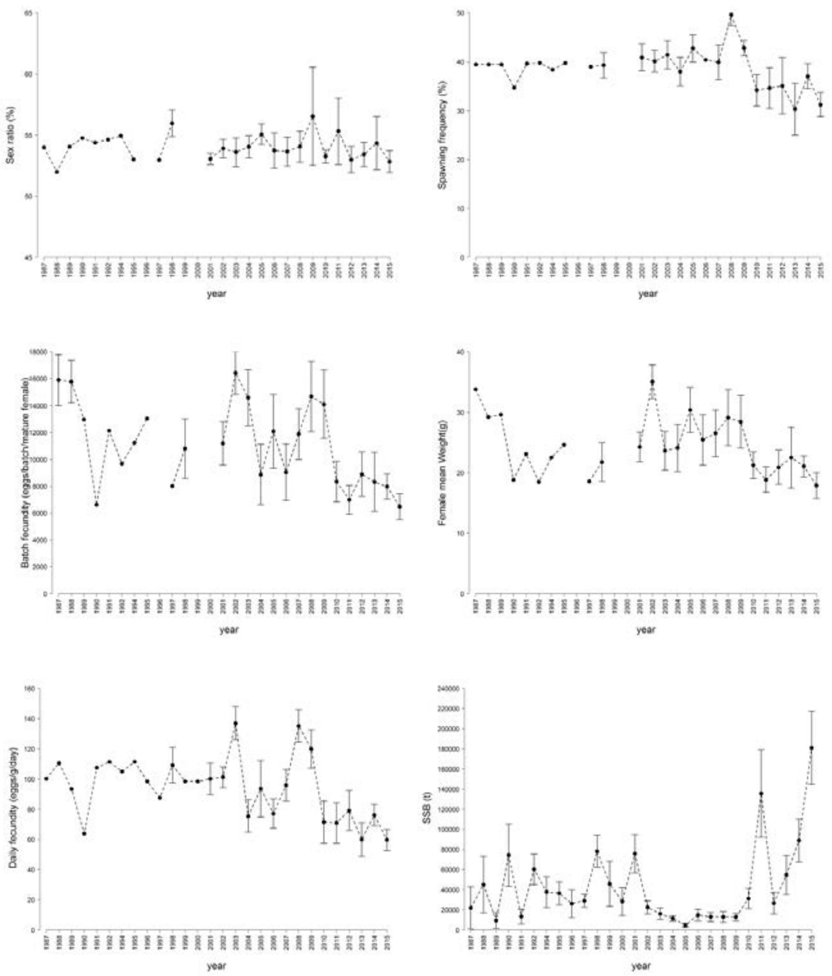


Figure 5.2.2.2.5. Time-series of anchovy DEPM adult parameters and total biomass. Vertical lines indicate 95% confidence intervals (i.e. ± 2 standard deviations). Sex ratio (mature females fraction of population by weight), spawning fraction (fraction of mature females spawning per day), batch fecundity (eggs spawned per mature females per batch), female mean weight (g), daily fecundity (number of eggs per g of biomass) and total biomass (tonnes).

5.2.3 GoC summer survey

5.2.3.1 Oceanographic conditions

Average sea-surface salinity and temperature in summer 2015 during the *ECOCADIZ 2015-07* survey are illustrated in Figure 5.2.3.1.1. A detailed description of the oceanographic conditions in that survey based on *in situ* and remotely sensed data are given in Sánchez-Leal *et al*. (in Annex 8.8).

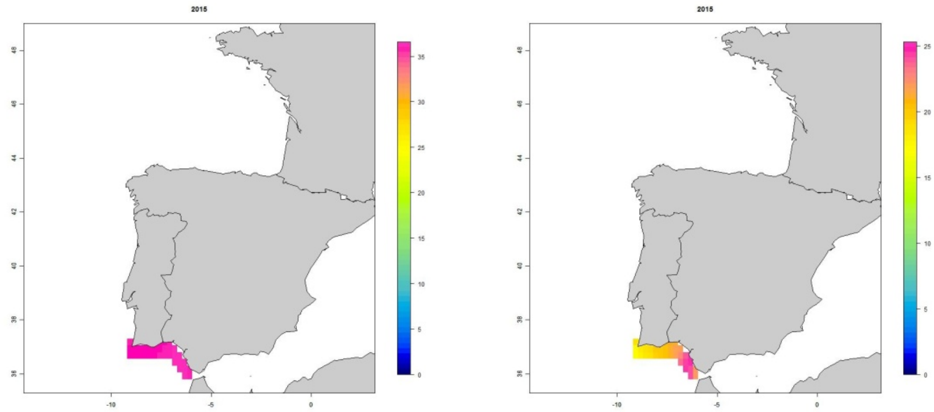


Figure 5.2.3.1.1. Average sea surface salinity (left panel) and temperature (right panel) in summer 2015 during the *ECOCADIZ 2015-07* survey (IEO).

5.2.3.2 Trawl species composition

A total of twenty two (22) fishing operations for echotrace ground-truthing (19 valid ones according to a correct gear performance and resulting catches), were carried out during the survey (Figure 5.2.3.2.1). The sampled depth range in the valid hauls oscillated between 37–172 m. A detailed description on the conduction of these hauls is given in Ramos *et al*. (2015a).

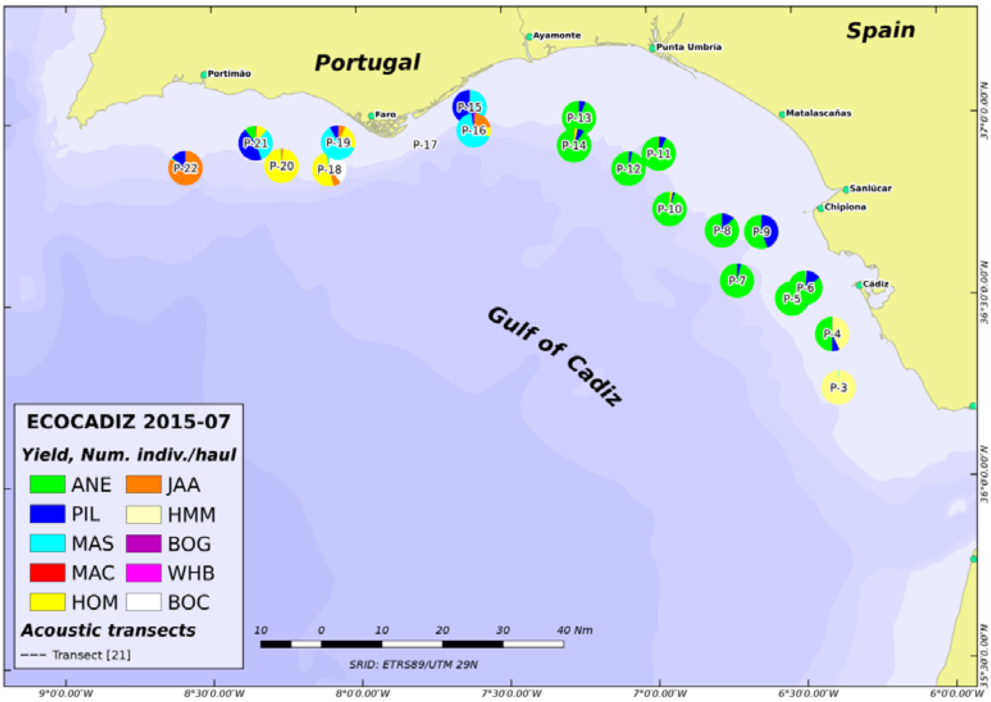


Figure 5.2.3.2.1. *ECOCADIZ 2015-07* survey (IEO). Species composition (percentages in number) in fishing hauls.

During the survey were captured 4 Chondrichthyan, 39 Osteichthyes, 4 Cephalopod, 8 Crustacean, 5 Echinoderm, 2 Polychaeta, 1 Sipunculidea, 2 Porifera, 4 Cnidarian and 1 Thaliacean species. The percentage of occurrence of the more frequent species in the hauls is shown in Table 5.2.3.2.1.

Table 5.2.3.2.1. ***ECOCADIZ 2015-07*** **survey (IEO). Percentage of occurrence and total yields in weight and numbers of the most frequent species captured during the survey.**

Species	# of fishing stations	Occurrence (%)	Total weight (kg)	Total number
Merluccius merluccius	19	100	169.218	2 745
Sardina pilchardus	18	95	1 956.451	45 055
Loligo spp	17	89	5.409	1 809
Trachurus trachurus	16	84	1 399.624	26 394
Scomber colias	15	79	1 914.333	17 822
Engraulis encrasicolus	15	79	1 401.372	155 790
Scomber scombrus	14	74	38.035	183
Boops boops	11	58	22.575	188
Trachurus picturatus	10	53	2 956.827	50 765
Alosa fallax	8	42	3.519	14
Spondyliosoma cantharus	8	42	14.108	78
Diplodus annularis	6	32	2.638	52
Eledone moschata	6	32	1.442	10
Aphia minuta	6	32	0.346	164
Pagellus erythrinus	6	32	94.348	568
Pagellus bellottii bellottii	5	26	7.978	56
Diplodus bellottii	5	26	3.668	67
Chelidonichthys lucerna	5	26	0.426	5
Diplodus vulgaris	4	21	13.038	89
Trachurus mediterraneus	4	21	325.372	1 910

The pelagic ichthyofauna were the most frequently captured species set and the one composing the bulk of the overall yields of the catches. Within this pelagic fish species set, sardine was the most frequent captured species in the valid hauls (95% presence index) followed by horse mackerel, chub mackerel, anchovy, and mackerel (with relative occurrences between 70–80%). Bogue and blue jack mackerel showed a medium relative frequency of occurrence (ca. 50–60%), whereas Mediterranean horse mackerel showed a low occurrence in the whole surveyed area (21%).

The species composition of these fishing hauls (as expressed in percentage) provides a first impression of the distribution pattern of the main species (Figure 5.2.3.2.1). Thus, anchovy showed a relatively wide distribution over the surveyed area, although the highest yields were recorded in the Spanish waters. Sardine was even more frequent and widely distributed than anchovy, with the highest yields being mainly recorded in the westernmost waters of the surveyed area. Mackerel, chub mackerel, horse mackerel, blue jack mackerel, and bogue, although they occurred in a great part of the study area, only showed relatively high yields in the Portuguese waters. Mediterranean horse mackerel was restricted to the easternmost Spanish waters.

5.2.3.3 Sardine and anchovy distributions derived from NASC

Sampling intensity by grid block is show in Figure 5.2.3.3.1.

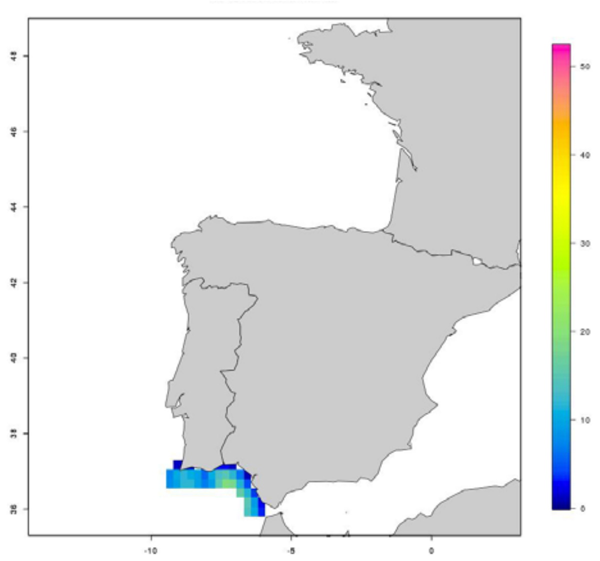


Figure 5.2.3.3.1. Number of data points within each grid of 0.25°x0.25° in summer 2015 during the *ECOCADIZ 2015-07* survey (IEO).

5.2.3.3.1 Sardine

Excepting the easternmost waters closer to the Strait of Gibraltar, where the species was absent, sardine was widely distributed all over the remaining surveyed area, preferably over the inner shelf, with the highest densities being recorded in two distinct zones: the coastal waters in front of the area comprised between Matalascañas and Chipiona, in the Spanish waters, and the inner-mid shelf waters between Cape San Vicente and Cape Santa Maria, in the Portuguese waters (Figure 5.2.3.3.1.1).

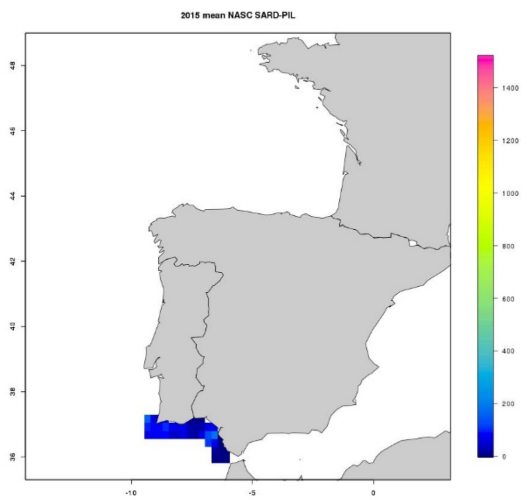


Figure 5.2.3.3.1.1. Spatial distribution of acoustic energy (NASC) attributed to Gulf of Cadiz sardine in summer 2015 during the *ECOCADIZ 2015-07* survey (IEO).

5.2.3.3.2. Anchovy

As described for sardine, anchovy also avoid the easternmost waters of the Gulf. The bulk of the population was mainly distributed all over the shelf between the Guadiana river mouth and Bay of Cadiz, especially over the outer shelf waters of the central part of the Gulf, between the Guadiana river mouth and Matalascañas. A secondary nucleus of anchovy density was recorded between Cape San Vicente and Albufeira, in the western Portuguese Algarve, with the species being quite scarce in the surroundings of the Cape of Santa Maria (Figure 5.2.3.3.2.1).

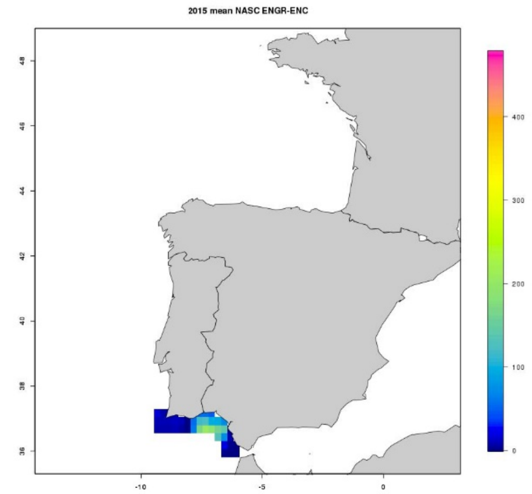


Figure 5.2.3.3.2.1. Spatial distribution of acoustic energy (NASC) attributed to Gulf of Cadiz anchovy in summer 2015 during the *ECOCADIZ 2015-07* survey (IEO).

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

5.2.3.4.1 Sardine

Sardine mean weight and length-at-age in the assessed population are not available to this WG. Alternatively, Figure 5.2.3.4.1.1 shows the mean length and weight along the time-series. The 2015 summer estimate of mean size (135 mm) is the lowest one within the series. This fact might be explained by the dominance of the juvenile fraction in the estimated population (main mode at 10.5 cm), which was mainly located in relatively shallow waters in front of the Guadiana and Guadalquivir river mouths and the Bay of Cadiz (Ramos *et al*., 2015a, WD). However, such a decrease in mean size is not coupled with a similar decreasing trend in the mean weight (26.6 g), which was even somewhat higher than the historical average. It could be probable that the contribution in biomass of the adult fraction in the assessed population (around at a secondary modal size class at 20 cm) is enough to compensate the greater relative contribution of juveniles.

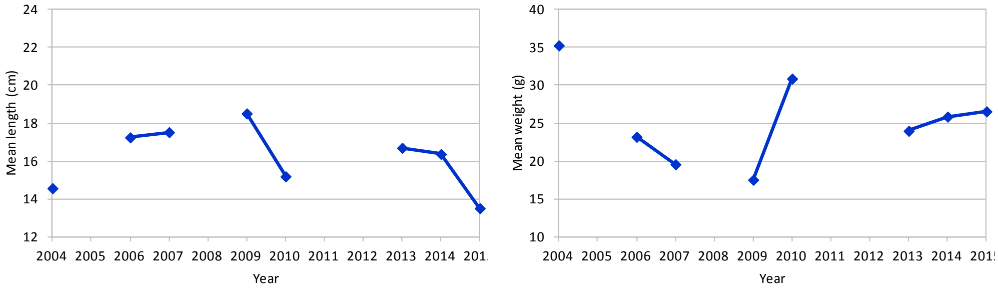


Figure 5.2.3.4.1.1. Sardine mean length and weight along ECOCADIZ survey series (gaps mean no survey).

5.2.3.4.2 Anchovy

Population estimates of Gulf of Cadiz anchovy mean length and weight at age are not yet available for this WG.

The size composition of anchovy by coherent post-strata (Ramos *et al*., 2015a, WD) confirms the usual pattern exhibited by the species in the area during the spawning season, with the largest fish being distributed in the westernmost waters and the smallest ones concentrated in the surroundings of the Guadalquivir river mouth and adjacent shallow waters, including those ones in front of the Bay of Cadiz. This summer small anchovies were also recorded in the coastal area close to the Guadiana river mouth. As it has been happening over the last years, during the 2015 survey some recruitment has also been recorded, probably as a consequence of the delayed survey dates. This fact seems to have been much more evident than in previous years because the markedly low mean length and weight estimated for the whole estimated population (106 mm; 8.0 g), the lowest record for both variables in the whole series (Figure 5.2.3.4.2.1).

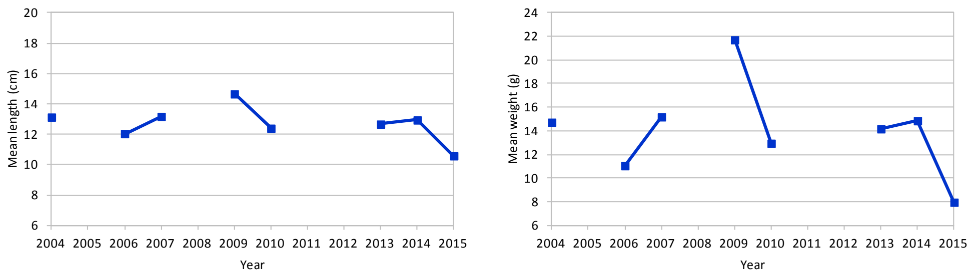


Figure 5.2.3.4.2.1. Anchovy mean length and weight along ECOCADIZ survey series (gaps mean no survey).

5.2.3.5 Sardine and anchovy biomass and abundance estimation

5.2.3.5.1 Sardine

The acoustic estimates by coherent post-strata are given in Ramos *et al*. (2015a, WD). Overall estimates along the time-series are shown in Figure 5.2.3.5.1.1. The estimates of Gulf of Cadiz sardine abundance and biomass in summer 2015 were 883 million fish and 23 460 tonnes. Although the population levels have showed some recovery from the lowest values in the series recorded in the two previous years, the 2015 estimates are still below the average value for the historical series.

Portuguese waters accounted for 27.6% of abundance (244 million fish) and 72.6% of the total estimated biomass (17 038 t), values from which could be inferred a large body size on average. In contrast, the estimates from the Spanish area (640 million fish – 72.4% of abundance –; 6422 t – 27.4% of biomass –), denote a dominance of the smallest sardines.

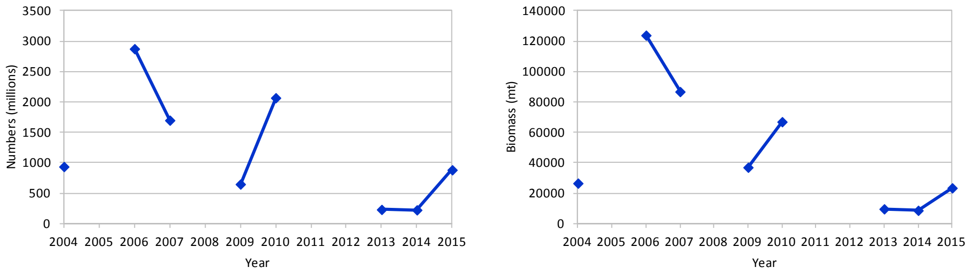


Figure 5.2.3.5.1.1. Sardine abundance (million fish) and biomass (tonnes) for ECOCADIZ time-series (gaps mean no survey).

The comparison of these estimates with their spring counterparts reveals some differences (Section 5.2.1.5 and Marques et *al*., 2015, WD). PELAGO survey estimated 400 million and 16 663 t of Gulf of Cadiz sardine (238 million and 15 031 t in Portuguese waters, 162 million and 1632 t in Spanish ones). As it could be easily deduced from the above values, spring and summer estimates from the Portuguese Algarve area were quite similar. However, ECOCADIZ survey estimated in summer fourfold more sardine in Spanish waters than PELAGO survey in spring, with the juvenile fraction being the dominant in both seasons. The progressive incorporation (recruitment) of juveniles coming from successive spawning events may be the reason for such differences.

5.2.3.5.2 Anchovy

The acoustic estimates by coherent post-strata arte given in Ramos *et al*. (2015a, WD). Overall acoustic estimates in summer 2015 were of 2674 million fish and 21 305 tonnes. These estimates together the remaining ones within its series are shown in Figure 5.2.3.5.2.1. The 2015 abundance estimate continues the notable increasing trend, which started last year and rises up the population levels well above those corresponding to the historical average. This increasing trend in abundance is not completely coupled to the trend exhibited by the biomass, which showed a relatively low decrease in relation to the previous year estimate. Even so, the 2015 biomass estimate situates only slightly below the historical average. By geographical strata, the Spanish waters yielded 93.7% (2506 million) and 90% (19 168 t) of the total estimated abundance and biomass in the Gulf confirming the importance of these waters in the species' distribution. The estimates for the Portuguese waters were 168 million and 2137 t.

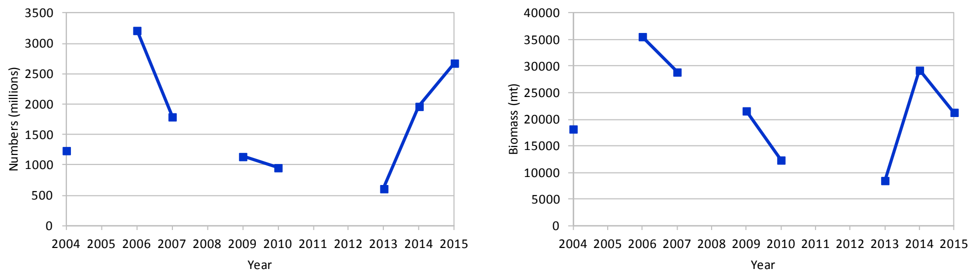


Figure 5.2.3.5.2.1. Anchovy abundance (million fish) and biomass (tonnes) for ECOCADIZ time-series (gaps mean no survey).

For this same survey area, the Portuguese spring survey PELAGO 15 estimated two months before 3689 million fish and 33 100 t (158 million and 2156 t in Portuguese waters, 3531 million and 30 944 t in Spanish ones; see Section 5.2.1.5 and Marques *et al*., 2015, WD). The comparison of these estimates with their summer counterparts evidences almost identical values for the Portuguese waters, whereas the ECOCADIZ survey estimated in summer at about 1000 million and 11 800 t less of anchovy in the Spanish waters. Even assuming a total mortality (Z) accumulated between surveys, the magnitude of such differences should be explainable by causes other than the above one. Marques *et al*. (2015, WD) warned about the need of corroborating the PELAGO spring estimates with the ECOCADIZ ones because of some uncertainty in the estimation. These authors advanced the possibility of a certain overestimation of the acoustic energy attributed to anchovy in the Spanish waters of the Gulf because this energy in this area was strongly masked by a dense plankton layer. ECOCADIZ surveys also routinely face to this same problem, since this situation is not uncommon in the area, by acoustically surveying in a multifrequency fashion, an approach that partially allows a more efficient discrimination of echoes.

5.2.3.6 Other fish species

Information on the spatial distribution (sA maps) of other fish species is detailed in Ramos *et al*. (2015a, WD). No acoustic estimates from these species are yet available for this WG.

5.2.3.7 Other observations: mammals and birds

Although a census of the occurrence of apical predators was carried out during the survey, the results from this census were still not available for the WG.

5.2.3.8 Sardine and anchovy egg distributions from CUFES sampling

5.2.3.8.1 Sardine

The occurrence of sardine eggs during the survey was almost negligible since the survey dates are outside the spawning season for the species.

5.2.3.8.2 Anchovy

The Gulf of Cadiz anchovy egg distribution from CUFES sampling is shown in Figure 5.2.3.8.2.1. Anchovy egg distribution in summer 2015 resembled the above-mentioned distribution for adult fish, with higher egg densities being mainly recorded in the middle-outer shelf waters located between the Guadiana and Tinto-Odiel river mouths. The highest egg density (121 eggs m^{-3}) was recorded in one station at a mean depth of 80.3 m located in the westernmost Spanish transect.

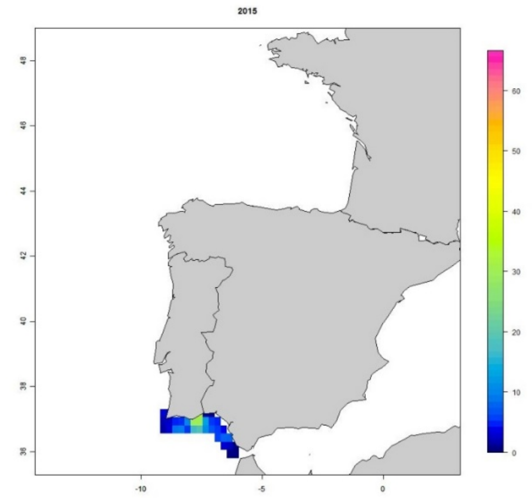


Figure 5.2.3.8.2.1. Gulf of Cadiz anchovy egg distribution from CUFES (eggs/m[3]) collected in summer 2015 during the *ECOCADIZ 2015-07* survey (IEO).

5.2.4 Autumn acoustic surveys in 2015

5.2.4.1 Oceanographic conditions

A detailed description of the oceanographic conditions in that survey based on *in situ* and remotely sensed data are given in Sánchez-Leal *et al*. (2015, WD).

5.2.4.2 Trawl species composition

A total of twenty one (21) fishing operations for echotrace ground-truthing (all of them valid according to a correct gear performance and resulting catches), were carried out during the survey (Figure 5.2.4.2.1). The sampled depth range oscillated between 41 and 155 m. A detailed description on the conduction of these hauls is given in Ramos *et al*. (2015b, WD).

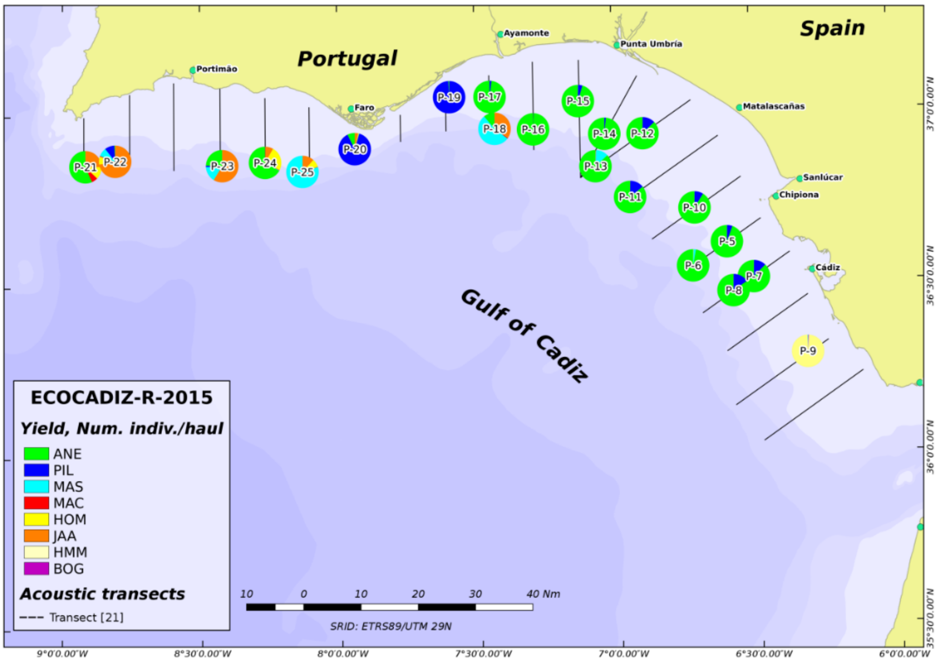


Figure 5.2.4.2.1. ***ECOCADIZ-RECLUTAS 2015-10*** **survey (IEO). Species composition (percentages in number) in fishing hauls.**

During the survey were captured 1 Chondrichthyan, 33 Osteichthyes, 6 Cephalopod, 3 Echinoderm, 1 Cnidarian, and 1 Bryozoan species. The percentage of occurrence of the more frequent species in the hauls is shown in Table 5.2.4.2.1.

Table 5.2.4.2.1. ***ECOCADIZ-RECLUTAS 2015-10*** **survey (IEO). Percentage of occurrence and total yields in weight and numbers of the most frequent species captured during the survey.**

SPECIES	# OF FISHING STATIONS	OCCURRENCE (%)	TOTAL WEIGHT (KG)	TOTAL NUMBER
Engraulis encrasicolus	20	95	1 145.293	191 529
Merluccius merluccius	19	90	25.617	273
Sardina pilchardus	15	71	7 653.437	99 986
Scomber colias	14	67	1 230.73	10 530
Trachurus trachurus	13	62	143.033	1 221
Scomber scombrus	12	57	18.756	108
Lepidopus caudatus	11	52	2.641	151
Trachurus picturatus	8	38	282.636	4 526
Boops boops	7	33	4.844	33
Trachurus mediterraneus	5	24	38.07	185

As described for the ECOCADIZ 2015-07 summer survey, the pelagic ichthyofauna also was both the most frequently captured species set and the one composing the bulk of the overall yields of the catches. Within this pelagic fish species set, anchovy was the most frequent species in the valid hauls (95% presence index), followed by sardine, chub-mackerel and horse mackerel (with relative occurrences between 60–70%). Mackerel showed a medium relative frequency (57%), and blue jack mackerel, bogue, and Mediterranean horse mackerel were rare species during the survey (20–40%).

The species composition of these fishing hauls (as expressed in terms of percentages in number) is shown in Figure 5.2.4.2.1. Anchovy was widely distributed all over the surveyed area, although showed the highest yields in those ones carried out in the Spanish waters. Sardine was a frequent species in the hauls conducted over the shelf fringe comprised between Cape Santa Maria and Bay of Cadiz, showing exceptional yields in those waters surrounding Cape Santa Maria. However, the occurrence of sardine in the hauls conducted in the westernmost waters was relatively rare. Mackerel, although relatively frequent in those hauls conducted over the middle-outer shelf waters of the whole surveyed area, showed, however, very low yields. Although in a lesser extent, that also was the case of chub-mackerel, only outstanding the yields from two hauls conducted in the outer shelf waters in front of Punta Umbría (Spanish waters) and Cuarteira (to the west of Cape Santa Maria). Blue jack mackerel was restricted to the Portuguese waters only and Mediterranean horse mackerel to the easternmost Spanish ones. Horse mackerel, although relatively frequent from the central waters of the Gulf to the west, only showed relatively important yields in the westernmost waters.

5.2.4.3 Sardine and anchovy distributions derived from NASC

Sampling intensity by grid block is shown in Figure 5.2.4.3.1.

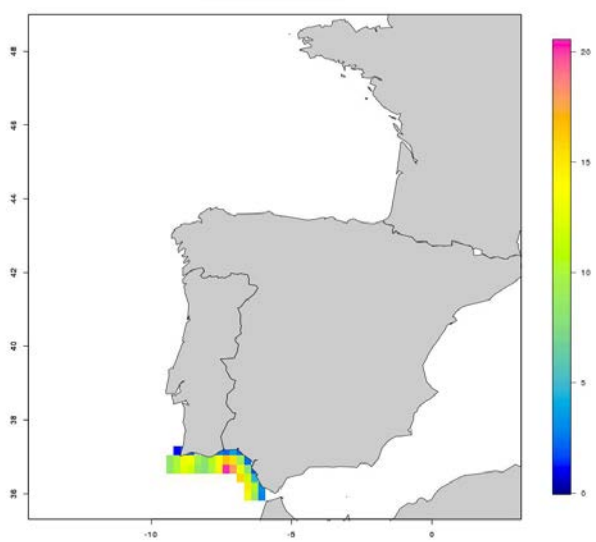


Figure 5.2.4.3.1. Number of data points within each grid of 0.25°x0.25° in autumn 2015 during the *ECOCADIZ-RECLUTAS 2015-10* survey (IEO).

5.2.4.3.1 Sardine

As it was observed in summer, sardine also was absent in autumn the easternmost waters of the Gulf. In the remaining surveyed area the species, although widely distributed, showed two main nuclei of acoustic density: the most important one located in the westernmost coastal Algarve waters, and a secondary zone comprising the shelf between Matalascañas and Bay of Cadiz. In these last waters sardine showed a somewhat more widespread distribution than in summer (Figure 5.2.4.3.1.1).

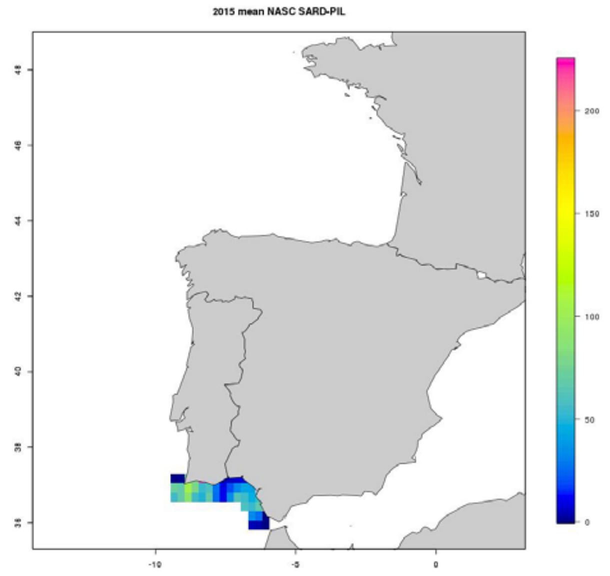


Figure 5.2.4.3.1.1. Spatial distribution of acoustic energy (NASC) attributed to Gulf of Cadiz sardine in autumn 2015 during the *ECOCADIZ-RECLUTAS 2015-10* survey (IEO).

5.2.4.3.2 Anchovy

Anchovy also avoid in autumn, as it did in summer, the easternmost waters of the Gulf, and showed a spatial pattern of distribution of the acoustic density very similar to the one described in summer, with the bulk of the population being mainly concentrated in an area comprising the shelf waters between the Guadiana river mouth and Bay of Cadiz. Anchovy acoustic densities in westernmost waters were not relevant (Figure 5.2.4.3.2.1).

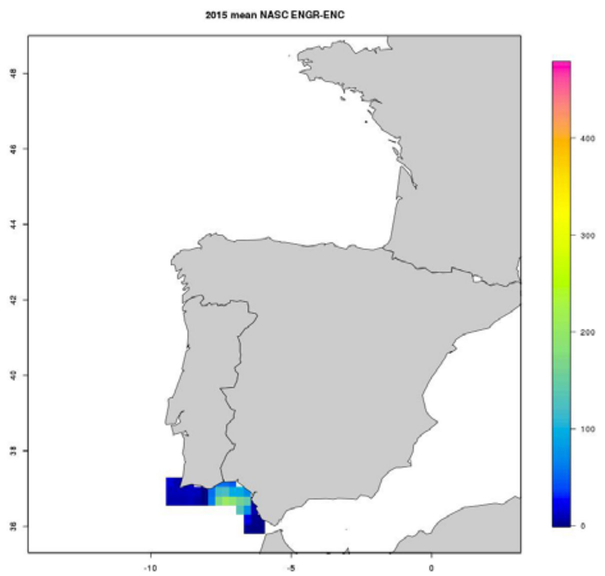


Figure 5.2.3.4.2.1. Spatial distribution of acoustic energy (NASC) attributed to Gulf of Cadiz anchovy in autumn 2015 during the *ECOCADIZ-RECLUTAS 2015-10* survey (IEO).

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

5.2.4.4.1 Sardine

Sardine mean weight and length-at-age in the assessed population are not available to this WG. Figure 5.2.4.4.1.1 shows the overall mean length and weight along the available short time-series. The autumn 2015 estimates of mean size (157 mm) and weight (36.0 g) are very close to those ones recorded in 2012 (165 mm, 36.7 g), but they both contrast to the values estimated in autumn 2014, when Gulf of Cadiz sardine population was composed on average by very large and heavy sardines (200 mm, 72.1 g) as a result of a notable dominance of the adult fraction in contrast to a very scarce presence of juveniles. Conversely, Gulf of Cadiz sardine population in 2012 and 2015 showed more complex and mixed size distributions, with juveniles composing the most important modal component. The sardine size composition by coherent post-strata in the autumn 2015 survey (Ramos *et al.*, 2015b, WD) indicates that juveniles were mainly distributed over the coastal waters comprised between the Guadiana river mouth and Bay of Cadiz.

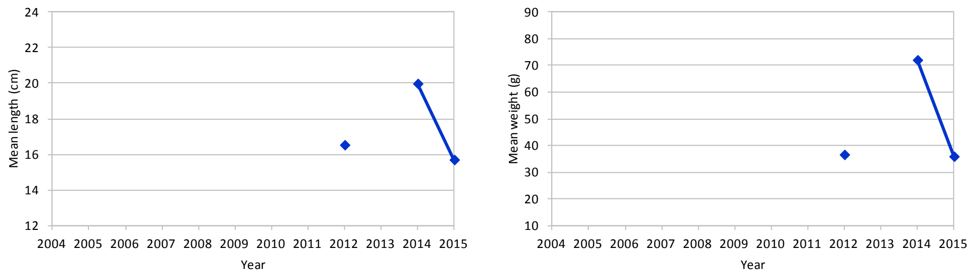
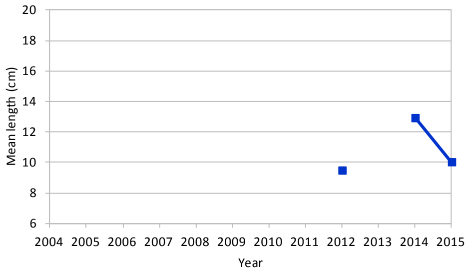


Figure 5.2.4.4.1.1. Sardine mean length and weight along *ECOCADIZ-RECLUTAS* survey series (gaps mean no survey).

5.2.4.4.2 Anchovy

Population estimates of Gulf of Cadiz anchovy mean length- and weight-at-age in autumn 2015 are not yet available for this WG. Figure 5.2.4.4.2.1 shows the overall mean length and weight along the available short time-series. The 2015 estimates were 100 mm and 5.9 g respectively, very similar values to those ones recorded in 2012 (95 mm, 5.9 g) but, again, as also occurred with sardine, they were very different from the high estimates in 2014 (129 mm, 14.9 g).

The anchovy size composition by coherent post-strata in the autumn 2015 survey (Ramos *et al.*, 2015b, WD) evidences that juveniles were mainly distributed in coastal waters between the Guadiana river mouth and Bay of Cadiz, as also was described for sardine juveniles.



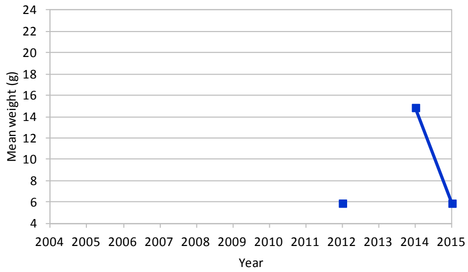


Figure 5.2.4.4.2.1. Anchovy mean length and weight along *ECOCADIZ-RECLUTAS* survey series (gaps mean no survey).

5.2.4.5 Sardine and anchovy biomass and abundance estimation

5.2.4.5.1 Sardine

The acoustic estimates by coherent post-strata are given in Ramos *et al*. (2015b, WD). Overall estimates along the short time-series are shown in Figure 5.2.4.5.1.1. The estimates of Gulf of Cadiz sardine abundance and biomass in autumn 2015 were 861 million fish and 30 992 t. Portuguese waters accounted for 48.9% of abundance (421 million) and 69.0% of the total estimated biomass (21 390 t), with the unbalanced percentages suggesting a larger and heavier body size on average than in the Spanish waters, where abundance and biomass estimates were of 440 million and 9602 t.

The autumn 2015 values represent with respect to those estimated in the previous year a notable increase in abundance but not in biomass, which experienced a slight decrease. Such a pattern is mainly caused by the increase and high relative importance of juveniles in the population during the 2015 survey season, which were mainly distributed in the Spanish coastal waters. Thus, sardine juveniles (≤ 16 cm, as a proxy of age 0 sardines) accounted in autumn 2015 for 71.1% (612 million) and 42.1% (13 037 t) of the overall estimated abundance and biomass (Table 5.2.4.5.1.1). These values are rather close to those ones recorded in 2012 (377 million, 62.5%; 9675 t, 43.7%), but they are very different from the 2014 estimates of sardine juveniles (29 million, 5.7%; 760 t, 2.1%).

Table 5.2.4.5.1.1. Sardine abundance (million fish) and biomass (tonnes) for *ECOCADIZ-RECLUTAS* time-series. Since there are no age-structured acoustic estimates available, fish ≤ 16 cm was considered as a proxy of age 0 fish.

Estimate/Year	Total population (≤ 16 cm as a proxy of Age 0 recruits)		
	2012	**2014**	**2015**
Biomass (t)	22 119 (9 675)	36 571 (760)	30 992 (13 037)
Abundance (million)	603 (377)	507 (29)	861 (612)

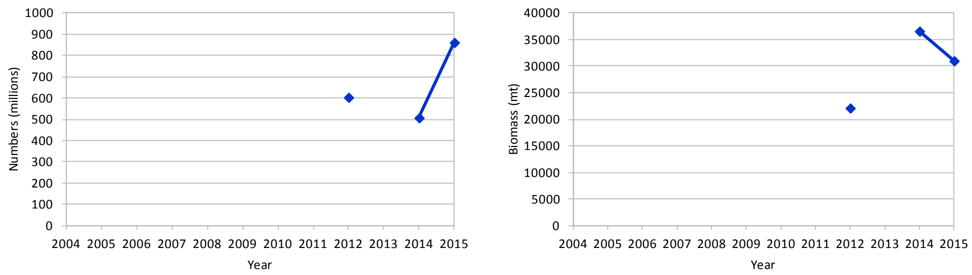


Figure 5.2.4.5.1.1. Sardine abundance (million fish) and biomass (tonnes) for *ECOCADIZ-RECLUTAS* time-series (gaps mean no survey).

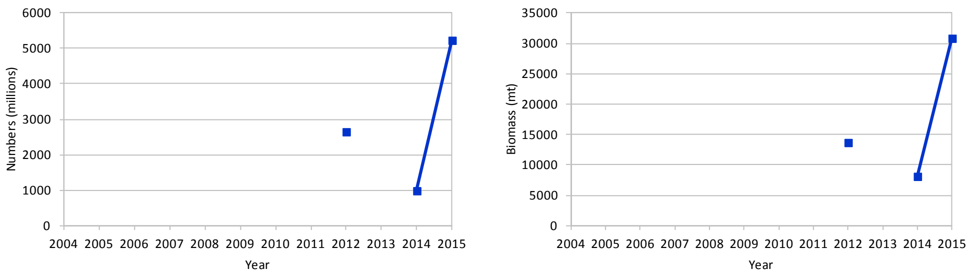
5.2.4.5.2 Anchovy

The acoustic estimates by coherent post-strata in the autumn 2015 survey are given in Ramos *et al*. (2015b, WD). Estimates for the whole surveyed area along the available series are shown in Figure 5.2.4.5.2.1. Gulf of Cadiz anchovy abundance and biomass in autumn 2015 were of 5227 million fish and 30 827 t, the highest values within its short series. Spanish waters concentrated 97.8% (5113 million) and 95.7% (29 491 t) of the total estimated abundance and biomass respectively. Portuguese estimates amounted to 115 million and 1335 t only.

Although there are no age-structured estimates still available for the 2015 survey, recruits (age 0 fish) may be assumed as those fish belonging to size classes ≤ 10 cm. By assuming this, this population fraction was estimated at 3816 million fish and 18 122 t, 73% and 59% of the total population abundance and biomass respectively (Table 5.2.4.5.2.1). Spanish waters concentrated 98% of the juveniles in the Gulf, both in number (3756 million) and biomass (17 920 t). Given the shortness of the series it would be too risky to advance that this 'historic' maximum corresponds to a good recruitment scenario. Notwithstanding the above, these estimates induce to optimistically perceive the present situation when they are compared with the estimates from previous years.

Table 5.2.4.5.2.1. Anchovy abundance (million fish) and biomass (tonnes) for *ECOCADIZ-RECLUTAS* time-series. Estimates of abundance and biomass of Age 0 fish are between parentheses. For 2015 there are no age-structured acoustic estimates available. In this case fish ≤ 10 cm was considered as a proxy of age 0 fish.

Estimate/Year	Total population (Age 0 recruits)		
	2012	**2014**	**2015 (≤ 10 cm)**
Biomass (t)	13 680 (13 354)	8 113 (5 131)	30 827 (18 112)
Abundance (million)	2 469 (2 619)	986 (814)	5 227 (3 816)



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

5.2.4.6 Other fish species

Information on the spatial distribution (sA maps) of other fish species is detailed in Ramos *et al*. (2015b, WD). No acoustic estimates from these species are yet available for this WG.

5.2.4.7 Other observations: mammals and birds

No census of the occurrence of apical predators was carried out during the survey.

5.2.4.8 Sardine and anchovy egg distributions from CUFES sampling

No CUFES sampling was carried out during the survey.

5.2.5 BoB autumn survey

5.2.5.1 Trawl species composition

Figure 5.2.5.1.1 is showing the catch composition from the pelagic trawl hauls, either performed at surface and middle waters (i.e. mainly targeted on juvenile anchovy) or bottom. In open waters, mictophidae and juvenile anchovy are the most important species. On the contrary, sardine was almost absent, being only caught in one single haul.

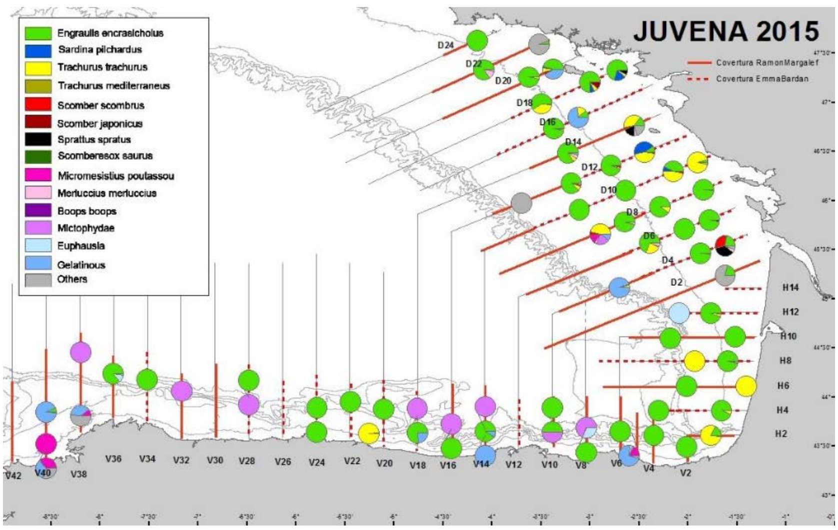


Figure 5.2.5.1.1. Trawl species composition during Juvena 2015

5.2.5.2 Anchovy and sardine distributions derived from NASC

Due to special characteristics of the Juvena survey, maps are provided for both, juvenile and adults. Figure 5.2.5.2.1 shows those corresponding to anchovy. Contrary to the main distribution area found in spring, adults were mainly located in the northern part, with some spots in the main spawning area located round the Garonne area. Most of the juveniles located in the Cantabrian Sea occurred in offshore; together with this , juveniles were also found on the French continental shelf, and in the northern coastal waters.

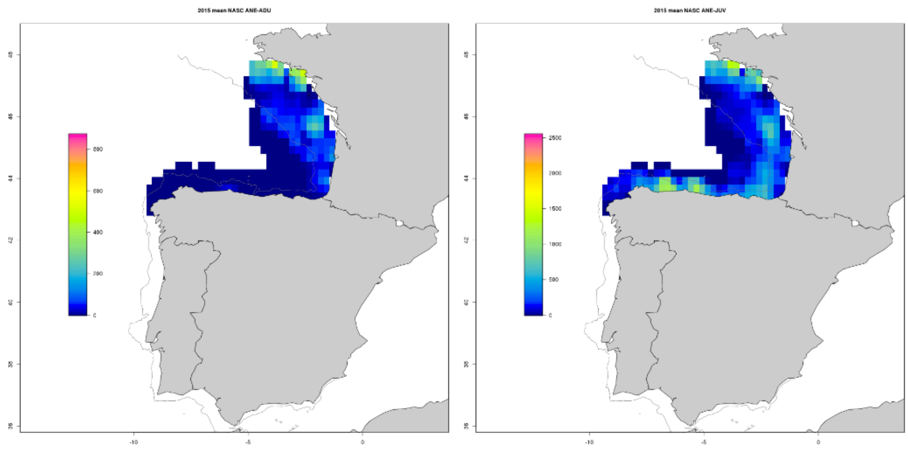


Figure 5.2.5.2.1. Average anchovy adult (left) and juvenile (Wright) abundance and distribution derived from NASC raw values. Colour scales are different.

Only the distribution area for anchovy has been estimated. This was the second largest record in the time-series (2003-15), but lower than that estimated in 2014 and close to that observed in 2010 and 2011 (figure 5.2.5.2.2).

Figure 5.2.5.2.2. Year positive area of juvenile anchovy estimated at Juvena time-series (2003–2015).

Sardine records were scarce and hence, its distribution area, with a very low density, is also located in the northern part (South Brittany). The most noticeable is the lack of juveniles out from this area, especially in the Spanish waters. Figure 5.2.5.2.3 shows the distribution area derived from the average block.

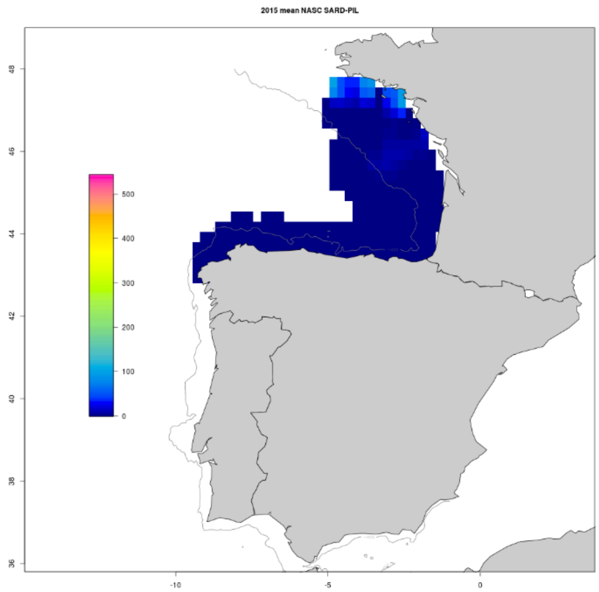


Figure 5.2.5.2.3. Average sardine abundance and distribution derived from NASC raw values.

5.2.5.3 Anchovy mean length and abundance

Figure 5.2.5.3.1 shows the evolution of the mean length and biomass estimates of juvenile anchovy in Juvena. The estimated biomass, although well above the historical mean, is lower than that estimated in 2014. Biomass and mean length seems to follow opposite trends, thus lower mean size is expected at higher biomass. As explained for the adults, this fact, which could be a consequence of a density-dependence relationship, has not been yet studied. Besides, the size of the positive area is directly related with biomass.

Figure 5.2.5.3.1. Biomass estimates and anchovy mean length (cm) in Juvena time-series (2003–2015).

5.2.5.4 Other observations: mammals and birds

Common dolphin was the most abundant marine mammal sighted during Juvena. In contrast to the situation observed in spring, fin whale was the second species most sighted (60 individuals). Regarding seabirds, northern gannet was the most abundant.

5.2.6 English Channel/Celtic Sea autumn survey

5.2.6.1 Trawl species composition

Figure 5.2.6.1.1 shows the catch composition from the pelagic trawl. Sardine, sprat, mackerel, and horse mackerel were the most abundant fish species. Jellyfish were also important. Fish occurred in large schools even in the deeper offshore waters of the western and central parts of the Bristol Channel

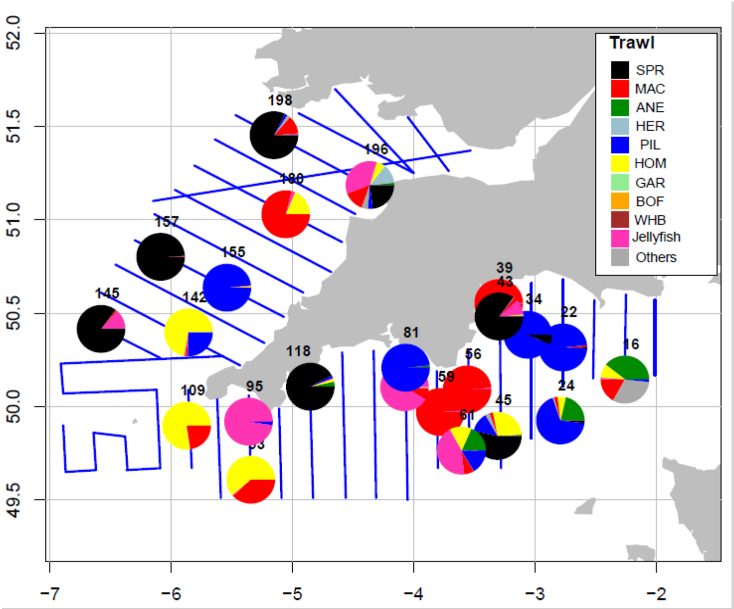


Figure 5.2.6.1.1. Trawl species composition during Peltic 2015

5.2.6.2 Anchovy and sardine distributions derived from NASC

Figures 5.2.6.2.1 and 5.2.6.2.2 show the anchovy and sardine distribution maps derived from the mean NASC. As in 2014, anchovy was found in large numbers in the western English Channel, this time extending further west than observed in previous years. Noticeably in this area were the larger number of 2 year-old (and older) specimens than in previous years. This year for the first time, anchovy was also observed in the inner Bristol Channel, where the predominantly smaller specimens were mixed with several other small clupeids in what is clearly an important nursery area.

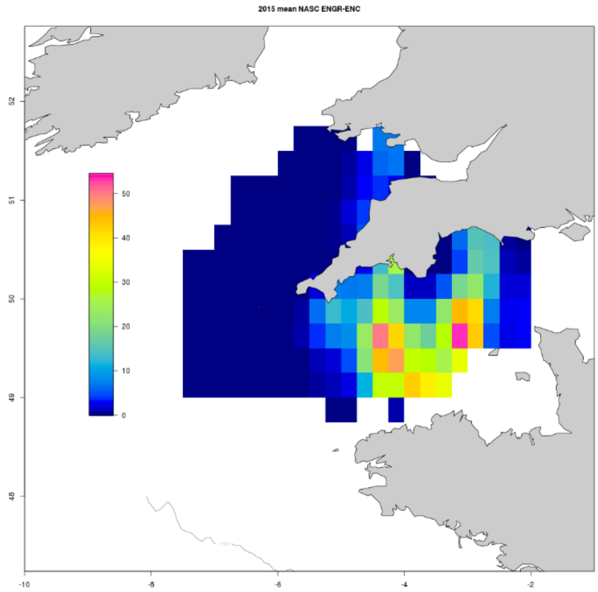


Figure 5.2.6.2.1. Average anchovy abundance and distribution derived from NASC raw values.

Sardine numbers also appeared to have increased, as has their distribution. 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 contrast to 2014, very few large specimens (> 20 cm) were present in the trawls. In the Bristol Channel sardine appeared to be concentrated in 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 in both magnitude and distribution although in 2015 for the first time (small numbers of) eggs were also observed in the Bristol Channel.

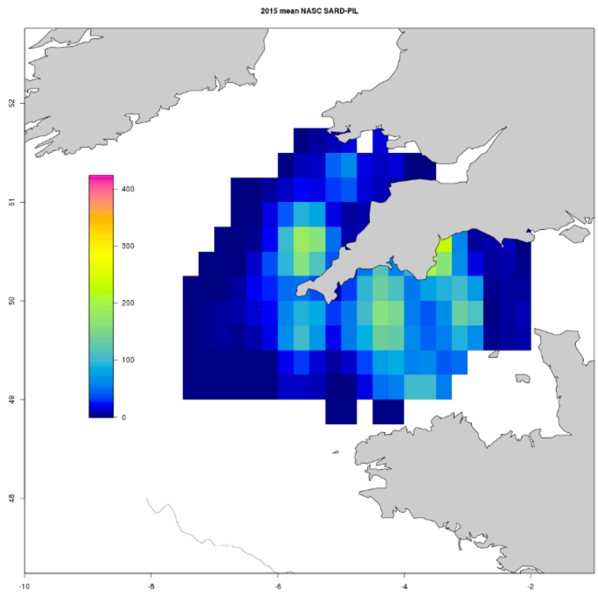


Figure 5.2.6.2.2. Average sardine abundance and distribution derived from NASC raw values.

5.2.6.3 Other fish species

Mackerel

Mackerel distribution is shown in Figure 5.2.6.3.1 Although mackerel were observed throughout the survey area, both in and offshore, highest densities were found in the western parts of the English Channel and Bristol Channel and particularly around the Isles of Scilly. Young of the year made up more than half of the mackerel population in the area.

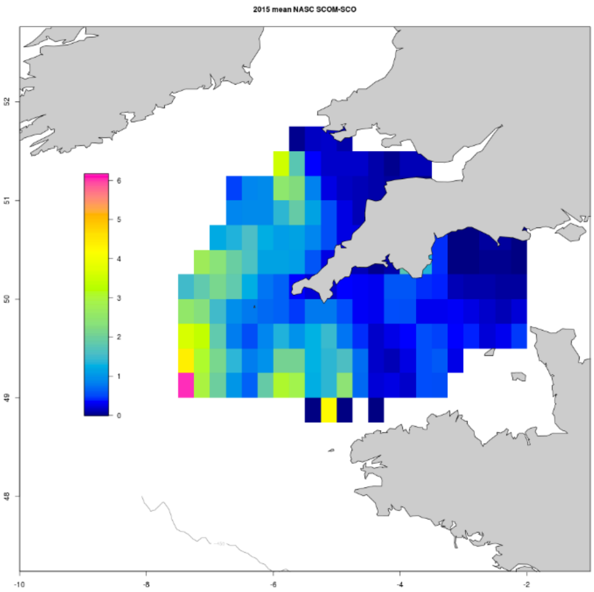


Figure 5.2.6.3.1. Average mackerel abundance and distribution derived from NASC raw values.

Horse mackerel

Horse mackerel distribution is shown in Figure 5.2.6.3.2 Horse mackerel were prevalent in the survey area although they dominated the offshore areas of the western Channel and around the Isles of Scilly. To distinct modes were observed in the length data, one at around 10cm and one at 15cm, generally associated with 0 and 1 year old fish.

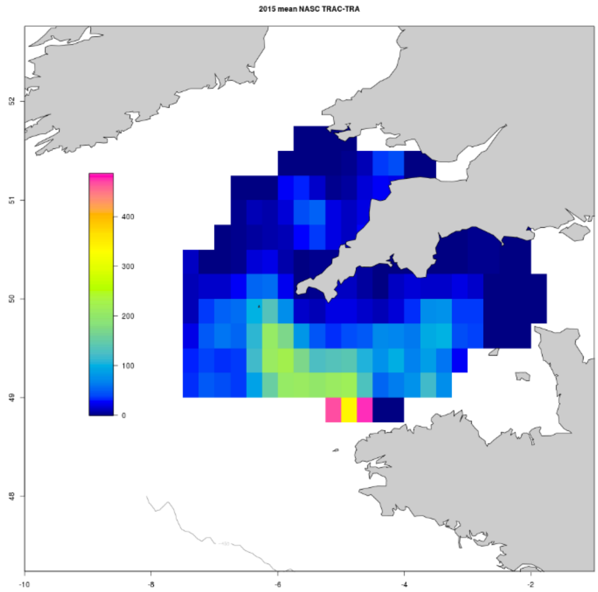


Figure 5.2.6.3.2. Average horse mackerel abundance and distribution derived from NASC raw values.

Herring

Herring distribution is shown in Figure 5.2.6.3.3 Main area was located close to the Bristol channel

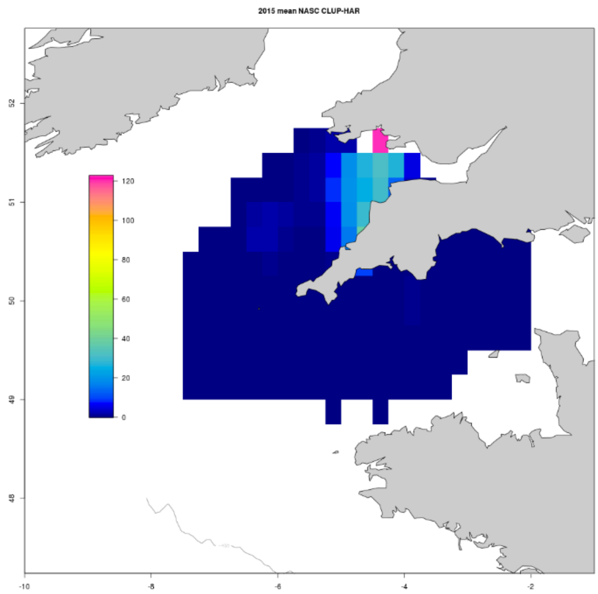


Figure 5.2.6.3.3. Average herring abundance and distribution derived from NASC raw values.

Sprat

Sprat distribution is shown in Figure 5.2.6.3.4. Western English Channel sprat was distributed further west than the traditional Lyme Bay region and was found also in good numbers in coastal waters off Plymouth. In the Bristol Channel, the usual small but dense surface schools stretched for many miles along the coast in the inner parts. In addition, this year very large schools were also prevalent in the deeper (> 80 m) offshore waters of the western and central parts of the Bristol Channel, which appeared to be associated with several aggregations of feeding fin whales. In contrast to the sprat in the western Channel which consisted of predominantly adult specimens (age 1-3), in- and offshore sprat in the Bristol Channel were predominantly age 0 (with a unimodal length distribution around 8 cm). Given the consistent occurrence of these very large juvenile sprat aggregations in this area, it is clearly an important nursery area.

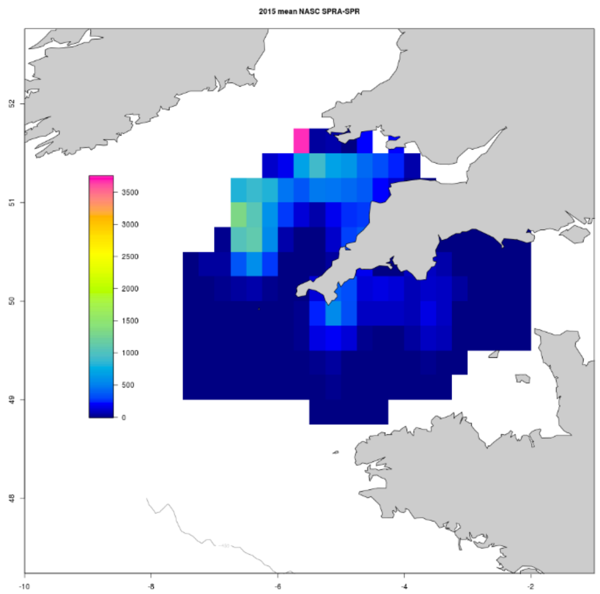


Figure 5.2.6.3.4. Average sprat abundance and distribution derived from NASC raw values.

Boarfish

Boarfish distribution is shown in Figure 5.2.6.3.5. It mainly occurred in the inner part of the Bristol Channel in a very low density.

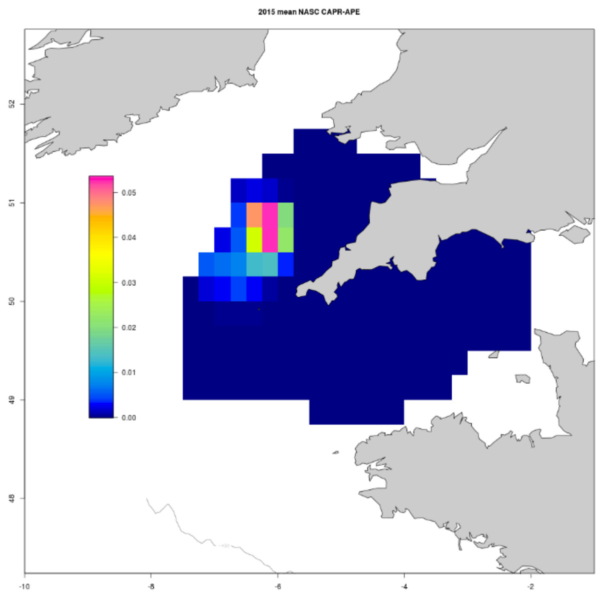


Figure 5.2.6.3.5. Average sprat abundance and distribution derived from NASC raw values.

6 Revisions to the work plan and justification

No changes in the work plan were proposed.

7 Next meeting

Next meeting of WGACEGG (joint meeting WGACEGG-MEDIAS) will be held in Capo Granitola, Italy, from 14 to 18 November 2016.

8 Annexes

Annex 8.1. List of participants

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Annex 8.2. Recommendations

Recommendation	Adressed to
1. To attain higher precision in the estimates for adult parameters (in particular batch fecundity and spawning fraction) the Group recommends that an effort is made in order to increase the number of fish samples for sardine during the DEPM surveys (including from commercial sources) and during the acoustic surveys if concurrent to DEPM sampling.	AZTI, IEO, IPMA
2. In order to produce an egg abundance index for sardine for the years without a dedicated DEPM, the Group recommends that (extra) samples could be obtained (used) from: (i) CalVET and Bongo nets during HOM and MAC EPMs 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.	AZTI, IEO, IPMA
3. With the aim of developing egg indices for sardine and anchovy using CUFES samples it is requested that: (i) CUFES eggs may be staged; (ii) vertical stratified sampling may be conducted opportunistically (but covering regions with distinct water column structure) during surveys for developing models which permit abundance estimates from CUFES that may represent the densities in the whole water column.	AZTI, IEO, IPMA
4. Since a number of small anchovy collected during the 2015 surveys in the BoB were visually classified as immature fish and later through histology confirmed as taking part in the active spawning fraction of the population it is considered important to study in more detail the macro *vs.* micro maturity classification for the BoB anchovy and the eventual implications of a misidentification for SSB estimation. It is recommended that a (two day) workshop may be set up in order to address the relevant issues	AZTI, Ifremer
5. For inter-calibration of egg staging and POFs readings it is thought important that an exchange of sardine and anchovy eggs and histology slides may be organized between institutes	AZTI, IEO, IPMA
6. As no consensus was found to explain the large discrepancies observed between acoustics and DEPM biomass estimates in 2015, it is recommended a workplan which should take into account among other things direct comparison with the same post-stratification; the regional variability of daily fecundity parameters; or the effect of the large amount of small juveniles on both methods.	AZTI, IEO, IPMA
7. In order to investigate the possible influence of the TS-depth dependence on the acoustic estimates, it is recommended to analyse the differences in school depth, specially for sardine.	AZTI, IEO, IPMA
8. Given the lack of a common TS/length relationship list for the same species, it is recommended further studies on TS for the main target species in order to unify them	AZTI, IEO, IPMA

Annex 8.3. Agenda

DATE	TIME	PLENARY/ SESSION 1	SESSION 2
16Nov	9:30	**Opening and general issues** Adoption of agenda ToR and Work Plan revision Informations	
	10:00	**WGACEGG general business** Report structure (assignment of tasks, deadlines) Survey protocols (submission to SGSIS PS) Grid maps Next meeting (link to WGHANSA)	
	10:45	Coffee	
	11:00	**Surveys reporting (ToR a, c)** DEPM Anchovy BoB – BIOMAN, 2015 Sardine IB – PT-DEPM-PIL, SAREVA, SP, 2014	
	13:00	Lunch	
	14:30	**Surveys reporting (ToR a,c)** Acoustics Spring (9a, 7c,b,a) PELAGO, 2015 PELACUS, 2015 PELGAS, 2015	
	16:30	Coffee	
	17:15	Discussion/Group Work	
	18:30	End Session	
		DAY 2	
17Nov	9:00 11:30	Acoustics Autumn PELTIC, 2015 (area 7) JUVENA 2015 Assessment results (WGHANSA, June15) Anchovy Sardine Coffee **Other presentations/General info (ToR a)** AtlantOs update, Workshop – WKSCRUT	
		Lunch	
	13:45	Discrepancies acoustics vs.DEPM – WGACEGG Work Plan Year 2	

		Anchovy Sardine	
	16:30	Proposal for Interreg Project – Mathieu *et al.*	
	17:30	**Other presentations:** Bottom-trawl survey Ifremer Acoustics, commercial vessels, IPMA	
		End of Session	End of Session
		DAY 3	
18Nov	9:00	P0 estimations for PIL from HOM/MAC egg surveys Anchovy GoC mortality, presented at FLC Spatial dynamics of juvenile anchovy in the BoB, AZTI Planning for joint manuscripts (subjects, where to submit, timings, assignment of work) **(ToR b, c)**	
	10:30	coffee	
	11:00	Report structure update writing/Group work	
	11:30	**Session on Acoustics** acoustic surveys to produce info for more species (e.g. HOM, WHB, BOC) **(ToR d)** target strengths research **(ToR d)** Survey protocols **(ToR g)** WGACEGG - Report common structure Joint publications	**Session on DEPM** **(ToR d)** Exploratory analyses (plan 2014 report): differences in length and other parameters in relation to fishing gear used for sardine contextualize the PIL DEPM results in relation to the annual reproductive cycle, (2013-2014, and series) Gulf of Cadiz anchovy on POFs analyses mean historic values of sardine spawning fraction per strata (taking into account population structure)vs.estimates from each surveys and to explore S according to population age structure, daily time of fishing, gear, number and size of samples, in order to check potential biases explore the information available on within season variability of P0 estimation developments on mortality estimation for sardine and GoC anchovy CUFES for egg P0 indices (ANE, PIL) **(ToR g)** test the application of DEPM to estimate biomasses per age for sardine and GoC anchovy 2014 historic series fluctuations of SSB and all DEPM parameters considering population structure and environmental variability Survey protocols **(ToR g)** WGACEGG - Report common structure

			Joint publications
	13:00	Lunch	
	14:30	Subgroups – Interreg proposal	
	15:30	Survey planning 2016 **(ToR f)**	
	16:00	Asses developments in technologies and data analysis for providing MSFD indicators and survey-base operational products for stakeholders **(ToR f)**	
	16:30	Planning year 3 work Deliverables Work with MEDIAS	
	17:30	Group work in subgroups Report writing	Group work in subgroups Report writing
	18:30	End of Session	End of Session
		DAY 4	
19Nov	9:00	Plenary session: undergoing work report writing bench mark meetings preparation issues	
	10:00	Group work in subgroups Report writing	Group work in subgroups Report writing
	13:00	lunch	
	14:30	Group work in subgroups Report writing	Group work in subgroups Report writing
	17:30	Plenary session: Report ToRs, recommendations, Planning workshops, WGALES, conferences, etc Work by correspondence	
	18:30	End of Session	
		DAY 5	
20Nov	9:00	Report ToRs, recommendations, Next meeting	
	10:30	Coffee	
	11:00	Report writing	
	12:30	End of meeting	

Annex 8.4. Developments in acoustics

Work in progress in TS measurements has been presented by Ifremer. During last WG meeting, a first attempt for measuring TS in *ex-situ* conditions has been presented. This device, a combined ROV with an open codend trawl called EROC-ENROL, in which the ROV is equipped with a 70 kHz split transducer and a video camera. Together with this *ex-situ* TS measurements, a study on the shape and volume of the swimbladder in order to determine the acoustics properties has been also undertook.

Promising results are being obtained with the EROC-ENROL, and this can be combined and compared with those obtained using other methods such as models or true *in situ* or cage experiences. In relation with no controlled conditions, as the fish are being measured when they are passing through a fishing gear, behaviour is necessarily different with that expected in natural conditions. Packing and specially tilt angles would be different from exhibited in non-stressed situations. A high reduction in tilt angle variability is expected and therefore, TS measurements, although real, would not reflect, thus bias, the mean TS, which is the one used for assessment purposes. On the other hand, making measurements at different depth would give a relation between TS/depth, which could be relevant to the accuracy of the assessment. However, the calibration of the acoustic equipment is still a challenge, as it has to be done at the working depths of the ROV.

Within the project Tomofish, Ifremer has measured the swimbladder volume in order to model the TS accounting tilt and frequency influence. Three kind of model has been simulated, KRM, prolate spheroid and finite elements. Fish were stored in captivity and the analysis has been done on those individuals which have not released bubble after death (i.e. had inflated swimbladder). Once obtained three-dimensional images in special those from the swimbladder, these have been used to produce the models simulating a great variety of tilt angles. Finally, these models will be compared with those measurements obtained both in in-situ and in ex-situ conditions.

Given the lack of conclusive results, the WG decided not to change, for the time being, the TS/length relationships until these works were consolidated.

Together with these studies, a sensitive analysis on TS/depth dependence has been done by Ifremer (Doray, WD). According to the available information on models that take into account a depth correction for anchovy and for herring, results on biomass estimates for anchovy and sardine obtained during the PELGAS surveys carried out in 2011–2015 (excluding 2013) have been re-evaluated according to the mean depth of the fish schools. To do that, the mean depth school was derived from the mean trawl depth from those ground-truth fishing hauls done during these surveys. From these exercises it should be noted that the choice of the b20 parameter is crucial as these parameter would explain most of the differences between biomass estimates for both species. Nevertheless, the correction done using the specific works on anchovy yielded similar results, thus without significant differences when applying the mean TS as stated in the PELGAS protocol or the TS/Depth model based on anchovy Accordingly, the anchovy depth distribution variations does not seem to be related with anchovy biomass variations.

Finally, the major findings and conclusions extracted from the ICES Workshop on scrutinisation procedures for pelagic ecosystem surveys (WKSCRUT) have been discussed. Although ground-truth fishing stations and multifrequency analysis are routinely used during the scrutiny process of the echograms, thus aiming at to increase the objectivity for allocation of the backscattering energy into the different fish species, scrutinisation is still heavily dependent on the expert knowledge. Major concerns are dealing with those untrawlable areas; the criteria on how to choose fishing stations to allocate NASC from non-trawling tracks or echotrace to a particular species (i.e. NDD criteria, image analysis…); results from a judgment of the gear catchability; and in the analysis of the frequency response in a multispecific context. All these issues require a decision-making process, which, for the time being, is difficult to implement without the criteria of the expert staff. On the other hand, the use of ancillary variables such us presence/absence of egg from CUFES and also oceanographic variables improve the scrutinisation decisions.

Annex 8.5. Developments in DEPM

8.5.1. Sardine Egg Production estimation using samples from horse mackerel and mackerel EPMs, 2007, 2010, 2013

Paz Díaz, A. Lago de Lanzós, , C. Franco, E. Henriques and MM Angélico

IPMA, IEO

Assessment models used at present for the sardine Atlantic-Iberian stock (WGHANSA) corroborated difficulties in dealing with two series of survey data collected with distinct periodicity. The spring acoustics surveys take place every year while the DEPM surveys are conducted on a triennial basis. In order to produce information on SSB (or Egg Production) estimation for the years without sardine dedicated DEPM it was decided by the Group (IPMA and IEO) in 2014 that the availability of egg samples/data from mackerel and horse-mackerel egg surveys would be investigated and tests towards egg production estimation would be initiated considering the more recent years.

The information gathered for the period 2007–2013 is summarized in Table 8.5.1.1. It is worth noting that the sampling grid and the plankton gear used for AEPM and DEPM surveys differ (see WGMEGS reports). During DEPM surveys a CalVET system is used (vertical hauls providing smaller water volumes), along a grid with higher spatial resolution, while during AEPM campaigns the hauls are further apart but are carried out with Bongo nets (oblique tows, higher volumes of water filtered). For some surveys, the sardine eggs were not yet staged and therefore the laboratorial work had to be completed for the present analyses.

Table 8.5.1.1. Survey information

Year	Survey	Institute	Gear and Mesh size (µ)	Nb. stations	Nb. eggs
2007	HOM-DEPM07-PT	IPMA	CalVET25 150	384	5369
2010	HOM-DEPM010-PT	IPMA	CalVET25 150	414	3018
2013	HOM-DEPM013-PT	IPMA	CalVET40 250	222	6919
2007	CAREVA 0307	IEO	Bongo40 250	98	5215
2010	CAREVA 0310	IEO	Bongo40 250	107	4818
2013	JUREVA 0413	IEO	Bongo40 250	101	1440

The first set of tests that were performed aimed at assessing eventual differences in the estimations related to the differences in the survey design and sampling gear/operation.

Moreover, for the IEO DEPM surveys 2008-2011-2014, it was decided to carry out an analys with a smaller number of samples selected as if an AEPM design had been adopted. The results using the sparser grid of stations (approximate to a AEPM grid) showed estimations of daily egg production (eggs/m²/day) similar to those obtained with the total number of samples collected (e.g. in 2008 the daily egg production estimated for the total number of samples was 156 eggs/m²/day and 189 eggs/m²/day for the samples selected).

Since it was shown that AEPM and DEPM data could be used to obtain comparable and coherent egg production estimation the next step was to solve questions related to hauls effective area estimation and spawning area delimitation (some surveys did not cover the whole expected spawning area). The information compiled allowed preliminary egg production estimations that are presented in Figure 8.5.1.1. Analyses were performed following the regular DEPM procedures and showed that for the 2007–2013 period it is possible to fill in some of the data gaps. However, further analyses need to be carried out in order to re-assess spawning area estimation and consider egg production by strata and attempt SSB calculation using adult parameter mean values. A WD will be prepared for the benchmark preparation meeting, which will take place in September 2016. The availability of egg data from AEPM surveys for other years prior to 2007 will be explored. And alternative data for egg production estimation will also be considered using CUFES surveying.

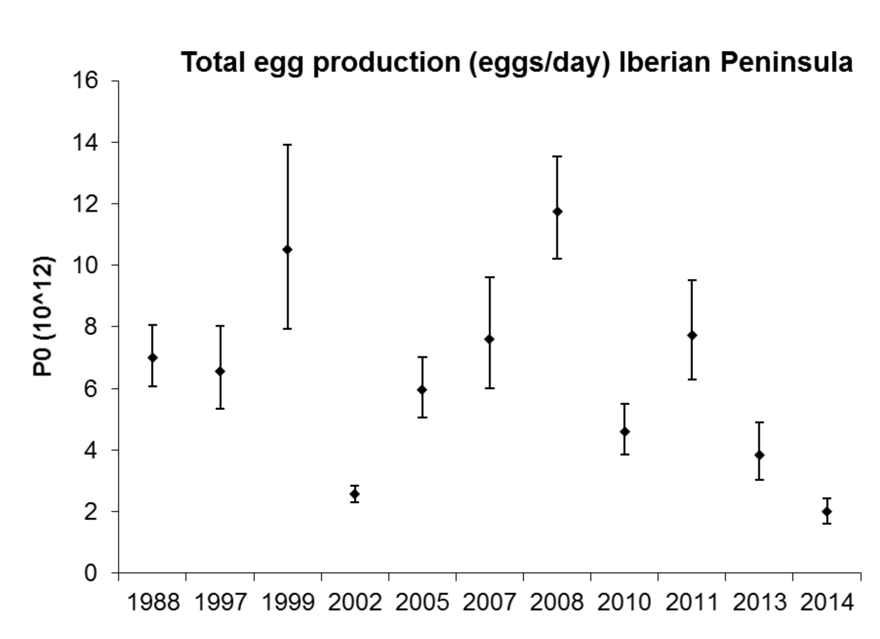

Figure 8.5.1.1. Egg Production estimations using data from EMPs in 2007, 2010, 2013 for the whole Atlanto-Iberian stock (ICES areas 9a, 8c).

8.5.2. Developments on anchovy egg mortality estimation

Implementing an external egg mortality model to estimate egg production for anchovy in the Gulf of Cadiz

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Introduction

Fish egg mortality is a relevant parameter for ecological studies and it is also required to estimate egg production by the Daily Egg Production Method (DEPM), with a consequent effect on the Spawning-stock biomass (SSB) estimation.

Daily egg production (P_0) and mortality (z) rates are estimated by fitting an exponential mortality model to the egg abundance by cohorts and corresponding mean age.

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

E[P]: density of eggs per age

P_0: rate of egg production (eggs/day/area)

Z: rate of mortality

Several issues relating to surveying and/or to the analytical procedures may affect DEPM applications. A common problem for many species and surveys around the world, and also noticed for the Gulf of Cadiz anchovy (**Table 8.5.2.1**), are spurious, positive or nearly positive, estimates of egg mortality.

Table 8.5.2.1. Mortality values estimated for anchovy eggs in the Gulf of Cadiz, during the DEPM survey series.

Year	Z (eggs hour^{-1})	Z (eggs day^{-1})	Pr(> |t|)	CV (%)
2005	-0.00164	-0.03941	0.213	79.6
2008	-0.05752	-1.38048	0.00139**	30.2
2011	-0.01227	-0.29448	0.382	113.8
2014	-0.01389	-0.33336	0.291	94.2

In order to overcome these often unreliable estimates from single surveys a possible solution is to reach mean estimates by aggregating data from various years and/or try to find other variables (e.g. environmental) which may assist in defining a more robust mortality modelling process (Bernal *et al.,* 2011).

The present work aims at compiling all available (staged) egg data for the Gulf of Cadiz anchovy and develop alternative mortality model(s) using mean estimation and including external variables (temperature and geographical stratification).

The present results highlight the first attempts of a work in progress towards developing mortality modelling approach for the Gulf of Cadiz anchovy based on compiled data with the objective of attaining yearly estimations in a more robust manner. Further progress will allow more coherent mortality rate calculation and may also consequently reduce bias and imprecision in SSB estimation.

Material and methods

The samples and dataset

Data on abundances by development stage were obtained from the IEO database from several research surveys carried out in waters of the Gulf of Cadiz in 2005–2014 (Table 8.5.2.2). A total of 17 601 anchovy eggs were classified into the 11 stages described by Moser and Ahlstrom (1985). For each sample the information on water temperature, sampling depth and location was also recovered.

Table 8.5.2.2. Overall information about sampling in each series of surveys.

Survey Series	Period	Sampler	Haul type	Mesh size (µ)	Number samples	N. staged eggs
GOLFO	June 2005, 2006, 2007; July 2006, 2007	Bongo-40	double oblique	200	89	9536
STOCA	July 2009, 2010	Bongo-40	double oblique	200	15	1351
DEPM	June 2005, 2008, July 2011, 2014	PairoVET	vertical	150	258	6714

Two spatial strata were defined on the basis of the regional oceanography and anchovy population structure. The limit was established in Cape Sta. Maria (Figure 8.5.2.1). Stratum 1 corresponds to Algarve and stratum 2 to Cádiz.

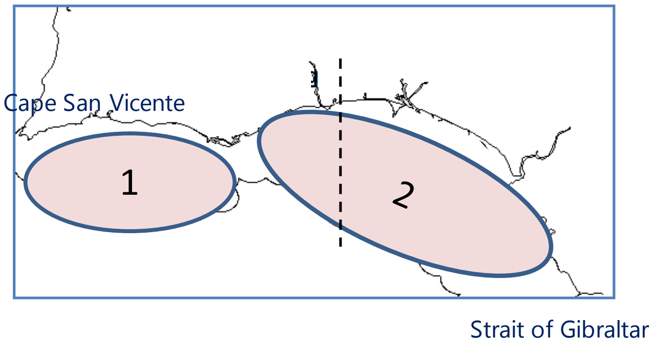

Figure 8.5.2.1. Gulf of Cadiz. Spatial strata defined to estimate Anchovy egg parameters. Dotted line indicated the limit of the division.

The process

In the DEPM, estimates of egg age and mortality are required to convert egg abundance into egg production.

The basic model relating observed egg abundance to production is a variation of a simple population growth model equation $D_a = D_0e^{(-ma)}$ reformulated as a generalized linear model (GLM). Estimates of both D_0 and m are obtained by fitting the mortality curve to the sampled density of eggs classified into cohorts.

E[Na] = g^{-1}(offset(log(Efarea)) + log(D0) − ma) (1)

E [Na] = expected number of eggs in a cohort of mean age a

D_0 = 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 offset term contains the logarithm of the effective area, which accounts for differences in volume or sampling depths between stations (ICES, 2004; Stratoudakis *et al.*, 2006).

The process to estimate mortality and egg production includes three steps:

1) *Estimation of daily cohort abundances by age*.

To achieve this, the aggregated dataset is used to estimate first the egg age, and then fix the spawning peak to define the daily cohorts and group the eggs into daily cohorts, estimating cohort's abundance and mean cohort age for all stations. Finally two cut points (lower and upper) were defined to eliminate bias coming from the tails.

Egg ageing is performed by the multinomial Bayesian approach described by Bernal *et al.* (2008) and using in situ SST;

p(age ∣ *stage, temp, time)*	*a p (stage* ∣ *age, temp)*	*p (age* ∣ *time)*
ageing	development model	synchronicity

Distribution of the daily spawning cycle was assumed as a normal probability distribution, with a peak at 22:00h GMT and a standard deviation of 2h. The upper age cutting limit was determined using a maximum age for the strata considered and it not dependent on the individual stations. The lower age cutting excluded the first cohort of stations in which the sampling time is included within the daily spawning period.

2) Egg mortality model fitting

The mortality curve (Equation 1) is fitted to the aggregated data using a Generalized Linear Model (GLM) assuming a negative binomial distribution. The general model is extended to allow both egg production and mortality to vary between spatial strata and temperature (Bernal *et al.*, 2011).

E[Na] = g^{-1}(offset(log(Efarea)) + Strata + Temp + Strata :Temp + age + Strata :age + Temp: age) (2)

Stepwise backward model selection was carried out from this model, using the likelihood ratio test. At each step, the term with least significance (< 5%) was dropped, and this procedure was repeated until dropping terms led to no improvement. A comparison with Akaike information criterion (AIC) profiles of the model selection procedure was also performed.

The ageing process and the GLM fitting were iterative until the value of z converged.

3) Estimate P_0 by DEPM years using the external model

Although the model described above can provide egg production and mortality, the approach described by Bernal *et al.* (2011) was adopted. The estimates of mortality obtained independently from the fitting process for the egg production model are used to estimate daily egg production for each DEPM survey. The estimate of daily egg production using Equation (1) is simply the average of the observed egg densities corrected by the survival rate. The Equation (2) can be reformulated as

*glm.nb(formula = cohort ~ offset(log(Efarea) - death * age) - 1 + Strata, data, weights = Rel.area)* (3)

The offset now includes both the effective area and the correction attributable to survival:

*offset(log(Efarea) - death * age)*

Results and discussion

About the eggs

The most abundant development stages in the samples were II and VI (Figure 8.5.2.2). These stages have a longer duration compared with other stages, as indicated by the width of the fitted curves , according to the multinomial approach by Bernal *et al.*, 2012 (Annex). Stages I and XI are quick and their spatial distribution very patchy therefore scarce in the samples (1% in both cases). The frequently low abundances of these stages have implication during mortality curve fitting. Stage I was most abundant in the period 20-2 hours with a maximum peak registered at 22 hours (Figure 8.5.2.3).

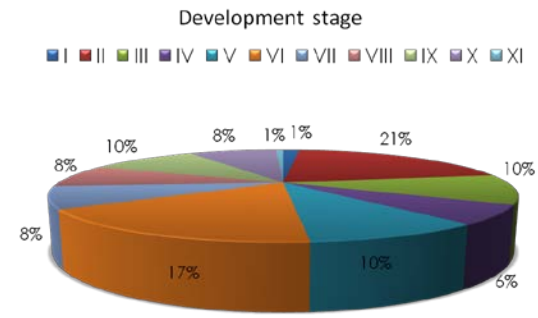

Figure 8.5.2.2. Proportion of anchovy eggs in samples by development stage by Moser and Ahlstrom (1985).

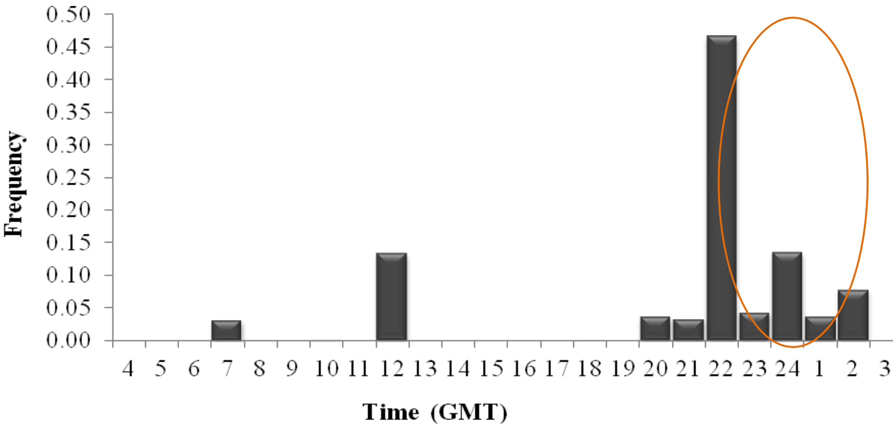

Figure 8.5.2.3. Frequency of occurrence of stage I egg in the samples along the day.

Daily cohort abundance by age

A frequent source of bias during mortality curve fitting arises from the observations at the tails of the abundance distribution and therefore lower and upper cut points are regularly defined. Here the upper age cutting limit is determined using a maximum age (dependent on the temperature) for the strata considered (Table 8.5.2.3 and Figure 8.5.2.4). The cut at the lower tail is defined as the limit where eggs were not fully spawned between (0 and 3 hrs). Figure 8.5.2.5 shows potential changes in mortality estimation due to variation in lower and upper cut points.

Table 8.5.2.3. Maximum temperature and maximum age by strata

Stratum	Max temp by strata	Max age by strata
Algarve	21.9 °C	37.6 h
Cádiz	23.4 °C	33.4 h

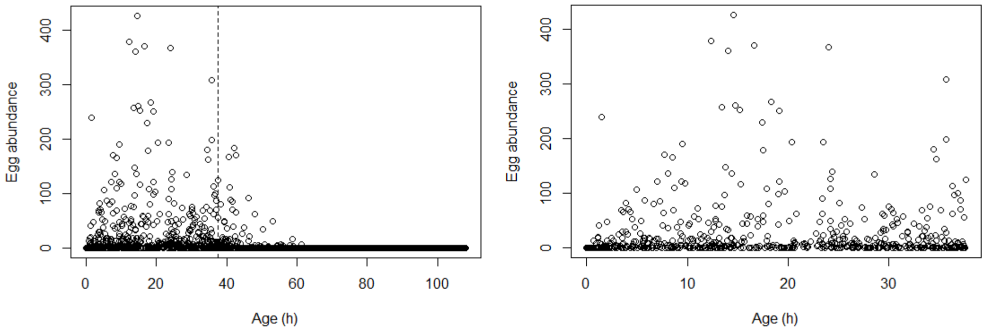

Figure 8.5.2.4. Egg abundance (egg m^{-2}) distribution by age. Before maximum age selection (left panel) and after maximum age selection (right panel). The dotted line is at 37.6 h (Table 8.5.2.3).

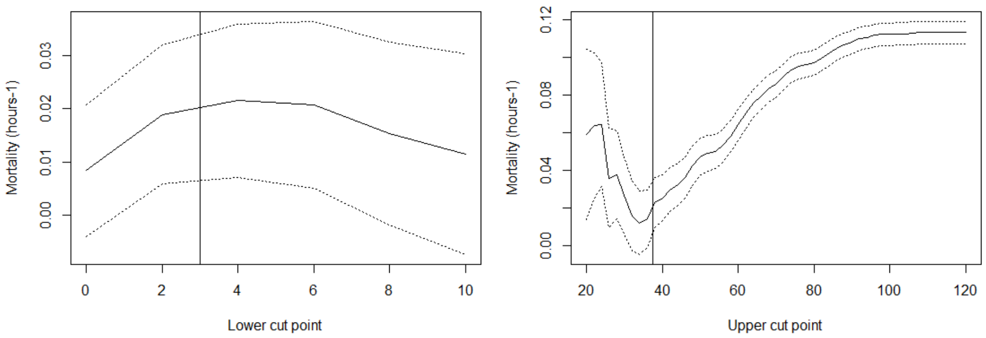

Figure 8.5.2.5. Mortality rate changes according to lower limit (left) and upper limit (right) cut points. The solid line represents the average mortality, while the dotted lines represent the confidence intervals (x-axis is given in hours).

<u>Mortality estimation: Model selection</u>

From the general full model three equally coherent models were selected (Table 8.5.2.4). The aggregation of data proved to be useful for the consistency of the estimations allowing statistically significant and biologically plausible mortality rates. Temperature and geographical stratification may improve model construction.

The daily mortality estimates obtained using the three models (Table 8.5.2.5) ranged from -0.42 to -0.72 within the limits found in the literature for the species (Table 8.5.2.6).

Table 8.5.2.4. Model selection after backward stepwise discard from the full model indicated in Equation (3)

Model	Term	Equation	AIC	Variance explained
1	Temp:age	Strata + Temp:age	4 032.1	97.3
2	Strata:age	Strata + age + Strata:age	4 031.7	97.3
3	age	Strata +age	4 030.0	97.3

Table 8.5.2.5. Summary of the selected model. Terms with age are associated with mortality, while the others are associated with egg production.

Model	Term	Estimate	Std. Error	P0 (eggs m⁻² day⁻¹)	Z (eggs day⁻¹)	Pr(>|z|)
1	Algarve	527 653	0.21399	195.7	-------	< 2e-16 ***
	Cádiz	539 972	0.16424	221.3	-------	< 2e-16 ***
	Temp:age	-0.00089	0.00032	-------	-0.42 (36)**	0.00621 **
2	Algarve	550 856	0.35576	246.8	-------	< 2e-16 ***
	Cádiz	540 055	0.17632	221.5	-------	< 2e-16 ***
	Algarve:age	-0.03014	0.01638	-------	-0.72 (54)	0.0658.
	Cádiz:age	-0.01943	0.00763	-------	-0.47 (39)*	0.0109 *
3	Algarve	534 800	0.21881	210.2	-------	< 2e-16 ***
	Cádiz	544 161	0.16337	230.8	-------	< 2e-16 ***
	age	-0.02142	0.00692	-------	-0.51 (32)**	0.00197 **

(▲estimation using temp 19.5°C)

Signif. codes: 0 '*' 0.001 '**' 0.01 '*'**

Table 8.5.2.6. Summary of *Engraulis encrasicolus* egg mortality rates (z) and daily egg production (P_0) from different studies.

Source	Year	P_0(eggsm⁻² day⁻¹)	Z (eggs day⁻¹)	Area
Present study	2005–2014	208.5	-0.42	Gulf of Cadiz
		234.2	-0.72/-0.47	
		220.5	-0.51	
Carvajalino 2011	1983–2008	93.9	-0.36	North area of NW Mediterranean
		67.4	-0.62	South area of NW Mediterranean
Santos *et al.*, 2008, 2011, 2013	2008	53.27	-0.32	Bay of Biscay
	2011	126.68	-0.3	
	2013	91.51	-0.21	
Palomera *et al.*, 2009	2008	55.67	-0.23	North area of NW Mediterranean
		24.53	-0.31	South area of NW Mediterranean
Somarakis *et al.*, 2004	1993	64.3	-1.09	NW Mediterranean
	1994	61.53	-0.47	

Future work includes re-analyses of the DEPM survey data using the external models developed in order to obtain egg production and mortality per survey and stratum.

Acknowledgements

A special thanks to Miguel Bernal, for making available some R routines and the useful help and comments about the daily egg production estimation methods and external mortality model.

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8.5.3. Sardine reproductive activity in 2013-2014 using samples from the commercial fleets

C. Nunes[3], A. Uriarte[1], I. Riveiro[2], M.M. Angelico[3], M. P. Jimenez[2], M. Santos[1], P. Carrera[2], P. Diaz Conde[2]

[1] AZTI, [2] IEO, [3] IPMA

The results obtained for all parameters estimated during the sardine 2014 DEPM survey were consistent and within the range of values estimated in previous surveys (see section 5.2.2, but considering that the Portuguese survey was conducted in 2014 later than usual, the group deemed important to analyse the reproductive activity during the survey and contextualize it within the 2013–2014 sardine reproductive season.

For that purpose, individual fish biological data collected regularly by both AZTI, IEO, and IPMA from the commercial fleet (from harbours of Hondarribia, Bermeo and Ondarroa for AZTI, Cádiz, Vigo, A Coruña and Santander for IEO, and Maosinhos, Peniche and Portimão for IPMA), within each national sampling programmne, during the period Jan. 2013-Dec. 2014 (Sept. 2014 for IEO and IPMA due to the purse-seine fishery closure) were used. The monthly evolution of the following variables were obtained for the females sampled:

a) the proportion of the different macroscopic maturity phases (results not shown)
b) the percentage of reproductively active fish (macroscopic maturity phases 3 and 4 for IPMA, and 3, 4, and 5 to IEO and AZTI)
c) the average gonado-somatic index (GSI), as the percentage of gonad weight over the fish gutted weight

The results show that during the surveys carried out by the three institutes, most of the female population was actively spawning (*ca.* 80% for both IEO and IPMA, no data available for AZTI; Figure 8.5.3.1). However, the results indicate that these survey periods did not correspond to the peak spawning during the 2013–2014 reproductive season, as the maximum number of active fish (≈ 100%) was observed by IEO and IPMA earlier in the season (December and January, respectively), the % having decreased significantly in February, and increased again to form a "second peak" when the surveys took place. Hydrated females were observed mostly in December for IEO, and December and April for IPMA. When the different areas were surveyed, the inactive fish were in a regressing/recovering/developing phase of the ovarian cycle, likely marking the end of the reproductive season for this fraction of the population. The evolution of the GSI corroborates the indication that peak spawning likely occurred previously to the surveys, as maximum GSI values were observed by IEO and IPMA, in December and January, respectively (Figure 8.5.3.2). Data from AZTI are not available for several months, restraining the analysis of the seasonal evolution, but the existent information suggests that most sardines were reproductively active during the Basque survey.

The analysis of the seasonal reproductive activity per subarea was similarly undertaken though more challenging, as data were no longer available for all months in each subarea. The existent information suggests that the "second peak" of spawning activity during IPMA survey was observed 1-2 months earlier off the South than off the West coasts, so that by the end of the survey, spawning activity seemed to start decreasing significantly on the South but was still high on the West (Figure 8.5.3.3). Similarly, for the areas covered by IEO, results suggest that spawning activity may have peaked earlier in the Gulf of Cadiz (November) compared to Galician and Cantabrian waters (December); area-stratified data do not allow to draw clear conclusions during the month exactly when IEO survey took place, but previous studies indicate that fish would be at the time actively spawning both in Cantabrian and Galician waters (e.g. Stratoudakis *et al.*, 2007)

In addition to the above analysis of the 2014 survey and corresponding reproductive season, the historical series of DEPM estimates show an interannual variability of the reproductive parameters estimated, with some years having been even characterized by unusual reproductive patterns, especially on the South and West Iberian coasts (e.g. 2011), and this variability is possibly related to varying population demography and condition, to contrasting/particular environmental conditions, and/or to surveys having taken place at relative different moments of sardine spawning seasons. Therefore, this type of analysis, as well as the assessment of the impact of the above mentioned factors on the estimation of the DEPM parameters, is noticeably important for a more thorough appraisal of the validity of the estimates obtained by the DEPM. The group thus agrees on that such type of assessment of the spawning activity of fish during the survey, and in the context of the population seasonal reproductive activity, be carried out routinely, at each survey year.

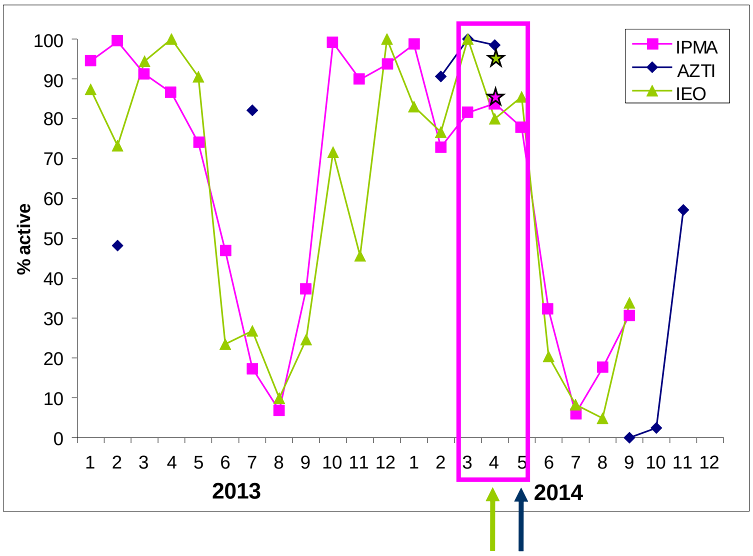

Figure 8.5.3.1. Monthly evolution of the percentage of reproductively active females obtained from the market samples collected by each of the institutes (macroscopic maturity phases 3 and 4 for IPMA, and 3, 4 and 5 to IEO and AZTI) during the period Jan. 2013 and Dec. 2014 (Sept. 2014 for IEO and IPMA due to the purse-seine fishery closure; data from AZTI are not available for several months). The pink rectangle locates the time during which the IPMA survey took place in 2014, whereas the green and blue arrows indicate the months when the IEO and AZTI surveys, respectively, were carried out. Comparatively, the pink and green stars correspond to the percentages of active fish estimated from the random females sampled during the IPMA and IEO surveys, respectively.

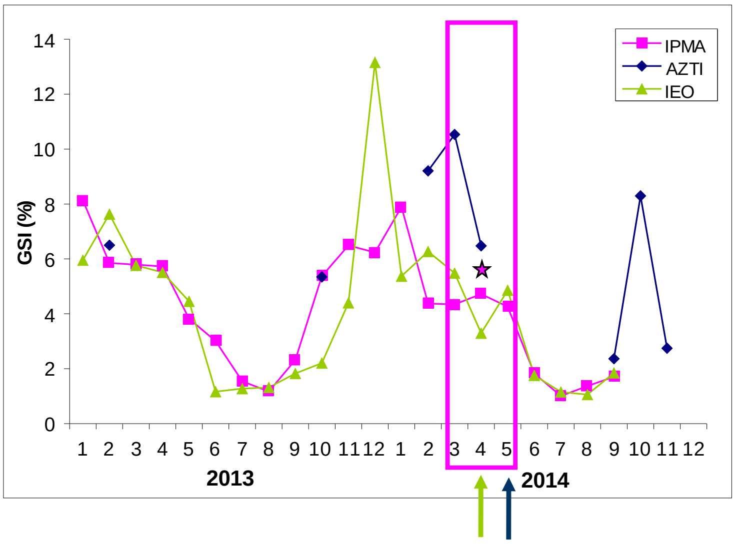

Figure 8.5.3.2. Monthly evolution of the female mean gonado-somatic index (GSI) obtained from the market samples collected by each of the institutes during the period Jan. 2013 and Dec. 2014 The pink rectangle locates the time during which the IPMA survey took place in 2014, whereas the green and blue arrows indicate the months when the IEO and AZTI surveys, respectively, were carried out. Comparatively, the pink star corresponds to the GSI estimated from the random females sampled during the IPMA survey.

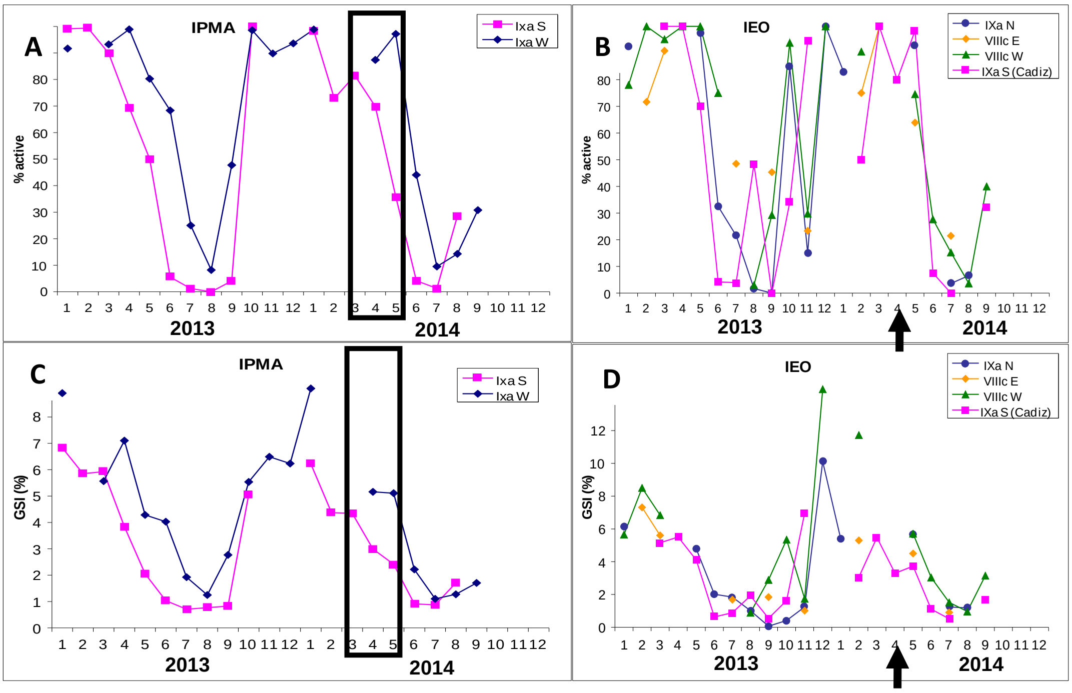

Figure 8.5.3.3. Monthly evolution, per subareas, of the percentage of reproductively active females (A and B) and of the female mean gonado-somatic index (GSI) (C and D) obtained from the market samples collected during the period Jan. 2013 and Dec. 2014 by IPMA (A and C: in pink: 9a South-Algarve and Spanish waters of the Gulf of Cadiz, in blue: 9a West) and IEO (B and D: in pink: 9a South-Spanish waters of the Gulf of Cadiz, in blue: 9a North, in green: 8c West, in orange: 8c East). The black rectangle locates the time during which the IPMA survey took place in 2014, whereas the black arrow indicates the month when the IEO survey was carried out.

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Annex 8.6. Acoustics and DEPM biomass estimations: comparisons, issues and plans for future work

Biomass estimations for sardine and anchovy derived from acoustics and DEPM surveying have shown considerable differences in some years of the series. This issue has been addressed by the Group in many occasions and has motivated dedicated exploration of the data for some specific years. During the 2015 meeting, the Group discussed in particular the differences in anchovy biomass estimation between the PELGAS and BIOMAN surveys in 2015. The discussions undertaken allowed listing of possible causes for the differences encountered in some years and promoted a work plan for further data investigation.

Possible causes for the differences in the biomass estimation by acoustics and DEPM:

- Time-lag between surveys

  The surveys are not entirely carried out simultaneously. For anchovy in the Bay of Biscay, the lag is restricted to one or two weeks but for sardine in the Iberian region, the lag can be as high as one or more months apart. Differences in fish distribution, reproductive phase and interval from recruitment may play a significant role, particularly in the latter case.

- Population structure and behaviour

  The structure of the population available during each survey may vary according to period of surveying and fish behaviour. The phase of the reproductive cycle affects the spatial and depth distribution of the fish, which in turn may have an impact on its availability for echosounding and trawling. In addition, the structure of the population if not completely captured by the surveying methods (both acoustics and DEPM) may lead to results of difficult interpretation. Fish distribution and behaviour are notably modified by the weather conditions; it is not uncommon to observe appreciable fish movements following events of stormy seas, which may also affect the reproductive patterns.

- Assignment of acoustic energy to species

  While the DEPM results derive from direct observations on fish eggs and ovaries, assignment of acoustic energy to species imply either a decision of the analyst on the school type or a partition of the energy based on the species composition of fishing hauls (sometimes in a number not as large as desired). In areas with significant species mixing and/or during periods of high plankton production the energy partition may be challenging. In addition depth corrected TS values may affect the estimations from surveys and the relative changes in biomass between years if they find contrasting bathymetrical distribution of fish.

- 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 distributions. This is particularly relevant when the data available do not allow estimations stratified by geographical area or population length (age) composition.

  The Group agreed to develop further studies in order to better understand the differences found in the estimates from acoustics and DEPM, in some years. Additional exploration of the data (for sardine and anchovy) may consider: (i) analyse fish spatial and depth distribution during surveys to be compared (i) use same regional stratification of the information for both survey types, (ii) calculate biomass estimation by age (length) for sardine, (iii) utilize CUFES data for egg production estimation and comparison to estimations undertaken for PairoVET data, (iv) discuss bias in energy partition for particular areas.

DEPM - Acoustics comparison (BIOMAN2015-PELGAS2015)

Differences between survey estimates

In 2015, the absolute estimates of anchovy biomass in the Bay of Biscay from the DEPM survey (BIOMAN) and Echointegration method (Acoustic-trawl, PELGAS) diverged largely. Although this is not the first time that these surveys diverge remarkably in the historical series, this year the difference is the largest in the series. It also happened in 1991, 2000, 2012, coinciding also with the presence of small anchovy.

Anchovy echotraces and egg distributions

The Main discrepancy in biomass was located around the Gironde estuary. In this area the acoustic survey recorded a big amount of echotraces of almost pure small anchovy, which have been corroborated by pelagic trawl hauls. Part of the small anchovies detected in the nursery area around the Gironde were in an earlier phase of maturation, not having yet arrived to spawning according to the acoustic survey, from a macroscopic maturity scales. Besides, the total number of eggs sampled by CUFES during this survey in the Gironde area indicated a relative decrease compared with last year. During the DEPM survey, although in a very low quantity either in vertical (PairoVET) or horizontal (CUFES) samplers, anchovy eggs were also found in that area. Fishing stations performed during this survey in the same area gave as well anchovy with 90 mm as mean length, which macroscopically seemed to be immature. After histology analysis, those were identified as mature and with spawning activity although with the lowest batch fecundity and spawning frequency comparing with the historical series.

Once scrutinized the echograms, the anchovy biomass estimated by echointegration in the Gironde resulted in a 55% of the total. For DEPM, although the areas were no strictly similar, only the 15% of the total biomass was estimated in that region.

Approaches

Two approaches, aiming at to explain such discrepancies, were discussed at the working group and summarized as follows.

- Anchovy TS-Depth dependence. This has been investigated in Doray (WD). The swimbladder produces at least 90% of swimbladdered fish. The swimbladder compresses with pressure at depth, which induces a decrease of the fish TS with increasing depth. Accordingly, any significant difference in mean depth of school among years would result in a bias in the final estimation. However, the analysis done on depth distribution interannual variability for the anchovy depth distribution per year based on 2011, 2012, 2014, and 2015 PELGAS surveys data, , showed moderate variability, which does not seem to be related to biomass fluctuations. In fact, the expected variability for this change would be close to only a 10%.

- The influence on DEPM estimates of the presence of very small fish around Gironde area. Those anchovies seemed immature macroscopically but after histological examination, they were actually mature though having a much reduced spawning activity. The samples in the Gironde area had a spawning frequency 7 times lower compared with the historical series, and a Batch fecundity 9 time lower than the mean of this year 2015. Estimation of adult parameters was made as a weighted average, with weighting factors proportional to the biomass each adult sample represent (with the proxy of biomass taken the quotient between egg abundance and Daily fecundity by subregions as usual and adopting the Garonne river mouth as a subregion). Although that 2% of the ovaries analysed histologically had atresia, which even low it is not normal to find it at the pick spawning, the estimation followed the standard procedures, thus, the results are consistent even when a sensitivity analysis is performed as explained in Santos *et al.,* (WD in Annex 8.8).

As no consensus was found to explain the large discrepancies observed between acoustics and DEPM biomass estimates in 2015, a workplan was proposed to further explore the potential factors explaining the 2015 discrepancies. This will include the following issues:

- comparing relative proportions of acoustic and DEPM biomass in identical (Bioman) post stratification regions to identify and better understand discrepancies
- Comparing CUFES and pairovet Ptot

Annex 8.7. Planning and coordination of surveys for 2016

Survey planning for 2016 is summarized in the table below.

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<tr><td>Aug</td><td colspan="11">ECOCADIZ</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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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 ichthyofaunal.

In October of 2016, 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 2015, 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 (2016), 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 2016 the annual anchovy DEPM survey in the Bay of Biscay (BIOMAN) will take place in May conducted by AZTI, covering the usual spawning grounds ranging from 5°W to the French coast for Cantabrian sea and from there to 48°N for the French area. This survey will be carried out as usual, following the standards defined in the manual for the DEPM survey (Annex 7 of WGACEGG 2010 report (ICES 2010: ICES CM 2010/SSGESST: 24).

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

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

Annex 8.8: Survey reports - Working Documents

1. Atlanto Iberian sardine spawning stock biomass during 2014 DEPM survey (ICES areas IXa and VIIIc), 15 pp.
   Paz Díaz, A. Lago de Lanzós, MM Angélico, C. Franco, J. R. Pérez, C. Nunes, E. Henriques, P.. Cubero and L. Iglesias
   IPMA, Lisboa, Portugal

2. Index of biomass of Bay of Biscay anchovy (*Engraulis encrasicolus*, L.) in 2015 applying the DEPM and sardine (*Sardina pilchardus*) egg abundance, 32 pp.
   M. Santos, L. Ibaibarriaga and A. Uriarte.
   AZTI-Tecnalia, Instituto Tecnológico Pesquero y Alimentario, Pasaia, Spain

3. Direct assessment of small pelagic fish by the PELGAS15 acoustic survey, 27 pp.
   Erwan Duhamel, Mathieu Doray, Martin Huret, Florence Sanchez, Matthieu Authier and Patricia Bergot
   IFREMER, France

4. PELACUS0315: IEO Pelagic Ecosystem Acoustic-trawl survey – Cruise report, coordinated by Pablo Carrera. 43 pp.

5. Acoustic survey carried out from 13 April to 18 May 2015 off the Portuguese Continental Waters and Gulf of Cadiz, onboard RV “Noruega”, 36 pp.
   Vitor Marques, Maria Manuel Angélico, Eduardo Soares, Sílvia Rodríguez-Climent, Andreia Silva, Paulo Oliveira, Raquel Marques, Luís Sobrinho-Gonçalves, Elisabete Henriques, Alexandra Silva
   IPMA, Lisboa, Portugal

6. Acoustic assessment and distribution of anchovy and sardine in ICES Subdivision IXa South during the ECOCADIZ 2015□07 Spanish survey (July□August 2015) with notes on the distribution of other pelagic species, 35 pp.
   Fernando Ramos, Joan Miquel, Jorge Tornero, Dolors Oñate, Paz Jiménez
   IEO Cadiz & Islas Baleares, Spain

7. Acoustic assessment and distribution of anchovy and sardine in ICES Subdivision IXa South during the ECOCADIZ□RECLUTAS 2015□10 Spanish survey (Octo ber 2015) with notes on the distribution of other pelagic species, 34 pp.
   Fernando Ramos, Jorge Tornero, Dolors Oñate, Pilar Córdoba
   IEO Cadiz & Islas Baleares, Spain

8. Physical oceanography conditions during ECOCADIZ 2015 cruises, 11 pp.
   Ricardo F. Sánchez Leal, Venicio Pita, José Rodríguez
   IEO, Cadiz, Spain

9. PELTIC15. Small pelagic fish in the coastal waters of the western Channel and Celtic Sea. Draft Survey report CEND22_15, 17 pp.
   Jeroen van der Kooij, Elisa Capuzzo, Joana Silva, Mike Bailey

10. Acoustic survey of anchovy juveniles in the Bay of Biscay: JUVENA 2015. Survey Report. 41 pp. Guillermo Boyra

Working Document presented at ICES Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VIII and IX (WGACEGG), Lowestoft, UK, 16-20 November 2015

Atlanto Iberian sardine spawning stock biomass during 2014 DEPM survey

(ICES areas IXa and VIIIc)

Paz Díaz, A. Lago de Lanzós, MM Angélico, C. Franco, J. R. Pérez, C. Nunes, E. Henriques, P. Cubero and L. Iglesias

Background

The present document includes an update on the results from the Atlanto Iberian sardine 2014 DEPM survey submitted to the WGACEGG in November 2014. For the preliminary SSB estimates presented at the 2014 meeting, an average spawning fraction value (using the whole series data) was considered for the southern (Algarve and Cadiz Bay) and western strata (western Portugal) since the information collected during the 2014 campaign in those areas was not fully processed. Detailed sampling and laboratorial methodology and survey description including environmental characterization and sampling effort can be found in the 2014 WGACEGG report (summaries in Tables 1 and 2). The results described here corresponding to spawning area and egg parameters are exactly the same presented in 2014 to the WGACEGG.

Results

Eggs

In total 793 PairoVET hauls and 798 CUFES samples were obtained (Table 2). The percentage of stations with sardine eggs was 29% for the vertical tows and 36% for the surface samples. Considering only one of the PairoVET nets (to be comparable between IEO and IPMA) 2405 (Figure 1) sardine eggs were gathered in total, of which 2092 came from the south and west of Portugal. The egg numbers obtained in the north, 313, were the lowest in the whole survey series for this area. In the western area the number of sardine eggs collected almost doubled compared to the 2011 survey.

Sardine egg distribution, obtained from the PairoVET and CUFES systems, for the whole area is presented in Figure 2. The egg distribution pattern derived from the observations from the two samplers is similar. In the positive egg strata, the highest egg abundance per haul was 5500 egg/m^{2}reached in the south, while the lowest egg abundance per haul was 704 egg/m^2 , registered on the northern coast.

The surveys covered a total area of 80830 km2 of which 25320 km^2 (31.3 %) were considered the spawning area (Table 3). The northern stratum represented 30 % of the spawning area while 27 % were in the southern coast and 43 % in the western shores. The percentage of stations in the whole area with sardine eggs was 28.9% (S: 46.3%, W: 38.1%, N: 16.7%). The total area occupied by eggs was much smaller than in 2011, this is particularly clear for the north coast of Spain (around 40%), while in the west the spawning area increased to almost the double.

Table 3 shows the mortality values obtained using geographical stratification (no strata and 3 strata). The mortality value for the southern region is much higher than for the western and northern strata. Mortality calculated for each one of the three strata defined shows negative and significantly different from zero values and was considered acceptable for egg production estimation, however the significance obtained for mortality value estimate with a common slope for the whole Atlanto Iberian stock was much better than the one obtained with three independent mortality estimates. For the 2014 DEPM data the options for GLM model with one or three slopes (mortality) give similar results for the egg production (intercept) by stratum.

Final egg production models (Table 3 and Figure 3) include individual egg production estimates for the southern, western and northern areas, with three independent mortality estimates (Model 2), three egg productions with a common slope for the whole Atlanto Iberian stock (Model 3), and finally, egg production with a single mortality, estimated for the whole Atlanto Iberian stock, is considered using Model 1.

The results from different GLM models (Table 3) could be considered an option for the final egg production estimation (negative and statistically significant mortality), minimal differences in the estimates by areas are introduced due to the choice of model used.

Owing to standardization of criteria in the analyses, during the 2012 sardine DEPM historic series revision, the results achieved by GLM model 3 were recommended to be used for assessment modelling and therefore to maintain consistency within the series analyses it is here also considered more adequate.

Total egg production (eggs/day) estimated for the Atlanto Iberian stock varies from 1.94×10^{12} (model 1) to 1.99×10^{12} (models 2 and 3). Using three P0s and one mortality estimates (Model 3), the added total egg production estimate was 1.99×10^{12} – 0.71×10^{12} corresponding to the south, 0.97×10^{12} to the west and 0.31×10^{12} to the north. The sum of total egg production for the 3 strata in 2014 was much lower than in 2011, in particular in the northern and southern regions but similar in the west (Table 3 and Figure 4). For all models used the daily egg production per m^2 (eggs/m^2/day) was higher for the southern region.

Adults

For the 2014 survey an effort was made to guarantee the level of sampling already achieved in the 2002, 2005 and 2008 surveys, however a high percentage of fishing hauls (56 %) over the total, resulted negative for sardine during the survey. On the whole, 44 fishing hauls which caught sardines were performed during the surveys covering the whole area, complemented by 20 samples obtained from the Portuguese purse-seine fleet. On the whole, almost 3330 sardines were sampled (Table 2), more than 1400 ovaries were collected, preserved and analysed histologically and *ca.* 1130 otoliths were removed for age determination. A total of 210 hydrated females were caught for batch fecundity estimation, which is a substantial number given the higher difficulty in obtaining sardines in 2014, and in comparison with 2011 (67 hydrated females).

At both WGHANSA and WGACEGG meetings in 2014, the laboratory tasks for processing IPMA samples were still underway, and therefore estimates presented for the S and W strata were preliminary at those meetings. At present, the results reported in this document are to be considered final estimates for the whole Atlanto Iberian stock.

Data were analysed and the parameters estimated for the two surveys jointly:

- The same linear regression between the non-hydrated females Wt and their corresponding Wnov was used for the whole surveyed area (Wt = 1.067 * Wnov - 0.706, R^2 = 0.996).
- The geographical distribution of female weight (not shown) and mean observed batch fecundity (Fobs = 17026, 11296 and 20928 eggs/female, respectively, for South, West and North strata) suggest the need for a spatial stratification in view of the parameters estimation. Fobs data were thus modelled against the Wnov and the Stratum (GLM: Fobs ~ Wnov:Stratum, negative binomial distribution and identity link) with three different strata, and the model obtained was statistically significant (Figure 5).

For the first time in the historical series, the minimum mean female weight (W) was obtained for the North coast (Table 3), which corresponds to a drop of 48% in relation to the previous survey estimate for this stratum. Minimum mean weights by haul were observed in Mid-Eastern Cantabrian waters (24-37 g), in Galicia (45-52 g), the North of Portugal (13-32 g), the Lisboa area (33-37 g) and in the Gulf of Cadiz (31 g). Mean female weight (W) was similar for the West and North coasts (52.6 g and 48.7 g, respectively) whereas in the South coast mean weight estimate was the highest of the historical series (60.7 g).

Though the model obtained with the three strata was statistically significant, in 2014, the relationship between the Fobs and the female Wnov was very similar for the three areas considered, i.e., that the batch fecundity estimated for a fish of the same weight would be similar off the North, West and South coasts (Figure 5). Similarly to the mean weight, mean batch fecundity estimate (F) was lowest off the Northern Spanish coast (17118 eggs/female), representing a decrease of 58% in relation to the previous survey and being the lowest estimate of the historical series. For the Portuguese and Cadiz areas, F estimates were almost identical: for the South stratum, the estimate (22673 eggs/female) is similar to the values obtained in 2008 and 2011 (20956 and 17157 eggs/female, respectively), whereas for the West stratum, mean batch fecundity has doubled in relation to the previous survey (21322 and 11838 eggs/female, respectively) though female mean weights were similar for these two surveys.

Spawning fraction estimates were very similar between strata (S = 0.08, 0.075 and 0.093 for south, west and north strata, respectively), and moreover almost identical to the values obtained in 2008 throughout all the stock area (Table 4). Compared to 2011, the 2014 estimate was lower for the northern Spanish coast, whereas the comparison is not feasable for the west and south coasts, as the estimates obtained in 2011 were unrealistic.

SSB estimate

SSB estimation for the north strata in 2014 (Figure 6) is the lowest of the whole series (23887 tons), even lower to those obtained in 1999 (41963) and 2002 (47747) when the model selected for the egg production estimate included a common mortality value for the three strata (model 3) (Table 4). Using egg production from model 2 (with three independent mortality estimates) the SSB estimation for the north stratum is slightly lower (21571). For the south and western areas, the values obtained are also the lowest of the whole series (39482 and 63216 tons, respectively) and represent a significant decrease in relation to the previous survey (82% and 42% of decrease, respectively).

Total SSB for the stock was estimated as 126584 tonnes, which corresponds to a 74% decrease of spawning biomass compared to 2011.

Remarks

The sardine stock in areas VIIIc and IXa has shown no strong recruitment for several years and biomass estimates from the research surveys (acoustics and DEPM) have been showing a decline in the population. As it occurred in 2011, also during the 2014 surveys was evident the low availability of sardine during the fishing operations in the majority of the area surveyed and the spawning area was for the joint strata the smallest of the time series, however only in the north effectively reduced compared to 2011. For the first time the sardines caught in the Cantabrian Sea were smaller than the individuals observed in the southern and western regions. The drop in SSB which was observed between the 2008 and 2011 surveys was further accentuated and the biomass estimates from DEPM, for all strata, were in 2014 the lowest of the time series.

Main remarks:

- spawning area in 2014 for the whole area slightly reduced compared to 2011 and the smallest of the historic series; patchy egg distribution everywhere and very low numbers in the north
- spawning area reduction particularly evident in the north (around 40% of the total spawning area in 2011) while in the west it increased to more than double
- daily egg production per m^2 (eggs/m2/day) was higher for the southern stratum, intermediate in the west coast and lower in the north; for all strata daily egg production per m^2 was much lower than in recent surveys
- sum of total egg production for the 3 strata in 2014 much lower than in 2011, in particular in the northern and southern regions, similar in the west
- mortality value (single mortality for whole area) one of the lowest of the series but with high CV
- during the 2014 survey the availability of adult sardine for trawling was limited in the whole area; nevertheless 44 samples were obtained, 12 in the south, 17 in the west and 15 in the north; extra samples (20) from purse-seiners were collected in Portugal
- the number of hydrated females collected was higher than in 2011
- for the first time, mean female weight and batch fecundity were lower for the north than for the west and south strata, and were the lowest observed off the Spanish coast in the whole series
- mean female weight obtained for the Spanish coast is much lower (48.7) than values reported from the whole historical series, which ranged between 70.1 g in 1997 and 85.8 g in 2011, whereas in the south coast mean weight estimate was the highest (60.7 g) observed since 1997 (values ranging between 38.8 g in 2002 and 56.3 g in 2008)
- batch fecundity doubled in the west area and increased slightly in the south in comparison to 2011; for the north the lowest values were observed which were similar to the estimates for west and south in previous years
- sardines were mainly aged 1 year off the North and West coast while age distribution in the South was much wider (mostly, 1-7 years old)
- spawning fraction estimates were very similar between strata, and almost identical to the values obtained in 2008 throughout all the stock area. spawning fraction for the north strata in 2014 was lower than in 2011 survey
- SSB estimates for the south, west and north strata (39482, 63216 and 23887 tons, respectively) and for the whole Atlanto Iberian stock (126584 tons) are the lowest of the whole series, and represent a substantial decrease of the biomass, compared to 2011 (74% for the whole stock)

- despite the fact that the Portuguese survey was conducted later than usual the population was actively spawning and the results obtained for all parameters estimated were consistent
- DEPM SSB estimates obtained in 2014 were very similar to the biomass estimated by the acoustic spring surveys (Figure 7)

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Table 1. Surveying, processing and analyses for eggs and adults

DEPM Surveys	Portugal (IPMA)	Spain (IEO)
Survey	**PT-DEPM14-PIL**	**SAREVA 0414**
Survey area	(IXa S, IXa W) South-West	NW & N Spain (IXa N + VIIIc)
SURVEY EGGS		
Sampling grid	8 (transect) x 3(station)	8 (transect) x 3(station)
PairofVET Eggs staged (n egg) (stages Gamulin and Hure, 1955)	All (2 net)	All (1 net)
Sampling maximum depth (m)	150	100
Temperature for egg ageing	3-5 m	10 m
Peak spawning hour	(PDF 21 ± 2 * 3)	
Egg ageing	Bayesian (Bernal et al, 2008)	
Strata	No strata/Stratum (South,West,North)	
Egg production	GLM, negative binomial, log link	
CUFES, mesh 335	3nm (sample unit)	3 nm (sample unit)
CUFES Eggs counted	All	All
CUFES Eggs staged	Subsampled of a minimun of 100	No
Hydrographic sensor	CTDF (FSI)	CTD (SBE 37) CTD SBE 25
Flowmeter	Y	Y
Clinometer	Y	Y
Environmental data	Fluorescence, Temperature, Salinity	Fluorescence (surface only), Temperature, Salinity
SURVEY ADULTS		
Biological sampling:	On fresh material, onboard the R/V or in laboratory; on frozen material for certain commercial samples (ovaries removed before)	On fresh material, on board of the R/V
Sample size	60 indiv randomly ; extra if needed (30 females min for histology) and if hydrated females found	60 indiv randomly (30 mature female); extra if needed and if hydrated found
Sampling for age	Otoliths from the same females sampled for histology	Otoliths from random males and females
Fixation	Buffered formaldehyde 4% (distilled water)	Buffered formaldehyde 4% (distilled water)
Preservation	Formalin	Formalin
Histology:		
- Embedding material	Paraffin	Resin
- Stain	Haematoxilin-Eosin	Haematoxilin-Eosin
S estimation	Day 1 and Day 2 POFs (according to Pérez et al. 1992a and Ganias et al. 2007)	Day 1 and Day 2 POFs (according to Pérez et al. 1992a and Ganias et al. 2007)
R estimation	The observed weight fraction of the females	The observed weight fraction of the females
F estimation	On hydrated females (without POFs), according to Pérez et al. 1992b and Ganias et al. 2010	On hydrated females (without POFs), according to Pérez et al. 1992b

Table 2. General Sampling DEPM 2014

Institute	**IPMA**	**IPMA**	**IEO**
Survey area	**IXa South**	**IXa West**	**IXa N & VIIIc**
SURVEY EGGS			
R/V	Noruega	Noruega	Vizconde de Eza
Date	15-26/4	15-21/3; 4-15/4	29/03-09/04 16/04-21/04
Transects	20	38	54
PairoVET stations	134	265	394
Positive stations	62	101	66
Tot. Eggs	2019	2164	313
Max eggs/m2	5500	1550	704
Temp (ºC) min/mean/max	14.5/16.3/19.1	12.8/14.9/18.5	12.3/13/14.9
Max age	52.7	58.3	74.2
CUFES stations	146	313	339
Positive CUFES stations	60	116	112
Tot. Eggs CUFES	2695	12709	2186
Max eggs/m3	78.3	61.7	25.2
Hydrographic stations	134	265	522
SURVEY ADULTS			
Number Hauls R/V	13	31	57
Number Hauls (Commercial Vessels)	4	16	---
Number RV (+) trawls	12	17	15
Date	26.03 - 11.04	16.03 - 11.05	15/03-07/04
Depth range (m)	23-66	21-134	36-167
Time range	01:00 – 18:30		7:30-20:30
Total sardine sampled	938	1635	755
Length range (mm)	135-236	85-265	132-252
Weight range (g)	20-97	4-136	15.5-120.4
Female for histology	444	705	262
Hydrated females	70	21	119
Otoliths	527	130	472
Female Ages Range	1-10	1-10	1-7

Table 3. Results DEPM 2014

Institute	IPMA	IPMA	IEO	TOTAL
Area	IXa South	IXa West	IXa N & VIIIc	
Survey area (Km^2)	14558.7	27357.3	38914.4	80830.5
Positive area (Km^2)	6824.8	11000.8	7494.5	25319.6
Z (hour^{-1})(CV%)				
Model 1	-0.016 ** (38.7)			
Model 2	-0.022 (61.2)	-0.013. (59.3)	-0.014 .(52.9)	
Model 3	-0.017 ** (36.4)			
P0 (eggs/m2/day)(CV%)				
Model 1	76.8 (22)			
Model 2	127.5 (46.6)	76.1 (28.4)	37.2 (33)	
Model 3	103.7 (27.4)	88.7 (23.2)	40.4 (26)	
P0 tot (eggs/day) (x10^{12}) (CV%)				
Model 1	1.94 (22)			1.94 (22)
Model 2	0.87 (46.6)	0.84 (28.4)	0.28 (33)	1.99 (24.1)
Model 3	0.71 (27.4)	0.97 (23.2)	0.31 (26)	1.99 (15.5)
Female Weight (g)				
Three strata (S, W and N)	60.7 (5.2)	52.6 (14.2)	48.7 (11.4)	
Batch Fecundity				
Three strata (S, W and N)	22673 (7)	21322 (16)	17118 (11.9)	
Sex Ratio				
Three strata (S, W and N)	0.602 (7.8)	0.505 (6.2)	0.397 (14.9)	
Spawning Fraction				
Three strata (S, W and N)	0.080 (15.4)	0.075 (19.4)	0.093 (34.4)	
Spawning Biomass (tons) (CV%)				
Model 2	48379 (50.5)	54743 (41)	21575 (52.6)	124698 (28.1)
Model 3	39482 (33.5)	63216 (37.6)	23887 (48.5)	126584 (23.4)

Model 1
1 strata for P0 and mortality
glm.nb(cohort ~ offset(log(Efarea)) + age, weights=Rel.area, data=aged.data)

Model 2
3 strata (Stratum) for P0 and 3 strata for mortality (age)
glm.nb(cohort ~ offset(log(Efarea)) -1 + Stratum+ Stratum:age, weights=Rel.area, data=aged.data)

Model 3
3 strata for P0 and 1 for mortality
glm.nb(cohort ~ offset(log(Efarea)) -1 + Stratum+ age, weights=Rel.area, data=aged.data)

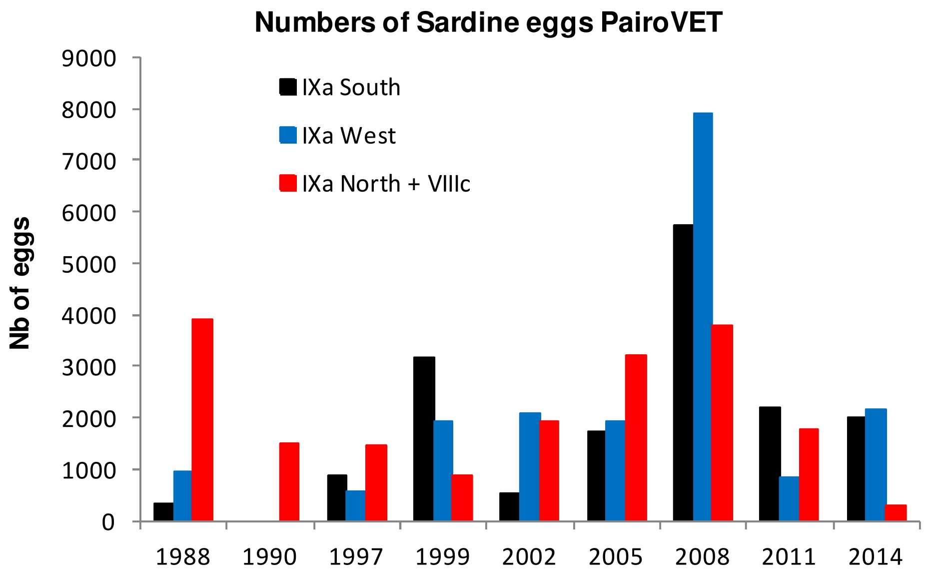


Figure 1. Number of sardine eggs (total eggs) from the CalVET sampler counted by strata South (IXa S) in black, West (IXa W) in blue and North (IXa N + VIIIc) in red.

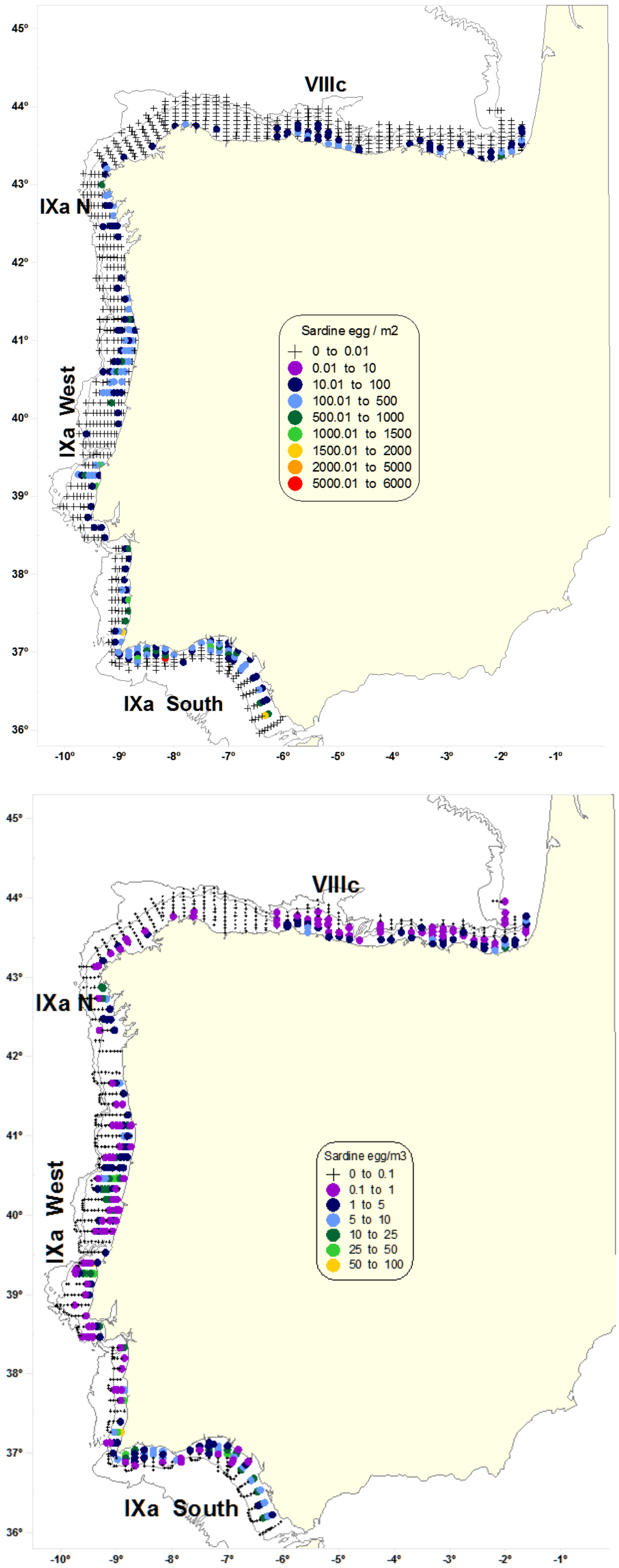


Figure 2. Sardine egg distribution. Upper panel: Egg/m^2 from PairoVET sampling; lower panel: Egg/m^3 from CUFES sampling; (+, egg absence)

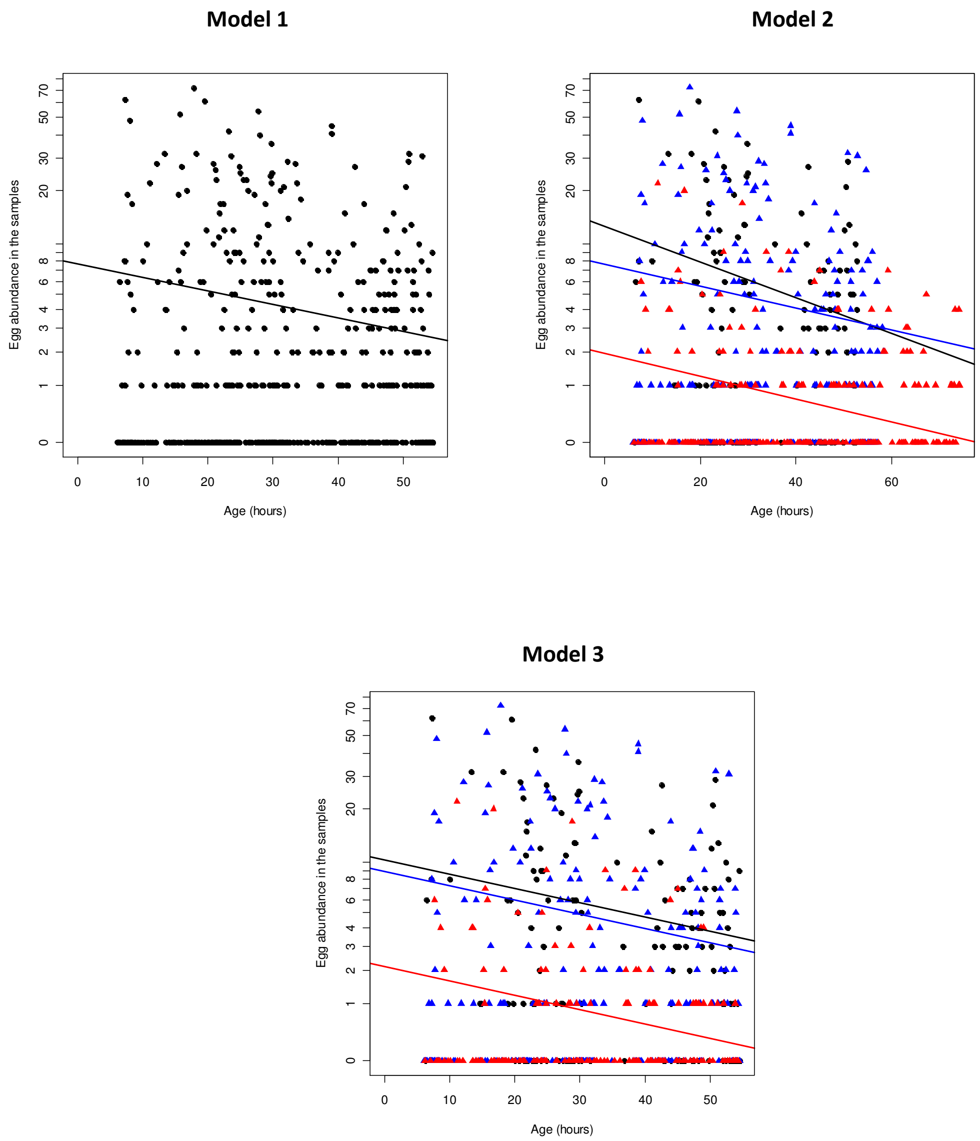
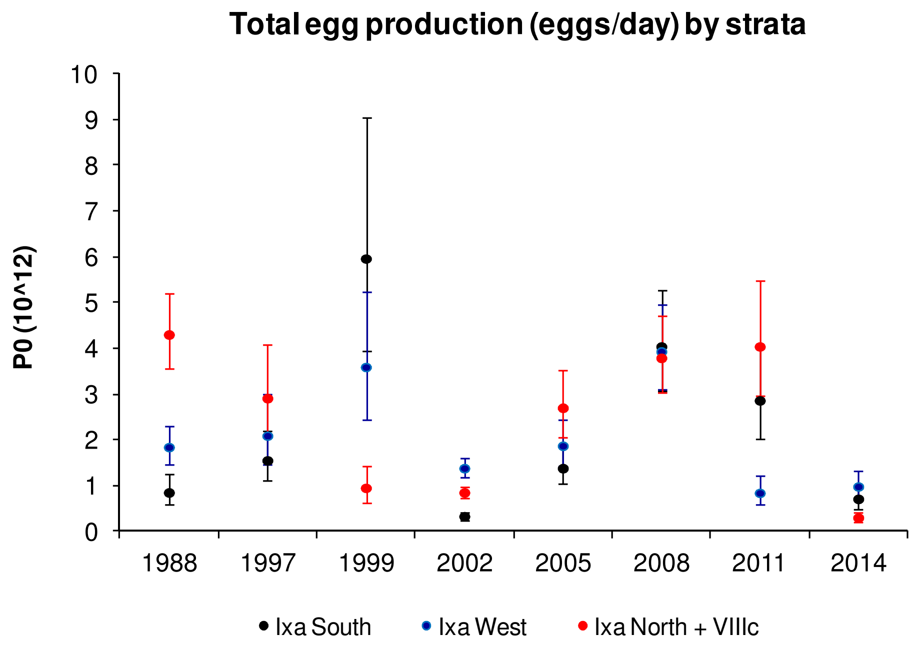


Figure 3. Abundance by age of eggs in the three spatial strata (black = south, blue = west, red = north) and its corresponding fitted mortality curve. Note that southern, western and northern mortality curves were forced to have a common slope (mortality) in Model 3



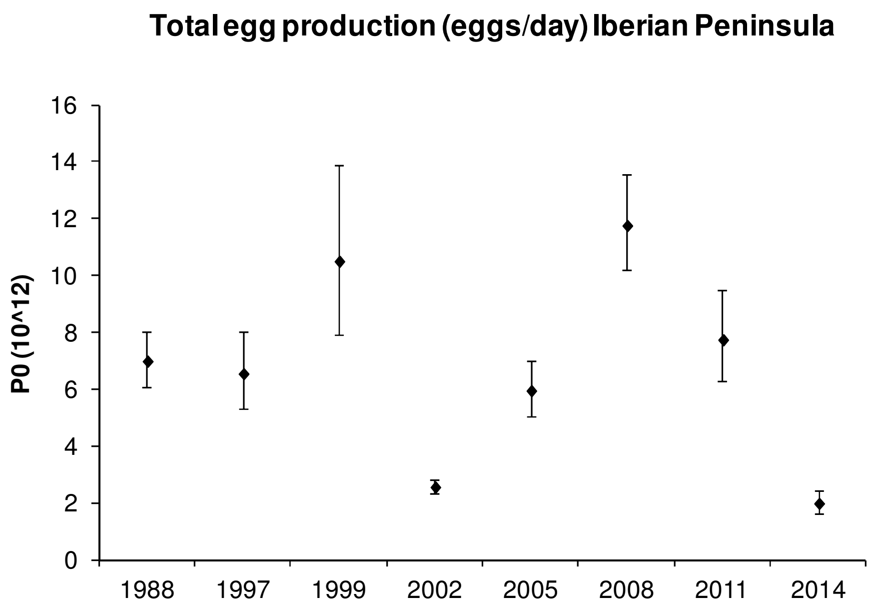
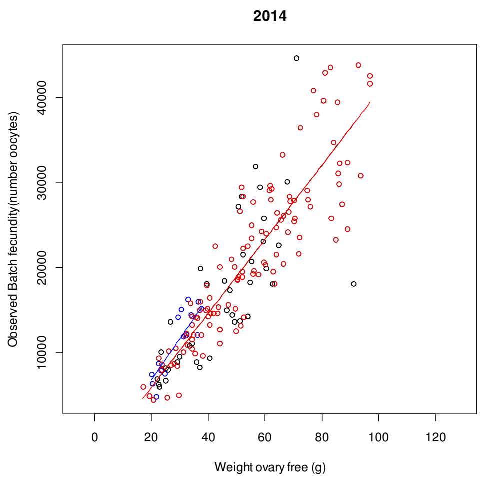


Figure 4. Total egg production (eggs/day*10^{12}) by spatial strata (top panel); black – IXa South, blue - IXa West , red – IXa North + VIIIc and for the total stock area off the Iberian Peninsula (bottom panel). Dots and lines indicate the estimates of egg production and their confidence intervals.




```
init.theta = 21.4605608)
Deviance Residuals:
    Min       1Q   Median       3Q      Max
-2.9682  -0.6637  -0.1172   0.5258   2.3213
Coefficients:
              Estimate Std. Error z value Pr(>|z|)
(Intercept)   -2834.42     595.58  -4.759 1.94e-06 ***
Wnov:Stratum1   436.16      20.12  21.676  < 2e-16 ***
Wnov:Stratum2   481.54      30.51  15.785  < 2e-16 ***
Wnov:Stratum3   436.35      15.57  28.017  < 2e-16 ***
 (Dispersion parameter for Negative Binomial(21.4606)
family taken to be 1)
    Null deviance: 950.29  on 171  degrees of freedom
Residual deviance: 173.35  on 168  degrees of freedom
  (3152 observations deleted due to missingness)
AIC: 3321.7
Number of Fisher Scoring iterations: 1
              Theta:  21.46 Std. Err.:  2.30
2 x log-likelihood:  -3311.728
```

Figure 5. Observed batch fecundity vs. gonad free weight of the hydrated females, the regression line of the corresponding model for the three geographical areas (black: South stratum, blue: West stratum, red: North stratum) (left panel) and results of the GLM obtained (right panel).

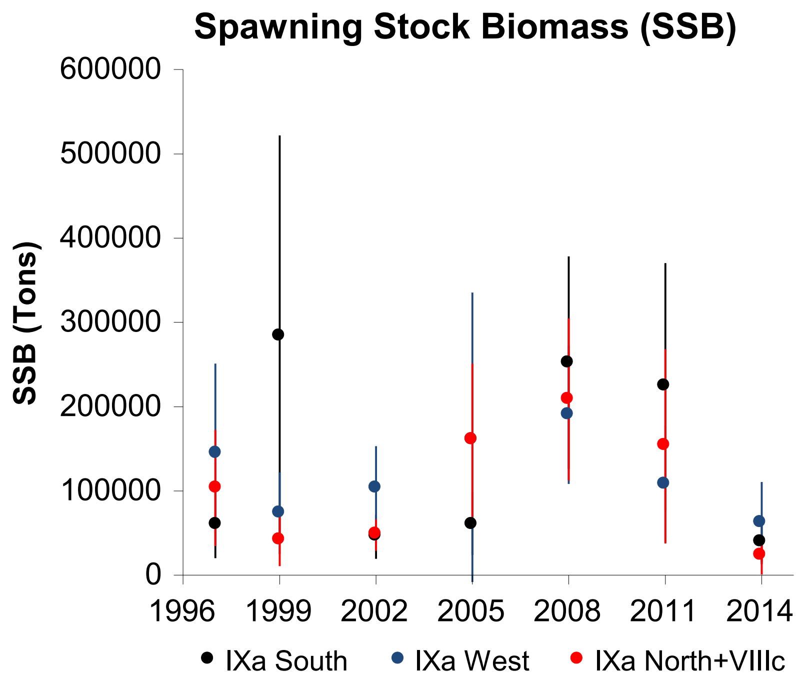


Figure 6. Spawning Stock Biomass (Tons) by spatial strata; black – IXa South, blue - IXa West , red – IXa North + VIIIc. Dots and lines indicate the estimates of SSB and their confidence intervals.

Table 4: Sardine DEPM surveys for the Atlanto-Iberian stock. Summary of the results for eggs, adults and SSB estimates.

Year	Strata	Mortality		Ptot		W		R		F		S		SSB	
		Estim	C.V	Estim	C.V.	Estim	C.V.	Estim	C.V.	Estim	C.V.	Estim	C.V.	Estim	C.V.
1988	IXa South	-0.019***	0.20	0.85	0.31										
	IXa West			1.84	0.17										
	IXa North+VIIIc			4.3	0.15										
	Total Iberian Peninsula			**6.99**	**0.11**										
1990	IXa North+VIIIc	-0.034***	0.24	3.56	0.26										
1997	IXa South	-0.032***	0.23	1.55	0.27	43.1	0.07	0.557	0.05	19062	0.12	0.104	0.13	60556	0.33
	IXa West			2.09	0.29	48.5	0.07	0.637	0.04	22569	0.13	0.049	0.18	144012	0.37
	IXa North+VIIIc			2.91	0.27	72.2	0.05	0.493	0.14	28544	0.07	0.144	0.10	103611	0.33
	Total Iberian Peninsula			**6.55**	**0.16**									**308178**	**0.22**
	VIIIb	-0.012*	0.41	1.74	0.20	74.5	0.12	0.508	0.08	32269	0.17	0.131	0.10	60332	0.310
1999	IXa South	-0.023**	0.34	5.96	0.33	42.1	0.05	0.531	0.03	22436	0.11	0.074	0.22	284749	0.42
	IXa West			3.59	0.30	44.9	0.06	0.639	0.05	24086	0.09	0.142	0.05	73672	0.33
	IXa North+VIIIc			0.95	0.33	65.9	0.09	0.514	0.04	34137	0.10	0.09	0.09	41963	0.37
	Total Iberian Peninsula			**10.5**	**0.22**									**400385**	**0.30**
	VIIIb			0.45	0.13	63.6	0.13	0.535	0.11	32704		0.131	0.10	13200	0.52
2002	IXa South			0.33	0.19	38.8	0.05	0.621	0.05	12881	0.06	0.035	0.19	45781	0.29
	IXa West			1.38	0.12	43.3	0.05	0.619	0.03	15212	0.07	0.061	0.18	103982	0.24
	IXa North+VIIIc			0.85	0.11	75.6	0.05	0.505	0.08	29623	0.06	0.09	0.11	47747	0.20
	Total Iberian Peninsula			**2.56**	**0.08**									**197511**	**0.15**
	VIIIb	-0.022***	0.18	1.67	0.19	62.9	0.06	0.492	0.23	24577		0.143		60720	
2005	IXa South	-0.011*	0.4	1.38	0.23	45.4	0.07	0.574	0.11	13169	0.08	0.135	0.13	61328	0.30
	IXa West			1.87	0.21	46.2	0.06	0.556	0.06	15304	0.44	0.063	0.21	160988	0.54
	IXa North+VIIIc			2.7	0.21	80.7	0.04	0.51	0.07	34147	0.04	0.078	0.17	160346	0.28
	Total Iberian Peninsula			**5.95**	**0.13**									**382662**	**0.26**
2008	IXa South	-0.024***	0.18	4.04	0.21	56.3	0.06	0.489	0.07	20956	0.06	0.088	0.08	252405	0.25
	IXa West			3.93	0.18	59.3	0.03	0.593	0.03	26424	0.04	0.078	0.10	190549	0.22
	IXa North+VIIIc			3.79	0.17	83.9	0.04	0.482	0.06	35139	0.04	0.09	0.13	208604	0.23
	Total Iberian Peninsula			**11.76**	**0.11**									**651558**	**0.14**
	VIIIb	-0.019***	0.26	1.4	0.23	55.4	0.11	0.483	0.09	15849	0.29	0.137	0.24	73942	0.47
2011	IXa South	-0.047***	0.13	2.86	0.27	54.3	0.07	0.498	0.09	17157	0.11	0.081	0.09	223745	0.33
	IXa West			0.84	0.29	50.1	0.06	0.496	0.04	11838	0.09	0.066	0.08	108154	0.32
	IXa North+VIIIc			4.04	0.24	85.9	0.03	0.487	0.12	40844	0.05	0.114	0.26	152954	0.38
	Total Iberian Peninsula			**7.74**	**0.16**									**484852**	**0.21**
	VIIIab	-0.014*	0.42	4.6	0.19	54.1	0.07	0.451	0.15	25336	0.10	0.133	0.338	136560	0.43
2014	IXa South	-0.017 **	0.36	0.71	0.27	60.72	0.05	0.602	0.08	22673	0.07	0.080	0.15	39482	0.34
	IXa West			0.97	0.23	52.63	0.14	0.505	0.06	21322	0.16	0.075	0.19	63216	0.38
	IXa North+VIIIc			0.31	0.26	48.70	0.11	0.397	0.15	17118	0.12	0.093	0.34	23887	0.48
	Total Iberian Peninsula			**1.99**	**0.16**									**126584**	**0.23**
	VIIIb	-0.021***	0.29	1.7	0.28	65.51	0.22	0.59	0.12	25545	0.24	0.084	0.25	86624	0.51

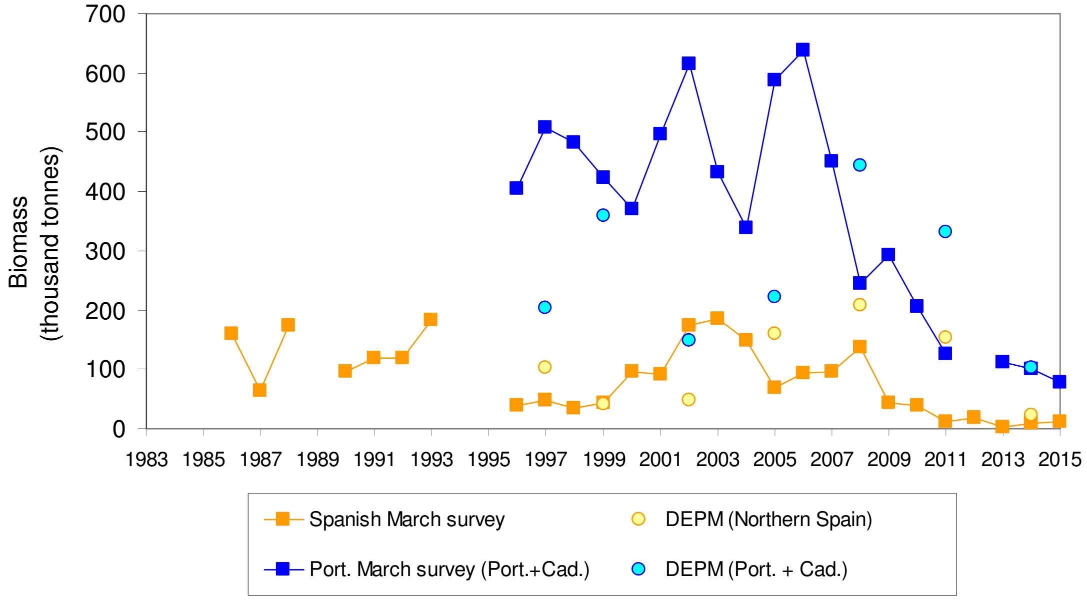


Figure 7. Biomass estimates from Spanish and Portuguese spring acoustic surveys and Spawning Stock Biomass estimates from DEPM surveys (thousand tons) for the period 1986-2015.

Working Document to WGACEGG, 16-20 November 2015, Lowestoft (UK)

Index of biomass of Bay of Biscay anchovy (*Engraulis encrasicolus*, L.) in 2015 applying the DEPM and sardine (*Sardina pilchardus*) egg abundance

by

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Abstract

The research survey BIOMAN 2015 for the application of the Daily Egg Production Method (DEPM) to the Bay of Biscay anchovy was conducted in May 2015 from the 5th to the 24th covering the whole spawning area of the species. Two vessels were used, one to collect plankton samples and a pelagic trawler to collect adult samples. The total area covered was 94,774 Km^2 and the spawning area was 81,956 Km^2 for anchovy and 39,110 Km^2 for sardine. 629 vertical plankton samples were obtained, 1,390 CUFES samples and 46 pelagic trawls were performed, from which 41 contained anchovy and 39 were selected for the analysis. 6 extra samples were obtained from the commercial fleet. And two from the acoustic survey performed in May. In total there were 47 samples available for anchovy adult parameters estimates.

Anchovy eggs were found in the Cantabrian Coast after 15 years without eggs in this area. In the French platform were encountered all over the platform well passed the 200m depth.
Sardine eggs were inside the 200m depth in the French platform until 46ºN, and Northern the eggs were encountered inside the 100m depth. Very few eggs were found in the Cantabrian coast, very close to the coast, but practically there were no eggs as the last 6 years.

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

The adult parameters, sex ratio (*R*), reviewed batch fecundity (*F*), spawning frequency (*S*) and weight of mature females (W_f), were estimated based on the adult samples obtained during the survey. The Daily Fecundity was particularly low due to the small size of the anchovy this year. Consequently, the Spawning Stock Biomass obtained for anchovy resulted in 181,063 t, the highest of the series, with a coefficient of variation of 10%. Total abundance of sardine was 6.03 E+12 eggs, below the last year estimate and at mean level of the historical series.

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 a limited TAC of 25,000 t for 2015(January to December).

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 iqual to the total biomass because at the spawning pick all anchovies are spawning. Since 1987, AZTI-Tecnalia (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.*, 2010). In addition, the anchovy Basque fishery has been continuously monitored. This information has been submitted annually to ICES, to advice on the exploitation of the fishery.

The survey for the application of the DEPM to estimate the Bay of Biscay anchovy biomass is one of the two surveys which give information about this population. The other one carried out at the same time in May, is the acoustic French survey. The biomass indices provided by the acoustic and DEPM surveys together with the information supplied by the fleet are used as input variables for a two stage biomass model used to assess the Bay of Biscay anchovy population (Ibaibarriaga *et al*., 2008). Since 2014 another input was incorporated to the model: the JUVENA index. JUVENA project aims at estimating the abundance of anchovy juvenile population and their growth condition at the end of the summer in the Bay of Biscay. The long term objective is to be able to assess the strength of the recruitment entering the fishery the next year. 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 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 2015 survey for the application of the DEPM to the Bay of Biscay anchovy in 2015. First, the data collection, the estimation of the total egg production and the reproductive parameters are described in detail. The batch fecundity was revised from a preliminary one presented in June and the spawning frequency was estimated after histological reading of ovaries from the adults collected during BIOMAN 2015. 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. 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 BIOMAN2015 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.

The collection of plankton samples was carried out on board R/V Ramón Margalef from the 5th to the 24th May. The area covered was the southeast of the Bay of Biscay (**Fig. 1**), which corresponds to the main spawning area and spawning season of anchovy. The sampling strategy was adaptive. The survey started from the West (transect 11, at 4º14’W), but as there were found anchovy eggs in this transect two more transects were prospected to the west until 5ºW looking for the western limit of the spawning area and covered the Cantabric Coast eastwards up to Pasajes (transect 25, approx. 1º50’W) (**Fig. 1**). Unfortunately the west limit was not found totally but the abundances in the last transect were low. 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 the Adour River. But due to the high abundances in all the French platform no more inter transects were performed in the Gironde estuary due to the lack of time. The sampling was stopped at R 39 at Bordeaux latitude for 60 hours due to bad weather and to refuel at la Rochelle port. Moreover one of the cufes stay was broken and the sampling was stopped for 5 hours to fix it.

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. According to that, a portion of the samples were sorted again to ensure no eggs were left in the sample. In the laboratory, anchovy eggs were classified into morphological stages (Moser and Alshtrom, 1985).

Sample depth, temperature, salinity and fluorescence profiles were obtained at each sampling station using a CTD RBR-XR420 coupled to the PairoVET. 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 transect was abandoned. The CUFES system had a CTD to record simultaneously temperature and salinity at 3 m depth, a flowmeter to measure the volume of the filtered water, a fluorimeter and a GPS (Geographical Position System) to provide sampling position and time. All these data were registered at real time using the integrated EDAS (Environmental Data Acquisition System) with custom software.

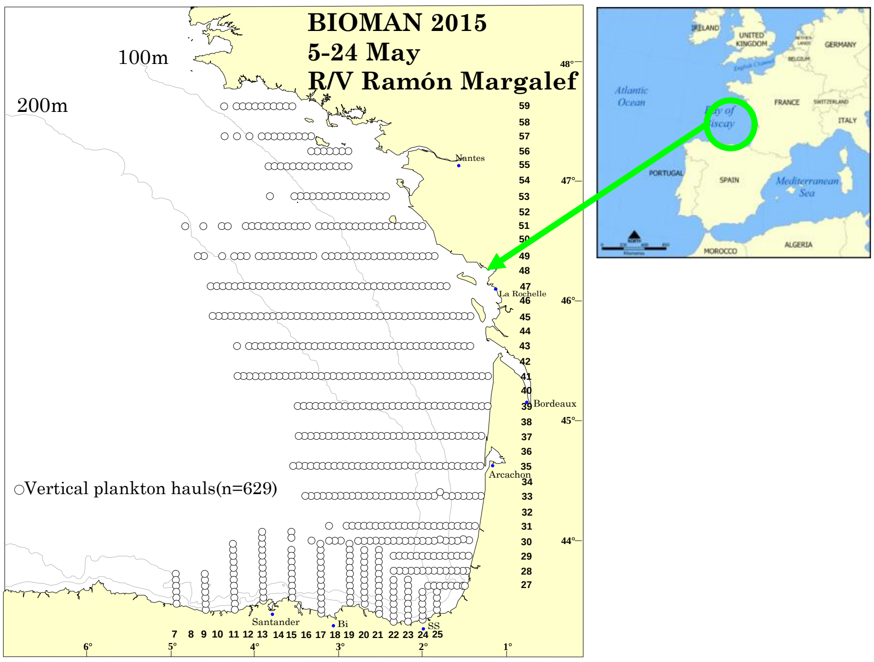

Figure 1: Plankton stations during BIOMAN 2015.

Adult samples were obtained on board R/V Emma Bardán (pelagic trawler) from the 7^{th} to the 25^{th} 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 6 additional anchovy adult samples were obtained from the commercial Basque purse seine fleet. And two samples one offshore at 46ºN 4ºW and one in the influence of the Adour River were obtained from the French acoustic survey. The spatial distribution of the adult anchovy samples is shown in **Figure 2**.

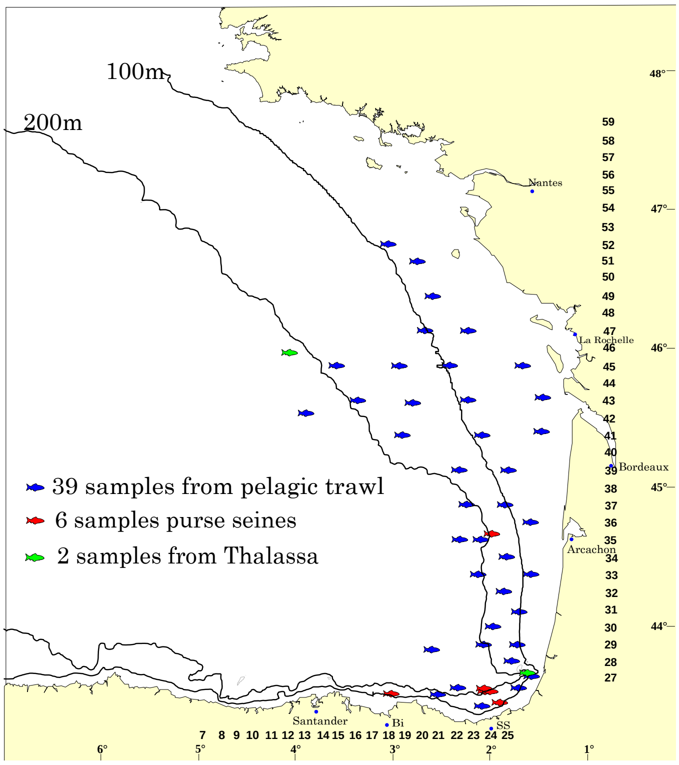

Figure 2: Spatial distribution of fishing hauls obtained from R/V Emma Bardán (blue), the purse seine fleet (red) and French acoustic survey (green) in 2015.

Total egg production

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

The first term *f(stage | age, temp)* is the pdf of stages given age and temperature. It represents the temperature dependent egg development, which is obtained by fitting a multinomial model like extended continuation ratio models (Agresti, 1990) to data from temperature dependent incubation experiments (Ibaibarriaga *et al.*, 2007, Bernal *et al.*, 2008). The second term is the prior distribution of age. A priori the probability of an egg that was sampled at time τ of having an age *age* is the product of the probability of an egg being spawned at time τ - *age* and the probability of that egg surviving since then (*exp(-Z age)*):

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

The pdf of spawning time *f(spawn=*τ *- age)* allows refining the ageing process for species with spawning synchronicity that spawn at approximately certain times of the day (Lo, 1985a; Bernal *et al*., 2001). Anchovy spawning time was assumed to be normally distributed with mean at 23:00h GMT and standard deviation of 1.25 (ICES, 2004). The peak of the spawning time was also used to define the age limits for each daily cohort (spawning time peak plus and minus 12 hours). Details on how the number of eggs in each cohort and the corresponding mean age are computed from the pdf of age are given in Bernal *et al.,* 2011. The incubation temperature considered was the one obtained from the CTD at 10m in the way down.

Given that this ageing process depends on the daily mortality rate which is unknown, an iterative algorithm in which the ageing and the model fitting are repeated until convergence of the *Z* estimates was used (Bernal *et al.*, 2001; ICES, 2004; Stratoudakis *et al.,* 2006). The procedure is as follows:

Step 1. Assume an initial mortality rate value

Step 2. Using the current estimates of mortality calculate the daily cohort frequencies and their mean age.

Step 3. Fit the GLM and estimate the daily egg production and mortality rates. Update the mortality rate estimate.

Step 4. Repeat steps (1)-(3) until the estimate of mortality converged (i.e. the difference between the old and updated mortality estimates was smaller than 0.0001).

Incomplete cohorts, either because the bulk of spawning for the day was not over at the time of sampling, or because the cohort was so old that its constituent eggs had started to hatch in substantial numbers, were removed in order to avoid any possible bias. At each station, younger cohorts were dropped if they were sampled before twice the spawning peak width after the spawning peak and older cohorts were dropped if their mean age plus twice the spawning peak width was over the critical age at which less than 99% eggs were expected to be still unhatched. In addition, eggs younger than 4 hours and older than 90% of the survey incubation time (Motos, 1994) were removed.

Once the final model estimates were obtained the coefficient of variation of P_0 was given by the standard error of the model intercept ($\log(P_0)$) (Seber, 1982) and the coefficient of variation of Z was obtained directly from the model estimates.

The analysis was conducted in R (www.r-project.org). The ”MASS” library was used for fitting the GLM with negative binomial distribution and the ”egg” library (http://sourceforge.net/projects/ichthyoanalysis/) for the ageing and the iterative algorithm.

Daily fecundity

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

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

where R is the sex ratio in weight, F is the batch fecundity (eggs per batch per female weight), S is the spawning frequency (percentage of females spawning per day) and W_f is the female mean weight.

From 1987 to 1993 the **sex ratio (*R*)** in numbers resulted to be not significantly different from 50%. Therefore, since 1994 the sex ratio in numbers is assumed to be 0.5 and the sex ratio in weight per sample is estimated as the ratio between the average female weight and the sum of the average female and male weights of the anchovies in each of the samples.

A linear regression model between total weight (W) and gonad free weight (W_{gf}) was fitted to data from non-hydrated females:

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

This model was used to correct the weight increase of hydrated anchovies. **The female mean weight (*W_f*)** per sample was calculated as the average of the individual female weights.

For **the batch fecundity (*F*)** the preliminary estimate given in June was revised. After the histological readings of the ovaries, it was checked if the ovaries considered *macroscopically* as hydrated in June, had no POFs and were certainly hydrated. 20 of the ovaries had POFs and were removed from the analysis. Moreover 19 hydrated ovaries not considered in June were added to the analysis to complete it. The hydrated egg method was followed (Hunter and Macewicz., 1985). In total there were 81 hydrated females to obtain the relation between the gonad free weight and the female weight. The number of hydrated oocytes in the ovaries was counted. This number was deduced from a sub-sampling of the hydrated ovary. Three pieces of approximately 50 mg were removed from the extremes and the centre of one of the ovary lobule of each hydrated anchovy. Those were weighted with precision of 0.1 mg and the number of hydrated oocytes counted. Finally the number of hydrated oocytes in the sub-sample was raised to the gonad weight of the female according to the ratio between the weights of the gonad and the weight of the sub-samples

The model between the number of hydrated oocytes and the female gonad free weight was fitted as a Generalized Linear Model with Gamma distribution and identity link:

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

Following equation 8 the batch fecundity of the females was estimate for the 1,503 females sampled. The average of the batch fecundity for the females of each sample as derived from the gonad free weight - eggs per batch relationship was then used as the sample estimate of batch fecundity.

Once sex ratio, female mean weight and batch fecundity were estimated per sample, overall mean and variance for each of these parameters were estimated following equations for cluster sampling (Picquelle & Stauffer, 1985):

(9) $$y = \frac{\sum_{i=1}^{n} M_i y_i}{\sum_{i=1}^{n} M_i}$$ and

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

where *Yi* and *Mi* are the mean of the adult parameter *Y* and the cluster sample size in sample *i* respectively. The variance equation for the batch fecundity was corrected according to Picquelle and Stauffer (1985) in order to account for the additional variance due to model fitting.

The weights *Mi* were taken to reflect the actual size of the catch and to account for the lower reliability when the sample catch was small (Picquelle and Stauffer, 1985). For the estimation of *W* and *F* when the number of mature females per sample was less than 20, the weighting factor was equal to the number of mature females per sample divided by 20; otherwise it was set equal to 1. In the case of R when the total weight of the sample was less than 800 g then the weighting factor was equal to the total weight of the sample divided by 800g, otherwise it was set equal to 1.

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

SSB and numbers at age

The Spawning Stock Biomass (*SSB*) was estimated as the ratio between the total egg production (P_{tot}) and daily fecundity (*DF*) estimates and its variance was computed using the Delta method (Seber, *1982*).

To deduce the numbers at age 4 regions, Garonne (Ga), Coast (Co), Centre (Ce) and Offshore (Off) were defined depending on the distribution of the adult samples (size, weight and age) and the distribution of anchovy eggs (**Figure 3**). Mean and variance of anchovy mean weights and proportions at age in the adult population were computed as a weighted average of the mean weight and age composition per samples (equations 9 and 10) where the weights were proportional to the population (in numbers) in each region. In particular, the weighting factors were proportional to the egg abundance divided by the numbers of adult samples in the region and the mean weight of anchovy per sample.

The DF by regions was approached by the general formula of this parameter (F*S*R/Wf) using the unweight mean of the adult parameters of the samples in the region (**Fig.3**).

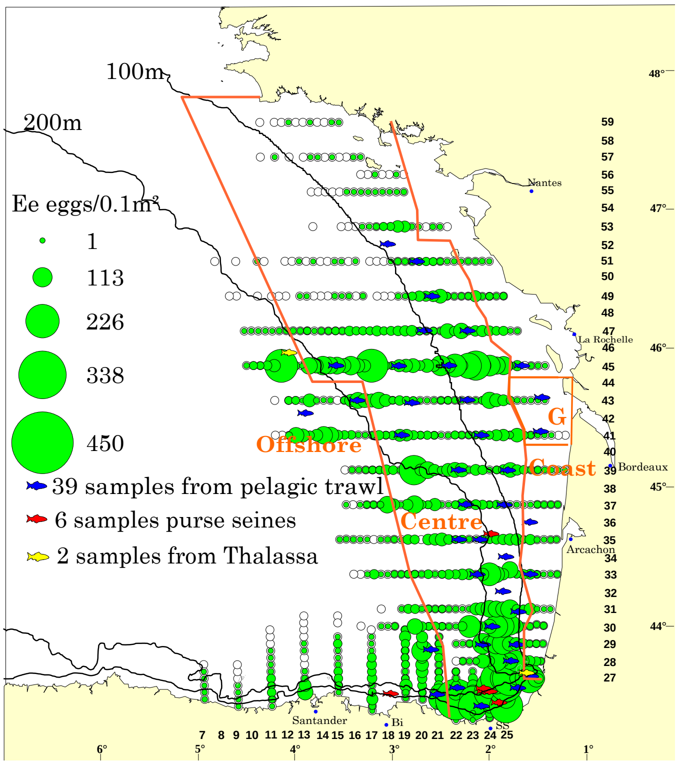

Figure 3: 4 regions defined to estimate the numbers at age. The orange lines represent the border of the regions; the green bubbles the abundance of anchovy eggs in each station and the blue, red and yellow fish the hauls from the different sources.

Results

Survey description

Anchovy eggs were found in the Cantabrian Coast after 15 years without eggs in this area. The spawning area started in the Cantabrian coast at 5ºW to the French coast and in the French platform the northern limit was found at 47º37'N. The eggs in the French platform where encountered all over the platform well passed the 200m depth (**Figure 4**). The total area covered was 94,774 km^2 and the spawning area was 81,956 km^2. The total number of PairoVET samples obtained was 629. From those, 542 had anchovy eggs (86%) with an average of 300 eggs m^{-2} per station and a maximum of 2,850 eggs m^{-2} in a station. A total of 18,834 anchovy eggs were encountered and classified. The number of CUFES samples obtained was 1,390 with 115,559 anchovy eggs in total (18,167 eggm^{-3}) with a mean of 13 eggm^{-3}.

A mean abundance of sardine eggs were encountered in relation with the historical series; very few eggs were encountered along Cantabrian coast, close to it. In the French platform the eggs were between coast and 100m until Arcachon and between 80m and 200m between Arcachon and Gironde estuary. From there to 48ºN, were from 100m to the coast, but as well some sardine eggs were encountered in 48º30'N at 200m depth (**Fig. 5**). The north limit of the spawning was not delimited properly due to the lack of time. In PairoVET from 629 samples a total of 267 (42%) stations had sardine eggs with an average of 51 eggs per m^{-2} per station and a maximum of 1,960 eggs m^{-2}.

Both samplers PairoVET (eggm^{-2}) and CUFES (eggm^{-3}) show very similar anchovy and sardine egg abundances distribution pattern (**Fig. 4 and 5**).

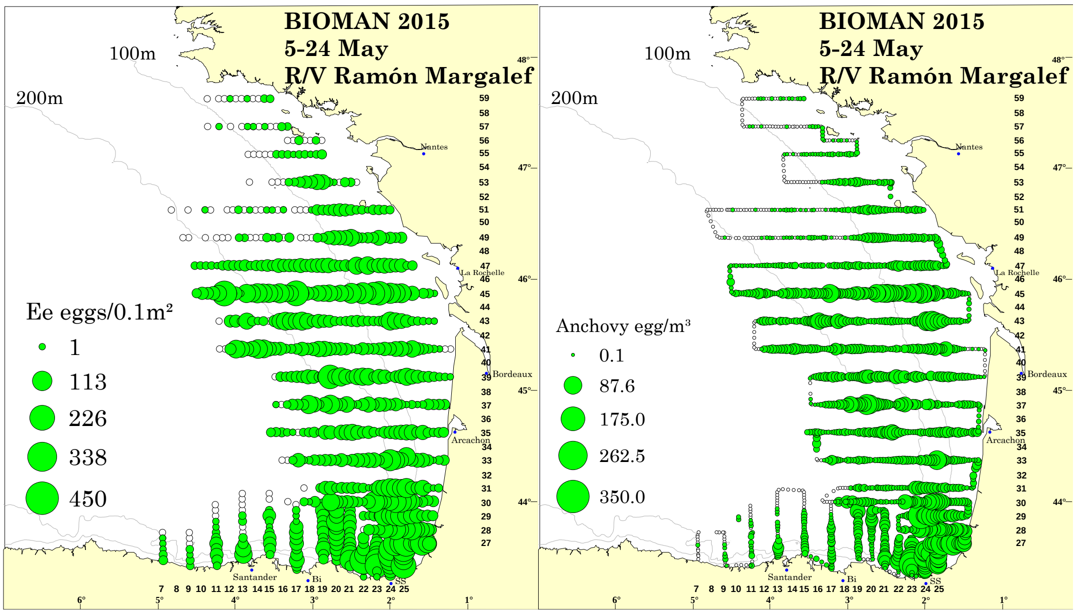

Figure 4: Distribution of anchovy egg abundances obtained with PairoVET (left) (eggs per 0.1m^2) and CUFES (right) (Egg per m^3) from the DEPM survey BIOMAN2015.

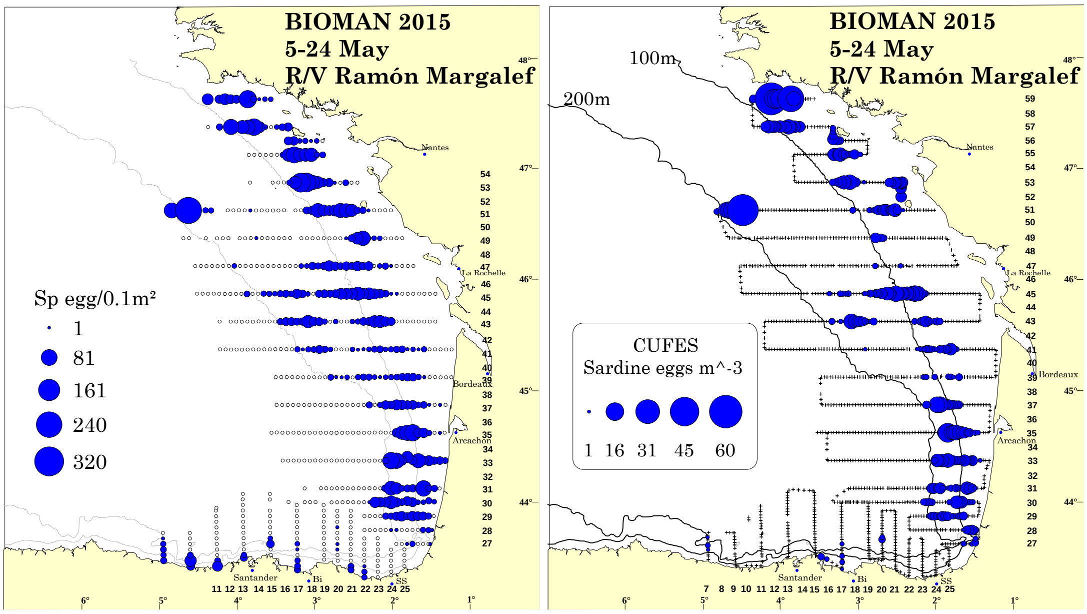

Figure 5: Sardine egg abundance distribution (eggs 0.1m^{-2}) obtained with PairoVET (Left) and with CUFES (eggs m^{-3}) (right) from the DEPM survey BIOMAN2015.

Figure 6 shows the sea surface temperature (SST) and sea surface salinity (SSS) maps overlapped with the abundance of anchovy eggs as observed during the BIOMAN2015 survey.

A mean SST of 15.1ºC (min: 12.5; max: 17.2) and SSS of 34.49 (min: 30.54; max: 35.48) were registered during the survey. The distribution patterns of sea surface temperature (SST) and sea surface salinity (SSS) observed were the typical for the region showing the signatures of the Adour and Garonne River off the French coast.

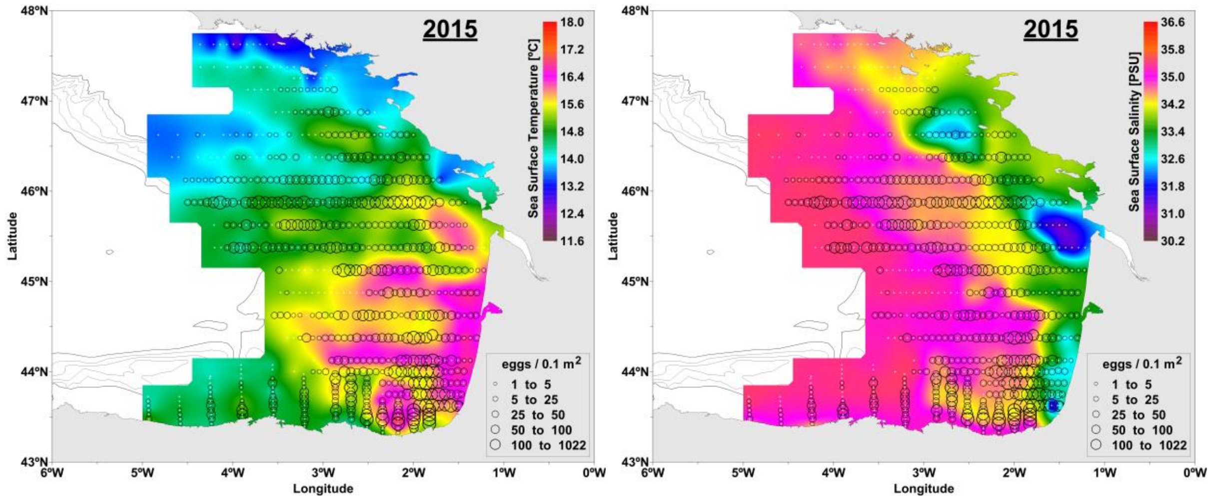

Figure 6: SST and SSS maps (left and right respectively) with anchovy egg distribution 2015.

Adult samples covered adequately the positive spawning area as shown in **Figure 2.** Overall 46 pelagic trawls were performed. 41 of those provide anchovy and 39 were selected for the analysis. The non-selected had a small amount of anchovy. Moreover, 6 samples were obtained from the purse seine fleet and two from the acoustic French survey that took place 10 days before this survey. In total there were 47 adult samples for the analysis (**Fig. 2**). The spatial distribution of the samples and their species composition is shown in **Figure 10.** Most hauls consisted of anchovy, horse mackerel, sardine and some mackerel. Adult anchovy was found in the same places where the anchovy eggs were found. Horse mackerel was found in the Cantabric coast and at the French platform in the area between 100m and 200m depth line, some sardine in Cantabric coast and in French platform from Arcachon to Nant and some mackerel.

Spatial distribution of mean weight and mine size for anchovy (males and females) are shown in **Figure 11**. As usually, less weight and size individuals were found all along the coast inside the 100 m depth isoline and in the influence of the Gironde estuary while heavier and bigger anchovies were found offshore once passed the isoline of 100m depth.

This year, during the biological analysis that was done on board in May, as usually, some immature anchovies were identified macroscopically, principally around the Gironde River. After the histological analysis it was found that those anchovies were active and mature. Due to that fact, the DEPM was applied as usually. 2% of the ovaries analysed histologically had atresia, even thought is low it isn't normal to find atresia at the pick spawning.

Apart of that, a sensitivity analysis was done and even thought, there was activity in the gonad, it was considered for the sensitivity analysis that those anchovies didn't contributed to the spawning and were considered as immature and were added to the spawning stock biomass estimate with the DEPM. The results were no very different from that applying the DEPM considering all samples mature as they were. So the result adopted was the one applying the DEPM with all samples mature.

Total daily egg production estimates

As a result of the adjusted GLM (**Fig. 7**) the daily egg production (P_0) was 132 egg m^{-2} day $^{-1}$ with a standard error of 10.75 and a CV of 0.08. The daily mortality (z) was 0.28 with a standard error of 0.04 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 1.08E+13 with a standard error of 8.81E+11 and a CV of 0.08.

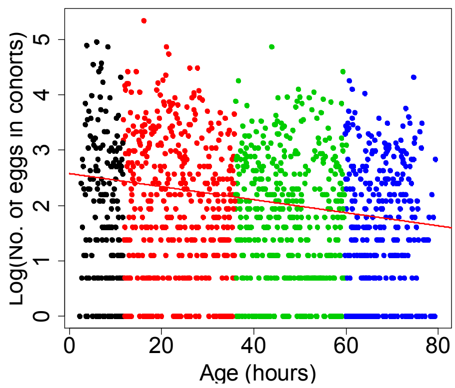

Figure 7: Exponential mortality model adjusted applying a GLM to the data obtained in the ageing, following the Bayesian method, in 2015 (spawning peak 23:00h).The red line is the adjusted line. Data in Log scale. The different colours of the bubbles represented the different cohorts.

Daily fecundity

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, 5 based on the macroscopic maturity scale from WKSPMAT, 2008) is given in **Table 1**. The extra females taken not in random, 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= 1,123). The **female mean weight** 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	-0.4168	0.0303	0
Slope	1.0996	0.0018	0

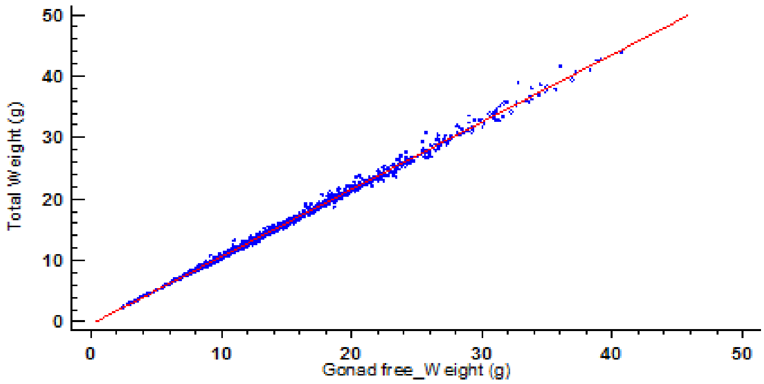

Figure 8: linear regression model between gonad-free-weight and total weight fitted to non-hydrated females.

A revision of the preliminary **batch fecundity (*F*)** given in June was completed (see material and methods). The females come from 20 samples, ranging from 4.9 to 36 g gonad free weight. It was tested whether the model coefficients changed between 3 strata Coast, Centre and offshore (the Garonne strata was considered into the Coast strata) (**Figure 3**). No statistically significant differences among the regions 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. The coefficients of the generalised linear model with Gamma distribution and identity link are shown in **table 2** and the fitted model in **Figure 9**. Hence, the overall batch fecundity estimate was obtained as a weighted sample mean of the batch fecundity per sample (Lasker, 1985).

For the **spawning frequency (*S*)** the estimate was calculated as describe above in material and methods. In June two estimates were reported, one estimated as the mean of the old historical series (S=0.25) and another one base on the mean of the new historical series (S= 0.40). In November S was estimated using the ovaries of the females obtained in the survey 2013, instead of a mean historical series. 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=0.30 C.V= 9%.

Estimates of the female mean weight, total mean weight, batch fecundity, sex ratio, new spawning frequency, daily fecundity and SSB with their CVs are given in **table 3**.

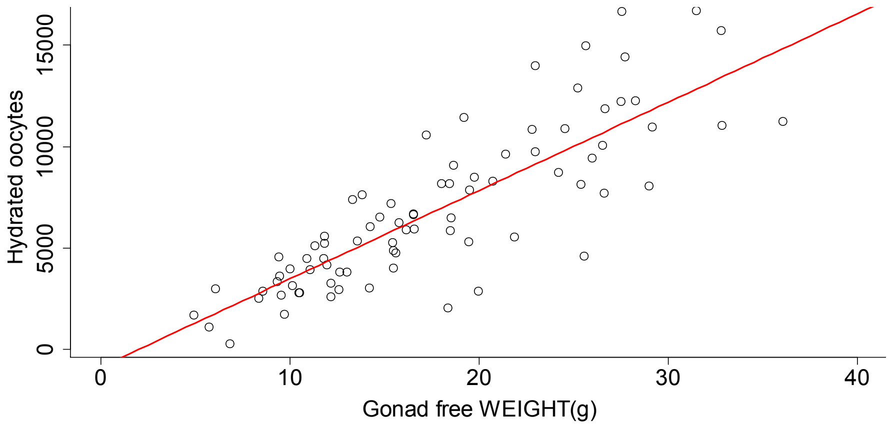

Figure 9: Generalised linear model between Weight gonad-free- and hydrated oocytes fitted to hydrated females.

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

Parameter	estimate	Standard error	Pr(>|t|)
Intercept	-854.74	325.2	0.0103*
W_{gf}	435.14	27.46	<2e-16***

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

Table 3: All the parameters to estimate anchovy Biomass using the Daily Egg Production Method (DEPM) for 2015: P_{tot} (total egg production), R (sex ratio), S (Spawning frequency), F (batch fecundity), W_f (female mean weight), DF (daily fecundity) and Biomass with correspondent Standard errors (S.e.) and coefficients of variation (CV).

Parameter	estimate	S.e.	CV
Ptot	1.08E+13	8.81E+11	0.0817
R'	0.53	0.0044	0.0084
S	0.31	0.0123	0.0395
F	6,479	478	0.0738
Wf	17.91	1.07	0.0597
DF	59.74	3.50	0.0586
BIOMASS (Tons)	**181,063**	18,202	0.1005

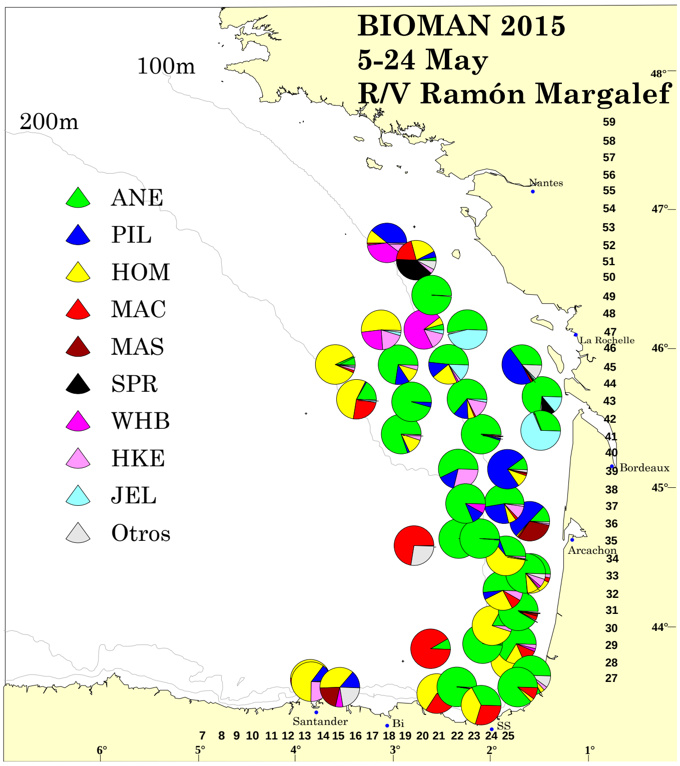

Figure 10: Spatial distribution and species composition from the 39 pelagic trawls fishing with R/V Emma Bardán during BIOMAN15.

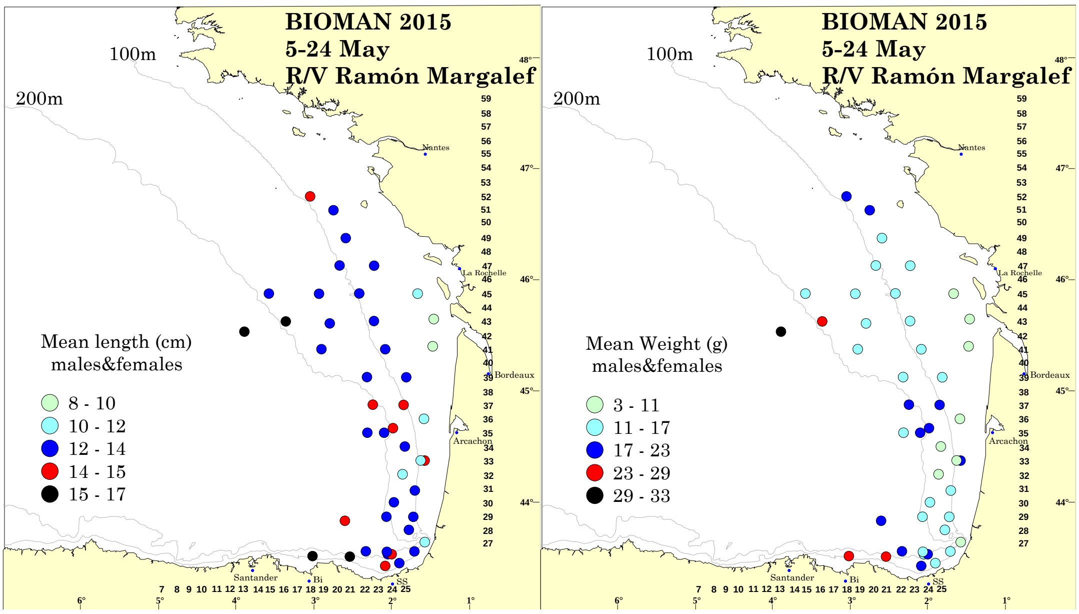

Figure 11: Anchovy (male and female) mean size (left) and weight (right) per haul 2015.

SSB and Numbers at age

The anchovy total biomass estimate obtained was 181,063t with a CV of 10.05% (**Table 3**).

For the purposes of producing population at age estimates, the age readings based on 2,422 otoliths from 47 samples were available. Estimates of anchovy mean weights and proportions at age in the population were the average of proportions at age in the samples, weighted by values proportional to the population each sample represent (as explained before in material & methods).

Given that mean weights of anchovies varied between regions (**Figure 3**) proportionality between the amount of samples and the approximate biomass indices by those 4 regions was checked. The approximate index of biomass by regions was set equal to egg abundance divided by the daily fecundity assigned to each region (**Table 4**). According to that table, the 47 samples selected do not suppose a balanced sampling between 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 index estimates.

The proportion by age, numbers by age, weight at age and biomass by age estimates are given in **Table 5, Figure 12**. 77% of the population in numbers and 63% in mass correspond to age 1 and 21 % of the population in numbers and 34% in mass corresponded to age 2. This is the year with the best recruitment of the historical series. **Figure 12** shows the distribution of anchovy age composition in space.

Table 4: Balance of adult sampling to egg abundance by 4 regions: Garonne-Ga, Coast-Co, Centre-Ce and Offshore-Off in the Bay of Biscay (see **Figure 3**). The 9th 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 47 adult samples selected for the analysis.

Region	Ga	Co	Ce	Off	Addition
Total egg abundance	5.56E+10	9.8E+11	1.81E+13	5.0E+12	2.4136E+13
% egg abundance	0.23%	4.08%	74.88%	20.82%	100.00%
DF	5.80	34.79	61.96	67.93	
Proxy of B	9.6E+09	2.8E+10	2.9E+11	7.4E+10	4.0E+11
%Proxy Biomass	2%	7%	72%	18%	100.00%
Nº of adult samples	2	5	34	6	47
%Proxy B/nº samples	0.012	0.014	0.021	0.03	
Proportion of B relative to Ga region	1.00	1.18	1.79	2.57	
W. factor proportional to the population	1/wi	1.18/wi	1.79/wi	2.57/wi	
Mean weight of anchovies by region	3.86	8.80	16.00	27.72	
Standard Deviation	0.66	1.52	3.42	5.34	
CV	17%	17%	21%	19%	

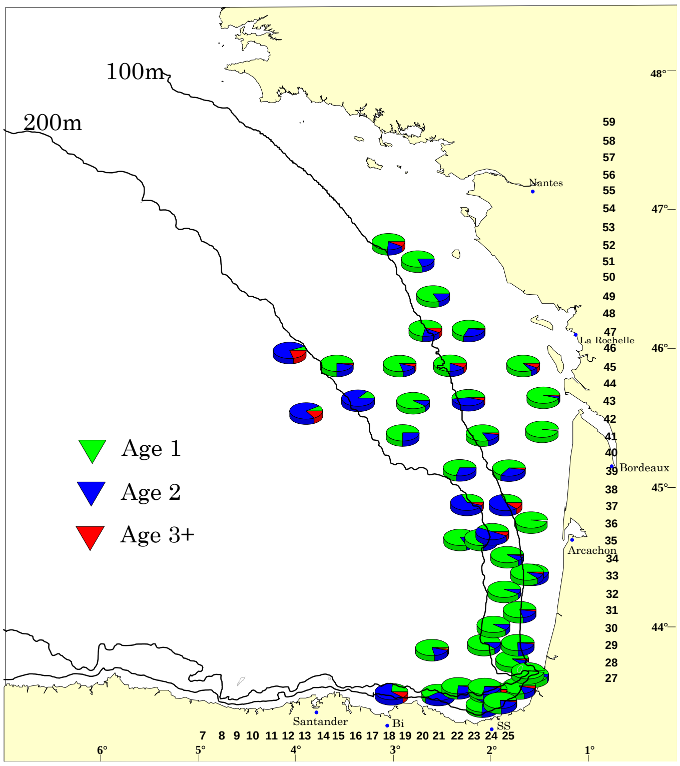

Figure 12: Anchovy age composition in space per haul 2015

Table 5: 2015 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)	**181,063**	18,202	0.1005
Total mean Weight (g)	14.43	1.00	0.0695
Population (millions)	12,589	1701	0.1351
Percentage at age 1	0.77	0.031	0.0406
Percentage at age 2	0.21	0.029	0.1378
Percentage at age 3	0.02	0.004	0.1860
Numbers at age 1	9,727	1,587.3	0.1632
Numbers at age 2	2,615	314.0	0.1201
Numbers at age 3	246	45.2	0.1832
Percent. at age 1 in mass	0.63	0.04	0.0639
Percent. at age 2 in mass	0.34	0.04	0.1065
Percent. at age 3 in mass	0.03	0.01	0.2043
B at age 1 (Tons)	113,677	14,472	0.1273
B at age 2 (Tons)	61,339	8,192	0.1335
B at age 3 (Tons)	6,086	1,371	0.2252

Biological Features	estimate	S.e.	CV
Weight at age 1 (g)	11.73	0.83	0.0708
Weight at age 2 (g)	23.42	0.96	0.0411
Weight at age 3 (g)	24.70	2.10	0.0850
Length at age 1 (mm)	120.98	3.10	0.0256
Length at age 2 (mm)	151.10	1.77	0.0117
Length at age 3 (mm)	153.17	3.55	0.0231

Historical perspective

In the Bay of Biscay the spawning area for anchovy in 2015 (81,956 km^2) was more than double of the mean historical series (1987-2015) that is 40,901km^2. The daily egg production (P_0) was the third highest of the series (mean = 82.69). The mortality (z) was about the mean historical series (mean = 0.25). The total daily egg production (P_{tot}) was almost three times the mean historical series (mean = 3.712E+12). (**Fig.13**)

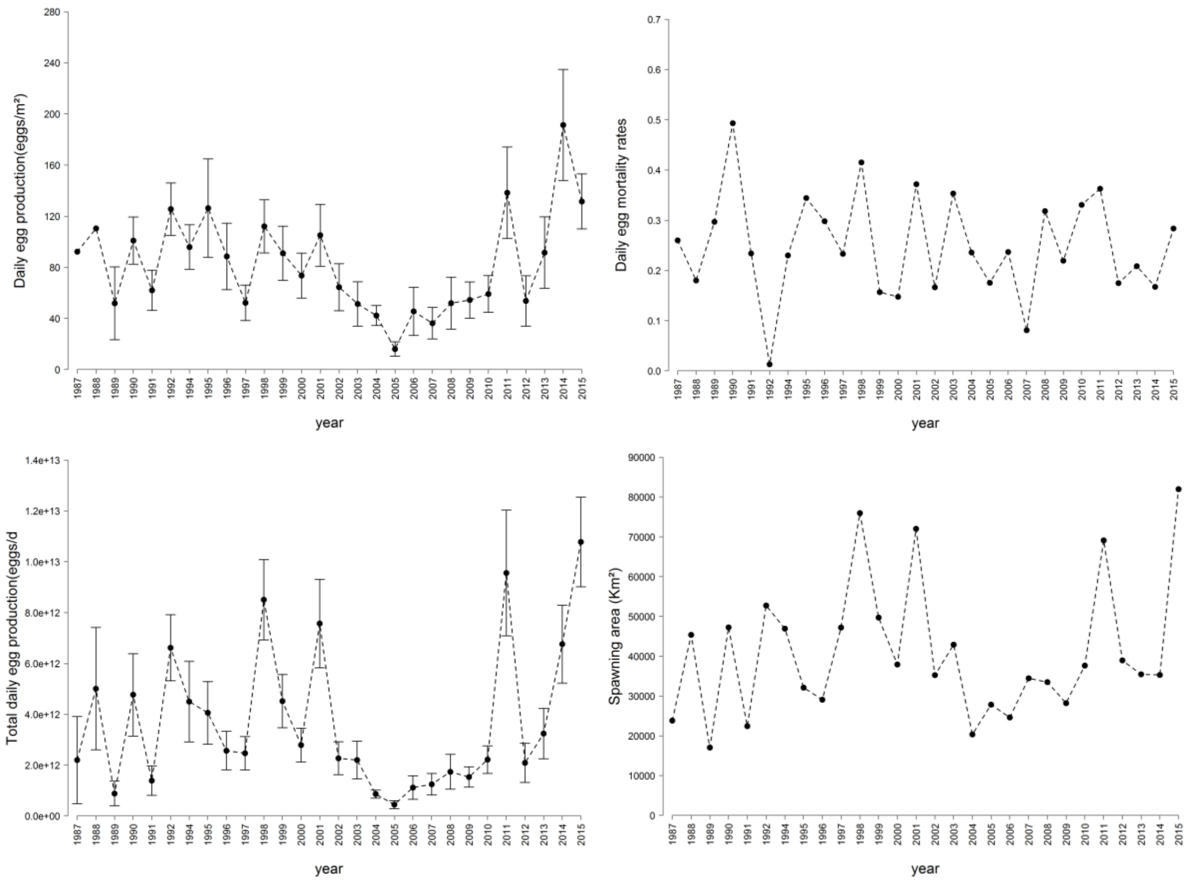

Figure 13: Time series of DEPM egg parameters and spawning area for anchovy: Daily egg production (P_0) ($eggsm^{-2}$), Daily egg mortality rates (z), total egg production (P_{tot})($eggsday^{-1}$) and Spawning area(Km^2). Vertical lines indicate 95% confidence intervals (i.e. ± 2 standard deviations).

The historical series of reproductive parameters for the DEPM for Anchovy in the Bay of Biscay in May are showed **figure 14**. Compering the adult parameters estimated in 2015 with the corresponding mean historical series (1987-2015), sex ratio (0.53) is at levels of the historical mean (0.54), female mean weight (17.91g) is the lowest of the historical series (mean = 24.41g). The batch fecundity this year (6,479 eggs per mature female per batch) is the lowest of the historical series (mean = 11,046 eggs per mature female per batch). The spawning fraction (0.31) is the second lowest of the series (mean = 38.7) and in consequence the daily fecundity (59.74 egg/g) is the lowest of the historical series (mean = 94.63 egg/g).

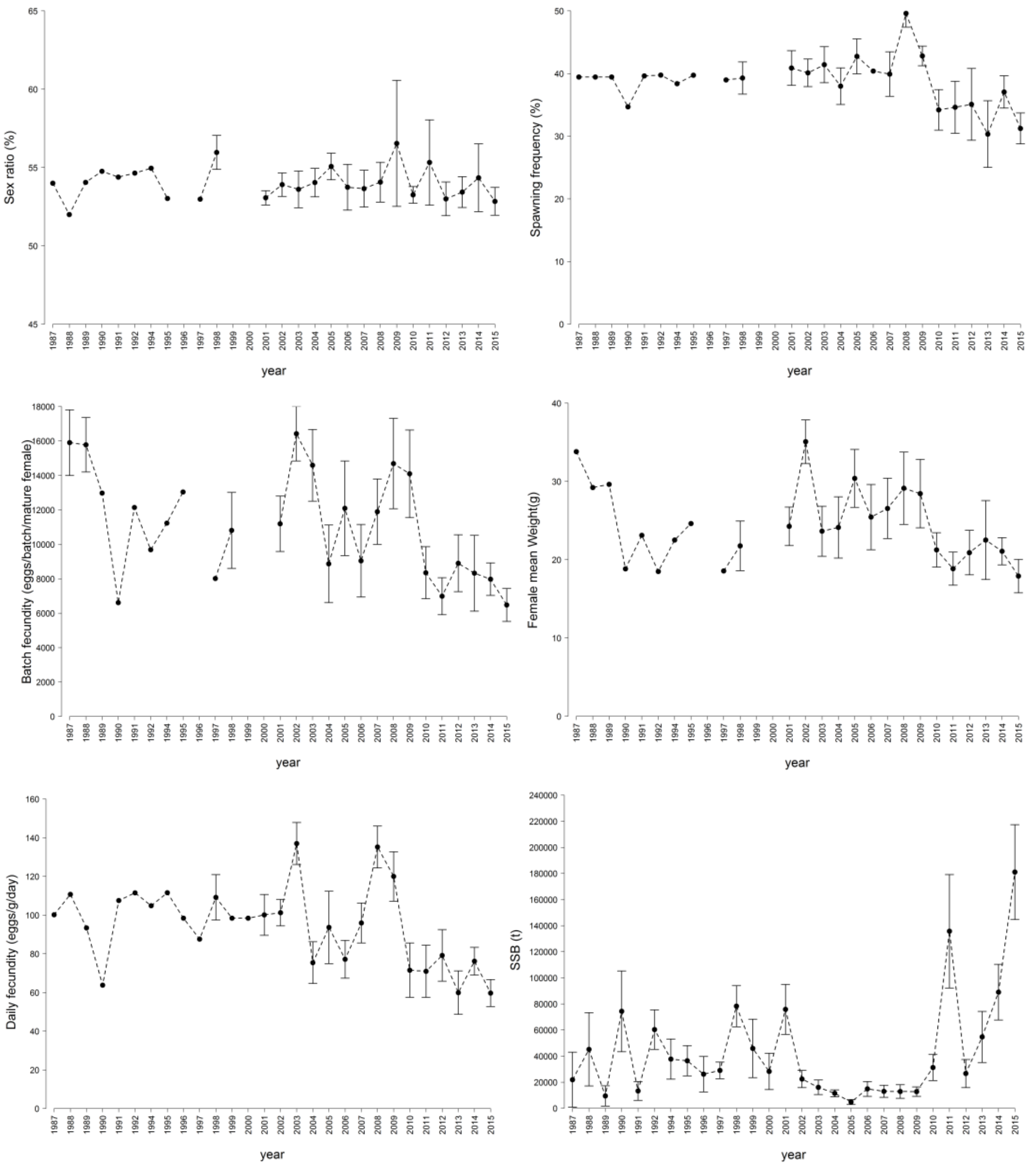

Figure 14: Time series of anchovy DEPM adult parameters and total biomass. Vertical lines indicate 95% confidence intervals (i.e. ± 2 standard deviations). Sex ratio (mature females fraction of population by weight), spawning fraction (fraction of mature females spawning per day), batch fecundity (eggs 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 15.** This is the year with the best recruitment of the historical series.

Distribution maps of anchovy egg abundances in the last 22 DEPM surveys were compiled (**Fig 17**).

Sardine total egg abundance

Total egg abundance for sardine was estimate as the sum of the numbers of eggs in each station multiply by the area each station represent. This year estimate is 5.5E+12 eggs (**table 6**), at same levels as year 2013 and lower than last year. The historical series of egg abundances is shown in **figure 16**. The sardine egg historical distribution is shown in **figure 18**.

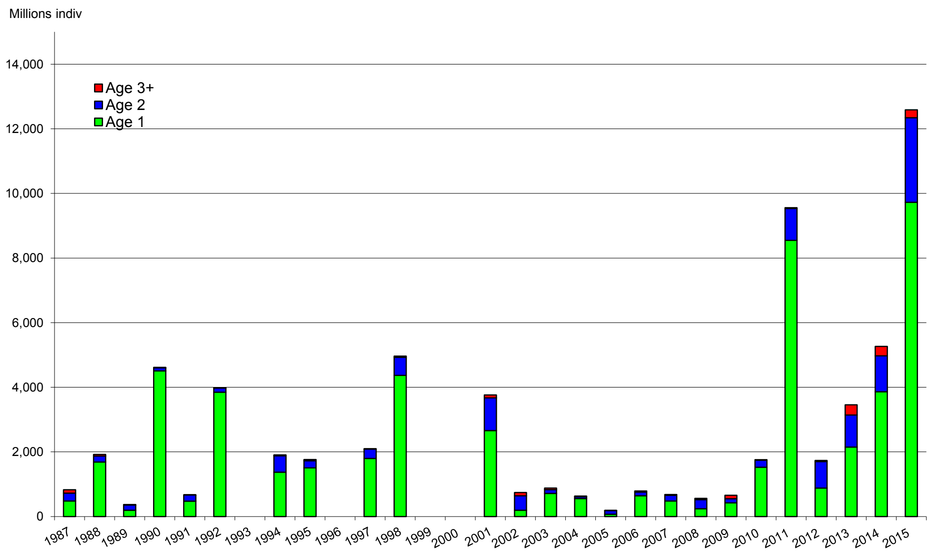

Figure 15: Historical series of numbers at age from 1987 to 2015

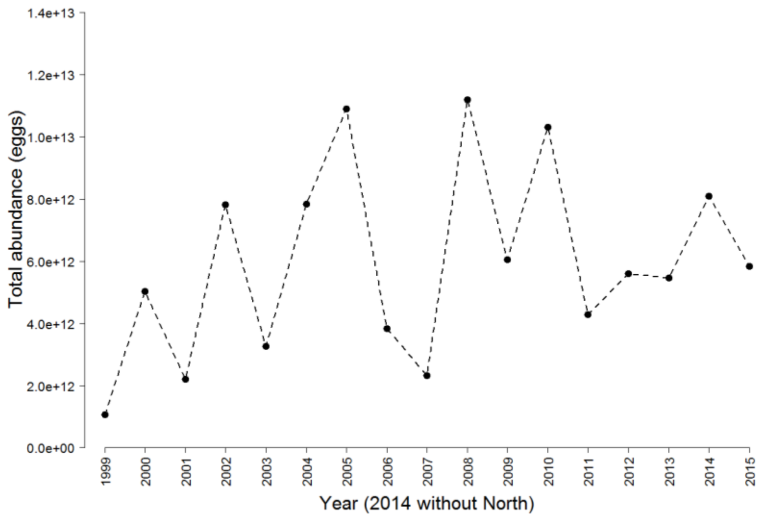

Figure 16: historical series of sardine egg abundances 1999-2015.

Table 6: Historical series of sardine egg abundances, considering all the area surveyed and without the Cantabric coast. Positive area considering all the area surveyed and without the Cantabric coast and the total area surveyed.

Year	Tot_ab_Sp eggs	Ab_tot without cantabric	pos area all	pos area without cantabric	tot area	
1999	1.3E+12	1.1E+12	26,679	21,528	59,193	
2000	6.1E+12	5.0E+12	46,286	40,055	63,978	
2001	3.5E+12	2.2E+12	30,232	23,036	92,376	
2002	9.0E+12	7.8E+12	41,309	36,487	55,765	
2003	3.4E+12	3.3E+12	29,273	26,791	70,424	
2004	9.3E+12	7.8E+12	38,113	32,792	50,411	
2005	1.1E+13	1.1E+13	44,569	37,631	61,619	
2006	4.3E+12	3.8E+12	26,916	24,001	53,991	
2007	2.5E+12	2.3E+12	18,885	16,824	56,079	
2008	1.1E+13	1.1E+13	30,759	27,040	69,150	
2009	7.5E+12	6.1E+12	34,746	28,171	60,733	
2010	1.1E+13	1.0E+13	36,361	32,305	61,940	
2011	4.5E+12	4.3E+12	22,851	20,632	98,405	
2012	5.7E+12	5.6E+12	20,054	19,438	80,381	
2013	5.5E+12	5.5E+12	25,423	25,146	77,838	
2014	1.4E+13	1.4E+13	55,563	53,930	104,015	with the North
2014	8.1E+12	8.1E+12	35,759	34,125	70,770	without the North
2015	6.0E+12	5.84E+12	39,110	35,712	94,774	

Acknowledgements

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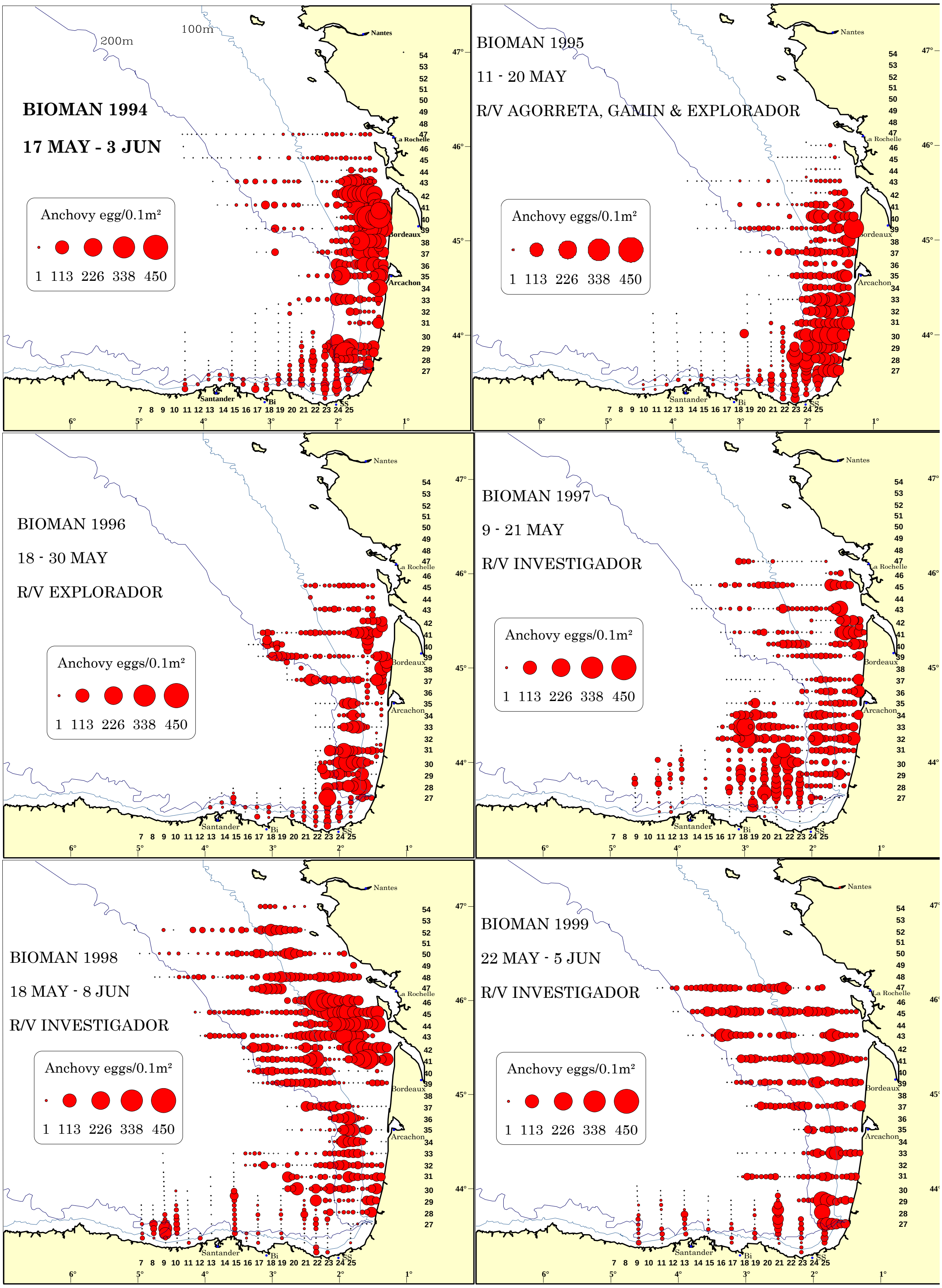
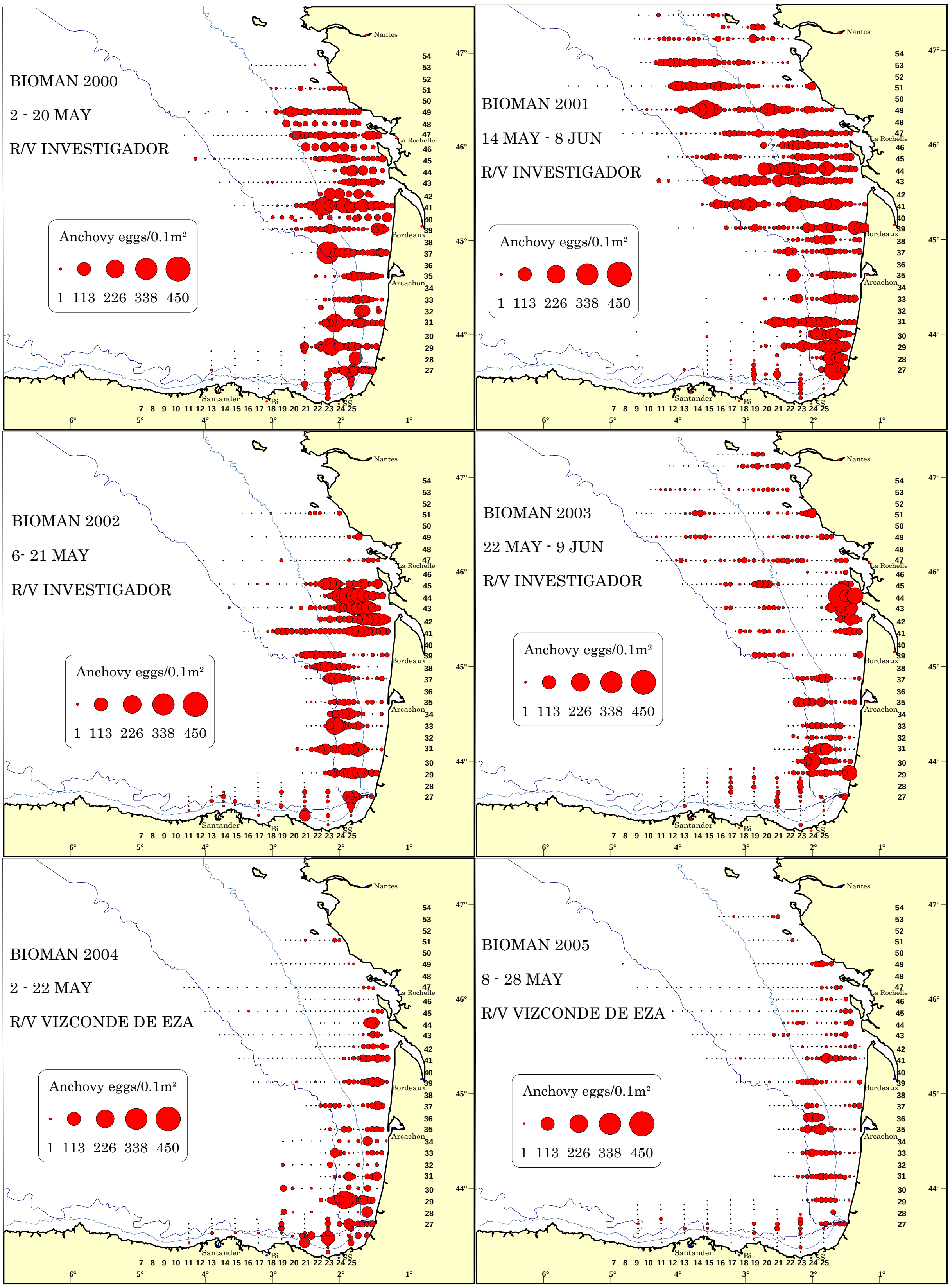
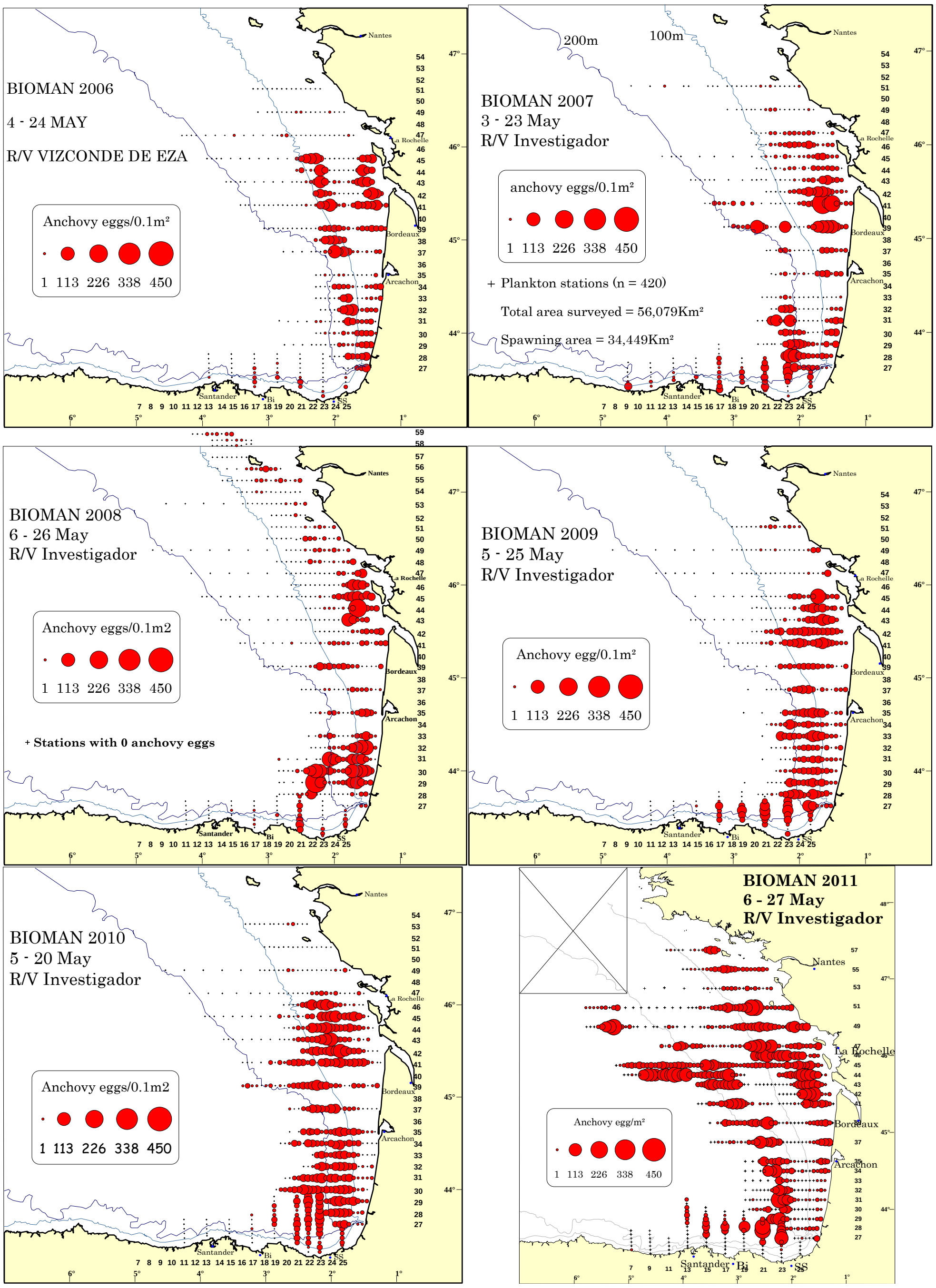

200m
100m
BIOMAN 1994
17 MAY - 3 JUN
Anchovy egg/0.1m²
1 113 226 338 450
BIOMAN 1995
11 - 20 MAY
R/V AGORRETA, GAMIN & EXPLORADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 1996
18 - 30 MAY
R/V EXPLORADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 1997
9 - 21 MAY
R/V INVESTIGADOR
Anchovy eggs/0.1m²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


BIOMAN 2000
2 - 20 MAY
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 2001
14 MAY - 8 JUN
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 2002
6- 21 MAY
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 2003
22 MAY - 9 JUN
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 2004
2 - 22 MAY
R/V VIZCONDE DE EZA
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 2005
8 - 28 MAY
R/V VIZCONDE DE EZA
Anchovy eggs/0.1m²
1 113 226 338 450
Nantes
La Rochelle
Bordeaux
Arcachon
Santander
Bi
SS
47°
46°
45°
44°
6°
5°
4°
3°
2°
1°


BIOMAN 2006
4 - 24 MAY
R/V VIZCONDE DE EZA
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 2007
3 - 23 May
R/V Investigador
200m
100m
anchovy eggs/0.1m²
1 113 226 338 450
+ Plankton stations (n = 420)
Total area surveyed = 56,079Km²
Spawning area = 34,449Km²
BIOMAN 2008
6 - 26 May
R/V Investigador
Anchovy eggs/0.1m2
1 113 226 338 450
+ Stations with 0 anchovy eggs
BIOMAN 2009
5 - 25 May
R/V Investigador
Anchovy egg/0.1m²
1 113 226 338 450
BIOMAN 2010
5 - 20 May
R/V Investigador
Anchovy eggs/0.1m2
1 113 226 338 450
BIOMAN 2011
6 - 27 May
R/V Investigador
Anchovy egg/m²
1 113 226 338 450
Nantes
La Rochelle
Bordeaux
Arcachon
Santander
Bi
SS

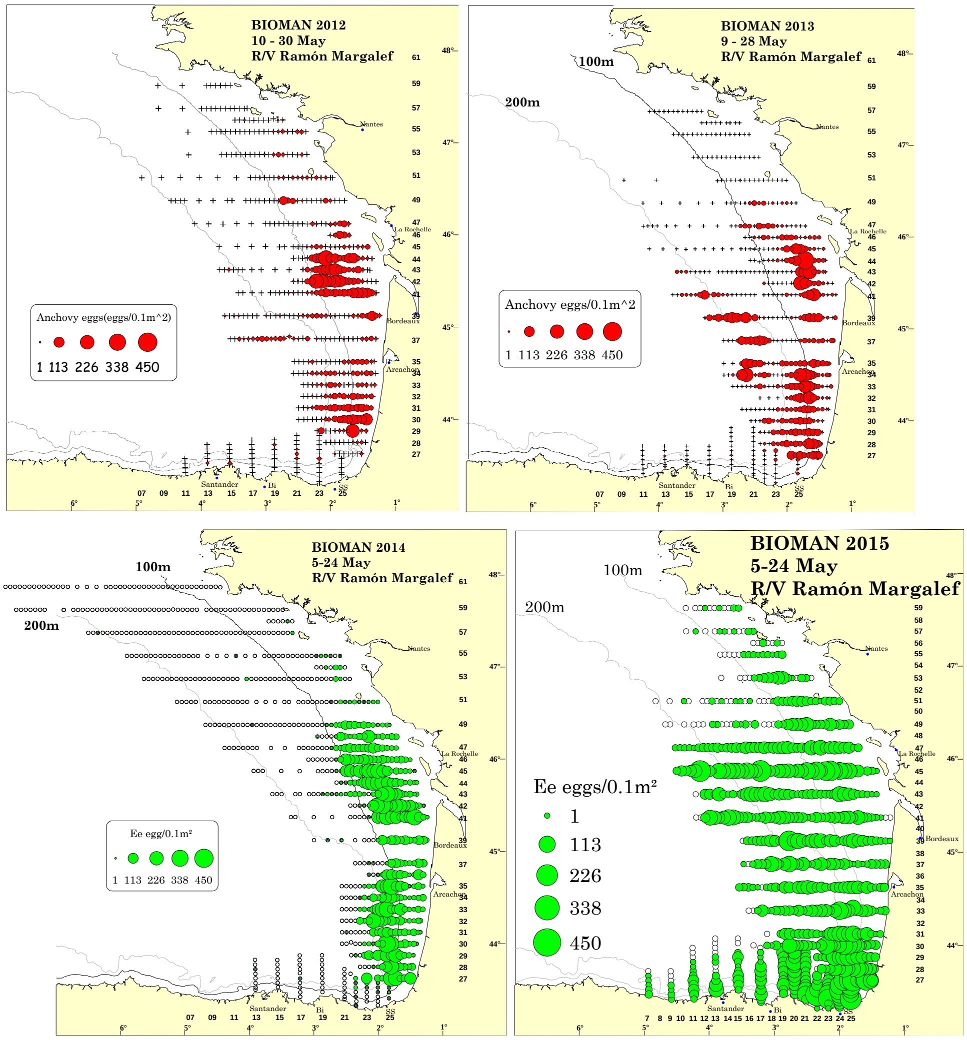
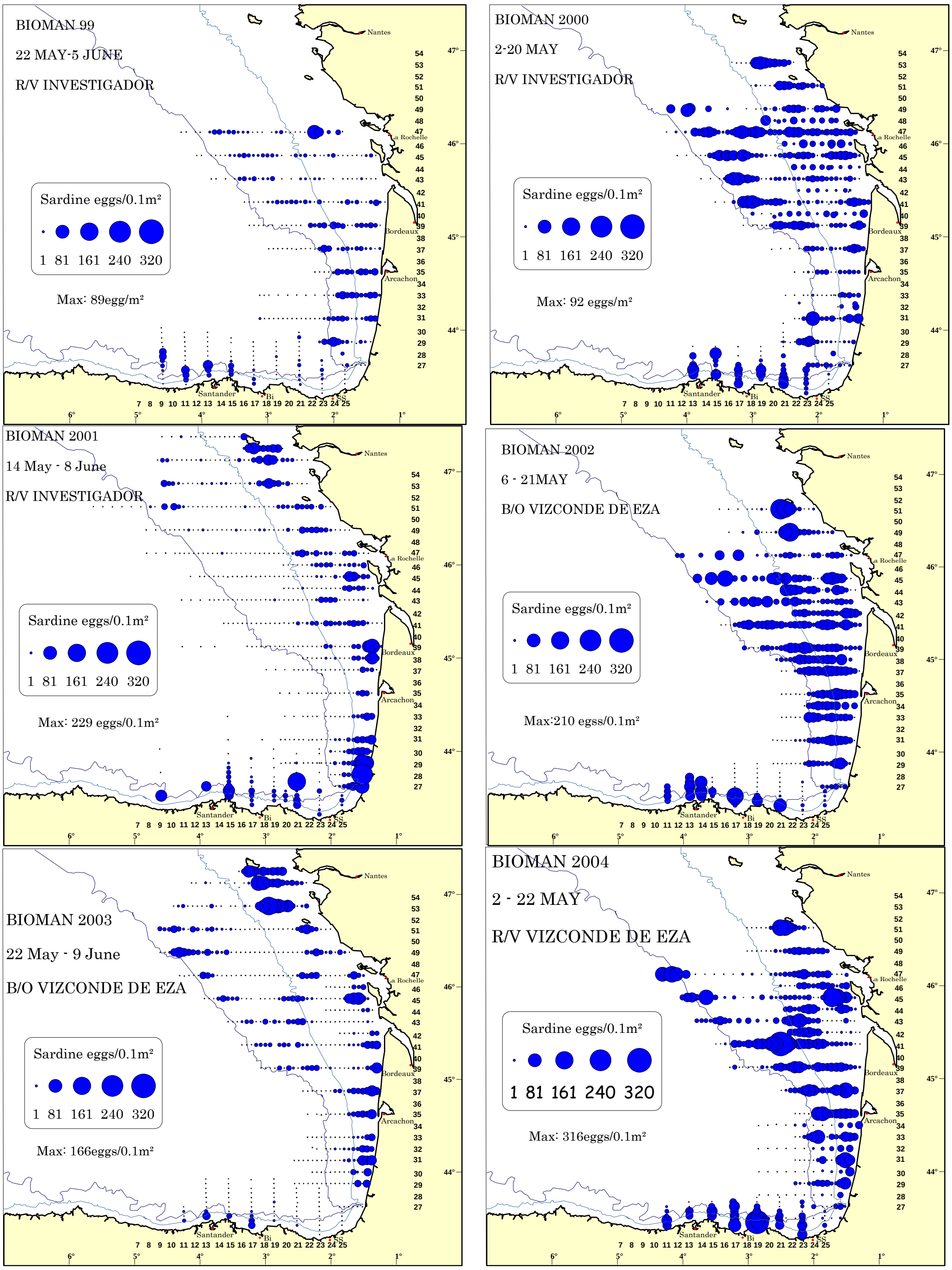
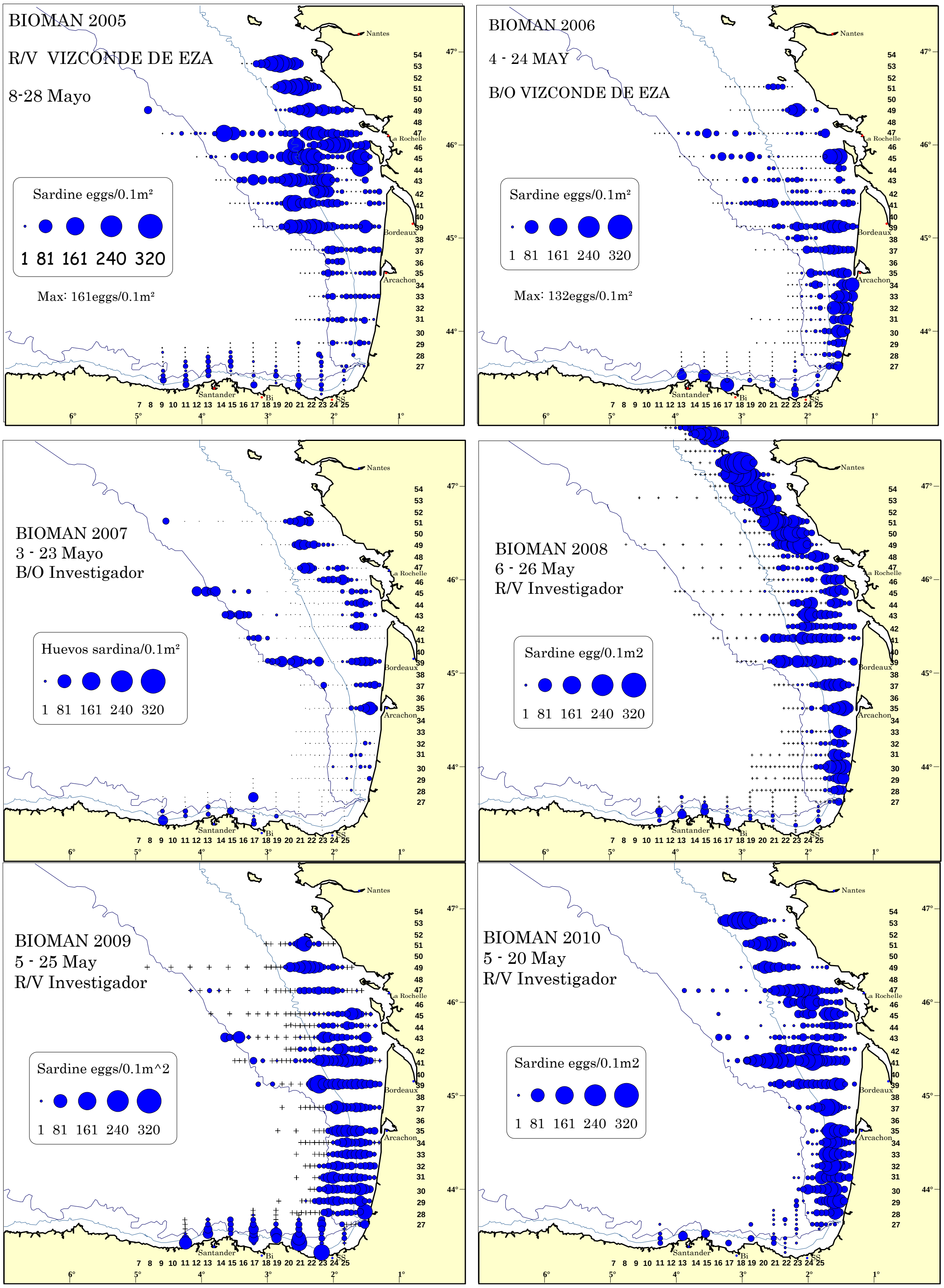


Figure 17: Anchovy egg distribution and abundance from 1994 to 2015.


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
47°
46°
45°
44°
6°
5°
4°
3°
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1°

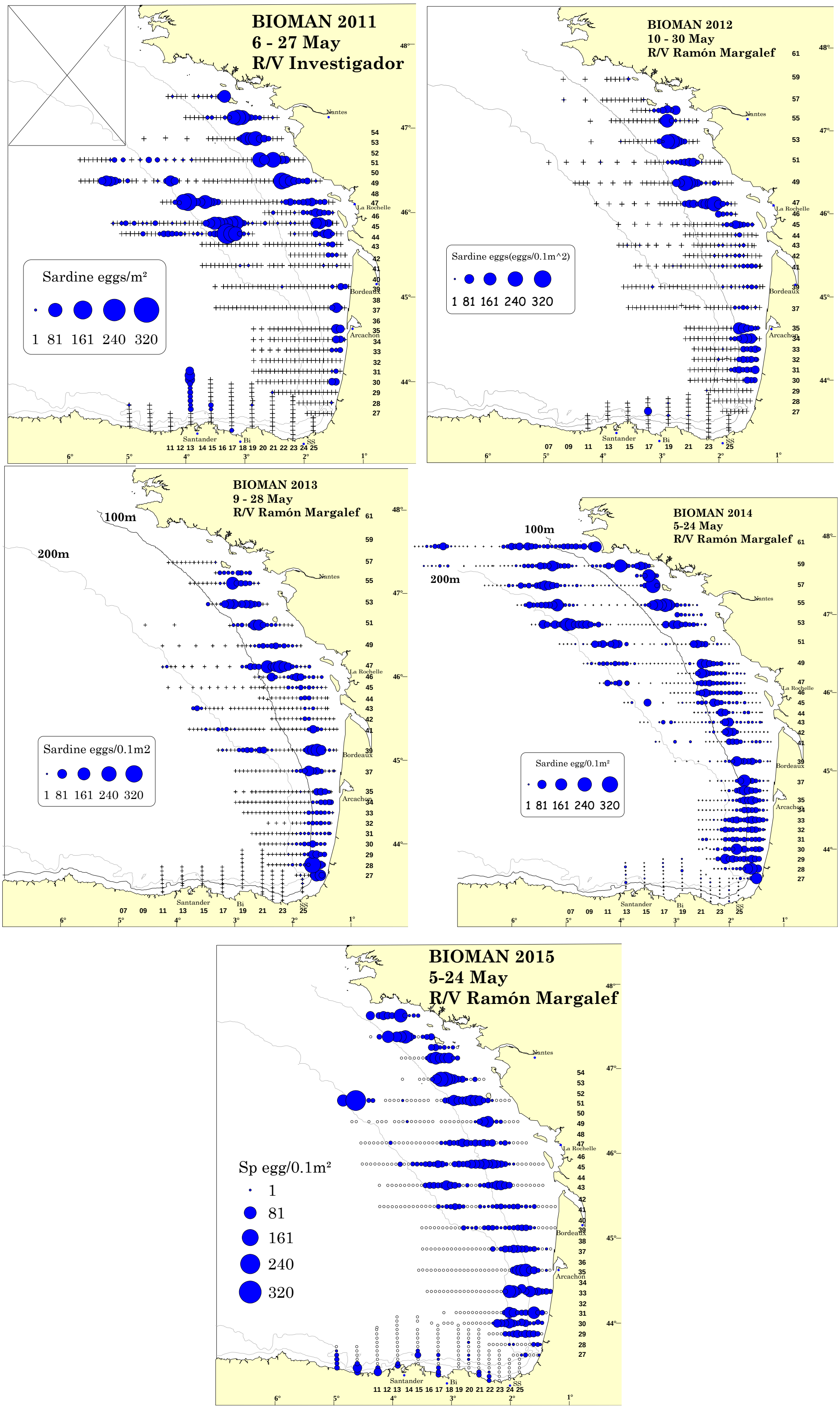

Figure 18: Sardine egg distribution and abundance from 1999 to 2015.

*Working Document for **WGHANSA***
(Lisbon, 24-29 June.2015)

Direct assessment of small pelagic fish by the PELGAS15 acoustic survey

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1. MATERIAL AND METHOD

1.1. PELGAS survey on board Thalassa

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

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

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

1) Continuous acquisition of acoustic data from six different frequencies and pumping sea-water under the surface in order to evaluate the number of fish eggs using a CUFES system (Continuous Under-water Fish Eggs Sampler). Concurrently, a visual counting and identification of cetaceans and birds (from board) carried out in order to characterise the higher level predators of the pelagic ecosystem.
2) Discrete sampling at stations (by pelagic trawls, plankton nets, CTD).

Satellite imagery (temperature and sea colour) and modelling have been also used before and during the survey to recognise the main physical and biological structures and to improve the sampling strategy.

The strategy this year was the identical to previous surveys (2000 to 2014). 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.

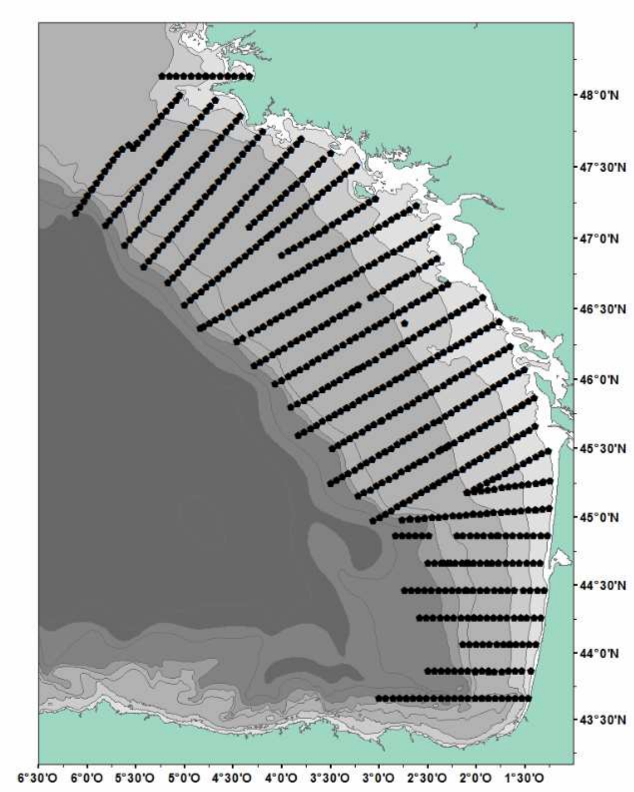


Fig. 1.1.1 - Transects prospected during PELGAS15 by Thalassa.

Three different echo-sounders were used during the survey :

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

- 6 split beam vertical echo-sounders (EK60), 6 frequencies, 18, 38, 70, 120, 200 and 333 kHz
- 1 horizontal echo-sounder on the starboard side for surface echo-traces
- 1 SIMRAD ME70 multi-beam echo-sounder (21 2 to 7°beams, from 70 to 120 kHz) used essentially for visualisation to observe the behaviour and shapes of fish schools during the whole survey. Nevertheless, only echoes stored on the vertical echo-sounder were used for abundance index calculation.

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

The calibration method was the same that the one described for the previous years (see WD 2001) and was performed at anchorage 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 5400 nautical miles from which 1990 nautical miles on one way transect were used for assessment. A total of 37679 fishes were measured (including 13 353 anchovies and 9022 sardines) and 3057 otoliths were collected for age determination (1607 of anchovy and 1450 of sardine).

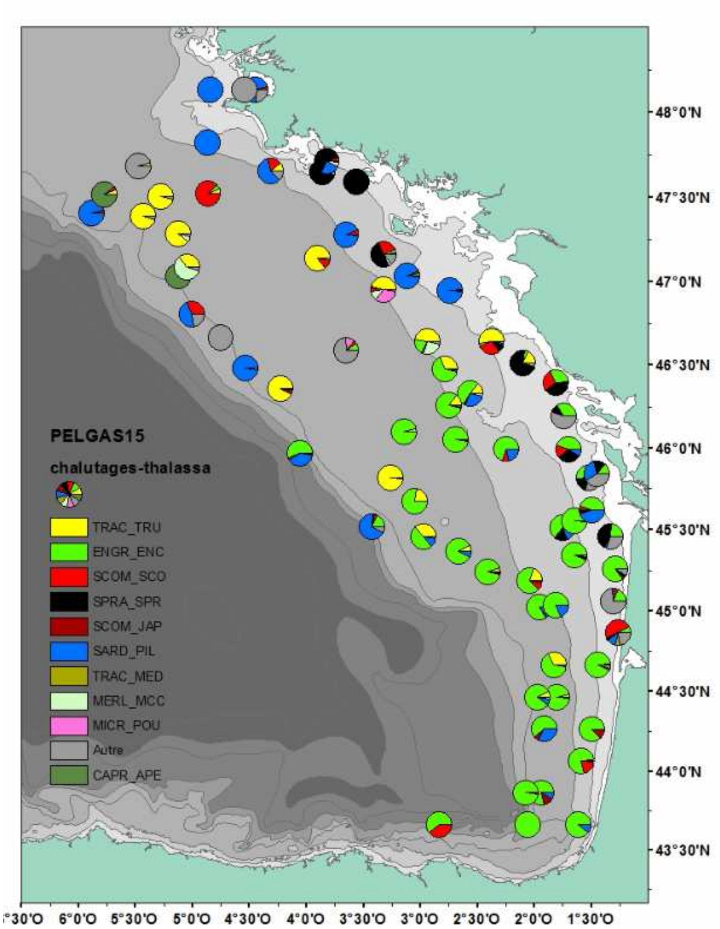


Fig. 1.1.2: Species distribution according to Thalassa identification hauls.

1.2. The consort survey

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

Four commercial vessels (two pairs of pelagic trawlers) participated to PELGAS15 survey:

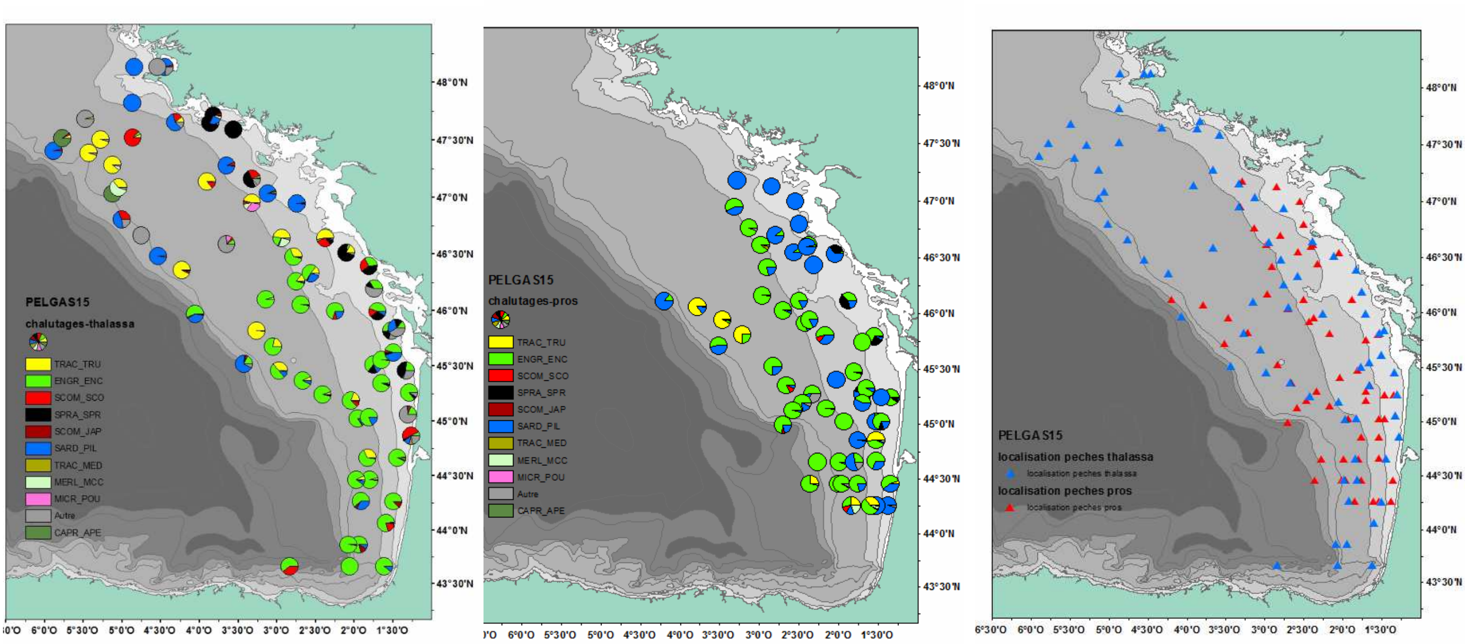
Vessel	gear	Period	Days at sea
Maïlys-Charlie / Pen Kiriac 3	Pelagic pair trawl	03/05 to 12/05/2015	9
Jeremi-Simon / Prométhée	Pelagic pair trawl	12/05 to 20/05/2015	9

The regular transects network agreed for several years for Thalassa is 12 miles separated parallel transects. Commercial vessels worked between standard transects and 2 NM northern. Sometimes, they carried out fishing operations on request (complementary to Thalassa, particularly for surface hauls or in very coastal areas) Their pelagic trawl was until 25 m vertical opening and the mesh of their codend was similar to Thalassa (12 mm).

A scientific observer was onboard to control every operation, and to collect biological data. The fishing operations were systematically agreed after a radio contact with Thalassa in order to confirm their usefulness. In some occasions, the use was to check the spatial extension of species already observed and identified by Thalassa (and therefore the spatial distribution), in others the objective was to enlarge the vertical distribution description by stratified catches. Globally, a great attention was given on a good distribution of samples to avoid over-sampling on some situations. Regularly a biological sample was provided by commercial vessels to Thalassa to improve otoliths collection and sexual maturity (160 otoliths of anchovy, 138 of sardine). A total of 16 674 fishes were measured onboard commercial vessels, including 8 150 anchovies and 4 506 sardines.

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

A total of 136 hauls were carried out during the assessment coverage including 73 hauls by Thalassa and 63 hauls by commercial vessels.



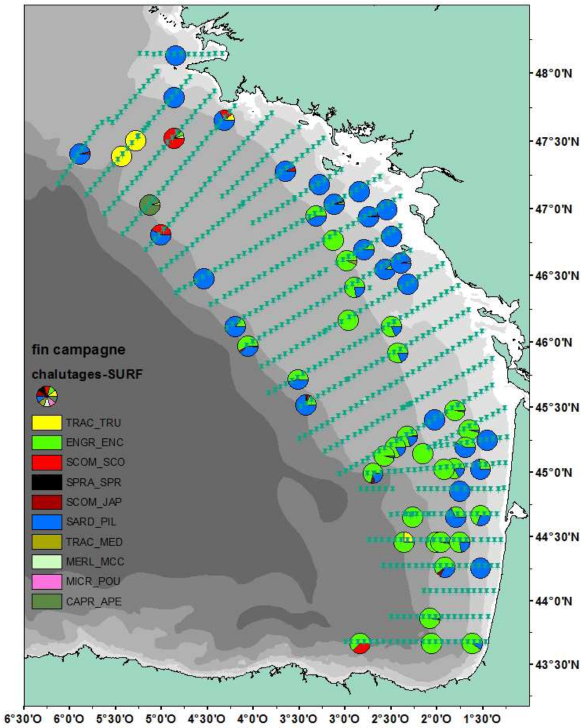
a) Thalassa (nb :73) *b) Commercial vessels (nb : 63)* *c) all fishing hauls (nb :136) thalassa in Blue and commercial in red*

Figure 1.2.2 : fishing operations carried out by Thalassa and commercial vessels during consort survey PELGAS15

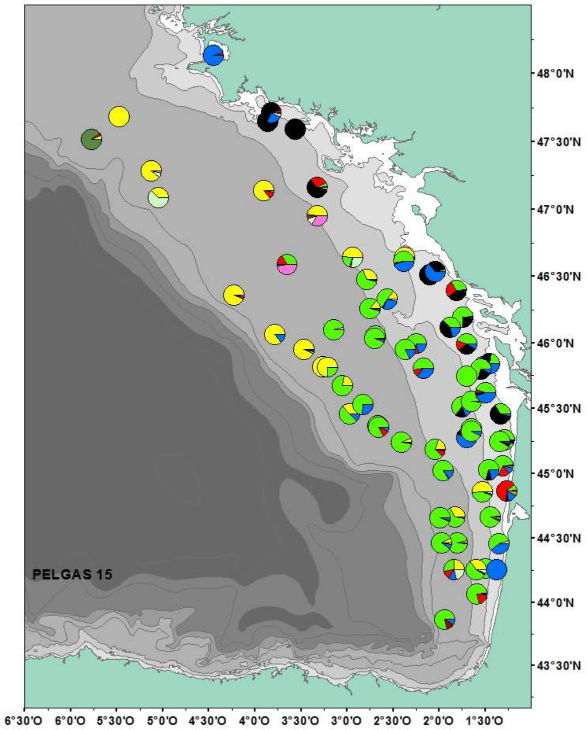
The collaboration between Thalassa and commercial vessels was excellent. It was once more a very good opportunity to explain to fishermen our methodology and furthermore, to verify that both scientists and fishermen observe the same types of echo-traces and have similar interpretations. Some fishing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

	thalassa	commercial	total
surface hauls	21	38	59
classic hauls	49	23	72
null	3	2	5
total	73	63	136

Table 1.2.3. : number of fishing operations carried out by Thalassa and commercial vessels during consort survey PELGAS15



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



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

Figure 1.2.4 : Vertical localisation of fishing operations carried out by Thalassa and commercial vessels during survey PELGAS15

2. ACOUSTICS DATA PROCESSING

2.1. Echo-traces classification

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

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

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

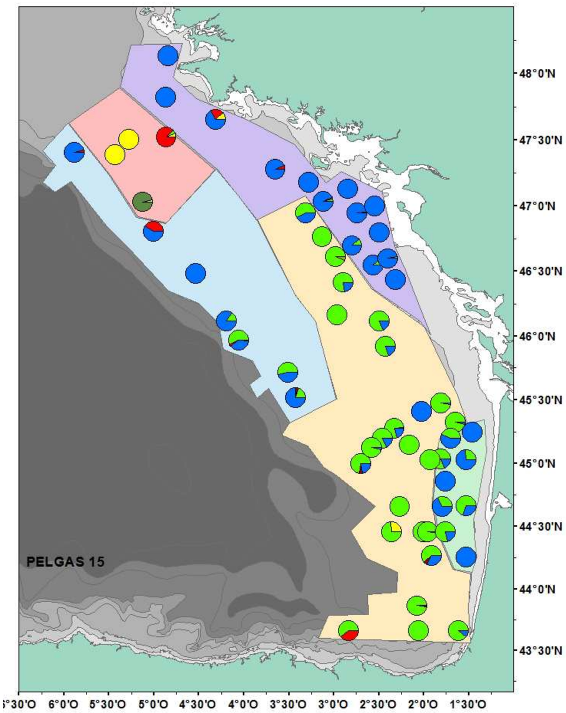
D3 – energies attributed to scattered detection corresponding to blue whiting, myctophids, boarfish, mackerel and horse mackerel.

D4 – energies attributed to sardine, mackerel and anchovy corresponding to echoes very close to the surface. this year boarfish and horse mackerel were also in this category

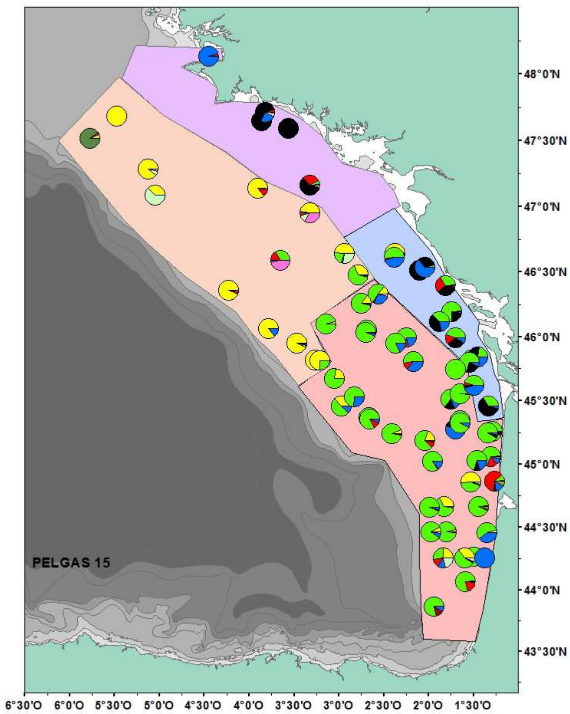
D8 – energies attributed exclusively to sardine (big and very dense schools).

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 the variable mixing of species. Figure 2.2. shows the strata considered to evaluate biomass of each species. For each strata, energies where converted into biomass by applying catch ratio, length distributions and weighted by abundance of fish in the haul surrounded area.



Coherent 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 PELGAS15 survey.

2.3. Biomass estimates

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

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

Anchovy was present this year the best abundance index never observed before, with around 370 000 tonnes, with highest densities in the Gironde area, from the coast to the shelfbreak and in the whole water column, from bottom to the surface.

Sardine was still well present this year, mostly in coastal waters from the South until the North of the bay of Biscay, and she was also spotted mainly near the surface in the Northern part, on the platform and at the shelfbreak.

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

Mackerel appears very dispersed all over the area and seems to be rather absent of te bay of Biscay.

	classic	surface	total
Anchovy	295 110	77 806	**372 916**
blue whiting	8 657	27	**8 684**
sardine	145 310	271 214	**416 524**
mackerel	73 466	169 468	**242 935**
sprat	91 248	0	**91 248**
horse mackerel	55 075	22 067	**77 142**

Table 2.3.1. Acoustic biomass index for the main species by strata during PELGAS15

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
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**
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
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**
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
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**
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
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**
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
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**
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*

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

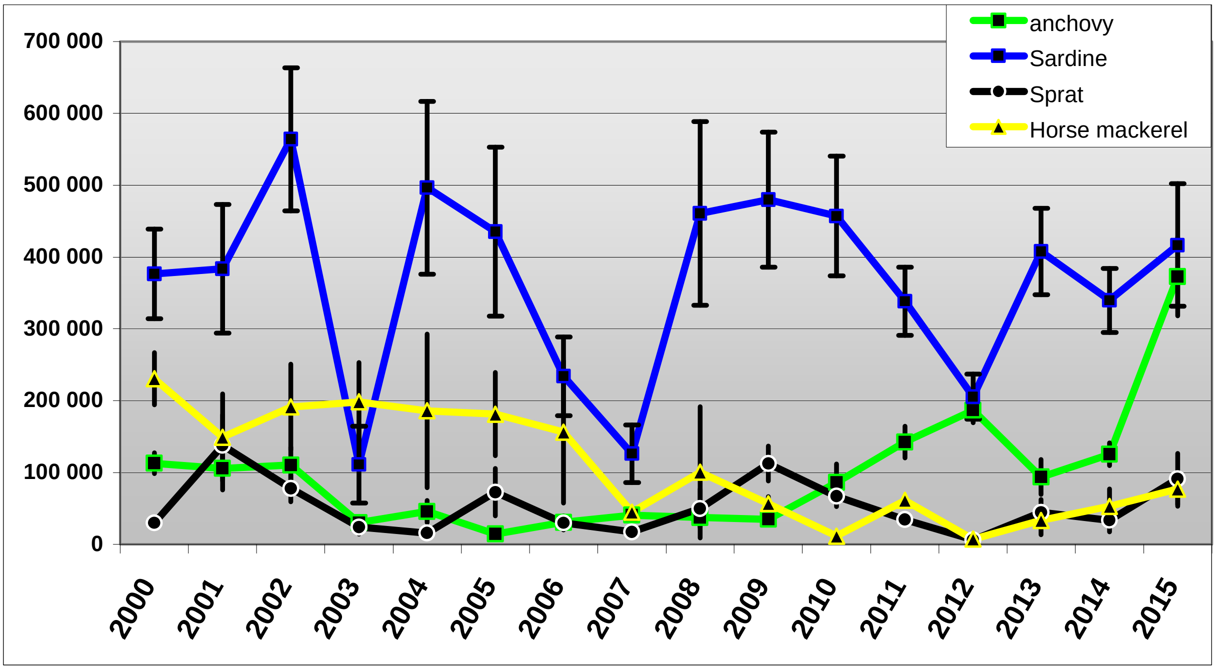


figure 2.3.1. – biomass estimate using Thalassa acoustic data along transects and all the consort identification fishing operations (Thalassa + commercial vessels) and coefficients of variation associated.

3. Anchovy data

3.1. anchovy biomass

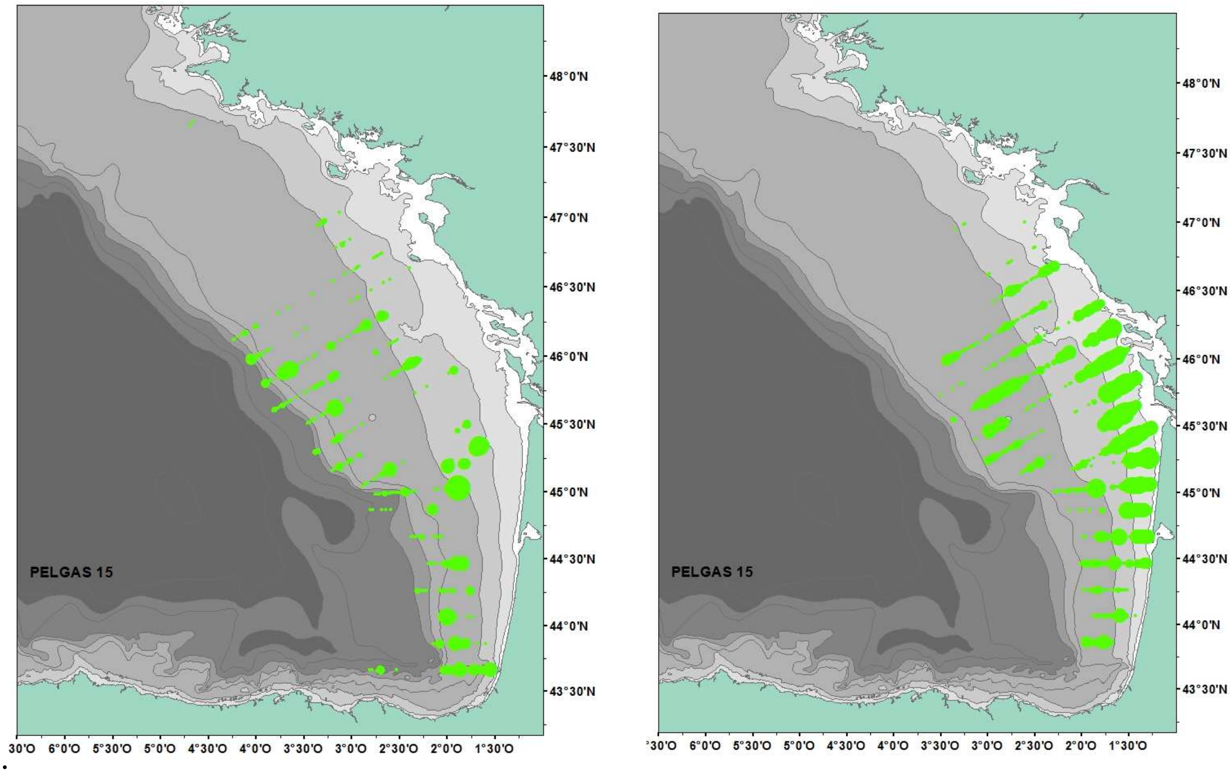
The biomass estimate of anchovy observed during PELGAS13 is **372 916** tons. (table 2.3.2.), which is the highest level never observed on the PELGAS series, and constituting an exceptional increase of this biomass in the bay o Biscay.

The main observation in 2015 is that sardine, anchovy and sprat (all clupeids grouped) were well present as densities never observed before. These echoes were systematically identified on each transect and revealed almost pure anchovy (very small) in the Gironde area (exclusively one year old in front of the river plume, and immature).

In the Gironde area, the configuration was unusual (in size and in Sa), with an acoustic energy attributed to anchovy far above the average and anchovies never observed so small at this period of the year. 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, from the south of the bay until the latitude of 46°30

On the South coast of Brittany, no real sightings of anchovy occurred this year



Surface distribution

Near-seabed distribution, between the bottom and 40m above

Figure 3.1. – Anchovy distribution according to PELGAS15 survey.

3.2. Anchovy length structure and maturity

Length distribution in the trawl hauls were estimated from random samples. The population length distributions (figures 3.2.1 and 3.2.2) has been estimated by a weighted average of the length distribution in the hauls. Weights used are acoustic coefficients (Dev*Xe Moule in thousands of individuals per n.m.^{2}) which correspond to the abundance in the area sampled by each trawl haul.

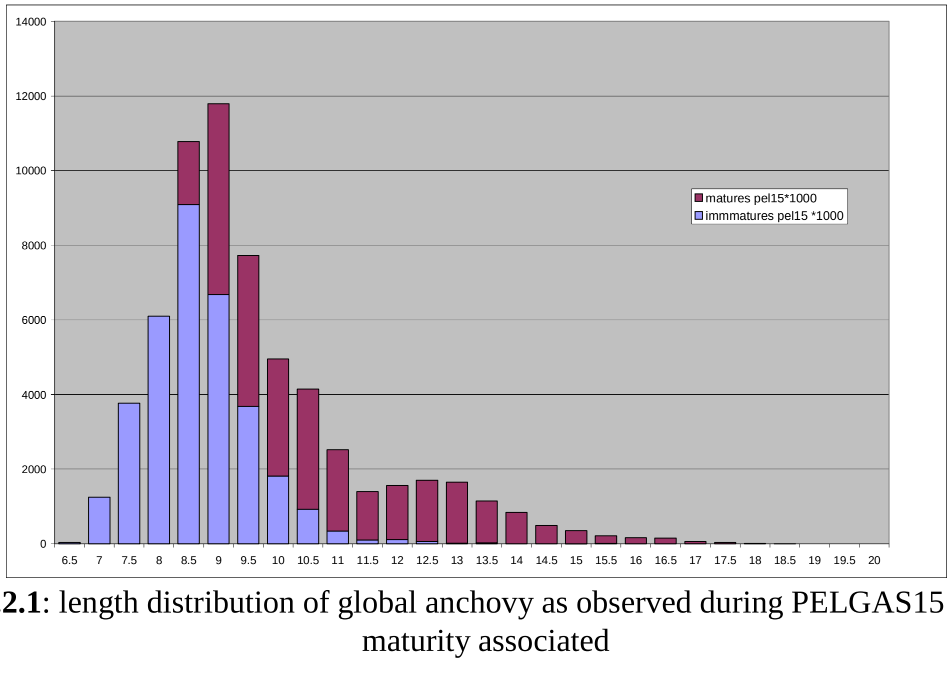


Figure 3.2.1: length distribution of global anchovy as observed during PELGAS15 survey and maturity associated

Globally, we observe that this year most part of the anchovies were small (mode < 11 cm) and constitutes the smallest anchovies never observed before. It is essential to notice than this year, mainly due to their very small lengths, lots of anchovies were immature, contrary to all other years when almost all individuals were in spawning period. Most of these immature fishes just started their maturation. So, they are 1 year old, they are considered as adults, but not spawning at the survey time.

A map was also realised to see how immatures were met this year (see figure 3.2.2.):

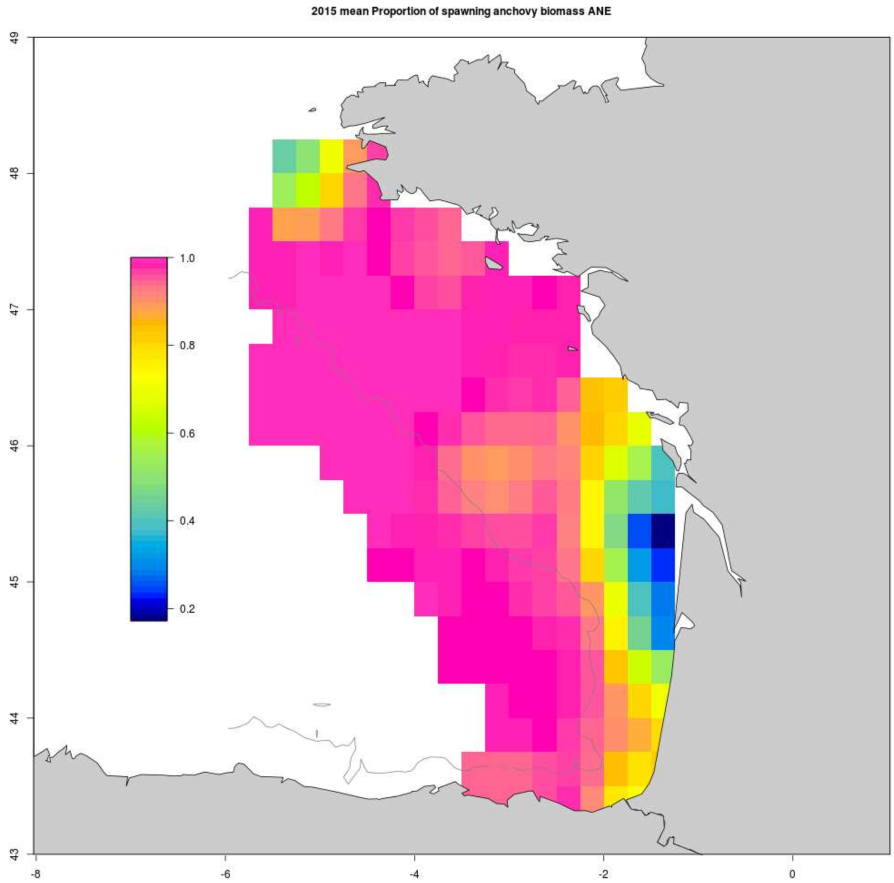


figure 3.2.2 : grid map of anchovy maturity during PELGAS15 survey

. 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 set number of fishes per length class (4 to 6 / half-cm), for a total amount of around 50 fish per haul. As there was more fishing operations where anchovy was present compared to previous surveys, the number of otoliths we took during the survey increased compared to last years (1607 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.

NB age	age				
length (mm)	1	2	3	4	5
65	100.0%				
70	100.0%				
75	100.0%				
80	100.0%				
85	100.0%				
90	100.0%				
95	100.0%				
100	100.0%				
105	100.0%				
110	100.0%				
115	100.0%				
120	96.4%	3.6%			
125	91.0%	7.4%	1.6%		
130	85.4%	13.0%	1.6%		
135	67.0%	30.1%	1.9%	1.0%	
140	69.9%	29.0%	1.1%		
145	44.3%	47.7%	5.7%	2.3%	
150	27.9%	70.6%	1.5%		
155	18.8%	75.0%	6.3%		
160	3.4%	89.7%	6.9%		
165	3.8%	88.5%	7.7%		
170	2.9%	88.6%	8.6%		
175		83.3%	10.0%	3.3%	3.3%
180		81.8%	18.2%		
185		77.8%	11.1%	11.1%	
190		33.3%	66.7%		
195			100.0%		
200		100.0%			

Table 3.3.1. PELGAS15 anchovy Age/Length key.

Applying the age distribution to the abundance in biomass and numbers, the distribution in age of the biomass has been calculated. The total biomass used here has been updated with the value obtained from the previous method based on strata.

Age distribution is shown in figures 3.3.2. The age distributions compared from 2000 to 2014 are shown in figure 3.3.3.

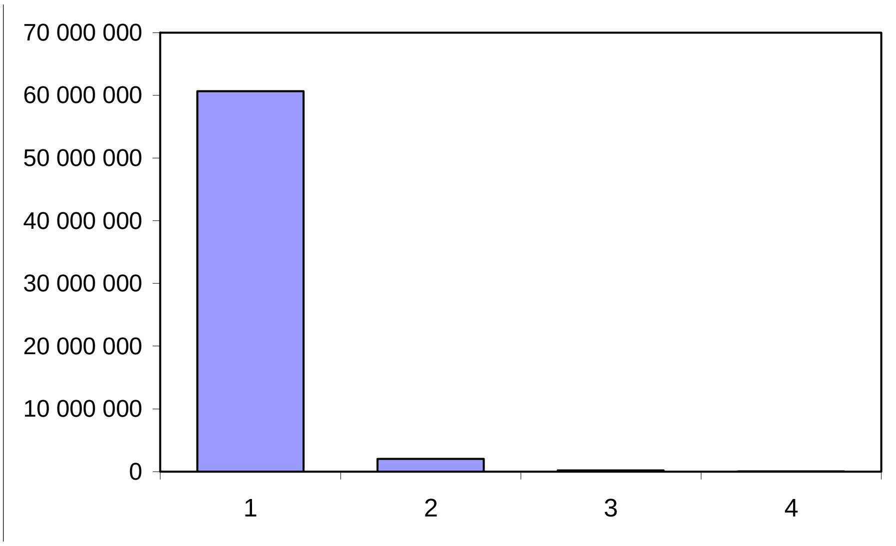


Figure 3.3.2– global age composition (numbers) of anchovy as observed during PELGAS15.

Looking at the numbers at age since 2000 (fig 3.3.3.), the number of 1 year old anchovies this year constitutes the very best recruitment of anchovy on the bay of Biscay never seen before.

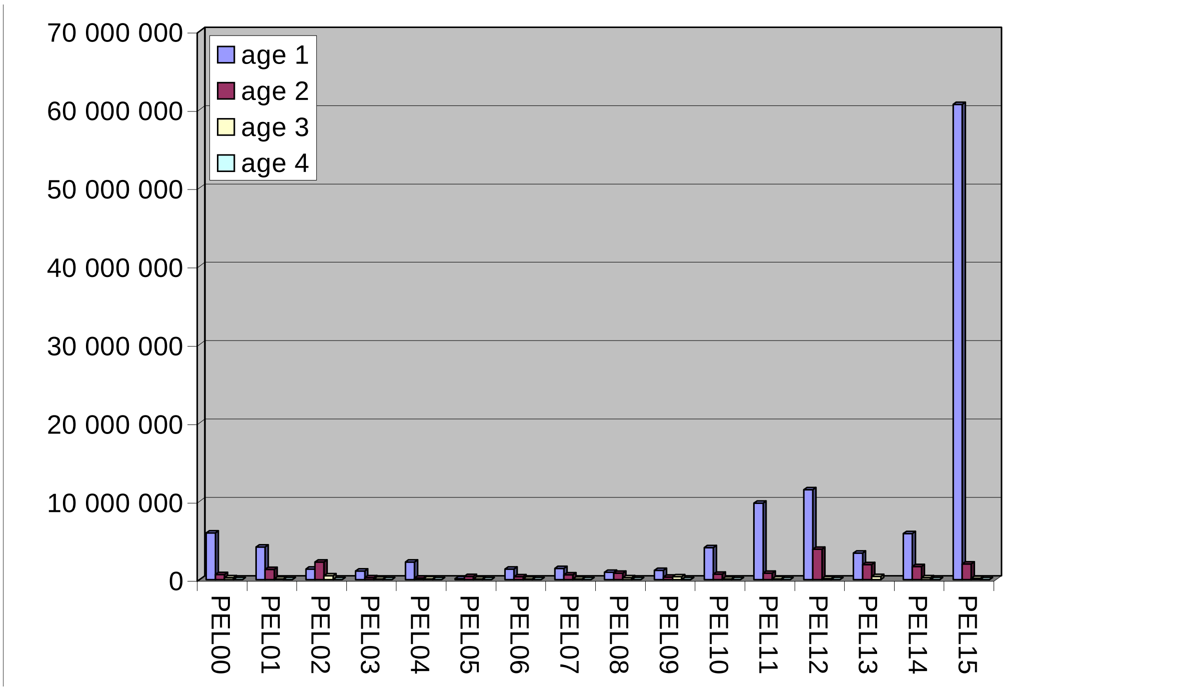


Figure 3.3.3 Anchovy numbers at age as observed during PELGAS surveys since 2000

This huge number of age 1 this year is due to a huge recruitment of age 1 in biomass (the best of the whole serie) and the fact that this one year old anchovy is the smallest never observed before (see paragraph 3.2.). We will see later the mean length and mean weight at age.

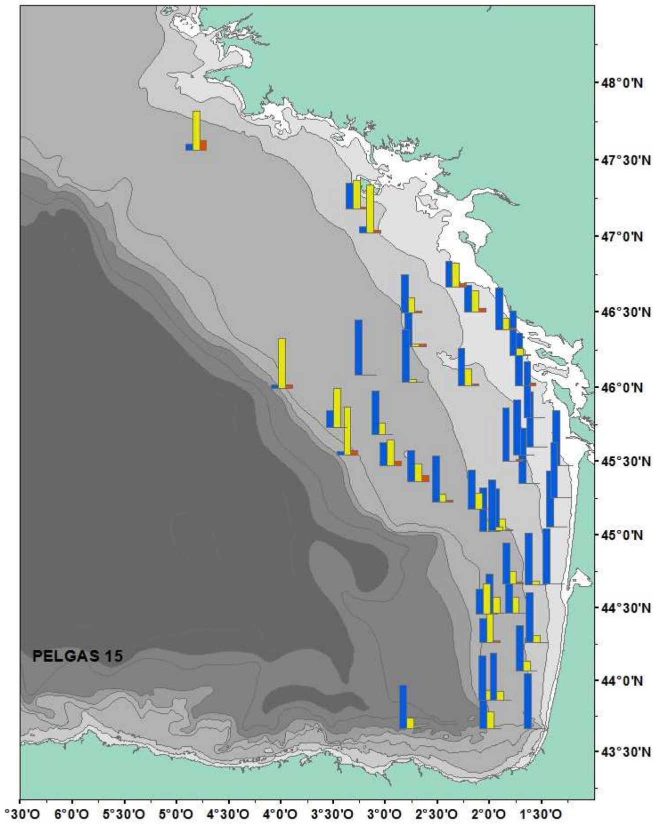


Figure 3.3.4 Anchovy proportion at age in each haul as observed during PELGAS15 survey (blue = age 1, yellow = age 2).

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 age1 were as usual predominant (almost pure) in the Gironde area, but also dispersed on the platform, mixed (or not) with age 2. It is particularly noticeable this year than age one is still present, even in minority, along the shelf break.

anchovy	pel 15 - % - N
age 1	96.5%
age 2	3.2%
age 3	0.3%
age 4	0.0%
age 5	0.0%

anchovy	pel 15 - % - W
age 1	84.0%
age 2	14.1%
age 3	1.6%
age 4	0.2%
age 5	0.0%

Figure 3.3.5 percentage by age of the Anchovy population observed during PELGAS15 in numbers (left) and biomass (right).

3.4. Weight/Length key

Based on 1607 weights of individual fishes, the following weight/length key was established (figure 4.5.) :

W= 2E-06L$^{3.2749}$ with R2 = 0.9712 *(with W in grams and L in mm)*

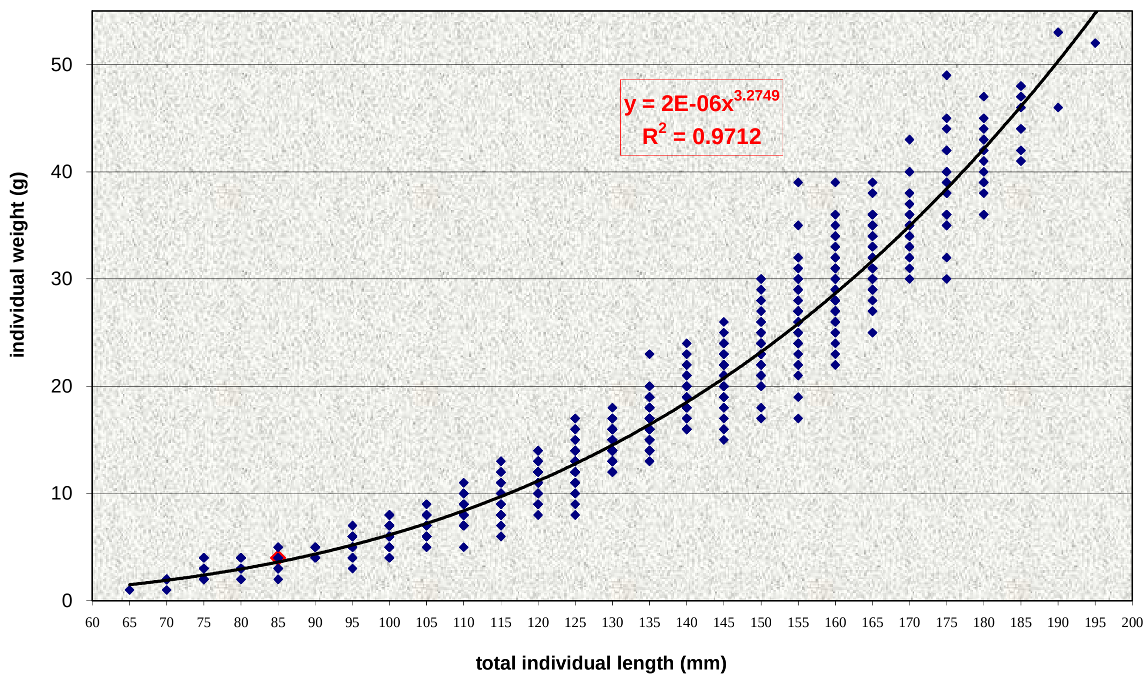


Fig. 3.4. – Weight/length key of anchovy established during PELGAS15

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

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, 661 CUFES samples were collected and counted, 64 vertical plankton hauls and 104 vertical profiles with CTD were carried out. Eggs were sorted and counted during the survey.

2015, as from 2011, was marked by a large quantity of collected and counted anchovy eggs.

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.

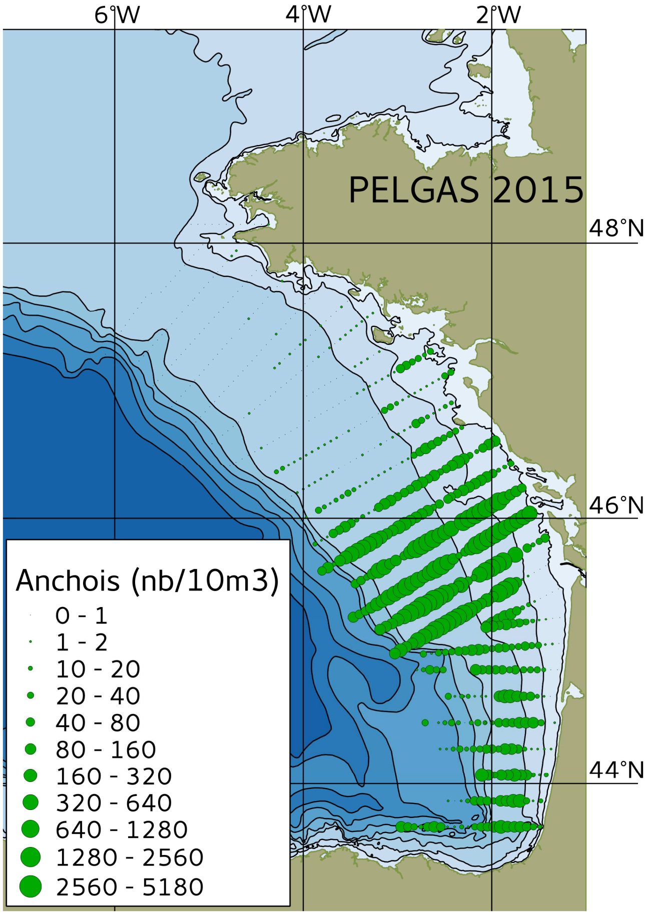


Figure 3.6.1 – Distribution of anchovy eggs observed with CUFES during PELGAS15.

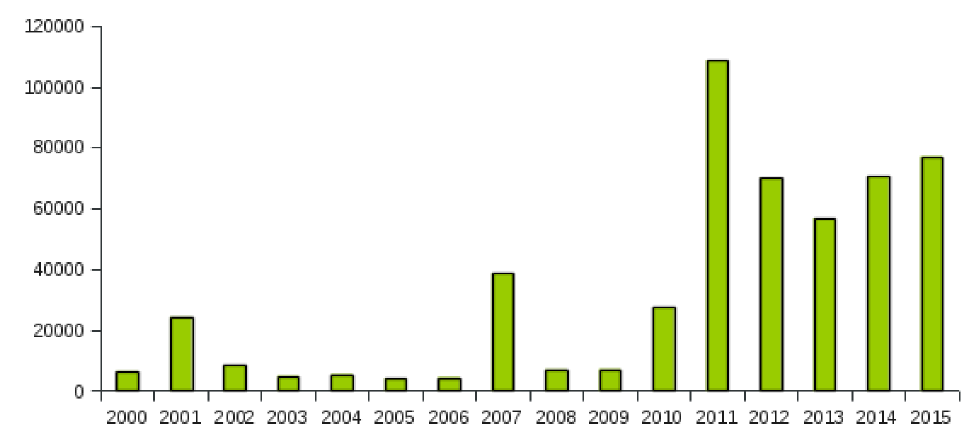


Figure 3.6.2 – Number of eggs observed during PELGAS surveys from 2000 to 2015

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.

In 2015 the estimates are : B=372 916 tonnes ; Ptot= 1.14E+13egg d^{-1}

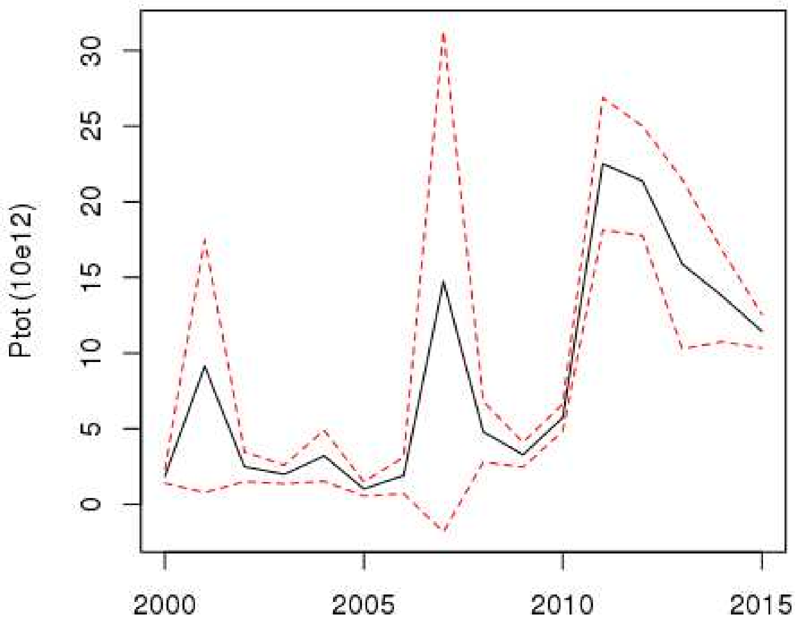


Figure 3.7.1 – Ptot serie from the CUFES index

The daily egg production Ptot depends on the spawning biomass (B) and the daily fecundity (DF). DF depends ultimately on environmental and trophic conditions, which determine individual fish fecundity (e.g., Motos et al., 1996). Daily egg production (Ptot) and spawning biomass (B) were linearly related (Fig 1). The slope of the linear regression is a (direct) estimate of the average DF over the series. Its value is : 92.26 eggs g-1. Residuals are particularly important for 2000, 2002 and 2007.

For first years of the serie (2000 to 2002) the mesh of the collector was 500 µm and is now 315 µm. But more investigation should be processed to asses the impact of the change of the mesh size on the aspect of the eggs collected, and on the number of them in each sample as well.

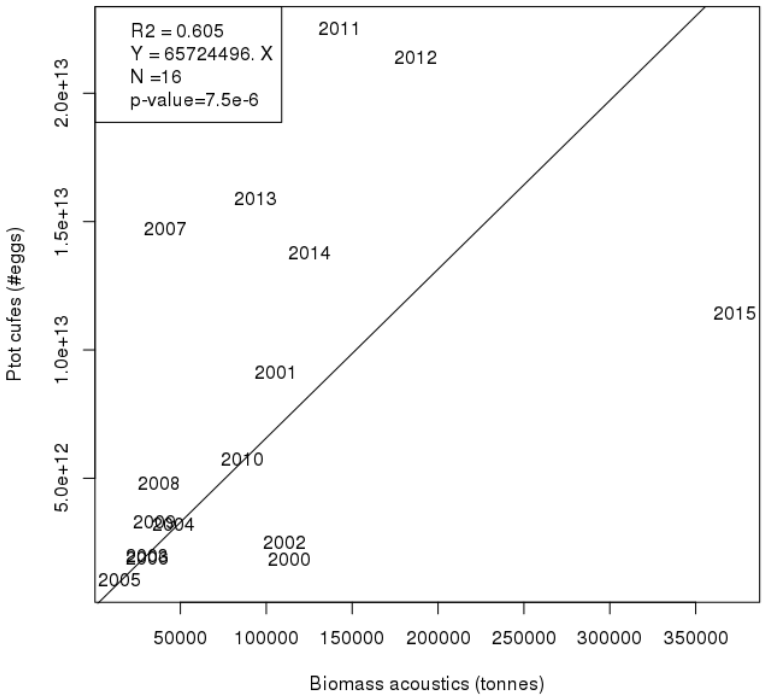


Figure 3.7.2 – Coherence between CUFES and Acoustic PELGAS survey indices

It must be noticed that with such a high acoustic biomass this year, the last point drives the linear regression. It must be simply explained by the fact that a high proportion of anchovies this year 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.

An other important thing is that this year is the first 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.

At this time, the only thing we are currently finishing to improve is the staging of the eggs.

4. SARDINE DATA

4.1. Adults

The biomass estimate of sardine observed during PELGAS15 is **416 524** tons (table 2.3.), which is at the average level of the PELGAS series, and constituting a small increase of the biomass compared to last year. 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. The estimate is representative of the sardine present in the survey area at the time of the survey and can be therefore considered as an estimate of the Bay of Biscay (VIIIab) sardine population.

Sardine was distributed all along the French coast of the bay of Biscay, from the South to the North. Then, sardine appeared almost pure along the Landes's coast, where a small upwelling occurred. Sardine was also present mixed with anchovy from the Gironde to the South coast of Brittany. Sardine appeared almost exclusively close to the surface in the Northern part of the bay of Biscay, along the shelf break, sometimes mixed with mackerel or anchovy. Sardine appears also along the southern coast of Brittany, sometimes mixed with sprat

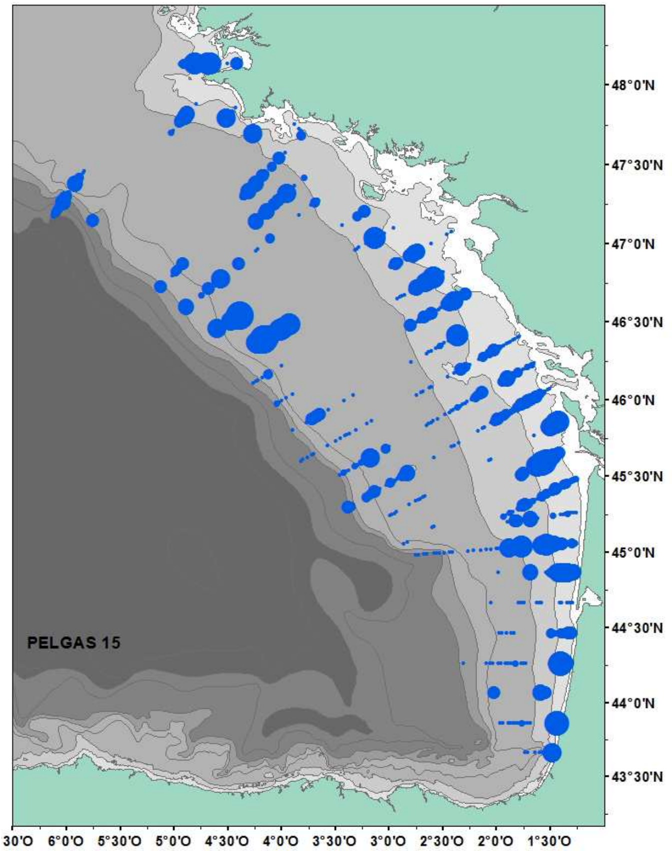


Figure 4.1.1 – distribution of sardine observed by acoustics during PELGAS15

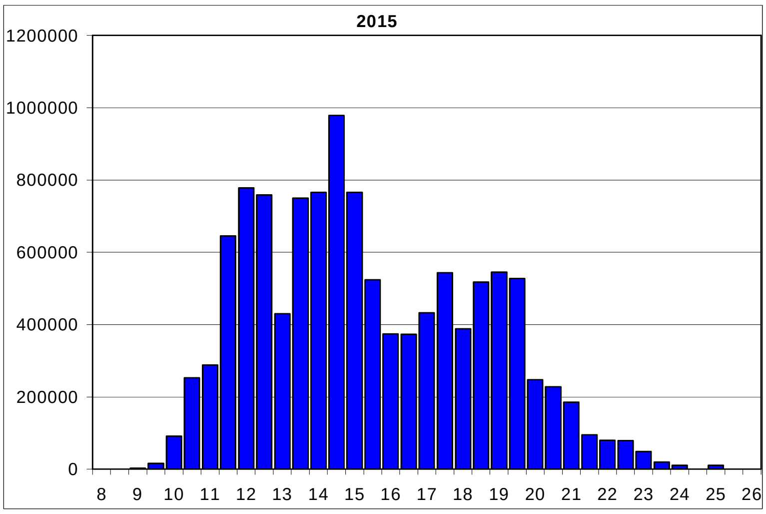


Figure 4.1.2. – length distribution of sardine as observed during PELGAS15

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.

As usual (but less than recent years), sardine shows a bimodal length distribution, the first one (about 14 cm, corresponding to the age 1, and present this year along the coast) and the second about 19 cm, which 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, and also along the shelf break). The older individuals (age 4 and more) seems to be rather absent of the bay of Biscay this year.

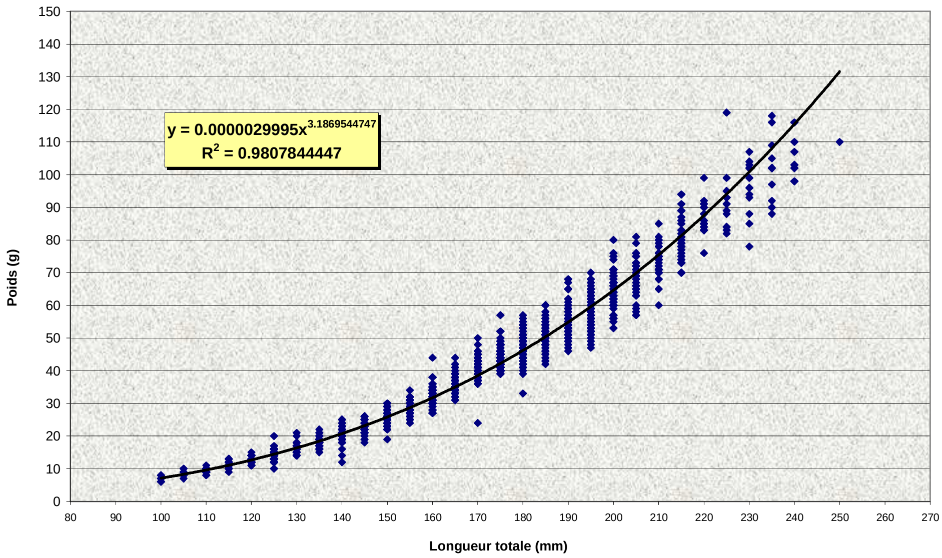


Figure 4.1.3 – Weight/length key of sardine established during PELGAS15

NB age	age								
length (mm)	1	2	3	4	5	6	7	8	9	Total
85	1	0	0	0	0	0	0	0	0	1
90	1	0	0	0	0	0	0	0	0	1
95	1	0	0	0	0	0	0	0	0	1
100	1	0	0	0	0	0	0	0	0	1
105	1	0	0	0	0	0	0	0	0	1
110	1	0	0	0	0	0	0	0	0	1
115	1	0	0	0	0	0	0	0	0	1
120	1	0	0	0	0	0	0	0	0	1
125	1	0	0	0	0	0	0	0	0	1
130	1	0	0	0	0	0	0	0	0	1
135	1	0	0	0	0	0	0	0	0	1
140	1	0	0	0	0	0	0	0	0	1
145	1	0	0	0	0	0	0	0	0	1
150	1	0	0	0	0	0	0	0	0	1
155	1	0	0	0	0	0	0	0	0	1
160	0.9375	0.046875	0.015625	0	0	0	0	0	0	1
165	0.65714286	0.34285714	0	0	0	0	0	0	0	1
170	0.2345679	0.74074074	0.02469136	0	0	0	0	0	0	1
175	0.08247423	0.79381443	0.12371134	0	0	0	0	0	0	1
180	0.06	0.63	0.3	0.01	0	0	0	0	0	1
185	0	0.42045455	0.56818182	0.01136364	0	0	0	0	0	1
190	0	0.27631579	0.63157895	0.07894737	0.01315789	0	0	0	0	1
195	0	0.13235294	0.66176471	0.19117647	0	0.01470588	0	0	0	1
200	0	0.15217391	0.56521739	0.2173913	0.04347826	0	0.02173913	0	0	1
205	0	0.02564103	0.58974359	0.23076923	0.1025641	0.05128205	0	0	0	1
210	0	0.02941176	0.44117647	0.26470588	0.20588235	0.02941176	0.02941176	0	0	1
215	0	0	0.13043478	0.30434783	0.2173913	0.17391304	0.13043478	0	0.04347826	1
220	0	0	0.2	0.26666667	0.06666667	0.26666667	0.13333333	0.06666667	0	1
225	0	0	0	0.06666667	0.13333333	0.46666667	0.2	0.13333333	0	1
230	0	0	0	0.15384615	0.23076923	0.30769231	0.30769231	0	0	1
235	0	0	0	0	0.44444444	0	0.33333333	0.22222222	0	1
240	0	0	0	0.14285714	0	0.57142857	0.14285714	0	0.14285714	1
245										
250	0	0	0	0	0	0	1	0	0	1

Table 4.1.4 : sardine age/length key from PELGAS15 samples (based on 1460 otoliths)

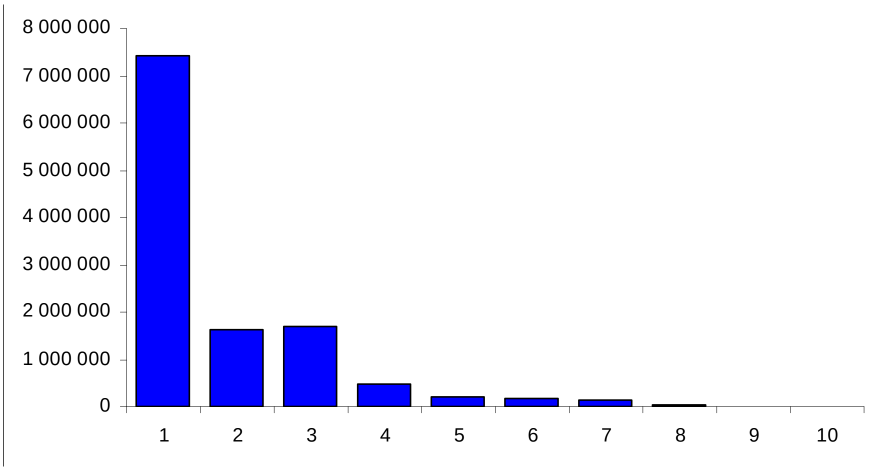


Figure 4.1.5.- Global age composition (nb) of sardine as observed during PELGAS 15

sardine	pel 15 - % - N
age 1	63.2%
age 2	13.7%
age 3	14.5%
age 4	4.1%
age 5	1.6%
age 6	1.4%
age 7	1.2%
age 8	0.2%
age 9	0.1%

sardine	pel 15 - % - W
age 1	33.5%
age 2	18.4%
age 3	25.9%
age 4	9.4%
age 5	4.3%
age 6	3.9%
age 7	3.9%
age 8	0.6%
age 9	0.3%

Figure 4.1.6 percentage by age of the sardine population observed during PELGAS15 in numbers (left) and biomass (right).

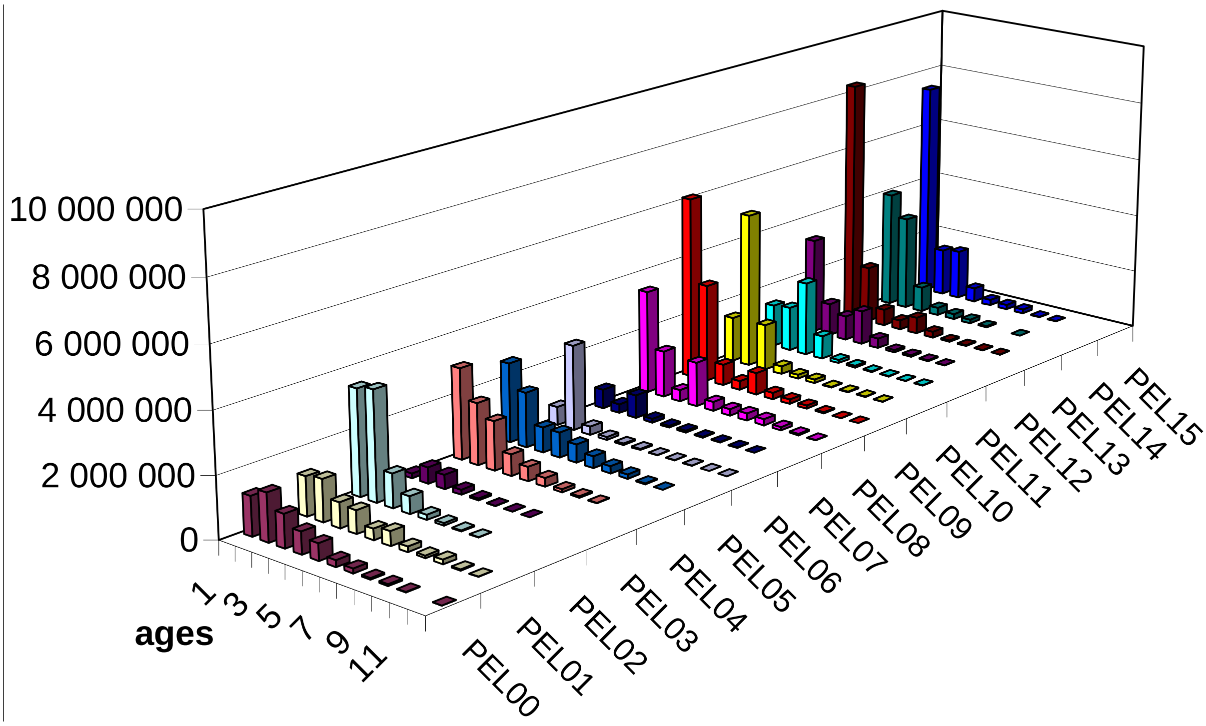


Figure 4.1.7- Age composition of sardine as estimated by acoustics since 2000

PELGAS serie of sardine abundances at age (2000-2015) is shown in Figure 4.1.7. Cohorts can be visually tracked on the graph. 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.

	age							
survey	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
PEL00	35.05	54.74	69.15	76.46	84.82	89.93	98.83	110.18
PEL01	41.28	58.85	76.83	83.84	93.68	96.92	103.41	105.35
PEL02	40.48	60.2	74.94	81.7	92.31	99.42	106.68	118.05
PEL03	53.35	68.04	73.15	78.11	86.04	93.33	88.74	96.09
PEL04	35.94	64.73	76.54	84.39	95.87	98.83	104.34	109.19
PEL05	34.44	63.45	73.29	79.62	84.88	88.96	90.04	105.42
PEL06	39.17	58.37	70.78	81.18	86.37	82.48	91.25	97.22
PEL07	37.55	65.96	71.77	79.05	84.02	94.45	100.37	96.93
PEL08	33.44	60.33	71.1	75.18	83.82	92.84	90.45	95.67
PEL09	29.51	57.13	73.62	81.28	83.26	88.35	95.67	91.44
PEL10	30.33	50.55	64.04	73.05	78.43	87.58	93.16	105.88
PEL11	27.37	50.13	58.69	69.84	78.35	83.00	84.28	108.17
PEL12	22.88	44.66	57.40	65.45	78.42	87.83	95.26	92.27
PEL13	21.16	44.33	55.82	68.30	77.42	84.27	89.28	99.10
PEL14	23.02	44.53	55.93	62.07	69.35	76.11	78.46	
PEL15	18.75	44.73	56.98	67.22	78.86	87.07	94.81	95.23

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 quite well with the one of anchovy for the southern part of the bay of Biscay until the 2 transects North of the Gironde. Then, sardine eggs are dominant in the northern part of the bay, with an extension along the coast and over the slope until the last transects at the Britany tip, but in quite low abundances.

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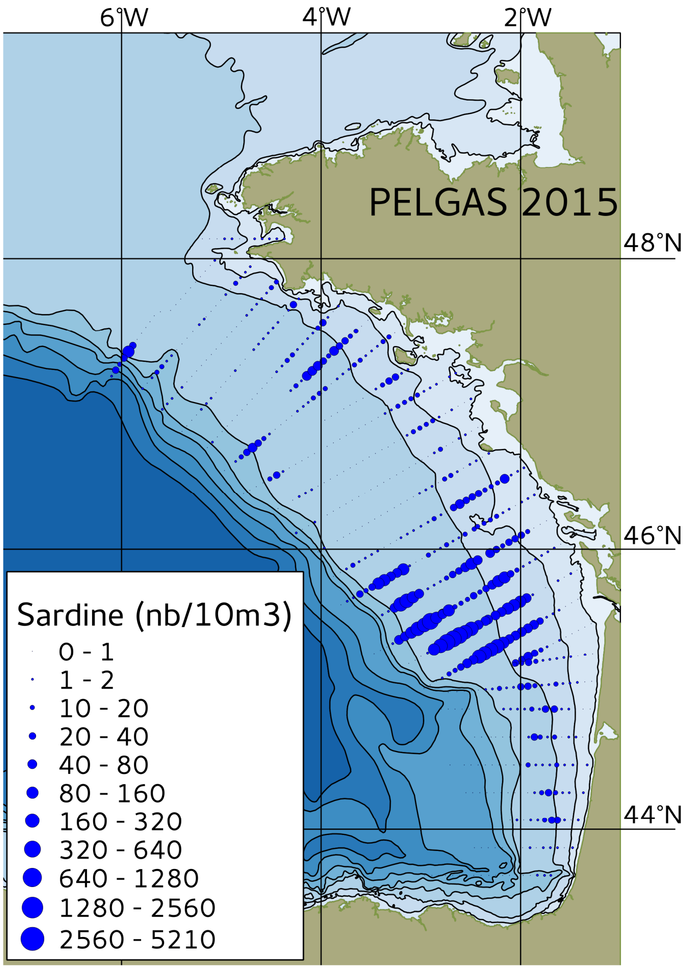


Figure 4.2.1. Distribution of sardine eggs observed with CUFES during PELGAS15.

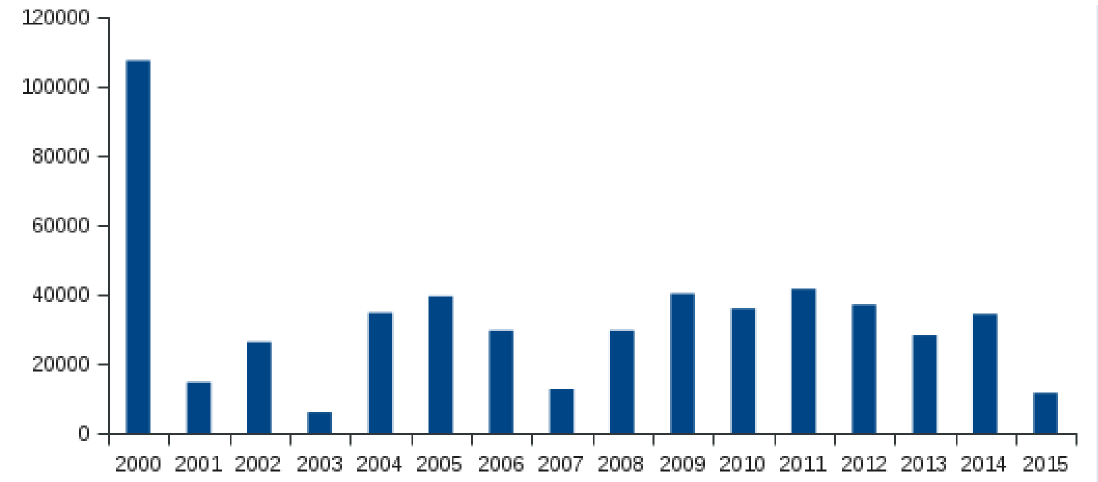


Figure 4.2.2. Number of eggs observed during PELGAS surveys from 2000 to 2015

2015 was marked by a relatively low abundance of sardine eggs as compared to the PELGAS time-series, according to the high abundance of age 1 individuals (see paragraph 4.1.), of whom 55% were not spawning (immature, maturing) 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 255 hours of sighting effort were performed for 30 days (Figure 5.1.), with an average of 8.5 hours of sighting effort per day. Weather conditions were generally 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.

5.1 – Birds

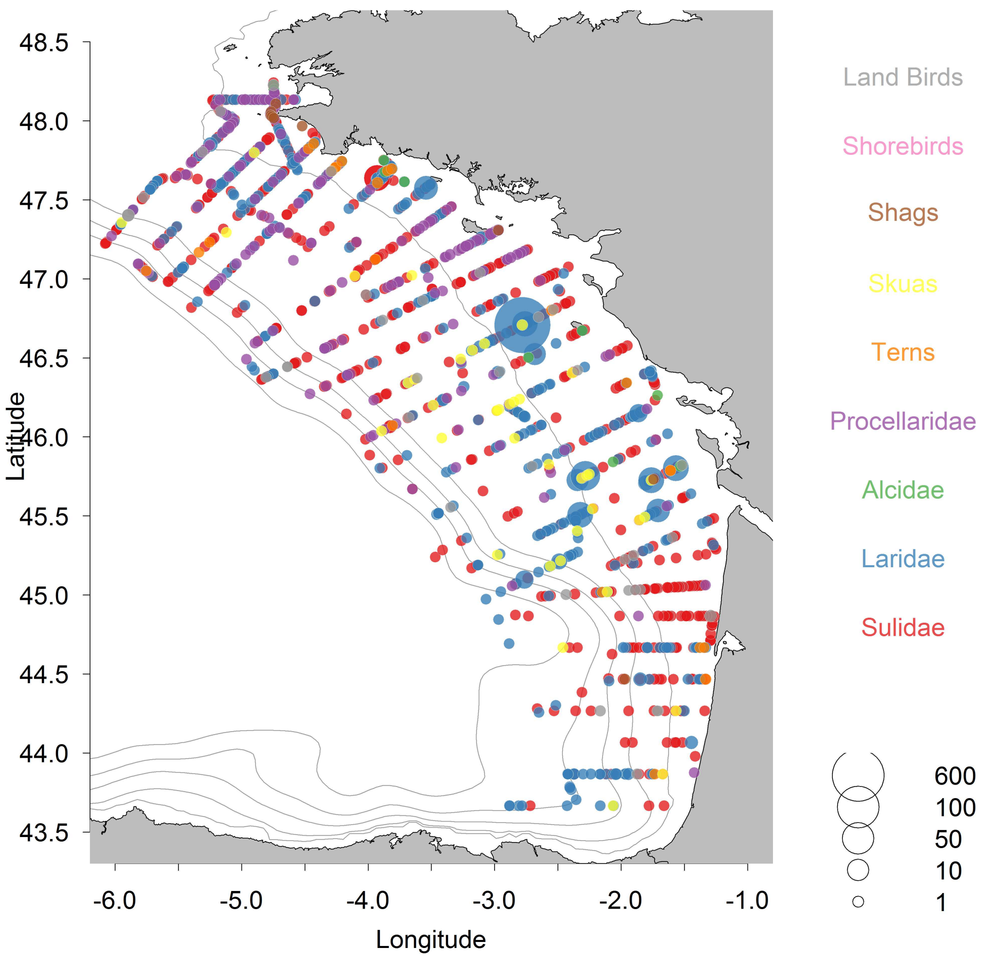


Figure 5.1. Distribution of birds observed during the PELGAS15 survey

Birds constitute the vast majority of sightings. Shorebirds and passerines accounted for less than 3% of bird sightings. 1,561 sightings of seabirds were found all over the Bay of Biscay (Figure 5.1), divided into 23 identified species and a raw estimate of 6,240 individuals.

Northern gannets accounted for 46% of all seabird sightings: its distribution is homogeneous across the Bay of Biscay.

The second most sighted species is the Northern Fulmar (Fulmar glacialis), mostly present in the northern part of the bay of Biscay. Few guillemots and no razobill were sighted in 2015. As in 2014, few terns were sighted. Large numbers of gulls were observed a few times, with one sighting of approx. 600 large gulls west of île d'Aix. Seabirds sightings have substantially decreased compared to 2014, which itself was below 2013 with respect to the number of sightings.

5.2 – Mammals

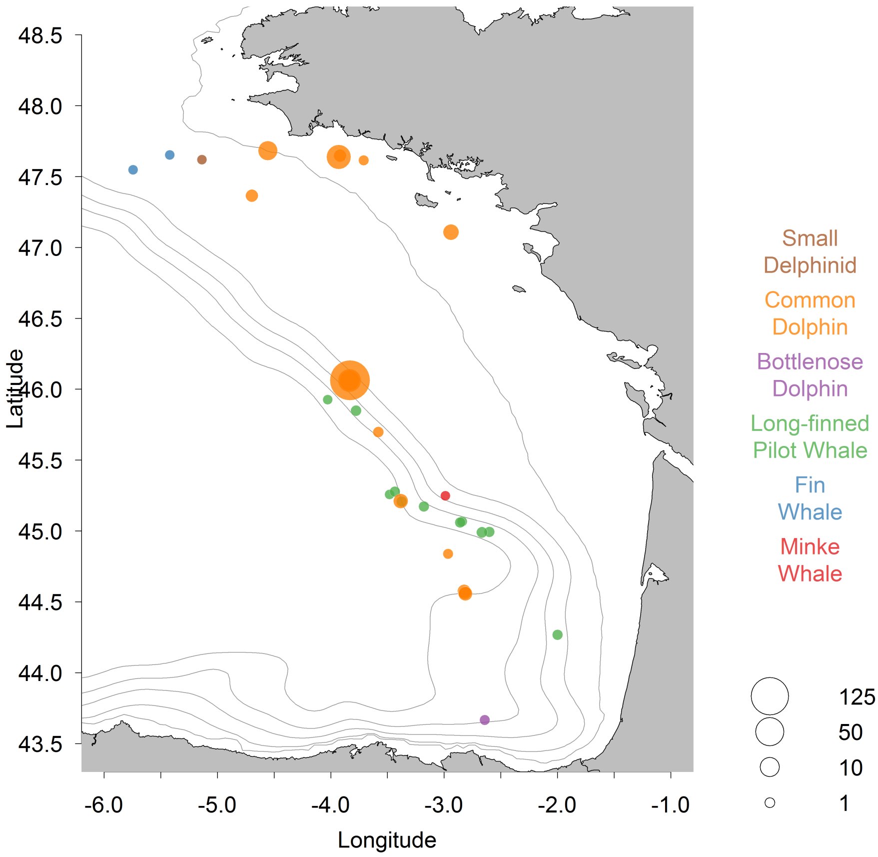


Figure 5.2. Distribution of mammals during the PELGAS15 survey.

A total of 36 sightings were recorded corresponding to a raw estimate of 500 individuals and 5 species of cetaceans clearly identified (Figure 2). The greatest diversity of marine mammals was observed in the Southern part of the Bay of Biscay. The overall distribution pattern is similar to that of previous PELGAS spring surveys.

Common dolphin is the most recorded species. Common dolphins were present on the inshore northern part of the continental shelf. No striped dolphins were sighted in 2015.

However, many long-finned pilot whales were sighted on the continental slope in the central part of the Bay of Biscay.

Bottlenose dolphins were sighted only once in the southern Bay of Biscay on the continental slope. A minke whale was sighting close to the Cap Ferret canyon and two fin whales were sighted in the northern part of the Bay of Biscay, which is rather unusual compared to previous years..

6. HYDROLOGICAL CONDITIONS

Before the survey, a nice and calm April month followed a wet winter. This was favorable to the establishment of the stratification, well marked from the beginning of the survey. Thermal stratification was associated to haline stratification over a large part of the shelf from the large run-off accumulation over winter and early-spring. Early spring blooms were quite intense, with a typical progression from the south to the north of the bay during april.

At the beginning of the survey, the stratification is then well established with a thermocline around 40m, but surface temperature are still relatively cold just above 14°C. Fresh conditions, even if without real wind events, keep these levels of temperature between 14 and 15°C throughout the survey conducted from the south to the north of the bay.

Surface phytoplanktonic production remains high along the coast under the influence of the plumes, with river runoffs also remaining strong. More offshore, chlorophyll maxima are well spotted at the thermocline, while at the end of the survey production can be quite homogeneous, certainly due to the wind event and associated mixing at the end of the first leg around 22th of May.

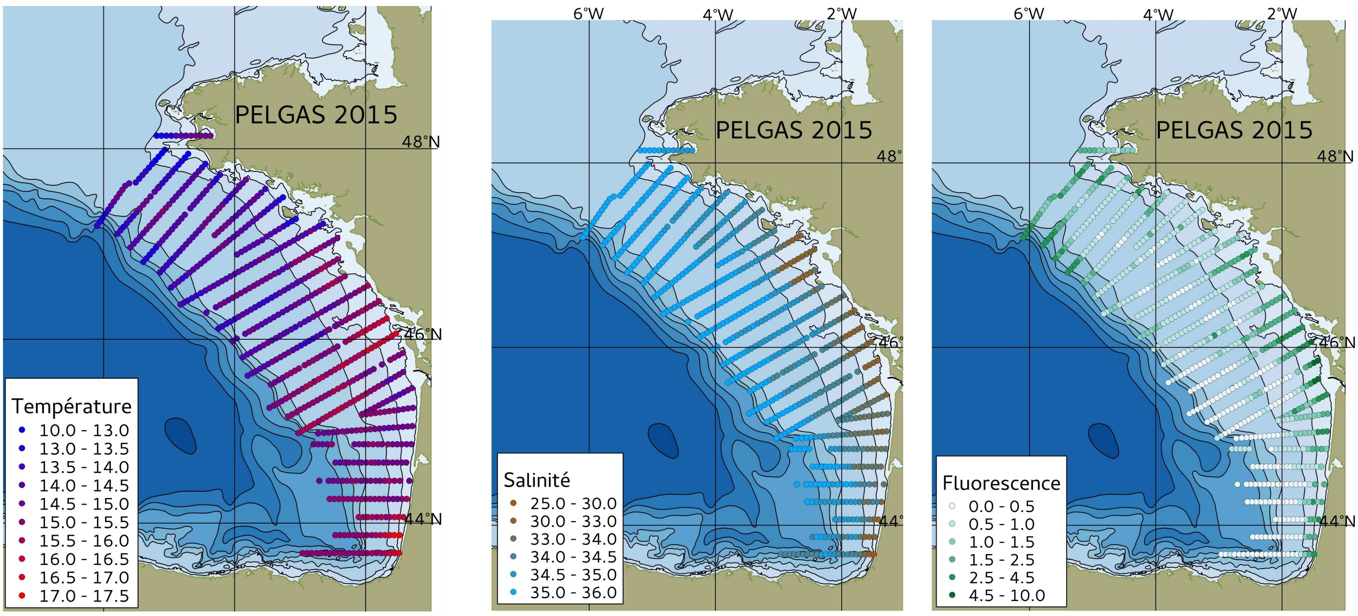


Figure 6.1. – Surface temperature, salinity and fluorescence observed during PELGAS15.

7. CONCLUSION

The Pelgas15 acoustic survey has been carried out with globally 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 130 valid identification hauls instead of about 50 before 2007 when Thalassa was alone to identify echotraces. Their participation increased the precision of identification of echoes and some double hauls permitted to confirm that results provided by the two types of vessels (R/V and Fishing boats) were comparable and usable for biomass estimate purposes. These commercial vessels participated to the PELGAS survey in a very good spirit of collaboration, with the financial help of "France Filière Pêche" which is a groupment of French fishing organisations.

Temperature and salinity recorded during PELGAS13 were close to the average of the serie, with a surface temperature still relatively cold (just above 14°C) maintained by an absence of real wind event.

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.

The PELGAS15 survey observed the highest level of anchovy biomass never observed before (**372 916 tons**), pushed by a huge recruitment (the abundance of age 1 in 2015 is more or less 4 times the highest before) far from the highest level observed on the time series (186 865 tons in 2012). In the South, anchovy was mostly concentrated in the middle of the platform, and in the middle part of the bay of Biscay, anchovy appeared as very small fish with highest concentrations front of the Gironde, never observed before. In this area, anchovy was present from the coast until the shelf break continuously.

One of the main observation this year is that this very small anchovy concentrated in coastal area is mainly immature, and explain the spatial pattern of eggs.

The biomass estimate of sardine observed during PELGAS15 is **416 524 tons**, which constitutes a small increase of the last year level of biomass, and confirms that this specie is still at a high level of abundance in the bay of Biscay.

The high proportion of age 1 (63% in number, but 33 % in mass) seems to show that an other good recruitment occured. 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. Old individuals (>4 years old) were rather absent of the area this year.

Concerning the other species, mackerel was rather absent this year compared to 2013 and 2014, while horse mackerel seems to be a bit more abundant for the third consecutive year, but still showing a low biomass.

CRUISE REPORT

PELACUS 0315

PELAGIC ECOSYSTEM ACOUSTIC-TRAWL SURVEY
R/V MIGUEL OLIVER

Coordinated by Pablo Carrera
Instituto Español de Oceanografía

INSTITUTO ESPAÑOL DE OCEANOGRAFÍA

Index

EXECUTIVE SUMMARY

The Spanish acoustic-trawl times PELACUS 0315 was carried out on board R/V Miguel Oliver from 14th March to 14th 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 3979 nautical miles were steamed, 1190 corresponding to the survey track. Besides, 66 fishing stations were performed.

PELACUS 0315 was characterised by a relative high strength of NE winds which led to change the survey sampling schedule. The area is typically covered continuously from the Spanish/Portuguese border to the French/Spanish one, but due to the wind the NW corner was steamed from the north-eastern part to the south-western one and also in the Cantabrian Sea, the inner part (i.e. Euskadi) was covered westward. Besides, this weather condition, together with the change in the strategy, would have been affected the mackerel fish distribution and abundance estimates: this was the first time in the time series that adult mackerel occurred in high quantities in IXaN while VIIIc-West was almost empty. Nevertheless, as compared with the biomass assessed in 2014 when the weather conditions were better and the therefore the stability would have increased the mackerel availability either for a change in the behaviour (i.e. spatial pattern distribution) or for an increase in the food availability, the estimated biomass in 2015 was lower. On the other hand, the increase in horse mackerel observed in 2014 was corroborated this year. In the case of anchovy, although during 2014 an important amount of new juveniles (young of the year) were detected during the JUVENA survey undertook in September in the Cantabrian waters, the anchovy distribution found at PELACUS was scarce in this area.

During PELACUS 0315 blue whiting has been observed performing nictimeral migration towards the surface. This is the first time this movement has been recorded and described.

TECHNICAL SUMMARY

Institution:	INSTITUTO ESPAÑOL DE OCEANOGRAFÍA
Survey name:	PELACUS 0315
Vessel name:	Miguel Oliver (70 mn length, 2x1000 kW diesel-electric
Dates:	09/03/2014-08/04/2014
Area:	NW-Spanish coast, Spanish Bay of Biscay (IXa-N and VIIIc)
Type:	Acoustic-Trawl
Main objective:	Biomass estimation by means of echointegration of the main pelagic fish population present in the surveyed area. Physical, chemical and biological characterisation of the pelagic ecosystem.
Sampling strategy	Systematic grid with tracks 8 nmi apart from 30 to 1000 isobath
Main sampling procedures	EK-60 at 18-38-70-120-200 kHZ acoustic frequencies. 1190 nmi prospected. Only day time
	CUFES, Intake at 5 m depth, 600 l min^{-1}. 3 nmi/sample, 355 samples (sardine and anchovy eggs)
	Pelagic fishing stations. 66 stations
	Marine mammals and birds observations. 165 legs (116.65 hours)
	Hydrological characterisation. 105 stations (CTD with rosette and plankton nets)

Personnel (1st leg)

ARAUJO FERNÁNDEZ, MARÍA HORTENSIA	LOUZAO ARSUARGA, MAITE
BLANCO GINER, MARIA DE LOS ANGELES	MIQUEL BATLE, JOAN
BURGOS CANTOS, CANDELARIA	MURCIA ABELLÁN, JOSÉ LUIS
CABRERO RODRÍGUEZ, AGUEDA HENAR	NOGUEIRA GARCIA, ENRIQUE
CARRERA LÓPEZ, PABLO	OLVEIRA DOMÍNGUEZ, BEATRIZ
CORDOBA SELLES, PILAR	OÑATE GARCIMARTÍN, MARÍA DOLORES
DUEÑAS LIAÑO, CLARA	OTERO PINZÁS, ROSENDO
FERNÁNDEZ LAMAS, ANGEL	PRECIADO RAMÍREZ, IZASKUN
GARABANA BARRO, DOLORES	SAAVEDRA PENAS, CAMILO
GÓMEZ GONZÁLEZ, ANTONIO	SANZ LLORENS, VANESSA
GONZÁLEZ GONZÁLEZ, ISABEL CRISTINA	VARELA ROMAY, JOSÉ

2nd leg

ANTOLÍNEZ BOJ, ANA	MURCIA ABELLÁN, JOSÉ LUIS
CARRERA LÓPEZ, PABLO	NAVARRO RODRÍGUEZ, MARIA ROSARIO
DELGADO ALCARAZ, JAVIER	OÑATE GARCIMARTÍN, MARÍA DOLORES
FERNÁNDEZ LAMAS, ANGEL	OTERO PINZÁS, ROSENDO
GARCÍA. BARCELONA, SALVADOR	PEREIRO RODRÍGUEZ, DIEGO
GÓMEZ PÉREZ, ELENA	PÉREZ RODRÍGUEZ, MONTSERRAT
GONZÁLEZ GONZÁLEZ, ISABEL CRISTINA	RIVEIRO ALARCÓN, MARÍA ISABEL
GONZÁLEZ-QUIRÓS, RAFAEL	SANTOS ATIENZA, EVA MARÍA
GRANELL MIYAR, TERESA	SOLLA COVELO, ANTONIO JOSÉ
LÓPEZ LÓPEZ, LUCÍA	VALEIRAS MOTA, XULIO
LOUREIRO CARIDE, MARÍA ISABEL	,

Main report authors	Pablo Carrera Isabel Riveiro Camilo Saavedra
Other collaborators	M. Begoña Santos Maite Louzao José Luís Murcia Xulio Valeiras Salvador García Barcelona Beatriz Olveira 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, both vessels , TH and MO have similar technical characteristics, as show in the following table:

	Thalassa	Miguel Oliver
Length	73.65 m	70.00 m
Width	14.90	14.40 m
Engine type	Diesel-electric	Diesel-electric
Engine power	2000 kW	2 x 1000 kW
Propeller	Fixed blades	Fixed blades
Tonnage	2803 GRT	2495 GRT
Propeller rpm at 10 knots	99	130

Table 1.: Main characteristics fro R/V Thalassa (left) and Miguel Oliver (right).

Intercalibration done after this survey gave rather similar results for both vessels although a slight difference between fishing gear performance was noticed. That used by R/V Miguel Oliver 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 Daily Egg Production Method to sardine.
- Characterise the main oceanographic conditions of the surveyed area
- Determine the distribution pattern, taxonomic diversity and dry biomass by size classes of the plankton population presented in the surveyed area.
- Determine the natural abundance of N15 in sardine, anchovy and mackerel and their trophic position.
- Determine the distribution area and density of apical predators
- Determine the distribution area and density of marine microplastics litter

MATERIAL AND METHODS

The methodology was similar to that of the previous surveys (see Iglesias et al. 2010 for further details). Survey design consisted in a grid with systematic parallel transects with random start, separated by 8 nm, perpendicular to the coastline, covering the continental shelf from 40 to 1000 m depth and from Portuguese-Spanish border to the Spanish -French one. (Figure 1)

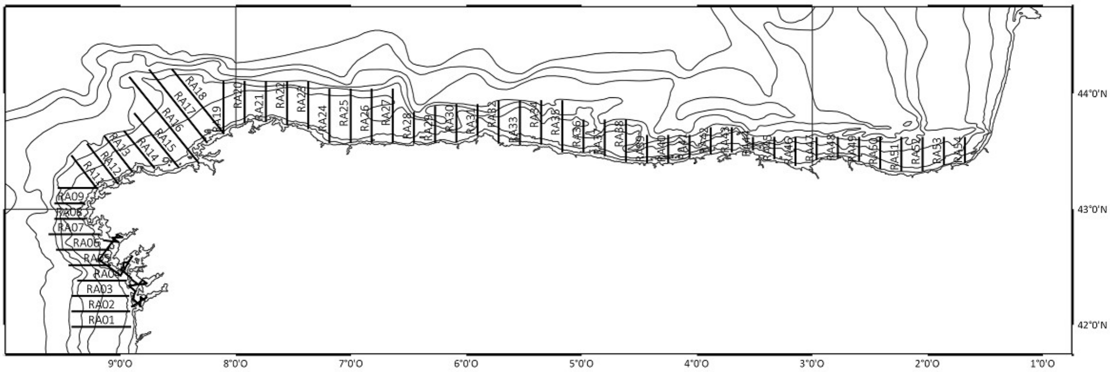


Figure 1 Survey track

The backscattering acoustic energy from marine organisms is measured continuously during daylight. Pelagic trawls are carried out whenever possible to help identify the species (and size classes) that reflect the acoustic energy. A continuous underwater fish egg sampler with an internal water intake located at 5 m depth is used to sample the composition of the ichthyoplankton while trained observers record marine mammal, seabird, floating litter and vessel presence and abundance. At night, data on the hydrography and hydrodynamics of the water masses are collected via the deployment of rosettes and conductivity, temperature and depth sensors. Information on the composition, distribution and biomass of phytoplankton and zooplankton is derived from the analyses of samples taken by plankton nets.

Sampling procedures

Acoustic

Acoustic equipment consisted on a Simrad EK-60 scientific echosounder, operating at 18, 38, 120 and 200 kHz. All frequencies were calibrated according to the standard procedures (Foote et al 1987). The elementary distance sampling unit (EDSU) was fixed at 1 nm. Acoustic data were obtained only during daytime at a survey speed of 8-10 knots. Data were stored in raw format and post-processed using SonarData Echoview software (Myriax Ltd.) (Higginbottom et al , 2000). All echograms were first scrutinized and also background noise was removed according to De Robertis and Higginbottom (2007). Fish abundance was calculated with the 38 kHz frequency as recommended at the PGAAM (ICES 2002), although echograms from 18, 120 and 200 kHz frequencies were used to visually discriminate between fish and other scatter-producing objects such as plankton or bubbles, and to distinguish different fish species according to the strength of their echo at each frequency. The 18, 120 and 200 kHz frequencies have been also used to create a mask allowing a better discrimination between fish species and plankton. The threshold used to scrutinize the echograms was –70 dB. The integration values were expressed as nautical area scattering coefficient (NASC) units or sA values (m2 nm -2) (MacLennan et al., 2002).

Main echosounder settings are shown in table 2

Transducer power	2000/2000/1000/200/90 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 knot.

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. It has a rope-rounded footrope, a kind of rockhopper with small rubber discs, which allows it to have a permanent contact with the sea bottom while preserving the net, making the demersal species be more available. As a second fishing gear used to identify school located on the seabed (i.e. horse mackerel schools) a GOV (14 m vertical opening) was used.

As general rig, 400 kg of clump weight were put at each side of the set back (2 m lower wing). Bridles (wings) had 100 m and a set of 20 mm steel wire were used at the beginning of the survey which were substituted by dyneema in the upper wing and polystil in lower wing. Besides a set of Apollo polyice doors (Thyborøn) wer used. Gear performance was controlled using a cabled Simrad Sonar 25/20 net sounder.

CUFES

CUFES system uses an internal pumping system with the intake located at 5 m depth. The sea water goes first to a tank of about $1m^3$ before to be pumped towards the concentrator.

Samples from CUFES were collected every three nmi while acoustically prospecting the transects. Once the sample is taken it is fixed in a buffered 4% formaldehyde solution. Anchovy and sardine eggs are sorted out and counted before being preserved in the same solution. The remaining ichthyoplankton (other eggs and larvae) are also preserved in the same way. Information on horse mackerel and mackerel (qualitative) was also recorded.

Plankton and hydrological characterisation

Continuous records of SSS, SST and flourometry are taken using a SeaBird Thermosalinograph coupled with a Turner Flourometer. Plankton and CTD and bottle rosette for water samples casts are performed at night. Five stations are placed over the transects, which are those of the acoustic prospection but that are extended onto open waters until the 1000-2000 m isobaths. The stations are evenly distributed over the surveyed area at a distance of 16-24 nmi.

Plankton was sampled using several nets (Bongo, WP2 and CalVet). Fractionated dried biomass at 53-200, 200-500, 500-1000 and >2000 µm fractions was calculated together with species composition and groups at fixed strata from samples collected at the CTD+bottle rosette carousel (pico and nanoplankton, microplankton and mesozooplankton). For this purpose, FlowCAM, LOPC and 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

Three observers placed above the bridge of the vessel at a height of 16 m above sea level work in turns of two prospecting an area of 180° (each observer cover a field of 90°). Observations are carried out with the naked eye although binoculars are used (7x50) to confirm species identification and determine predator behaviour. Observations are carried out during daylight while the vessel prospects the transects and while it covers the distance between transects at an average speed of 10 knots. Observers record species, number of individuals, behaviour, distance to the vessel and angle to the trackline and observation conditions (wind speed and direction, sea state, visibility, etc.). Observers also record presence, number and type of boats and type, size and number of floating litter. The same methodology is used on the PELGAS surveys and both observer teams shared a common database.

Marine Microplastic Litter characterisation

A "manta net neuston sampler" was used. This trawl device has a collector of 350 µm. Tows were performed for 15 min at 4 knots speed. The samples were evenly distributed along the surveyed area.

Fish Biological sampling

Catches from fishing trawl hauls were sorted and weighted. All fish species were measured (total length, 1cm classes for all species except clupeids measured at 0.5 cm). When needed, random subsamples of 80-200 specimen were taken. For the main species an additional biological sampling was done for weight, age, sex, maturity stage analysis, complemented by stomach contents analysis (sardine and anchovy); N^{15} isotope analysis (sardine, anchovy and mackerel); sampling for gonad microscopic maturity analysis (mackerel); and, sampling for estimation of fecundity adult parameters (sardine). Besides, specific sampling was also done for genetic purposes to boarfish, mackerel and hake.

Data analysis

NASC Allocation

Two pelagic gears have been used to identify the species and size classes responsible for the acoustic energy detected and to provide samples. Choice of net was also dependant on the availability of enough unobstructed ground for the net to be deployed and recovered and for effective fishing to occur. Haul duration is variable and ultimately depends on the number of fish that enters the net and the conditions where fishing takes place although a minimum duration of 20 minutes is always attempted. The quality of the hauls for ground-truthing of the acoustic data was classified on account of weather condition, haul performance and the catch composition in numbers and the length distribution of the fish caught as follows:

	0	1	2	3
Gear performance Fish behaviour	Crash	Bad geometry Fish escaping	Bad geometry No escaping	God geometry No escaping
Weather conditions	Swell >4 m height Wind >30 knots	Swell: 2 -4 m Wind: 30-20 knots	Swell: 1-2m Wind 20-10 knots	Swell <1 m Wind < 10 knots
Fish number	total fish caught <100	Main species >100 Second species <25	Main species > 100 Second species< 50	Main species > 100 Second species > 50
Fish length distribu-tion	No bell shape	Main species bell shape	Main species bell shape Seconds: almost bell shape	Main species bell shape Seconds: bell shape

Hauls considered as the best representation of the fish community for a specific area were used to allocate NASC of each EDSU within this area 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:

$$s_{A_i} = s_A \frac{w_{li} \cdot \sigma_{bs}}{\sum_{li} w_{li} \cdot \sigma_{bs}}$$

where w_{li} is the proportion in number of *l* length class and species *i* in the hauls, and σ_{bs} is its correspondent proportion of backscattering cross section. The target strength (TS) is also taken into account as follows:

$$\sigma_{bs}=10^{TS/10} \quad \text{(in dB)}$$

This is computed from the formula TS =20 logL_T+ b_{20} (Simmonds and MacLennan, 2005), where L_T is the length class (0.5 cm). The b_{20} values for the most important species present in the surveyed area are shown in following table:

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 *fi* the s_A values for 18, 120 and 200 kHz.

Echointegration estimates

Once backscattering energy was allocated to fish species, the spatial distribution for each species was analysed taking into account both the NASC values and the length frequency distributions (LFD) to provide homogeneous assessment polygons. These are calculated as follows: an empty track determine the along-coast limit of the polygon, whilst three consecutive empty ESDU determine a gap or the across-coast limit. Within each polygon, the LDF is analysed.

LFD were obtained for all positive hauls for a particular species (either from the total catch or from a representative random sample of 100-200 fish). For the purpose of acoustic assessment, only those LFD which were based on a minimum of 30 individuals were considered. Differences in probability density functions (PDF) were tested using Kolmogorov-Smirnov test. PDF distributions without significant differences were joined, providing a homogeneous PDF strata. Spatial distribution was then analysed within each stratum and finally mean s_A value and surface (square nautical miles) were calculated using a GIS based system. These values, together with the length distributions, are used to calculate the fish abundance in number as described in Nakken and Dommasnes (1975). Numbers were converted into biomass using the length weight relationships derived from the fish measured on board. Biomass estimation was carried out on each strata (polygon) using the arithmetic mean of the backscattering energy (NASC, s_A) attributed to each fish species and the surface expressed in square nautical miles. For purposes of comparison, results are given by ICES Sub-Divisions (IXaN, VIIIcW, VIIIcEw , VIIIcEe and VIIIb)

Otoliths are taken from anchovy, sardine, horse mackerel, blue whiting, mackerel and hake (*Merluccius merluccius*) in order to determine age and to obtain the age-length key (ALK) for each species and area.

Centre of gravity

For each main specie, a centre of gravity (Woillez et al. 2007) was calculated as a weighted average of each sample location (allocated NASC value as weighting factor). Due to the particular topography of the NW Spanish area, instead longitude and latitude, we have used depth and a new variable called "distance from the origin" calculated as follows:

- Locations below 43º10 N: distance is calculated as (Lat-41.5)*60, being *Lat* the latitude of the middle point of any particular EDSU within this region.
- Location between 43º10' N and 8ºW (i.e. NW corner): distance is calculated as $((I.Lat-43.18333)^2+(I.Lon*(\cos(I.Lat*pi()/180))-6.714441)^2)^{0.5})*60+(43.1833-41.5)*60$, being *I.Lat* and *I.Lon* the coordinates at which a normal straight line from middle point of any particular EDSU within this region intercepts a line defined by the following geographical coordinates: 43º11N-9º12.50'W and 43º39.50'N-8º06'W.
- Location between 8ºW and the Spanish-French border: distance is calculated as 158.329+(Lon+5.8755324052)*60, being *Lon* the corrected longitude (longitude multiplied by the cosine of the mean latitude.

RESULTS

The survey started on 14th March and ended on 16th April. A total of 3979 nautical miles were steamed, 1190 of them corresponding to the survey track. Contrary to the previous year, weather conditions were too windy, and this forced to change the sampling strategy in NW area and in the inner part of the Bay of Biscay where the area was porspected westward instead of the normal eastward direction. Besides , some pings were also removed due to the presence of bubbles sweep down. Also most of the tracks located in the NW corner (i.e. VIIIc-west), were sternway steamed in order to avoid bubbles sweep down.

Calibration

During the technical stop done in winter, a 70 kHz frequency transducer was installed. Besides all the transducers were re-installed in the startboard part of the vessel gondola. Due to the presence of strong currents in the Vigo Bay, calibration was done in both sites, the Vigo Bay (15/03) and the Muros Bay (16/03), with the following results:

		200 kHz	120 kHz	70 kHz	38 kHz	18 kHz
Main	TS	-39.10 dB	-39.50 dB	-41.40	-42.30 dB	-42.70 dB
	Depth	23.0	22.4	22.9	22.5	18.1
	Gain	27.00 dB	27.00 dB	27.0 dB	24.88 dB	22.40 dB
	Two way Beam Angle	-20.70 dB	-21.00 dB	-21.0 dB	-20.60 dB	-17.00 dB
	Angles (deg)	7.0 x 7.0	7.0 x 7.0	7.0 x 7.0	8.6 x 6.12	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	0.192 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
Beam Model Results	Transducer Gain	27.05 dB	27.68 dB	26.87 dB	24.74 dB	22.91 dB
	Sa Corr	-0.21 dB	-0.30 dB	-0.40 dB	-0.55 dB	-0.72 dB
	Athw Beam Angle	6.24 deg	6.40 deg	6.81 deg	7.17 deg	11.26 deg
	Along. Beam Angle	6.24 deg	6.19 deg	6.56 deg	7.51 deg	10.68 deg
	Athw Offset Angle	-0.18deg	-0.10 deg	-0.07 deg	-0.01 deg	0.09 deg
	Along. Offset Angle	0.05 deg	-0.03 deg	-0.04 deg	-0.12 deg	0.24 deg
Data dev from beam model	RMS	0.44 dB	0.37 dB	0.49 dB	0.50 dB	0.53 dB
Data dev polynomial model	RMS	0.41 dB	0.32 dB	0.45 dB	0.47 dB	0.51 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

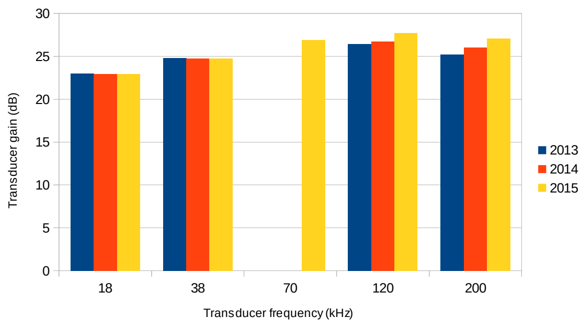


Figure 2: Transducer gain results from the calibrations 2013-15

Main oceanographic conditions

Figure 3a-c shows the several cuts from the shoreline to the self-break along the surveyed area of temperature and salinity while in figure 4 the salinity and temperature at 10, 100 and 250 is shown. In the western areas (i.e. IXa-N) wind induced upwelling together with the intrusion of fresh waters in the upper layers have characterized the oceanographic conditions. As a consequence, inside the Rías Baixax (i.e. inlets) fish density was low and the bulk of the fish has occurred in the self. Besides no thermal horizontal stratification was observed, and the warmer and saltier waters were located offshore. In the north western areas, the NE winds have also forced and upwelling event, extending the less saltier water offshore, although the strength of the upwelling was lower than that observed in the western part and hence, an incipient thermocline has occurred. At surface level, in the eastern part the influence of the river plumes forced by the NE winds led to a very low salinitiy; similar phenomena has been observed in coastal waters of the Rías Baixas. In the same way, subsurface waters were colder in the western areas

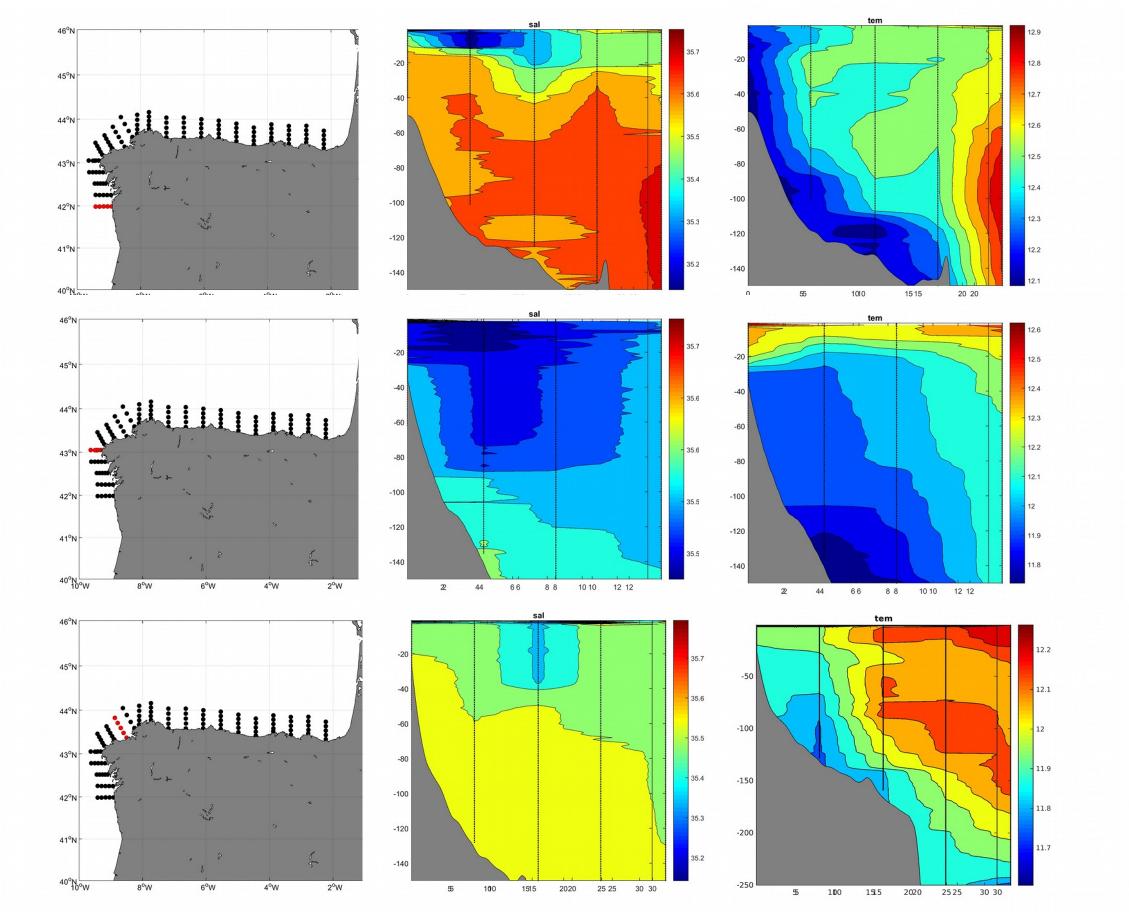


Figure 3a: Vertical profiles of temperature and salinity from CTD casts obtained at transect normal to the coastline along the surveyed area. (salinity, central pictures, temperature, right figures; scales are different)

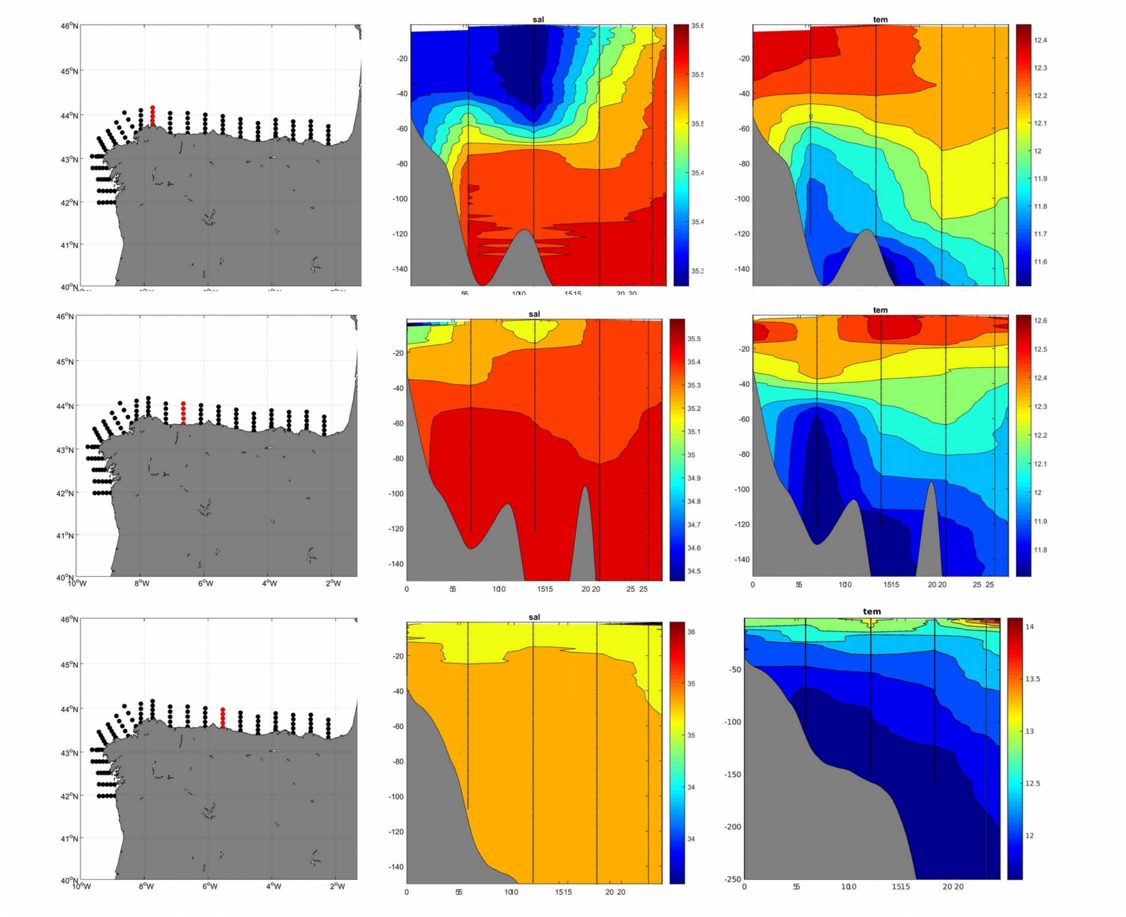


Figure 3b: Cont'd.

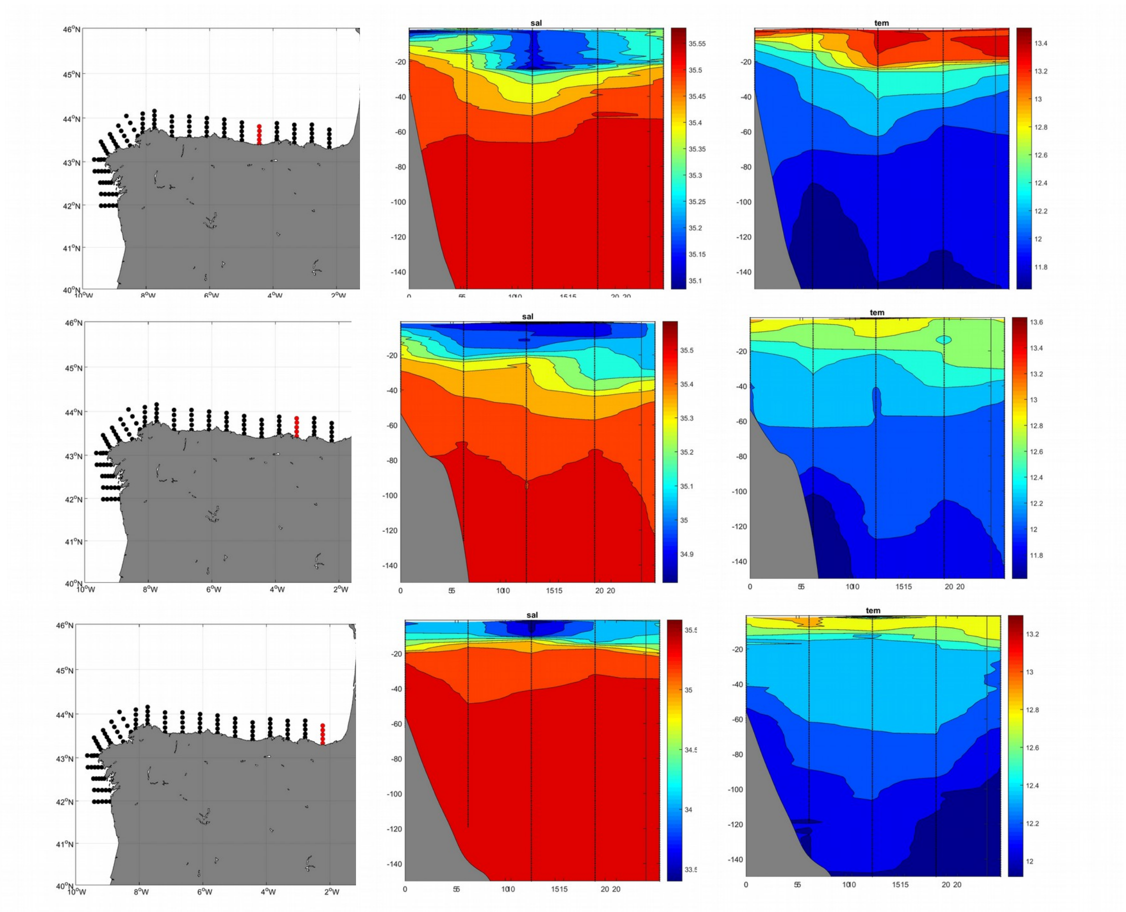


Figure 3c: Cont'd.

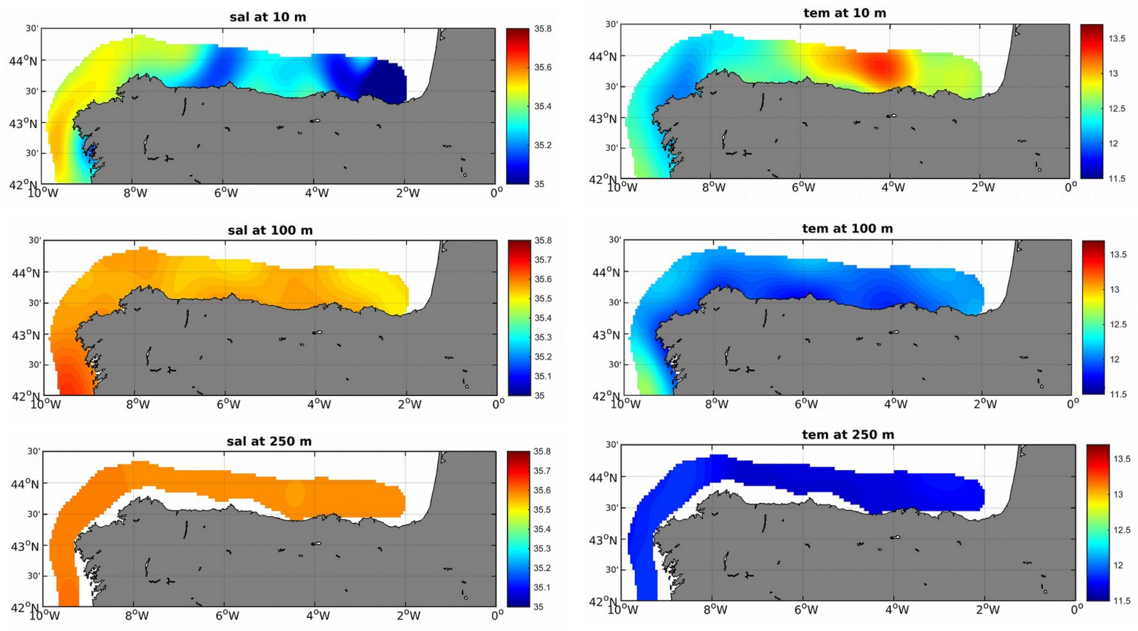


Figure 4: Horizontal profiles of temperature and salinity at 10, 100 ad 250 m depth from CTD casts obtained at transect normal to the coastline along the surveyed area. (salinity, central pictures, temperature, right figures; scales are different; above, 10 m, center; 100m; below, 250 m))

Fishing stations

Without including the trawl hauls done at the beginning of the survey for checking and setting up purposes, 66 fishing station were performed. Most of the fishing stations were performed under good conditions. A total of 57 mt has been caught corresponding to 374 thousand specimens, 28428 of them being measured. As shown in table 6, mackerel was the most abundant fish species and represented the 71% of the total weight in catches and was present in the 91% of the hauls. Horse mackerel also occurred in most of the hauls (94%) and represented the 16% of the total catch in weight. Finally, blue whiting and hake accounted for the 18% and 1% respectively of the total catch in number and were present in more than the 50% of the trawl hauls. This species, together with bogue occurred in more than the 50% of the trawl hauls. On the contrary, sardine, which accounted for the 4% of the total catch in number, has been only caught in the 29% of the hauls. In some areas, specially close to the self break, mackerel length distribution was bimodal with a mode located at 22 cm and the other in 36 cm, which was the common mode for the rest of the areas; besides, round Cape Peñas (between 5º40'W and 6º40'W) a third mode has been observed at 31 cm. The bulk of the distribution found in IXa had a mode of 36 cm, being mostly composed by adult spawning fish. As seen in other years, horse mackerel showed a great variety in both mean lengths and length distributions along the surveyed area, with modes ranged between 20 and 26 cm; there was also an important amount of juveniles with mode at 10 cm located in the eastern part of the Cantabrian Sea. For blue whiting, in most of the areas two modes of 17-18 cm and 23-24 has been also observed.On the contrary, the mean length of blue whiting samples was around of 22.5 cm in almost all the hauls and only in two samples obtained near the Llanes Canyon (4º30'W) mean length was lower (21.3 cm).

	TOTAL CAP	No ind.	No fst	Samp weight	No meas. Ind.	Mean length	%PRES	% weight	% no
WHB	2467	67226	36	164	3286	18.83	54.55	4.30	17.97
MAC	40750	127269	60	2442	7638	36.14	90.91	71.11	34.02
HAK	205	2449	42	333	2029	21.61	63.64	0.36	0.65
HOM	9086	115866	62	668	6661	20.53	93.94	15.85	30.97
PIL	722	13992	19	110	1791	18.86	28.79	1.26	3.74
JAA	60	289	16	62	289	28.81	24.24	0.10	0.08
BOG	2190	13111	34	463	2280	25.55	51.52	3.82	3.50
MAS	489	1949	24	196	997	30.14	36.36	0.85	0.52
BOC	683	11181	13	44	786	14.24	19.70	1.19	2.99
SBR	171	454	8	172	455	28.33	12.12	0.30	0.12
ANE	372	16938	13	11	600	14.78	19.70	0.65	4.53
HMM	114	3367	4	46	1616	13.65	6.06	0.20	0.90
Total	57309	374091		4710	28428				

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 5 shows the backscattering energy proportion allocated to each species on account the fish proportion in number obtained in each trawl haul. Blue whiting accounted for the major proportion in backscattering energy along the self break areas, while that allocated to horse mackerel was important in the fishing stations performed on the self. On the other hand, it should be noted the high quantity of backscattering energy allocated to sea bream and other sparids close to the coast; the catches of these fish species were relevant in almost all the coastal waters. For sardine, only at the inner part of the Bay of Biscay (Euskadi) and in south Galicia, the allocated energy was important.

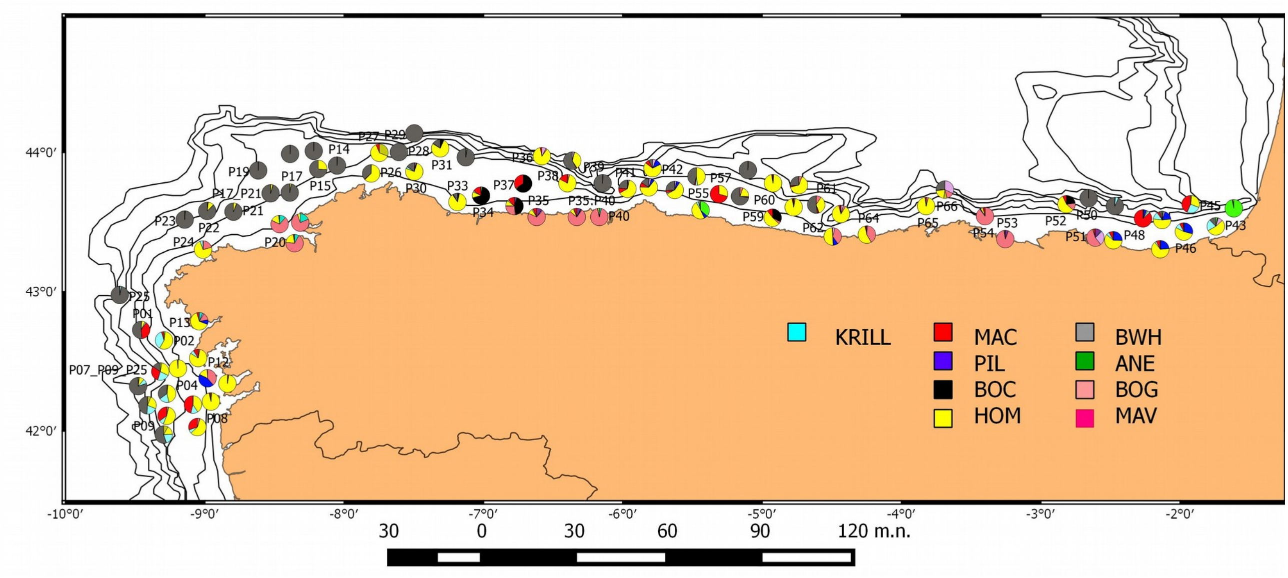


Figure 5: Backscattering energy proportion allocated to each species at each fishing station. (KRILL -M. norvegica; MAC-mackerel; PIL-sardine; BOC-boarfish; HOM- horse mackerel; WHB-blue whiting; ANE- anchovy; BOG-bogue; and MAV-M. muelleri)

CUFES sardine eggs distribution

355 CUFES stations were done and 7588 sardine eggs were collected in 159 samples (45% positive stations), which, although the number of eggs is still low, the number of positive stations has increased since the last three years. Nevertheless, the bulk of the distribution indicates a very coastal distribution, agreeing with that observed in previous years (figure 6). In Galicia, excluding the Rias Baixas, the presence is scarce and, other hand, the maxima is reached, as in previous years, in the inner part of the Bay of Biscay.

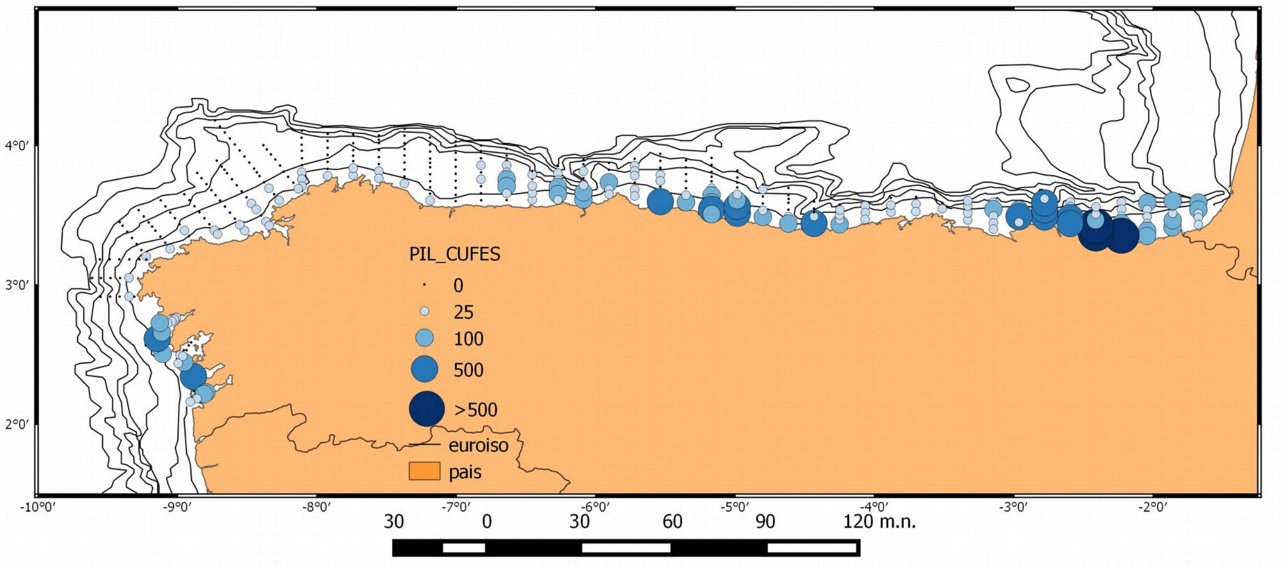


Figure 6. Number of sardine egg collected at the CUFES stations

Acoustic

A total of 254.571 s_A were attributed to fish species which is little bit higher than that of the previous year when accounted for 251.893 s_A. Table 7 shows the fishing station used to allocate backscattering energy when echotraces were similar to those found around these fishing stations.

Fishing station	Transects
P01	RA06, RA07
P03	RA05
P04	RA03, RA04, RA06, RA05, RA07, RA07
P05	RA02, RA03, RA05, RA04, RA05, RA05
P06_P08	RA01, RA02, RA04, RA03, RA05, RA05
P07_P09	RA01, RA02, RA04, RA03, RA05, RA05
P07_P09_P25	RA06, RA07
P10	RA01, RA03, RAP, RA04
P11	RA01, P11, , P11
P12	RA05, Rias
P13	RA06, RA07, Rias
P14	RA20, RA22, RA24, RA23, RA25, RA25
P14_P16	RA17, RA18, , RA19
P15	RA15, RA16, RA18, RA17, RA19, RA19
P17	RA17, RA18, RA19
P17_P21	RA14, RA15, ,RA16
P18_P20	RA08, RA10, RA12, RA11, RA14, RA14, RA15, RA16, RA17, RA18, RA19
P19	RA13, RA14, RA16, RA15, RA17, RA17, RA19
P22	RA08, RA09, RA11, RA10, RA12, RA12, RA13
P23	RA08, RA09, RA11, RA10, RA12, RA12, RA13

P24	RA08, RA09, RA11, RA10, RA12, RA12, RA13, RA14
P26	RA21, RA22
P30	RA20, RA21, RA22
P31	RA23, RA24, RA26, RA25
P33	RA23, RA24, RA26, RA25, RA27, RA27, RA28, RA29, RA30,
P34_P35	RA23, RA25, RA27, RA26
P35_P40	RA26, RA27, RA30, RA28
P36	RA27, RA28, RA30, RA29
P36_P39	RA30
P39	RA28, RA29, RA31, RA30, RA32, RA32
P40	RA21, RA31, RA32
P41_P42	RA30, RA31, RA32
P42_P55	RA33, RA34
P43_P46	RA54
P44	RA54
P45	RA53
P45_P46_P47	RA52
P46_P47	RA50, RA51, RA53, RA52, RA54, RA54
P47	RA48, RA49
P47_P52	RA47, RA49
P48	RA50, RA51
P49_P50	RA44, RA45, RA47, RA46, RA48, RA48, RA49, RA50, RA51, RA52, RA53
P51	RA48, RA49, RA51, RA50, RA52, RA52, RA53, RA54
P52	RA45, RA46, RA48, RA47, RA45, RA45, RA46
P54	RA44, RA45, RA46
P56	RA33, RA34
P58	RA33, RA34, RA36, RA35, RA37, RA37, RA38, RA41
P58_P61	RA35, RA36
P59	RA35, RA36
P60	RA35, RA36
P60_P61	RA38
P60_P63	RA37, RA38, , RA39
P61	RA39
P62	RA35, RA36, RA38, RA37, RA39, RA39
P64	RA40, RA41, RA43
P65	RA41, RA42
P66	RA41, RA42

Table 7: Fishing station used for backscattering energy allocation and transects

Table 8 shows the backscattering energy distributed by species and ICES subdivision, either by direct allocation (DA) or through the proportion found at the fishing stations (Fst). Direct assignation was feasible accounting for its special acoustic properties, morphology and geographical characteristics for some board fish, horse mackerel and especially, mackerel. This year the occurrence of isolated blue whiting schools, ground-truthed by fishing stations. Up to 40% of the backscattering energy attributed to mackerel was directly allocated. For sardine this percentage was the 33% while for blue whiting was only a 15%.

		WHB	MAC	HAK	HOM	PIL	JAA	BOG	MAS	BOC	SBR	HMM	ANE	Other	total
IXa	**DA**	0	226	0	498	0	0	1617	0	0	0	0	0	123	2465
	Fst	6589	1620	2426	42186	3353	633	4321	459	0	1531	0	2	5	63126
VIIIc-W	**DA**	42	37	0	1982	0	0	33	0	115	0	0	0	0	2209
	Fst	33060	243	316	7886	25	38	12728	7	3	2846	0	0	0	57152
VIIIc-Ew	**DA**	5807	3415	0	6729	54	0	0	0	472	0	0	0	0	16477
	Fst	19536	2731	800	66440	1783	31	7493	2154	2546	174	164	2058	8	105918
VIIIc-Ee	**DA**	5305	703	0	0	2864	0	0	0	0	0	0	0	13	8885
	Fst	5848	2049	529	7969	838	0	6938	1215	2258	106	657	591	33	29033
Total	**DA**	11153	4382	0	9209	2918	0	1650	0	587	0	0	0	137	30036
	Fst	65033	6643	4071	124481	5999	702	31481	3835	4807	4658	820	2651	46	255228
Total		76186	11025	4071	133690	8916	702	33131	3835	5394	4658	820	2651	183	285264

Table 8: Backscattering energy (s_A) allocated by species, both by direct allocation (DA) and by the fish proportion found at the ground-truth fishing stations, and by ICES Sub-Division (WHB-blue whiting; MAC-mackerel; HOM- horse mackerel; PIL-sardine; JAA-blue jack mackerel; BOG-bogue; MAS-chub mackerel; BOC-boarfish; SBR-sea breams and similar specie; HMM-mediterranean horse mackerel; ANE-Anchovy; Other species and- unallocated NASC)

Spatial patterns

Table 9 and figure 7 summarizes the spatial indices of the main fish species.

	WHB	MAC	HAK	HOM	PIL	JAA	BOG	MAS	BOC	SEAB	MAV	ANE	HMM	
Total	76186	11025	4071	133690	8916	702	33131	3835	5394	4658	183	2651	820	
Depth	312.17	125.12	224.32	123.04	87.89	311.37	76.86	116.00	127.19	68.28	674.88	93.63	68.26	
s.d.	645.72	83.19	134.71	382.11	55.27	48.13	99.83	55.36	40.68	21.81	58.98	9.09	8.99	
ic	77.02	9.92	16.07	45.58	6.59	5.74	11.91	6.60	4.85	2.60	7.04	1.08	1.07	
Dist 200	6.15	5.41	6.86	5.85	8.04	6.96	7.46	5.01	7.60	7.68	5.83	10.59	8.79	
s.d.	19.90	8.08	3.77	26.80	5.63	1.22	11.51	3.50	7.39	3.24	0.51	3.84	1.89	
ic	2.37	0.96	0.45	3.20	0.67	0.15	1.37	0.42	0.88	0.39	0.06	0.46	0.22	
Dist	206.27	254.87	137.58	185.54	252.28	59.03	202.19	281.67	288.67	119.42	132.52	310.44	367.58	
s.d.	447.65	182.45	129.38	595.49	231.49	24.88	340.27	106.61	93.88	65.77	33.21	53.96	35.12	
ic	53.40	21.76	15.43	71.03	27.61	2.97	40.59	12.72	11.20	7.85	3.96	6.44	4.19	

Table 9: Center of gravity according to the weighting average calculated using Distance to the Origin (Dist.Org.; expressed in nautical miles), distance to 200 m isobath (Dist 200) and depth (DEPTH, expressed in meters) together with its standard deviation and confidence interval. (WHB-blue whiting; MAC-mackerel; HAK -hake; HOM- horse mackerel; PIL-sardine; JAA-blue jack mackerel; BOG-bogue; MAS-chub mackerel; BOC-boarfish; SEAB: Sea breams an other sparidae; MAV-pearlside, ANE-anchovy ; HMM-mediterranean horse mackerel.

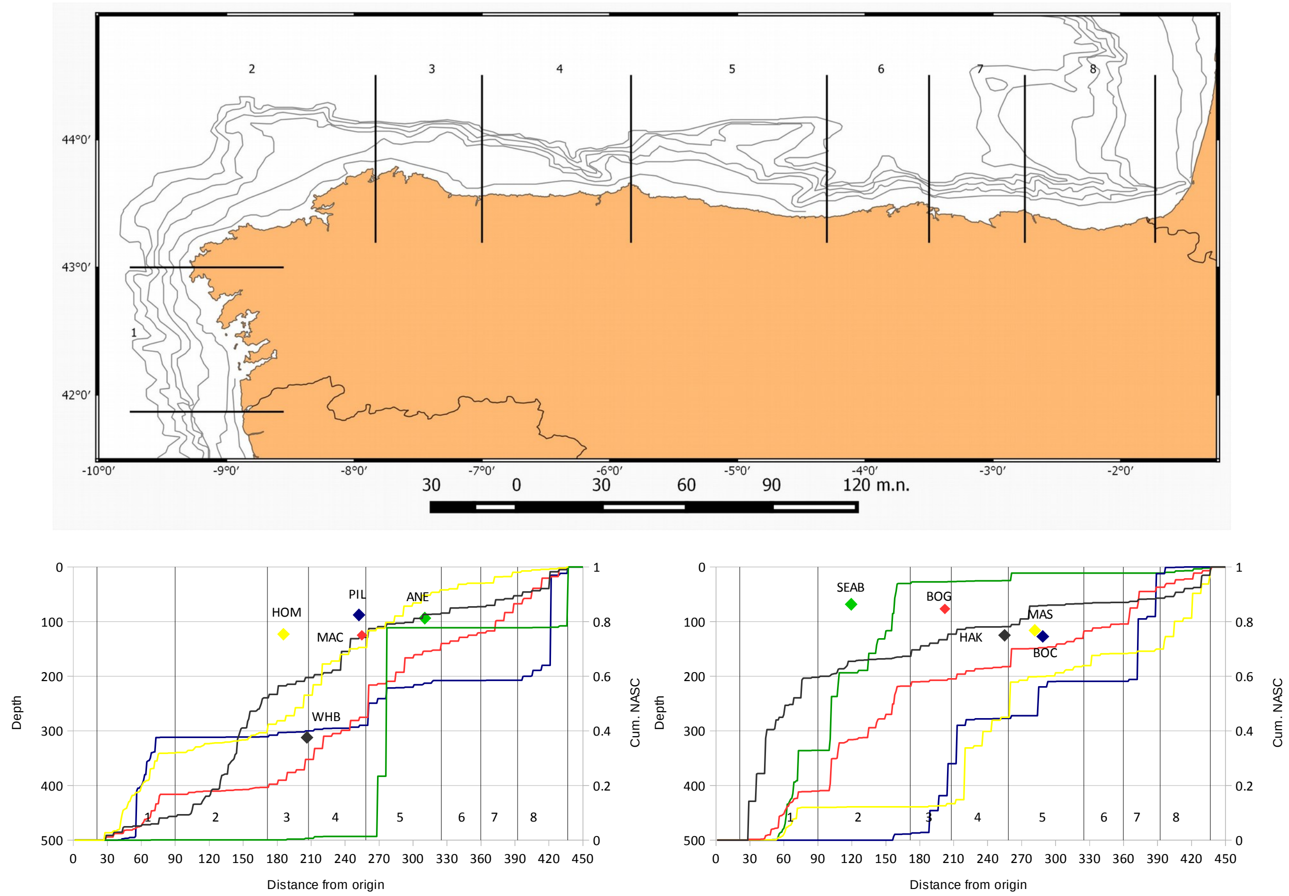


Figure 7: Centre of gravity of NASC distribution for the main fish species and cumulated probability density function along the survey. Surveyed area was divided into geographical zones in order to better understand the plots.

Horse mackerel accounted higher NASC values at 38 kHz, with almost the 35% of the total cumulated backscattering energy recorded in IXaN (area 1)and only a small contribution from VIIIcW (area 2); in the Cantabrian sea, seems to be evenly distributed. The bulk of the distribution was found at 123 m depth although the variability around this point was high; besides, as the species is evenly distributed the center of gravity, found at 186 nmi away from the origin, also showed a wide dispersion. Sardine has a marked distribution area, with the bulk of the distribution found in both IXaN and VIIIb together with VIIIc-Ee (areas 1 and 8) and also around Cape Peñas (area 5); contrary to that observed in previous years, the center of gravity was found at shallower waters. For mackerel, it should be noticed the 20% of the total cumulated NASC found at IXaN, together with the practical absence of this species in VIIIcW as observed for both horse mackerel and sardine. Again, as observed for horse mackerel, mackerel was found evenly distributed along the Cantabrian Sea. On the contrary, blue whiting was mainly found at VIIIc-W and also in the western part of the Cape Peñas (area 4). For anchovy, although in a very low quantities, the bulk of the distribution was clearly found in the eastern part of the Cape Peñas (80% of the total cumulated NASC).

For the other species, it should be noted the high presence of hake, mainly juveniles in IXaN; also this year the high detections of Sparidae fish, mainly in the western coastal waters (IXaN and VIIIc-W) were important.

Sardine distribution and assessment

A total of 10,815 tons of sardine (200 million fish) were estimated to be present in the surveyed area. That represents an small increase in relation to 2014 abundance and biomass, thus being still at the lower levels of the time series. Fish were mainly found in the inner part of the Cantabrian area (mainly in VIIIc East-east subdivision) and inside Rias Baixas (South Galicia, ICES sub-areas IXa-N) and was almost absent in VIIIc-West (figure 8). Most fish in the entire surveyed area were assigned as belonging to the age 1 (29% of the abundance and 20% of the biomass), age 2 (28% of the abundance and 26% of the biomass) and age 3 (27% of the abundance and 29% of the biomass) years classes.

By sub-area, IXa subdivision represents 21.1%, VIIIc West 0.3%, VIIIcEast-West 25.4% and VIIIcEast-East 53.1% of the total abundance. Galicia populations (IXaN and VIIIcW subdivisions) were dominated by age 1 fish whilst the Cantabrian area was mainly composed by older individuals.

The distribution of sardine eggs indicates a coastal distribution, agreeing with that observed in previous years. Sardine eggs showed a widespread distribution in the surveyed area, with higher percentage of positive stations than in earlier years.

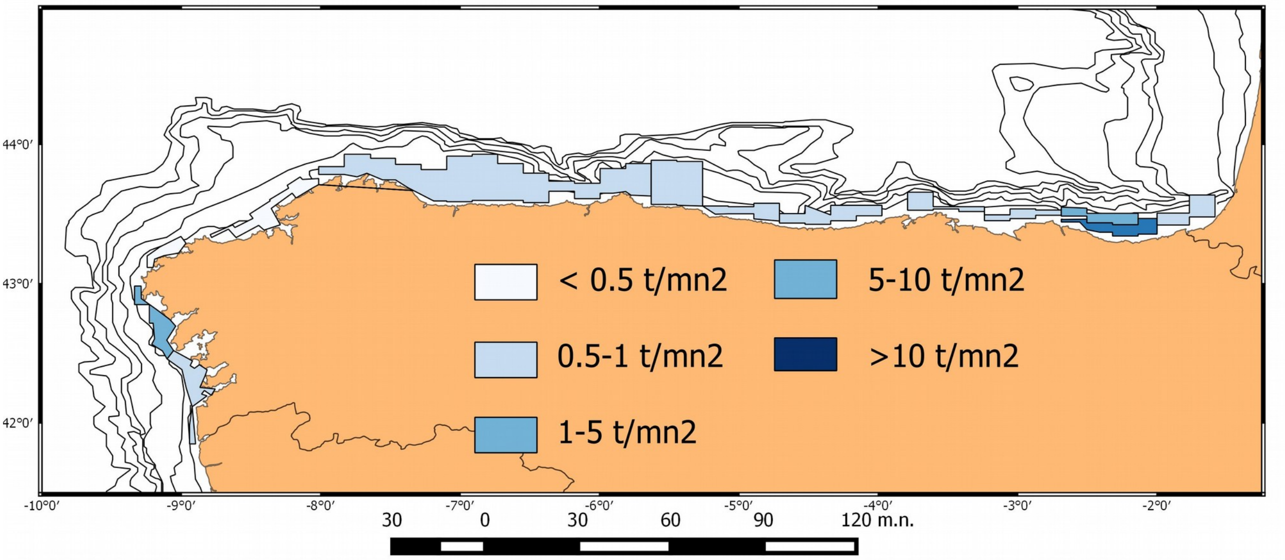


Figure 8. Sardine spatial distribution in PELACUS0314 cruise. Polygons are drawn to encompass the observed echoes, and polygon colour indicates the mean density expressed as tonnes per squared nautical mile (<0.5; 0.5-1; 1-5; 5-10; and >10)

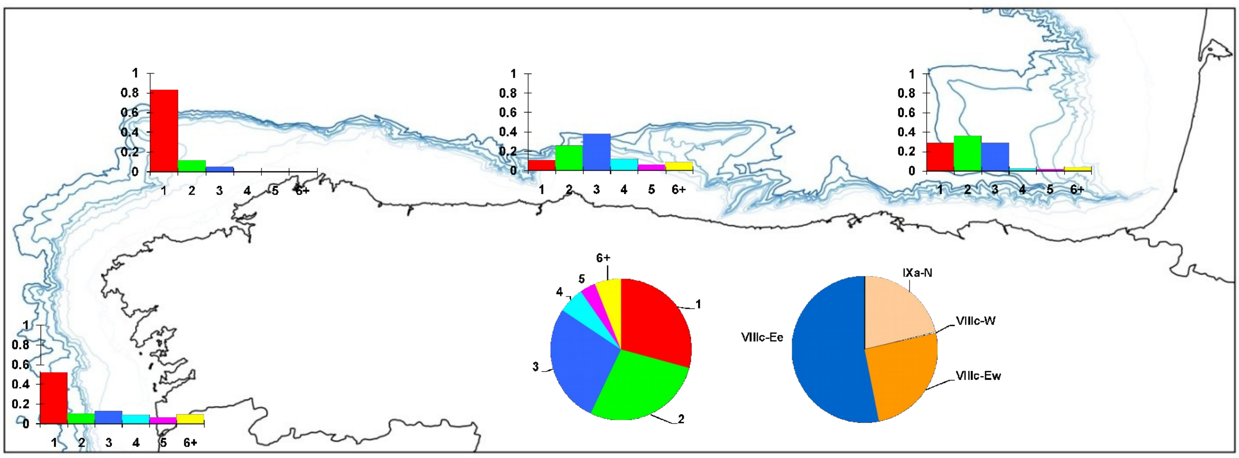


Figure 9. Sardine: relative abundance at age in each sub-area (i.e. the proportion of all age classes within sub-area sum to 1) estimated in the PELACUS0315. The pie chart shows the contribution of each sub-area and each age group to the total stock numbers.

Zone	Area	No	Mean	Area	Fishing st.	PDF	No (million fish)	Biomass (tonnes)	Density (Tn/nmi-2)
IXa	Rias Baixas	51	33.47	149	P08-P09-P11	S01	25	921	6
	Muros	29	43.96	122		S02	16	1283	10
	Total	***80***	***37.27***	***271***			***40***	***2204***	8
VIIIc-W	Costa da Morte	8	0.99	61	P32-P33-P34	S02	0	11	0
	Artabro	28	0.26	177	P37	S03	0	8	0
	Total	***36***	***0.42***	***239***			***1***	***19***	0
VIIIc-Ew	West	152	7.26	1174	P32-P33-P34	S02	27	1966	2
	Central	54	11.05	409			17	952	2
	East	23	6.23	172			4	219	1
	Total	**229**	***8.05***	**1754**			***48***	***3138***	2
VIIIc-Ee	Laredo	20	0.52	159	P43	S04	0	18	0
	Euskadi_off	14	17.57	102	P46-P49-P52	S05	5	443	4
	Euskadi_coast	17	186.82	123			96	4561	37
	Total	**51**	***67.30***	**383**			**101**	**5023**	13
VIIIb	Euskadi	16	16.93	128	P46-P49-P52	S05	9	431	3
	Total	***16***	***16.93***	***128***			***9***	***431***	3
	Total IXa	***80***	***37***	***271***			***40***	***2204***	8
	Total VIIIc	***316***	***17***	***2376***			***150***	***8161***	3
	Total VIIIb	***16***	***17***	***128***			***9***	***431***	3
	Total Spain	***412***	***20.74***	***2775***			***199***	***10795***	4

Table 10: Sardine acoustic assessment

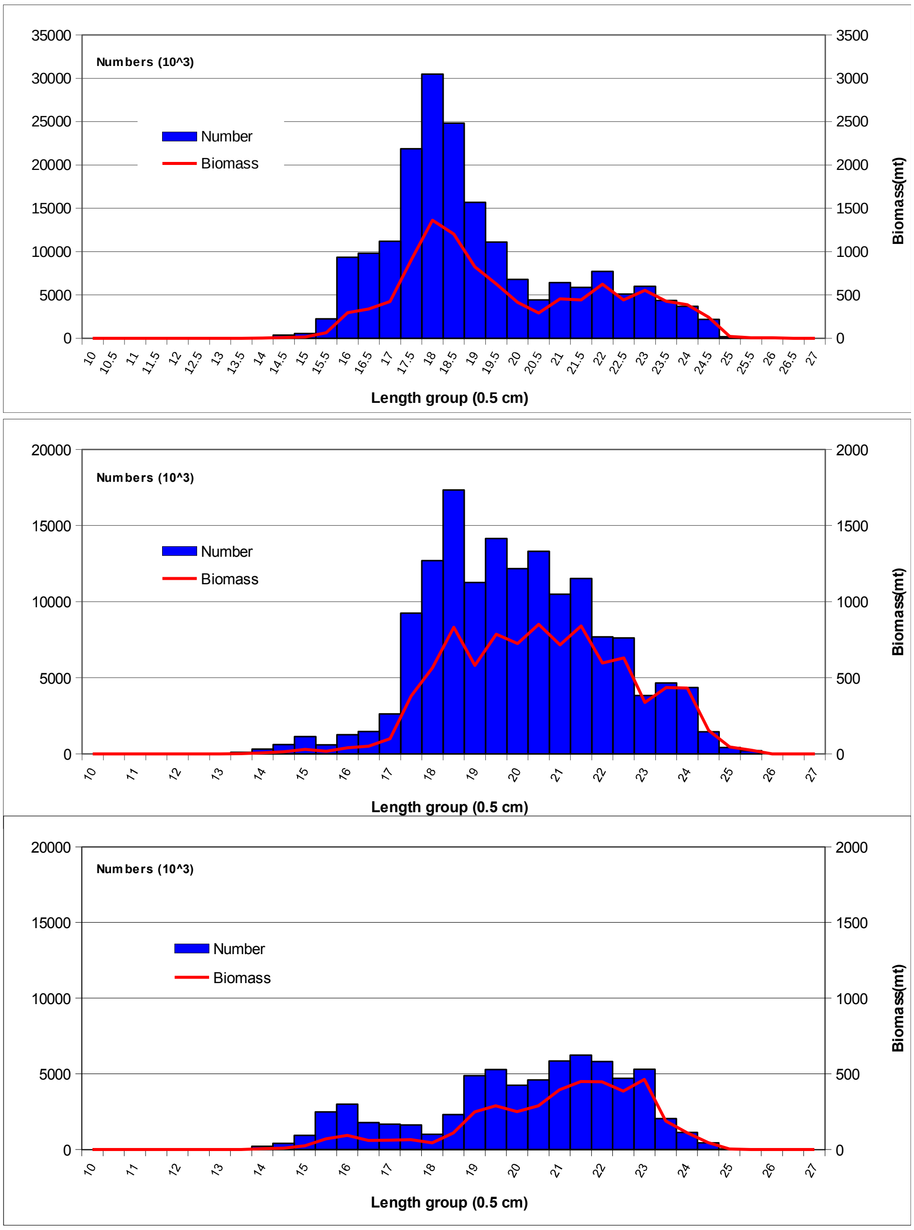


Figure 10. Sardine length distribution in both number and biomass during the PELACUS0315 (above), PELACUS0314

(middle) and PELACUS 0313 (below) surveys.

Mackerel distribution and assessment

Mackerel was the most important fish species, both in number and spatial distribution. Figure 11 shows the spatial distribution.

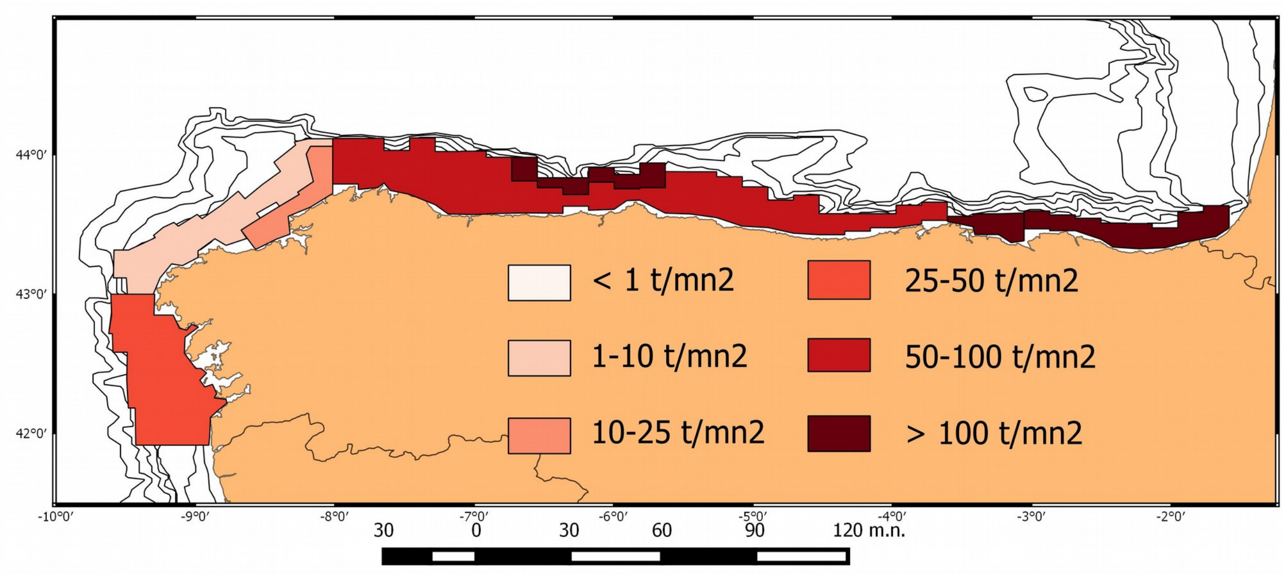


Figure 11. Mackerel: spatial distribution PELACUS0315 cruise. Polygons are drawn to encompass the observed echoes, and polygon colour indicates the mean density expressed as tonnes per squared nautical mile (<1,; 1-10; 10-25; 25-50; 50-100; and >500)

Table 11 shows the mackerel assessment. 487.489 mt has been estimated, corresponding to 1.586 million fish, which is much lower than that estimated in 2014 but higher than that of 2013. As said, previously, adult mackerel occurred in big quantities also in IXa-N, which was the first time this fact was recorded.

		SURVEY:	PELACUS 0315 MACKEREL					
Zone	**Area**	**No**	**Mean**	**Surface**	**Fishing st.**	**PDF**	**No (million fish)**	**Biomass (tonnes)**
Ixa-N	Ixa-N-South	235	7.86	1479.41	P01-P03-P04-P05-P06-P08-P11-P13	ST01	211	73605
	Total	***235***	***8***	***1479***			***211***	***73605***
VIIIc-w	Offshore	141	1.17	1094.82	P15-P17-P08-P21-P24	ST02	31	7419
	Artabro	60	1.68	388.01	P20	ST03	12	4118
	Total	***201***	***1***	***1483***			***42***	***11537***
VIIIc-E	VIIIc-Ew-Coast	371	11.97	2884.01	P26-P30-P33-P34-P35-P37-P38-P41-P56-P57-P59-P60-P62-P63-P64-P66	ST04	636	207317
	VIIIc-Ew-Off	48	35.79	356.76	P26-P39-P42	ST05	292	71722
	VIIIc-Ee-laredo	24	24.68	189.90	P53-P54	ST06	87	28020
	VIIIc-offshore	80	26.88	606.10	P46-P47-P48-P51-P52	ST07	317	95288
	Total	***523***	***17***	***4037***			***1332***	***402347***
	Total VIIIc	***724***	***13***	***6999***			***1375***	***413884***
	Total Spain	***959***	***11***	***6999***			***1586***	***487489***

Table 11 Mackerel acoustic assessment

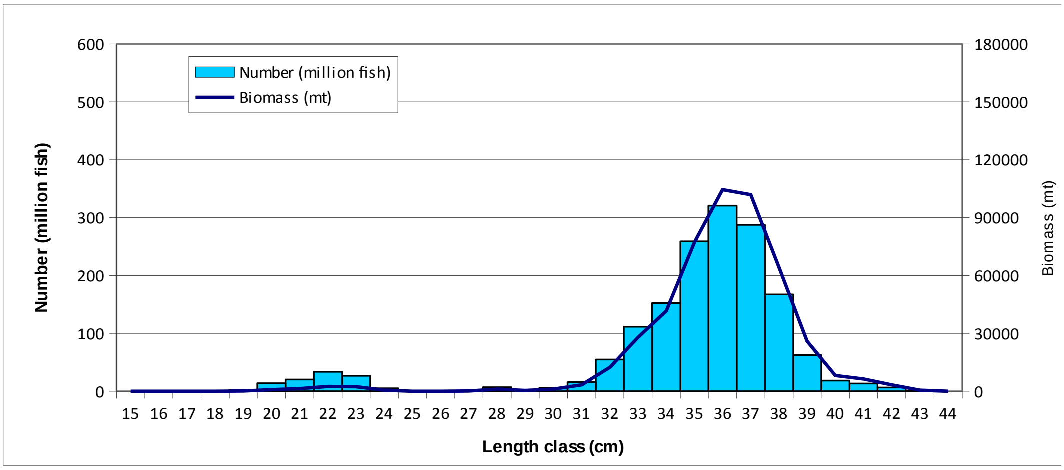


Figure 12. Mackerel length distribution in both number and biomass during PELACUS0315 survey.

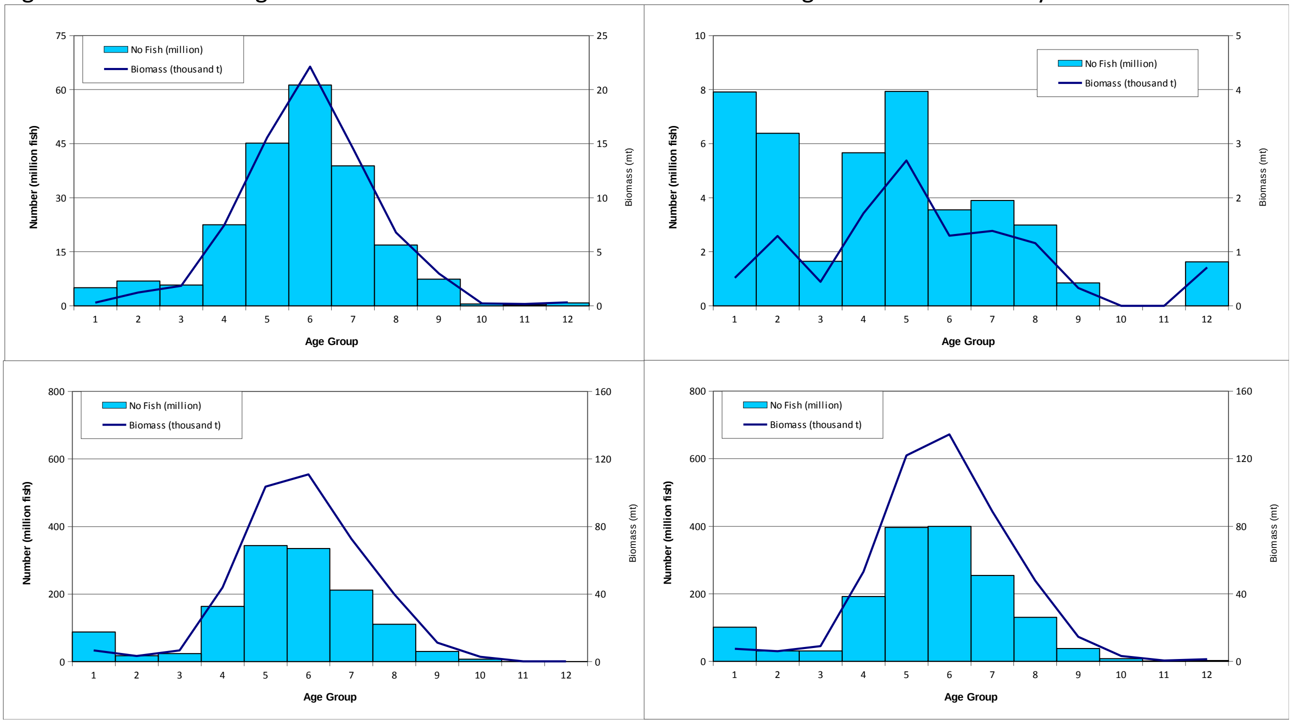


Figure 13. Mackerel abundance and biomass by age group during PELACUS0315 survey.

Comparing with the previous year, the total mackerel biomass assessed represents a decrease of a 39 % (798 154 t corresponding to 2,786 million fish). As it seems there is a relationship between mackerel behaviour and weather conditions (mackerel occurs in layers located at 30 m deth on average and this layer would become more important in terms of biomass if the weather conditions are good), the weakness of this layer in both 2013 and 2015 could be related with the rough weather conditions found during these surveys and hence, the lower estimates of these, could be partially explained by this conditions.

SURVEY: PELACUS 0315. MACKEREL

BIOMASS (thousand tonnes). ZONE: VIIIc+IXaN

Length	AGE GROUPS 1	2	3	4	5	6	7	8	9	10	11	12	Total	No fish (million)
10														
11														
12														
13														
14														
15														
16														
17														
18														
19	0.09												0.09	2
20	0.81												0.81	14
21	1.34												1.34	20
22	2.50												2.50	34
23	2.27												2.27	27
24	0.46												0.46	5
25														
26		0.02											0.02	0
27		0.08											0.08	1
28		1.10											1.10	7
29		0.40		0.02									0.42	2
30		1.00	0.05										1.04	5
31		2.11	0.34	0.53	0.29								3.27	16
32		1.28	0.60	9.48	1.07								12.42	55
33			0.89	10.90	12.46	3.27	0.35						27.86	112
34			1.85	8.79	20.01	7.55	2.45	1.01					41.65	152
35			2.46	9.26	27.91	24.15	9.67	3.80					77.27	259
36			1.15	7.05	30.46	33.26	21.40	7.67	2.90	0.55			104.44	321
37			1.35	5.53	19.10	32.64	26.42	12.88	3.37	0.45		0.10	101.84	288
38			0.32	1.49	7.82	21.29	17.58	10.82	3.57	0.84		0.43	64.16	167
39					2.30	8.54	7.18	5.04	2.12	0.64		0.19	26.02	63
40					0.43	1.38	1.84	2.16	1.47	0.52	0.26	0.12	8.18	18
41						1.89	1.79	1.54	1.08			0.09	6.40	13
42						0.33		2.81			0.17	0.03	3.34	6
43						0.07				0.18		0.25	0.50	1
44														
Biomass (thousand t)	7	6	9	53	122	134	89	48	15	3	0	1	487.49	1586
%	1.53	1.23	1.85	10.88	24.99	27.56	18.19	9.79	2.98	0.65	0.09	0.25		
M. weight	69.45	188.16	288.49	275.87	308.53	338.87	352.67	370.23	383.03	393.88	483.85	435.44	299.24	
No Fish (million)	101	31	31	192	397	400	254	130	38	8	1	3	1586	
%	6.38	1.94	1.96	12.09	25.02	25.20	16.02	8.22	2.42	0.52	0.06	0.17		
M. length	22.33	30.58	34.99	34.50	35.74	36.82	37.28	37.86	38.27	38.60	41.19	39.85	35.40	
s.d.	1.15	1.51	1.74	1.70	1.52	1.54	1.40	1.75	1.46	1.66	0.95	1.96	3.96	

Table 12. Mackerel abundance in number (thousand fish) and biomass (tons) by age group in PELACUS0315.

Behaviour:

Although weaker than the previous year, mackerel occurred in a pelagic layer, at around 30-50 m depth. In order to test if there is a significant difference in mean length and length distribution Results for both parameters obtained at the pelagic tows performed during PELACUS 0315 were compared with those achieved by the artisanal fleet which is targeting on this mackerel layers. No significant differences were observed and both mean size and length structures are similar, thus

Dmax	LL201501	LL201502	LL201401	LL201402	LL201302	PELACUS 0315
LL201501		**0.1524**	0.0365	0.1057	0.1600	0.0826
LL201502	**0.1524**		0.1760	0.0769	0.0373	0.2221
LL201401	0.0365	0.1760		0.0992	0.1548	0.0732
LL201402	0.1057	0.0769	0.0992		0.0596	0.1520
LL201302	0.1600	0.0373	0.1548	0.0596		0.2116
PELACUS 0315	**0.0826**	**0.2221**	0.0732	0.1520	0.2116	
Aver	35.83	36.56	35.75	36.28	36.55	35.48
Std	2.67	2.32	2.92	3.31	2.85	2.37

Table 13 Pair comparison of the statistics Dmax from the Kolmogorov Smirnoff test together with the mean size and its

deviation obtained from some samples of the artisanil fleet targeting in mackrel and from PELACUS 035

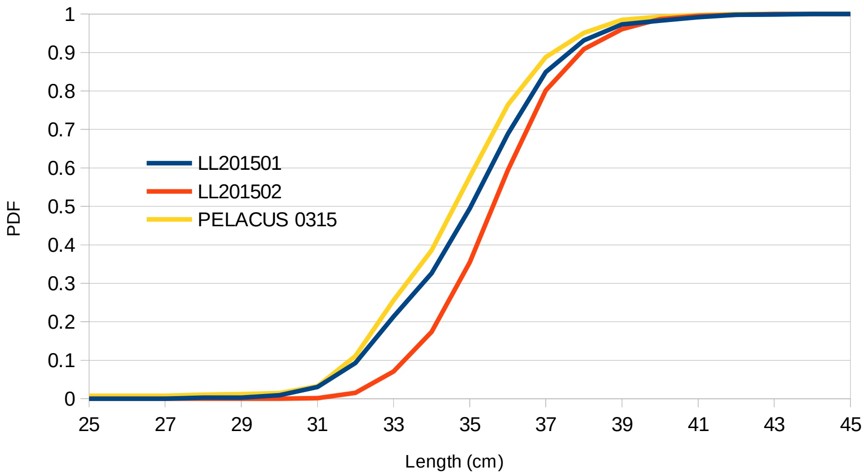


Figure 14 Cumulated probability density functions from PELACUS 0315 and those samples from the artisanal fleets obtained almost at the same temporal and spatial scale in relation to the survey samples.

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). Although the density was still low, there has been found small extension of the distribution area towards open waters in pelagic layers. Nevertheless, as observed last year, it seems that the distribution is spreading through the continental shelf (figure 15). Mean length was rather homogeneous along the surveyed area at around 19 cm as mean length which was smaller than that estimated last year (22.5 cm).

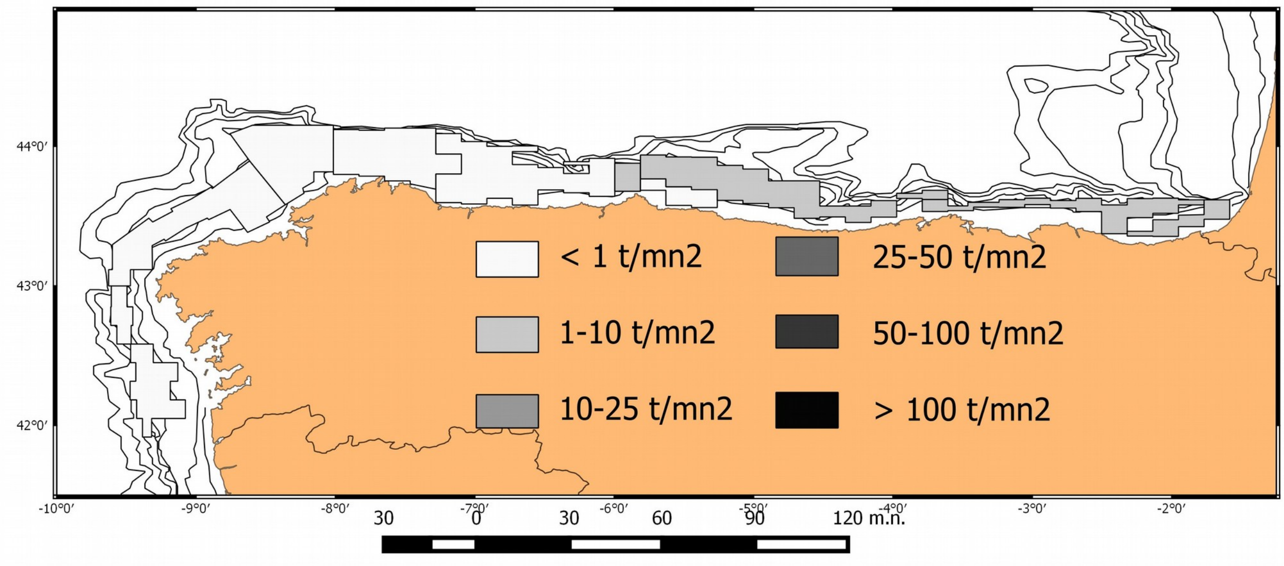
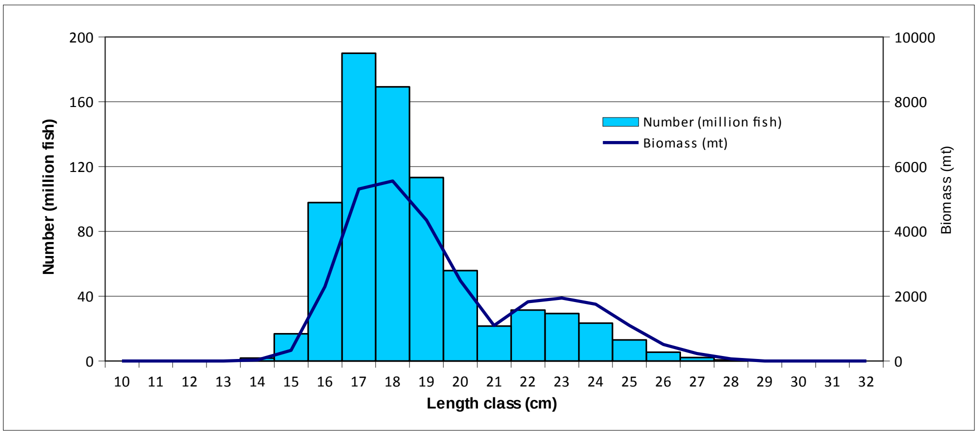


Figure 15. Blue whiting spatial distribution PELACUS0315 cruise. Polygons are drawn to encompass the observed echoes, and polygon colour indicates the mean density expressed as tonnes per squared nautical mile (<1,; 1-10; 10-25; 25-50; 50-100; and >100)

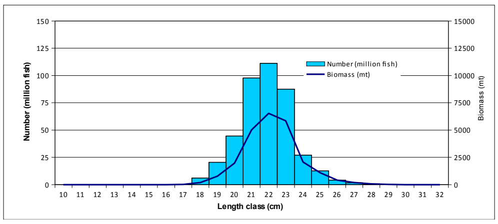
Table 14 shows the blue whiting assessment. A total of 28.8 thousand tonnes corresponding to 771.5 million fish has been estimated. Comparing to previous years, blue whiting is increasing its biomass from 7146 mt (123 million fish) assessed in 2012, 13488 mt (corresponding to 299 million fish) in 2013; and 22870 mt (392 million fish). The increase in number was higher than that in biomass due to the lower mean size of the fish found this year. Accordingly, length structure and age composition are dominated by smaller fish and age group 1 respectively (figures 16 and 17).

Zone	Area	No	Mean	õ^2	Area	Fishing st.	PDF	No (million fish)	Biomass (tonnes)
IXa	IXa	63	104.59	192	554	P01-P07-P09-P19-P21-P22-P23-P25	S01	65	2698
	Total	**63**	**104.59**		**554**			**65**	**2698**
VIIIc-W	VIIIc_W	109	145.49	251	867	P01-P07-P09-P19-P21-P22-P23-P25	S02	142.66	5878.90
	Capelada	76	217.90	331	704	P15-P16-P17	S02	213.72	6451.78
	Total	***185***	***175***		***1571***			***356***	***12331***
VIIIc-E	Masma	97	52.15	146	761	p26-p28-p29-p30-p32	S03	53	1723
	Asturias Oc	125	96.93	441	1003	P31-P33-P34-P39	S04	98	4826
	Penas	13	27.56	46	96	P41		2	139
	Penas_coast	21	18.16	32	165	P56-P66		2	165
	Canor	118	66.07	150	908	P42-P55-P56-P61-P50-P49		76	2692
	Santander_off	6	51.21	83	50	P56-P66		2	139
	Euskadi	52	200.23	406	433	P42-P55-P56-P61-P50-P49	S05	109	3890
	Francia	25	29.85	141	181	P42-P55-P56-P61-P50-P49	S06	7	243
	Total	***457***	***81.35***		***3599***			***350***	***13817***
Total IXa		***63***	***105***		***554***			***65***	***2698***
Total VIIIc		***642***	***108***		***5170***			***706***	***26148***
Total Spain		***705***	***108.06***		***5724***			***771***	***28845***

Table 11: Blue whiting assessment



Last years **2013** **2014**



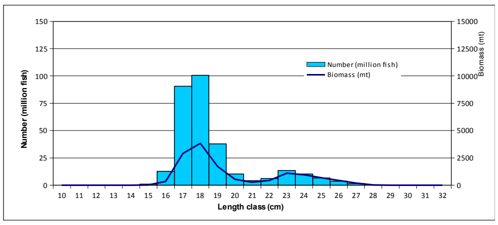
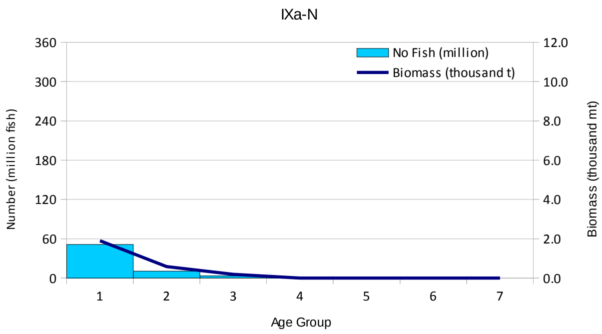
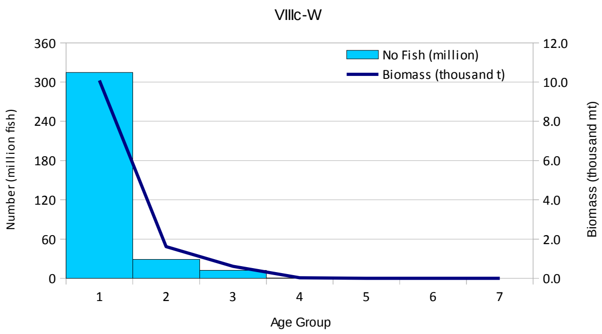
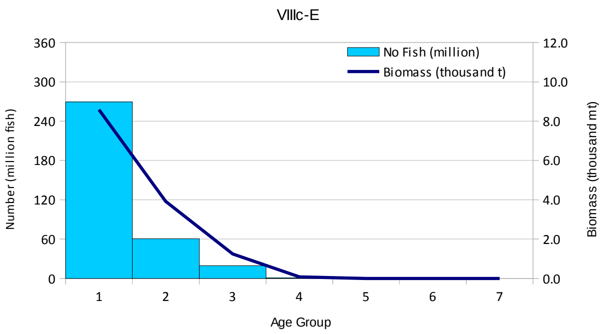


Figure 16. Blue whiting length distribution in both number and biomass during the PELACUS0315 (above) and PELACUS 0313 and 0314 (below) surveys.







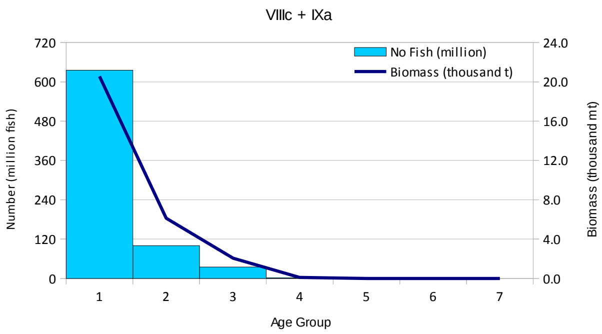


Figure 17. Blue whiting age composition by ICES Divisionin both number and biomass during PELACUS0315.

Blue whiting nictimeral and schooling behaviour:

Due to the extension of the surveyed area until the 1000 m isobath occurred in 2013, the full blue whiting distribution could be covered during PELACUS time-series. Although, the extension towards oceanic waters is unusual in the Spanish area, this can be sometimes found. The typical layer as seen in northern waters (i.e. from France northwards) and recorded by the IEO during the SEFOS surveys undertook in 1994 and 1996 (figure 18), has never seen during the PELACUS time series. In the Spanish area, the normal occurrence is in a diffuse layer of about 100-150 m thickness, in a low density and mixed, as stated, with other organisms such as hake, krill, pearlside, lantern and other myctophids fishes.

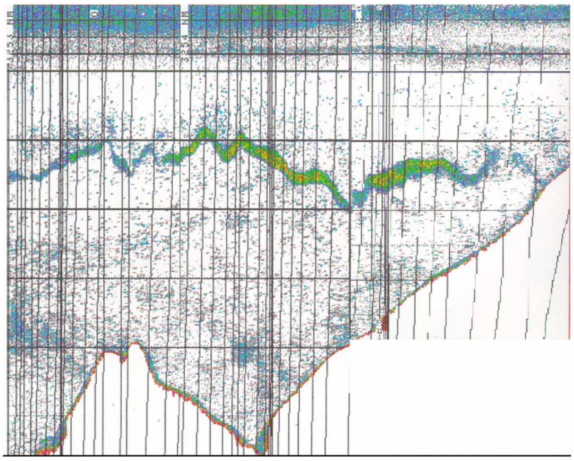


Figure 18. Blue whiting pelagic layer observed during SEFOS 0396 survey in the French self-break area (45ºN) the extension of this layer was around 5-7 nautical miles.

Nevertheless, in some occasions, around the self-break, it can be seen either isolate schools or a rather continuous layer. In the former case, according to the results achieved at the ground-truth fishing station, these schools seems to be monospecific while in the later, blue whiting is caught with other species. (figure 19)

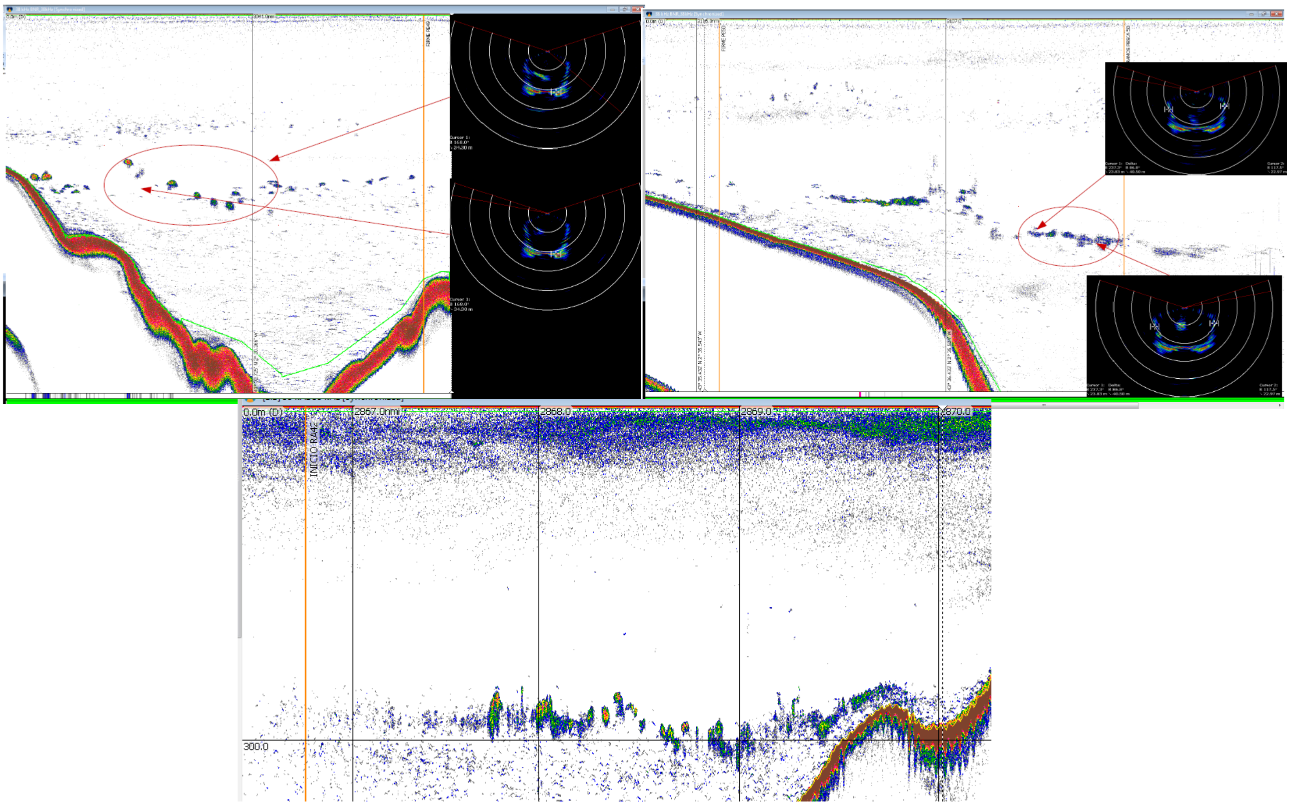


Figure 19. Blue whiting occurrence in open waters during PELACUS time series. Above mono-specific schools and below, layer associated with other fish species.

During PELACUS 0315 a nictimeral movement of blue whiting towards the surface has been observed. At sunset, the schools, located close to the self-break, performed a vertical migration towards a plankton layer located at the surface; it seems this movement would end at the sunrise.

Two fishing hauls carried out at sunset and other two done at sunrise seems to corroborate this observation, as shown in figure 20.

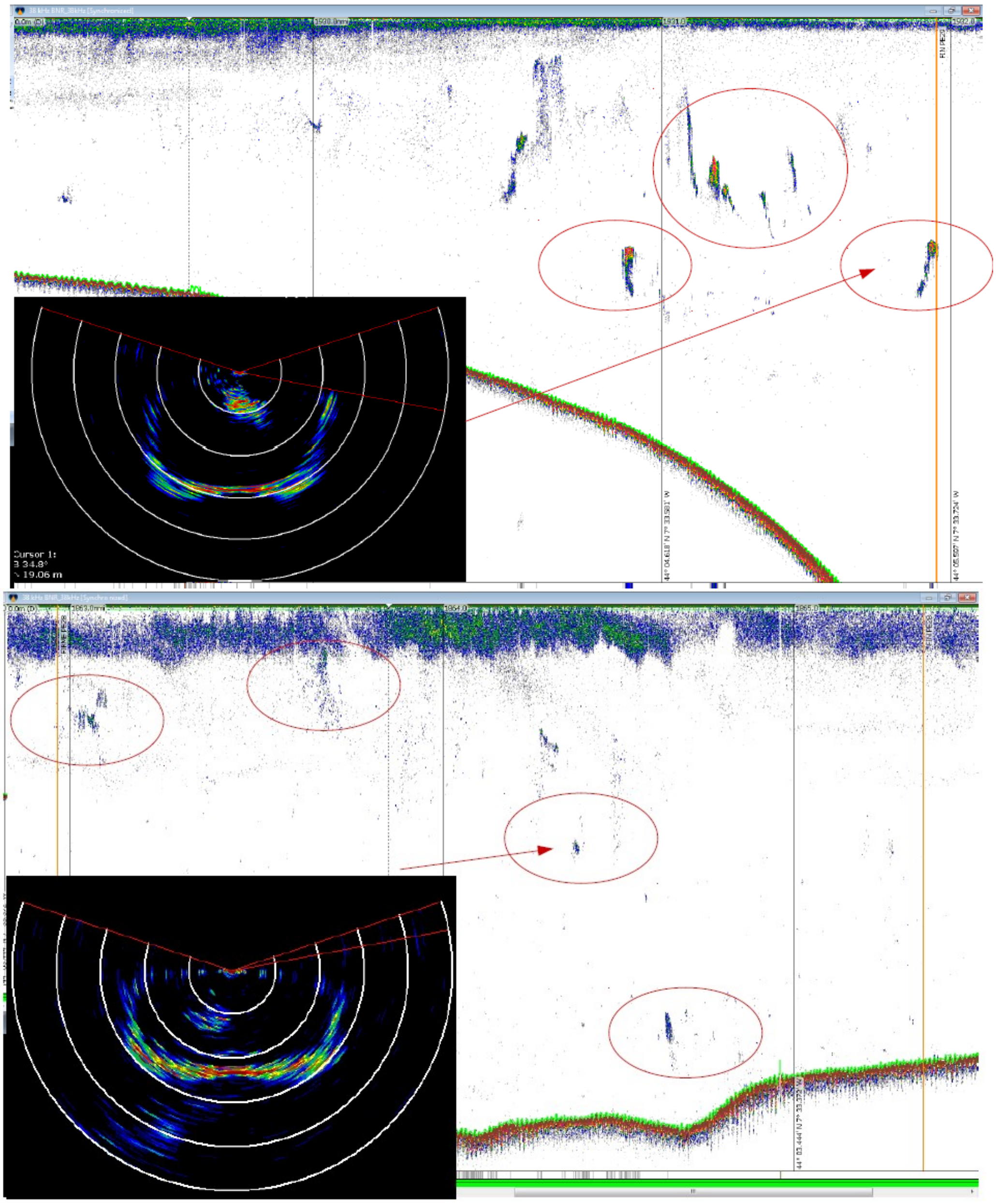


Figure 20. Nictimeral behaviour observed for blue whiting during PELACUS 0315. Above, at sunset (rising), showing also the fishing haul performed and encircled in red the blue whiting schools and below at sunrise (descending).

Horse mackerel distribution and assessment

Horse mackerel density was higher than that found the previous year. In IXaN, the bulk of the distribution occurred within the Rías Baixas in a very dense and near bottom schools (figure 21).

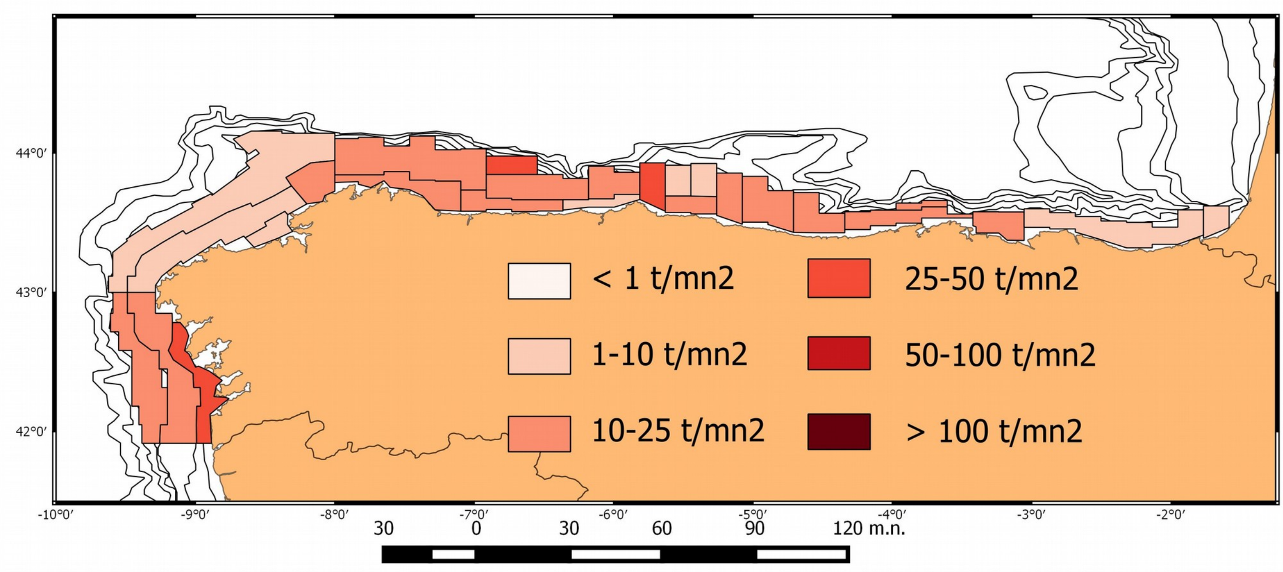


Figure 21. Horse mackerel spatial distribution PELACUS0315 cruise. Polygons are drawn to encompass the observed echoes, and polygon colour indicates the mean density expressed as tonnes per squared nautical mile (<1,; 1-10; 10-25; 25-50; 50-100; and >100

Total biomass was estimated to be 94010 mt (1278 million fish). Almost 27 thousand tonnes (203 millions fish)of those were located in IxaN, that is belonging to South stock (table 12, figure 22 and 23). However, as can be observed in figure 22 and 23, in VIIIc age and length structures are quite similar to that found in southern waters, with the bulk of the fish belonging to age group 3. On the contrary, although age group 3 was also important (in biomass is the most important), the most noticeable in VIIIc-E and VIIIb is the presence of a high quantity of fish below 16 cm belonging to age group 1.

Comparing with previous year, there was an important increase from 44 to 94 thousand tonnes. Indeed, in 2013 total biomass was estimated to be only 6 thousand tonnes. Both, age group 3 and 1, corresponding to the 2014 and 2012 recruitment, seem to be above the most recent ones.

Zone	Area	No	Mean	Surface	Fishing st.	PDF	No (million fish)	Biomass (tonnes)
IXa-N	Rías Baixas	89	282.89	286.12	P08-P10-P12-P13	ST01	92	8674
	IXa-Coast	78	152.73	611.41	P04-P06-P11	ST02	88	10988
	IXa-off	62	87.73	515.13	P07-P09	ST03	24	7271
	Total	***229***	***186***	***1412.66***			***203.28***	***26932.98***
VIIIc-w	VIIIcW_South_Coast	87	58.30	660.86	P24	ST04	37	4449
	VIIIcW_Off	127	7.77	1101.08	P17-P21-P22	ST05	6	1173
	VIIIcW_Artabro_Coast	13	36.61	102.17	P18-P20	ST06	4	457
	VIIIcW_North	31	92.37	195.58	P15	ST07	18	2051
	Total	***258***	***36***	***298***			***65.49***	***8129.73***
VIIIc-Ew	VIIIcEw_Masma_Coast	34	122.62	275.30	P30-P33	ST08	42	3255
	VIIIcEw_Masma_Off	96	127.99	729.64	P26-P31	ST09	82	10787
	VIIIcEw_Ast_Occ_Coast	25	129.62	191.06	P34-P35	ST10	47	2630
	VIIIcEw_Ast_Occ_Off	42	213.02	328.64	P37-P38	ST11	72	7412
	VIIIcEw_Navia_Off	17	599.28	126.48	P36	ST12	164	5987
	VIIIcEw_Avilés_Coast	11	28.69	90.42	P40	ST13	4	236
	VIIIcEw_Peñas_Occ	24	125.14	188.45	P41	ST14	31	2239
	VIIIcEw_Peñas_Or	20	411.40	145.55	P42	ST15	166	3960
	VIIIcEw_Xixón_Off	15	28.18	106.26	P55	ST16	5	264
	VIIIcEw_Xixón_Coast	15	187.45	118.04	P56	ST17	72	1258
	VIIIcEw_R34	15	55.56	113.68	P57	ST18	5	806
	VIIIcEw_R35	21	148.53	161.01	P58	ST19	27	2414
	VIIIcEw_R36-R37	38	168.05	288.64	P59-P60	ST20	46	5360
	VIIIcEw_R38-R39	26	198.74	205.75	P61-P62-P63	ST21	53	3912
	VIIIcEw_R40-R44	28	143.55	212.80	P64-P65	ST22	64	2429
	VIIIcEw_R42-R43_Off	6	78.71	46.55	P66	ST23	3	489
	Total	***433***	***170***	***3328***			***883.40***	***53437.10***
VIIIc-Ee	VIIIcEe_Laredo	21	148.96	164.18	P53	ST24	84	1721
	VIIIcEe_Euskadi	66	64.45	517.54	P46-P47-P51-P52-P54	ST25	37	3440
	Total	***87***	***85***	***682***			***121***	***5162***
	Total VIIIc	***778***	***116***	***4308***			***1069***	***66728***
VIIIb	VIIIb_Euskadi	14	42	94	P43	ST26	6	349
	Total	***14***	***42***	***94***			***6***	***349***
	Total Spain	***1007***	***132***	***5720***			***1278***	***94010***

Table 12: Horse mackerel assessment

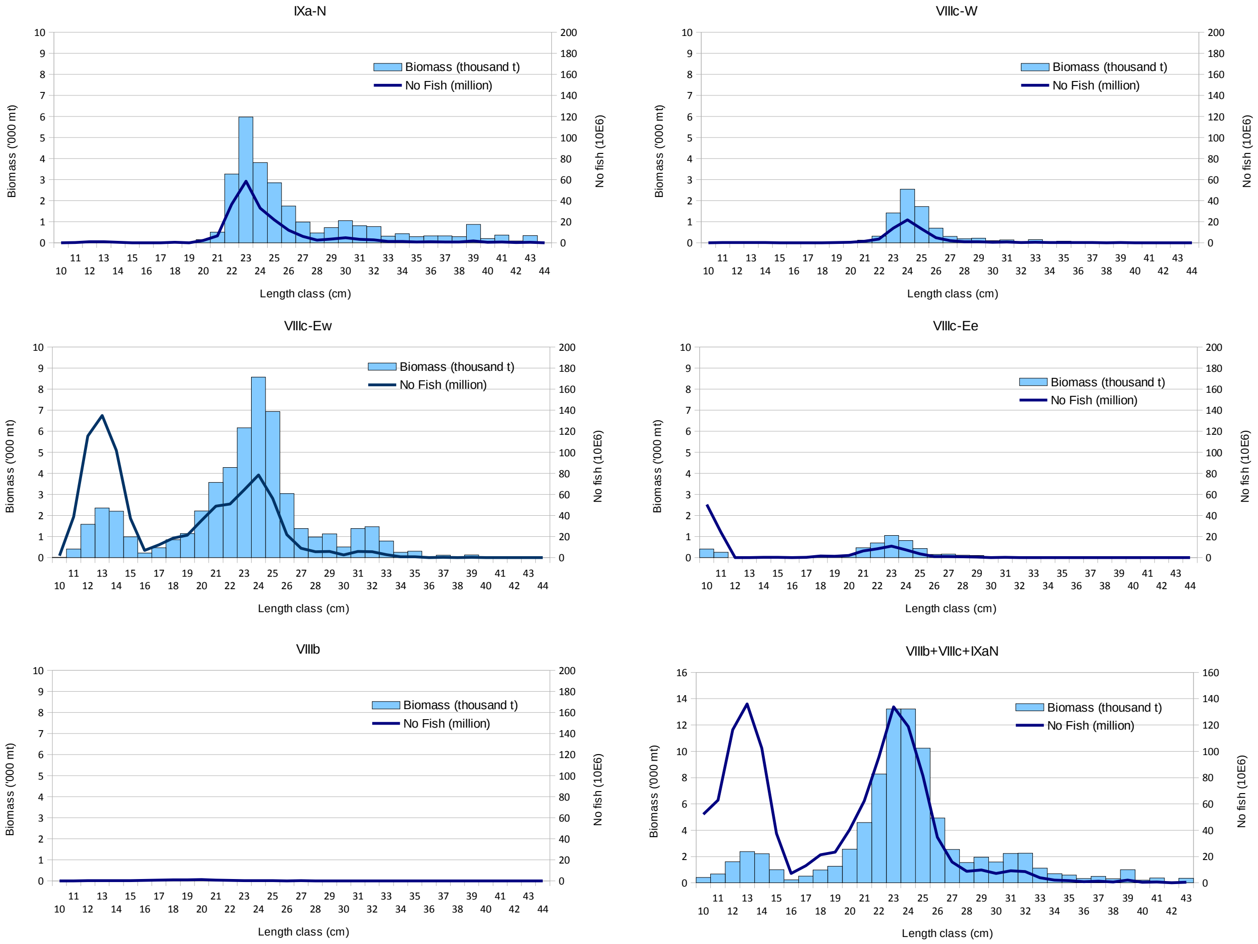


Figure 22. Horse mackerel length distribution in both number and biomass during the PELACUS0315

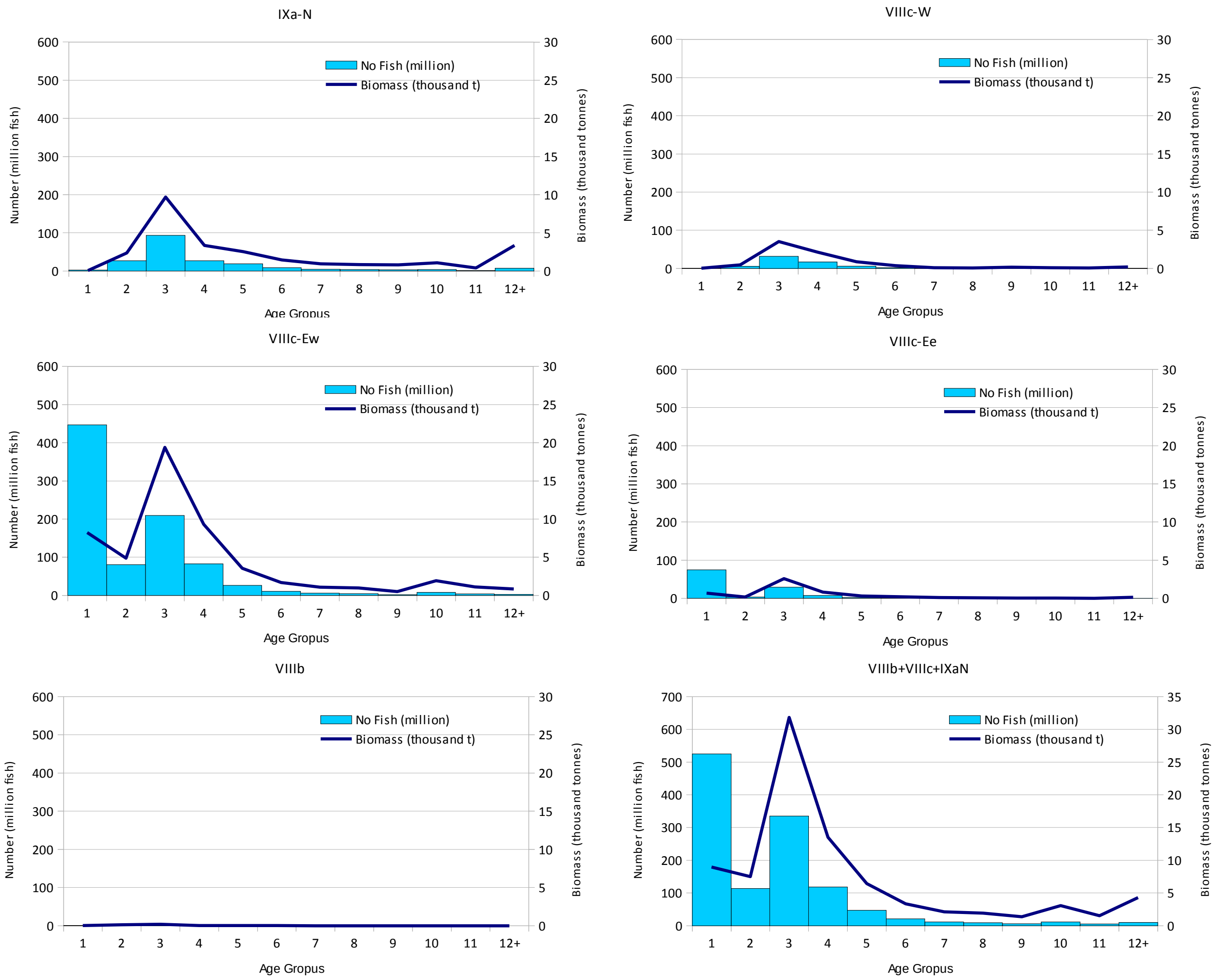


Figure 23: Horse mackerel numbers and biomass by age group during the PELACUS0315 .

Boarfish distribution and assessment

Boarfish spatial distribution was smaller than that observed in the previous year. Besides, the density was also very low (figure 24). 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.

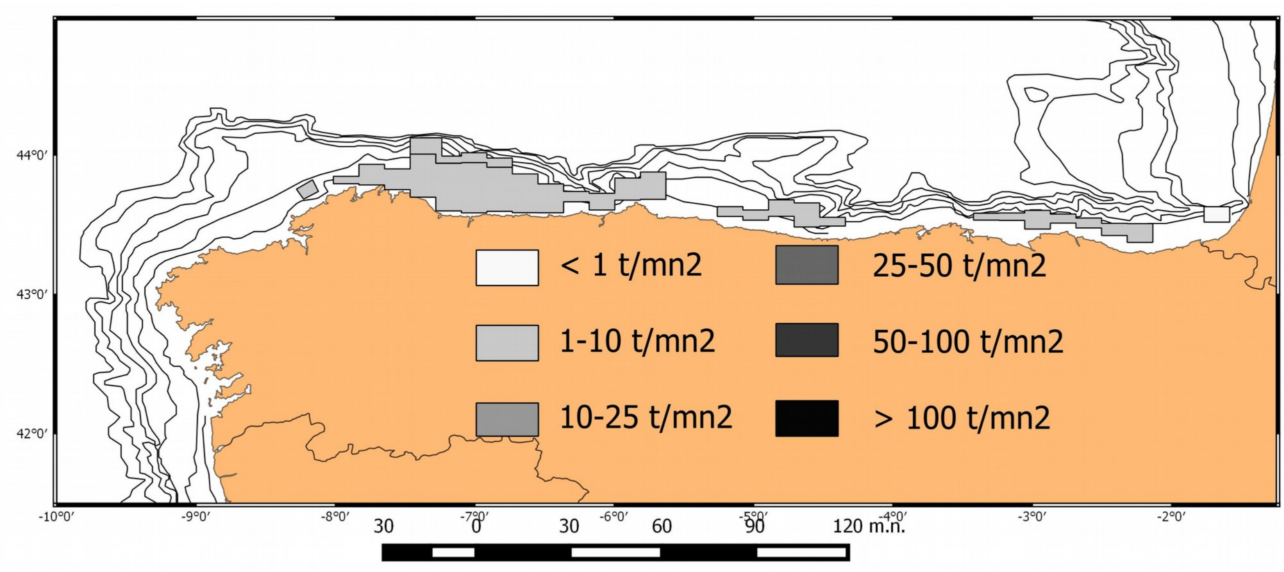


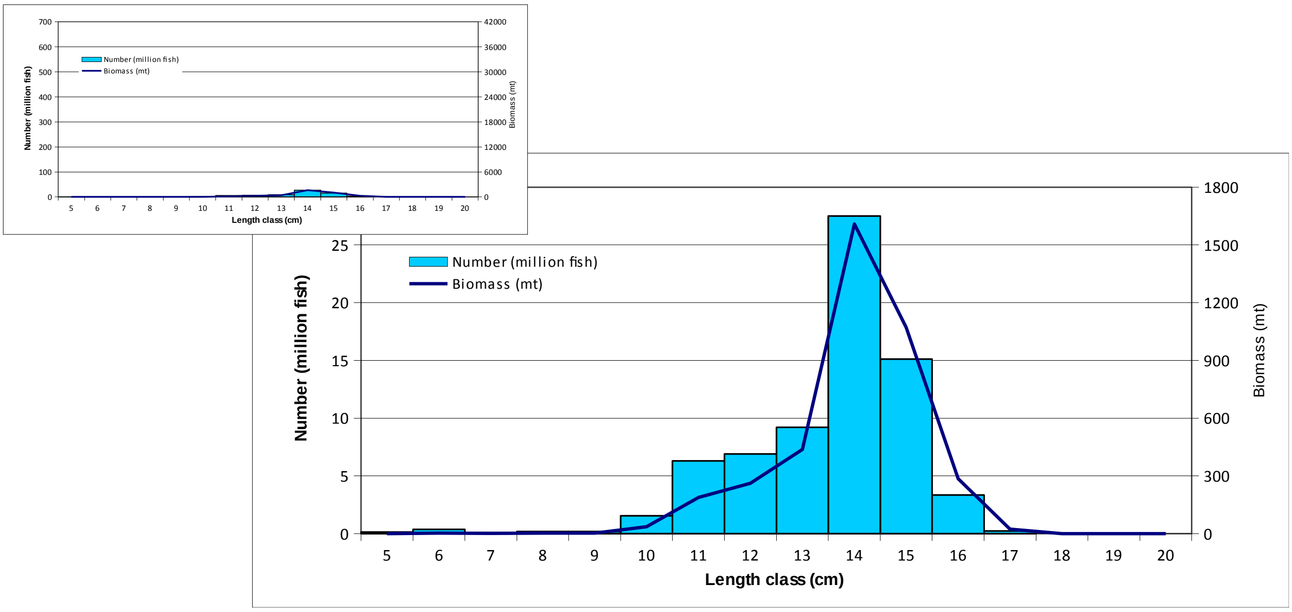
Figure 24. Board fish spatial distribution PELACUS0315 cruise. Polygons are drawn to encompass the observed echoes, and polygon colour indicates the mean density expressed as tonnes per squared nautical mile (<1,; 1-10; 10-25; 25-50; 50-100; and >100)

For the assessment we have kept the old TS/length relation ship for comparison purposes, but, together with this, we have used the new one estimation.

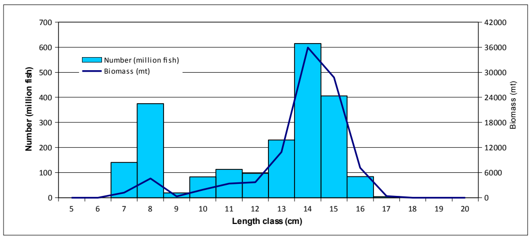
Accordingly, the estimated biomass was the lowest in the time series, being only 4 thousand tonnes (71 million fish), and far from the 25344 tonnes assessed last year (table 13). In the same way, using the old TS estimation which was so much lower than the new one (6.4 dB), the total biomass reached 98220 mt (2167 million fish), which was 6 times higher than that of the previous year (16067 tonnes, corresponding to 437 million fish), but still far from the maximum assessed in 2011 when more than 220 thousand tonnes were estimated. In 2012 the total biomass assessed were 33.238 corresponding to 518 million fish.

Zone	Area	No	Mean	Area	Fishing st.	PDF	No (million fish)	Biomass (tonnes)
VIIIc-W	Capelada	5	22.97	30.14	P21	S01	1.02	66.73
	Total	*5*	*23*	*30*			*1*	*67*
VIIIc-E	Canocc	168	11.66	1299.29	P24	S02	22	1461
	Canocc_off	18	21.38	159.79	P27	S03	8	265
	Can_cent	29	23.34	239.29	P28	S04	9	505
	Cant_or	36	62.64	286.65	P32-P40-P42-P44-P45-P46	S05	30	1623
	Francia	7	0.44	53.22	P32-P40-P42-P44-P45-P46	S05	0	1
	Total	*258*	*20.46*	*2038*			*70*	*3854*
Total VIIIc		*263*	*21*	*2068*			*71*	*3921*
Total Spain		*263*	*21*	*2068*			*71*	*3921*

Table 13: Boarfish acoustic assessment



Last years **2013** **2014**



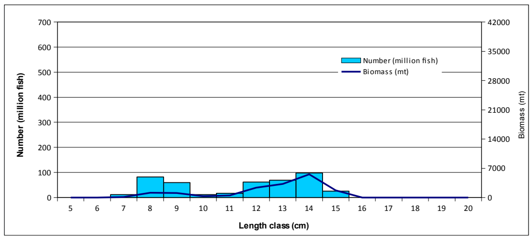


Figure 25. Boarfish length distribution in both number and biomass during the PELACUS0315 (above) and PELACUS 0313 and 0314 (below) .

Main difference with previous years was the lack of small fish, which had a mean size of 8cm. This year only the mode located at 14 was found.

Anchovy distribution and assessment

Although in the last two years, given the low density in anchovy records, no assessment was performed (i.e. the backscattering energy allocated to anchovy was below an acceptable threshold to be considered in terms of an accurate estimation), this year, due to the strength of the recruitment, in some areas it was possible to produce an assessment. Figure 26 shows the relativity density according to the backscattering energy.

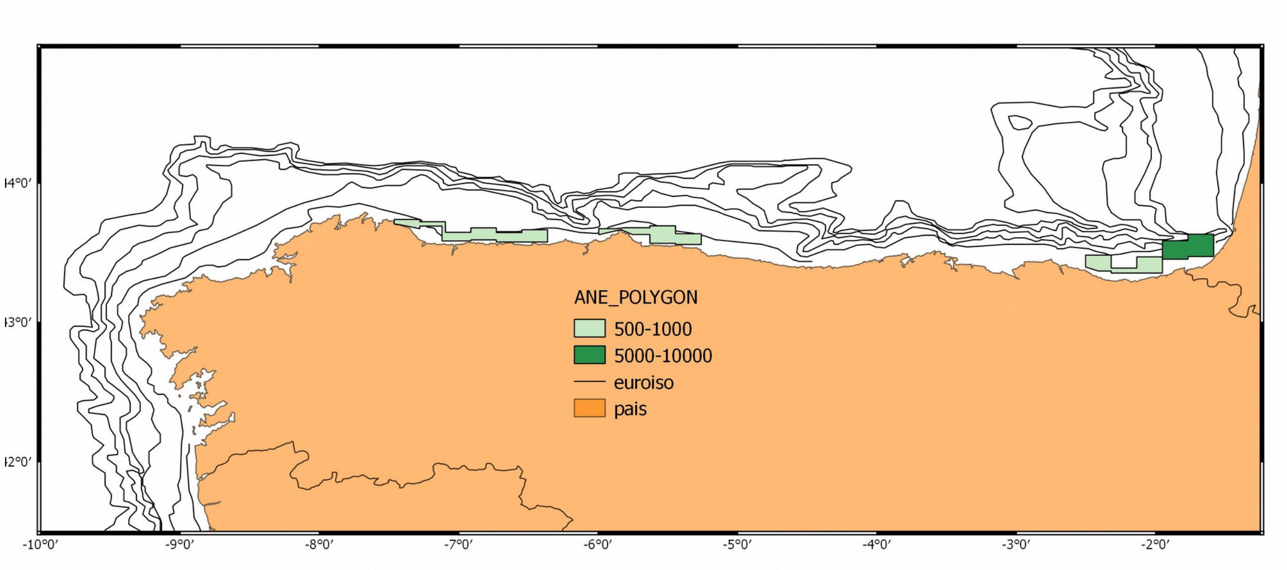


Figure 26. Anchovy spatial distribution. Polygons are drawn to encompass the observed echoes, and polygon colour indicates the mean density expressed as kilograms per squared nautical mile.

Two main areas were found, around Cape Peñas and at the inner part of the Bay of Biscay. At the mouth of the Rias in IXaN, some schools were also observed, although in a very small quantity, thus, unrelevant in terms of biomass estimation. Besides, egg distribution obtained from CUFES agreed with this distribution as shown in figure 27.

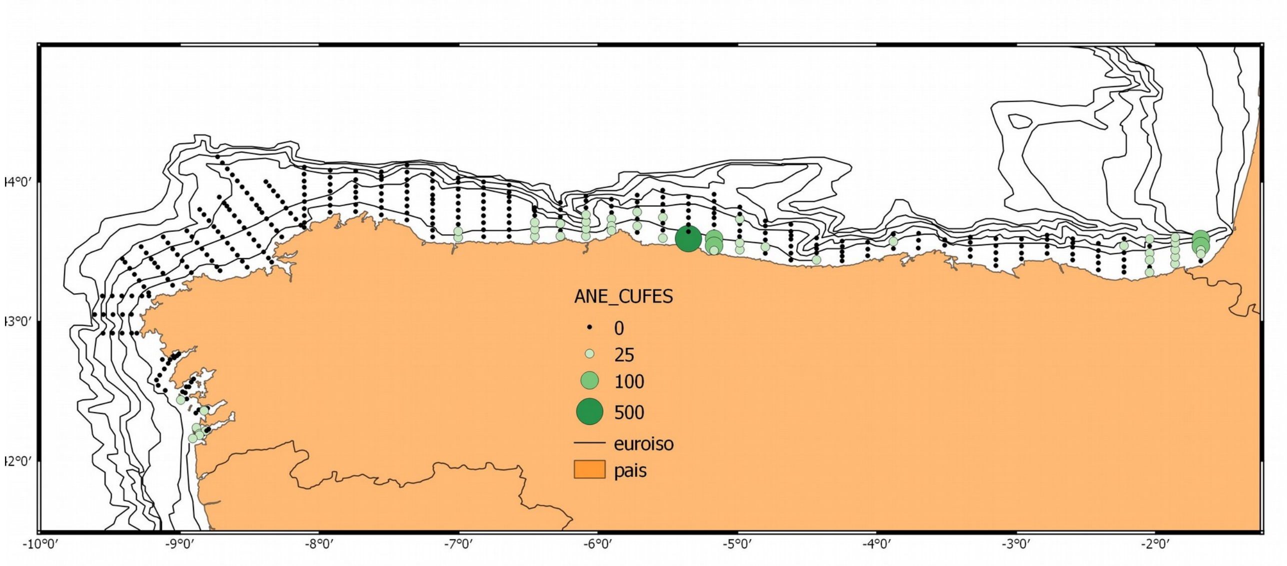


Figure 27. Anchovy egg spatial distribution.

Table 14 shows the assessment. 2829 tonnes corresponding to 140 millions were estimated, most of then located around Cape Peñas area.

Zone	Area	No	Mean	Area	Fishing st.	PDF	No (million fish)	Biomass (tonnes)
VIIIc-Ew	Masma	20	0.52	159	P43	S04	1	11
	Asturias	16	126.52	131	P46-P49-P52	S05	108	2262
	Total	**36**	***56.52***	**289**			**108**	**2273**
VIIIc-Ee	Euskadi 8cee	16	0.38	125			0	5
	Total	**16**	**0**	**125**			**0**	**5**
VIIIb	Euskadi 8b	19	30.77	141	P46-P49-P52	S05	31	551
	Total	***19***	***30.77***	***141***			***31***	***551***
	Total VIIIc	***52***	***39***	***414***			***109***	***2278***
	Total VIIIb	***19***	***31***	***141***			***31***	***551***
	Total Spain	***71***	***36.98***	***555***			***140***	***2829***

Table 14: Anchovy acoustic assessment

The largest fish were located around Cape Peñas, with a mean length of 14.9 cm. In the inner part of the bay of Biscay mean size ranged from 11.95 in VIIIc-Ee and 14.13 cm in VIIIb (figure 28)

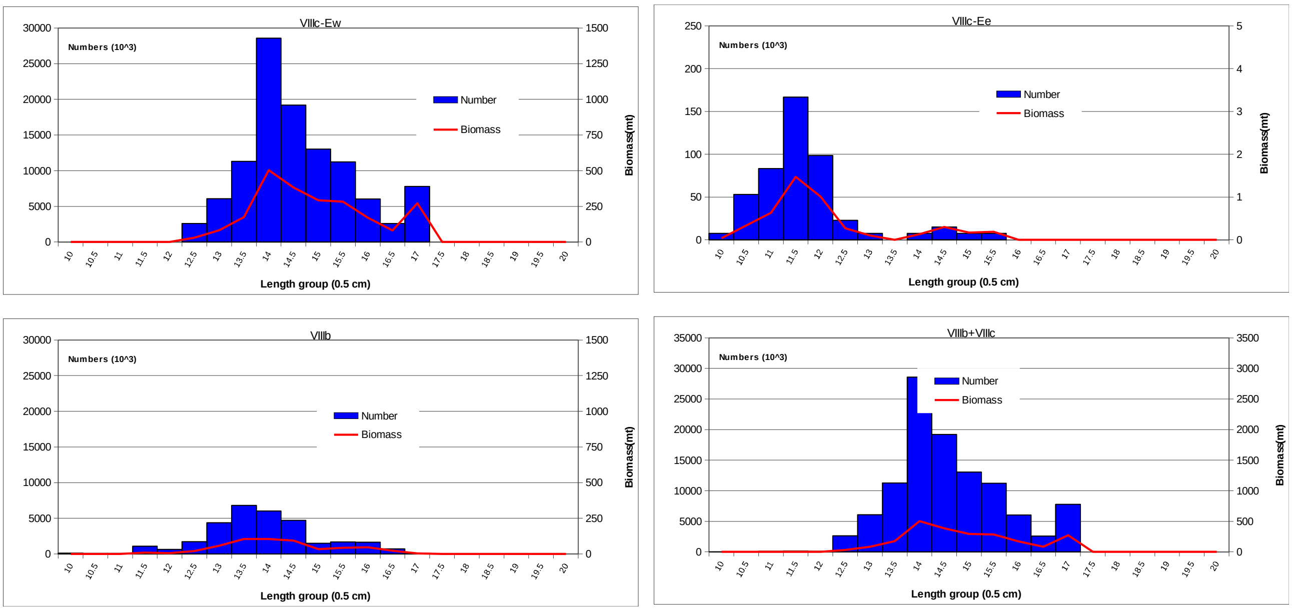


Figure 28. Anchovy length distribution in both number and biomass during by ICES divisions (the scales are different for the total and for VIIIc-Ee)

Other fish species

Bogue (Boops boops) had an important contribution to the pelagic community. This specie was well distributed as shown in figure 29.

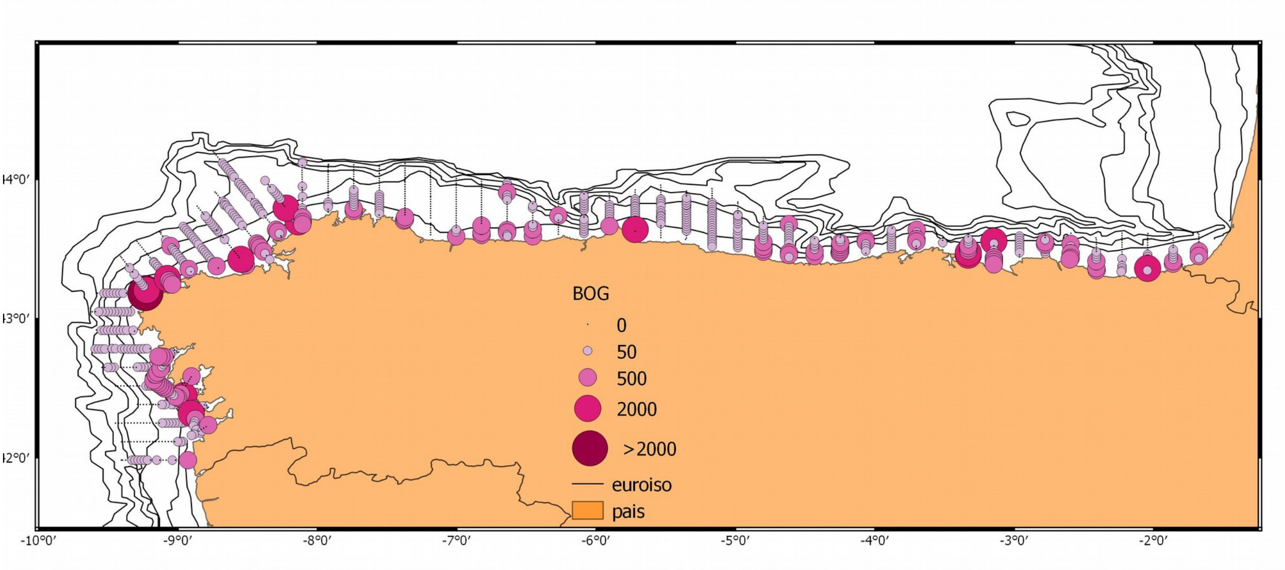


Figure 29. Density distribution (NASC) of bogue during PELACUS0315

The distribution of chub mackerel was also wide, although the density was smaller than that observed for bogue. However, it is an important species in the inner part of the Bay of Biscay.

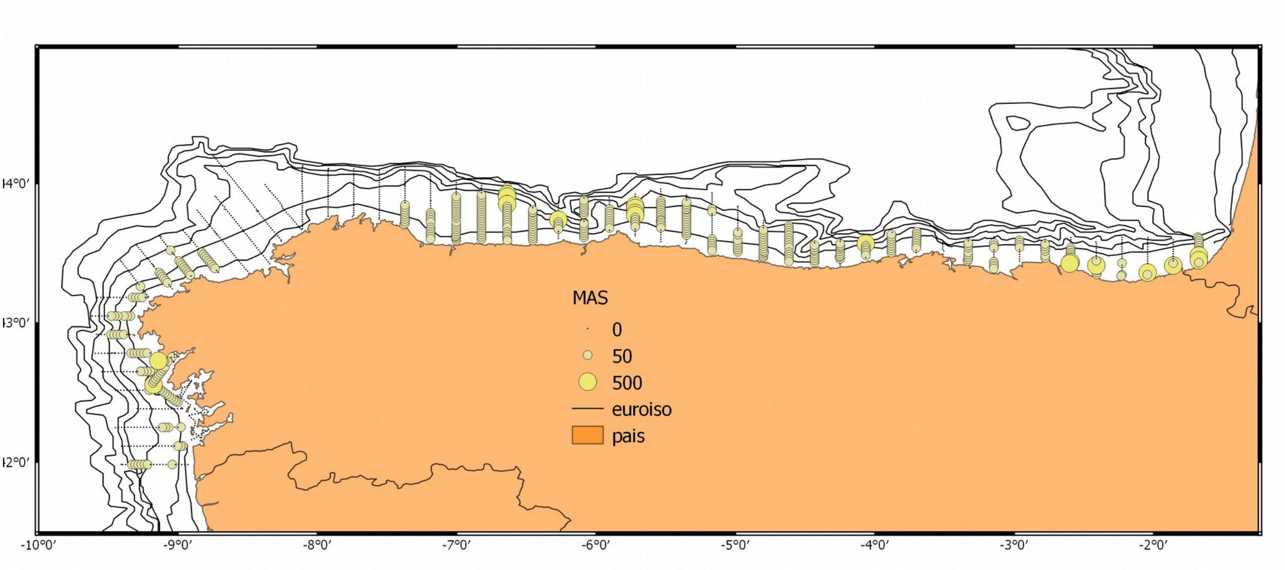


Figure 30. Density distribution (NASC) of chub mackerel during PELACUS0315

Finally mediterranean horse mackerel was mainly located, as usually, at the inner part of the Bay of Biscay, although it has been also observed in the western part of the Cape Peñas.

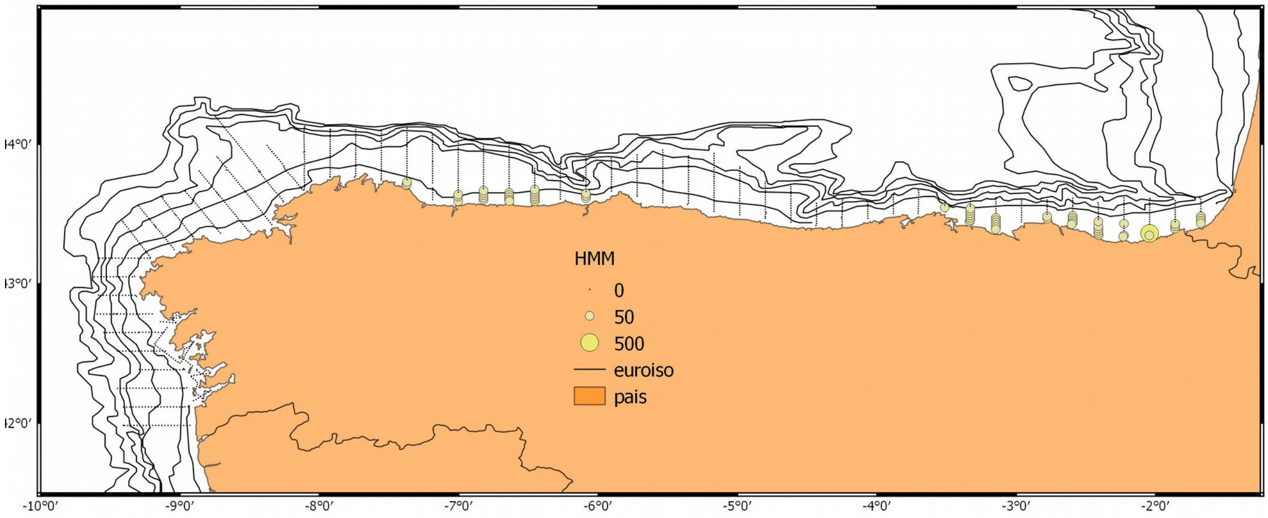


Figure 31. Density distribution (NASC) of mediterranean horse mackerel during PELACUS0315

Top predators

A total of 165 legs were done corresponding to 116.65 hours (4.49 hours/day on average and round 39 nmi per day. Overall 7479 marine birds, 377 marine mammals, 805 human activities(268 plastic debris and 537 vessels), 197 inland and coastal birds, 7 pelagic organisms (sunfish among them) and one oceanographic phenomena were recorded

Marine birds:

21 taxa were recorded. Gannet (*Morus bassanus*), yellow legged gull (*Larus michahellis*) and lesser black-backed gull (*Larus fuscus*) were the most abundance species (table 15). Higher concentrations were located in the NW area. For *Laridae*, yellow legged gull seemed to occur in more coastal waters than lesse black-backed one. In addition, gannets were also mainly located in coastal waters, although those specimen undertaking a northward migration were also observed offshore (figures 32 and 33)

Name	Number
Larus sp	2627
Sula bassana	2238
Larus michahellis	1134
Larus fuscus	1120
Laridae spp	148
Catharacta skua	50
Phalacrocorax carbo	44
Phalacrocorax aristotelis	42
Sterna sandvicensis	28
Larus argentatus	17
Larus melanocephalus	7
Puffinus puffinus	5
Alca torda	4
Larus ridibundus	4
Alcidae sp	2
Fratercula arctica	2
Larus marinus	2
Puffinus mauretanicus	2
Calonectris diomedea	1
Phalacrocorax sp	1
Fulmarus glacialis	1

Table 15 Marine birds observations during PELACUS 0315.

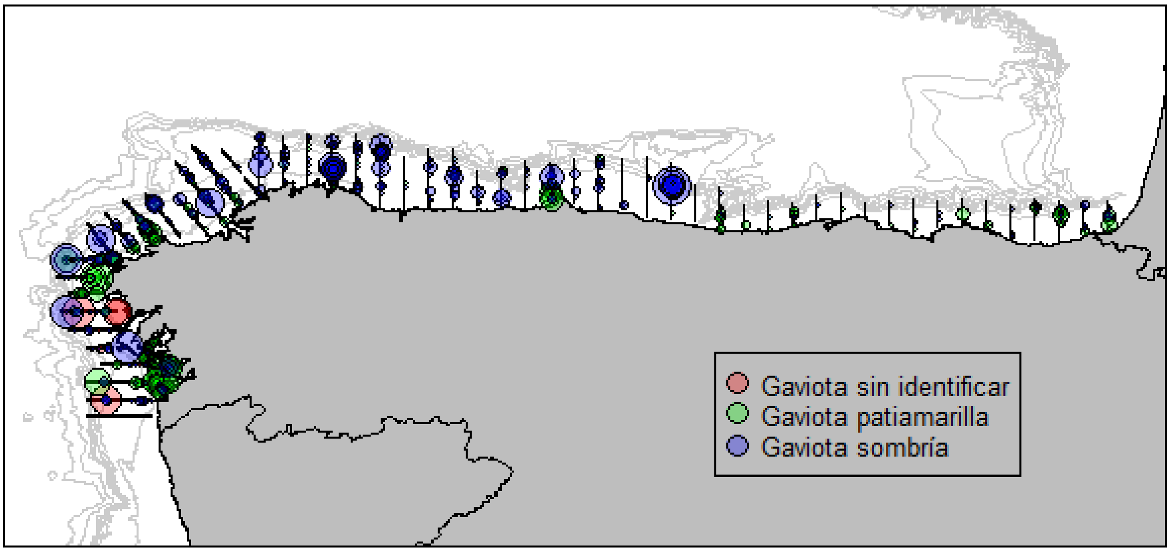


Figure 32 Observations of laridae during PELACUS 0315. In green, yellow legged gull; blue lesser black-backed gull; and red only Larus spp.

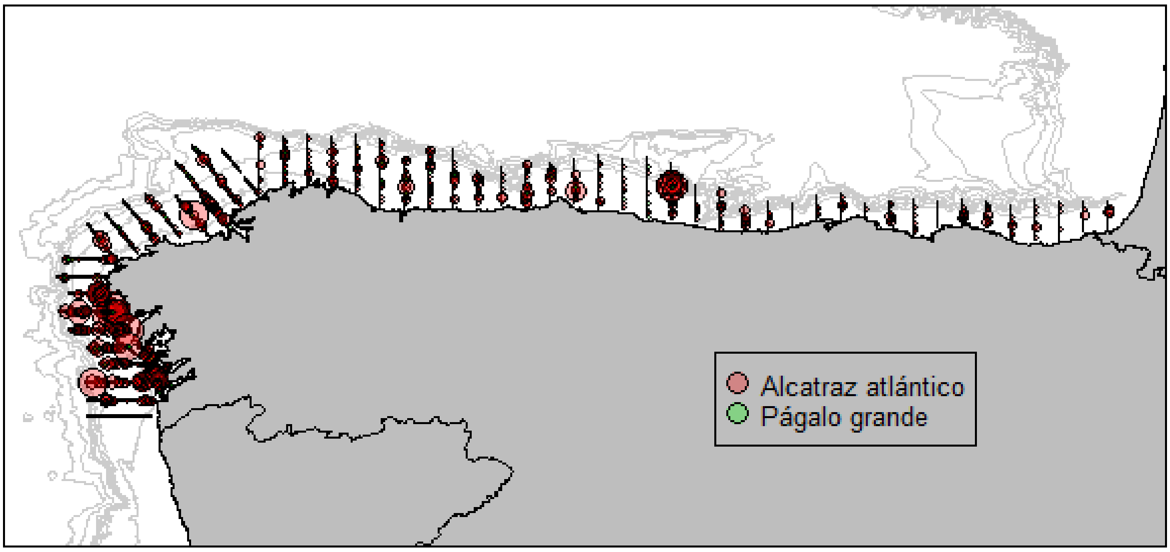


Figure 33 Observations of gannet (red) and skua (green) during PELACUS 0315.

Finally table 16 is showing the observations of inland and coastal birds

Name	Number
Anthus spp	107
Passeriformes	27
Calidris alba	23
Hirundo rustica	10
Phylloscopus spp	5
Anthus pratensis	3
Motacilla alba	2
Apus spp	1
Calidris alpina	1
Calidris spp	1
Erithacus rubecula	1

Falco tinnunculus	1
Hirundo spp	1
Motacilla flava	1
Motacilla spp	1
Streptopelia decaocto	1
Turdus philomelos	1
Upupa epops	1
Melanitta nigra	9

Figure 16 Inland and coastal birds observations during PELACUS 0315

Marine mammals:

Only 4 different species were observed, as shown in table 17. Contrary to that observed in the previous year, common dolphin (*Delphinus delphis*) was the most important species (239 observations), followed by Bottlenose dolphin (*Tursiops truncatus*) (104) and only few long-finned pilot whale (*Globicephala melas*) were seen, most of then occurred in the Cantabrian Sea together with the bottlenose dolphin. On the contrary, common dolphin mainly occurred in the western area (figure 34)

Name	Number
Delphinus delphis	239
Tursiops truncatus	104
Globicephala melas	31
Delphinidae sp	3

Table 17 Marine mammals observations during PELACUS 0315.

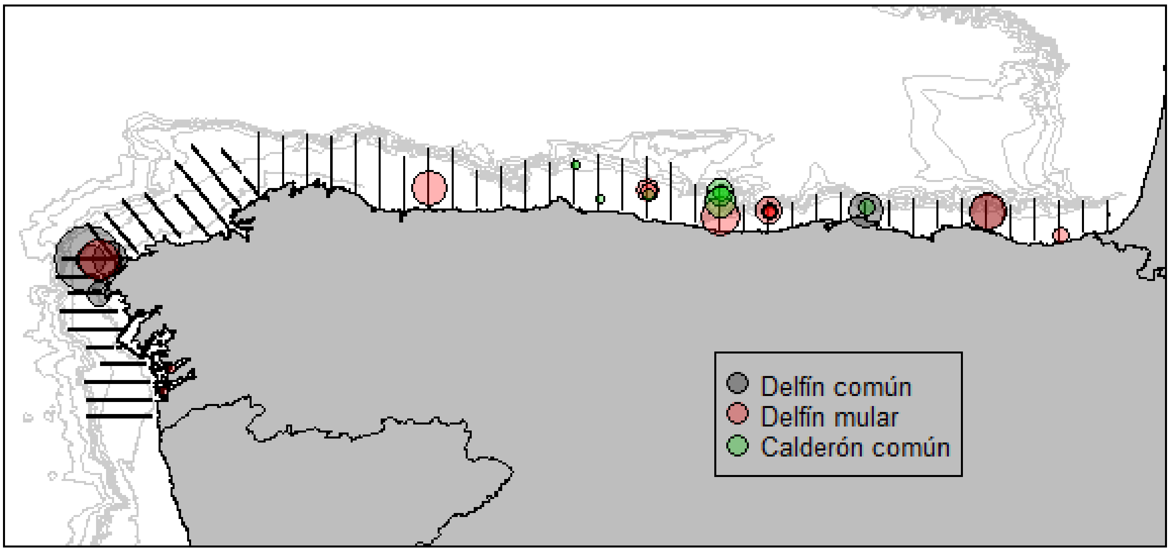


Figure 34. Marine mammals distribution during PELACUS 0315. Grey, common dolphin; red bottlenose dolphing; and green, long-finned pilot whale.

CONCLUSIONS

PELACUS 0315 was characterised by a relative high strength of NE winds which led to change the survey sampling schedule, which has affected the normal development of the survey, and might also affected the availability and accessibility of some species such as mackerel.

Although the number of sardine eggs recorded by the CUFES has increased, sardine population is still at the lowest values of the time series. Moreover, no signal of an increase in the incoming year class has been detected. Age group one is still very low. The decrease in mackerel biomass was also noticeable, and again, without signal of recruitment. For this specie the expansion to IXa in the adult fraction, would be related with the wind conditions occurred in VIIIc-W, but in turn this increase didn't compensate the low density detected in northern waters.

Besides, the increase of the horse mackerel biomass is mainly related with the strength of the 2013 year class. On the contrary boarfish is, as sardine, at the lowest level even recorded. Finally, anchovy seems to colonize the Cantabrian sea area, specially in the central part, close to Cape Peñas. This could be related with the expansion of juveniles observed during the JUVENA survey which takes place in September along the Bay of Biscay.

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We would like to thank all the participants in PELACUS. We wish also to thank the captain and the crew of R/V Miguel Oliver for giving us all the solutions we needed to overtake all the challenges dealing with this multidisciplinary survey. Also José Ignacio Díaz got us all the support from the IEO.

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Working Document to be presented at WGACEGG, Lowestoft, 16-20 Novembro 2015

Acoustic survey carried out from 13 April to 18 May 2015 off the Portuguese Continental Waters and Gulf of Cadiz, onboard RV "Noruega"

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ABSTRACT

The acoustic survey PELAGO15 was carried out onboard RV "Noruega", from 13th April to 18th May. The main objective was to describe the spatial distribution and to estimate the abundance of sardine and anchovy off the Portuguese and the Spanish Gulf of Cadiz shelves. The estimated sardine biomass was 77.9 thousand tonnes, representing a decrease of 23% in relation to the 2014 survey and reflecting mainly the lack of sardine in the Gulf of Cadiz, which was traditionally, one of the main recruitment areas of the Iberian sardine stock. This estimate corresponds also to a minimum historical value of the survey series since 1996. The population was largely dominated by age 1 individuals from the 2014 recruitment, but with low abundance, reflecting a low 2014 sardine recruitment.

On the contrary, anchovy estimated biomass was very high, above the historical mean, due mainly to the Gulf of Cadiz anchovy estimation. 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 was also above the historical mean.

The temperature, salinity and fluorescence distribution patterns observed along the survey track was normal for this season. The sea surface temperature varied from 14.5ºC, in the northern part, to 21º C in the Cadiz area. The plankton samples are being processed and therefore only partial results are available at present. The observations from the CUFES samples already sorted for the inner shelf waters, highlight a fairly good agreement between the sardine egg distribution and the regions of higher acoustic energy for the species. In the Bay of Cadiz, where sardine schools were very scarce, egg densities were also very low.

1. INTRODUCTION

The Portuguese acoustic survey (PELAGO series) funded by EU-DCF and national programmes, takes place each year during spring covering the shelf waters of Portugal and Cadiz Bay. The main objectives of the campaign include monitoring the abundance distribution through echo-integration, and the study of several biological parameters for sardine (*Sardinha 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-Continous 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.

In 2015, the PELAGO survey was carried out during 24 days in the period from 13 of April to 18 of May. Despite the fact that the weather conditions were favourable the survey was interrupted during a total of 11, non consecutive, days due to logistics and technical issues.

2. ACOUSTIC SURVEY

MATERIAL AND METHODS

Survey execution and abundance estimation followed the methodologies adopted by the ICES WGACEGG. The survey area, over the shelf until the 200 m isobath, was covered following a parallel grid with a mean distance between transects of 8 nautical miles. Average survey speed was 8 knots and the acoustic signals were integrated over one nautical mile intervals. Echo integration was carried out with a Simrad 38 kHz EK500 scientific echo sounder. The acoustic data was recorded in MOVIES+ (Weill *et al*., 1993), which was also used to integrate the fish acoustic energy. The echogram bottom was manually corrected prior to the acoustic energy extraction. In the beginning of the survey, an acoustic calibration with a copper sphere was carried out, following the standard procedures (Foote *et al.*, 1981). For presentation purposes and results comparison, the surveyed area was divided, as usual, into 4 sub-areas or regions: OCN (from Caminha to Nazaré), OCS (from Nazaré to Cape S. Vicente), Algarve (from Cape S. Vicente to V. R. Santo António) and Cadiz (from V. R. Santo António to Cape Trafalgar).

To collect the biological data, a pelagic and a bottom 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 it was not always possible to make hauls in some areas.

Biological sampling of sardine and anchovy was performed in each haul. Sardine and anchovy otoliths were collected and used for age reading and for the production of the Age Length Keys (ALK's). For each species, the abundance (x 1 000) by age group and area was estimated from the combination of the ALK and the estimates of abundance at length from the echo-integration in each area.

Fish egg and larvae were collected using the CUFES system (335 µm mesh net). The water was pumped, from 3 m depth, underway along the acoustic transects; plankton samples were taken every 3 miles. Concurrently, data on surface temperature, salinity and fluorescence were acquired by the sensors associated to the CUFES sampler and GPS information gathered from the vessel system; compilation was carried out using the EDAS software.

RESULTS

TRAWL HAULS

During the survey 33 trawl hauls were performed (Figure 2.1); 20 of these hauls had sardine sampled and 12 of them caught anchovy. 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, some Mediterranean horse mackerel (*Trachurus mediterraneus*) and blue jack mackerel (*Trachurus picturatus*) were also found. Anchovy was mainly found off Cadiz Bay, but it was also caught, in less quantity, in the west coast, from Matosinhos to Nazaré.

SPATIAL DISTRIBUTION AND ABUNDANCE

Sardine

As seen in Figure 2.2, in the Occidental North zone (OCN- Caminha to Nazaré), sardine was mainly distributed offshore Póvoa de Varzim, near Aveiro and South of Figueira da Foz. In this area 822 million sardines were estimated, corresponding to 32.6 thousand tonnes.

In the Occidental South Zone (OCS – Nazaré to Cabo S.Vicente) sardine was concentrated between Peniche and Lisboa. Sardine in this zone presented an estimated biomass of 15 thousand tonnes, consisting in 238 million individuals.

In the Algarve area, sardine was mainly found near Lagos and Portimão and between Faro and V. Real de Santo António. The abundance result for this area was 238 million sardines (15 thousand tonnes).

In the Gulf of Cadiz sardine was scarce, the survey having estimated 162 million individuals, which corresponds to 2 thousand tonnes, the second lowest value of the whole historical series (the minimum value was obtained for the PELAGO11 survey).

Anchovy

Anchovy was found between Aveiro and Nazaré, being more abundant than in previous years (Figures 2.7 and 2.8). In the West coast, an estimation of 645 million anchovies was obtained, corresponding to a biomass of 8237 tonnes.

In the Algarve, anchovy was found only near Vila Real de Santo António. An abundance of 158 million individuals was obtained, equivalent to a biomass of 2156 tonnes.

In the Cadiz Bay, anchovy was mainly distributed offshore, near the bottom and inside a dense plancton layer. In this area, the biomass and abundance estimated (30944 tonnes and 3531 million anchovies, respectively) were one of the highest values of the whole series. However these values should be corroborated later by the IEO ECOCADIZ survey, because the anchovy acoustic energy in this area was masked by the referred dense plancton layer.

Length and age structure

Sardine

In the OCN zone, sardine presented a unimodal length structure with a mode at 16.5 cm (Figure 2.2) and was mainly composed of 1 year-old individuals (Figure 2.5).
Sardine length structure in the OCS zone presented 3 modes: 6.5 cm, 13 cm and 21 cm, the younger individuals being found in front of the Tagus River (Lisbon). The age structure was also dominated by age 1 sardines.
Off the Algarve, sardine presented a length distribution with a mode at 20 cm, and the strongest age classes were 3 and 5 years.
In Cadiz, age 1 sardines dominated, and the modal length was 10 cm.
In conclusion, Figure 2.5 shows that age 1 was dominant (88% in numbers) in all areas, except in Algarve where sardine age distribution was broader, from ages 1 to 7, with a main mode at age 3 and a second mode at age 5 (which correspond to, respectively, the 2012 and 2010 annual classes). The high age 1 percentage indicates that most of the sardine population is composed of the individuals resulting from the 2014 recruitment. Figure 2.6 shows that sardine recruitment level is low.

Anchovy

Age 1 dominates the anchovy age structure in all areas. The length structure was unimodal in all areas areas, the modal length being smaller in the Cadiz area (10.5 cm) and slightly larger in Algarve (12 cm) and in the west coast (11 cm).

OTHER SMALL PELAGIC FISH DISTRIBUTION

In this survey, bogue (*Boops boops*) was the pelagic fish more abundant in the fishing hauls (Figure 2.1) with a percentage, in weight, of 45.4%. Other pelagic species, like chub mackerel (*Scomber colias*) and jack mackerel (*Trachurus trachurus*), were less abundant than usually.

3. PLANKTON AND ENVIRONMENTAL SURVEYING

Methodology

Gear for plankton and hydrology surveying:

- CUFES: mesh size 335 µm, continuous sampling at the surface (~ 3m)
- CalVET: adapted structure (double nets CalVET (25cm 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, along the acoustic transects, zooplankton samples and temperature, salinity and fluorescence observations were gathered (Figure 2.1). The data, together with GPS information were compiled using the EDAS software.

During the night period (when acoustic surveying is not running) 13 transects, selected over the entire survey area in order to cover the main oceanographic patterns, were occupied to collect zooplankton samples of the water column and profiles of temperature, salinity and fluorescence ($chlorophyll_a$). In each transect, CTDF casts were performed 3 nmiles apart and CalVET samples were taken every other station. Oblique zooplankton tows through the whole water column were undertaken with Bongo nets at three locations per transect (inner shelf, mid shelf and outer shelf). All plankton samples were preserved onboard (buffered formaldeyde solution at 4% in distilled water) for further processing in the laboratory.

In the laboratory the ichthyoplankton was sorted from the CUFES samples. Sardine and anchovy eggs were identified and counted and the clupeiform larvae (sardine+anchovy) were also quantified.
For the zooplankton community the analyses were undertaken using image analyses methodologies. Sub-samples were scanned at 3200 dpi using a flat bed scanner. The organisms were then segmented

and mesasured by the R-package Lotofpel 0.6 (Lopez-Urrutia *et al.*) and the identification was carried out with classifiers developed by an expert taxonomist using the routines in Plankton Identifier 1.3.4. (Gasparini & Antajan). The availability of two measurements (thread and linear measurement from adjusted ellipse) allowed the refinement in size description, by applying different weighted averages between them, adapted to each taxonomic group. Two size descriptors were used: Length and Width. Estimation of carbon biomass was performed according to conversion factors from Alcaraz et al. 2003 and further adjusted to different high taxonomic groups. Around 9000 organisms were measured, identified and distributed across more than 50 taxonomic groups.

Plankton distribution

A total of 471 CUFES samples were collected along the 69 transects of acoustic surveying from the northern Portugal-Spain border to Cape Trafalgar, close to the entrance to Gibraltar Strait (Figure 3.1). During the night period surveying for zooplankton sampling and CTDF profiling was carried out along 13 pre-defined transects. In total, 121 CTDF casts were conducted and 62 CalVET hauls (124 samples) and 39 Bongo tows (78 samples) were carried out (Figure 3.2).

The sardine egg distribution (Figure 3.3) showed a fairly good agreement with the mapped acoustic energy for the species (Figure 2.2). Higher egg densities were observed in the regions where the main schools of sardine were detected. In the Bay of Cadiz where sardine was barely available, the number of eggs collected by the CUFES system was very low. Anchovy eggs (Figure 3.4) were more abundant in the western region of Cadiz Bay, where also the acoustics energy for the species was relevant (Figure 2.7), eggs were also observed in high densities in a few spots over the western shelf, namely between Douro and Aveiro, south of Cabo Mondego and off Lisbon. Fish eggs of species other than sardine and anchovy (Figure 3.5) were particularly abundant in the southern and southwestern shores over the majority of the platform surveyed. Clupeiform larvae (Figure 3.6., sardine and anchovy not yet sorted apart) were collected in higher numbers in the regions where acoustic energy attributed to sardine and/or anchovy were registered but since they were not yet sorted apart it is not possible to map the species distribution separately.

Figures 3.7 and 3.8 show zooplankton abundances respectively at the surface, biovolumes in CUFES samples, and in the water column, biomass, in mgC/m^3, from Bongo samples. Although collected with different systems there is a fair agreement between the areas of higher biomass at the surface and the results obtained from the water column; higher zooplankton concentrations were observed over the NW coast off rio Minho, Douro-Aveiro coastal region, south of Cabo Mondego, off Promontório da Estremadura and between Setubal and Sines. In the southern shores the zooplankton biomass were comparatively lower than on the NW coast and but higher in the Bay of Biscay, particularly in the mid shelf stations, than off Algarve. The zooplankton size spectra (length, width) represented in figures 3.9 and 3.10 show the presence of a bimodal distribution in the majority of the samples with the coastal stations with higher biomasses of smaller organisms (modes around 0.8-1.2 mm in length) and the offshore stations with higher carbon contribution coming from larger individuals (> 2mm, in length, mainly 7-10mm in length and 0.8-1mm in width). The community composition in mid-shelf stations evidenced a mixture of both smaller and larger individuals.

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

Survey interruptions caused discontinuity in the spatial sampling coverage and these breaks may have potentially provoked some discontinuity in the temperature and salinity distribution patterns observed. Moreover, during surveying of the southern coast, the Algarve shelf was sampled from west to east while Cadiz Bay was occupied in the opposite direction (Figure 3.1).

During the survey period the weather conditions were generally favourable, off the northwestern coast the winds were mostly weak, occasionally from south, with only one day of strong northerly winds (examples in figure 3.13). The region from Lisbon to Portimão was also covered under calm seas and fairly mild air temperatures. In the southern coast, Cadiz Bay was surveyed after an event of strong easterly winds which caused warming of the surface waters that spread towards Algarve. Off the southern shores, the water temperature was between 17 and 21ºC, slightly above the recorded in 2014 but within the range observed in region during de season in other years (Figures 3.1 and 3.12). The temperature and salinity distribution patterns observed for the western coast were also the typical for this period and the surface temperature ranged from 14.5 to 18ºC. Moreover, the temperature and salinity profiles obtained (examples from three sections in Figures 3.11 to 3.13) allowed the detection in depth and extension of the buoyant plume (warmer than the surrounding waters during this period) over the northern shelf, the increase in temperature and salinity towards the south reaching maximum values (temperature 20.5-21ºC, salinity, 36.5) in the eastern corner of the Bay of Cadiz where the influence of the warmer and more saline waters from the south and Mediterranean are evident. In all the sections represented (all are available but not shown here) the water column stratification typical of spring is apparent. The maximum chlorophyll values were observed at the bottom of the thermocline (pycnocline) within a layer between 20 and 30-35m approximately; high fluorescence observations were also noticeable at the surface in the inshore areas and close to the main river mouths.

CONCLUSIONS

The sardine biomass and abundance (77.9 thousand tonnes; 2403 million) in the surveyed area corresponds to a decrease of 23% in relation to the estimates of the previous year survey and is a new minimum value for the time series, since 1996. This is mainly due to the low abundance estimated for the Gulf of Cadiz, one of the main recruitment areas of the Iberian stock.
The sardine population was mostly composed of young individuals (80% with age 1) but in low numbers, revealing a low 2014 recruitment.

The anchovy biomass estimated (41.3 thousand tonnes; 4334 million) corresponds to an increase of 34% in relation to the previous year, and is the highest value obtained since 1999, due mainly to the high abundance estimation in the Gulf of Cadiz. However these numbers must be confirmed during the IEO ECOCADIZ survey in July, because of some uncertainty in the estimation.

It is also apparent that species like chub mackerel and jack mackerel, that were abundant in last year's survey, have had less expression in the trawl hauls. On the contrary, bogue dominates in the fishing hauls, mainly in the southern area.

The distribution pattern of the temperature, salinity and fluorescence observed along the survey track was typical for this season. The surface sea temperature varied from 14.5ºC in the North to 21ºC in the Gulf of Cadiz.

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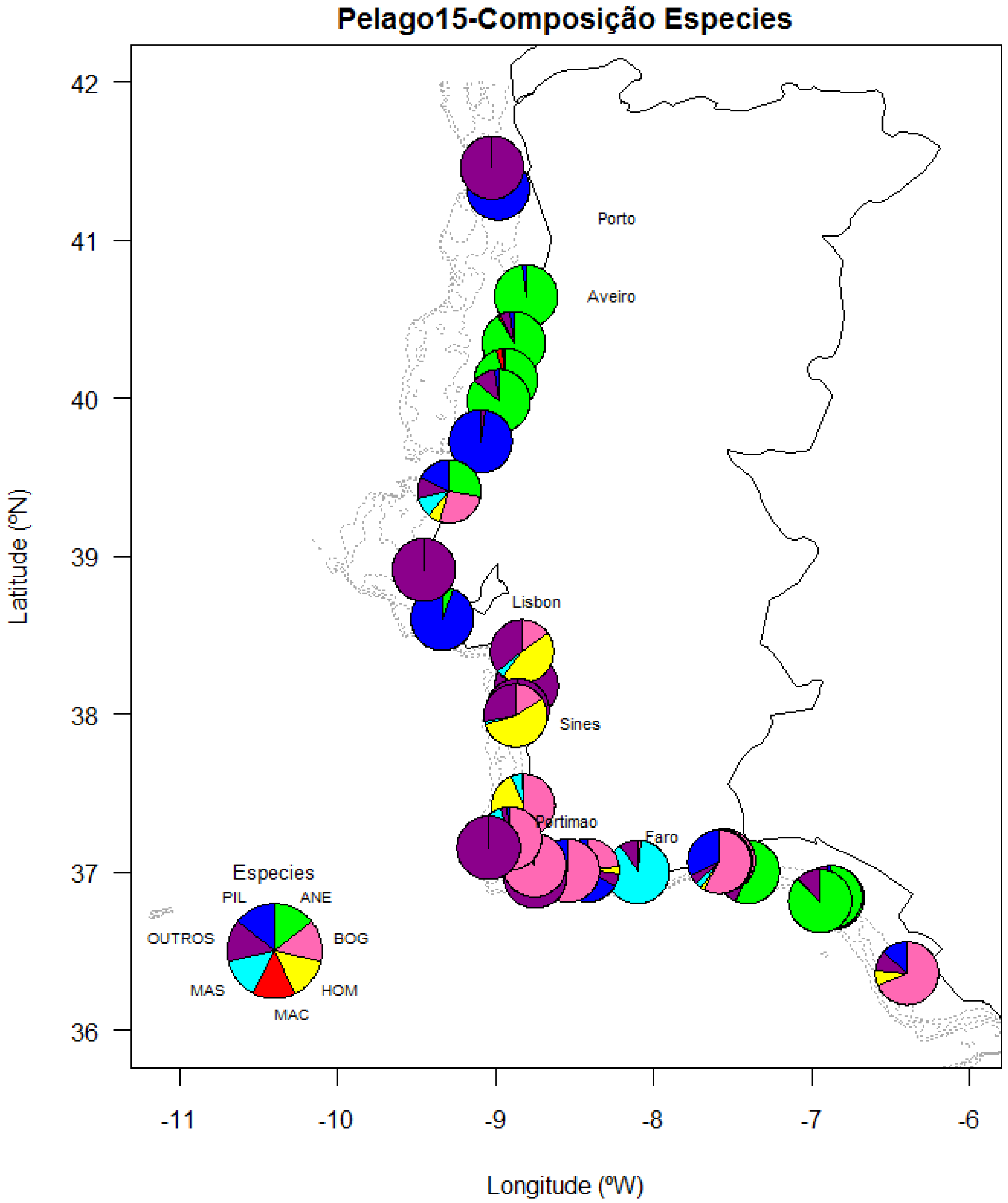

Figure 2.1 – PELAGO15: Fishing trawl location and haul species composition (in number). (PIL-sardine, ANE-anchovy; BOG-bogue, HOM-jack mackerel, MAC-mackerel, MAS-chub mackerel)

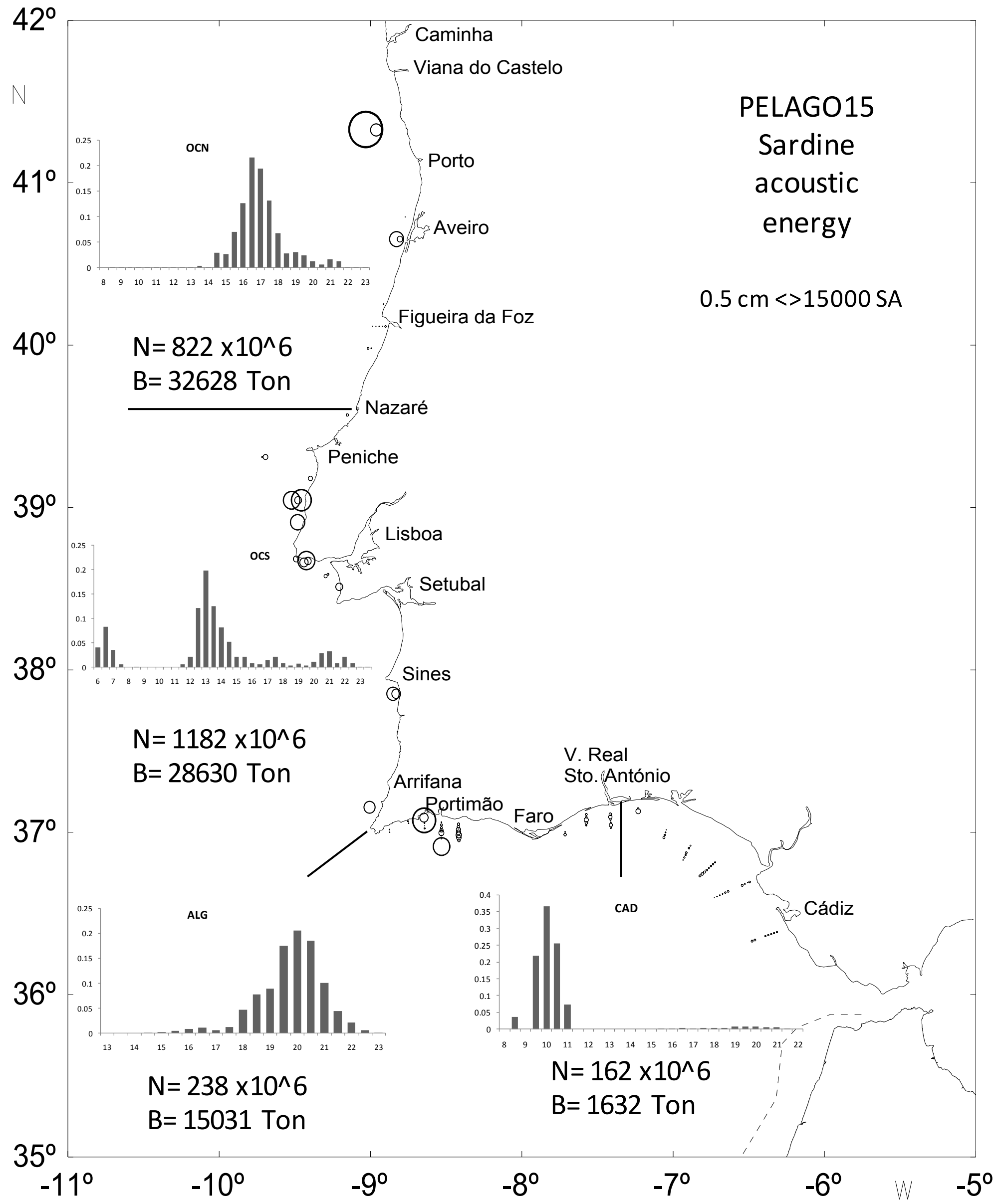

Figure 2.2 – Sardine acoustic energy spatial distribution. Circle area is proportional to the acoustic energy (S_A m^2/nm^2). Sardine abundance and length structure for each zone.

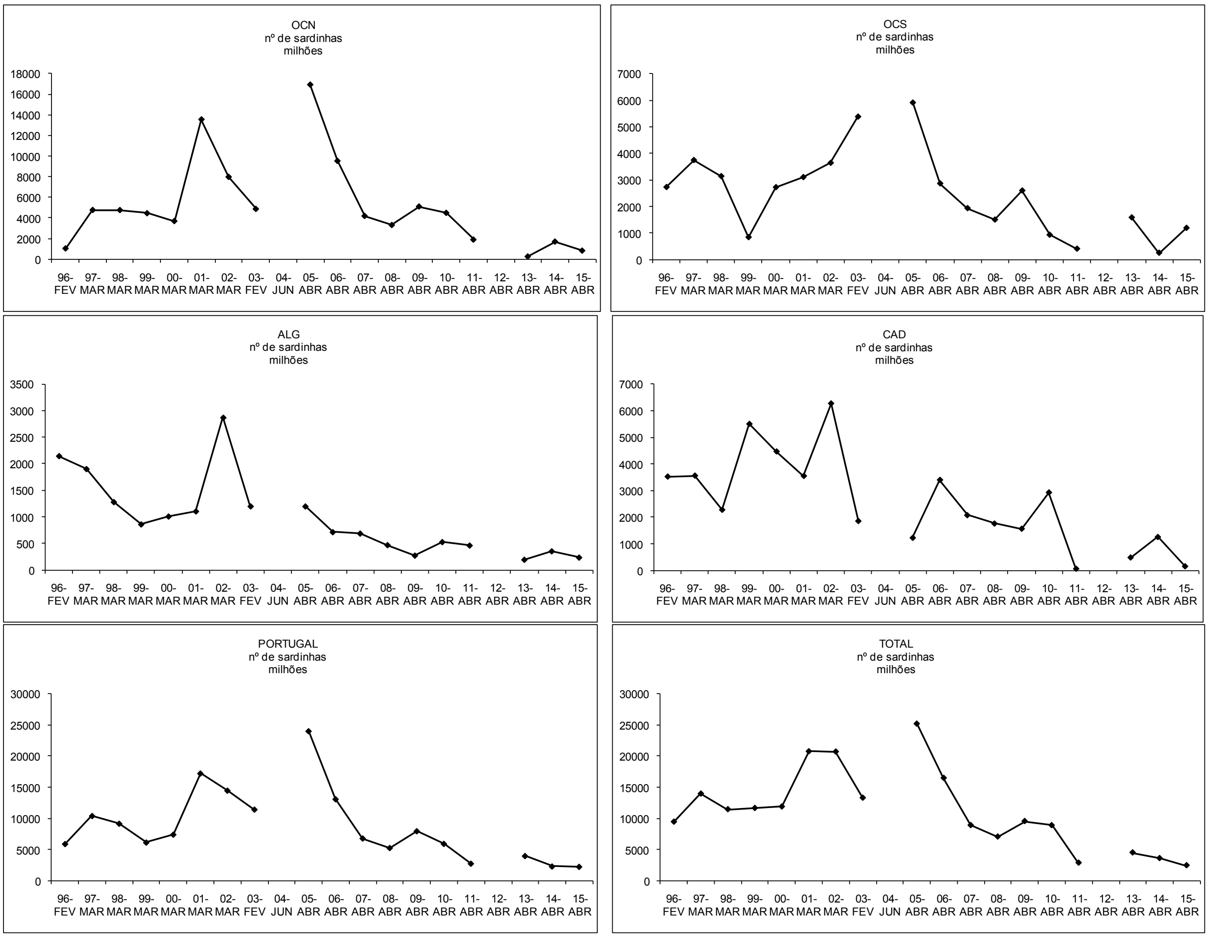

Figure 2.3 – Sardine abundance (million) evolution in each zone, in Portugal and in the Total area, along the acoustic survey series since 1996.

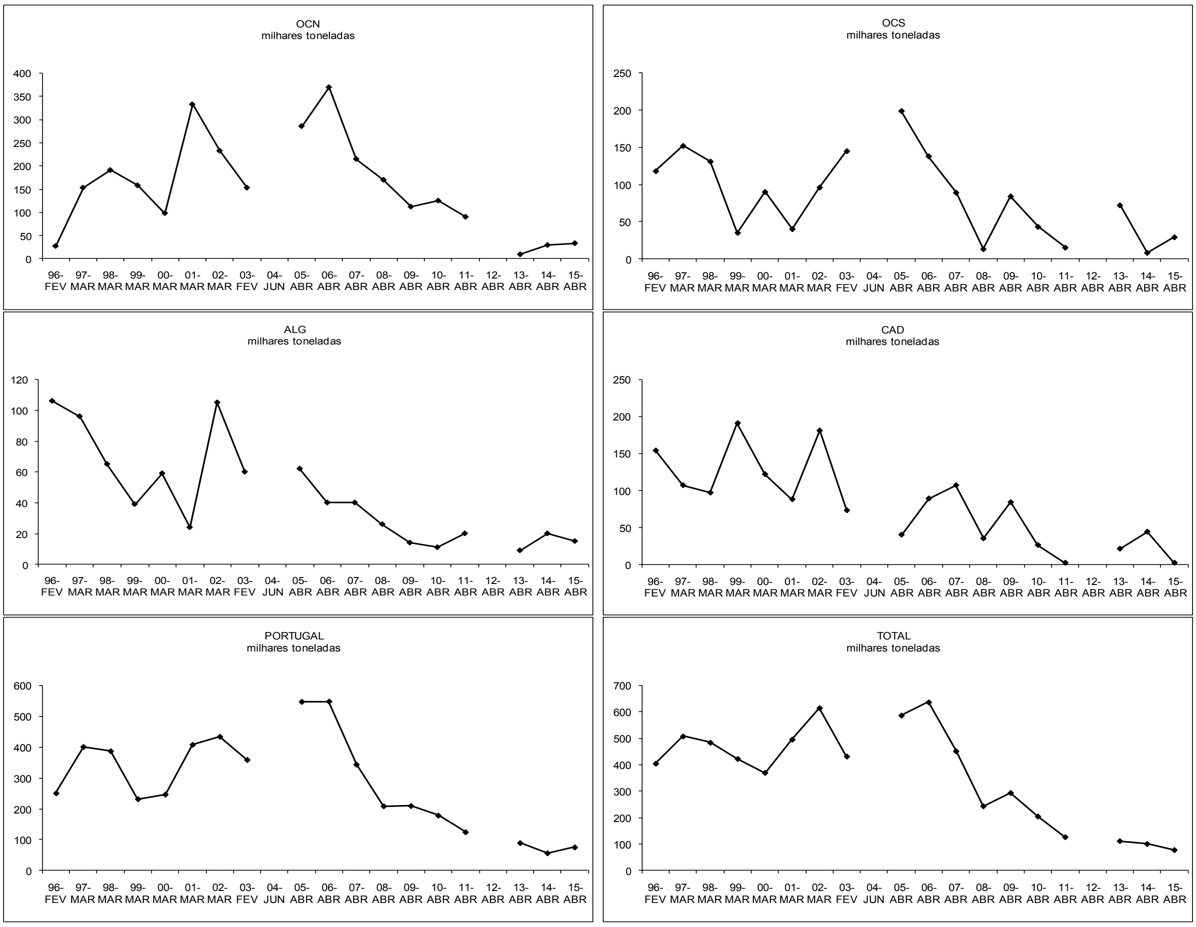

Figure 2.4 – Sardine biomass (thousand tonnes) evolution in each zone, in Portugal and in the Total area, along the acoustic survey series since 1996.

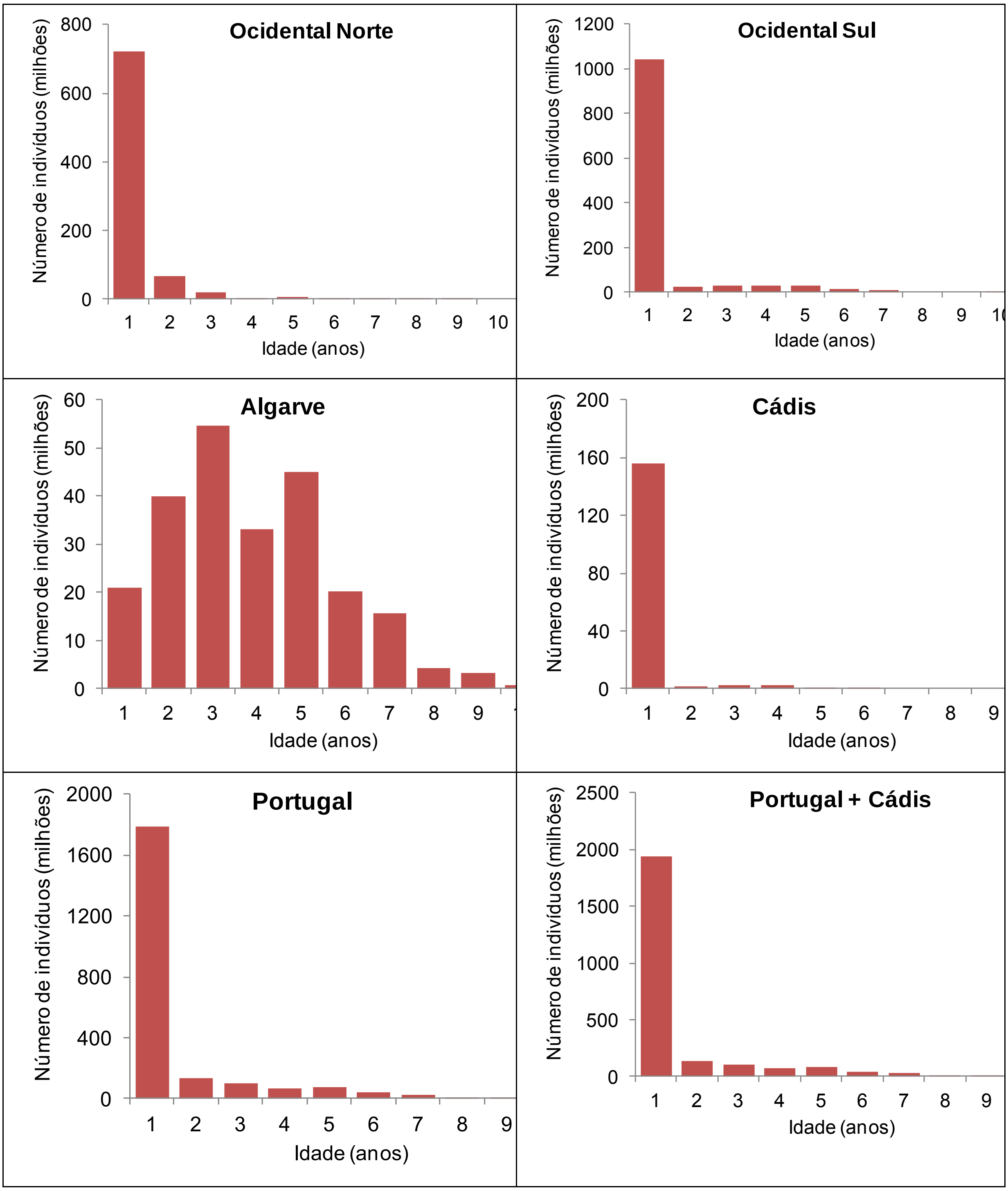

Figure 2.5 – PELAGO15: sardine abundance, by age group, for the considered geographic areas and for the Total area.

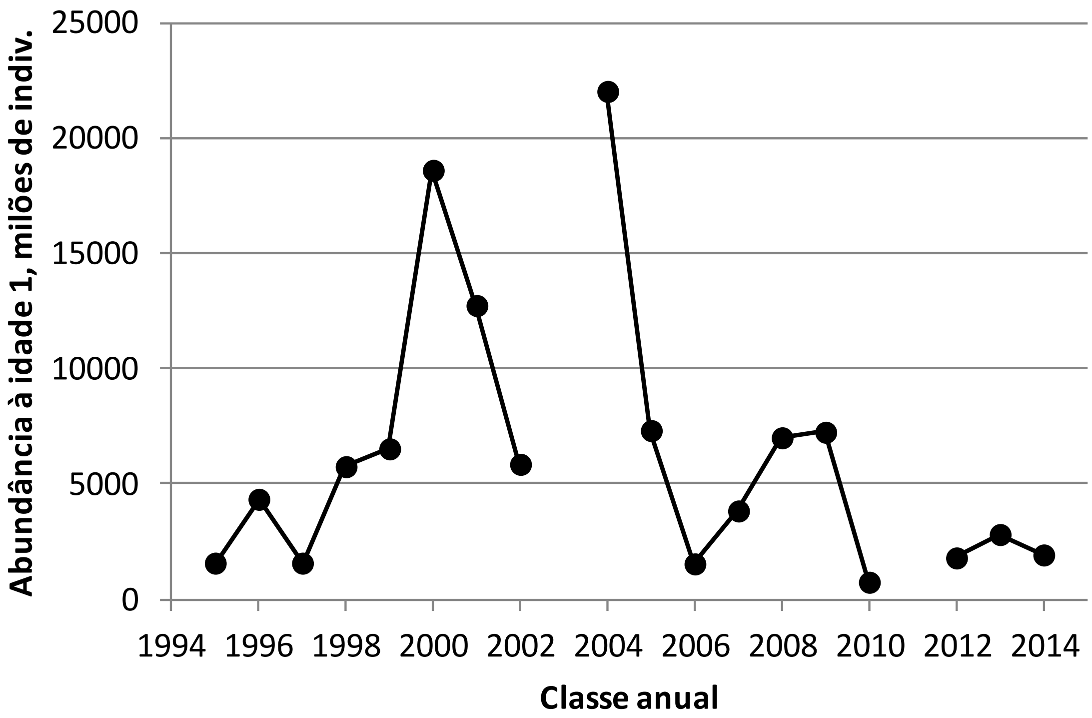

Figure 2.6 – Sardine recruitment index, resulting from the Spring acoustic surveys.

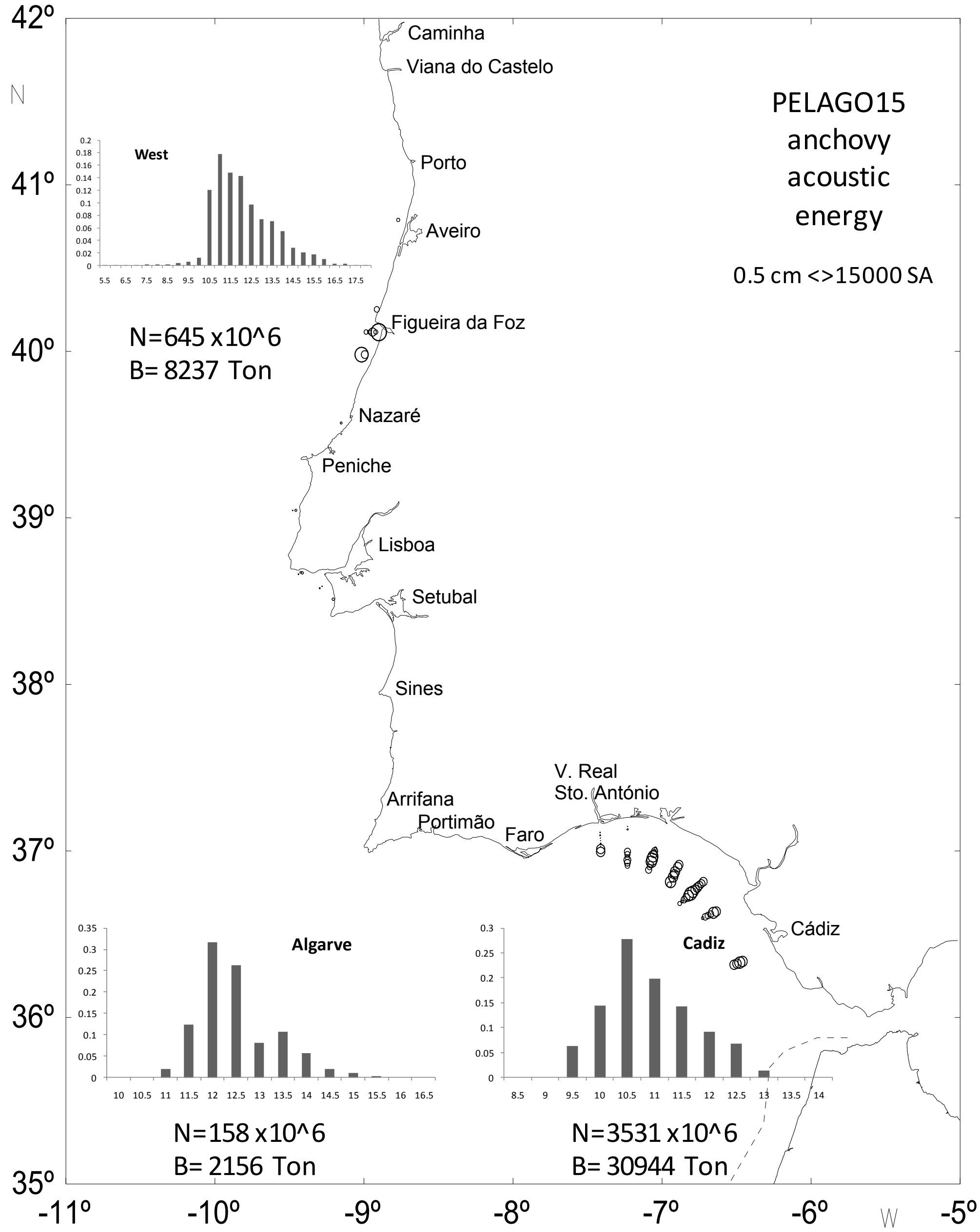

Figure 2.7 – Anchovy acoustic energy spatial distribution. Circle area is proportional to the acoustic energy (S_A m^2/nm^2). Sardine abundance and length structure for each zone.

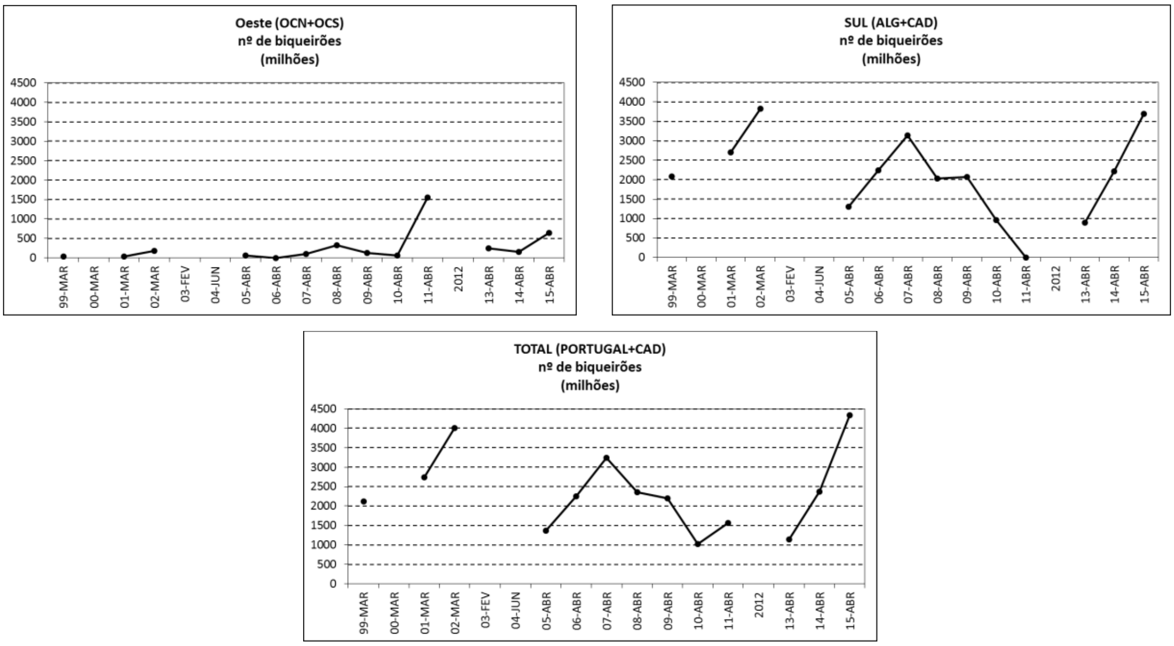

Figure 2.8 –Abundance (million) anchovy evolution for the West and South coasts and for the Total Area, along the survey series since 1999.

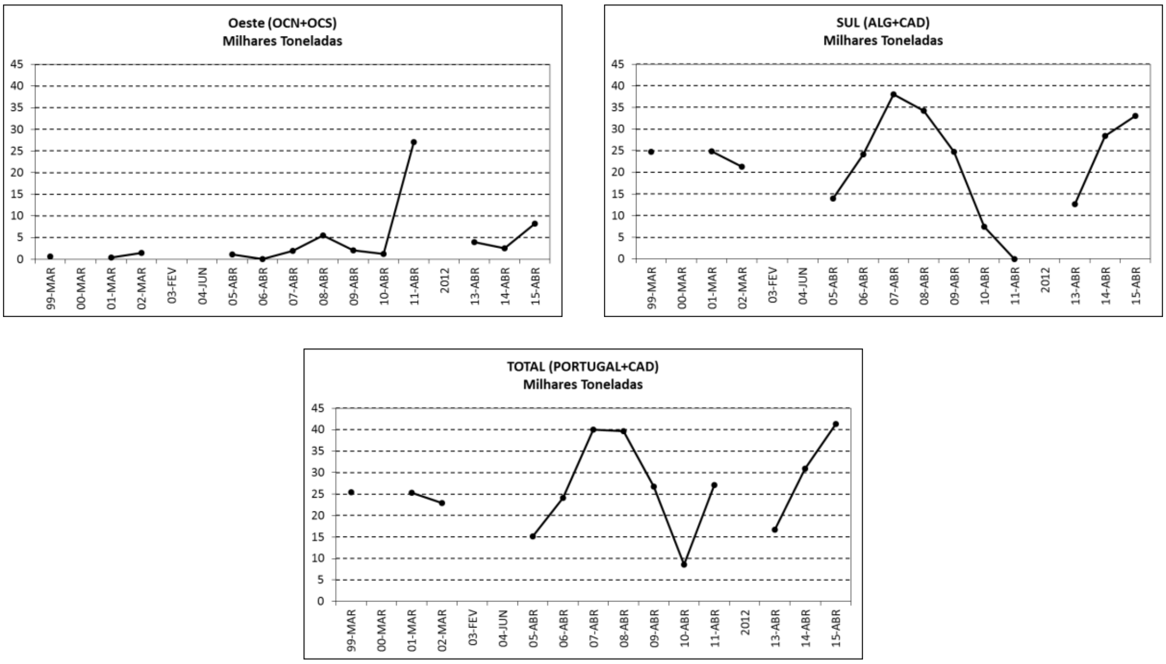

Figure 2.9 – Anchovy biomass (thousand tonnes) evolution for the west and South coasts and for the Total Area, along the survey series since 1999.

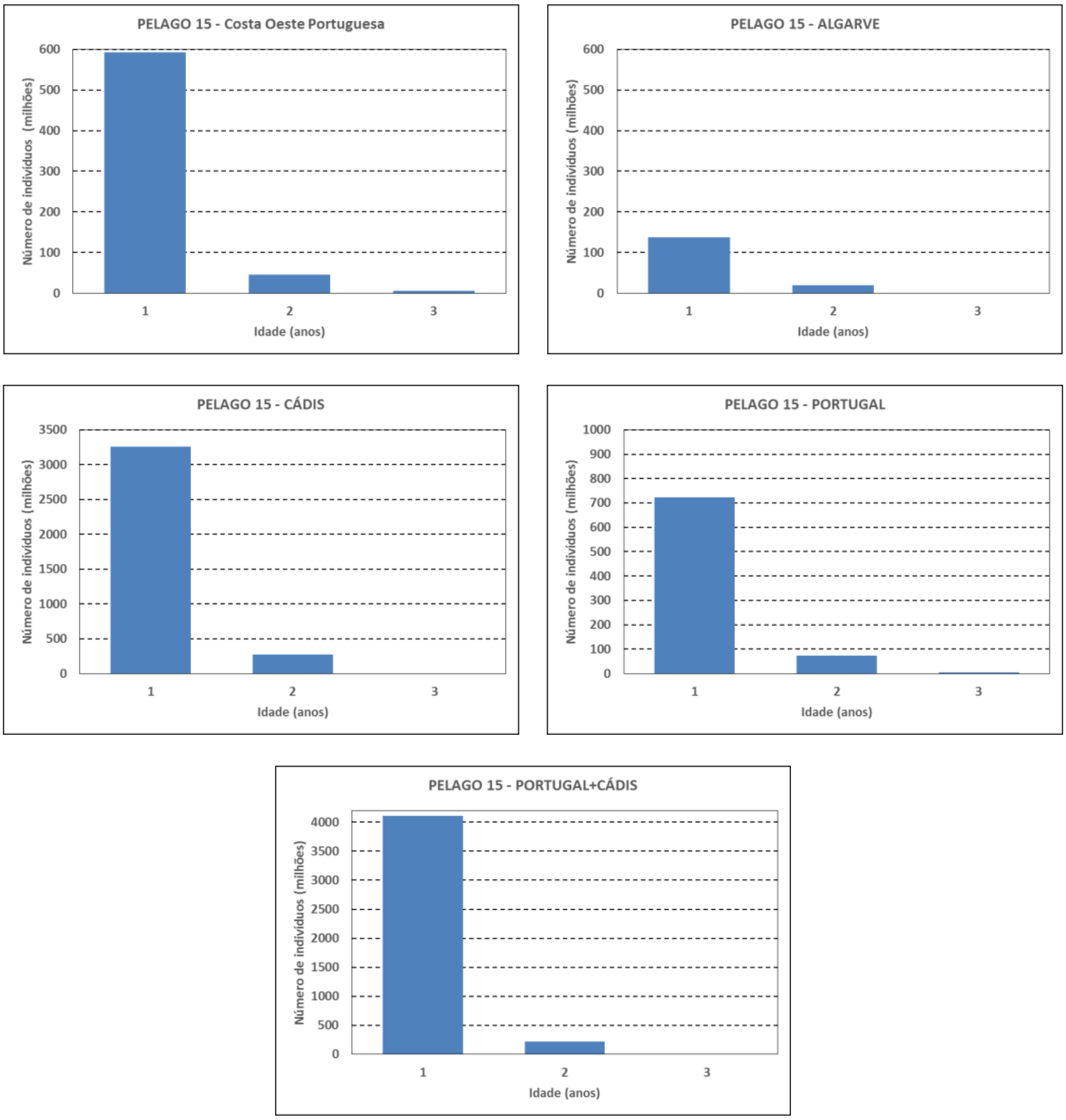

Figure 2.10 – PELAGO15: Anchovy abundance in each age group, for the considered geographic areas and for the Total Area.

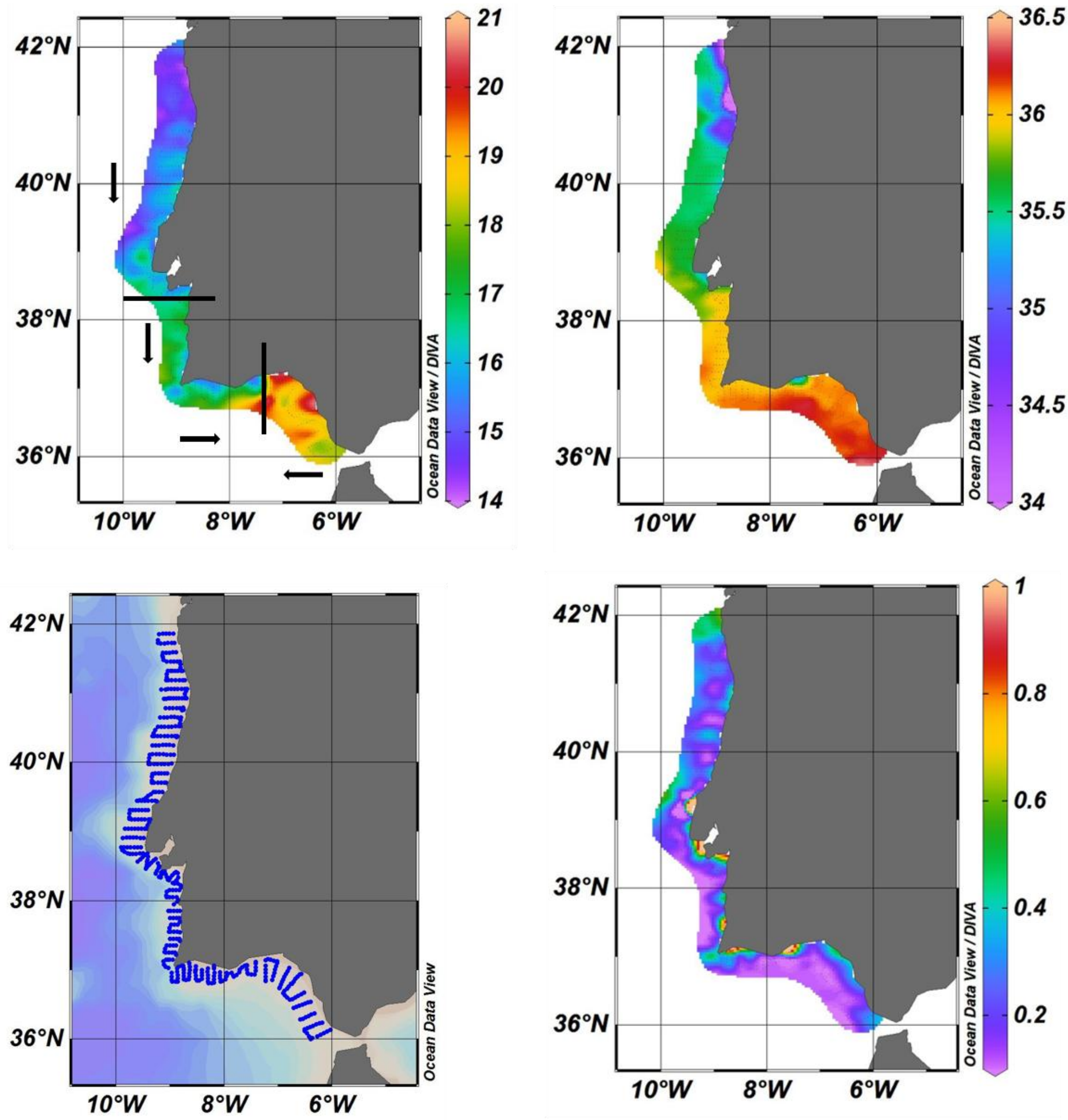

Figure 3.1 – Temperature (ºC) (top left panel), salinity (top right panel) and fluorescence (volt) (bottom right panel) distributions using the data obtained by the sensors associated to the CUFES-EDAS system and location of the CUFES samples (bottom left panel). In the top right panel the black lines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

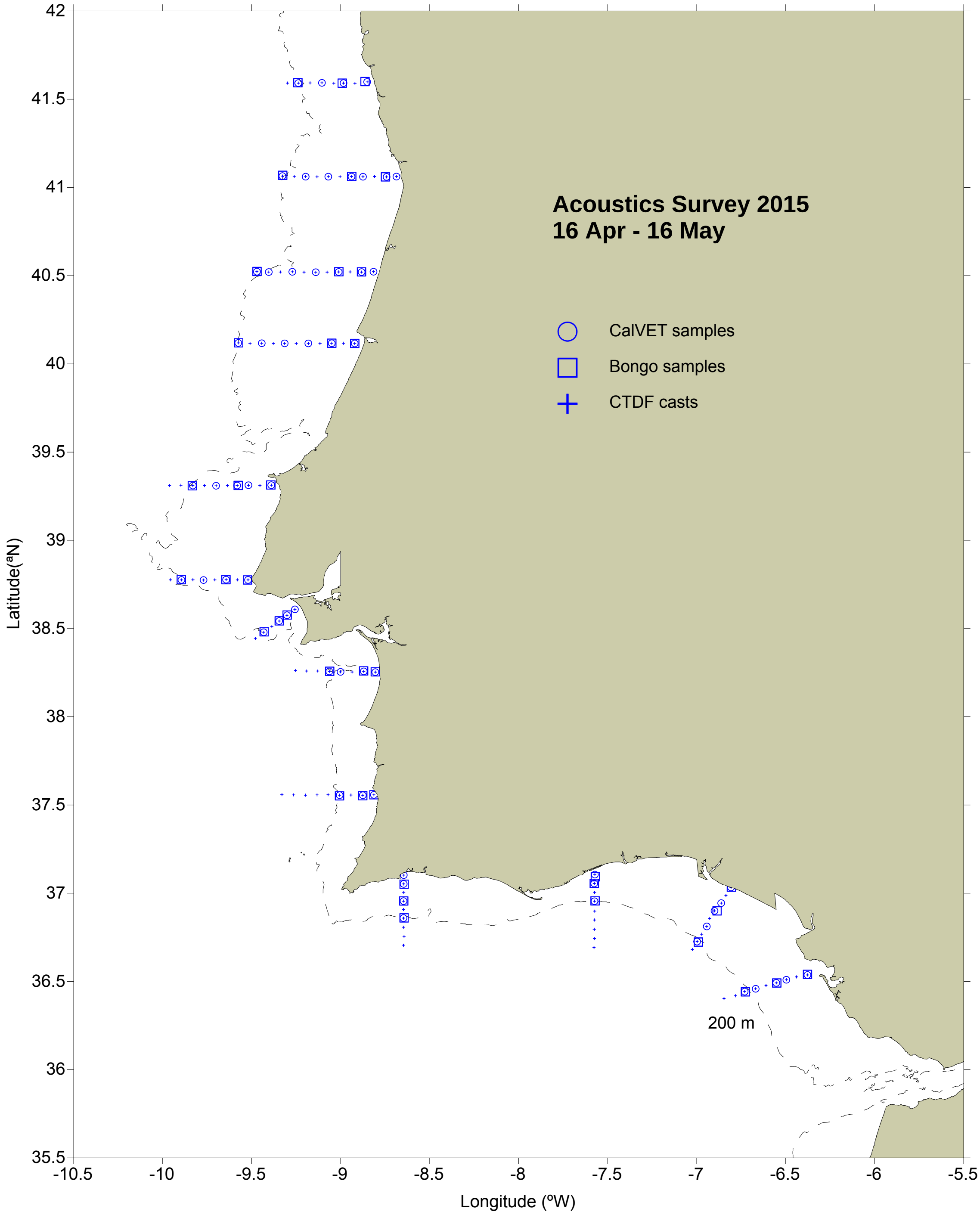

Figure 3.2 – Location of the CTDF (cross) profiles and plankton tows carried out using the CalVET (circle) and BONGO (rectangle) nets along the transects A to M (north to south) occupied during the night period.

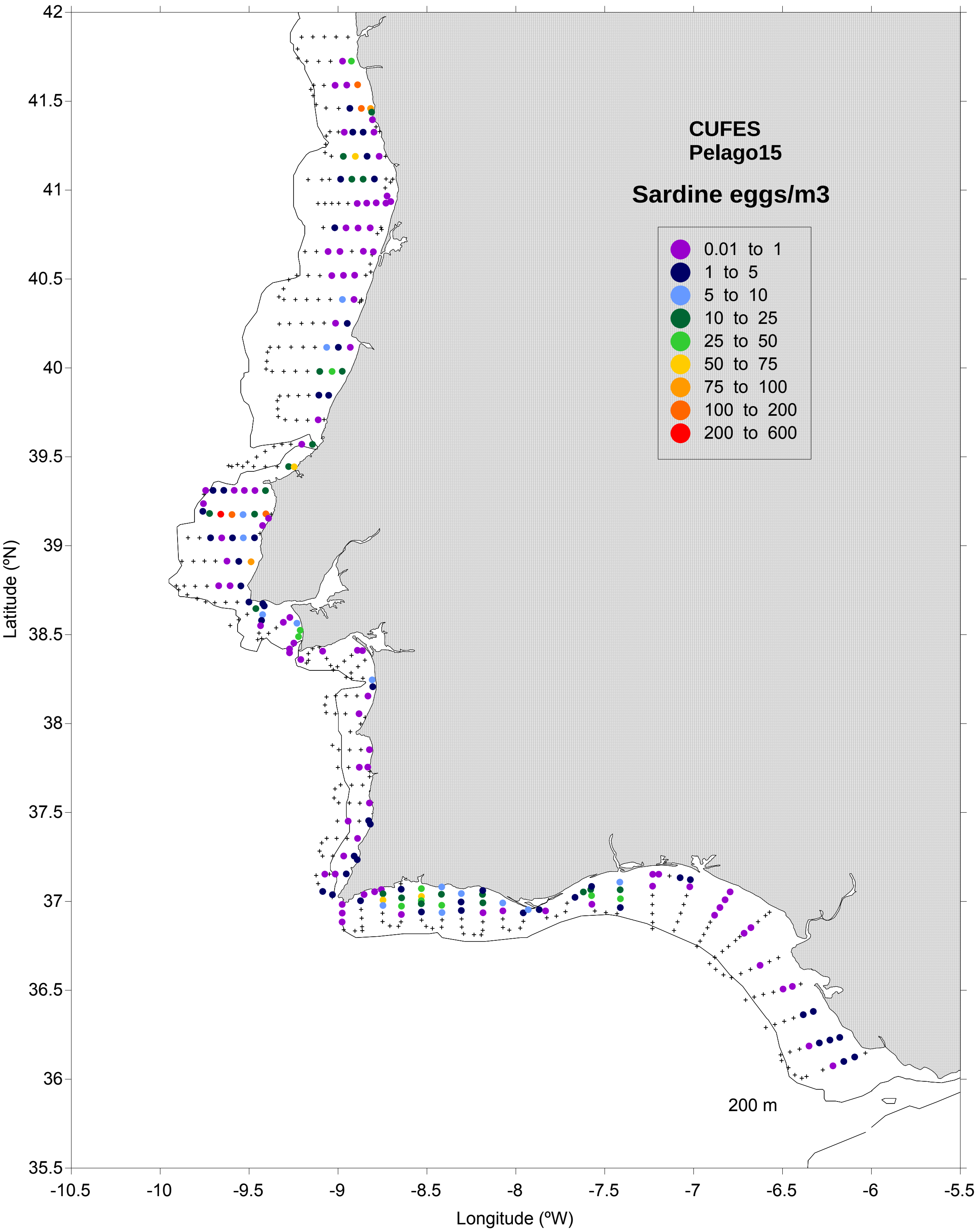

Figure 3.3 – Sardine egg distributions (eggs/m^3) from CUFES sampling.

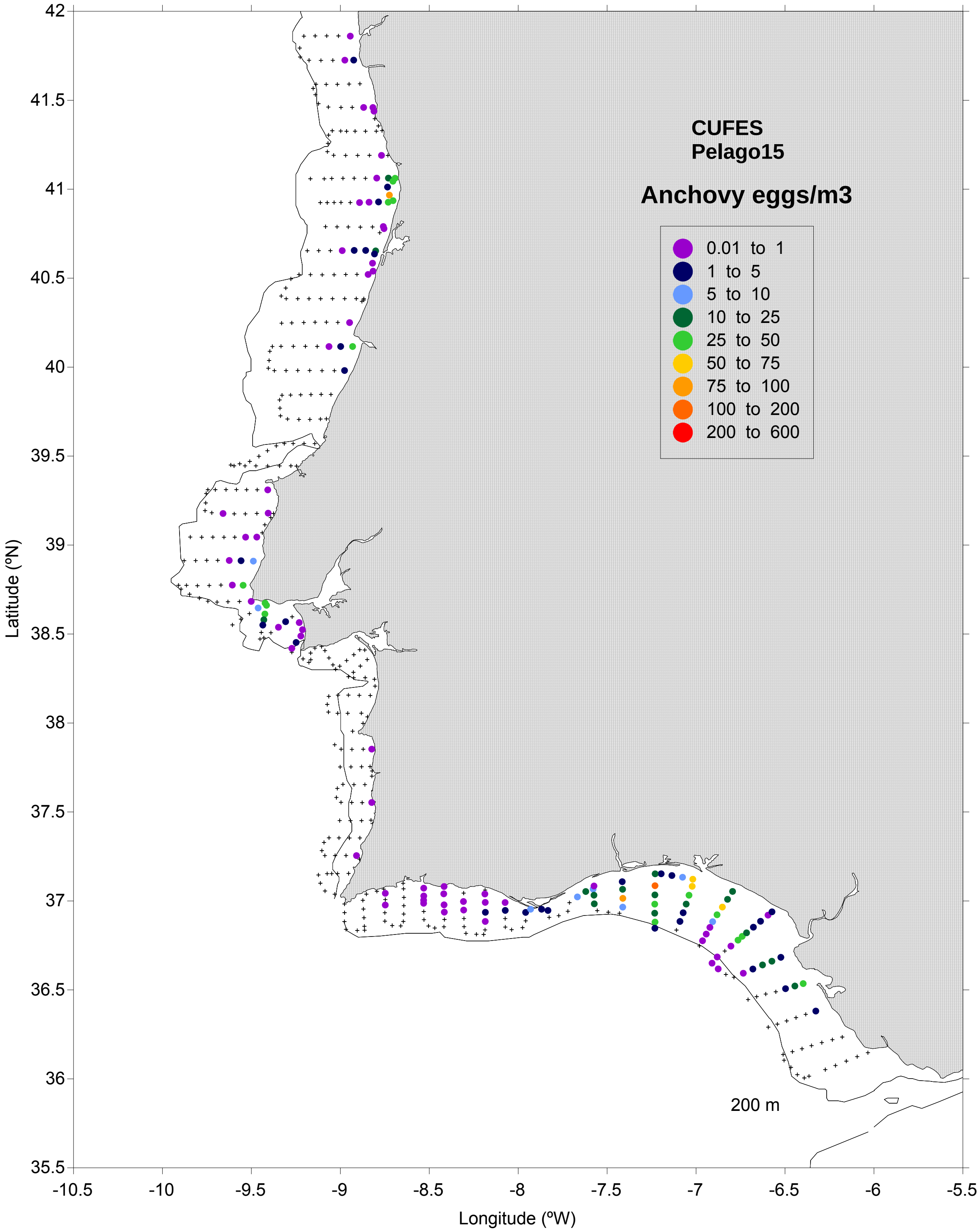

Figure 3.4 – Anchovy egg distributions (eggs/m^3) from CUFES sampling.

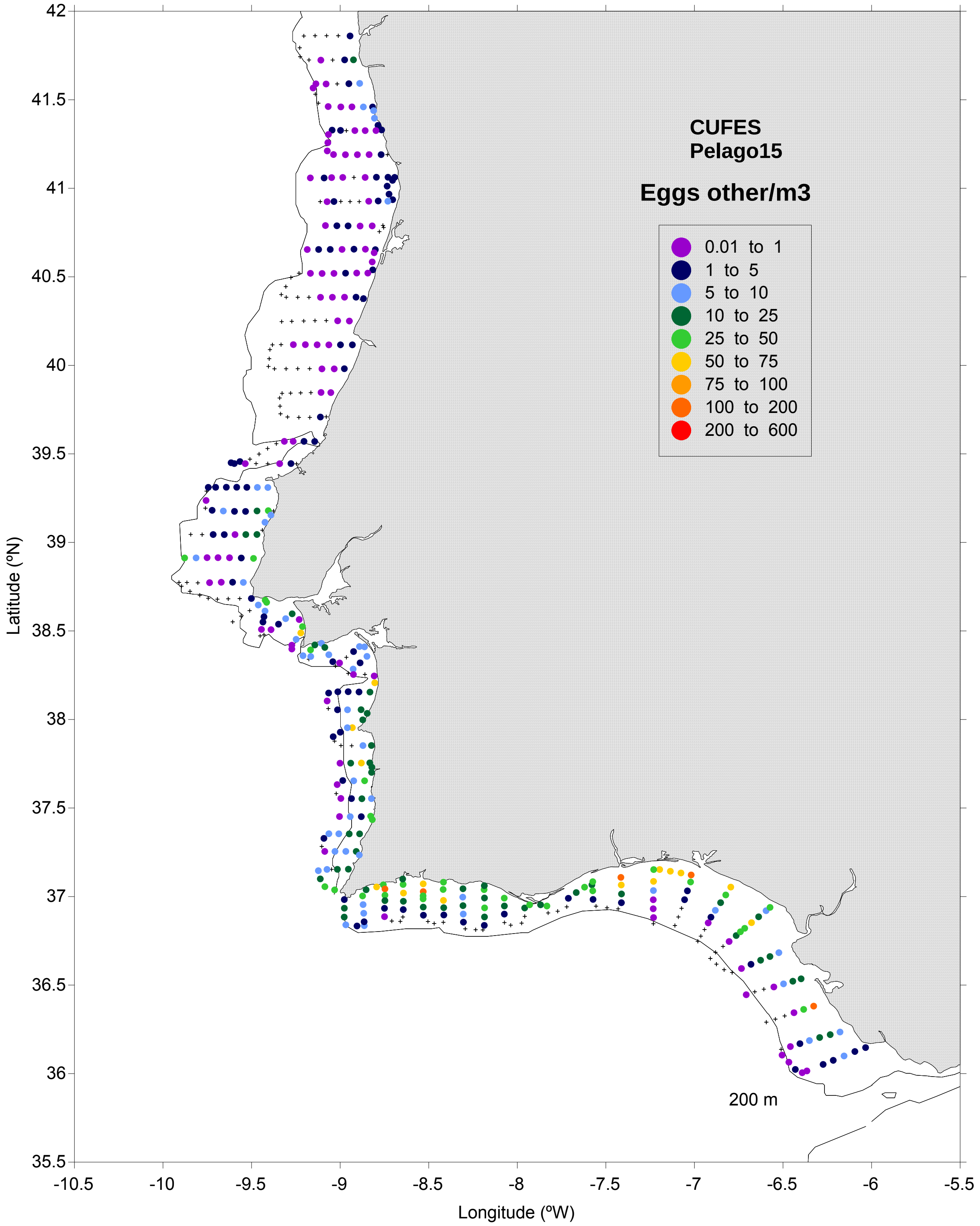

Figure 3.5 – Eggs of other fish (other than PIL and ANE) distribution (eggs/m^3) from CUFES sampling.

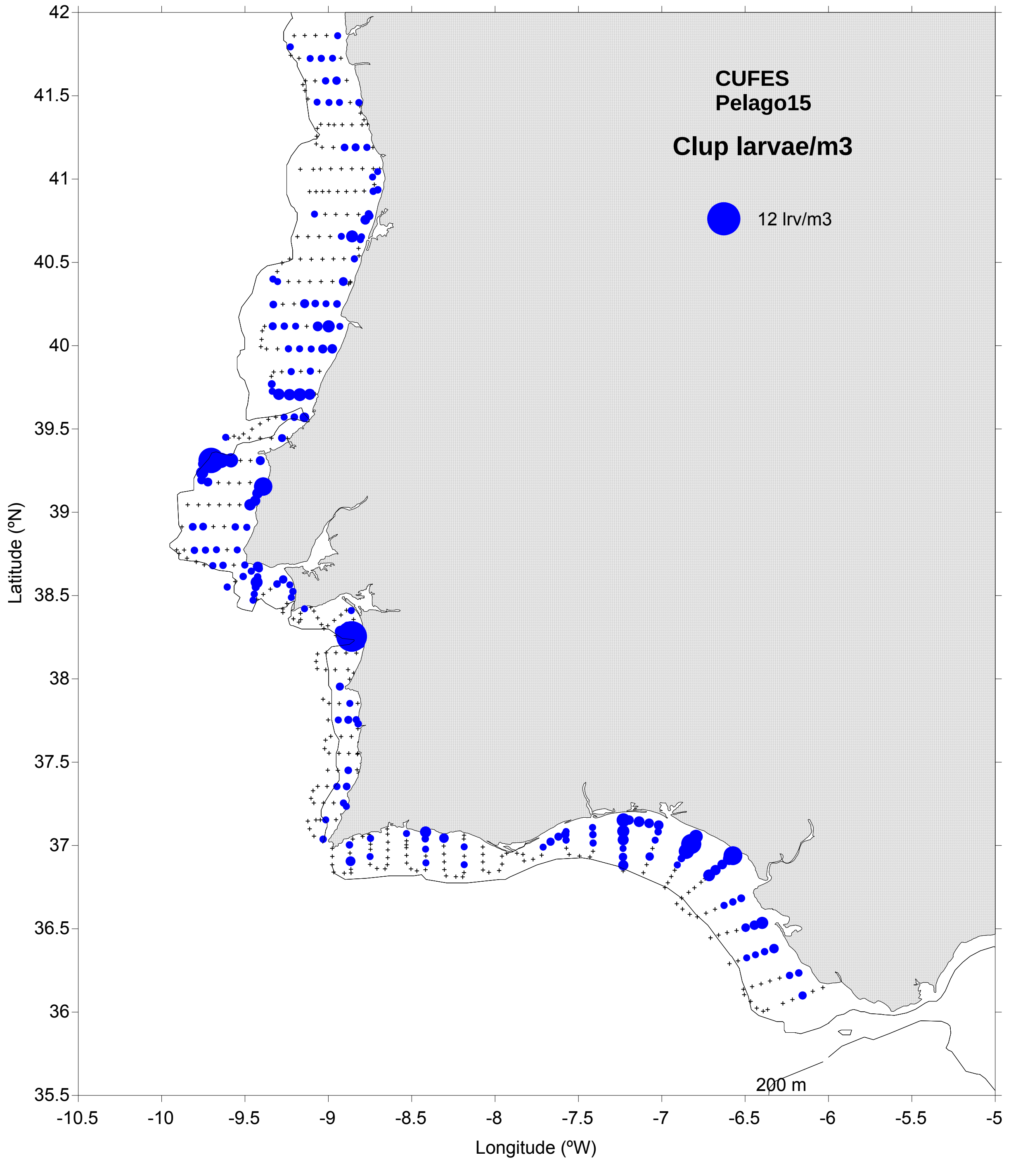

Figure 3.6 – Clupeiform larvae (PIL and ANE not sorted apart yet) distribution (larvae/m^3) from CUFES sampling.

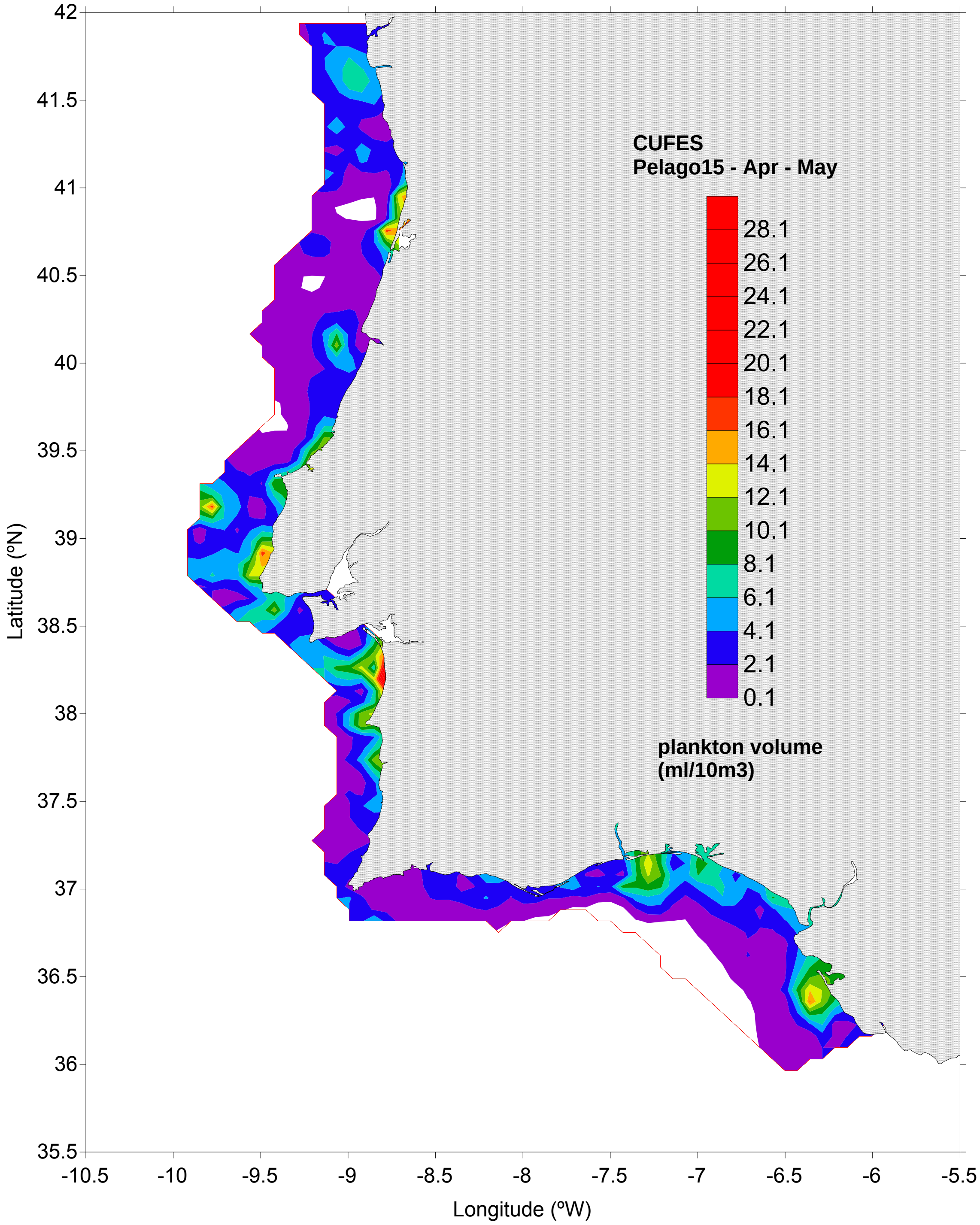

Figure 3.7 – Plankton distribution (ml/10m^3) from CUFES sampling.

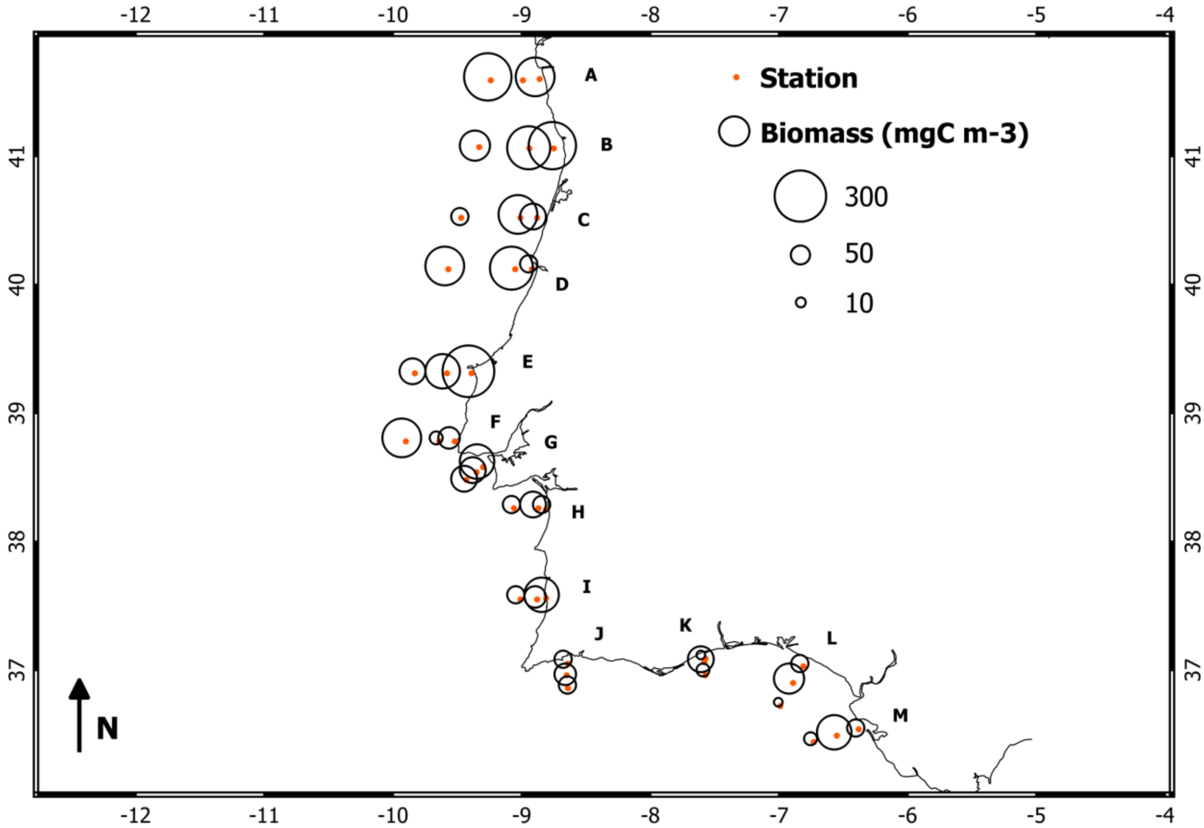

Figure 3.8 – Zooplankton biomass (mgC/m^3) collected during Bongo tows with 200 µm mesh at inshore, midshore and offshore locations along the transects indicated A to M (see also figure 3.2).

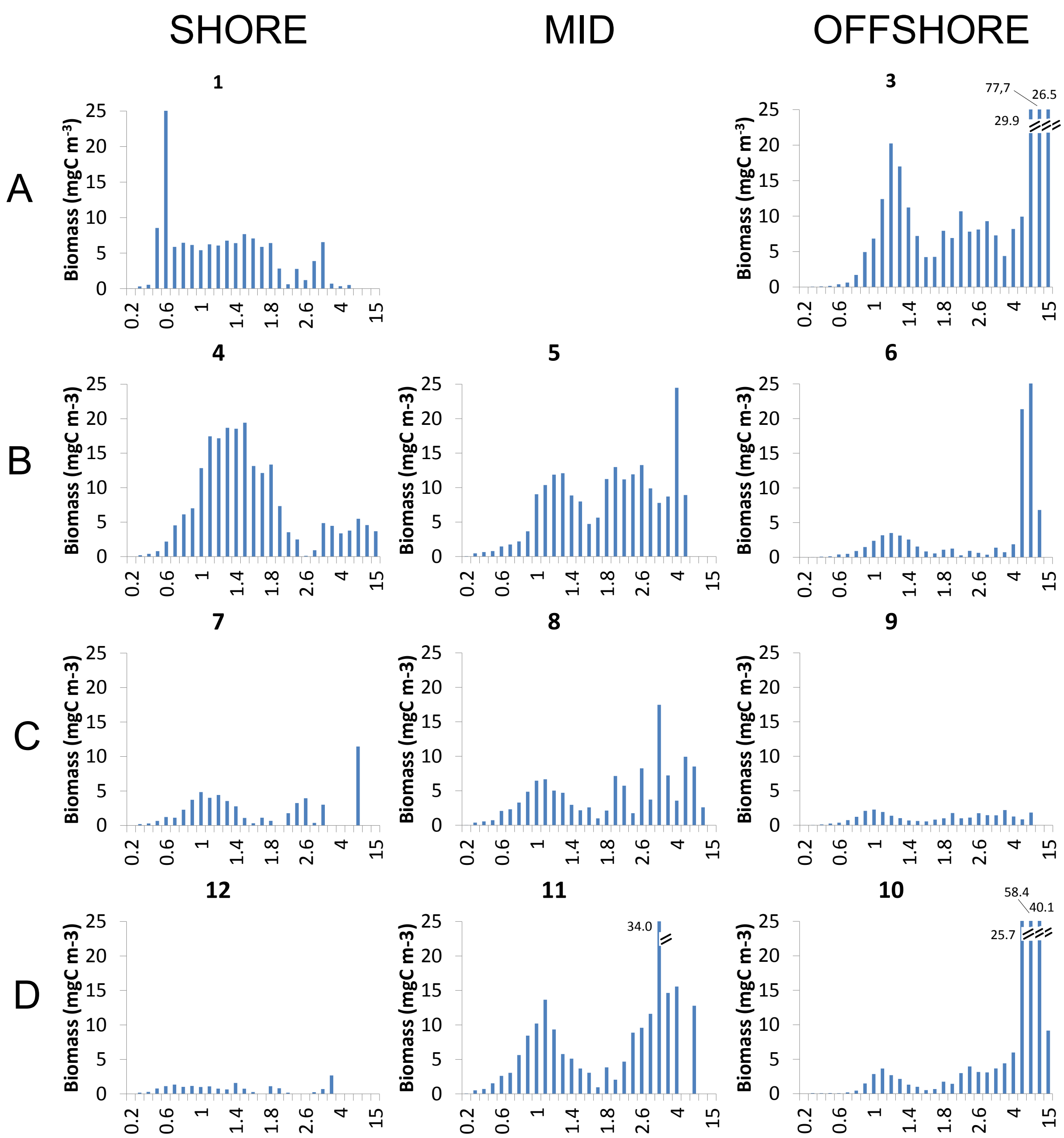

Figure 3.9 – Zooplankton biomass (mgC/m^3) by size (length) class. Samples collected during Bongo tows with 200 µm mesh at inshore, midshore and offshore locations along the transects A to D indicated in figure 3.2 and figure 3.8.

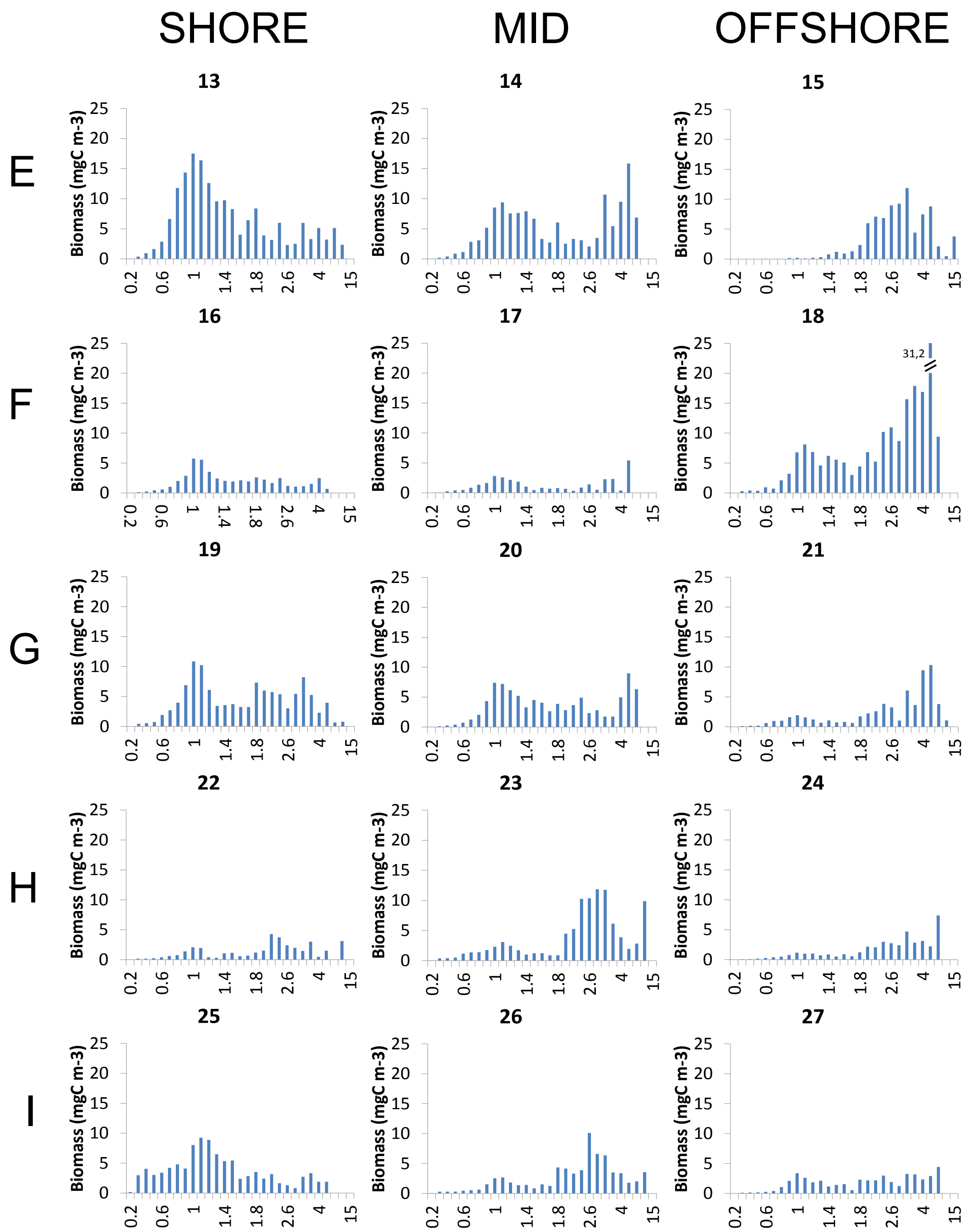

Figure 3.9 (continuation) – Zooplankton biomass (mgC/m^3) by size (length) class. Samples collected during Bongo tows with 200 µm mesh at inshore, midshore and offshore locations along the transects E to I indicated in figure 3.2 and figure 3.8.

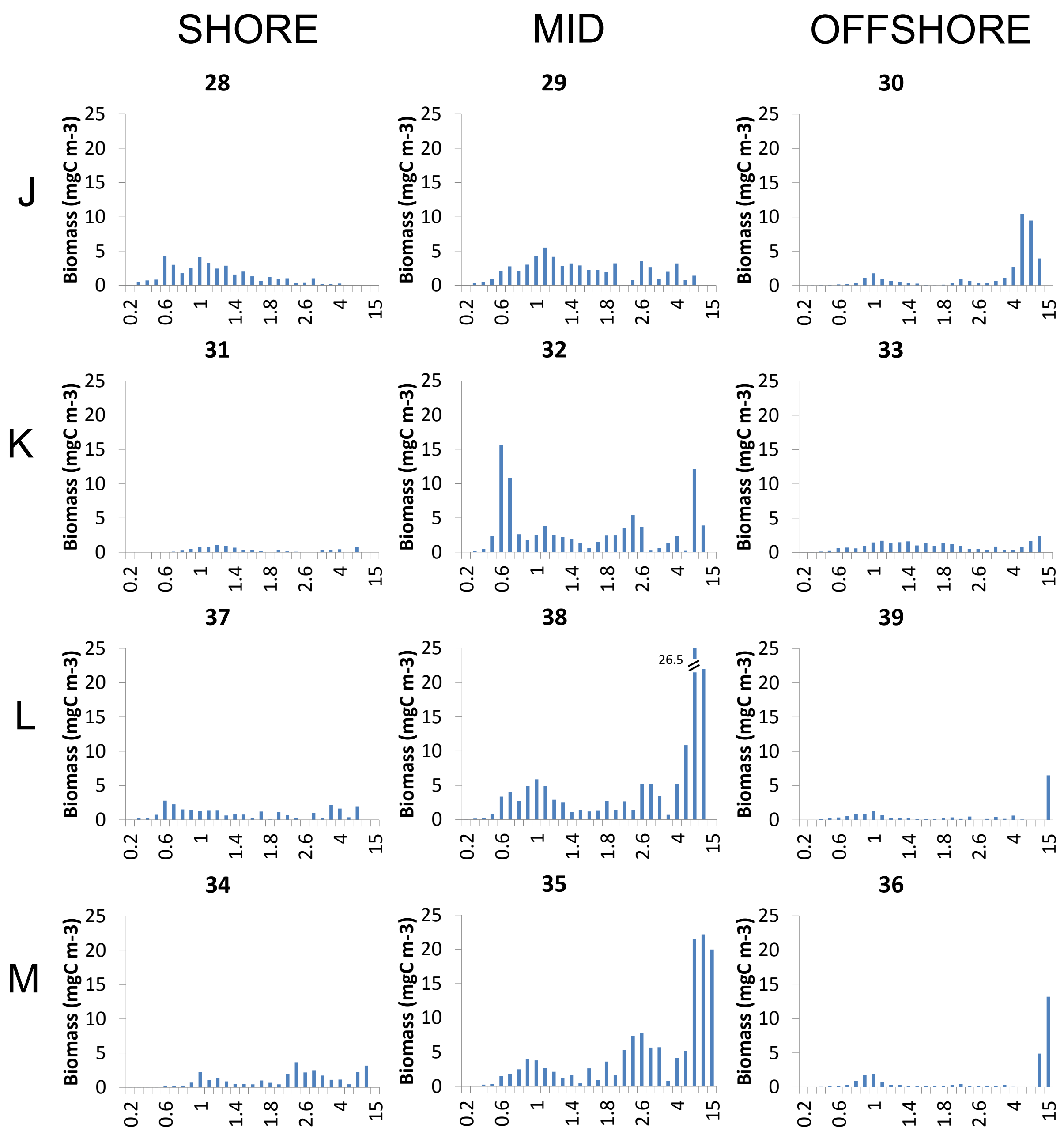

Figure 3.9 (continuation) – Zooplankton biomass (mgC/m^3) by size (length) class. Samples collected during Bongo tows with 200 µm mesh at inshore, midshore and offshore locations along the transects J to M indicated in figure 3.2 and figure 3.8.

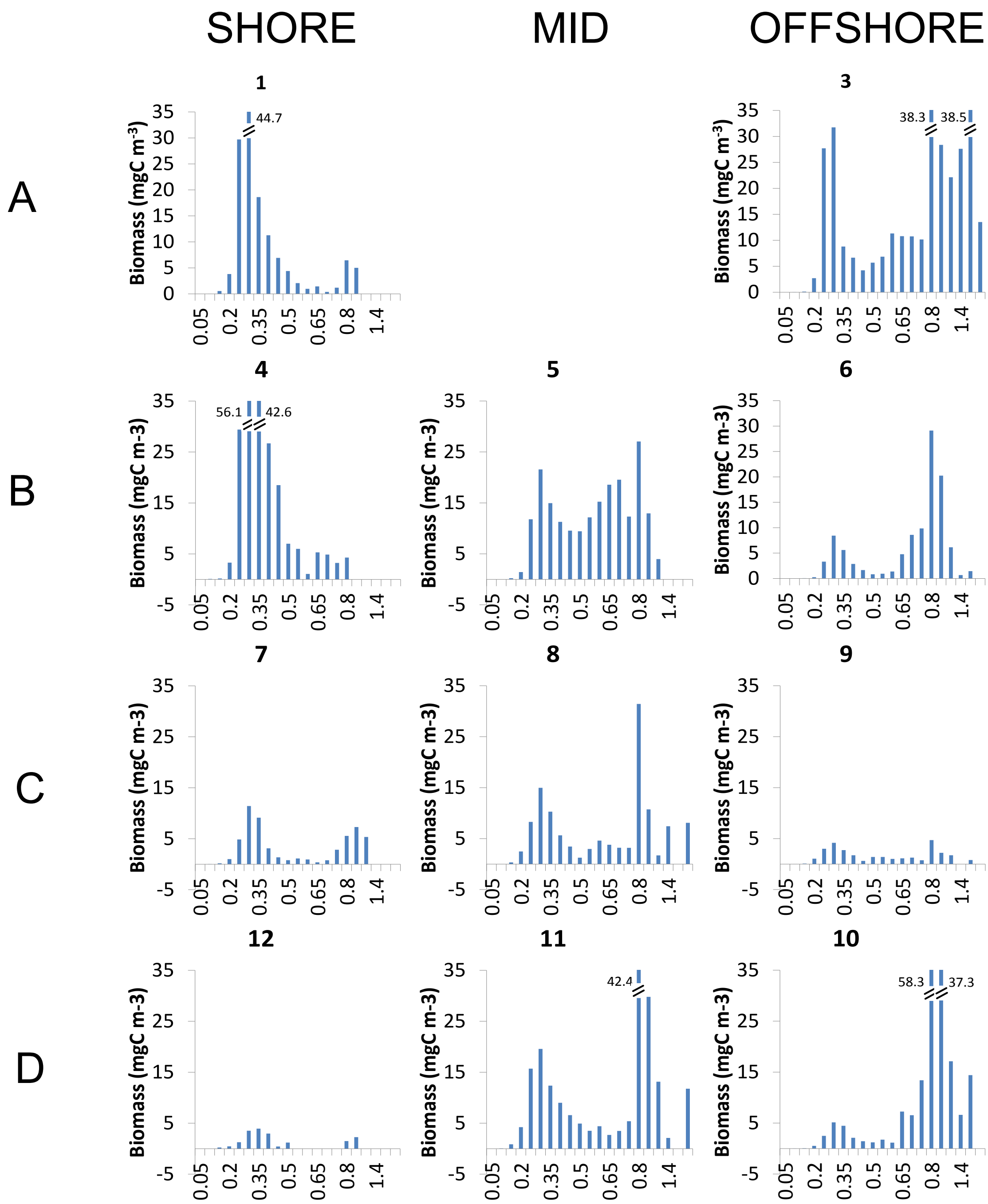

Figure 3.10 – Zooplankton biomass (mgC/m^3) by size (width) class. Samples collected during Bongo tows with 200 µm mesh at inshore, midshore and offshore locations along the transects A to D indicated in figure 3.2 and figure 3.8.

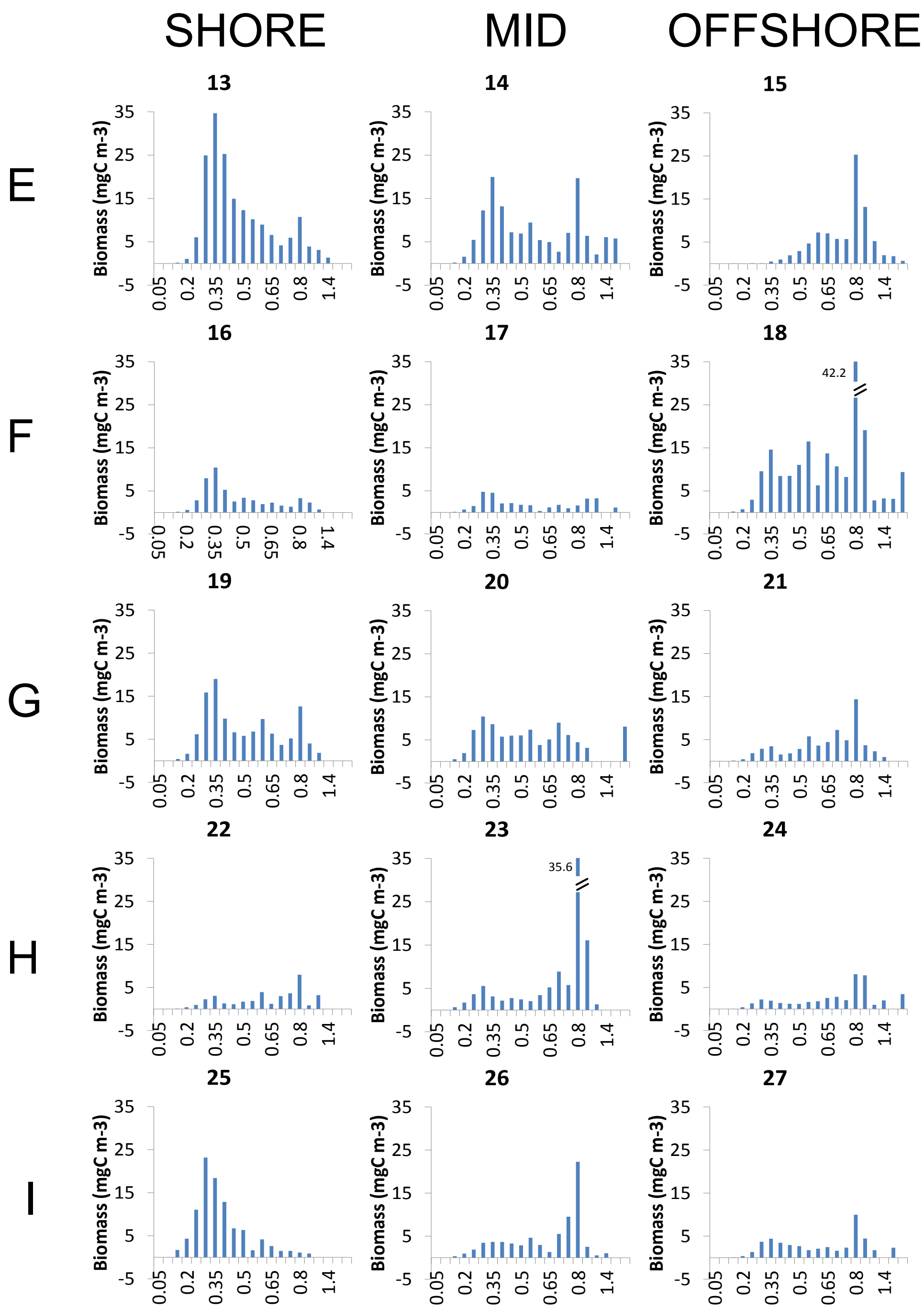

Figure 3.10 (continuation) – Zooplankton biomass (mgC/m^3) by size (width) class. Samples collected during Bongo tows with 200 µm mesh at inshore, midshore and offshore locations along the transects E to I indicated in figure 3.2 and figure 3.8.

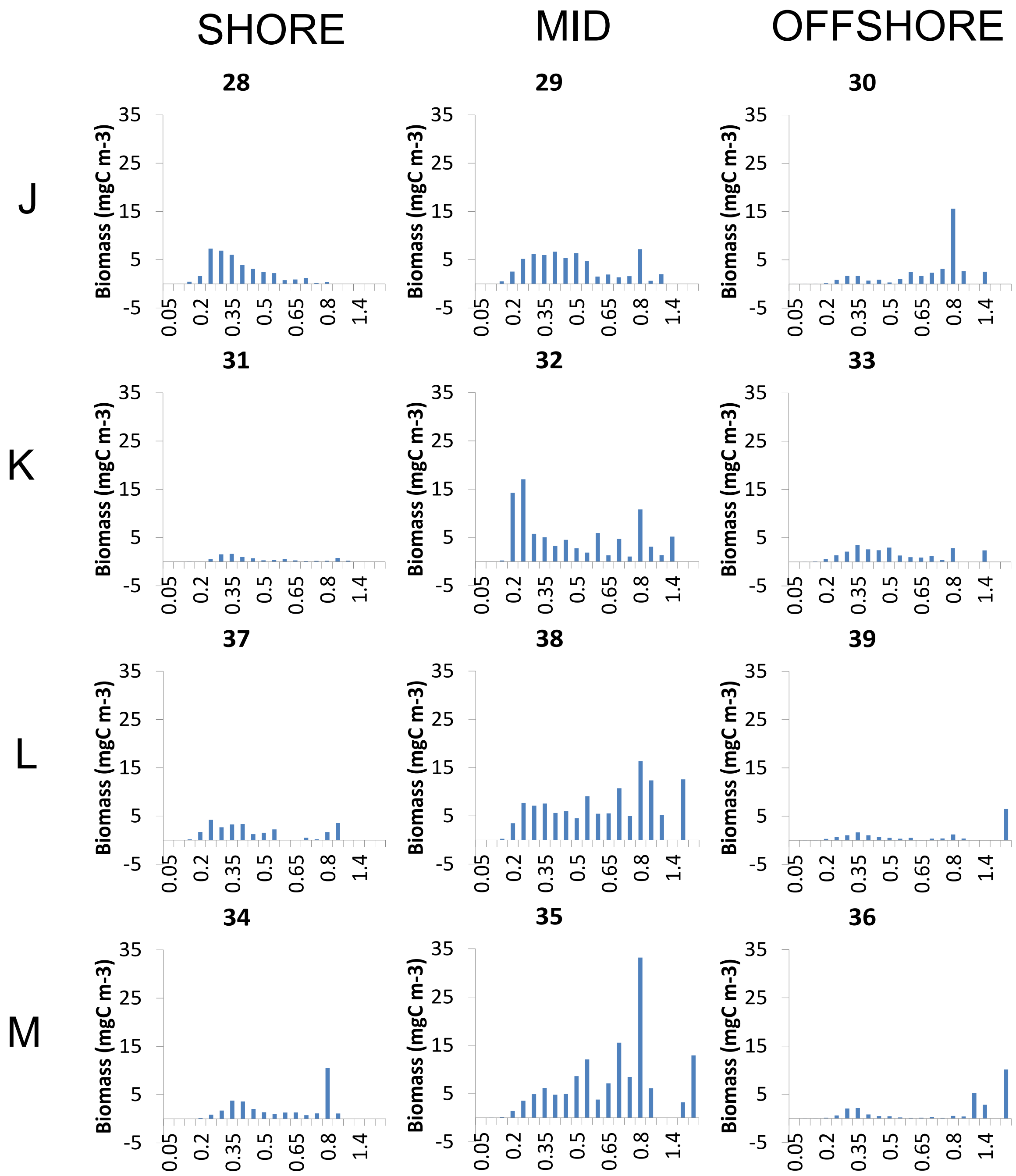

Figure 3.10 (continuation) – Zooplankton biomass (mgC/m^3) by size (width) class. Samples collected during Bongo tows with 200 µm mesh at inshore, midshore and offshore locations along the transects J to M indicated in figure 3.2 and figure 3.8.

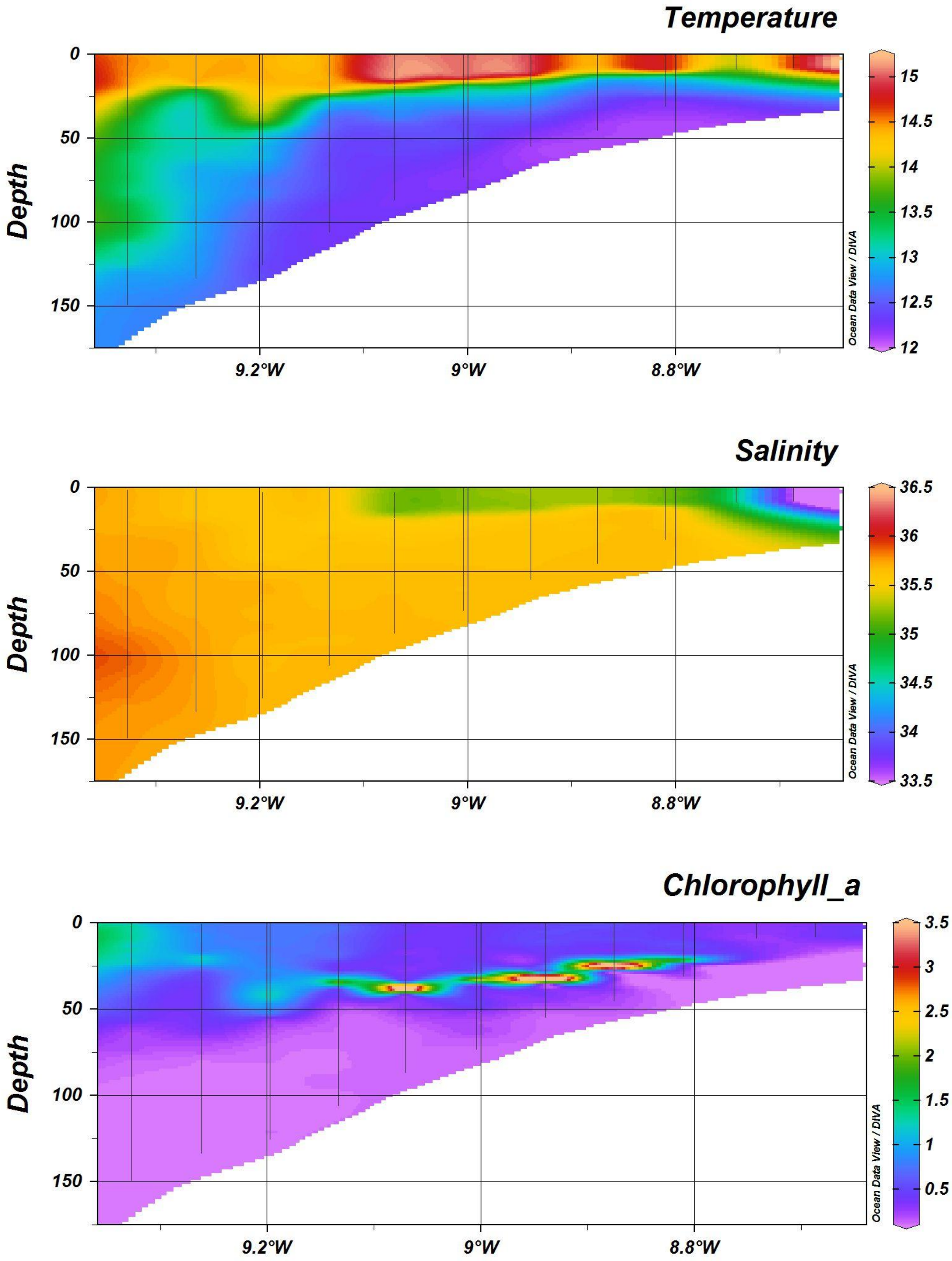

Figure 3.11 –Temperature (ºC) (top), salinity (centre) and chlorophyll_a (µg/l) (bottom) distributions along transect B, close to the river Douro mouth (41.1ºN).

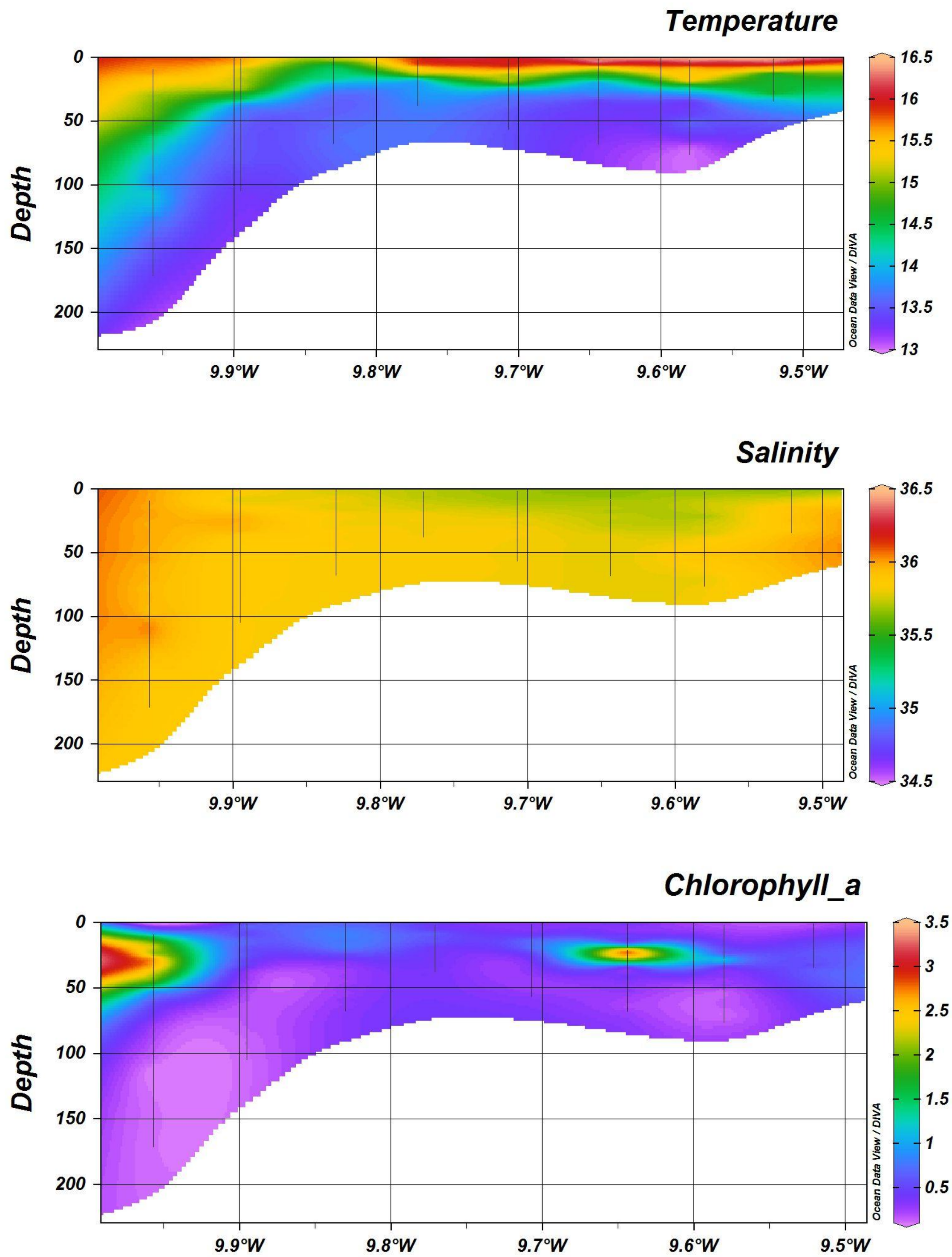

Figure 3.12 – Temperature (ºC) (top), salinity (centre) and chlorophyll_a (µg/l) (bottom) distributions along transect F, “Promontório da Estremadura” (38.8ºN).

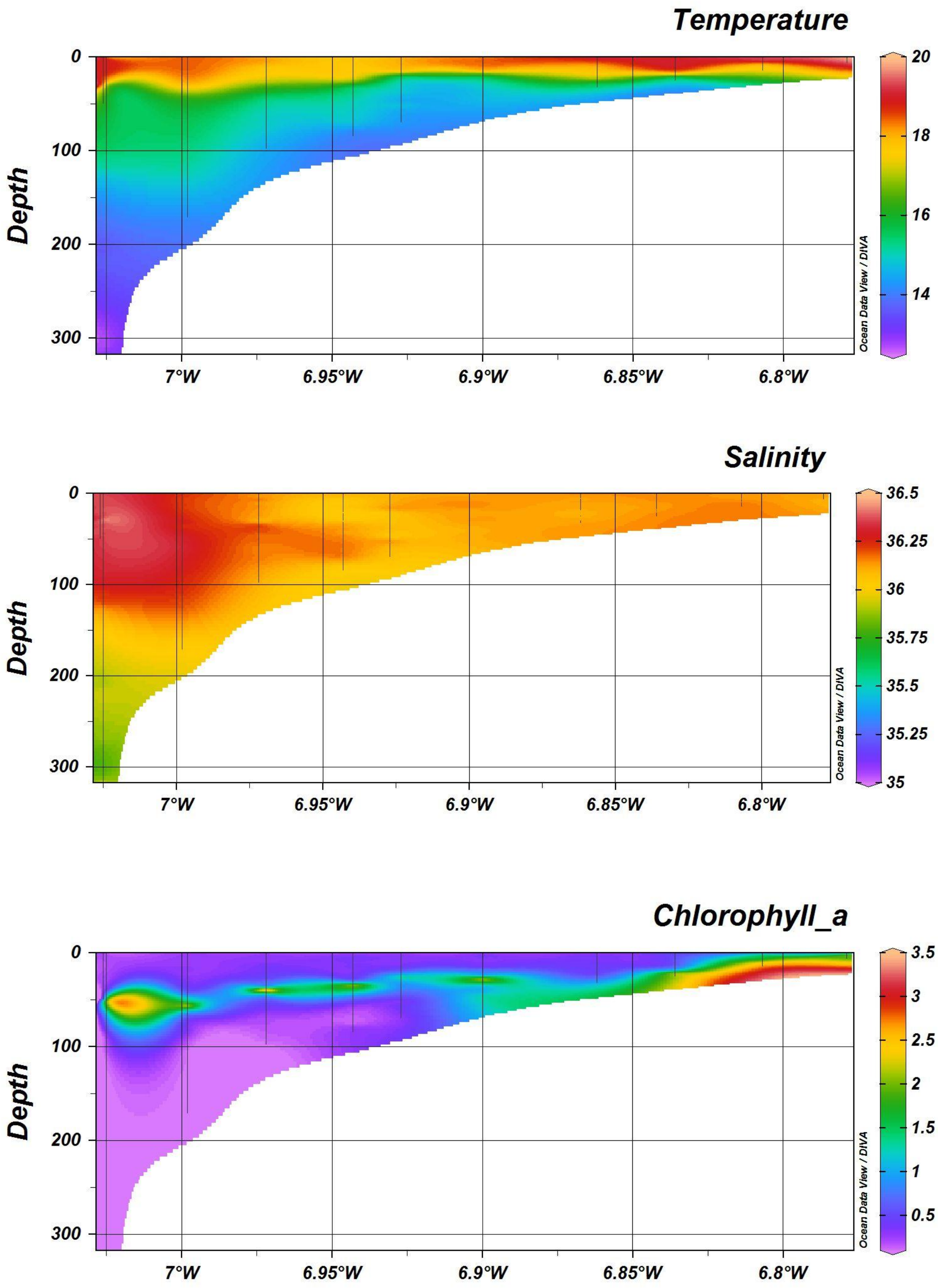

Figure 3.13 – Temperature (ºC) (top), salinity (centre) and chlorophyll_a (µg/l) (bottom) distributions along transect L, off Cadiz (37.1ºN, -6.8ºW - 36.7ºN, -7ºW).

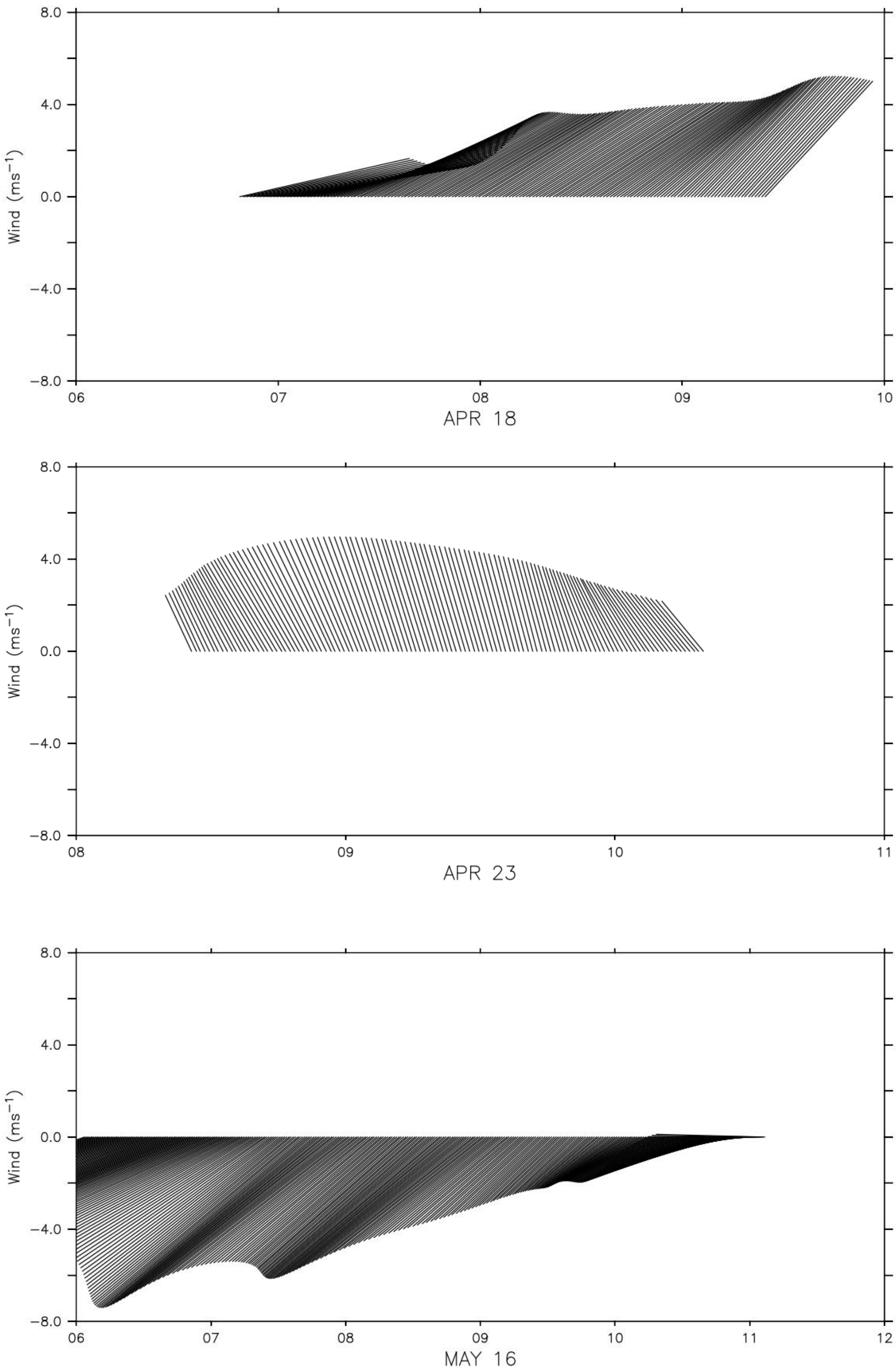

Figure 3.14 – Wind intensity (m/s) and direction (5 minutes interval observations) registered onboard along transects B, F and L respectively during surveying in 18 and 23 of April and 16 of May.

Working document presented in the:
ICES Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VIII and IX (WGACEGG). Lowestoft, UK, 16-20 November 2015..

Acoustic assessment and distribution of anchovy and sardine in ICES Subdivision IXa South during the *ECOCADIZ 2015-07* Spanish survey (July-August 2015) with notes on the distribution of other pelagic species.

By

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ABSTRACT

The present working document summarises a part of the main results obtained from the Spanish (pelagic ecosystem-) acoustic survey conducted by IEO between 28th July and 10th August 2015 in the Portuguese and Spanish shelf waters (20-200 m isobaths) off the Gulf of Cadiz onboard the R/V *Miguel Oliver*. The 21 foreseen acoustic transects were sampled. A total of 19 valid fishing hauls were carried out for echo-trace ground-truthing purposes. CUFES sampling (117 stations) was carried during the survey in order to describe the extension of the anchovy spawning area. A census of top predator species was also carried out along the sampled acoustic transects. This working document only provides abundance and biomass estimates for anchovy and sardine which are presented without age structure. The distribution of all the mid-sized and small pelagic fish species susceptible of being acoustically assessed is also shown from the mapping of their back-scattering energies. Sardine was the most frequent species in the fishing hauls, followed by horse mackerel, chub mackerel, anchovy and mackerel. However, the most abundant species in these hauls was anchovy, followed at quite a distance by blue jack mackerel, sardine, horse mackerel and chub mackerel. As usual, the bulk of the anchovy population was concentrated in the central part of the surveyed area, with the smallest anchovies mainly occurring in the surroundings of the Guadiana and Guadalquivir river mouths and Bay of Cadiz, and larger/older anchovies occurring in the westernmost waters. The total biomass estimated for anchovy, 21.3 kt (2 506 million fish), was slightly below the historical average, but it still in the range of population levels featuring to a recovered population. The comparison of these estimates with their spring counterparts from the PELAGO survey evidences almost identical values for the Portuguese waters, whereas the ECOCADIZ survey estimated in summer at about 1000 million and 11800 t less of anchovy in the Spanish waters. Such differences might be attributable to a possible overestimation of the acoustic energy attributed to anchovy in the Spanish waters of the Gulf by the PELAGO survey because of the difficulties in the discrimination of anchovy echoes in this area from a dense plankton layer where the species was embedded. Sardine was widely distributed all over the surveyed area but in the easternmost waters closer to the Strait of Gibraltar and showed two main nuclei of density: the coastal waters of the central part of the Gulf, and the inner-mid shelf waters between Cape San Vicente and Cape Santa Maria. Sardine yielded a total of 23.5 kt (883 million fish), population levels which have showed some recovery from the lowest historical values recorded in the two previous years but still below the historical average. In contrast to the abovementioned for anchovy, ECOCADIZ survey estimated in summer 4 fold more sardine in Spanish waters than PELAGO survey in spring, with the juvenile fraction being the dominant in both seasons. The progressive incorporation (recruitment) of juveniles coming from successive spawning events may be the reason for such seasonal differences.

INTRODUCTION

ECOCADIZ surveys constitute a series of yearly acoustic surveys conducted by IEO in the Subdivision IXa South (Algarve and Gulf of Cadiz, between 20 – 200 m depth) under the “pelagic ecosystem survey” approach onboard R/V *Cornide de Saavedra* (until 2013, since 2014 on onboard R/V *Miguel Oliver*). This series started in 2004 with the *BOCADEVA 0604* pilot acoustic - anchovy DEPM survey. The following surveys within this new series (named *ECOCADIZ* since 2006 onwards) are planned to be routinely performed on a yearly basis, although the series, because of the available ship time, has shown some gaps in those years coinciding with the conduction of the triennial anchovy DEPM survey (the true *BOCADEVA* series, which first survey started in 2005).

Results from the *ECOCADIZ* series are routinely reported to ICES Expert Groups on both stock assessment (formerly in WGMHSA, WGANC, WGANSA, at present in WGHANSA) and acoustic and egg surveys on anchovy and sardine (WGACEGG).

The present Working Document advances some results from the *ECOCADIZ 2015-07* survey. These results will only refer to the acoustic estimates (not age-structured) and spatial distribution of anchovy and sardine and to inferences on the spatial distribution of other pelagic species from the distribution of the acoustic energy attributed to each of these species.

MATERIAL AND METHODS

The *ECOCADIZ 2015-07* survey was carried out between 28th July and 10th August 2015 onboard the Spanish R/V *Miguel Oliver* covering a survey area comprising the waters of the Gulf of Cadiz, both Spanish and Portuguese, between the 20 m and 200 m isobaths. The survey design consisted in a systematic parallel grid with tracks equally spaced by 8 nm, normal to the shoreline (**Figure 1**).

Echo-integration was carried out with a *Simrad™ EK60* echo sounder working in the multi-frequency fashion (18, 38, 70, 120, 200 kHz). Average survey speed was about 10 knots and the acoustic signals were integrated over 1-nm intervals (ESDU). Raw acoustic data were stored for further post-processing using *Myriax Software Echoview™* software package (by *Myriax Software Pty. Ltd.,* ex *SonarData Pty. Ltd.*). Acoustic equipment was previously calibrated during the *MEDIAS 07 2015* acoustic survey, a survey conducted in the Spanish Mediterranean waters just before the *ECOCADIZ* one, following the standard procedures (Demer *et al*., 2015).

Survey execution and abundance estimation followed the methodologies firstly adopted by the ICES *Planning Group for Acoustic Surveys in ICES Sub-Areas VIII and IX* (ICES, 1998) and the recommendations given more recently by the *Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES areas VIII and IX* (WGACEGG; ICES, 2006a,b).

Fishing stations for echo-trace ground-truthing were opportunistic, according to the echogram information, and they were carried out using a ca. 16 m-mean vertical opening pelagic trawl (*Tuneado* gear) at an average speed of 4 knots. Gear performance and geometry during the effective fishing was monitored with *Simrad™ Mesotech FS20/25* trawl sonar. Trawl sonar data from each haul were recorded and stored for further analyses.

Ground-truthing haul samples provided biological data on species and they were also used to identify fish species and to allocate the back-scattering values into fish species according to the proportions found at the fishing stations (Nakken and Dommasnes, 1975).

Length frequency distributions (LFD) by 0.5-cm class were obtained for all the fish species in trawl samples (either from the total catch or from a representative random sample of 100-200 fish). Only those LFDs based on a minimum of 30 individuals and showing a normal distribution were considered for the purpose of the acoustic assessment.

Individual biological sampling (length, weight, sex, maturity stage, stomach fullness, and mesenteric fat content) was performed in each haul for anchovy, sardine (in both species with otolith extraction and with additional preservation of gonads in anchovy mature females), mackerel and horse-mackerel species, and bogue.

The following TS/length relationship table was used for acoustic estimation of assessed species (recent IEO standards after ICES, 1998; and recommendations by ICES, 2006a,b):

Species	b_{20}
Sardine (*Sardina pilchardus*)	-72.6
Round sardinella (*Sardinella aurita*)	-72.6
Anchovy (*Engraulis encrasicolus*)	-72.6
Chub mackerel (*Scomber japonicus*)	-68.7
Mackerel (*S. scombrus*)	-84.9
Horse mackerel (*Trachurus trachurus*)	-68.7
Mediterranean horse-mackerel (*T. mediterraneus*)	-68.7
Blue jack mackerel (*T. picturatus*)	-68.7
Bogue (*Boops boops*)	-67.0

The *PESMA 2010* software (J. Miquel, unpublished) has got implemented the needed procedures and routines for the acoustic assessment following the above approach.

A *Continuous Underway Fish Egg Sampler* (CUFES), a *Sea-bird Electronics™ SBE 21 SEACAT* thermosalinograph and a *Turner™ 10 AU 005 CE Field* fluorometer were used during the acoustic tracking to continuously monitor the anchovy egg abundance and to collect some hydrographical variables (sub-surface sea temperature, salinity, and *in vivo* fluorescence; **Figure 2**). Vertical profiles of hydrographical variables were also recorded by night from 157 CTD casts by using *Sea-bird Electronics™ SBE 911+ SEACAT* (with coupled *Datasonics* altimeter, *SBE 43* oximeter, *WetLabs ECO-FL-NTU* fluorimeter and *WetLabs C-Star 25 cm* transmissometer sensors) and *LADCP T-RDI WHS* 300 kHz profilers (**Figure 3**). *VMADCP RDI 150 kHz* records were also continuously recorded by night between CTD stations. Information on presence and abundance of sea birds, turtles and mammals was also recorded during the acoustic sampling by one onboard observer.

ECOCADIZ 2015-07 was also utilized this year as an observational platform for the IFAPA (Instituto de Investigación y Formación Agraria y Pesquera)/IEO research project entitled *Ecology of the early stages of the anchovy life-cycle: the role of the coupled Guadalquivir estuary-coastal zone of influence in the species' recruitment process (ECOBOGUE)*. Thus, 4 *Bongo 90* coastal stations were carried out at sunset in the surroundings of the Guadiana (2 stations) and Guadalquivir (2 stations) river mouths to collect anchovy larvae for genetics studies (**Figure 2**).

RESULTS

Acoustic sampling

The acoustic sampling started on 29th July in the coastal end of the transect RA01 and finalized on 07th August in the oceanic end of the transect RA21 (**Table 1, Figure 1**). Transects were acoustically sampled in the E-W direction. The whole 21-transect sampling grid was sampled. The acoustic sampling usually started at 06:00 UTC although this time might vary depending on the duration of the works related with the hydrographic sampling. The foreseen start of transects RA14 and RA15 by the coastal end had to be displaced to deeper waters in order to avoid the occurrence of open-sea fish farming/fattening cages.

Groundtruthing hauls

Twenty two (22) fishing operations, with 19 of them being considered as valid ones according to a correct gear performance and resulting catches, were carried out (**Table 2**, **Figure 4**). Null hauls were actually composed by 2 initial trials for checking the behaviour and configuration of the available fishing gears (fishing stations # 01 and 02) and one fishing haul (fishing station # 17) carried out in pure pelagic fashion which finally resulted unsuccessful.

As usual in previous surveys, some fishing hauls were attempted by fishing over an isobath crossing the acoustic transect as close as possible to the depths where the fishing situation of interest was detected over that transect. In this way the mixing of different size compositions (*i.e.*, bi-, multi-modality of length frequency distributions) was avoided as well as a direct interaction with fixed gears. The mixing of sizes is more probable close to nursery-recruitment areas and in regions with a very narrow continental shelf. Given that all of these situations were not very uncommon in the sampled area, 42% of valid hauls (8 hauls) were conducted over isobath.

Because of many echo-traces usually occurred close to the bottom, all the pelagic hauls were carried out like a bottom-trawl haul, with the ground rope working over or very close to the bottom. According to the above, the sampled depth range in the valid hauls oscillated between 38-172 m.

During the survey were captured 4 Chondrichthyan, 39 Osteichthyes, 4 Cephalopod, 8 Crustacean, 5 Echinoderm, 2 Polychaeta, 1 Sipunculidea, 2 Porifera, 4 Cnidarian and 1 Thaliacean species. The percentage of occurrence of the more frequent species in the trawl hauls is shown in the enclosed text table below (see also **Figure 5**. The pelagic ichthyofauna was the most frequently captured species set and the one composing the bulk of the overall yields of the catches. Within this pelagic fish species set, sardine was the most frequent captured species in the valid hauls (18 hauls, 95% presence index) followed by horse mackerel, chub mackerel, anchovy and mackerel (with relative occurrences between 70-80%). Bogue and blue jack mackerel showed a medium relative frequency of occurrence (ca. 50-60%), whereas Mediterranean horse mackerel showed a low occurrence in the whole surveyed area (21%).

For the purposes of the acoustic assessment, anchovy, sardine, mackerel species, horse & jack mackerel species, and bogue were initially considered as the survey target species. All of the invertebrates, and both bentho-pelagic (*e.g.*, manta rays) and benthic fish species (*e.g.*, flatfish, gurnards, etc.) were excluded from the computation of the total catches in weight and in number from those fishing stations where they occurred. Catches of the remaining non-target species were included in an operational category termed as "*Others*".

According to the above premises, during the survey were captured a total of 10.5 tonnes and 307 thousand fish (**Table 3**). 28% of this fished biomass corresponded to blue-jack mackerel, 19% to sardine, 18% to chub mackerel, anchovy and horse mackerel 13% each, 3% to Mediterranean horse mackerel, and contributions lower than 1% by the remaining species. However, the most abundant species in ground-truthing trawl hauls was anchovy (51%) followed by a long distance by blue jack mackerel (17%), sardine (15%), horse mackerel (9%) and chub mackerel (6%).

Species	# of fishing stations	Occurrence (%)	Total weight (kg)	Total number
Merluccius merluccius	19	100	169,218	2745
Sardina pilchardus	18	95	1956,451	45055
Loligo spp	17	89	5,409	1809
Trachurus trachurus	16	84	1399,624	26394
Scomber colias	15	79	1914,333	17822
Engraulis encrasicolus	15	79	1401,372	155790
Scomber scombrus	14	74	38,035	183
Boops boops	11	58	22,575	188
Trachurus picturatus	10	53	2956,827	50765
Alosa fallax	8	42	3,519	14
Spondyliosoma cantharus	8	42	14,108	78
Diplodus annularis	6	32	2,638	52
Eledone moschata	6	32	1,442	10
Aphia minuta	6	32	0,346	164
Pagellus erythrinus	6	32	94,348	568
Pagellus bellottii bellottii	5	26	7,978	56
Diplodus bellottii	5	26	3,668	67
Chelidonichthys lucerna	5	26	0,426	5
Diplodus vulgaris	4	21	13,038	89
Trachurus mediterraneus	4	21	325,372	1910

The species composition, in terms of percentages in number, in each valid fish station is shown in **Figure 5**. A first impression of the distribution pattern of the main species may be derived from the above figure. Thus, anchovy showed a relatively wide distribution over the surveyed area, although the highest yields were recorded in the Spanish waters. The size composition of anchovy catches confirms the usual pattern exhibited by the species in the area during the spawning season, with the largest fish being distributed in the westernmost waters and the smallest ones concentrated in the surroundings of the Guadalquivir river mouth and adjacent shallow waters, including those ones in front of the Bay of Cadiz. This summer small anchovies were also recorded in the coastal area close to the Guadiana river mouth (**Figure 6**). Sardine was even more frequent and widely distributed than anchovy, with the highest yields being mainly recorded in the westernmost waters of the surveyed area. Juvenile sardines were almost exclusively captured in the shallowest hauls conducted in front of the Guadiana and Guadalquivir river mouths and the Bay of Cadiz (**Figure 7**). Mackerel, chub mackerel, horse mackerel, blue jack mackerel and bogue, although they occurred in a great part of the study area, only showed relatively high yields in the Portuguese waters. Mediterranean horse mackerel was restricted to the easternmost Spanish waters.

Back-scattering energy attributed to the "pelagic assemblage" and individual species

A total of 315 nmi (ESDU) from 21 transects has been acoustically sampled by echo-integration for assessment purposes. From this total, 207 nmi (11 transects) were sampled in Spanish waters, and 108 nmi (10 transects) in the Portuguese waters. The enclosed text table below provides the nautical area-scattering coefficients attributed to each of the selected target species and for the whole "pelagic fish assemblage".

$S_{A\,(m^2\,nmi^{-2})}$	Total spp.	Anchovy	Sardine	Mackerel	Chub mack.	Horse mack.	Medit. h-mack.	Blue jack-mack.	Bogue	Blue whiting	Boarfish
Total Area	104460	34311	15772	19	23790	10073	8354	10636	562	942	1
%	100	32,8	15,1	0,02	22,8	9,6	8	10,2	0,5	0,9	0
Portugal	56412	2355	8744	1	23650	9719	0	10546	454	942	1
%	54,0	6,9	55,4	6,7	99,4	96,5	0,0	99,2	80,8	100,0	100,0
Spain	48048	31956	7028	18	140	354	8354	90	108	0	0
%	46,0	93,1	44,6	93,3	0,6	3,5	100,0	0,8	19,2	0,0	0,0

For this “pelagic fish assemblage” has been estimated a total of 104 460 m^2 nmi^{-2}. Portuguese waters accounted for 54% of this total back-scattering energy and the Spanish waters the remaining 46%. However, given that the Portuguese sampled ESDUs were almost the half of the Spanish ones, the (weighted-) relative importance of the Portuguese area (*i.e.*, its density of “pelagic fish”) is actually much higher. The mapping of the total back-scattering energy is shown in **Figure 8**. By species, anchovy (33%), chub mackerel (23%) and sardine (15%) were the most important species in terms of their contributions to the total back-scattering energy. Blue jack mackerel and Horse mackerel were the following species in importance with 10% each. Mediterranean horse mackerel only contributed with 8%, followed by negligible energetic contributions by mackerel, bogue, boarfish (*Capros aper*) and blue whiting (*Micromesistius poutassou*). Round sardinella was not recorded during the survey.

Some inferences on the species’ distribution may be carried out from regional contributions to the total energy attributed to each species: Mediterranean horse mackerel, mackerel and anchovy seemed to show greater densities in the Spanish waters, whereas blue whiting, boarfish, chub mackerel, blue jack mackerel, horse mackerel, and bogue could be considered as typically “Portuguese species” in this survey.

According to the resulting values of integrated acoustic energy, the species acoustically assessed in the present survey finally were anchovy, sardine, mackerel, chub mackerel, blue jack mackerel, horse mackerel, Mediterranean horse mackerel and bogue. For the time being the only available acoustic estimates of abundance and biomass are the ones for anchovy and sardine. Furthermore, these estimates are not still presented with age-structure. For the remaining species only the spatial distribution of NASCs will be shown in the present WD.

Spatial distribution and abundance/biomass estimates

Anchovy

Parameters of the survey’s length-weight relationship for anchovy are given in **Table 4**. The back-scattering energy attributed to this species and the coherent strata considered for the acoustic estimation are shown in **Figure 9**. The estimated abundance and biomass by size class are given in **Table 5** and **Figure 10**.

Anchovy avoided the easternmost waters of the Gulf. The bulk of the population was mainly distributed all over the shelf between the Guadiana river mouth and Bay of Cadiz, especially over the outer shelf waters of the central part of the Gulf, between the Guadiana river mouth and Matalascañas. A secondary nucleus of anchovy density was recorded in the western Portuguese Algarve, between Cape San Vicente and Albufeira, with the species being quite scarce in the surroundings of the Cape of Santa Maria (**Figure 9**).

The size class range of the assessed population varied between the 6.5 and 17 cm size classes, with two modal classes at 8.0 and 10.5 cm. The size composition of anchovy by coherent post-strata confirms the usual pattern exhibited by the species in the area during the spawning season, with the largest fish being distributed in the westernmost waters and the smallest ones concentrated in the surroundings of the Guadalquivir river mouth and adjacent shallow waters, including those ones in front of the Bay of Cadiz (**Table 5**, **Figures 9** and **10**, see also **Figure 6**). This summer small anchovies were also recorded in the coastal area close to the Guadiana river mouth. As it has been happening in the last years, during the 2015 survey some recruitment has also been recorded, probably as a consequence of the delayed survey dates. This fact seems to have been much more evident this summer than in previous years because the markedly low mean length and weight estimated for the whole estimated population (106 mm; 8.0 g), the lowest record for both variables in the whole series.

Ten coherent post-strata have been differentiated according to the S_A value distribution and the size composition in the fishing stations. The acoustic estimates by homogeneous post-stratum and total area are shown in **Table 5** and **Figure 10**. Overall acoustic estimates in summer 2015 were of 2674 million fish and 21305 tonnes. By geographical strata, the Spanish waters yielded 93.7% (2506 million) and 90% (19168 t) of the total estimated abundance and biomass in the Gulf confirming the importance of these waters in the species' distribution. The estimates for the Portuguese waters were 168 million and 2137 t.

The Gulf of Cadiz anchovy egg distribution from CUFES sampling is shown in **Figure 11**. Anchovy egg distribution in summer 2015 resembled the abovementioned distribution for adult fish, with higher egg densities being mainly recorded in the middle-outer shelf waters located between the Guadiana and Tinto-Odiel river mouths. The highest egg density (121 eggs m^{-3}) was recorded in one station at a mean depth of 80.3 m located in the westernmost Spanish transect.

Sardine

Parameters of the survey's size-weight relationship for sardine are shown in **Table 4**. The back-scattering energy attributed to this species and the coherent strata considered for the acoustic estimation are shown in **Figure 12**. Estimated abundance and biomass by size class are given in **Table 6** and **Figure 13**.

Excepting the easternmost waters closer to the Strait of Gibraltar, where the species was absent, sardine was widely distributed all over the remaining surveyed area, preferably over the inner shelf, with the highest densities being recorded in two distinct zones: the coastal waters in front of the area comprised between Matalascañas and Chipiona, in the Spanish waters, and the inner-mid shelf waters between Cape San Vicente and Cape Santa Maria, in the Portuguese waters (**Figure 12**).

Sizes of the assessed population ranged between 7.5 and 22.5 cm size classes. The length frequency distribution of the population was clearly bimodal, with one main mode at 10.5 cm size class and a secondary one at 20.0 cm (**Table 6**; **Figure 13**). The 2015 summer estimate of mean size (135 mm) is the lowest one within the series. This fact might be explained by the dominance of the juvenile fraction in the estimated population (main mode at 10.5 cm), which was mainly located in relatively shallow waters in front of the Guadiana and Guadalquivir river mouths and the Bay of Cadiz (**Table 6**, **Figure 13,** see also **Figure 7**). However, such a decrease in mean size is not coupled with a similar decreasing trend in the mean weight (26.6 g), which was even somewhat higher than the historical average. It could be probable that the contribution in biomass of the adult fraction in the assessed population (around at a secondary modal size class at 20 cm) is enough to compensate the greater relative contribution of juveniles.

Nine size-based homogeneous sectors were delimited for the acoustic assessment. The estimates of Gulf of Cadiz sardine abundance and biomass in summer 2015 were 883 million fish and 23460 t. Portuguese waters accounted for 27.6% of abundance (244 million fish) and 72.6% of the total estimated biomass (17038 t), values from which could be inferred a large body size on average. In contrast, the estimates from the Spanish area (640 million fish – 72.4% of abundance –; 6422 t – 27.4% of biomass –), denote a dominance of the smallest sardines.

Mackerel

Parameters of the survey's length-weight relationship are shown in **Table 4**. The distribution of the back-scattering energy attributed to this species is shown in **Figure 14**.

Mackerel was mainly distributed over the central part of the Gulf, with a null occurrence in both extremes of the surveyed area (**Figure 14**).

Chub mackerel

Parameters of the survey's length-weight relationship are shown in **Table 4**. The distribution of the back-scattering energy attributed to this species is shown in **Figure 15**.

Although practically occurring all over the surveyed area, chub mackerel showed the highest densities westward the Guadiana river mouth (**Figure 15**).

Blue jack-mackerel

The survey's length-weight relationship for this species is given in **Table 4**. The distribution of the back-scattering energy attributed to this species is illustrated in **Figure 16**.

The distribution pattern of blue jack mackerel almost mimics the previously described one for chub mackerel, suggesting the occupation of similar habitats by both species, although blue jack mackerel was absent in the most part of the Spanish waters (**Figure 16**, see also **Figure 15** for comparison).

Horse mackerel

The survey's length-weight relationship for horse mackerel is shown in **Table 4**. The back-scattering energy attributed to this species is shown in **Figure 17**.

Horse mackerel also showed widely distributed over the surveyed area, sharing the same distribution pattern than the above described for chub mackerel and blue jack mackerel. Again, the westernmost Portuguese shelf waters were those ones where the species recorded the highest densities (**Figure 17**).

Mediterranean horse-mackerel

The survey's length-weight relationship for this species is shown in **Table 4**. Back-scattering energy attributed to the species is represented in **Figure 18**.

Mediterranean horse-mackerel was only present over the Spanish inner shelf waters, with the densest concentrations being recorded in the coastal fringe between Cadiz Bay and Cape Trafalgar (**Figure 18**).

Bogue

Parameters of the survey's length-weight relationship for bogue are shown in **Table 4**. Back-scattering energy attributed to bogue is shown in **Figure 19**.

Although showing a relatively widespread distribution, bogue showed their higher acoustic densities in the westernmost Portuguese inner shelf waters (**Figure 19**).

Boarfish and Blue whiting

Boarfish showed an incidental occurrence in the surveyed area, just in the outer shelf waters to the east of Cape Santa Maria. Blue whiting showed a very restricted distribution which was confined to the outer shelf of the westernmost Portuguese waters.

Oceanographic conditions

A detailed description of the oceanographic conditions in that survey based on *in situ* and remotely sensed data is given in Sánchez-Leal *et al*. (2015).

(SHORT) DISCUSSION

The historical series of anchovy biomass estimates is shown in **Figure 22**. The summer 2015 abundance estimate continues the notable increasing trend which started last year and rises up the population levels well above those corresponding to the historical average. This increasing trend in abundance is not completely coupled to the trend exhibited by the biomass, which showed a relatively low decrease in relation to the previous year estimate. Even so, the 2015 biomass estimate situates only slightly below the historical average.

For this same surveyed area, the Portuguese spring survey PELAGO 15 estimated two months before 3689 million fish and 33100 t (158 million and 2156 t in Portuguese waters, 3531 million and 30944 t in Spanish ones; see Marques *et al*., 2015, WD). The comparison of these estimates with their summer counterparts evidences almost identical values for the Portuguese waters, whereas the ECOCADIZ survey estimated in summer at about 1000 million and 11800 t less of anchovy in the Spanish waters. Even assuming a total mortality (Z) accumulated between surveys, the magnitude of such differences should be explainable by causes other than the above one. Marques *et al*. (2015, WD) warn about the need of corroborating the PELAGO spring estimates with the ECOCADIZ ones because of some uncertainty in the estimation. These authors advanced the possibility of a certain overestimation of the acoustic energy attributed to anchovy in the Spanish waters of the Gulf because this energy in this area was strongly masked by a dense plankton layer. ECOCADIZ surveys also routinely face to this same problem, since this situation is not uncommon in the area, by acoustically surveying in a multi-frequency fashion, an approach that partially enables a more efficient discrimination of echoes.

Regarding sardine, although its population levels have showed some recovery from the lowest values recorded in the two previous years, the 2015 estimates are still below the historical average (**Figure 22**). The comparison of the ECOCADIZ 2015-07 estimates with their spring counterparts reveals some differences (see Marques et *al*., 2015, WD). PELAGO survey estimated 400 million and 16663 t of Gulf of Cadiz sardine (238 million and 15031 t in Portuguese waters, 162 million and 1632 t in Spanish ones). As it could be easily deduced from the above values, spring and summer estimates from the Portuguese Algarve area were quite similar. However, ECOCADIZ survey estimated in summer 4 fold more sardine in the Spanish waters than PELAGO survey in spring, with the juvenile fraction being the dominant in both seasons. The progressive incorporation (recruitment) of juveniles coming from successive spawning events may be the reason for such differences.

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Table 1. *ECOCADIZ 2015-07 s*urvey. Descriptive characteristics of the acoustic tracks.

Acoustic Track	Location	Date	Start				End			
			Latitude	Longitude	UTC time	Mean depth (m)	Latitude	Longitude	UTC time	Mean depth (m)
R01	Trafalgar	29/07/15	36º 13.597' N	5º 07.650 ' W	06:04	25	36º 02.168' N	6º 28.736' W	08:15	180
R02	Sancti-Petri	29/07/15	36º 08.782' N	6º 33.470' W	09:07	216	36º 19.203' N	6º 14.817' W	11:01	27
R03	Cádiz	30/07/15	36º 27.127' N	6º 19.269' W	06:11	32	36º 16.250' N	6º 37.899' W	10:18	246
R04	Rota	30/07/15	36º 23,429' N	6º 42.054' W	11:20	256	36º 34.556' N	6º 23.076' W	18:10	21
R05	Chipiona	31/07/15	36º 40.078' N	6º 29.990' W	06:04	23	36º 30.970' N	6º 46.291' W	07:41	197
R06	Doñana	31/07/15	36º 37.019' N	6º 53.573' W	10:21	203	36º 46.447' N	6º 35.889' W	13:35	23
R07	Matalascañas	01/08/15	36º 43.959' N	6º 58.038' W	06:21	177	36º 53.689' N	6º 40.752' W	09:56	20
R08	Mazagón	01/08/15	37º 15.670' N	6º 44.432' W	10:53	21	36º 49.652' N	7º 06.395' W	14:34	104
R09	Punta Umbría	02/08/15	36º 49.694' N	7º 06.360' W	07:22	165	37º 03.332' N	6º 56.760' W	11:07	20
R10	El Rompido	02/08/15	37º 06.881' N	7º 06.895º W	12:08	23	36º 49.822' N	7º 06.803' W	14:46	219
R11	Isla Cristina	03/08/15	37º 06.955' N	7º 16.991' W	05:59	23	36º 53.200' N	07º 16.714' W	09:29	144
R12	V.R. do Sto. Antonio	03/08/15	36º 56.377' N	7º 26.502' W	14:35	160	37º 06.321' N	7º 26.516' W	15:34	22
R13	Tavira	04/08/15	36º 57.223' N	7º 36.072' N	06:07	123	37º 04.910' N	7º 36.085' W	06:48	20
R14	Fuzeta	04/08/15	36º 55.905' N	7º 45.988' W	13:53	160	36º 59.233' N	7º 45.876' W	14:19	80
R15	Cabo Sta. María	05/08/15	36º 55.104' N	7º 56.026' W	06:08	75	36º 52.102' N	7º 55.999' W	06:26	158
R16	Cuarteira	05/08/15	36º 50.191' N	8º 05.871' W	07:32	114	37º 01.264' N	8º 05.895' W	10:18	20
R17	Albufeira	06/08/15	36º 49.383' N	08º 15.490' W	06:05	196	37º 02.430' N	8º 15.428' W	09:10	26
R18	Alfanzina	06/08/15	37º 03.963' N	8º 25.288' N	10:50	35	36º 50.324' N	8º 25.303' W	12:21	217
R19	Portimao	07/08/15	37º 05.382' N	8º 35.410' W	06:02	34	36º 51.380' N	8º 35.400' W	07:26	209
R20	Burgau	07/08/15	36º 52.436' N	8º 44.940' W	10:19	109	37º 03.855' N	8º 45.005' W	11:41	29
R21	Punta de Sagres	07/08/15	37º 00.430' N	8º 55.024' W	12:43	24	36º 50.616' N	8º 55.007' W	13:42	192

Table 2. *ECOCADIZ 2015-07* survey. Descriptive characteristics of the fishing stations. Null hauls in light grey.

Fishing station	Date	Start		End		UTC Time		Depth (m)		Duration (min.)		Trawled Distance (nm)	Acoustic transect	Zone (landmark)
		Latitude	Longitude	Latitude	Longitude	Start	End	Start	End	Effective trawling	Total manoeuvre			
01	28-07-2015	36º 28.2810 N	6º 28.9879 W	36º 27.3140 N	6º 28.4989 W	16:32	16:45	56,84	55,30	00:13	n.a	1,04	n.a.	TEST HAULS
02	28-07-2015	36º 23.2678 N	6º 27.4259 W	36º 23.4269 N	6º 27.3890 W	17:42	17:45	60,45	60,34	00:03	00:33	0,16	n.a	
03	29-07-2015	36º 16.0768 N	6º 20.4979 W	36º 13.9151 N	6º 23.9889 W	11:59	12:52	52,12	47,45	00:53	01:16	3,55	R02i	Sancti-Petri
04	30-07-2015	36º 25.3319 N	6º 24.1559 W	36º 22.4079 N	6º 22.3459 W	07:43	08:33	47,02	47,00	00:50	01:14	3,27	R03	Cádiz
05	30-07-2015	36º 30.6919 N	6º 29.9479 W	36º 29.0750 N	6º 32.6220 W	13:47	14:27	71,42	55,33	00:40	01:03	2,69	R04	Rota
06	30-07-2015	36º 30.4319 N	6º 27.3649 W	36º 32.7900 N	6º 29.6270 W	16:28	17:08	47,42	46,53	00:40	01:06	2,98	R04	Rota
07	31-07-2015	36º 32.1890 N	6º 43.8599 W	36º 33.9099 N	6º 40.9610 W	08:11	08:51	91,05	116,11	00:40	01:13	2,90	R05	Chipiona
08	31-07-2015	36º 42.2129 N	6º 43.7989 W	36º 40.5919 N	6º 46.7429 W	12:08	12:50	97,10	67,92	00:42	01:12	2,87	R06	Doñana
09	31-07-2015	36º 40.1559 N	6º 36.1929 W	36º 41.9270 N	6º 38.2270 W	15:57	16:33	37,67	38,30	00:36	00:59	2,41	No data	No data
10	01-08-2015	36º 45.7310 N	6º 54.8749 W	36º 44.5930 N	6º 57.0380 W	07:23	07:53	131,12	110,11	00:30	01:14	2,08	R07	Matalascañas
11	01-08-2015	36º 53.4738 N	6º 59.1979 W	36º 55.1390 N	6º 56.6409 W	13:06	13:44	69,20	93,43	00:38	01:16	2,64	R08	Mazagón
12	02-08-2015	36º 53.1990 N	7º 03.5749 W	36º 50.6160 N	7º 04.8579 W	08:26	09:07	130,89	104,76	00:41	01:14	2,78	No data	No data
13	03-08-2015	37º 00.5039 N	7º 15.4910 W	37º 00.5039 N	7º 12.9119 W	07:44	08:13	72,48	73,57	00:29	01:00	2,07	No data	No data
14	03-08-2015	36º 55.5198 N	7º 13.7529 W	36º 56.3809 N	7º 16.9010 W	11:38	12:17	110,84	111,74	00:39	01:18	2,67	R11	Isla Cristina
15	04-08-2015	37º 02.1679 N	7º 37.8149 W	37º 02.9720 N	7º 35.6199 W	07:44	08:15	50,65	61,04	00:31	00:56	1,93	R13	Tavira
16	04-08-2015	37º 00.1430 N	7º 35.9080 W	36º 57.3060 N	7º 35.9339 W	11:38	12:20	172,28	96,77	00:42	01:16	2,83	R13	Tavira
17	04-08-2015	36º 55.4850 N	7º 45.5340 W	36º 57.4188 N	7º 46.4499 W	14:59	15:27	87,60	107,63	00:28	00:49	2,07	R14	Fuzeta
18	05-08-2015	36º 53.4990 N	8º 05.7380 W	36º 51.6169 N	8º 05.7679 W	08:15	08:42	110,27	95,71	00:27	01:00	1,88	R16	Cuarteira
19	05-08-2015	36º 56.9801 N	8º 02.9600 W	36º 56.9579 N	8º 04.8430 W	11:33	11:55	43,93	43,65	00:22	00:56	1,51	R16	Cuarteira
20	06-08-2015	36º 54.3800 N	8º 15.6069 W	36º 52.0390 N	8º 15.5600 W	07:02	07:35	114,12	96,95	00:33	01:03	2,34	R17	Albufeira
21	06-08-2015	36º 56.9989 N	8º 19.3429 W	36º 57.0169 N	8º 22.3990 W	14:33	15:09	80,31	77,36	00:36	00:54	2,45	R17	Albufeira
22	07-08-2015	36º 52.0619 N	8º 35.4089 W	36º 53.7950 N	8º 35.3470 W	08:11	08:37	111,72	116,30	00:26	01:14	1,73	R19	Portimao

Table 3. *ECOCADIZ 2015-07* survey. Catches by species in number (upper panel) and weight (in kg, lower panel) from valid fishing stations.

ABUNDANCE (nº)												
Fishing station	***Anchovy***	***Sardine***	***Chub mack.***	***Mackerel***	***Horse-mack.***	***Blue Jack-mack.***	***Medit. Horse-mack.***	***Bogue***	***Blue whiting***	***Boarfish***	**Other spp.**	**TOTAL**
03	0	0	10	0	0	0	1695	0	0	0	212	**1917**
04	155	22	0	0	0	0	133	1	0	0	316	**627**
05	8197	3856	0	2	4	0	0	4	0	0	37	**12100**
06	6701	1106	1	0	6	0	65	8	0	0	154	**8041**
07	9156	335	2	4	4	0	0	0	0	0	128	**9629**
08	21701	2961	2	3	8	0	0	1	0	0	153	**24829**
09	8440	6585	3	0	3	0	17	4	0	0	110	**15162**
10	28617	600	0	4	905	2	0	0	0	0	118	**30246**
11	7674	506	4	71	3	0	0	1	0	0	117	**8376**
12	25052	760	3	13	44	58	0	0	0	0	180	**26110**
13	30597	2069	0	1	0	0	0	0	0	0	141	**32808**
14	7837	551	9	9	212	65	0	0	0	0	249	**8932**
15	0	10930	6064	25	10	27	0	37	0	0	176	**17269**
16	7	189	6116	3	789	1913	0	0	0	105	30	**9152**
18	87	10	221	21	6086	881	0	0	4569	0	711	**12586**
19	0	21	164	0	62	16	0	2	0	0	167	**432**
20	104	8	22	18	16498	271	0	4	24	0	397	**17346**
21	1465	6250	4645	5	1376	46	0	81	0	0	357	**14225**
22	0	8296	556	4	384	47486	0	45	101	7	60	**56939**
TOTAL	**155790**	**45055**	**17822**	**183**	**26394**	**50765**	**1910**	**188**	**4694**	**112**	**3813**	**306726**

BIOMASS (kg)												
Fishing station	***Anchovy***	***Sardine***	***Chub mack.***	***Mackerel***	***Horse-mack.***	***Blue Jack-mack.***	***Medit. Horse-mack.***	***Bogue***	***Blue whiting***	***Boarfish***	**Other spp.**	**TOTAL**
03	0	0	3,194	0	0	0	281,800	0	0	0	45,402	**330,396**
04	1,186	0,548	0	0	0	0	26,150	0,226	0	0	42,210	**70,320**
05	44,500	44,100	0	0,538	0,270	0	0	0,614	0	0	2,722	**92,744**
06	32,950	13,212	0,242	0	0,162	0	13,850	1,662	0	0	13,614	**75,692**
07	84,200	4,306	0,210	0,528	0,122	0	0	0	0	0	7,571	**96,937**
08	133,700	35,810	0,402	0,632	0,178	0	0	0,148	0	0	7,189	**178,059**
09	28,750	62,926	0,700	0	0,142	0	3,572	0,658	0	0	34,792	**131,540**
10	280,850	7,650	0	0,806	8,500	0,068	0	0	0	0	19,482	**317,356**
11	59,450	5,752	0,512	13,450	0,056	0	0	0,202	0	0	7,544	**86,966**
12	321,900	10,488	0,180	2,192	0,386	1,124	0	0	0	0	40,941	**377,211**
13	259,800	25,550	0	0,226	0	0	0	0	0	0	6,738	**292,314**
14	119,650	10,050	0,412	1,546	2,648	1,398	0	0	0	0	21,150	**156,854**
15	0	761,420	768,076	5,949	0,741	1,585	0	5,173	0	0	34,064	**1577,008**
16	0,204	11,550	468,300	0,532	11,650	93,800	0	0	0	0,614	3,514	**590,164**
18	1,602	0,422	25,485	3,984	582,350	59,950	0	0	88,650	0	34,062	**796,505**
19	0	1,390	20,200	0	4,250	1,008	0	0,208	0	0	28,776	**55,832**
20	2,640	0,458	1,884	4,768	680,650	11,700	0	0,416	0,508	0	26,548	**729,572**
21	29,990	466,830	582,570	1,284	103,412	2,806	0	8,650	0	0	20,468	**1216,010**
22	0	493,989	41,966	1,600	4,107	2783,388	0	4,618	1,768	0,034	4,857	**3336,327**
TOTAL	**1401,372**	**1956,451**	**1914,333**	**38,035**	**1399,624**	**2956,827**	**325,372**	**22,575**	**90,926**	**0,648**	**401,644**	**10507,807**

Table 4. *ECOCADIZ 2015-07* survey. Parameters of the size-weight relationships for survey's target species. FAO codes for the species: PIL: *Sardina pilchardus*; ANE: *Engraulis encrasicolus*; MAS: *Scomber colias*; MAC: *Scomber scombrus*; JAA: *Trachurus picturatus;* HOM: *Trachurus trachurus*; HMM: *Trachurus mediterraneus*; BOG: *Boops boops*; WHB: *Micromesistius poutassou*; BOC: *Capros aper*.

Parameter	PIL	ANE	MAS	MAC	JAA	HOM	HMM	BOG	WHB	BOC
n	832	935	346	147	375	779	167	102	67	104
a	0,0032841	0,0025842	0,0037685	0,0011541	0,0045714	0,0063080	0,0288680	0,0144710	1,1600958	0,0275365
b	3,3258776	3,3588280	3,2463239	3,5490388	3,2085855	3,0986631	2,6106969	2,8711550	1,0360549	2,8409697
r^2	0,9881491	0,9799551	0,9683588	0,9671916	0,9820176	0,9946606	0,8350312	0,9553940	0,2086417	0,8461715

Table 5. *ECOCADIZ 2015-07* survey. Anchovy (*E. encrasicolus*). Estimated abundance (absolute numbers and million fish) and biomass (t) by size class (in cm). Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figure 9**.

***ECOCADIZ 2015-07*. *Engraulis encrasicolus*. ABUNDANCE (in number and million fish)**															
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	**POL09**	**POL10**	***n***			**millions**		
											PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
6	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
6,5	0	0	83224	0	563323	0	0	0	0	0	83224	563323	646547	**0,1**	**1**	**1**
7	0	0	332895	0	2253295	0	9668684	0	0	0	332895	11921979	12254874	**0,3**	**12**	**12**
7,5	0	0	1748750	0	11836929	0	125546382	0	0	0	1748750	137383311	139132061	**2**	**137**	**139**
8	0	0	2415592	0	16350649	0	251166011	8955528	0	0	2415592	276472188	278887780	**2**	**276**	**279**
8,5	0	0	1415855	0	9583635	0	170666904	82567194	0	0	1415855	262817733	264233588	**1**	**263**	**264**
9	0	0	499342	0	3379941	0	38674731	143227947	0	0	499342	185282619	185781961	**0,5**	**185**	**186**
9,5	0	0	720954	0	4879991	0	12891577	137394611	2352741	599718	720954	158118638	158839592	**1**	**158**	**159**
10	0	0	5074524	310517	34348415	1943326	6445792	106566167	16879684	1759172	5385041	167942556	173327597	**5**	**168**	**173**
10,5	0	0	20161712	776870	136470504	4861929	3222893	68179072	79551178	1839134	20938582	294124710	315063292	**21**	**294**	**315**
11	0	0	16925684	2098723	114566489	13134560	0	45095297	119168678	1199435	19024407	293164459	312188866	**19**	**293**	**312**
11,5	0	0	8601135	5483546	58219323	34318002	0	16411715	118218004	479774	14084681	227646818	241731499	**14**	**228**	**242**
12	1059733	18848	2785264	10779193	18852880	67460064	0	12022733	64637723	119944	14643038	163093344	177736382	**15**	**163**	**178**
12,5	4178377	83124	2035197	11790257	13775835	73787667	0	2968197	26995896	79962	18086955	117607557	135694512	**18**	**118**	**136**
13	11869012	224008	833290	11708481	5640368	73275886	0	0	20568164	79962	24634791	99564380	124199171	**25**	**100**	**124**
13,5	16077667	322849	499342	7459560	3379941	46684608	0	1978797	5738474	79962	24359418	57861782	82221200	**24**	**58**	**82**
14	7327298	141969	249671	4298906	1689972	26904101	0	0	1024998	0	12017844	29619071	41636915	**12**	**30**	**42**
14,5	3148922	77693	0	1984884	0	12422116	0	0	2663482	0	5211499	15085598	20297097	**5**	**15**	**20**
15	363337	34438	0	914965	0	5726179	0	0	0	0	1312740	5726179	7038919	**1**	**6**	**7**
15,5	363337	82166	0	228741	0	1431545	0	0	0	0	674244	1431545	2105789	**1**	**1**	**2**
16	0	85552	83224	0	563323	0	0	0	0	0	168776	563323	732099	**0,2**	**1**	**1**
16,5	0	63318	0	0	0	0	0	0	0	0	63318	0	63318	**0,1**	**0**	**0,1**
17	0	22235	0	0	0	0	0	0	0	0	22235	0	22235	**0,02**	**0**	**0,02**
17,5	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
18	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
TOTAL *n*	44387683	1156200	64465655	57834643	436354813	361949983	618282974	625367258	457799022	6237063	167844181	2505991113	2673835294	**168**	**2506**	**2674**
Millions	**44**	**1**	**64**	**58**	**436**	**362**	**618**	**625**	**458**	**6**						

Table 5. *ECOCADIZ 2015-07* survey. Anchovy (*E. encrasicolus*). Cont'd.

***ECOCADIZ 2015-07 . Engraulis encrasicolus* . BIOMASS (t)**													
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	**POL09**	**POL10**	**PORTUGAL**	**SPAIN**	**TOTAL**
6	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
6,5	0	0	0,131	0	0,888	0	0	0	0	0	**0,131**	**0,888**	**1,019**
7	0	0	0,667	0	4,517	0	19,383	0	0	0	**0,667**	**23,90**	**24,567**
7,5	0	0	4,386	0	29,688	0	314,878	0	0	0	**4,386**	**344,566**	**348,952**
8	0	0	7,474	0	50,591	0	777,139	27,710	0	0	**7,474**	**855,440**	**862,914**
8,5	0	0	5,338	0	36,133	0	643,456	311,299	0	0	**5,338**	**990,888**	**996,226**
9	0	0	2,269	0	15,358	0	175,735	650,816	0	0	**2,269**	**841,909**	**844,178**
9,5	0	0	3,910	0	26,463	0	69,908	745,062	12,758	3,252	**3,910**	**857,443**	**861,353**
10	0	0	32,551	1,992	220,334	12,466	41,348	683,587	108,278	11,285	**34,543**	**1077,298**	**1111,841**
10,5	0	0	151,767	5,848	1027,280	36,598	24,260	513,217	598,821	13,844	**157,615**	**2214,02**	**2371,635**
11	0	0	148,427	18,404	1004,673	115,181	0	395,456	1045,031	10,518	**166,831**	**2570,859**	**2737,690**
11,5	0	0	87,288	55,649	590,836	348,275	0	166,553	1199,729	4,869	**142,937**	**2310,262**	**2453,199**
12	12,370	0,220	32,513	125,827	220,073	787,472	0	140,343	754,527	1,400	**170,93**	**1903,815**	**2074,745**
12,5	55,790	1,110	27,174	157,423	183,934	985,210	0	39,631	360,448	1,068	**241,497**	**1570,291**	**1811,788**
13	180,331	3,403	12,661	177,892	85,697	1113,314	0	0	312,502	1,215	**374,287**	**1512,728**	**1887,015**
13,5	276,638	5,555	8,592	128,352	58,157	803,273	0	34,048	98,738	1,376	**419,137**	**995,592**	**1414,729**
14	142,146	2,754	4,844	83,397	32,785	521,928	0	0	19,885	0	**233,141**	**574,598**	**807,739**
14,5	68,590	1,692	0	43,235	0	270,579	0	0	58,016	0	**113,517**	**328,595**	**442,112**
15	8,852	0,839	0	22,291	0	139,506	0	0	0	0	**31,982**	**139,506**	**171,488**
15,5	9,865	2,231	0	6,211	0	38,868	0	0	0	0	**18,307**	**38,868**	**57,175**
16	0	2,580	2,510	0	16,988	0	0	0	0	0	**5,090**	**16,988**	**22,078**
16,5	0	2,114	0	0	0	0	0	0	0	0	**2,114**	**0**	**2,114**
17	0	0,819	0	0	0	0	0	0	0	0	**0,819**	**0**	**0,819**
17,5	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
18	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
TOTAL	**754,582**	**23,317**	**532,502**	**826,521**	**3604,395**	**5172,67**	**2066,107**	**3707,722**	**4568,733**	**48,827**	**2136,922**	**19168,454**	**21305,376**

Table 6. *ECOCADIZ 2015-07* survey. Sardine (*S. pilchardus*). Estimated abundance (absolute numbers and million fish) and biomass (t) by size class (in cm). Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figure 12**.

***ECOCADIZ 2015-07*. *Sardina pilchardus*. ABUNDANCE (in number and million fish)**															
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	**POL09**	***n***			**millions**		
										PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
7	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
7,5	0	0	0	7305	0	197399	0	0	0	7305	197399	204704	**0,01**	**0,2**	**0,2**
8	0	0	0	32227	0	870879	0	0	0	32227	870879	903106	**0,03**	**1**	**1**
8,5	0	0	0	39531	0	1068278	0	0	0	39531	1068278	1107809	**0,04**	**1**	**1**
9	0	0	0	24922	0	673480	0	0	0	24922	673480	698402	**0,02**	**1**	**1**
9,5	0	0	0	18047	0	487692	0	0	0	18047	487692	505739	**0,02**	**0,5**	**1**
10	0	0	0	22507	0	608204	0	122006765	0	22507	122614969	122637476	**0,02**	**123**	**123**
10,5	0	0	0	292628	0	7907822	0	212672346	117919	292628	220698087	220990715	**0,3**	**221**	**221**
11	0	0	0	1174259	0	31732573	0	103202054	3601884	1174259	138536511	139710770	**1**	**139**	**140**
11,5	0	0	0	1610526	21828	43522023	23989	43803039	9479733	1632354	96828784	98461138	**2**	**97**	**98**
12	0	0	0	766362	574791	20709766	631704	3134117	6374908	1341153	30850495	32191648	**1**	**31**	**32**
12,5	0	0	0	325618	807617	8799340	887584	0	2530870	1133235	12217794	13351029	**1**	**12**	**13**
13	0	0	0	64687	1462442	1748056	1607246	3134117	1180673	1527129	7670092	9197221	**2**	**8**	**9**
13,5	0	0	0	29172	465653	788322	511760	0	235061	494825	1535143	2029968	**0,5**	**2**	**2**
14	0	0	1624	11329	509308	306161	559737	149242	0	522261	1015140	1537401	**1**	**1**	**2**
14,5	0	0	0	8049	145517	217523	159925	223865	0	153566	601313	754879	**0,2**	**1**	**1**
15	0	0	0	8049	21828	217523	23989	596976	0	29877	838488	868365	**0,03**	**1**	**1**
15,5	0	0	0	8049	0	217523	0	895464	0	8049	1112987	1121036	**0,01**	**1**	**1**
16	0	0	0	4025	0	108761	0	373111	0	4025	481872	485897	**0,00**	**0,5**	**0,5**
16,5	0	136956	1624	0	0	0	0	596976	0	138580	596976	735556	**0,1**	**1**	**0,7**
17	1500732	546470	0	0	0	0	0	298488	0	2047202	298488	2345690	**2**	**0,3**	**2**
17,5	0	1777020	19487	0	0	0	0	74623	0	1796507	74623	1871130	**2**	**0,1**	**2**
18	3001465	3774009	50343	0	0	0	0	149242	0	6825817	149242	6975059	**7**	**0,1**	**7**
18,5	14305683	4792190	58462	0	0	0	0	0	0	19156335	0	19156335	**19**	**0**	**19**
19	26350523	4419867	82822	0	0	0	0	0	0	30853212	0	30853212	**31**	**0**	**31**
19,5	36894631	3637778	47095	0	0	0	0	149242	0	40579504	149242	40728746	**41**	**0,1**	**41**
20	45158403	1926381	40599	0	0	0	0	0	23358	47125383	23358	47148741	**47**	**0,02**	**47**
20,5	43657671	629735	4872	0	0	0	0	0	0	44292278	0	44292278	**44**	**0**	**44**
21	26350523	268675	0	0	0	0	0	0	0	26619198	0	26619198	**27**	**0**	**27**
21,5	12044840	44988	0	0	0	0	0	0	0	12089828	0	12089828	**12**	**0**	**12**
22	760111	0	0	0	0	0	0	0	0	760111	0	760111	**1**	**0**	**1**
22,5	3001465	0	0	0	0	0	0	0	0	3001465	0	3001465	**3**	**0**	**3**
23	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
TOTAL *n*	213026047	21954069	306928	4447292	4008984	120181325	4405934	491459667	23544406	243743320	639591332	883334652	**244**	**640**	**883**
Millions	**213**	**22**	**0**	**4**	**4**	**120**	**4**	**491**	**24**						

Table 6. *ECOCADIZ 2015-07* survey. Sardine (*S. pilchardus*). Cont'd

***ECOCADIZ 2015-07*. *Sardina pilchardus*. BIOMASS (t)**												
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	**POL09**	**PORTUGAL**	**SPAIN**	**TOTAL**
7	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
7,5	0	0	0	0,022	0	0,588	0	0	0	**0,022**	**0,588**	**0,610**
8	0	0	0	0,118	0	3,194	0	0	0	**0,118**	**3,194**	**3,312**
8,5	0	0	0	0,176	0	4,765	0	0	0	**0,176**	**4,765**	**4,941**
9	0	0	0	0,134	0	3,614	0	0	0	**0,134**	**3,614**	**3,748**
9,5	0	0	0	0,115	0	3,118	0	0	0	**0,115**	**3,118**	**3,233**
10	0	0	0	0,170	0	4,592	0	921,183	0	**0,170**	**925,775**	**925,945**
10,5	0	0	0	2,589	0	69,954	0	1881,340	1,043	**2,589**	**1952,337**	**1954,926**
11	0	0	0	12,083	0	326,534	0	1061,967	37,064	**12,083**	**1425,565**	**1437,648**
11,5	0	0	0	19,151	0,260	517,538	0,285	520,879	112,727	**19,411**	**1151,429**	**1170,840**
12	0	0	0	10,468	7,851	282,879	8,629	42,810	87,076	**18,319**	**421,394**	**439,713**
12,5	0	0	0	5,081	12,601	137,297	13,849	0	39,489	**17,682**	**190,635**	**208,317**
13	0	0	0	1,147	25,933	30,997	28,501	55,576	20,936	**27,08**	**136,01**	**163,090**
13,5	0	0	0	0,585	9,340	15,812	10,265	0	4,715	**9,925**	**30,792**	**40,717**
14	0	0	0,037	0,256	11,504	6,915	12,643	3,371	0	**11,797**	**22,929**	**34,726**
14,5	0	0	0	0,204	3,686	5,510	4,051	5,671	0	**3,890**	**15,232**	**19,122**
15	0	0	0	0,228	0,618	6,156	0,679	16,896	0	**0,846**	**23,731**	**24,577**
15,5	0	0	0	0,254	0	6,854	0	28,215	0	**0,254**	**35,069**	**35,323**
16	0	0	0	0,141	0	3,802	0	13,044	0	**0,141**	**16,846**	**16,987**
16,5	0	5,296	0,063	0	0	0	0	23,083	0	**5,359**	**23,083**	**28,442**
17	63,993	23,302	0	0	0	0	0	12,728	0	**87,295**	**12,728**	**100,023**
17,5	0	83,328	0,914	0	0	0	0	3,499	0	**84,242**	**3,499**	**87,741**
18	154,368	194,101	2,589	0	0	0	0	7,676	0	**351,058**	**7,676**	**358,734**
18,5	804,958	269,649	3,29	0	0	0	0	0	0	**1077,897**	**0**	**1077,897**
19	1618,328	271,448	5,087	0	0	0	0	0	0	**1894,863**	**0**	**1894,863**
19,5	2467,622	243,305	3,150	0	0	0	0	9,982	0	**2714,077**	**9,982**	**2724,059**
20	3282,209	140,013	2,951	0	0	0	0	0	1,698	**3425,173**	**1,698**	**3426,871**
20,5	3441,276	49,638	0,384	0	0	0	0	0	0	**3491,298**	**0**	**3491,298**
21	2248,229	22,923	0	0	0	0	0	0	0	**2271,152**	**0**	**2271,152**
21,5	1110,311	4,147	0	0	0	0	0	0	0	**1114,458**	**0**	**1114,458**
22	75,570	0	0	0	0	0	0	0	0	**75,570**	**0**	**75,570**
22,5	321,296	0	0	0	0	0	0	0	0	**321,296**	**0**	**321,296**
23	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
TOTAL	15588,160	1307,150	18,465	52,922	71,793	1430,119	78,902	4607,920	304,748	**17038,49**	**6421,689**	**23460,179**

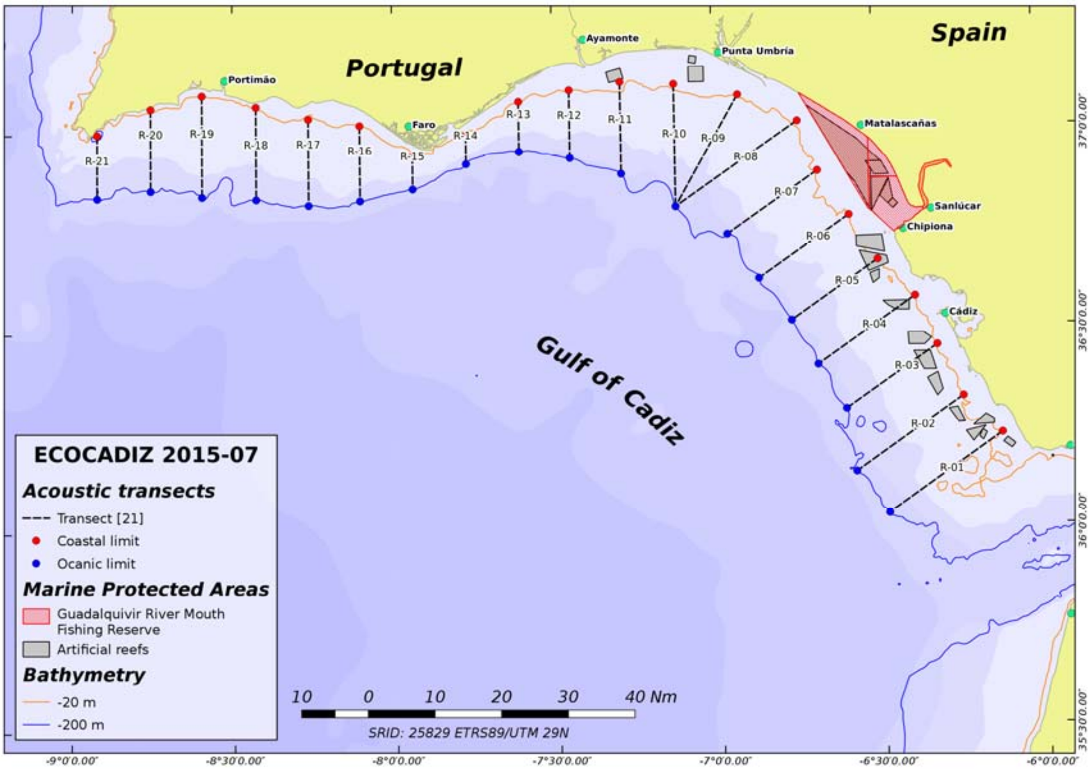


Figure 1. *ECOCADIZ 2015-07* survey. Location of the acoustic transects sampled during the survey. The different protected areas inside the Guadalquivir river mouth Fishing Reserve and artificial reef polygons are also shown.

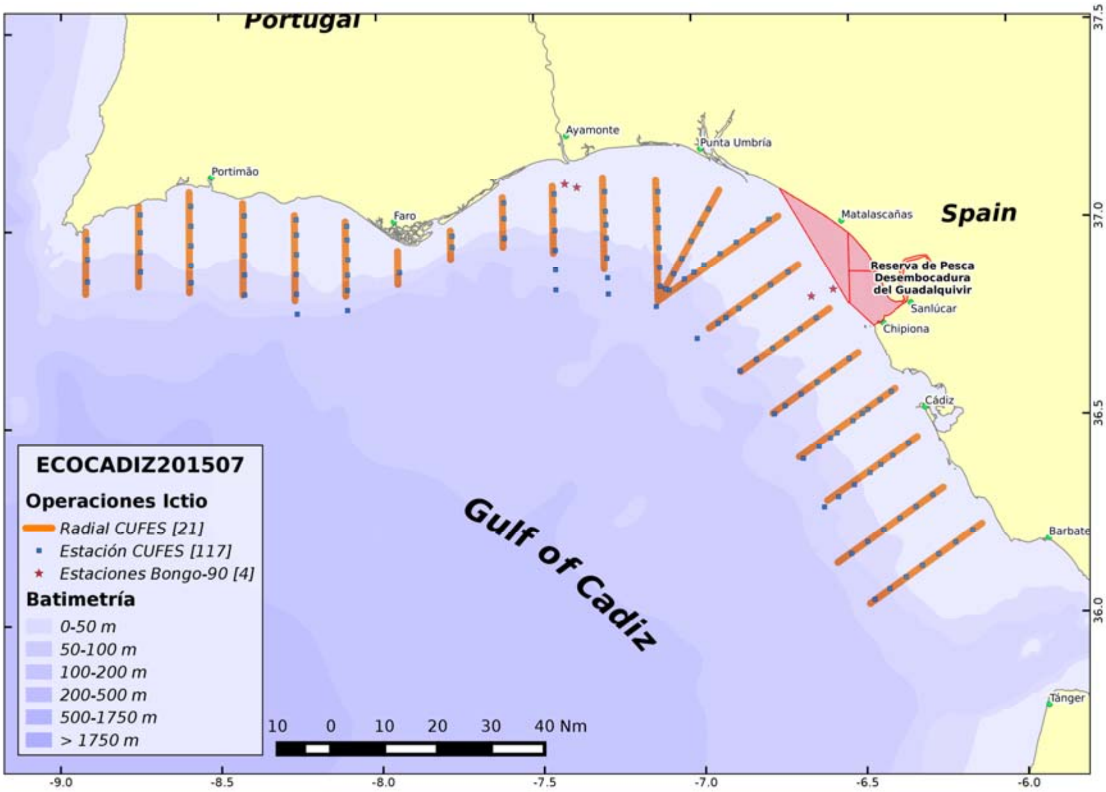


Figure 2. *ECOCADIZ 2015-07* survey. Location of CUFES and Bongo-90 sampling stations.

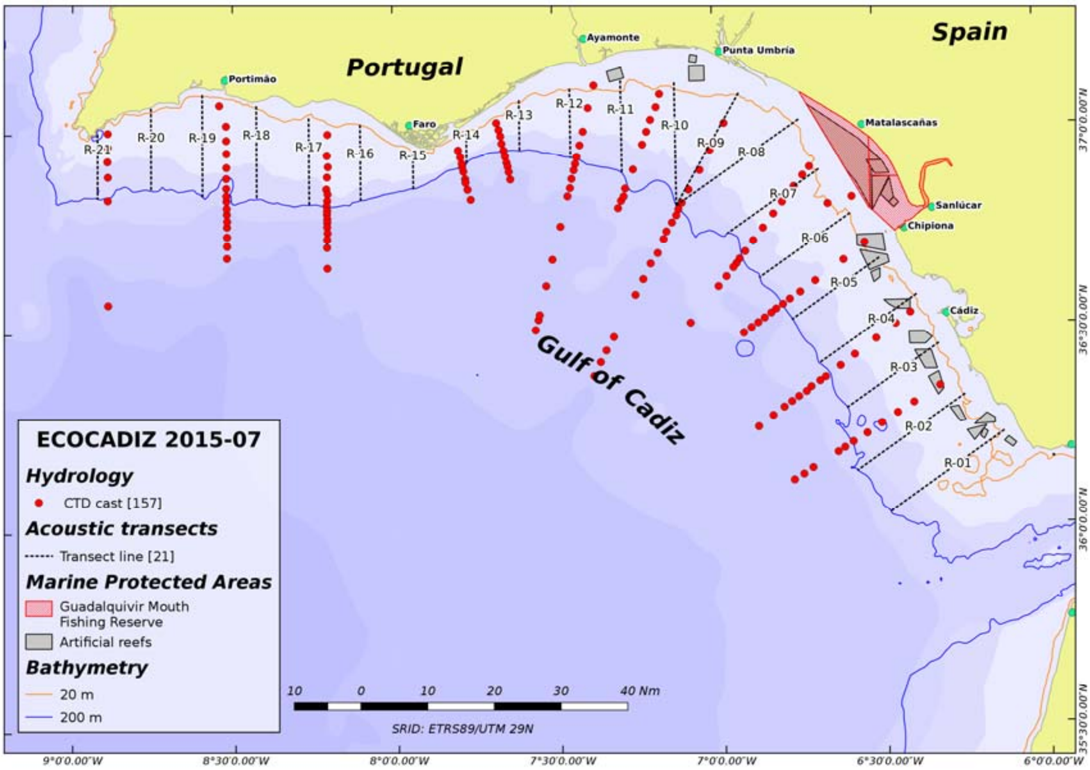


Figure 3. *ECOCADIZ 2015-07* survey. Location of CTD-LADCP stations.

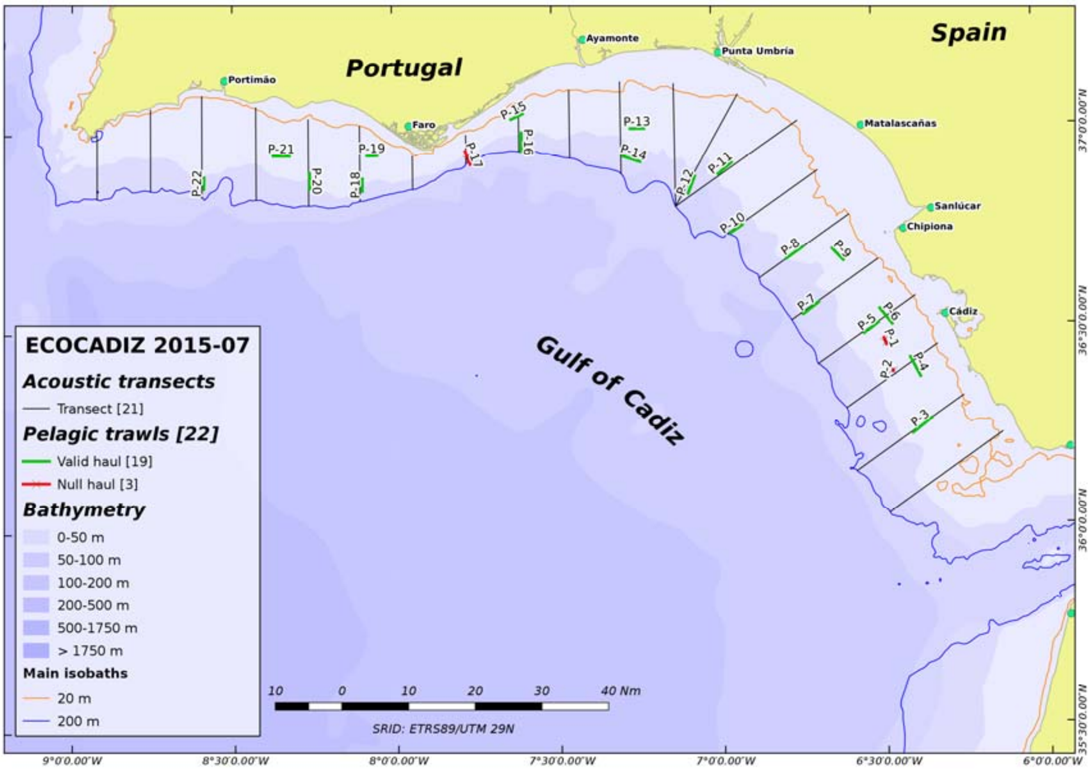


Figure 4. *ECOCADIZ 2015-07* survey. Location of ground-truthing fishing hauls. Null hauls in red.

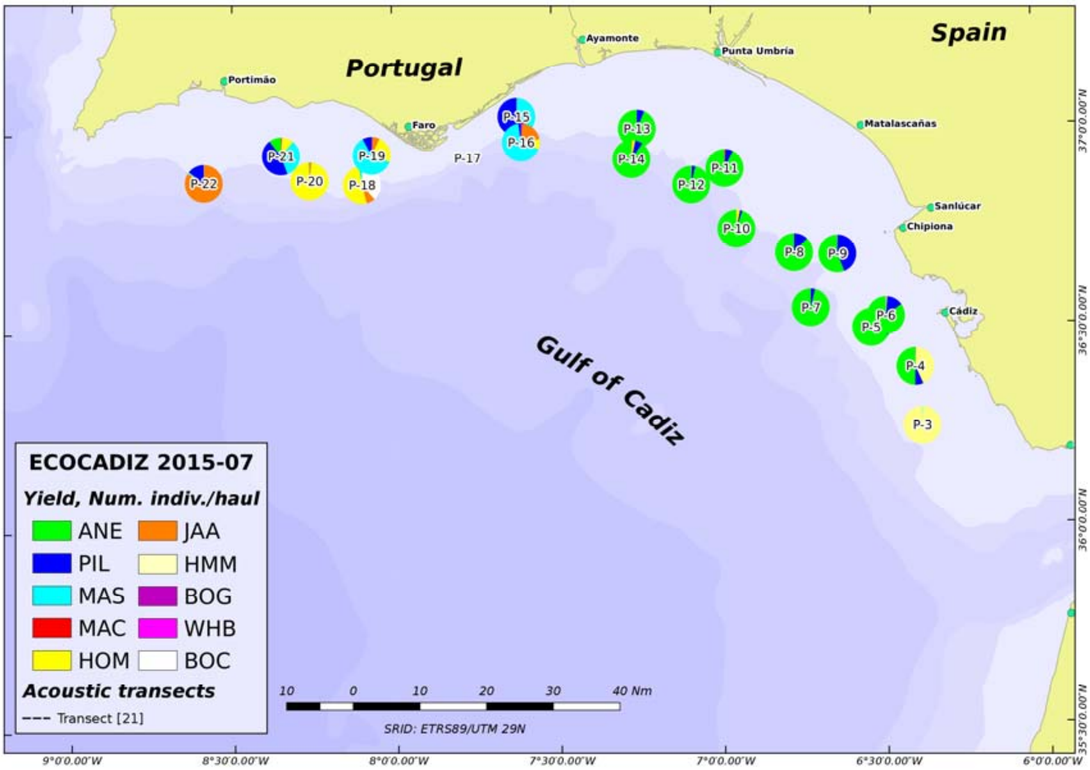


Figure 5. *ECOCADIZ 2015-07* survey. Species composition (percentages in number) in fishing hauls.

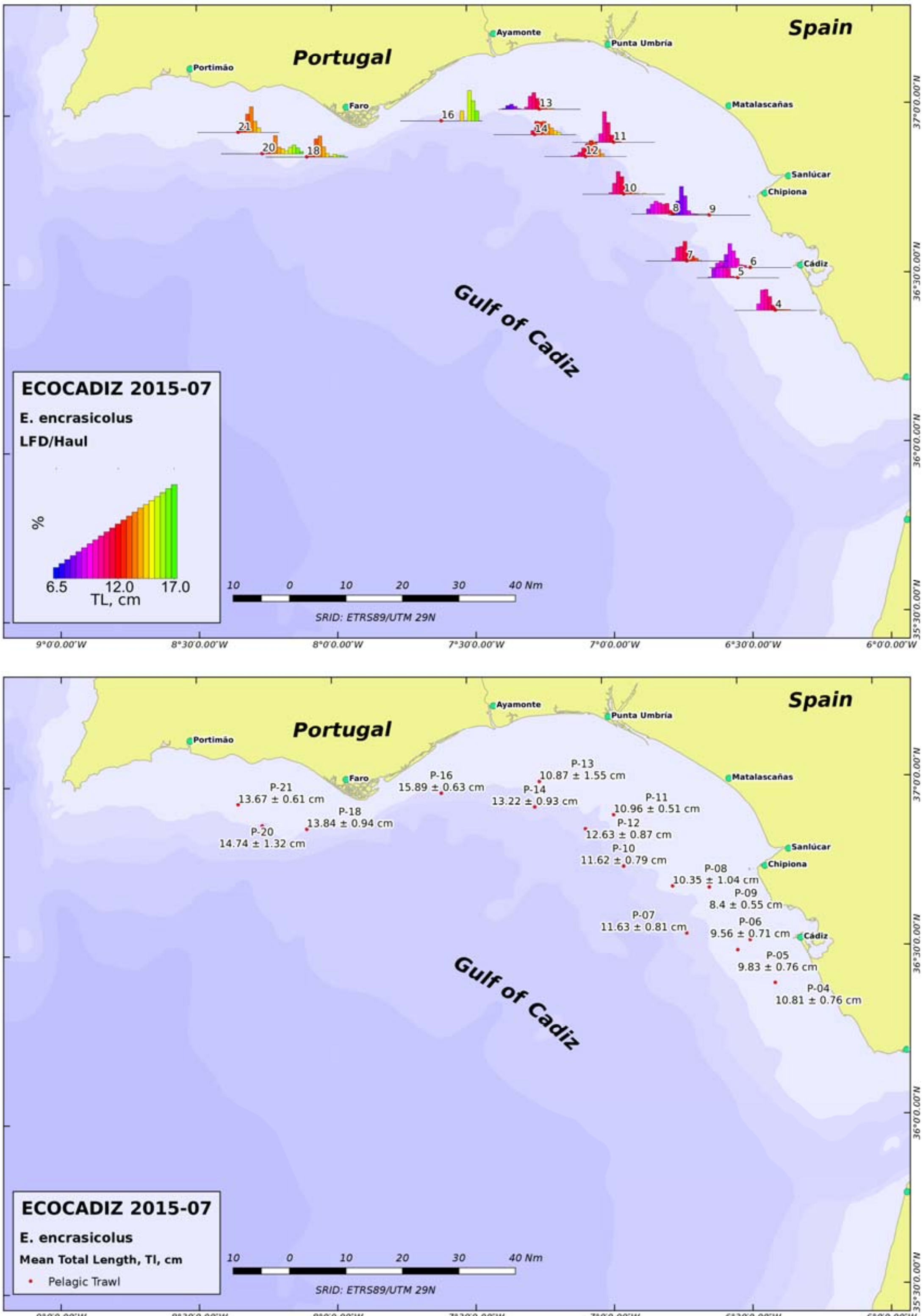


Figure 6. *ECOCADIZ 2015-07* survey. *Engraulis encrasicolus*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

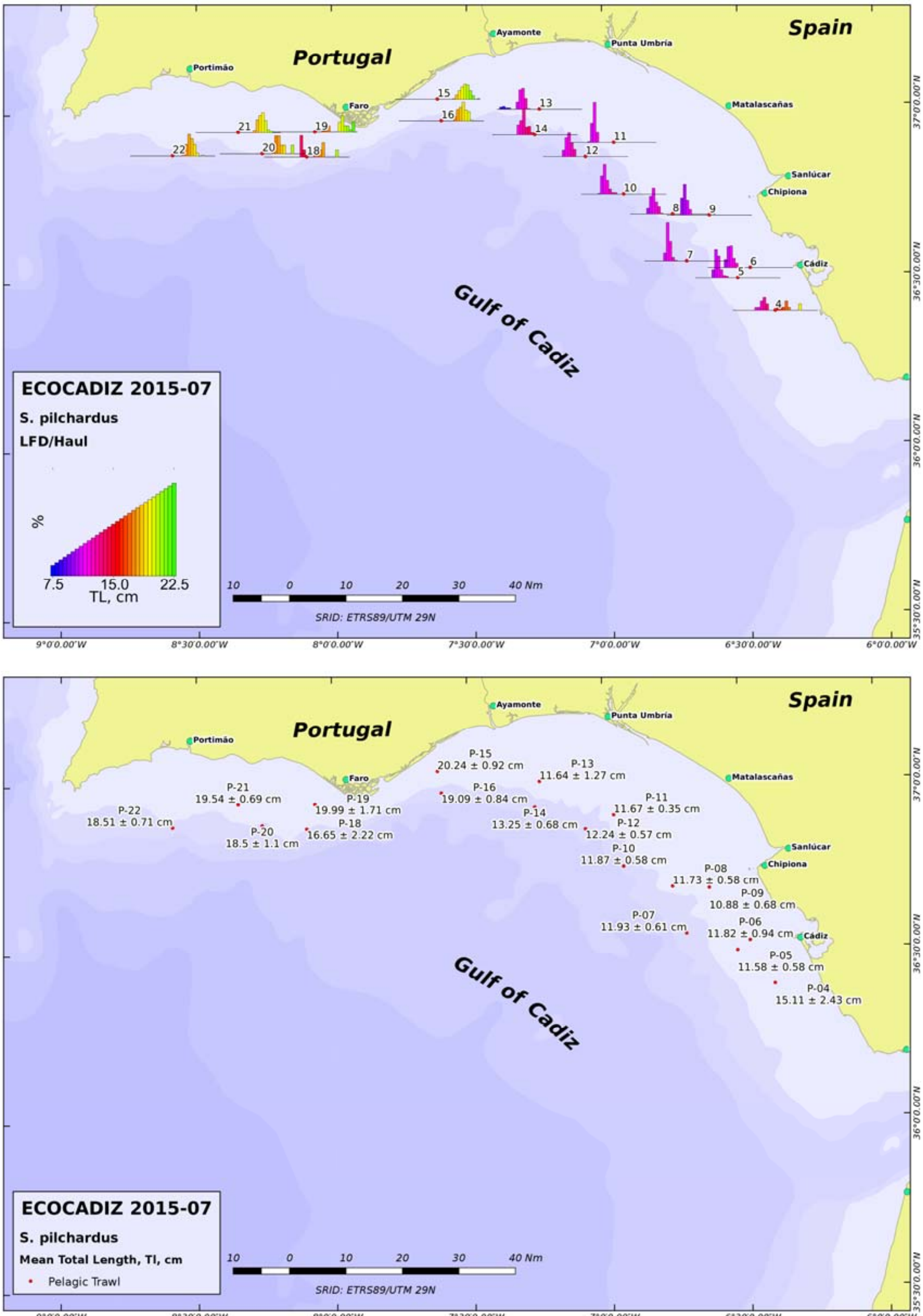


Figure 7. *ECOCADIZ 2015-07* survey. *Sardina pilchardus*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

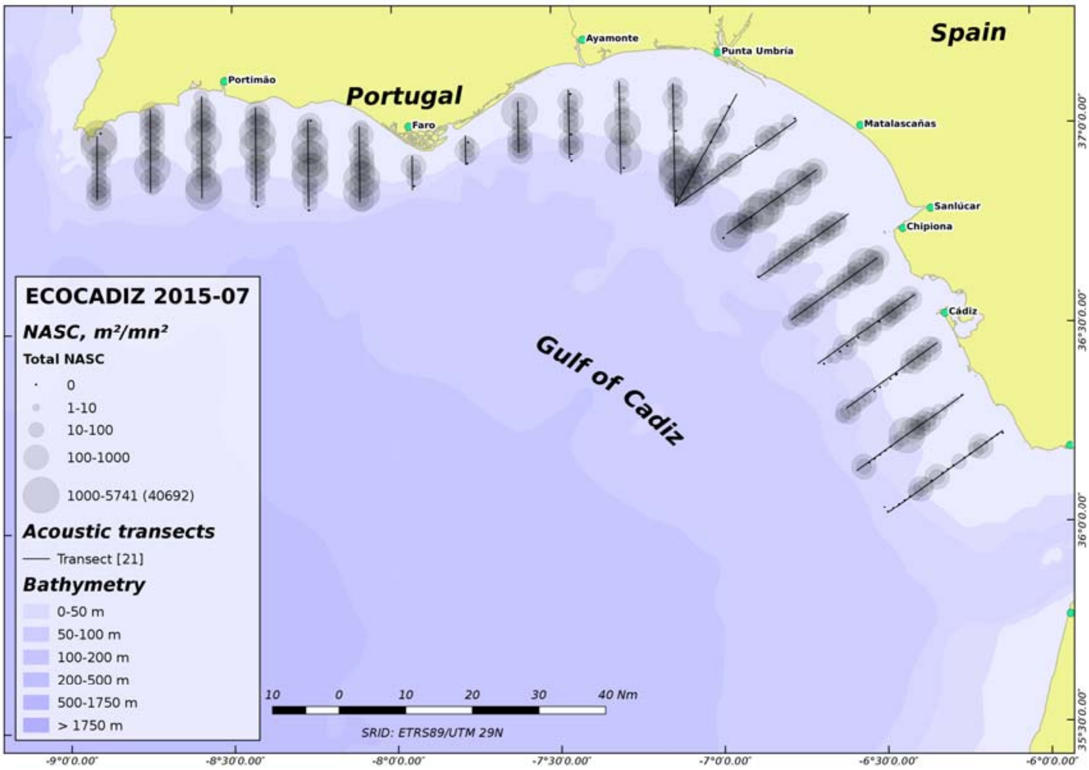


Figure 8. *ECOCADIZ 2015-07* survey. Distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the pelagic fish species assemblage.

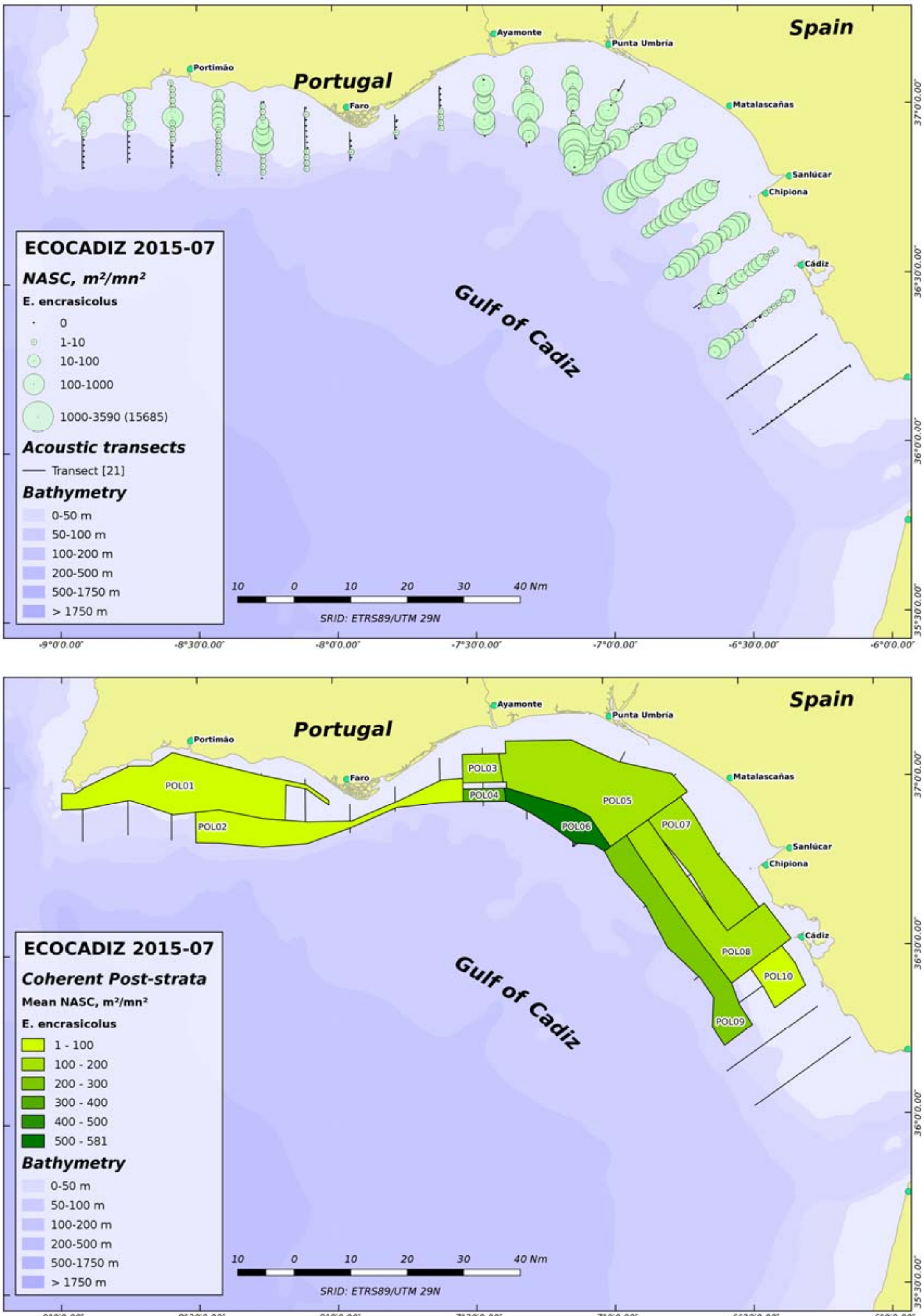


Figure 9. *ECOCADIZ 2015-07* survey. Anchovy (*Engraulis encrasicolus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

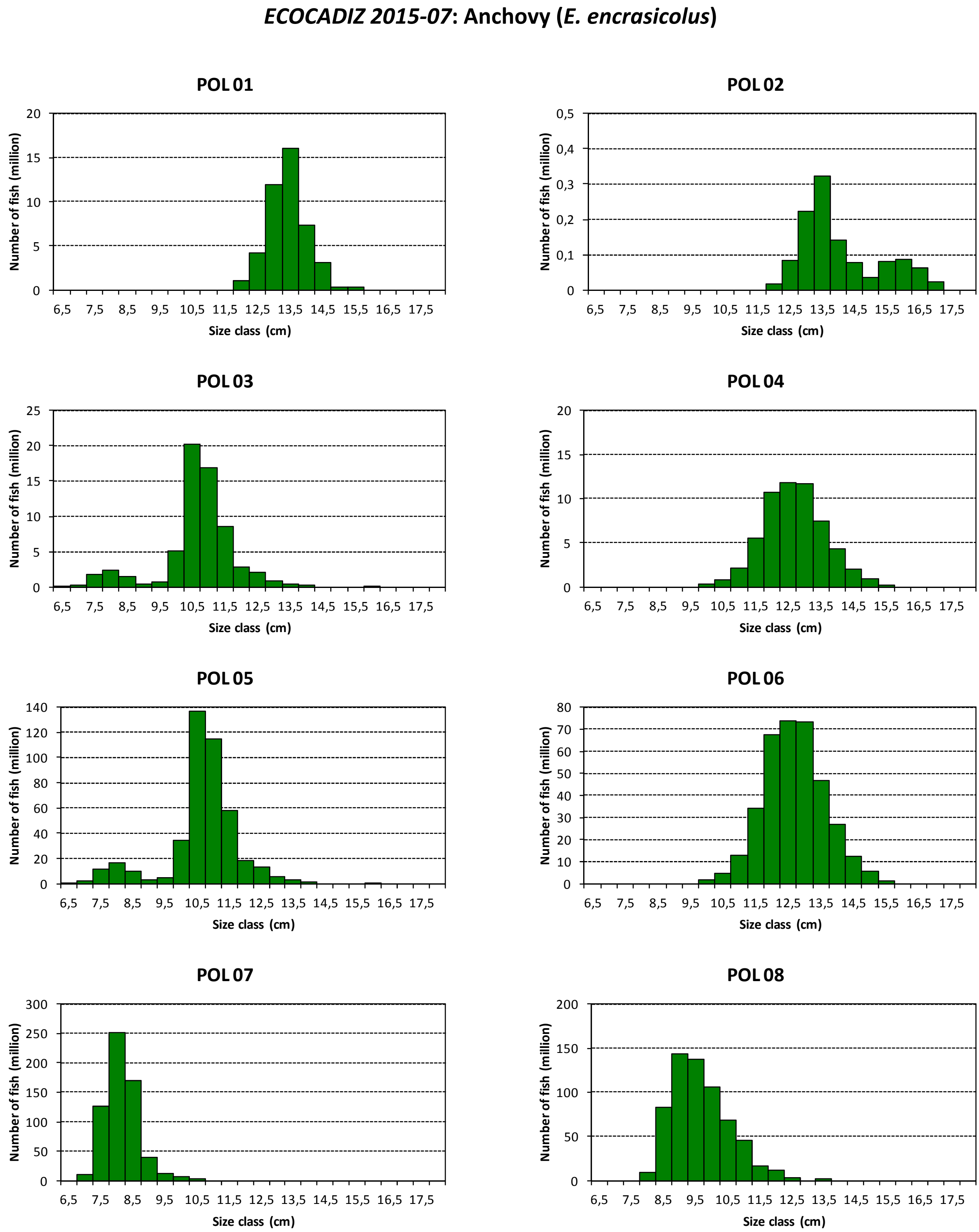


Figure 10. *ECOCADIZ 2015-07* survey. Anchovy (*E. encrasicolus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 9**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

***ECOCADIZ 2015-07*: Anchovy (*E. encrasicolus*)**

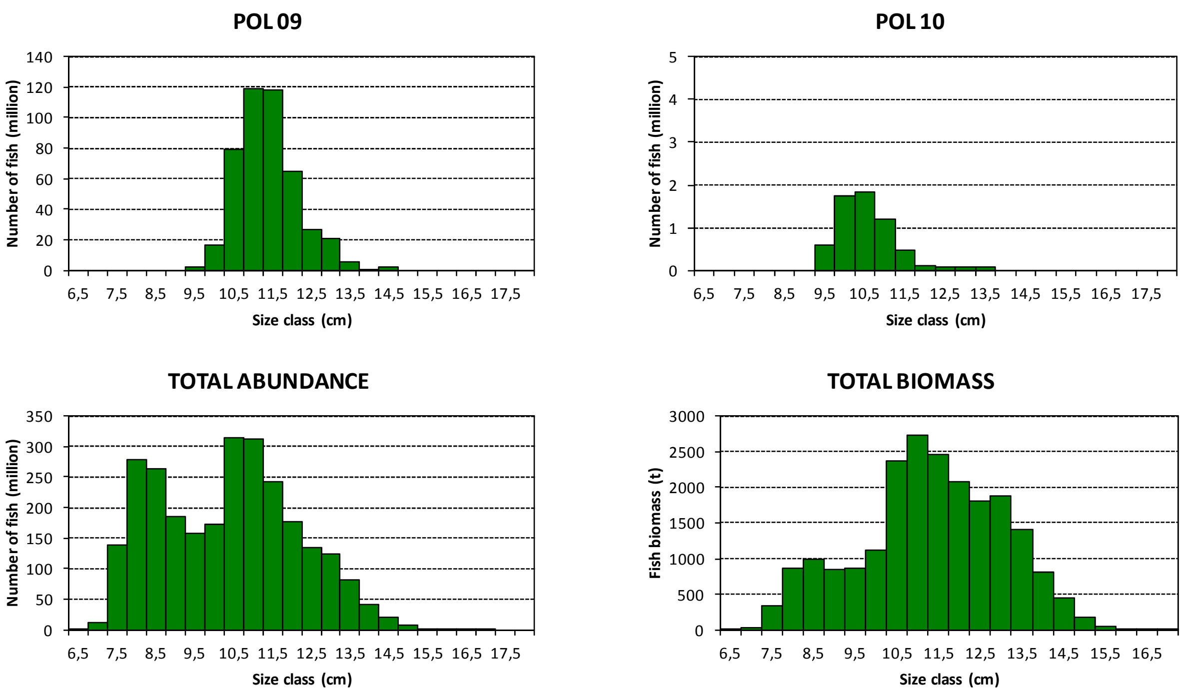
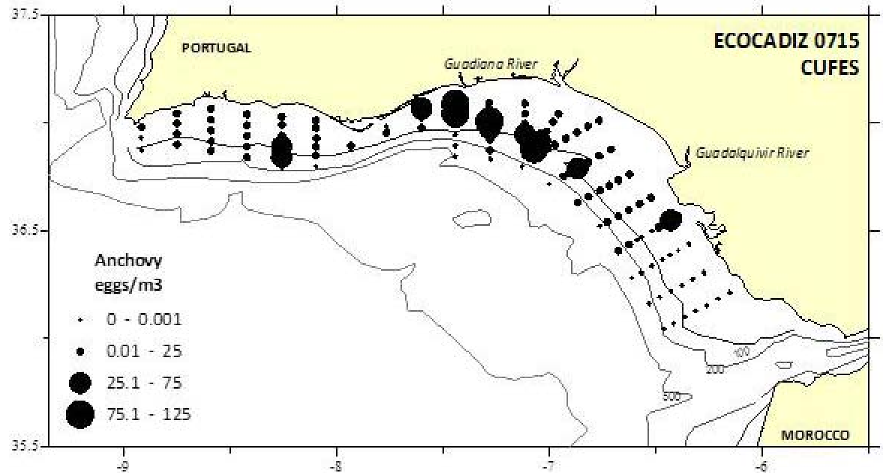


Figure 10. *ECOCADIZ 2015-07* survey. Anchovy (*E. encrasicolus*). Cont'd.



ECOCADIZ 2015-07 CUFES sampling		Spanish waters	Portuguese waters	Gulf of Cadiz
#Transects		11	10	21
#Stations		76	41	117
Anchovy eggs	# total	4640	3966	8606
	# max.	649	743	743
	Total density (eggs/m^3)	566.0	443.7	1009.7
	Max. density (eggs/m^3)	120.7	115.0	120.7
	Mean density (eggs/m^3)	7.5	10.8	8.6

Figure 11. *ECOCADIZ 2015-07* survey. Anchovy (*E. encrasicolus*). Distribution of anchovy egg densities as sampled by CUFES (eggs m^{-3}).

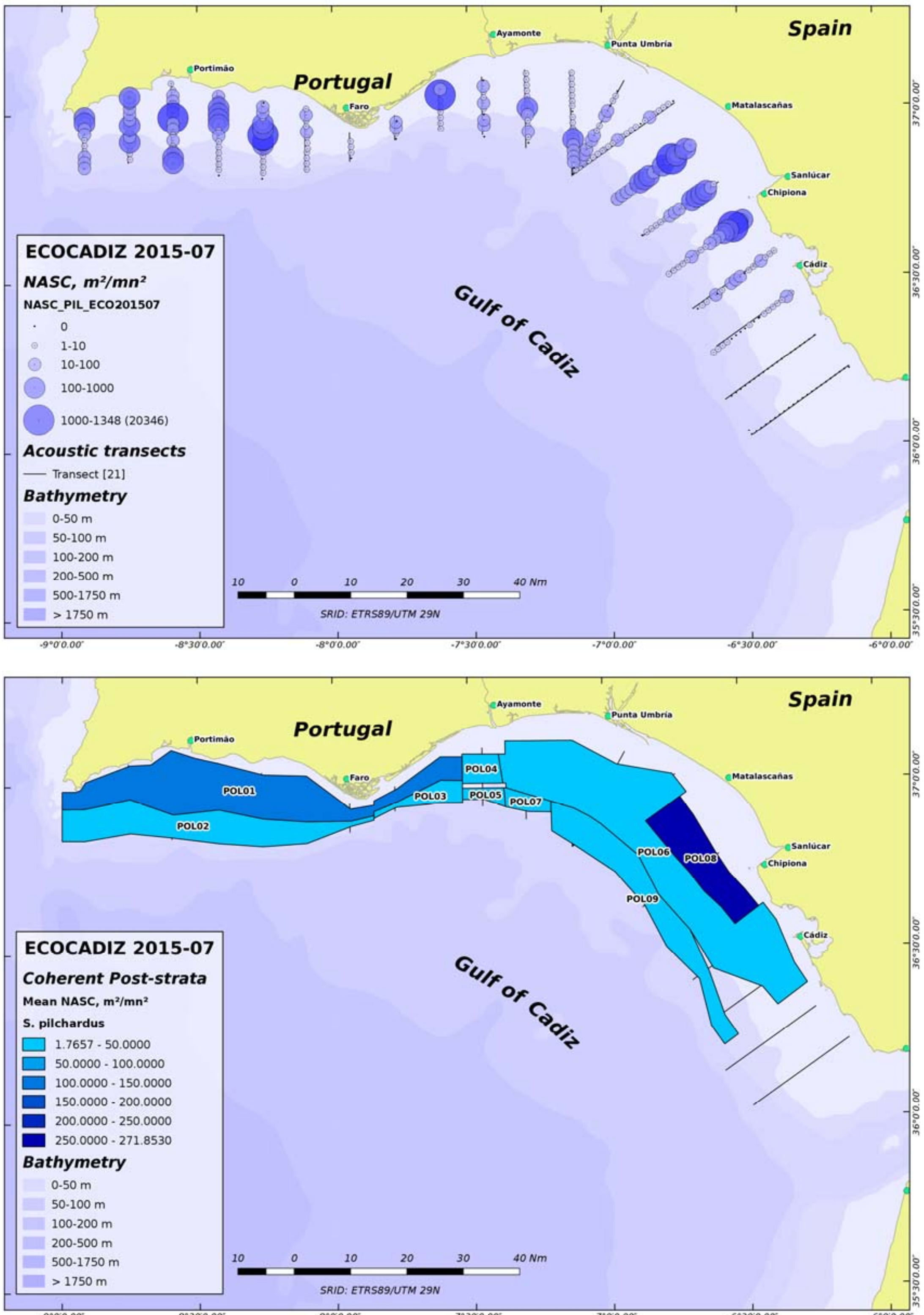


Figure 12. *ECOCADIZ 2015-07* survey. Sardine (*Sardina pilchardus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

***ECOCADIZ 2015-07*: Sardine (*S. pilchardus*)**

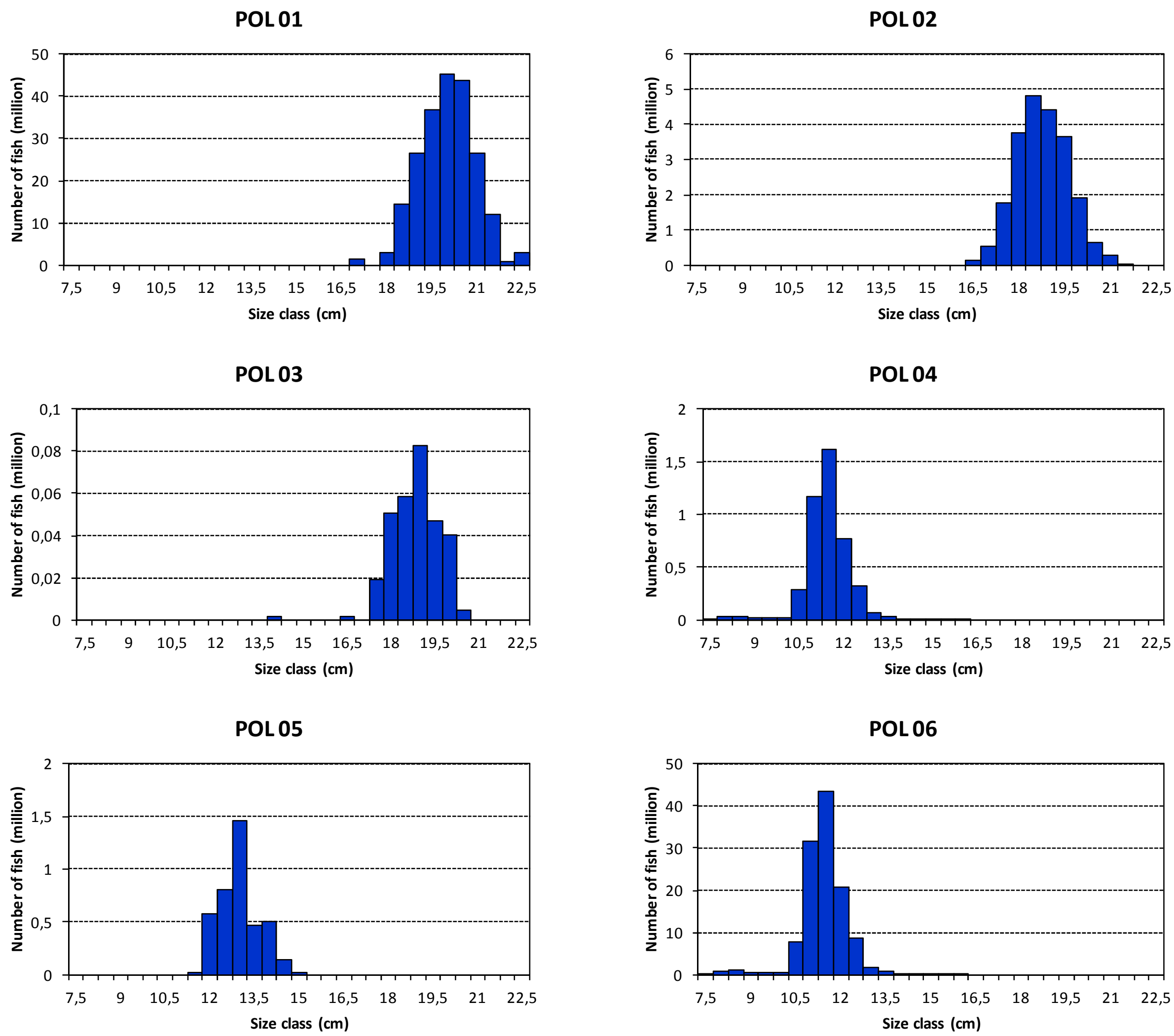


Figure 13. *ECOCADIZ 2015-07* survey. Sardine (*S. pilchardus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 12**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

***ECOCADIZ 2015-07*: Sardine (*S. pilchardus*)**

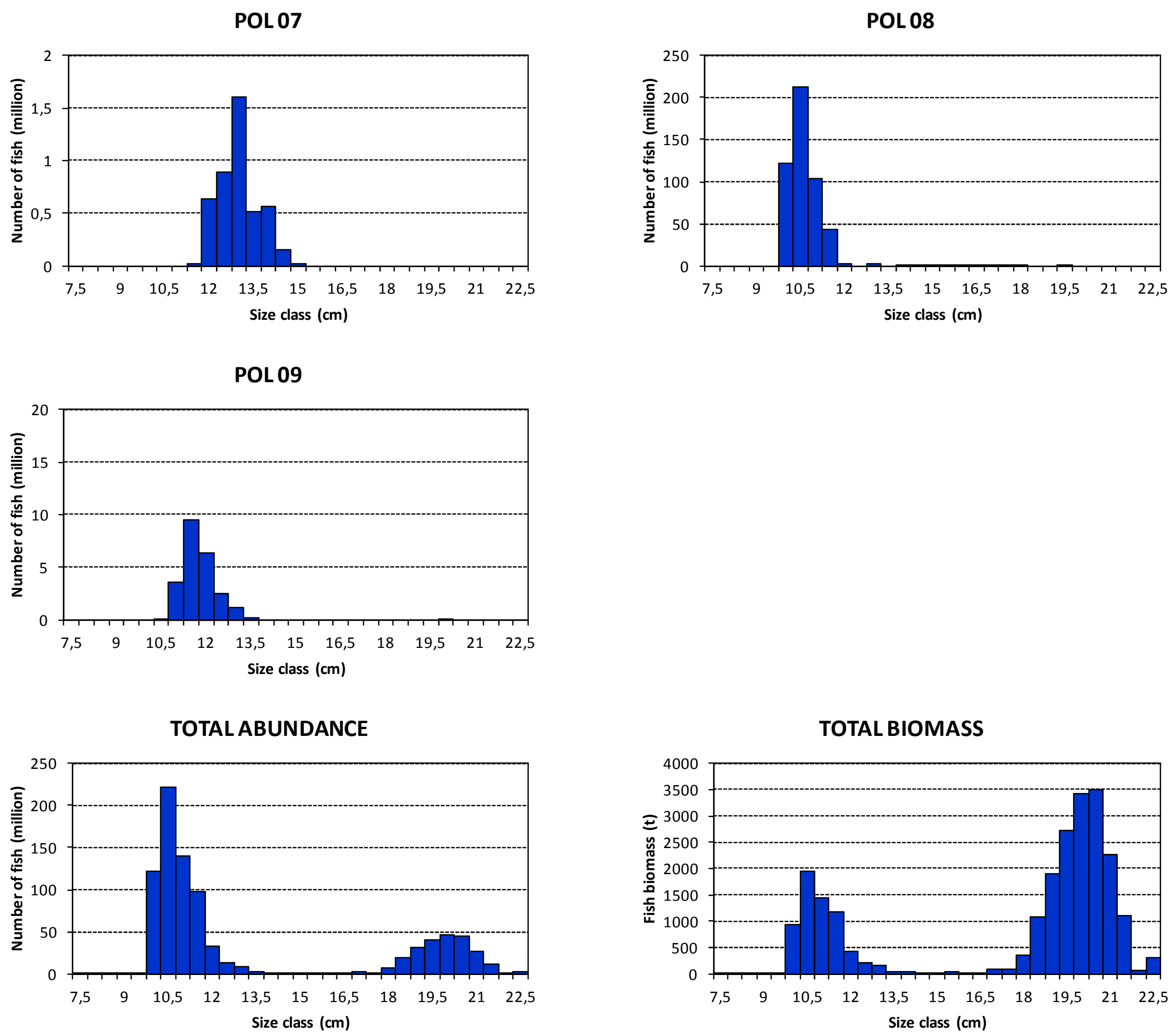


Figure 13. *ECOCADIZ 2015-07* survey. Sardine (*S. pilchardus*). Cont'd.

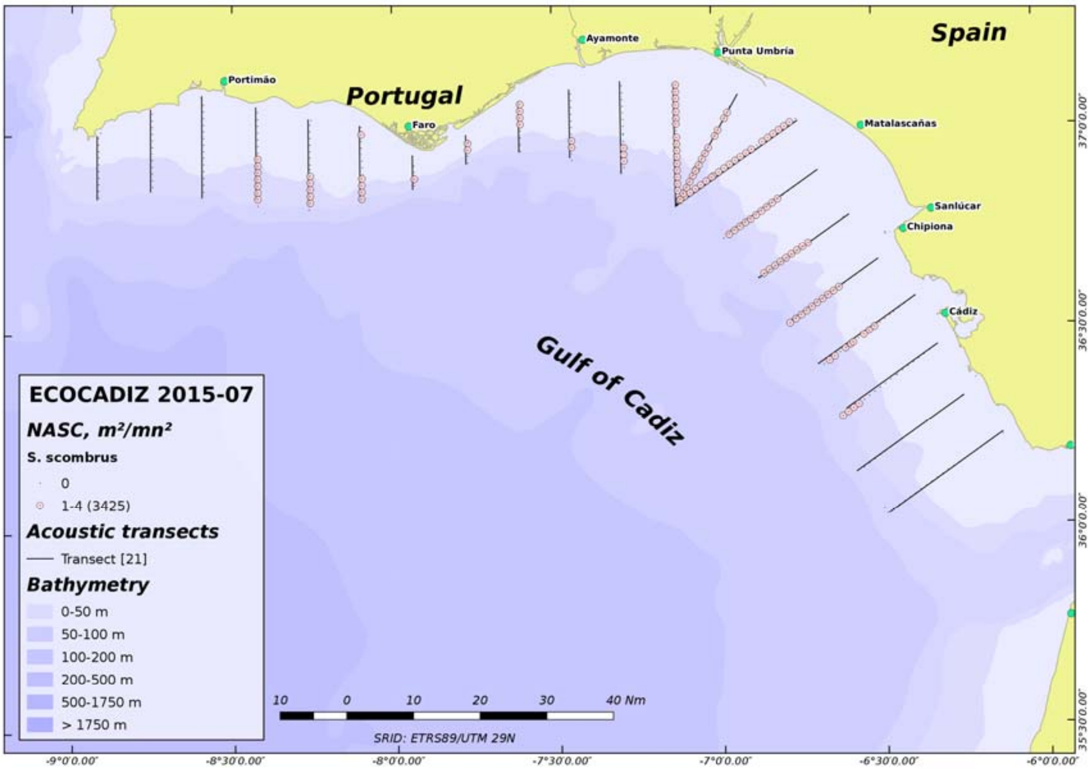


Figure 14. *ECOCADIZ 2015-07* survey. Mackerel (*Scomber scombrus*). Distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species.

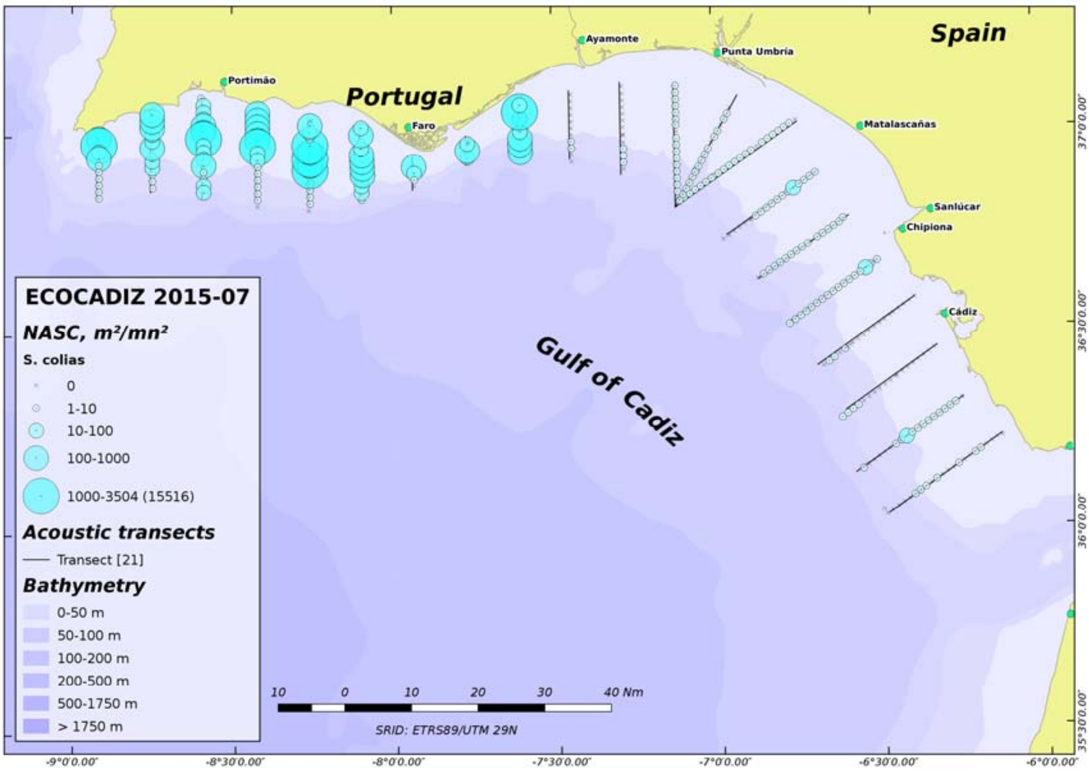


Figure 15. *ECOCADIZ 2015-07* survey. Chub mackerel (*Scomber colias*). Distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species.

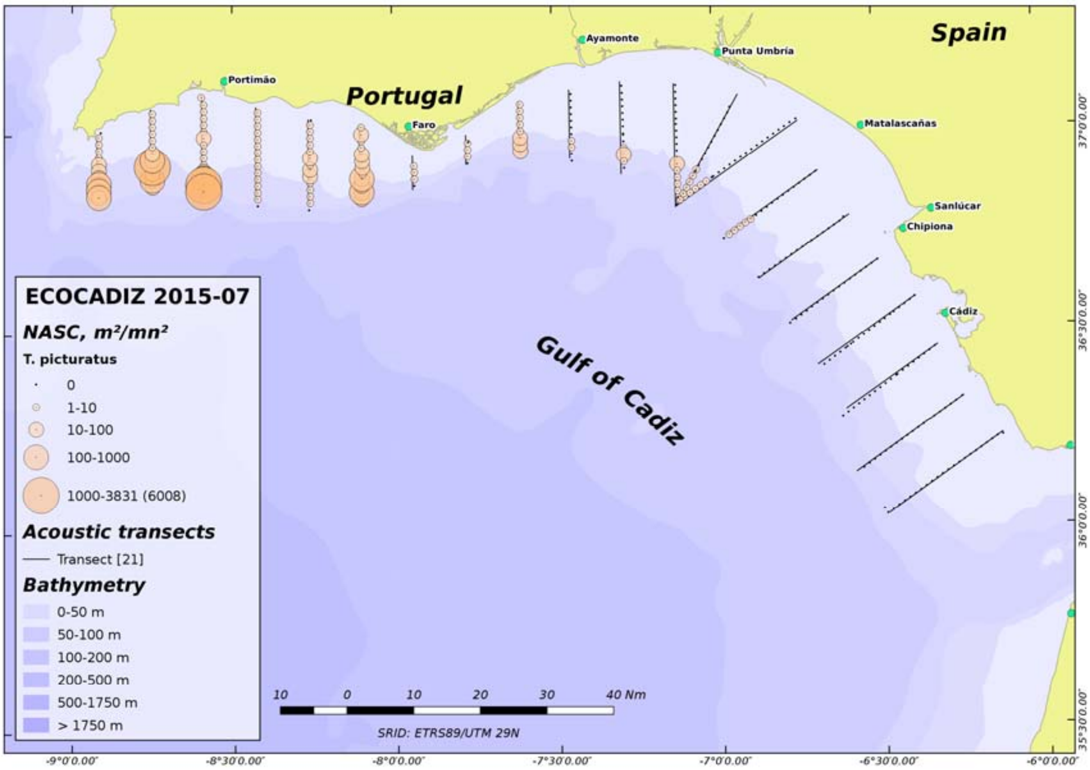


Figure 16. *ECOCADIZ 2015-07* survey. Blue jack mackerel (*Trachurus picturatus*). Distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species.

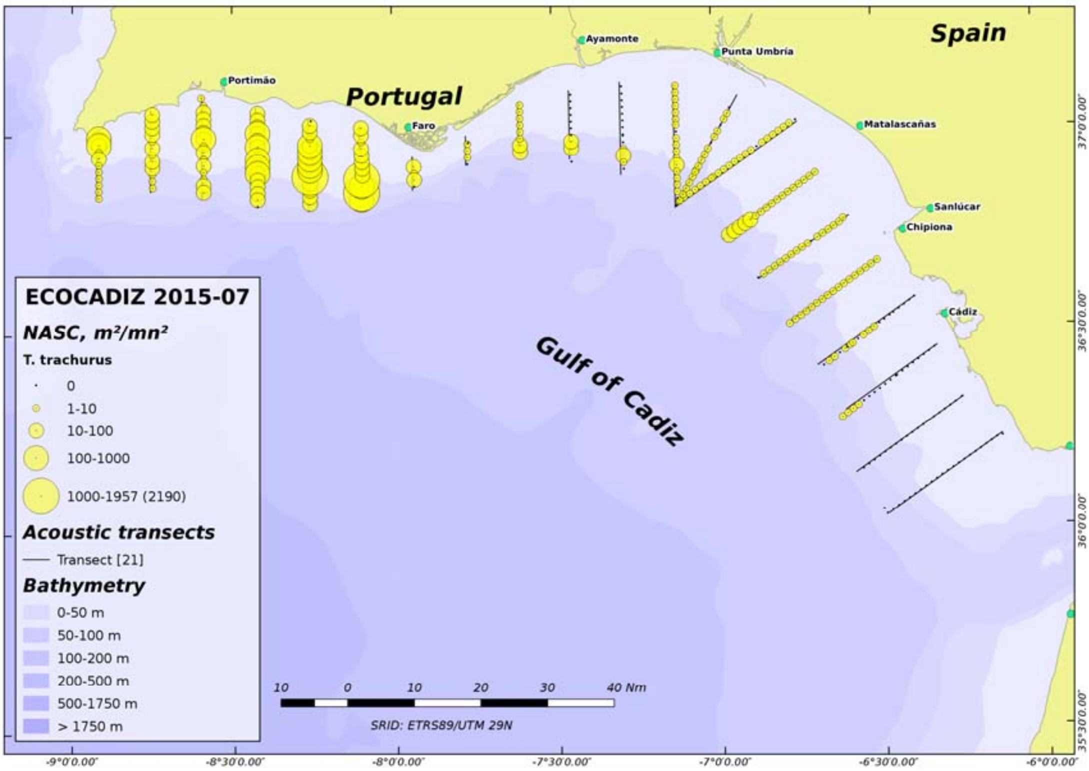


Figure 17. *ECOCADIZ 2015-07* survey. Horse mackerel (*Trachurus trachurus*). Distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species.

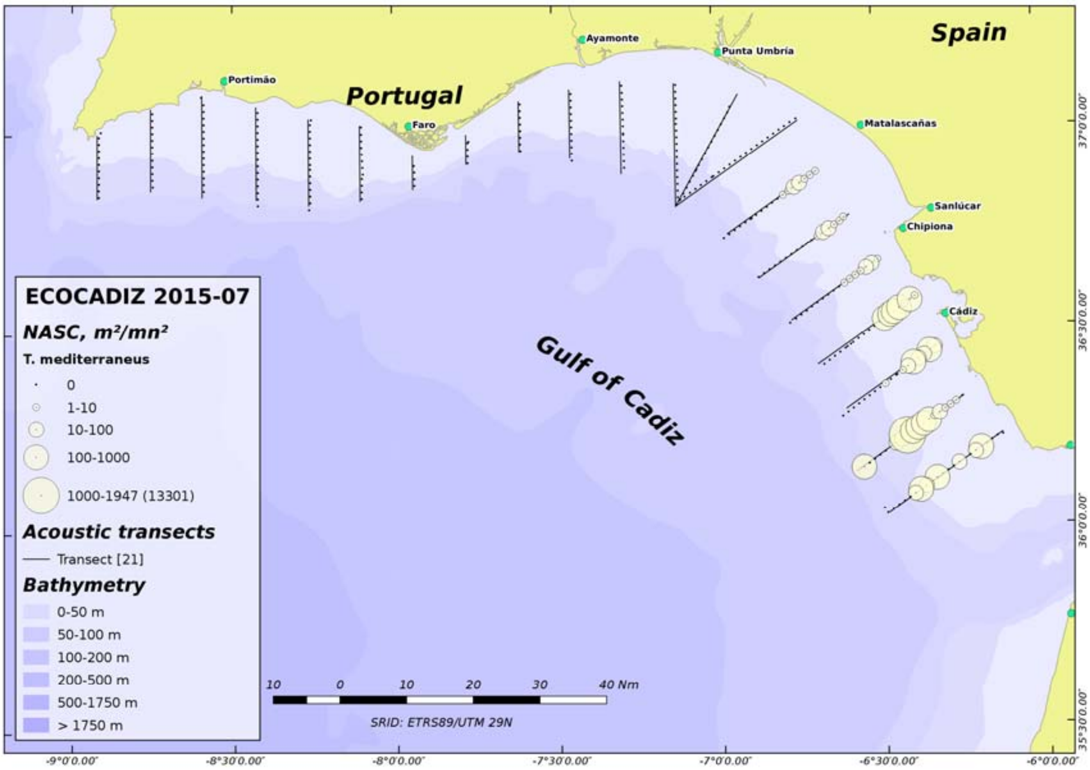


Figure 18. *ECOCADIZ 2015-07* survey. Mediterranean horse mackerel (*Trachurus mediterraneus*). Distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species.

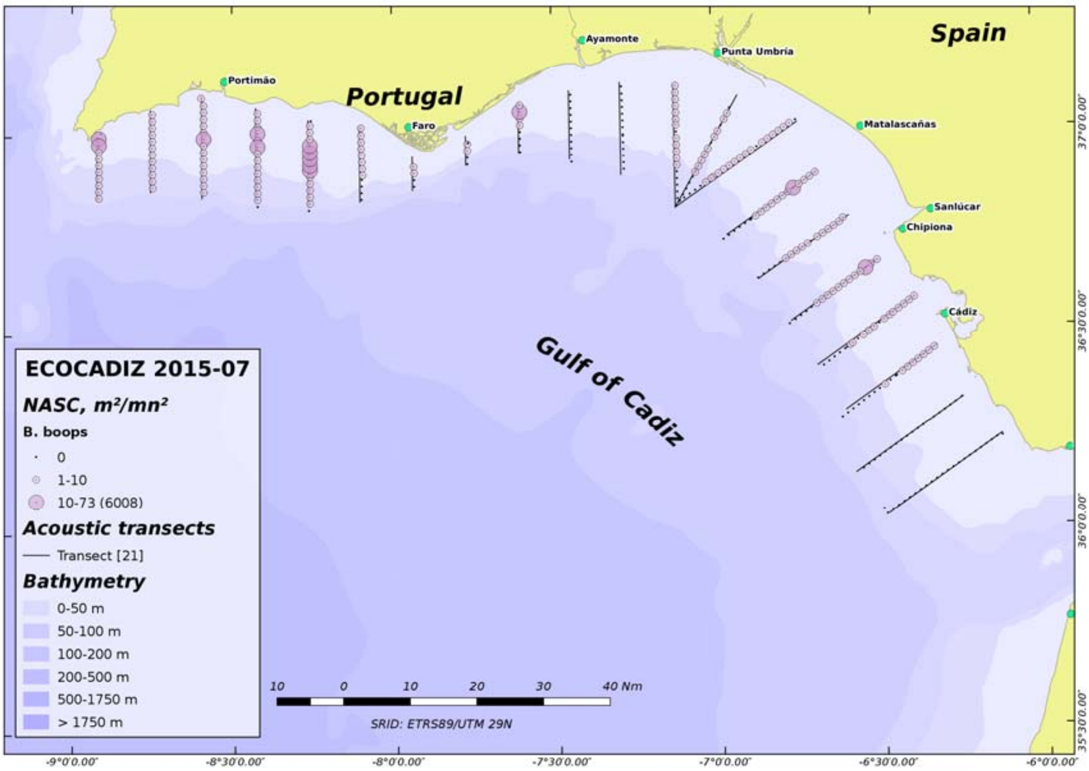


Figure 19. *ECOCADIZ 2015-07* survey. Bogue (*Boops boops*). Distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species.

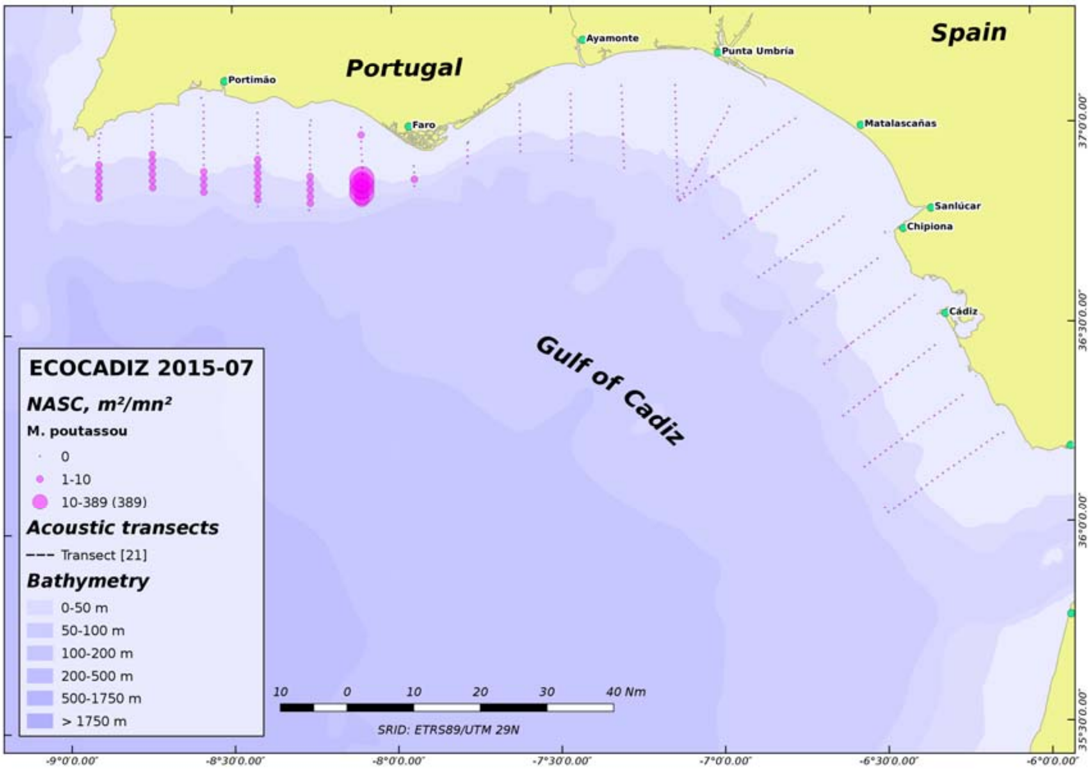


Figure 20. *ECOCADIZ 2015-07* survey. Blue whiting (*Micromesistius poutassou*). Distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species.

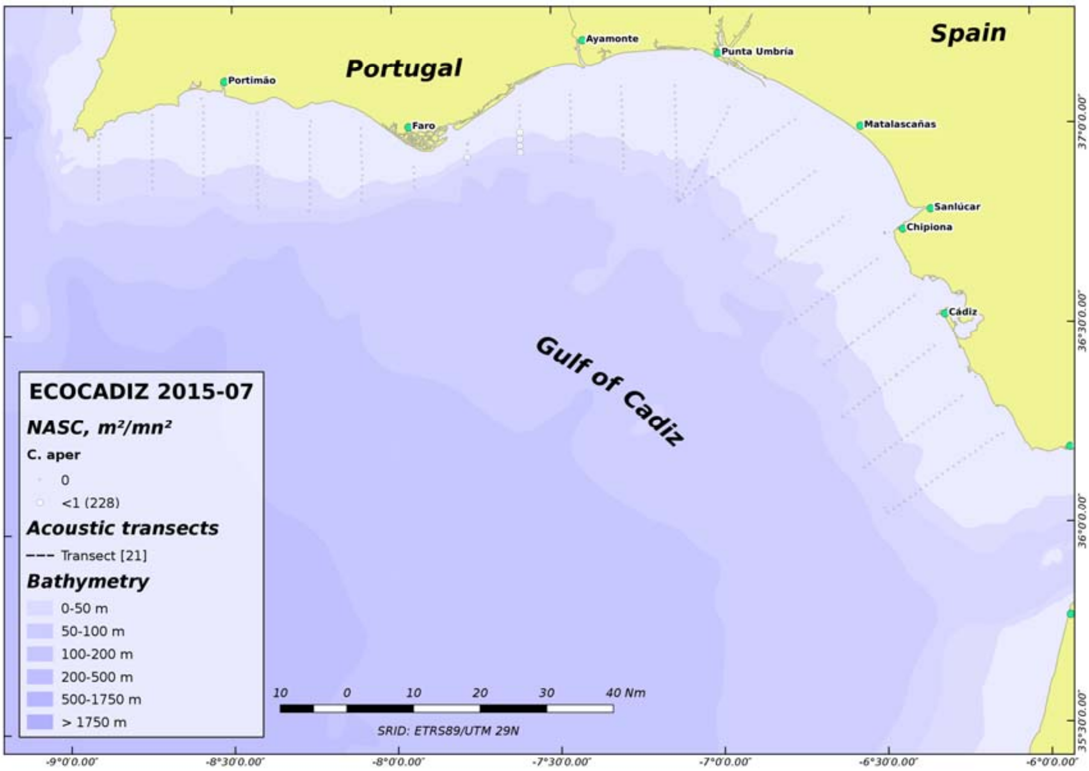
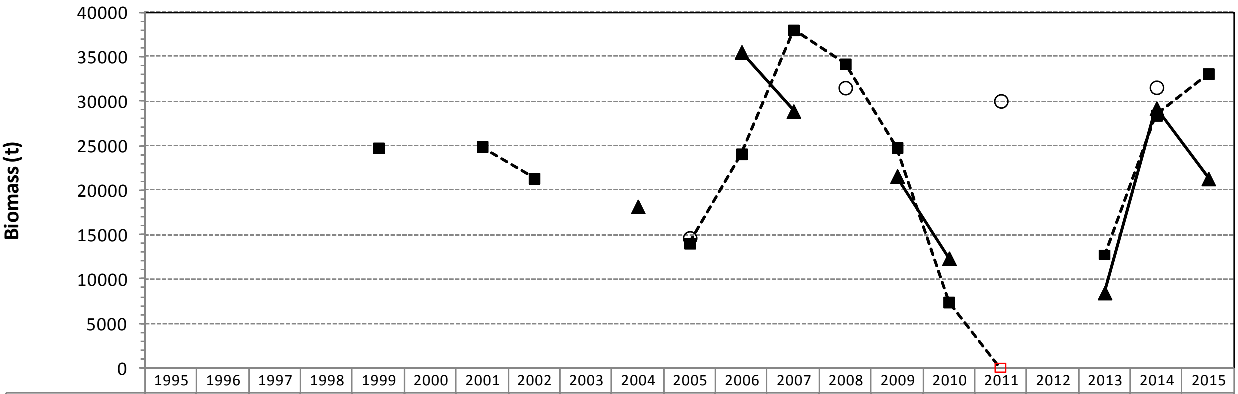


Figure 21. *ECOCADIZ 2015-07* survey. Boarfish (*Capros aper*). Distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species.

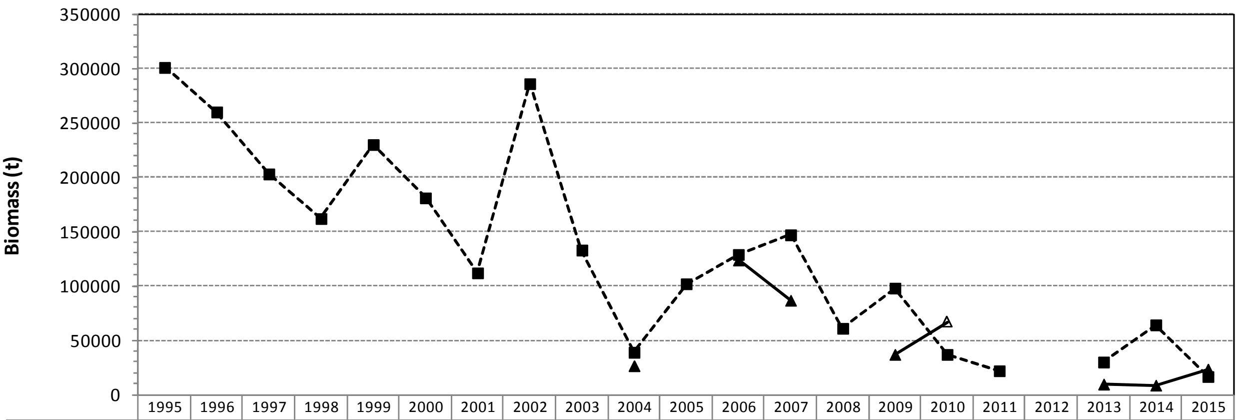
Biomass trends (in tons)

Anchovy biomass estimates



	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
PELAGO					24763		24913	21335			14041	24082	38020	34200	24800	7395	0		12700	28408	33100
ECOCADIZ										18177		35539	28882		21580	12339			8487	29219	21305
BOCADEVA											14637			31527			30037			31569	

Sardine biomass estimates



	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
PELAGO	301000	260000	203000	162000	230000	181000	112000	286000	133000	39000	102000	129000	147000	61000	98000	37000	22000		30000	64227	16663
ECOCADIZ										26568		123849	86777		37020	66964			9670	8697	23460

Figure 22. Trends in biomass estimates (in tons) for the main assessed species in Portuguese (*PELAGO*) and Spanish (*ECOCADIZ*) survey series. Gaps for the 2005, 2008 and 2011 anchovy acoustic estimates in the *ECOCADIZ* series are filled with the *BOCADEVA* Spanish egg survey estimates. Note that the *ECOCADIZ* survey in 2010 partially covered the whole study area. The anchovy null estimate in 2011 from the *PELAGO* survey should be considered with caution.

Working document presented in the:
ICES Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VII, VIII and IX (WGACEGG). Lowestoft, UK, 16-20 November 2015.

Acoustic assessment and distribution of anchovy and sardine in ICES Subdivision IXa South during the *ECOCADIZ-RECLUTAS 2015-10* Spanish survey (October 2015) with notes on the distribution of other pelagic species.

By

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ABSTRACT

The present working document summarises part of the main results obtained during the *ECOCADIZ-RECLUTAS 2015-10* Spanish (pelagic ecosystem-) acoustic survey. The survey was conducted by IEO between 10th and 29th October 2015 in the Portuguese and Spanish shelf waters (20-200 m isobaths) off the Gulf of Cadiz onboard the R/V *Ramón Margalef*. The survey's main objective is the acoustic assessment of anchovy and sardine juveniles (age 0 fish) in the recruitment areas of the Gulf of Cadiz. Acoustic estimates available for the WG were for the time being only those ones for anchovy and sardine, and they were provided without any age-structure. Gulf of Cadiz anchovy abundance and biomass in autumn 2015 were of 5 227 million fish and 30 827 t, the highest values within its short series Preliminary (size-based) estimates of the abundance and biomass of Gulf of Cadiz anchovy recruits (≤10 cm, as a proxy of age 0 anchovies) rise up to 3 816 million fish and 18 122 t. This juvenile fraction accounted for 73% and 59% of the total estimated population abundance and biomass respectively. Spanish waters concentrated 98% of the juveniles in the Gulf, both in terms of number (3 756 million) and biomass (17 920 t), although this autumn the recruitment area showed a greater extension, even reaching the coastal waters of the eastern Algarve. As compared with the previous last years, these estimates and observations suggest a better recruitment scenario that the one provided by the 2014 survey. Similar perception is also obtained from the autumn 2015 estimates for Gulf of Cadiz sardine: 861 million fish and 30 992 t, values which represent with respect to those estimated in 2014 a notable increase in abundance but not in biomass, which experienced a slight decrease. Such a pattern is caused by the increase of the juvenile fraction in the population in the autumn 2015 survey in terms both absolute and relative. These juveniles were mainly distributed in the Spanish coastal waters as well. Thus, sardine juveniles (≤16 cm) accounted in autumn 2015 for 71.1% (612 million) and 42.1% (13 037 t) of the overall estimated abundance and biomass.

INTRODUCTION

During the 2007 and 2008 meetings of the ICES *Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES areas VIII and IX* (WGACEGG) was advanced the possibility of carrying out, since 2009 on, internationally coordinated yearly surveys aimed at the direct estimation of the anchovy and sardine recruitment in the Division IXa (ICES, 2007, 2008). The conduction of such surveys would require, at least in the Gulf of Cadiz, of an appropriate acoustic sampling of the shallowest waters of its central part, an area which the conventional surveys (either Spanish or Portuguese) do not sample but, however, used to form a great part of the recruitment areas of these species.

The general objective of these surveys should initially be focused in the acoustic assessment by vertical echo-integration and mapping of the abundance and biomass of recruits of small pelagic species (especially anchovy and secondarily sardine), as well as the mapping of both the oceanographic and biological conditions featuring the recruitment areas of these species in the Division IXa. The long term objective of the surveys would be to be able to assess the strength of the incoming recruitment to the fishery the next year.

The first attempt by the IEO of acoustically assessing the abundance of anchovy and sardine juveniles in their main recruitment areas off the Gulf of Cadiz dates back to 2009 (*ECOCADIZ-RECLUTAS 1009* survey). However, that survey was unsuccessful as to the achievement of their objectives because of the succession of a series of unforeseen problems which led to drastically reduce the foreseen sampling area to only the 6 easternmost transects. The continuation of this survey series was not guaranteed for next years and in fact no survey of these characteristics was carried out in 2010 and 2011. In 2012, the *ECOCADIZ-RECLUTAS 1112* survey was financed by the Spanish Fisheries Secretariat and planned and conducted by the IEO with the aim of obtaining an autumn estimate of Gulf of Cadiz anchovy biomass and abundance. The survey was conducted with the R/V *Emma Bardán*. Although the survey was restricted to the Spanish waters only it has been considered as the first survey within its series. *ECOCADIZ-RECLUTAS 2014-10* survey was the next one and it was conducted with the R/V *Ramón Margalef*.

Given the closeness between the dates of the survey and the WG, the present Working Document advances some results from the *ECOCADIZ-RECLUTAS 2015-10* survey, the third in the series. These results will only refer to the acoustic estimates (not age-structured) and spatial distribution of anchovy and sardine as well as to inferences on the spatial distribution of other pelagic species from the distribution of the acoustic energy attributed to each of them.

MATERIAL AND METHODS

The *ECOCADIZ-RECLUTAS 2015-10* survey was carried out between 10th and 29th October 2015 onboard the Spanish R/V *Ramón Margalef* covering a survey area which comprised the waters of the Gulf of Cadiz, both Spanish and Portuguese, between the 20 m and 200 m isobaths. The survey design consisted in a systematic parallel grid with tracks equally spaced by 8 nm, normal to the shoreline (**Figure 1**).

Echo-integration was carried out with a *Simrad™ EK60* echo sounder working in the multi-frequency fashion (18, 38, 70, 120, 200, 333 kHz). Average survey speed was about 10 knots and the acoustic signals were integrated over 1-nm intervals (ESDU). Raw acoustic data were stored for further post-processing using *Myriax Software Echoview™* software package (by *Myriax Software Pty. Ltd.,* ex *SonarData Pty. Ltd.*). Acoustic equipment was calibrated during 11th and 13th October in the Bay of Algeciras following the new ICES standard procedures (Demer *et al*., 2015).

Survey execution and abundance estimation followed the methodologies firstly adopted by the ICES *Planning Group for Acoustic Surveys in ICES Sub-Areas VIII and IX* (ICES, 1998) and the recommendations given more recently by the *Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES areas VIII and IX* (WGACEGG; ICES, 2006a,b).

Fishing stations for echo-trace ground-truthing were opportunistic, according to the echogram information, and they were carried out using a *Gloria HOD 352* pelagic trawl gear (ca. 10 m-mean vertical opening net) at an average speed of 4 knots. Gear performance and geometry during the effective fishing was monitored with *Simrad™ Mesotech FS20/25* trawl sonar. Trawl sonar data from each haul were recorded and stored for further analyses.

Ground-truthing haul samples provided biological data on species and they were also used to identify fish species and to allocate the back-scattering values into fish species according to the proportions found at the fishing stations (Nakken and Dommasnes, 1975).

Length frequency distributions (LFD) by 0.5-cm class were obtained for all the fish species in trawl samples (either from the total catch or from a representative random sample of 100-200 fish). Only those LFDs based on a minimum of 30 individuals and showing a normal distribution were considered for the purpose of the acoustic assessment.

Individual biological sampling (length, weight, sex, maturity stage, stomach fullness, and mesenteric fat content) was performed in each haul for anchovy, sardine (in both species with otolith extraction), mackerel (2 spp.) and horse-mackerel species (3 spp.), and bogue.

The following TS/length relationship table was used for acoustic estimation of assessed species (recent IEO standards after ICES, 1998; and recommendations by ICES, 2006a,b):

Species	b_{20}
Sardine (*Sardina pilchardus*)	-72.6
Round sardinella (*Sardinella aurita*)	-72.6
Anchovy (*Engraulis encrasicolus*)	-72.6
Chub mackerel (*Scomber japonicus*)	-68.7
Mackerel (*S. scombrus*)	-84.9
Horse mackerel (*Trachurus trachurus*)	-68.7
Mediterranean horse-mackerel (*T. mediterraneus*)	-68.7
Blue jack mackerel (*T. picturatus*)	-68.7
Bogue (*Boops boops*)	-67.0

The *PESMA* software (J. Miquel, unpublished) has got implemented the needed procedures and routines for the acoustic assessment following the above approach and it has been the software package used for the acoustic estimation.

Egg sampling by CUFES was not carried out during the survey. A *Sea-bird Electronics™ SBE 21 SEACAT* thermosalinograph and a *Turner™ 10 AU 005 CE Field* fluorometer were used during the acoustic tracking to continuously collect some hydrographical variables (sub-surface sea temperature, salinity, and *in vivo* fluorescence). Vertical profiles of hydrographical variables were also recorded by night from 170 $CTDO_2$-LADCP casts by using *Sea-bird Electronics™ SBE 911+ SEACAT* (with coupled *Datasonics* altimeter, *SBE 43* oximeter, *WetLabs ECO-FL-NTU* fluorimeter and *WetLabs C-Star 25 cm* transmissometer sensors) and *LADCP T-RDI WHS 300 kHz* profilers (**Figure 2**). *VMADCP RDI 150 kHz* records were also continuously recorded by night between CTD stations. Census of top predators was not recorded during the survey.

RESULTS

Acoustic sampling

The acoustic sampling was carried out between 15th and 27th October. The complete grid (21 transects) was sampled. However, the sampling scheme followed to accomplish this grid was highly conditioned by two events of different nature: the realization of joint NATO naval exercises in the Spanish waters during a great part of the survey and the entry of a persistent system of low pressure threatening with strong storms in the westernmost part of the surveyed area during the last days of the survey. As described above, the consecutive implementation of different naval exercises' polygons conditioned the order of realization of the acoustic transects during the survey's first leg. Thus, the acoustic sampling started by the coastal end of the transect R05 on 15th October and proceeded eastward up to the R01 on 17th. The acoustic sampling stopped on 18th-19th October in order to satisfy the R/V's refuelling and victualling needs. Transects from R06 to R15 were carried out in the usual way (in the westward direction) between 20th and 24th. In order to avoid the abovementioned incoming system of low pressure, the westernmost section of the sampling grid (transects R16 – R21) was sampled in the W-E direction (**Table 1**; **Figure 1**).

In order to perform the acoustic sampling with daylight, this sampling started at 06:45 UTC until 25th October and at 07:45 UTC since 26th October on, although this time might vary depending on the duration of the works related with the hydrographic sampling the previous night.

Groundtruthing hauls

A total of twenty one (21) fishing operations for echo-trace ground-truthing (all of them valid according to a correct gear performance and resulting catches), were carried out during the survey (**Table 2**, **Figure 3**). Four additional trial fishing hauls were carried out during the two previous days to the acoustic sampling in order to test different configurations of towing warp lengths, angles of attack of the doors (by adjusting the backstraps) and weights. Because of many echo-traces usually occurred close to the bottom, all the pelagic hauls were carried out like a bottom-trawl haul, with the ground rope working over or very close to the bottom. According to the above, the sampled depth range in the valid hauls oscillated between 41-155 m.

During the survey were captured 1 Chondrichthyan, 33 Osteichthyes, 6 Cephalopod, 3 Echinoderm, 1 Cnidarian and 1 Bryozoan species. The percentage of occurrence of the more frequent species in the hauls is shown in the enclosed Text Table below (see also **Figure 4**). The pelagic ichthyofauna was both the most frequently captured species set and the one composing the bulk of the overall yields of the catches. Within this pelagic fish species set, anchovy was the most frequent species in the valid hauls (95% presence index), followed by sardine, chub-mackerel and horse mackerel (with relative occurrences between 60-70%). Mackerel showed a medium relative frequency (57%), and blue jack mackerel, bogue and Mediterranean horse mackerel were rare species during the survey (20-40%).

For the purposes of the acoustic assessment, anchovy, sardine, mackerel species, horse & jack mackerel species, and bogue were initially considered as the survey target species. All of the invertebrates, and both bentho-pelagic (*e.g.*, manta rays) and benthic fish species (e.g., flatfish, gurnards, etc.) were excluded from the computation of the total catches in weight and in number from those fishing stations where they occurred. Catches of the remaining non-target species were included in an operational category termed as "Others".

Species	# of fishing stations	Occurrence (%)	Total weight (kg)	Total number
Engraulis encrasicolus	20	95	1145,293	191529
Merluccius merluccius	19	90	25,617	273
Sardina pilchardus	15	71	7653,437	99986
Scomber colias	14	67	1230,73	10530
Trachurus trachurus	13	62	143,033	1221
Scomber scombrus	12	57	18,756	108
Lepidopus caudatus	11	52	2,641	151
Trachurus picturatus	8	38	282,636	4526
Boops boops	7	33	4,844	33
Trachurus mediterraneus	5	24	38,07	185

According to the above premises, during the survey were captured a total of 10 677 kg and 311 thousand fish (**Table 3**). 72% of this "total" fished biomass corresponded to sardine, 11% to chub mackerel, 11% to anchovy, 3% to blue jack-mackerel, 1% to horse mackerel and contributions lower than 1% for the remaining species. The most abundant species in ground-truthing trawl hauls were anchovy and sardine (61% and 32% respectively) followed by chub mackerel (3%), with each of the remaining species accounting for less than 1.5%.

The species composition of these fishing hauls (as expressed in terms of percentages in number) is shown in **Figure 4**. First impressions on the species' distribution patterns could be inferred from the relative contribution of the species in the fishing hauls. Thus, anchovy was widely distributed all over the surveyed area, although showed the highest yields in those ones carried out in the Spanish waters. The size composition of anchovy catches indicates that smallest recruits showed this year a more widespread distribution than in previous surveys within its series, with high occurrences in the coastal waters off the eastern Algarve, surroundings of the Guadiana and Guadalquivir river mouths and Bay of Cadiz (**Figure 5**). Sardine was a frequent species in the hauls conducted over the shelf fringe comprised between Cape Santa Maria and Bay of Cadiz, showing exceptional yields in those waters surrounding Cape Santa Maria. However, the occurrence of sardine in the hauls conducted in the westernmost waters was relatively rare. The sardine size composition in the positive hauls indicates that juveniles were mainly distributed over the coastal waters comprised between the Guadiana river mouth and Bay of Cadiz whereas the largest sardines were captured in the Portuguese waters (**Figure 6**). Mackerel, although relatively frequent in those hauls conducted over the middle-outer shelf waters of the whole surveyed area, showed, however, very low yields. Although in a lesser extent, that also was the case of chub-mackerel, only outstanding the yields from two hauls conducted in the outer shelf waters in front of Punta Umbría (Spanish waters) and Cuarteira (to the west of Cape Santa Maria). Blue jack mackerel was restricted to the Portuguese waters only and Mediterranean horse mackerel to the easternmost Spanish ones. Horse mackerel, although relatively frequent from the central waters of the Gulf to the west, only showed relatively important yields in the westernmost waters.

Back-scattering energy attributed to the "pelagic assemblage" and individual species

A total of 335 nmi (ESDU) from 21 transects has been acoustically sampled by echo-integration for assessment purposes. The enclosed text table below provides the nautical area-scattering coefficients attributed to each of the selected target species and for the whole "pelagic fish assemblage".

$S_{A\ (m^2\ nmi^{-2})}$	Total spp.	Anchovy	Sardine	Mackerel	Chub mack.	Horse mack.	Medit. h-mack.	Blue jack-mack.	Bogue	Blue whiting	Boarfish
Total Area	97463	53102	21205	11	7932	994	4537	8831	115	321	415
%	100	54,5	21,8	0,01	8,1	1,0	4,7	9,1	0,1	0,3	0,4
Portugal	31305	1741	13151	6	5887	954	0	8831	2	317	415
%	32,1	3,3	62,0	55,1	74,2	96,0	0,0	100	1,6	98,9	100
Spain	66158	51361	8054	5	2045	40	4537	0	114	3	0
%	67,9	96,7	38,0	44,9	25,8	4,0	100	0	98,4	1,1	0

For this “pelagic fish assemblage” has been estimated a total of 97 463 m^2 nmi^{-2}. The highest NASC values have been recorded in the sector of Alfanzina-Portimao (R18 – R19), although the zone between Tavira (R13) and Rota (R04) recorded the bulk of the acoustic energy (**Figure 7**). By species, anchovy accounted for 54% of this total back-scattered energy, followed by sardine (22%), blue-jack mackerel (9%), chub mackerel (8%), Mediterranean horse mackerel (5%), horse mackerel (1%), and the remaining species with relative contributions of acoustic energies lower than 1%.

From the regional contributions to the total energy attributed to each species it could be inferred that blue-jack mackerel, boarfish, blue whiting and horse mackerel have been typically Portuguese species. Chub mackerel and sardine also showed greater acoustic densities in Portuguese waters. Conversely, anchovy, Mediterranean horse mackerel and bogue were exclusively recorded in Spanish waters.

According to the resulting values of integrated acoustic energy, the species acoustically assessed in the present survey finally were anchovy, sardine, mackerel, chub mackerel, blue jack mackerel, horse mackerel, Mediterranean horse mackerel and bogue. For the time being the only available acoustic estimates of abundance and biomass are the ones for anchovy and sardine. Furthermore, these estimates are not still presented with age-structure. For the remaining species only the spatial distribution of NASCs will be shown in the present WD

Spatial distribution and abundance/biomass estimates

Anchovy

Parameters of the survey’s length-weight relationship for anchovy are given in **Table 4**. The mapping of the backscattering energy (nautical area scattering coefficient, NASC, in m^2 nmi^{-2}) attributed to the species and the coherent strata considered for the acoustic estimation are shown in **Figure 8**. The estimated abundance and biomass by size are given in **Table 5** and **Figure 9**.

Anchovy avoid in autumn 2005, as it also did in summer, the easternmost waters of the Gulf, and showed a spatial pattern of distribution of the acoustic density very similar to the one described in summer, with the bulk of the population being mainly concentrated in an area comprising the shelf waters between the Guadiana river mouth and Bay of Cadiz. Anchovy acoustic densities in the westernmost waters were not relevant (**Figure 8**).

The size range recorded for the estimated population was comprised between 8 and 17.5 cm size classes, with a marked mode at 9 cm size class and a very residual secondary mode at 15 cm. A similar size composition is also recorded for the estimated biomass, although the main mode is located at 9.5 cm size class (**Table 5**, **Figure 9**). The mean size and weight of the estimated population were 100 mm and 5.9 g respectively. The anchovy size composition by coherent post-strata in the autumn 2015 survey evidences that juveniles were mainly distributed in the coastal waters between the Guadiana river mouth and Bay of

Cadiz, although this autumn the recruitment area showed a greater extension, even reaching the coastal waters of the eastern Algarve (**Table 5**, **Figure 9**).

Gulf of Cadiz anchovy abundance and biomass in autumn 2005 were of 5 227 million fish and 30 827 t, the highest values within its short series. Spanish waters concentrated 97.8% (5 113 million) and 95.7% (29 491 t) of the total estimated abundance and biomass respectively. Portuguese estimates amounted to 115 million and 1 335 t only.

Although there are no age-structured estimates still available for the 2015 survey, recruits (age 0 fish) may be assumed as those fishes belonging to size classes ≤10 cm. By assuming this, this population fraction was estimated at 3 816 million fish and 18 122 t, 73% and 59% of the total population abundance and biomass respectively (**Table 6**). Spanish waters concentrated 98% of the juveniles in the Gulf, both in terms of number (3756 million) and biomass (17920 t).

Sardine

Parameters of the survey's size-weight relationship for sardine are shown in **Table 4**. The mapping of the backscattering energy (nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species and the coherent strata considered for the acoustic estimation are shown in **Figure 10**. Estimated abundance and biomass by size class are given in **Table 7** and **Figure 11**.

As it was observed in summer, sardine also avoided in autumn the easternmost waters of the Gulf. In the remaining surveyed area the species, although widely distributed, showed two main nuclei of acoustic density: the most important one located in the westernmost coastal Algarve waters, and a secondary zone comprising the shelf between Matalascañas and Bay of Cadiz. In these last waters sardine showed a somewhat more widespread distribution than in summer (**Figure 10**).

The size frequency distribution of this species showed in autumn 2015 a range comprised between the 10 and 23.5 cm size classes, with three modes, both for the biomass and abundance at 11.5, 16 and 20.5 cm (**Table 7**, **Figure 11**). Mean size and weight for the whole population were estimated at 157 mm and 36.0 g, respectively. The sardine size composition by coherent post-strata in the autumn 2015 survey indicates that juveniles were mainly distributed over the coastal waters comprised between the Guadiana river mouth and Bay of Cadiz.

The estimates of Gulf of Cadiz sardine abundance and biomass in autumn 2015 were 861 million fish and 30 992 t. Portuguese waters accounted for 48.9% of abundance (421 million) and 69.0% of the total estimated biomass (21 390 t), with the unbalanced percentages suggesting a larger and heavier body size on average than in the Spanish waters, where abundance and biomass estimates were of 440 million and 9 602 t. Juveniles were therefore mainly distributed in the Spanish coastal waters. Thus, sardine juveniles (≤16 cm, as a proxy of age 0 sardines) accounted in autumn 2015 for 71.1% (612 million) and 42.1% (13 037 t) of the overall estimated abundance and biomass (**Table 8**).

Mackerel

Parameters of the survey's length-weight relationship are shown in **Table 4**. The mapping of the backscattering energy (nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species is shown in **Figure 12**.

The species showed a very scattered distribution in the Gulf, mainly confined to the outer shelf waters (**Figure 12**).

Chub mackerel

Parameters of the survey's length-weight relationship are shown in **Table 4**. The mapping of the backscattering energy (nautical area scattering coefficient, NASC, in m2 nmi-2) attributed to the species is shown in **Figure 13**.

Chub mackerel neither showed a continuous distribution, with wide voids especially occurring in the inner-middle shelf waters in front of Doñana National Park. The highest integration values were recorded in the outer shelf waters between Tinto-Odiel river moutht and Burgau (R20), outstanding the Algarve westernmost waters (**Figure 13**).

Blue jack mackerel

Parameters of the survey's length-weight relationship are shown in **Table 4**. The mapping of the backscattering energy (nautical area scattering coefficient, NASC, in m2 nmi-2) attributed to the species is shown in **Figure 14**.

The species only occurred in the Portuguese waters, with the highest integration values being recorded in the Algarve westernmost outer shelf waters (**Figure 14**).

Horse-mackerel

The survey's length-weight relationship for this species is shown in **Table 4**. The mapping of the backscattering energy (nautical area scattering coefficient, NASC, in m2 nmi-2) attributed to the species is represented in **Figure 15**.

Horse mackerel was practically absent in the easternmost waters of the Gulf. The occurrence of the species was somewhat more constant over the remaining surveyed area, although the highest densities are also recorded in the Algarve westernmost outer shelf waters (**Figure 15**).

Mediterranean horse-mackerel

The survey's length-weight relationship for this species is shown in **Table 4**. The mapping of the backscattering energy (nautical area scattering coefficient, NASC, in m2 nmi-2) attributed to the species is shown in **Figure 16**.

The species was exclusively restricted to the Spanish waters, but even here showed a rather scattered distribution pattern, with the highest integration values being recorded in the eastern extreme of the surveyed area, close to the Strait of Gibraltar (**Figure 16**).

Bogue

Parameters of the survey's length-weight relationship are shown in **Table 4**. The mapping of the backscattering energy (nautical area scattering coefficient, NASC, in m2 nmi-2) attributed to the species is shown in **Figure 17**.

The presence of the species in Portuguese waters was accidental, whereas in the Spanish ones, although it showed a relatively continuous distribution, the acoustic integration was quite low (**Figure 17**).

Oceanographic conditions

A detailed description of the oceanographic conditions in that survey based on *in situ* and remotely sensed data is given in Sánchez-Leal *et al*. (2015).

(SHORT) DISCUSSION

Gulf of Cadiz anchovy abundance and biomass in autumn 2015 were of 5 227 million fish and 30 827 t, the highest values within its short series (**Table 6**, **Figure 18**). Preliminary (size-based) estimates of the abundance and biomass of Gulf of Cadiz anchovy recruits rise up to 3 816 million fish and 18 122 t. This juvenile fraction accounted for 73% and 59% of the total estimated population abundance and biomass respectively. Spanish waters concentrated 98% of the juvenile in the Gulf, both in terms of number (3 756 million) and biomass (17 920 t). Such a dominance of the recruit component in the assessed population has resulted in mean size and weight estimates for the whole population of 10 cm and 5.9 g respectively, which were very similar very similar values to those ones recorded in autumn 2012 (9.5 cm, 5.9 g), but very different to the high estimates obtained in autumn 2014 (129 mm, 14.9 g). Given the shortness of the series it would be too much risky to advance that this 'historic' maximum might correspond to a good recruitment scenario. Notwithstanding the above, these estimates induce to optimistically perceive the present situation when they are compared with the estimates from previous years.

Regarding sardine, the autumn 2015 values (861 million fish and 30 992 t) represent with respect to those estimated in the previous year a notable increase in abundance but not in biomass, which experienced a slight decrease. Such a pattern is mainly caused by the increase and high relative importance of juveniles in the population during the 2015 survey season, which were mainly distributed in the Spanish coastal waters. Thus, sardine juveniles (≤16 cm, as a proxy of age 0 sardines) accounted in autumn 2015 for 71.1% (612 million) and 42.1% (13 037 t) of the overall estimated abundance and biomass (**Table 8**). These values are rather close to those ones recorded in 2012 (377 million, 62.5%; 9 675 t, 43.7%), but they are very different to the 2014 estimates of sardine juveniles (29 million, 5.7%; 760 t, 2.1%). The autumn 2015 estimates of mean size (15.7 cm) and weight (36.0 g) are relatively close to those ones recorded in 2012 (16.5 cm, 36.7 g), but they both contrast with the values estimated in autumn 2014, when Gulf of Cadiz sardine population was composed on average by very large and heavy sardines (20.0 cm, 72.1 g) as a result of a notable dominance of the adult fraction in contrast to a very scarce presence of juveniles. Conversely, Gulf of Cadiz sardine population in 2012 and 2015 showed more complex and mixed size distributions, with juveniles composing the most important modal component.

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Table 1. *ECOCADIZ-RECLUTAS 2015-10* survey. Descriptive characteristics of the acoustic tracks.

Acoustic Track	Location	Date	Start				End			
			Latitude	Longitude	UTC time	Mean depth (m)	Latitude	Longitude	UTC time	Mean depth (m)
R01	Trafalgar	17/10/15	36º 02.170' N	6º 28.540' W	11:56	167	36º 13.910 N	6º 07.080' W	14:06	24
R02	Sancti-Petri	17/10/15	36º 19.386' W	6º 14.580' W	06:28	33	36º 08.780' N	6º 33.740' W	10:58	178
R03	Cádiz	16/10/15	36º 27.400' N	6º 19.02' W	13:50	26	36º 17.827' N	6º 36.248' W	15:33	182
R04	Rota	16/10/15	36º 34.884' N	6º 22.416' W	06:41	21	36º 24.594' N	6º 41.390' W	10:25	214
R05	Chipiona	15/10/15	36º 40.840' N	6º 28.610' W	11:03	21	36º 31.288' N	6º 46.121' W	14:45	195
R06	Doñana	20/10/15	36º 47.791 N	6º 33.572' W	06:35	20	36º 37.900' N	6º 51.710' W	10:14	224
R07	Matalascañas	20/10/15	36º 44.070' N	6º 58.380' W	11:04	180	36º 54.372' N	6º 39.510' W	15:06	20
R08	Mazagón	21/10/15	37º 01.761' N	6º 43.452' W	06:38	19	36º 49.380' N	7º 06.100' W	10:39	207
R09	Punta Umbría	21/10/15	36º 49.730' N	7º 06.430' W	12:55	192	37º 05.800' N	6º 55.040' W	16:39	18
R10	El Rompido	22/10/15	37º 08.155' N	7º 07.189' W	06:44	21	36º 49.910' N	7º 07.28' W	10:05	211
R11	Isla Cristina	22/10/15	36º 53.540' W	7º 17.300' W	11:01	146	37º 06.110' N	7º 17.330' W	14:05	26
R12	V.R. Do Sto. Antonio	23/10/15	37º 06.551' N	7º 26.824' W	06:47	27	36º 56.190' N	7º 26.850' W	10:29	209
R13	Tavira	23/10/15	36º 57.090' N	07º 36.450' W	13:06	130	37º 04.470' N	7º 37.050 'W	13:55	22
R14	Fuzeta	24/10/15	36º 59.055' N	7º 46.638' W	06:49	72	36º 55.382' N	7º 46.371' W	07:12	216
R15	Cabo Sta. María	24/10/15	36º 51.968' N	7º 56.344' W	08:01	126	36º 55.490' N	7º 56.410' W	09:57	70
R16	Cuarteira	27/10/15	36º 50.010' N	8º 6.180' W	11:52	111	37º 01.711' N	8º 06.198' W	15:52	20
R17	Albufeira	27/10/15	37º 02.306' N	8º 15.916' W	07:48	33	36º 49.302' N	8º 15.805' W	09:11	191
R18	Alfanzina	26/10/15	36º 50.474' N	8º 25.687' W	10:12	182	37º 04.272' N	8º 25.602' W	15:25	22
R19	Portimao	26/10/15	37º 6.021' N	8º 35.703 W	07:40	30	36º 51.144' N	8º 35.620' W	09:13	210
R20	Burgau	25/10/15	36º 52.290' N	8º 45.320' W	11:40	110	37º 03.924' N	8º 45.338' W	15:16	25
R21	Punta de Sagres	25/10/15	37º 59.970' N	8º 55.339' W	07:43	24	36º 50.689' N	8º 55.345' W	08:38	208

Table 2. *ECOCADIZ-RECLUTAS 2015-10* survey. Descriptive characteristics of the fishing stations. Null hauls in light grey.

Fishing Station	Date	Start		End		UTC Time		Depth (m)		Duration (min)		Trawled Distance (nm)	Acoustic Transect	Zone (landmark)
		Latitude	Longitude	Latitude	Longitude	Start	End	Start	End	Effective Trawling	Total Manoeuvre			
01	13-10-2019	35º 59.0800 N	6º 13.2799 W	35º 59.2399 N	6º 13.5799 W	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	TEST HAULS
02	14-10-2018	36º 03.2830 N	6º 27.2080 W	36º 04.4593 N	6º 28.3053 W	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	
03	14-10-2018	36º 04.7891 N	6º 29.7353 W	36º 07.1468 N	6º 32.7894 W	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	
04	14-10-2018	36º 17.1569 N	6º 35.6245 W	36º 19.7817 N	6º 36.6497 W	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	
05	15-10-2015	36º 36.3290 N	6º 36.8989 W	36º 37.6080 N	6º 34.5639 W	12:27	13:00	61	45,49	00:33	01:16	2,273	R05	Chipiona
06	15-10-2015	36º 31.9679 N	6º 44.9079 W	36º 33.7600 N	6º 41.5730 W	15:10	16:01	138,11	99,07	00:51	01:32	3,229	R05	Chipiona
07	16-10-2015	36º 30.1320 N	6º 31.2920 W	36º 31.3000 N	6º 28.8759 W	08:01	08:36	60,64	48,64	00:35	01:05	2,27	R04	Rota
08	16-10-2015	36º 27.5340 N	6º 36.0999 W	36º 29.1751 N	6º 33.0299 W	11:27	12:13	94,06	72,10	00:46	01:26	2,969	R04	Rota
09	17-10-2015	36º 16.4360 N	6º 18.2319 W	36º 18.3959 N	6º 19.4634 W	07:52	08:25	41,50	41,88	00:33	----	2,196	R02	Sancti-Petri
10	20-10-2015	36º 42.5213 N	6º 43.6841 W	36º 43.5041 N	6º 41.5994 W	08:00	08:30	65,21	47,5	00:30	01:12	1,942	R06	Doñana
11	20-10-2015	36º 45.8257 N	6º 55.3040 W	36º 44.4132 N	6º 57.7558 W	11:50	12:27	112,44	154,96	00:37	01:23	2,423	R07	Matalascañas
12	21-10-2015	36º 55.6257 N	6º 54.7148 W	36º 56.7561 N	6º 52.4469 W	08:19	08:51	58,12	47,72	00:32	01:03	2,14	R08	Mazagón
13	21-10-2015	36º 50.0638 N	7º 04.9497 W	36º 51.1762 N	7º 02.8828 W	11:13	11:44	142,99	115,41	00:30	01:17	1,997	R08	Mazagón
14	21-10-2015	36º 57.1992 N	7º 01.2099 W	36º 55.3378 N	7º 02.5242 W	14:12	14:43	70,43	90,06	00:31	01:13	2,137	R09	Punta Umbría
15	22-10-2015	37º 01.9042 N	7º 06.5516 W	37º 02.2793 N	7º 08.3826 W	07:59	08:22	49,49	49,57	00:22	00:52	1,513	R10	El Rompido
16	22-10-2015	36º 58.4851 N	7º 17.4195 W	36º 56.0456 N	7º 17.3699 W	11:55	12:32	97,21	115,36	00:37	01:16	2,437	R11	Isla Cristina
17	23-10-2015	37º 03.0953 N	7º 25.2331 W	37º 03.0943 N	7º 28.2297 W	08:11	08:48	68,21	71,22	00:36	01:10	2,399	R12	V. R. do Sto. Antonio
18	23-10-2015	36º 57.2833 N	7º 24.2319 W	36º 57.7005 N	7º 27.3007 W	11:17	11:55	118,55	117,93	00:37	01:20	2,495	R12	V. R. do Sto. Antonio
19	23-10-2015	37º 03.6027 N	7º 34.0692 W	37º 02.6358 N	7º 37.1117 W	14:56	15:34	51,02	49,01	00:38	01:17	2,62	R13	Tavira
20	24-10-2015	36º 54.1349 N	7º 56.9514 W	36º 54.3636 N	7º 55.5737 W	08:46	09:02	83,79	85,74	00:16	01:01	1,128	R15	Cabo Sta. María
21	25-10-2015	36º 51.3152 N	8º 53.8619 W	36º 51.4428 N	8º 56.0116 W	09:23	09:47	137,47	149,83	00:24	01:13	1,73	R21	Ponta de Sagres
22	25-10-2015	36º 52.2242 N	8º 46.6308 W	36º 52.3818 N	8º 50.3875 W	12:11	12:54	130,12	128,45	00:43	01:25	3,018	R20	Burgau
23	26-10-2015	36º 51.4796 N	8º 23.5631 W	36º 51.5034 N	8º 26.7776 W	12:00	12:36	129,62	136,85	00:35	01:30	2,58	R16	Cuarteira
24	27-10-2015	36º 50.4104 N	8º 15.8558 W	36º 53.5617 N	8º 15.8366 W	09:25	10:09	120,27	102,57	00:44	01:31	3,147	R17	Albufeira
25	27-10-2015	36º 49.4671 N	8º 08.9748 W	36º 51.2215 N	8º 06.4984 W	13:20	13:56	111,98	109,44	00:35	01:32	2,65	R16	Cuarteira

Table 3. *ECOCADIZ-RECLUTAS 2015-10* survey. Catches by species in number (upper panel) and weight (in kg, lower panel) from valid fishing stations.

ABUNDANCE (nº)												
Fishing station	***Anchovy***	***Sardine***	***Chub mack.***	***Mackerel***	***Horse-mack.***	***Blue Jack-mack.***	***Medit. Horse-mack.***	***Bogue***	***Blue whiting***	***Boarfish***	**Other spp.**	**TOTAL**
05	44946	2574	0	0	0	0	10	3	0	0	17	**47550**
06	2627	0	63	3	8	0	0	0	0	0	66	**2767**
07	28817	4032	1	0	0	0	0	2	0	0	4	**32856**
08	4507	816	0	1	0	0	0	0	0	0	18	**5342**
09	0	0	1	0	0	0	169	1	0	0	66	**237**
10	25570	2450	0	0	2	0	0	2	0	0	30	**28054**
11	13880	2234	0	12	0	0	0	0	0	0	21	**16147**
12	15428	2239	0	0	1	0	1	6	0	0	52	**17727**
13	5403	0	784	17	8	0	0	0	3	0	37	**6252**
14	30882	470	0	10	3	0	2	0	0	0	48	**31415**
15	5554	257	3	0	0	0	3	0	0	0	40	**5857**
16	3678	9	5	3	1	0	0	0	0	0	26	**3722**
17	7767	147	1	0	0	0	0	0	0	0	22	**7937**
18	33	0	159	3	1	100	0	0	0	0	13	**309**
19	638	75726	22	0	0	3	0	18	0	0	29	**76436**
20	743	8844	30	2	72	344	0	0	0	0	8	**10043**
21	55	0	0	6	12	24	0	0	0	0	3	**100**
22	12	144	128	11	117	1067	0	0	92	1638	23	**3232**
23	691	41	433	0	1	1655	0	0	0	0	1	**2822**
24	297	0	2	2	107	35	0	1	656	0	113	**1213**
25	1	3	8898	38	888	1298	0	0	0	0	13	**11139**
TOTAL	**191529**	**99986**	**10530**	**108**	**1221**	**4526**	**185**	**33**	**751**	**1638**	**650**	**311157**

Table 3. *ECOCADIZ-RECLUTAS 2015-10* survey. Cont'd.

BIOMASS (kg)												
Fishing station	***Anchovy***	***Sardine***	**Chub mack.**	***Mackerel***	***Horse-mack.***	***Blue Jack-mack.***	***Medit. Horse-mack.***	***Bogue***	***Blue whiting***	***Boarfish***	**Other spp.**	**TOTAL**
05	222,930	48,120	0	0	0	0	2,716	0,722	0	0	14,444	288,932
06	20,800	0	8,940	0,518	0,063	0	0	0	0	0	2,188	32,509
07	149,850	181,842	0,258	0	0	0	0	0,526	0	0	0,576	333,052
08	37,400	29,600	0	0,160	0	0	0	0	0	0	3,362	70,522
09	0	0	0,202	0	0	0	35	0,108	0	0	18,688	53,998
10	117,720	32,351	0	0	0,130	0	0	0,228	0	0	5,404	155,833
11	132,234	43,500	0	2,758	0	0	0	0	0	0	0,939	179,431
12	76,100	42,880	0	0	0,082	0	0,228	0,860	0	0	4,622	124,772
13	53,640	0	88,760	3,012	0,300	0	0	0	0,062	0	15,238	161,012
14	203,500	9,032	0	2,870	0,098	0	0,024	0	0	0	0,384	215,908
15	29,540	5,928	0,462	0	0	0	0,102	0	0	0	3,362	39,394
16	32,080	0,548	0,708	0,688	0,020	0	0	0	0	0	2,562	36,606
17	39,440	2,380	0,208	0	0	0	0	0	0	0	1,282	43,310
18	0,519	0	10,602	0,406	0,020	6,524	0	0	0	0	1,214	19,285
19	2,900	6469,700	3,726	0	0	0,528	0	2,280	0	0	10,806	6489,94
20	5,680	776,620	3,950	0,308	12,620	33,340	0	0	0	0	1,44	833,958
21	1,266	0	0	0,418	1,408	1,031	0	0	0	0	7,417	11,540
22	0,282	9,280	9,780	0,840	9,900	71,720	0	0	1,846	36,34	2,474	142,462
23	16,840	1,420	27,920	0	0,092	67,111	0	0	0	0	2,364	115,747
24	2,546	0	0,254	0,400	11,960	4,138	0	0,120	13,380	0	4,052	36,850
25	0,026	0,236	1074,960	6,378	106,340	98,244	0	0	0	0	6,227	1292,411
TOTAL	**1145,293**	**7653,437**	**1230,730**	**18,756**	**143,033**	**282,636**	**38,070**	**4,844**	**15,288**	**36,34**	**109,045**	**10677,472**

Table 4. *ECOCADIZ-RECLUTAS 2015-10* survey. Parameters of the size-weight relationships for survey's target species. FAO codes for the species: PIL: *Sardina pilchardus*; ANE: *Engraulis encrasicolus*; MAS: *Scomber colias*; MAC: *Scomber scombrus*; JAA: *Trachurus picturatus;* HOM: *Trachurus trachurus*; HMM: *Trachurus mediterraneus*; BOG: *Boops boops*; WHB: *Micromesistius poutassou*; BOC: *Capros aper*.

Parameter	PIL	ANE	MAS	MAC	JAA	HOM	HMM	BOG	WHB	BOC
n	737	889	362	97	304	236	66	32	107	102
a	0,001983119	0,00335699	0,002454871	0,0190372	0,004206426	0,006720766	0,004801032	0,003232334	0,015974591	0,025043736
b	3,495249731	3,218559213	3,365609239	2,71907671	3,211602406	3,066669677	3,151832574	3,341745323	2,583276171	2,903514744
r^2	0,973730232	0,990704252	0,966445106	0,873747952	0,957809047	0,993093103	0,973584407	0,966143357	0,67657836	0,939962959

Table 5. *ECOCADIZ-RECLUTAS 20154-10* survey. Anchovy (*E. encrasicolus*). Estimated abundance (absolute numbers and million fish) and biomass (t) by size class (in cm). Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figures 8** and **9**.

***ECOCADIZ-RECLUTAS 2015-10* . *Engraulis encrasicolus* . ABUNDANCE (in number and million fish)**																	
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	**POL09**	**POL10**	**POL11**	***n***			**millions**		
												PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
8	0	0	2822	0	544551	5447066	0	0	17266799	3752988	0	547373	26466853	27014226	**1**	**26**	**27**
8,5	0	9361	20071	0	4198251	41994502	0	0	423430585	70468955	0	4227683	535894042	540121725	**4**	**536**	**540**
9	0	0	51431	0	23561167	235678982	4700937	878260	829594370	263147792	0	23612598	1334000341	1357612939	**24**	**1334**	**1358**
9,5	0	270334	14269	0	21770754	217769739	150009770	1073346	311088939	479046286	2444478	22055357	1161432558	1183487915	**22**	**1161**	**1183**
10	0	900162	11447	0	9081139	90837337	225014664	4808911	95074846	263898943	18390518	9992748	698025219	708017967	**10**	**698**	**708**
10,5	0	858076	0	0	5539105	55406874	248466818	33759985	51872031	32241935	62613256	6397181	484360899	490758080	**6**	**484**	**491**
11	0	543158	0	0	2267321	22679688	103131723	110227805	69138831	8260164	71165639	2810479	384603850	387414329	**3**	**385**	**387**
11,5	0	373371	0	1387162	789672	7898980	51578993	137725158	25936016	3752988	39691943	2550205	266584078	269134283	**3**	**267**	**269**
12	0	231746	0	462387	306552	3066399	23452155	95262098	8669217	0	14900851	1000685	145350720	146351405	**1**	**145**	**146**
12,5	0	108844	0	308258	0	0	4700937	36241971	0	0	3461584	417102	44404492	44821594	**0**	**44**	**45**
13	0	38635	0	154129	159675	1597210	0	12327550	0	0	1483536	352439	15408296	15760735	**0**	**15**	**16**
13,5	546005	73763	0	616517	0	0	0	7569755	0	0	1483536	1236285	9053291	10289576	**1**	**9**	**10**
14	2575156	11709	0	154129	0	0	0	5068160	0	0	960941	2740994	6029101	8770095	**3**	**6**	**9**
14,5	7195349	23419	0	154129	0	0	0	0	0	0	0	7372897	0	7372897	**7**	**0**	**7**
15	8942563	0	0	1078904	0	0	0	1073346	0	0	0	10021467	1073346	11094813	**10**	**1**	**11**
15,5	8130505	11709	0	616517	0	0	0	0	0	0	0	8758731	0	8758731	**9**	**0**	**9**
16	6039804	11709	0	154129	0	0	0	0	0	0	0	6205642	0	6205642	**6**	**0**	**6**
16,5	3246246	11709	0	0	0	0	0	0	0	0	0	3257955	0	3257955	**3**	**0**	**3**
17	998692	0	0	0	0	0	0	0	0	0	0	998692	0	998692	**1**	**0**	**1**
17,5	109201	0	0	0	0	0	0	0	0	0	0	109201	0	109201	**0**	**0**	**0**
TOTAL *n*	37783521	3477705	100040	5086261	68218187	682376777	811055997	446016345	1832071634	1124570051	216596282	114665714	5112687086	5227352800	115	5113	5227
Millions	**38**	**3**	**0,1**	**5**	**68**	**682**	**811**	**446**	**1832**	**1125**	**217**						

Table 5. *ECOCADIZ-RECLUTAS 2014-10* survey. Anchovy (*E. encrasicolus*). Cont'd.

ECOCADIZ-RECLUTAS 2015-10. *Engraulis encrasicolus*. BIOMASS (t)														
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	**POL09**	**POL10**	**POL11**	**PORTUGAL**	**SPAIN**	**TOTAL**
8	0	0	0,008	0	1,628	16,284	0	0	51,621	11,220	0	**1,636**	**79,125**	**80,761**
8,5	0	0,034	0,073	0	15,168	151,723	0	0	1529,822	254,599	0	**15,275**	**1936,144**	**1951,419**
9	0	0	0,222	0	101,796	1018,252	20,310	3,795	3584,266	1136,931	0	**102,018**	**5763,554**	**5865,572**
9,5	0	1,384	0,073	0	111,428	1114,596	767,785	5,494	1592,225	2451,870	12,511	**112,885**	**5944,481**	**6057,366**
10	0	5,412	0,069	0	54,597	546,121	1352,806	28,912	571,597	1586,581	110,565	**60,078**	**4196,582**	**4256,660**
10,5	0	6,013	0	0	38,819	388,296	1741,276	236,593	363,524	225,954	438,799	**44,832**	**3394,442**	**3439,274**
11	0	4,406	0	0	18,393	183,986	836,641	894,207	560,878	67,009	577,321	**22,799**	**3120,042**	**3142,841**
11,5	0	3,484	0	12,944	7,368	73,706	481,286	1285,12	242,010	35,019	370,367	**23,796**	**2487,508**	**2511,304**
12	0	2,473	0	4,934	3,271	32,720	250,244	1016,484	92,504	0	158,998	**10,678**	**1550,950**	**1561,628**
12,5	0	1,321	0	3,741	0	0	57,054	439,857	0	0	42,012	**5,062**	**538,923**	**543,985**
13	0	0,531	0	2,117	2,193	21,940	0	169,334	0	0	20,378	**4,841**	**211,652**	**216,493**
13,5	8,450	1,142	0	9,541	0	0	0	117,146	0	0	22,958	**19,133**	**140,104**	**159,237**
14	44,707	0,203	0	2,676	0	0	0	87,988	0	0	16,683	**47,586**	**104,671**	**152,257**
14,5	139,582	0,454	0	2,990	0	0	0	0	0	0	0	**143,026**	**0**	**143,026**
15	193,124	0	0	23,300	0	0	0	23,18	0	0	0	**216,424**	**23,180**	**239,604**
15,5	194,799	0,281	0	14,771	0	0	0	0	0	0	0	**209,851**	**0**	**209,851**
16	160,021	0,310	0	4,084	0	0	0	0	0	0	0	**164,415**	**0**	**164,415**
16,5	94,819	0,342	0	0	0	0	0	0	0	0	0	**95,161**	**0**	**95,161**
17	32,067	0	0	0	0	0	0	0	0	0	0	**32,067**	**0**	**32,067**
17,5	3,844	0	0	0	0	0	0	0	0	0	0	**3,844**	**0**	**3,844**
TOTAL	**871,413**	**27,790**	**0,445**	**81,098**	**354,661**	**3547,624**	**5507,402**	**4308,110**	**8588,447**	**5769,183**	**1770,592**	**1335,407**	**29491,358**	**30826,765**

Table 6. *ECOCADIZ-RECLUTAS* surveys series. Anchovy (*E. encrasicolus*). Acoustic estimates of biomass (t) and abundance (million fish) for the whole Gulf of Cadiz anchovy population and for the juvenile fraction (*i.e*. age 0 fish, between parentheses). Because of the age-structured estimates from the 2015 survey are not still available, the recruit fraction in that survey has been assumed as the one composed by fish with sizes ≤10 cm as a proxy for age 0 fish.

Estimate/Year	Total Population (Recruits at age 0)		
	2012	2014	2015 (aprox. ≤10 cm)
Biomass (t)	13680 (13354)	8113 (5131)	30827 (18112)
Abundance (millions)	2469 (2619)	986 (814)	5227 (3816)

Table 7. *ECOCADIZ-RECLUTAS 2015-10* survey. Sardine (*S. pilchardus*). Estimated abundance (absolute numbers and million fish) and biomass (t) by size class (in cm). Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figures 10** and **11**.

***ECOCADIZ-RECLUTAS 2015-10*. *Sardina pilchardus*. ABUNDANCE (in number and million fish)**														
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	***n***			**millions**		
									PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
10	0	0	0	0	0	606600	0	0	0	606600	606600	**0**	**1**	**1**
10,5	0	0	2682	36072	0	2830406	923978	0	2682	3790456	3793138	**0**	**4**	**4**
11	0	0	59207	796275	0	24045393	5979710	0	59207	30821378	30880585	**0**	**31**	**31**
11,5	0	0	311487	4189219	1159661	77057292	14278084	36761	311487	96721017	97032504	**0**	**97**	**97**
12	0	0	401620	5401422	6278269	41310613	7356962	36761	401620	60384027	60785647	**0**	**60**	**61**
12,5	0	0	230003	3093328	19519945	18612695	5526438	73521	230003	46825927	47055930	**0**	**47**	**47**
13	0	0	114071	1534149	30442510	15445420	2301230	637183	114071	50360492	50474563	**0**	**50**	**50**
13,5	0	0	47858	643646	37279004	8329064	453272	796478	47858	47501464	47549322	**0**	**48**	**48**
14	0	0	14231	191401	24140520	4312159	0	588169	14231	29232249	29246480	**0**	**29**	**29**
14,5	1292232	0	2682	36072	10426312	1010607	697342	673943	1294914	12844276	14139190	**1**	**13**	**14**
15	25069325	0	8046	108215	342947	1659316	226637	355352	25077371	2692467	27769838	**25**	**3**	**28**
15,5	59959623	0	0	0	342947	606600	0	428873	59959623	1378420	61338043	**60**	**1**	**61**
16	114233421	0	10728	144287	0	163428	0	551408	114244149	859123	115103272	**114**	**1**	**115**
16,5	25069325	0	0	0	16331	84217	0	1262112	25069325	1362660	26431985	**25**	**1**	**26**
17	21192626	129761	16093	216430	65323	163428	0	1262112	21338480	1707293	23045773	**21**	**2**	**23**
17,5	0	129761	8046	108215	32662	161760	0	1066056	137807	1368693	1506500	**0**	**1**	**2**
18	0	386581	8046	108215	201471	205537	0	833239	394627	1348462	1743089	**0**	**1**	**2**
18,5	0	881545	26201	352373	370281	770028	348671	637183	907746	2478536	3386282	**1**	**2**	**3**
19	14214566	3632742	25580	344030	658908	1700148	2632468	281831	17872888	5617385	23490273	**18**	**6**	**23**
19,5	20675732	5648440	34247	460588	642577	2749919	6467850	281831	26358419	10602765	36961184	**26**	**11**	**37**
20	34890298	10262372	33626	452245	746063	1861908	7705633	159296	45186296	10925145	56111441	**45**	**11**	**56**
20,5	34890298	11396209	8046	108215	577254	1295748	8751646	36761	46294553	10769624	57064177	**46**	**11**	**57**
21	16799033	8797660	8046	108215	310285	1420405	3504145	0	25604739	5343050	30947789	**26**	**5**	**31**
21,5	3876699	3785705	8046	108215	97985	525720	1569020	0	7670450	2300940	9971390	**8**	**2**	**10**
22	0	2156903	2682	36072	16331	161760	1220349	0	2159585	1434512	3594097	**2**	**1**	**4**
22,5	0	375138	2682	36072	0	0	174336	0	377820	210408	588228	**0**	**0**	**1**
23	0	122530	0	0	0	42109	174336	0	122530	216445	338975	**0**	**0**	**0**
23,5	0	122530	0	0	0	0	0	0	122530	0	122530	**0**	**0**	**0**
TOTAL *n*	372163178	47827877	1383956	18612971	133667586	207132280	70292107	9998870	421375011	439703814	861078825	**421**	**440**	**861**
Millions	**372**	**48**	**1**	**19**	**134**	**207**	**70**	**10**						

Table 7. *ECOCADIZ-RECLUTAS 2015-10* survey. Sardine (*S. pilchardus*). Cont'd.

***ECOCADIZ-RECLUTAS 2015-10*. *Sardina pilchardus*. BIOMASS (t)**											
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	**PORTUGAL**	**SPAIN**	**TOTAL**
10	0	0	0	0	0	4,102	0	0	**0**	**4,102**	**4,102**
10,5	0	0	0,021	0,288	0	22,606	7,38	0	**0,021**	**30,274**	**30,295**
11	0	0	0,554	7,455	0	225,124	55,985	0	**0,554**	**288,564**	**289,118**
11,5	0	0	3,395	45,66	12,639	839,87	155,621	0,401	**3,395**	**1054,191**	**1057,586**
12	0	0	5,064	68,103	79,158	520,856	92,759	0,463	**5,064**	**761,339**	**766,403**
12,5	0	0	3,335	44,855	283,049	269,893	80,136	1,066	**3,335**	**678,999**	**682,334**
13	0	0	1,892	25,447	504,957	256,197	38,171	10,569	**1,892**	**835,341**	**837,233**
13,5	0	0	0,904	12,152	703,826	157,252	8,558	15,037	**0,904**	**896,825**	**897,729**
14	0	0	0,304	4,094	516,377	92,239	0	12,581	**0,304**	**625,291**	**625,595**
14,5	31,182	0	0,065	0,87	251,594	24,387	16,827	16,263	**31,247**	**309,941**	**341,188**
15	679,697	0	0,218	2,934	9,298	44,988	6,145	9,635	**679,915**	**73,000**	**752,915**
15,5	1819,710	0	0	0	10,408	18,41	0	13,016	**1819,710**	**41,834**	**1861,544**
16	3867,024	0	0,363	4,884	0	5,532	0	18,666	**3867,387**	**29,082**	**3896,469**
16,5	943,472	0	0	0,000	0,615	3,169	0	47,499	**943,472**	**51,283**	**994,755**
17	883,935	5,412	0,671	9,027	2,725	6,817	0	52,642	**890,018**	**71,211**	**961,229**
17,5	0	5,981	0,371	4,988	1,505	7,456	0	49,135	**6,352**	**63,084**	**69,436**
18	0	19,634	0,409	5,496	10,233	10,439	0	42,32	**20,043**	**68,488**	**88,531**
18,5	0	49,210	1,463	19,67	20,67	42,985	19,464	35,569	**50,673**	**138,358**	**189,031**
19	869,939	222,326	1,566	21,055	40,325	104,05	161,108	17,248	**1093,831**	**343,786**	**1437,617**
19,5	1384,013	378,101	2,292	30,831	43,013	184,077	432,952	18,865	**1764,406**	**709,738**	**2474,144**
20	2548,797	749,684	2,456	33,037	54,501	136,016	562,91	11,637	**3300,937**	**798,101**	**4099,038**
20,5	2775,624	906,601	0,64	8,609	45,922	103,08	696,219	2,924	**3682,865**	**856,754**	**4539,619**
21	1452,393	760,619	0,696	9,356	26,826	122,804	302,958	0	**2213,708**	**461,944**	**2675,652**
21,5	363,551	355,017	0,755	10,148	9,189	49,301	147,14	0	**719,323**	**215,778**	**935,101**
22	0	218,995	0,272	3,662	1,658	16,424	123,905	0	**219,267**	**145,649**	**364,916**
22,5	0	41,165	0,294	3,958	0	0	19,13	0	**41,459**	**23,088**	**64,547**
23	0	14,507	0	0	0	4,985	20,641	0	**14,507**	**25,626**	**40,133**
23,5	0	15,627	0	0	0	0	0	0	**15,627**	**0**	**15,627**
TOTAL	**17619,337**	**3742,879**	**28,000**	**376,579**	**2628,488**	**3273,059**	**2948,009**	**375,536**	**21390,216**	**9601,671**	**30991,887**

Table 8. *ECOCADIZ-RECLUTAS* surveys series. Sardine (*S. pilchardus*). Acoustic estimates of biomass (t) and abundance (million fish) for the whole Gulf of Cadiz sardine population and for the juvenile fraction (*i.e*. age 0 fish, between parentheses). Because of the age-structured estimates from the surveys composing the series are not still available, the recruit fraction has been assumed as the one composed by fish with sizes ≤16.5 cm as a proxy for age 0 fish.

Estimate/Year	**Total Population (Recruits at age 0 ≈ ≤16.5 cm)**		
	2012	**2014**	**2015**
Biomass (t)	22119 (9675)	36571 (760)	30992 (13037)
Abundance (millions)	603 (377)	507 (29)	861 (612)

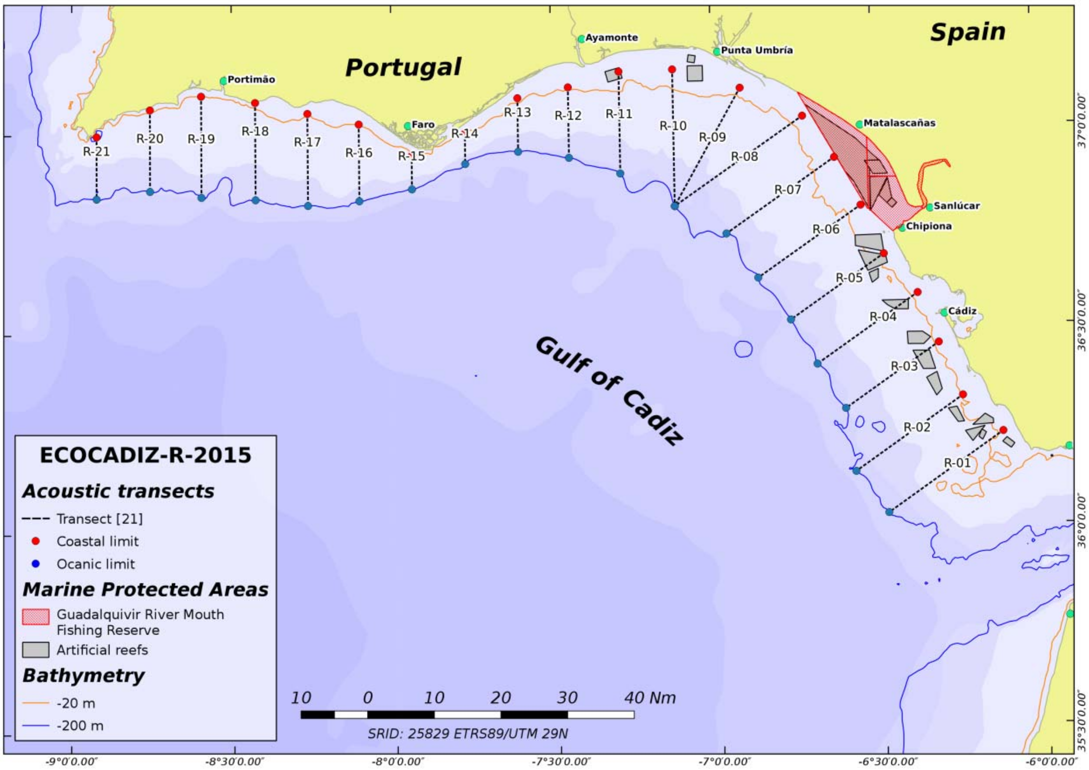


Figure 1. *ECOCADIZ-RECLUTAS 2015-10* survey. Location of the acoustic transects sampled during the survey. The different protected areas inside the Guadalquivir river mouth Fishing Reserve and artificial reef polygons are also shown.

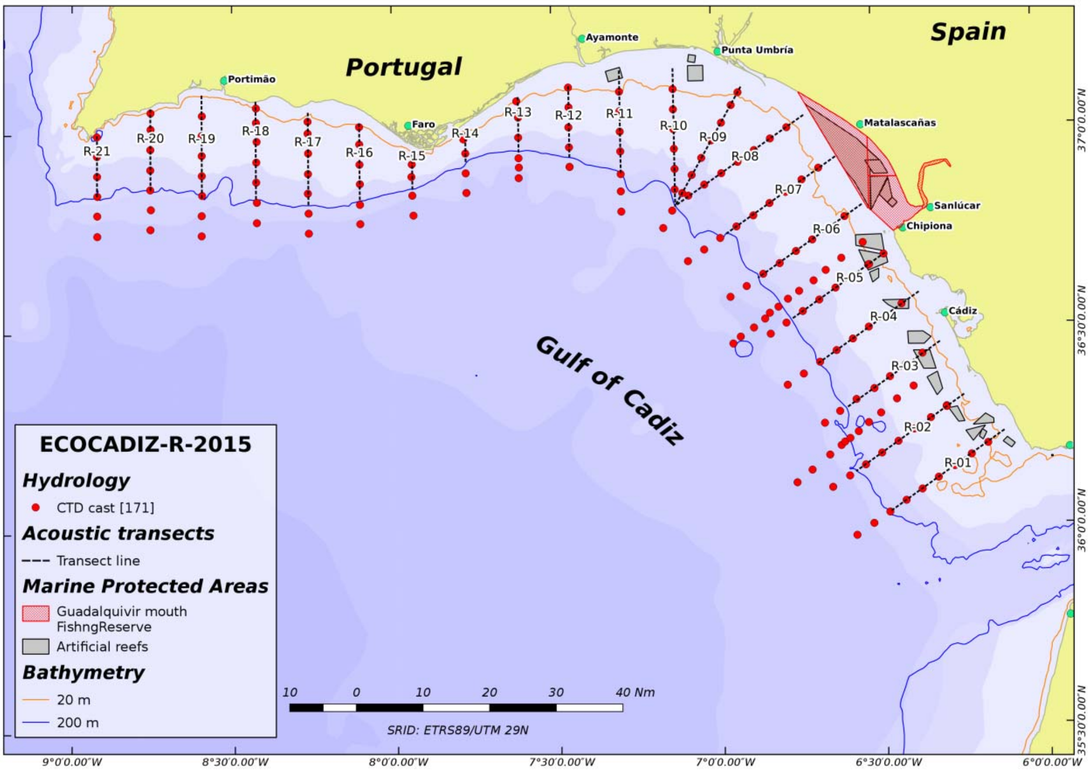


Figure 2. *ECOCADIZ-RECLUTAS 2015-10* survey. Location of CTD-LADCP stations.

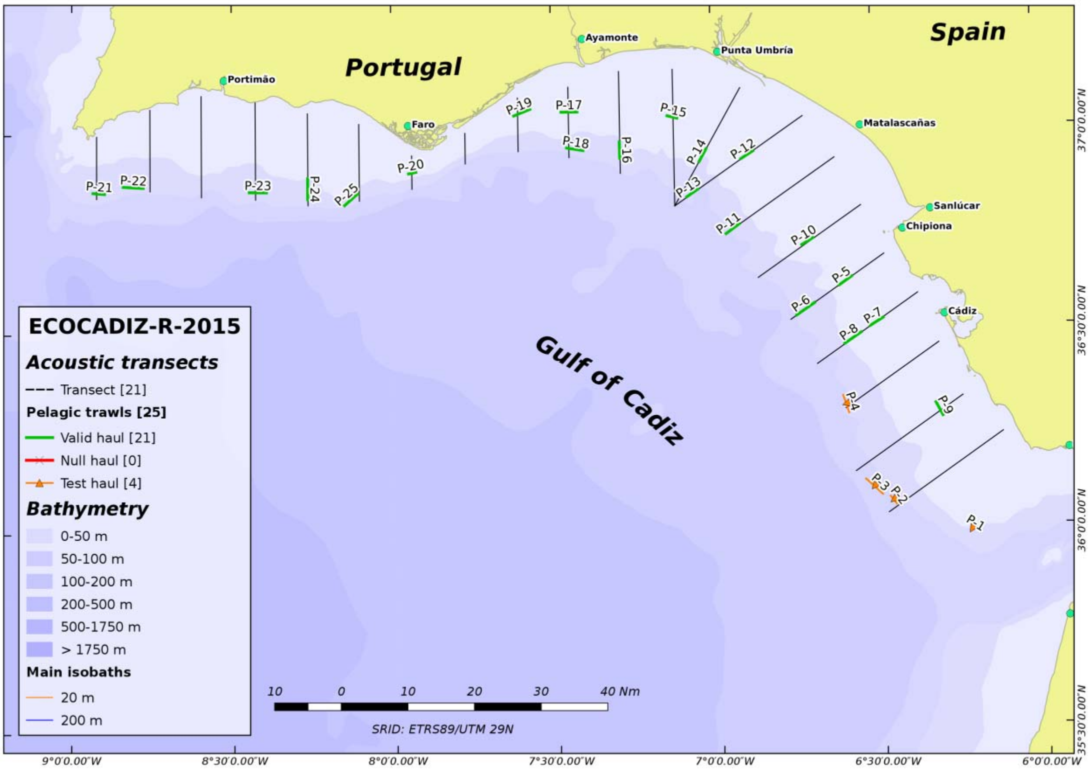


Figure 3. *ECOCADIZ-RECLUTAS 2015-10* survey. Location of groundtruthing fishing hauls. Null hauls in red.

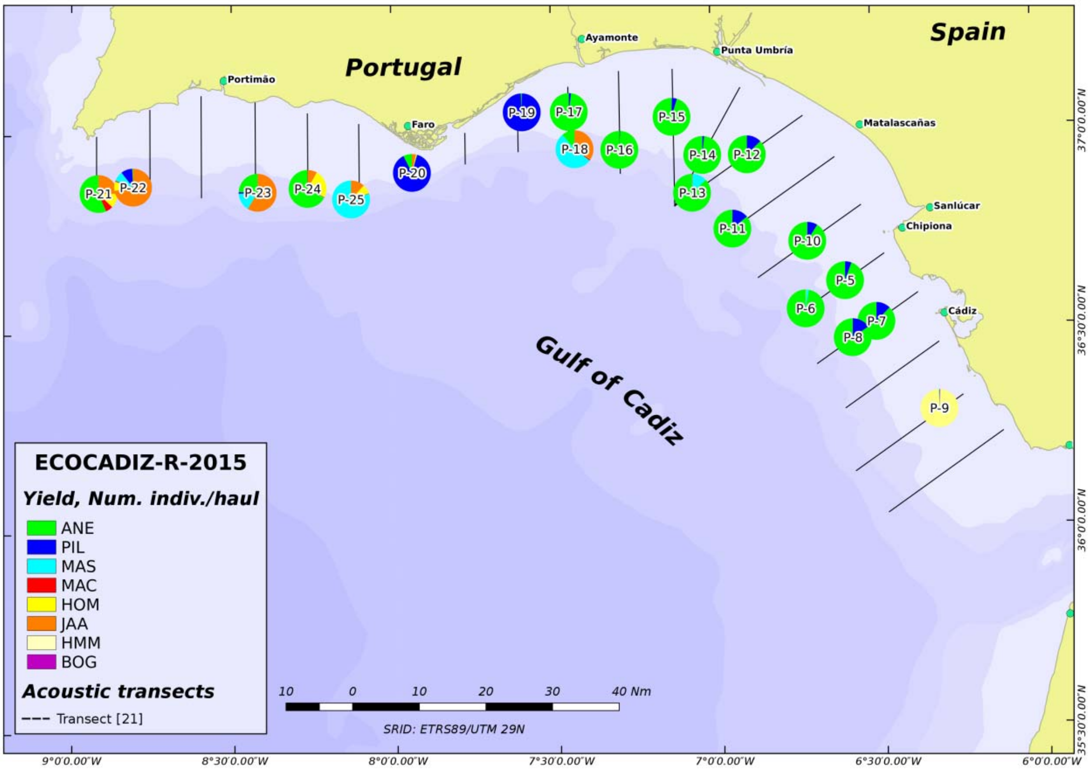


Figure 4. *ECOCADIZ-RECLUTAS 2015-10* survey. Species composition (percentages in number) in valid fishing hauls.

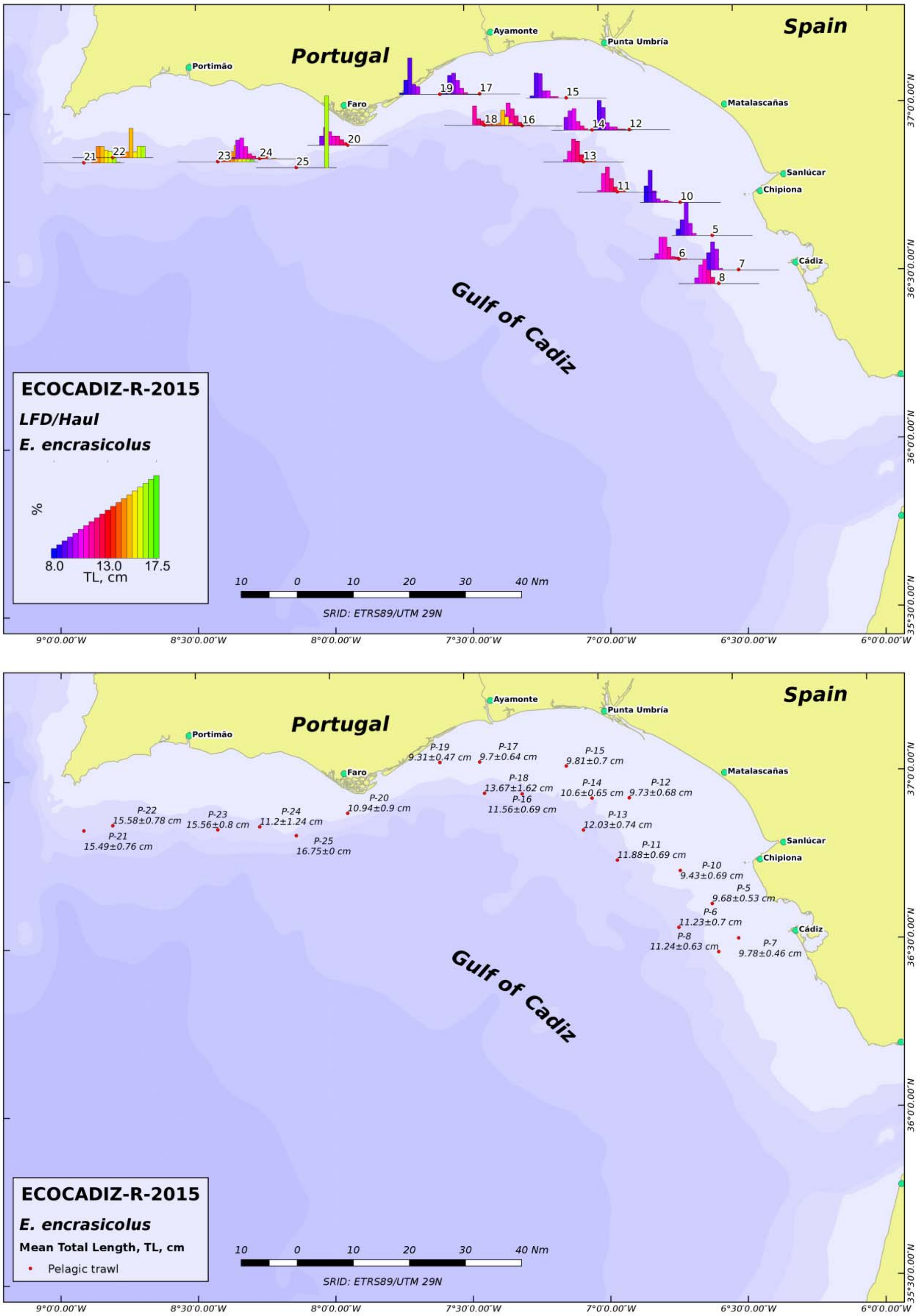


Figure 5. *ECOCADIZ-RECLUTAS 2015-10* survey. *Engraulis encrasicolus*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

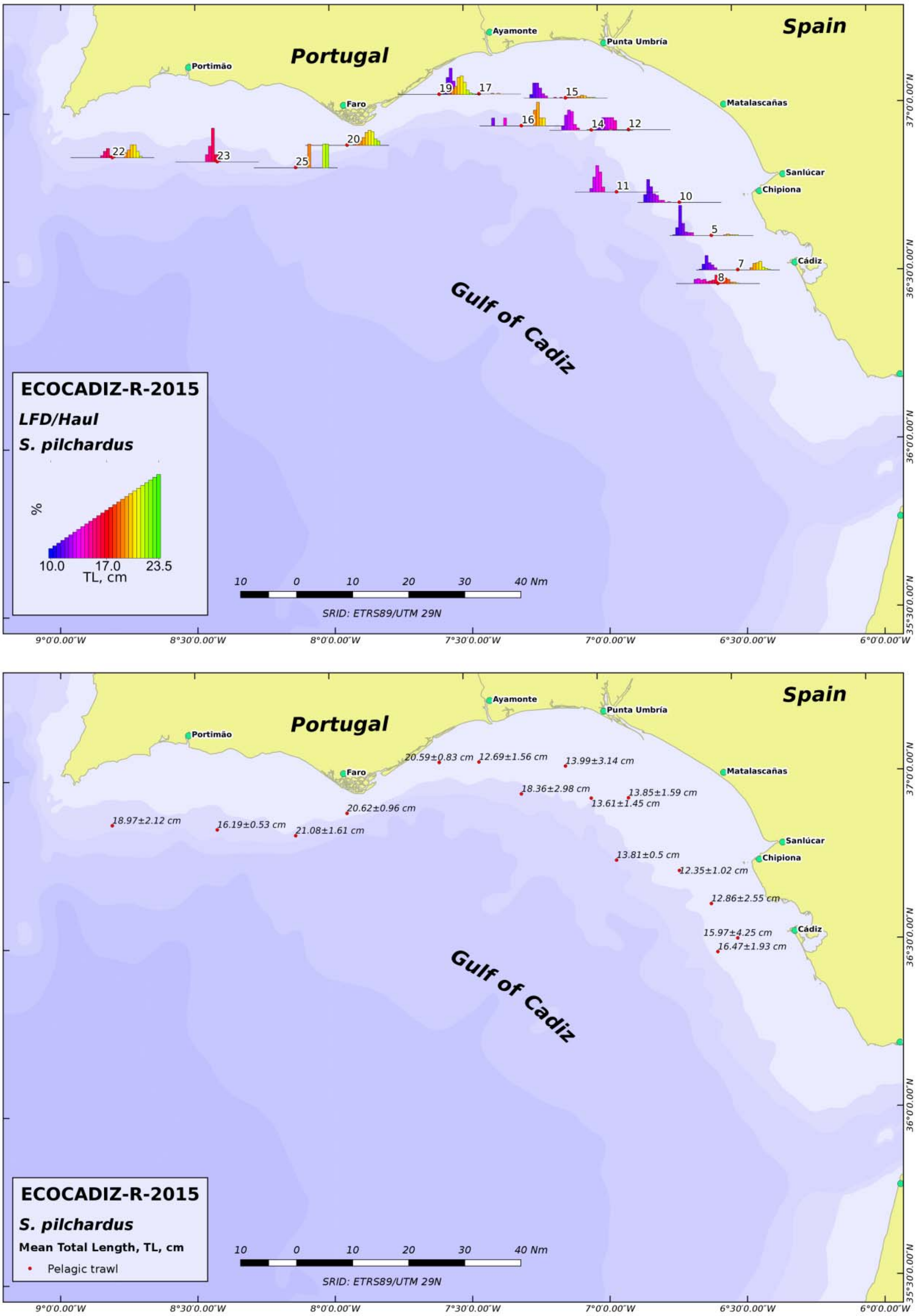


Figure 6. *ECOCADIZ-RECLUTAS 20154-10* survey. *Sardina pilchardus*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

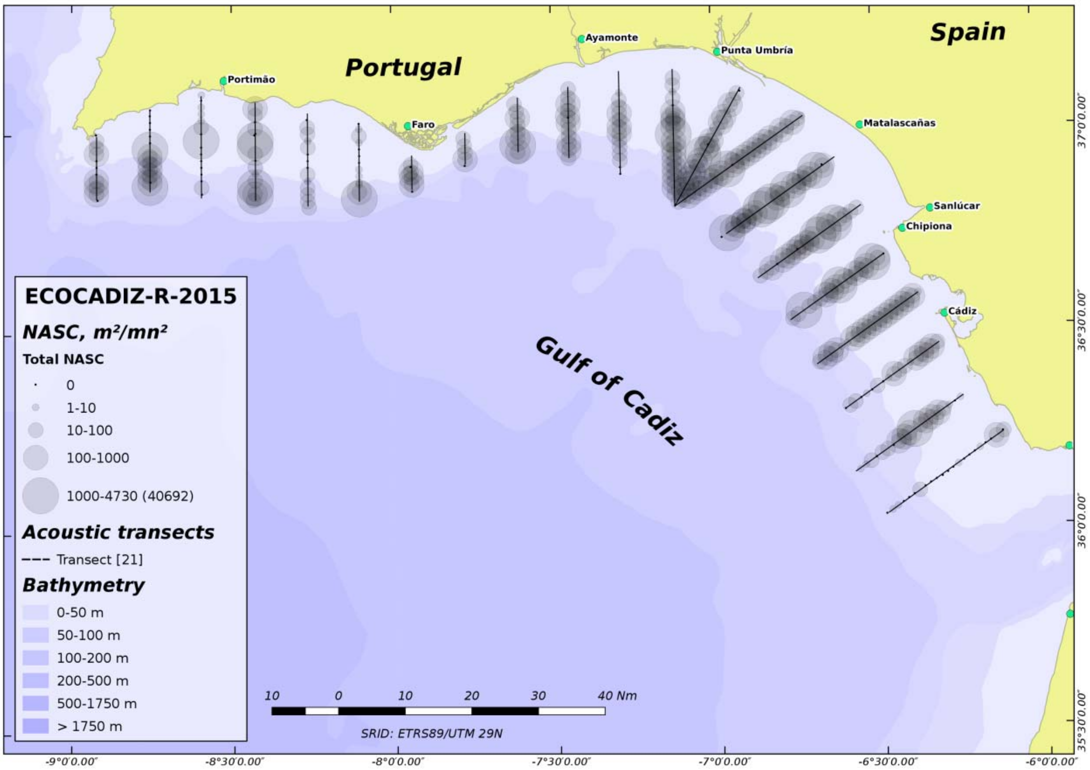
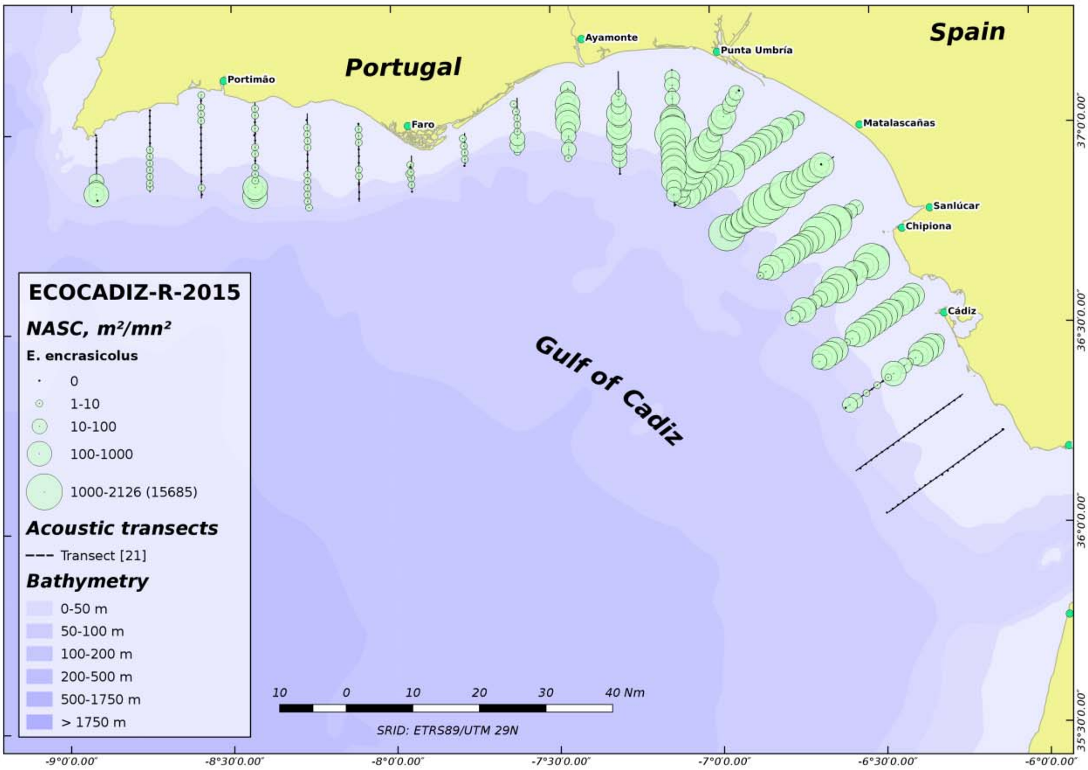


Figure 7. *ECOCADIZ-RECLUTAS 2015-10* survey. Distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the pelagic fish species assemblage.



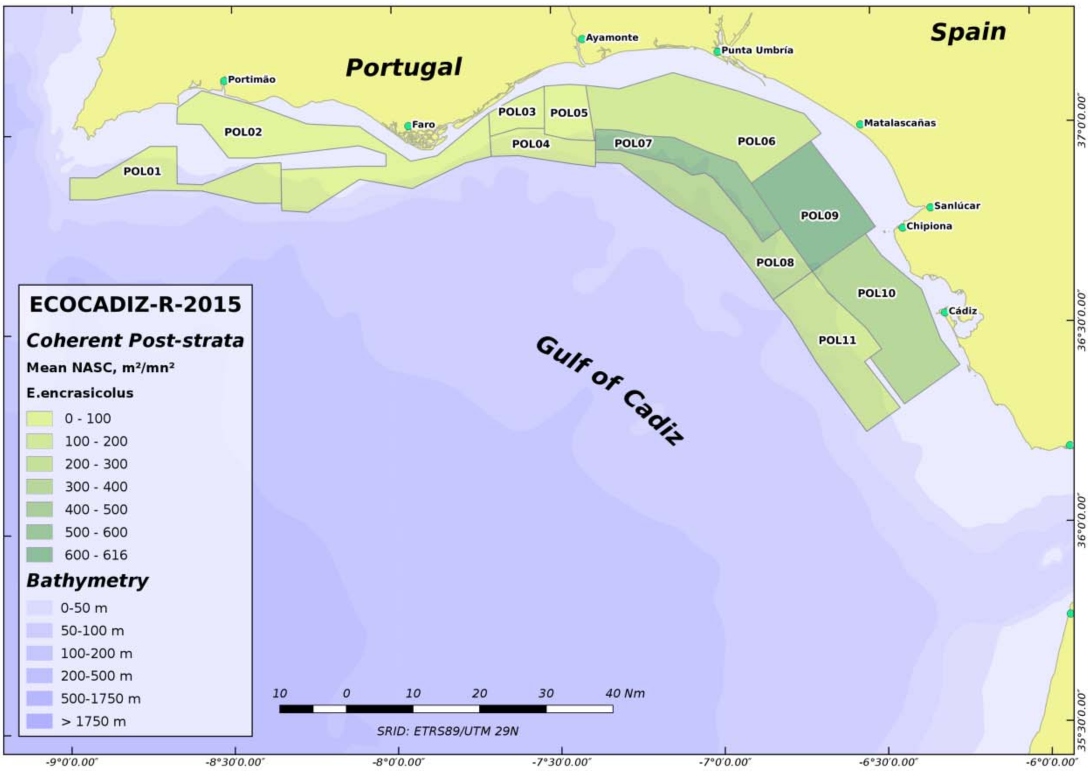


Figure 8. *ECOCADIZ-RECLUTAS 2015-10* survey. Anchovy (*Engraulis encrasicolus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

***ECOCADIZ-RECLUTAS 2015-10*: Anchovy (*E. encrasicolus*)**

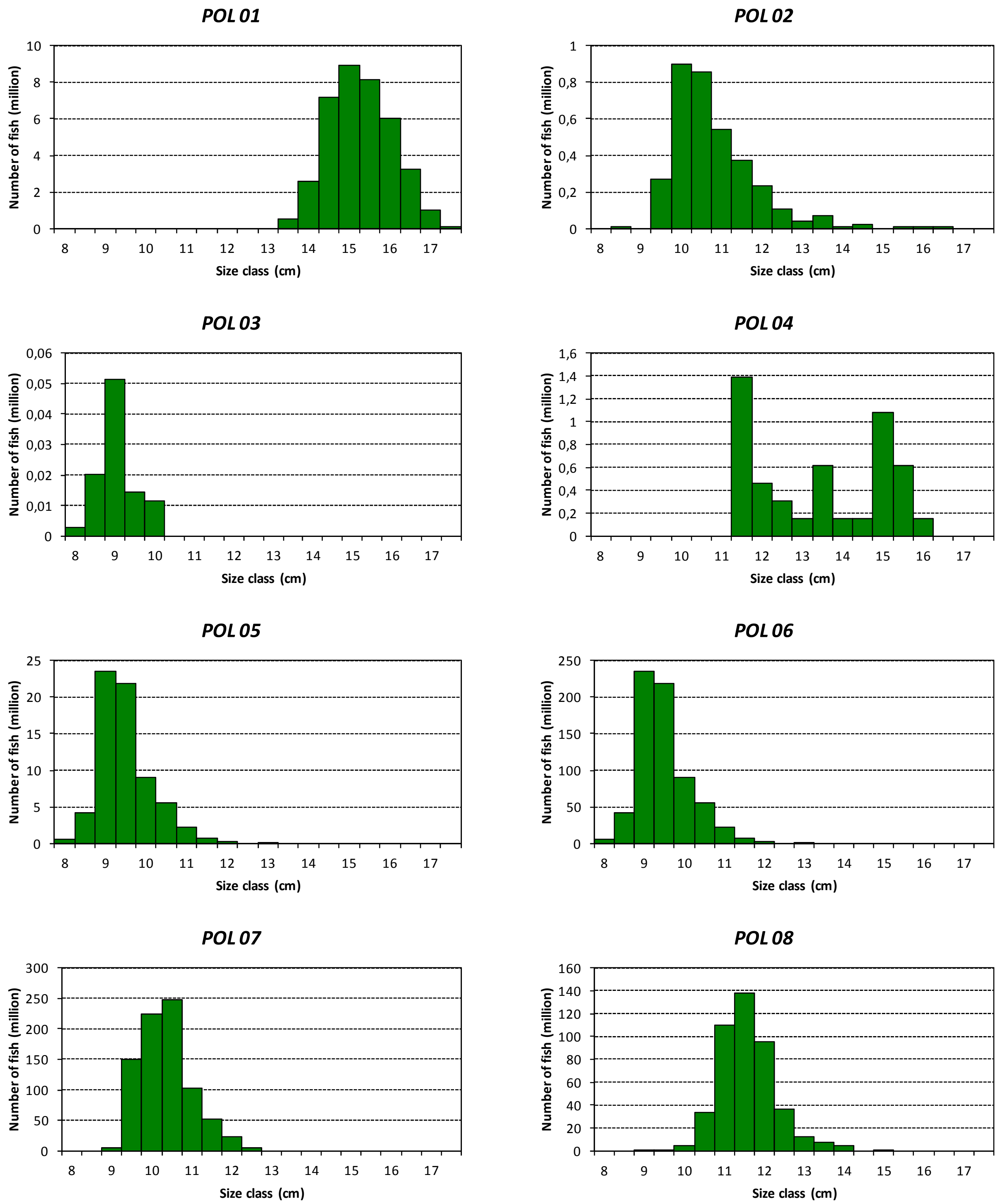


Figure 9. *ECOCADIZ-RECLUTAS 2015-10* survey. Anchovy (*E. encrasicolus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 8**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

ECOCADIZ-RECLUTAS 2015-10: Anchovy (*E. encrasicolus*)

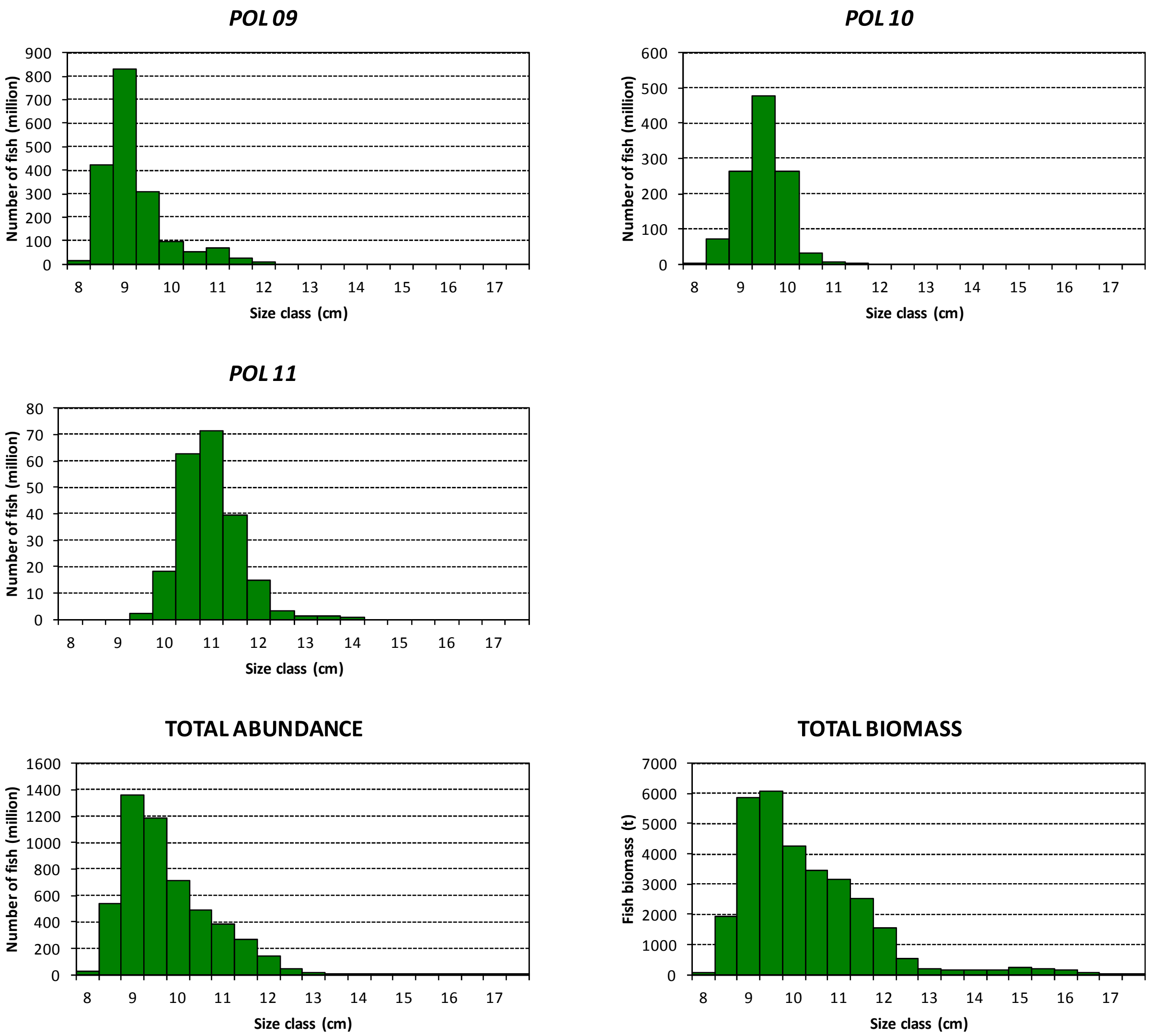
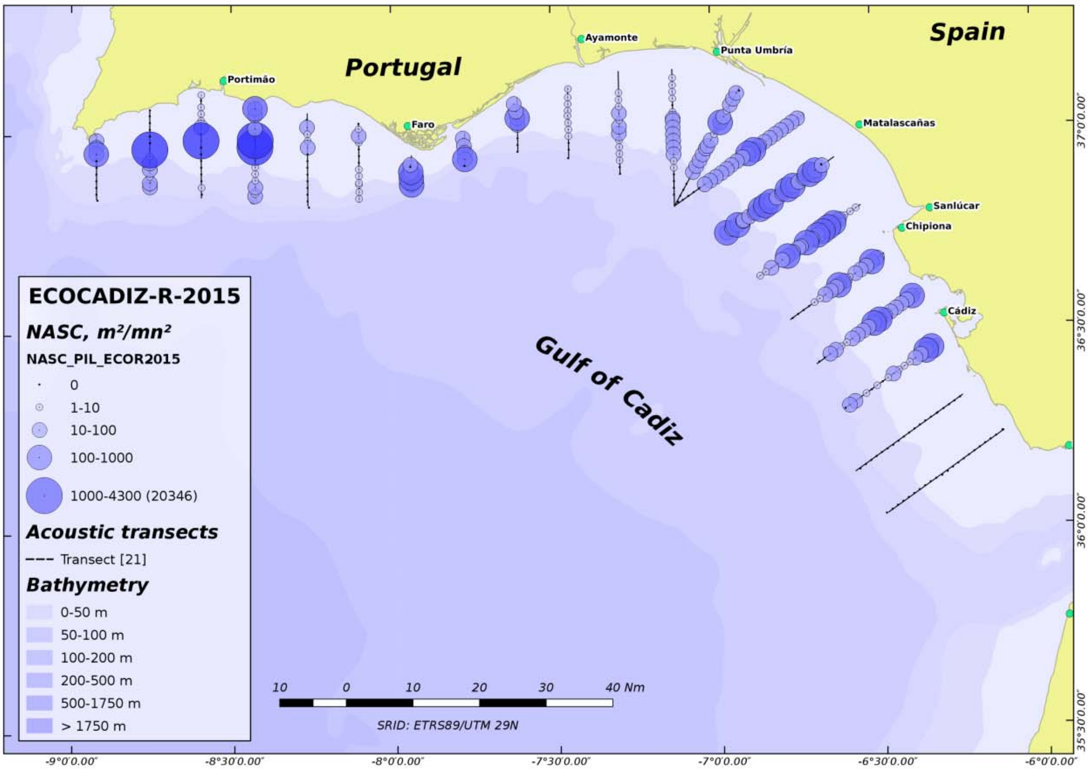


Figure 9. *ECOCADIZ-RECLUTAS 2015-10* survey. Anchovy (*E. encrasicolus*). Cont'd.



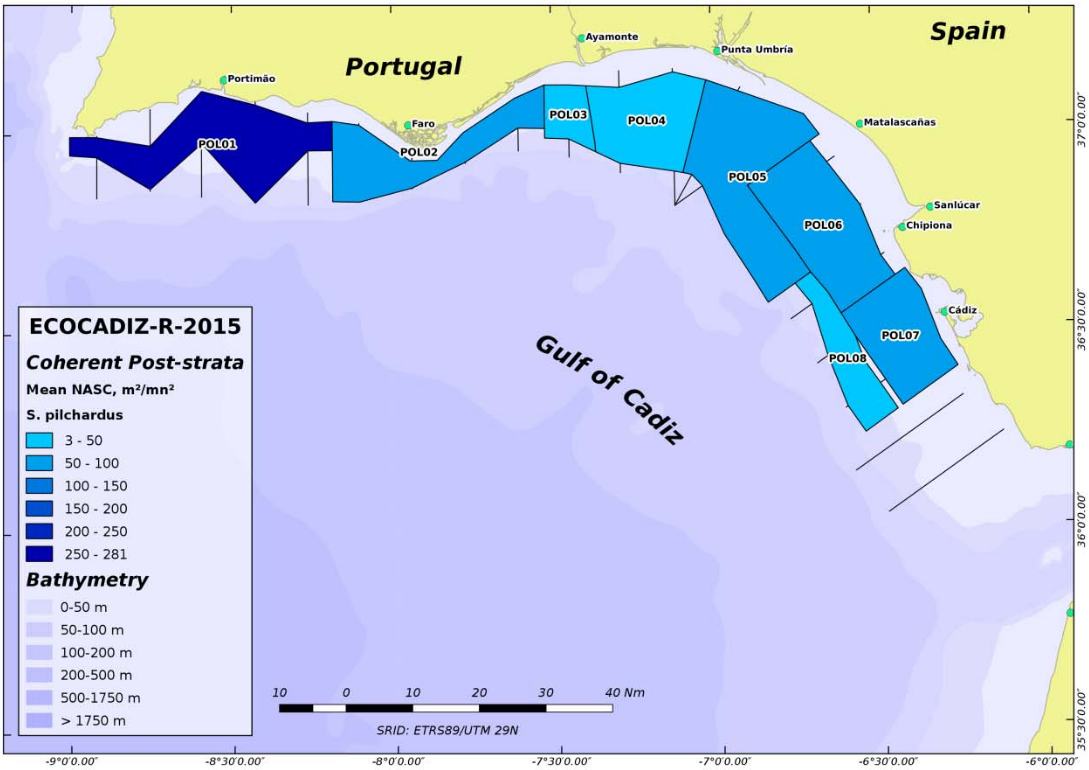


Figure 10. *ECOCADIZ-RECLUTAS 2015-10* survey. Sardine (*Sardina pilchardus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

***ECOCADIZ-RECLUTAS 2015-10*: Sardine (*S. pilchardus*)**

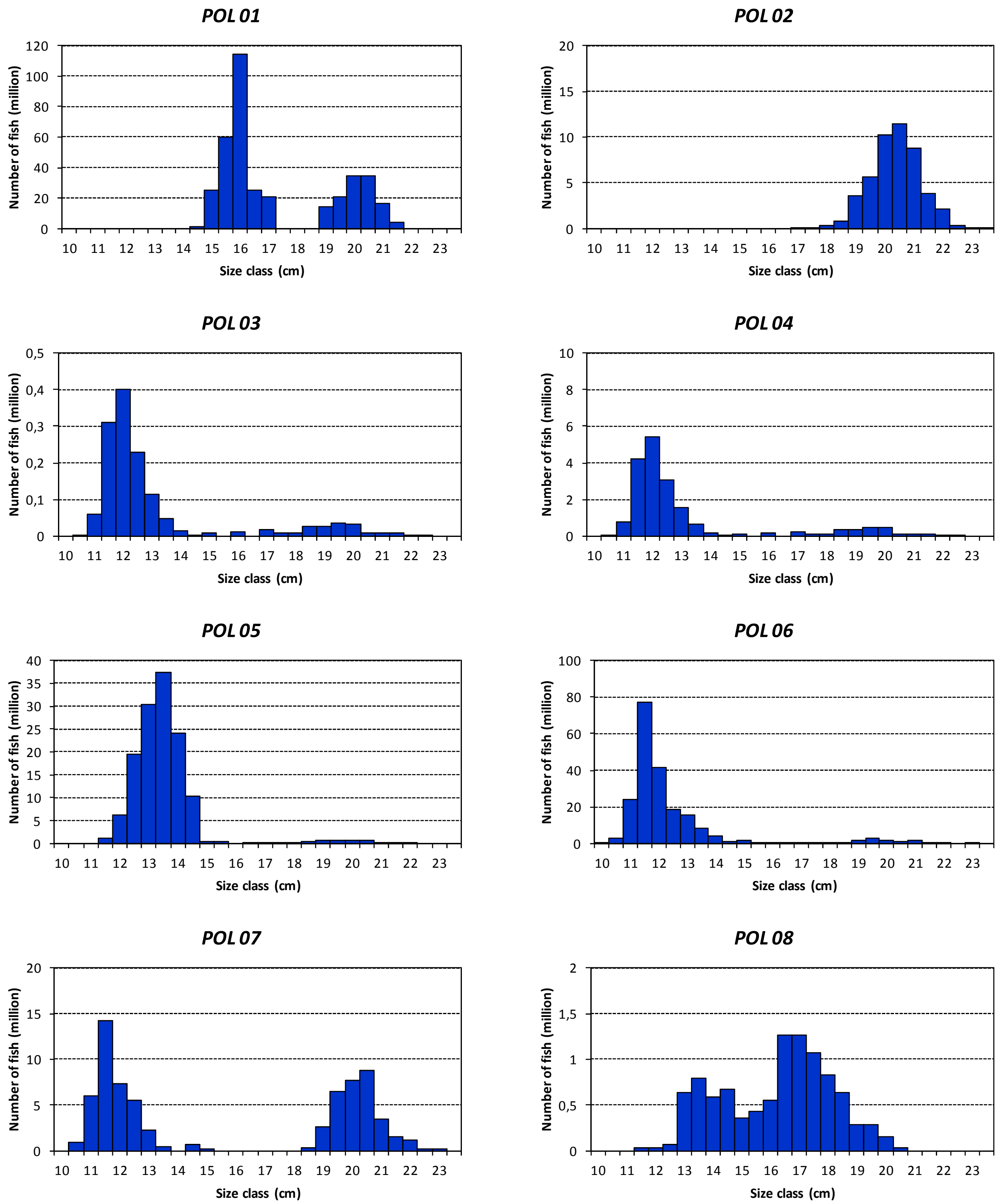


Figure 11. *ECOCADIZ-RECLUTAS 2015-10* survey. Sardine (*S. pilchardus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 10**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

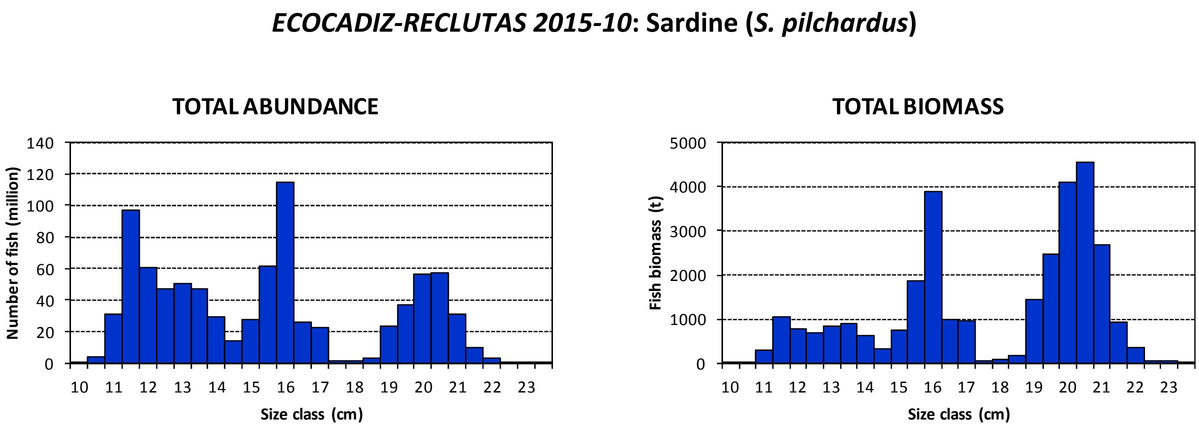


Figure 11. *ECOCADIZ-RECLUTAS 2015-10* survey. Sardine (*S. pilchardus*). Cont'd.

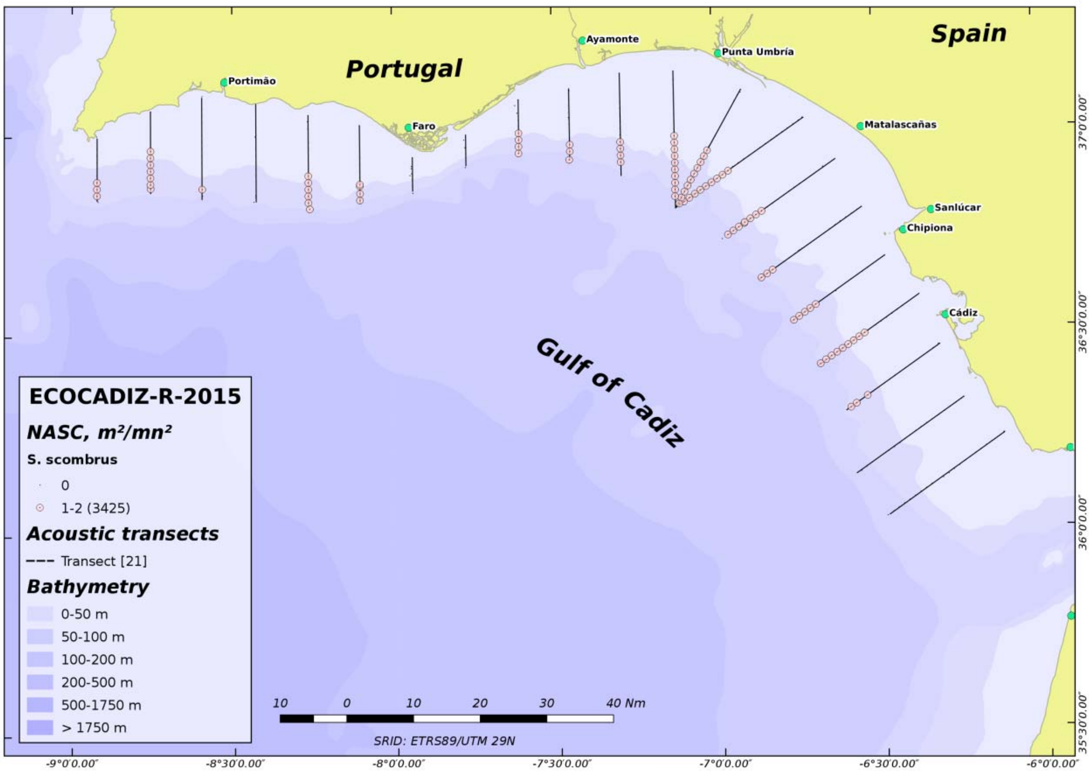


Figure 12. *ECOCADIZ-RECLUTAS 2015-10* survey. Mackerel (*Scomber scombrus*). Distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species

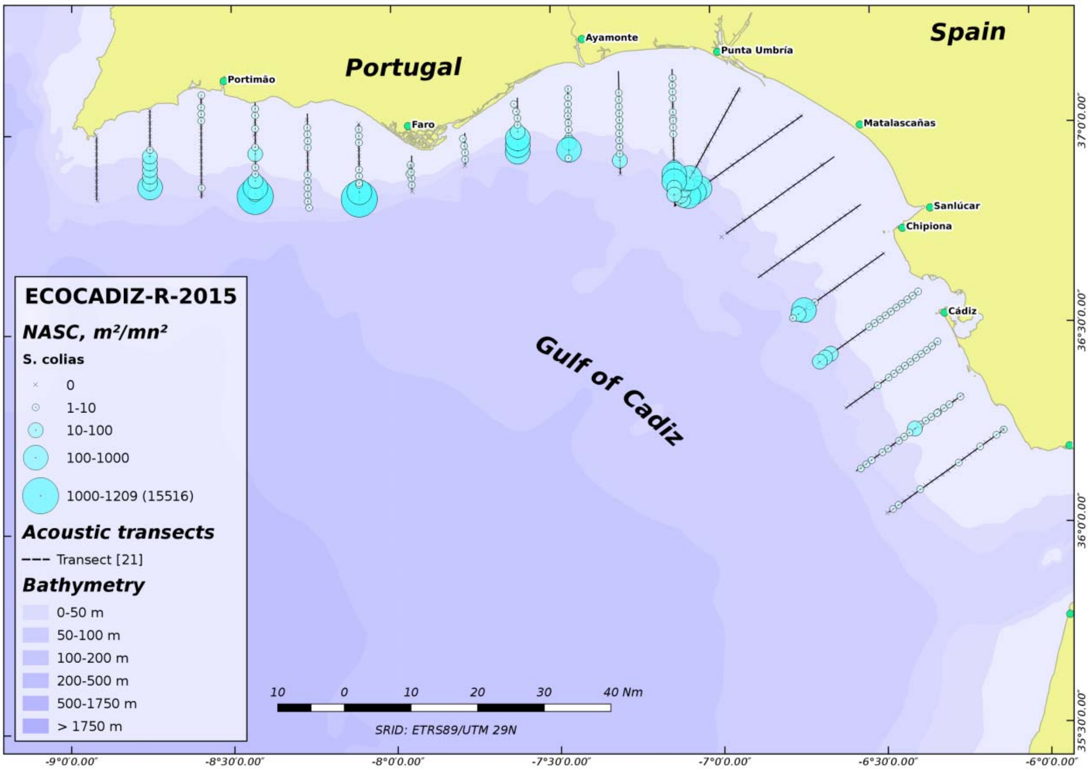


Figure 13. *ECOCADIZ-RECLUTAS 2015-10* survey. Chub mackerel (*Scomber colias*). Distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species.

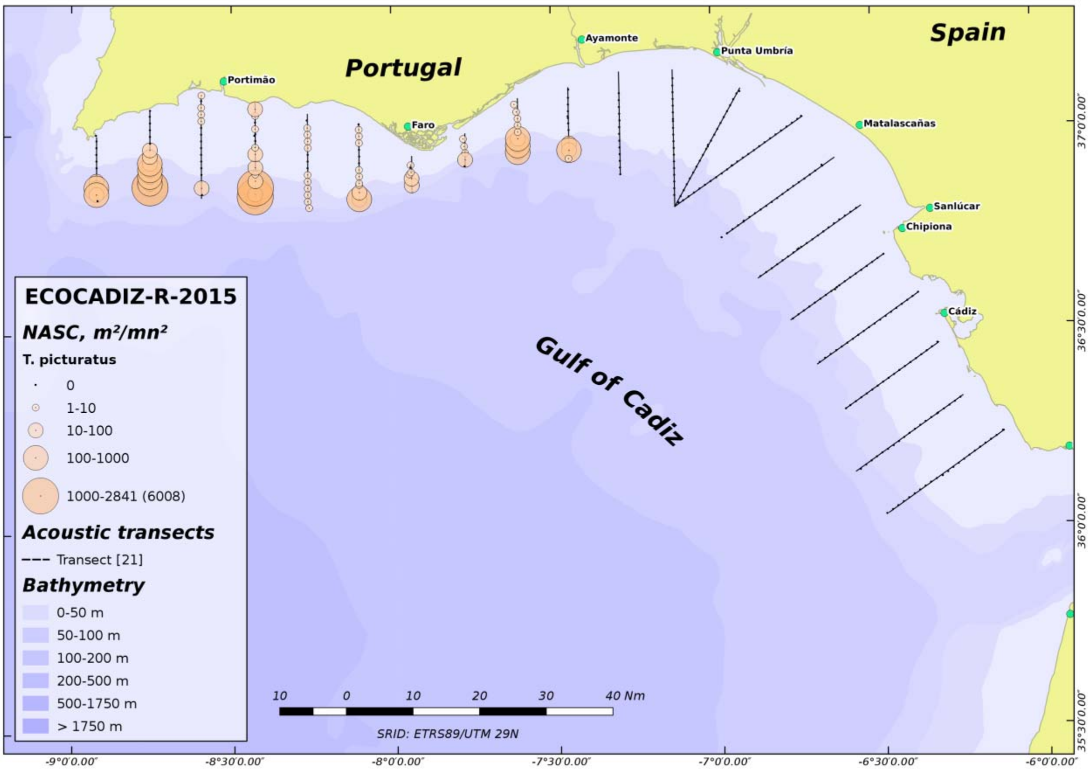


Figure 14. *ECOCADIZ-RECLUTAS 2015-10* survey. Blue jack mackerel (*Trachurus picturatus*).Distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species.

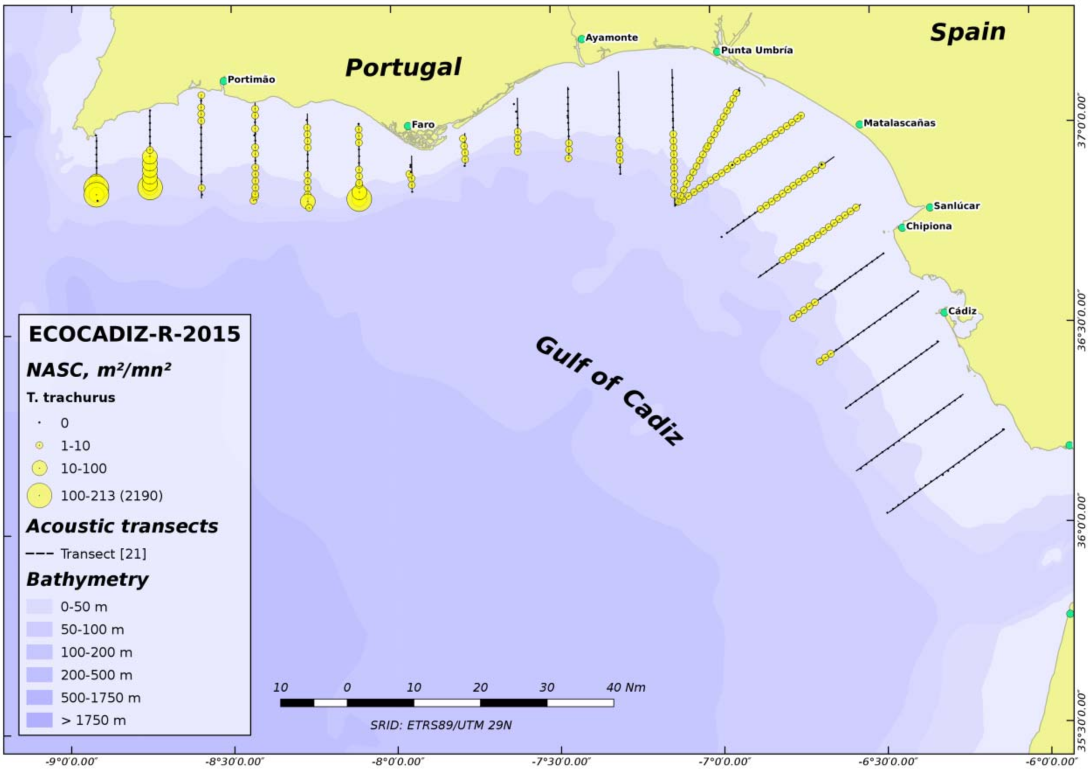


Figure 15. *ECOCADIZ-RECLUTAS 2015-10* survey. Horse mackerel (*Trachurus trachurus*). Distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species.

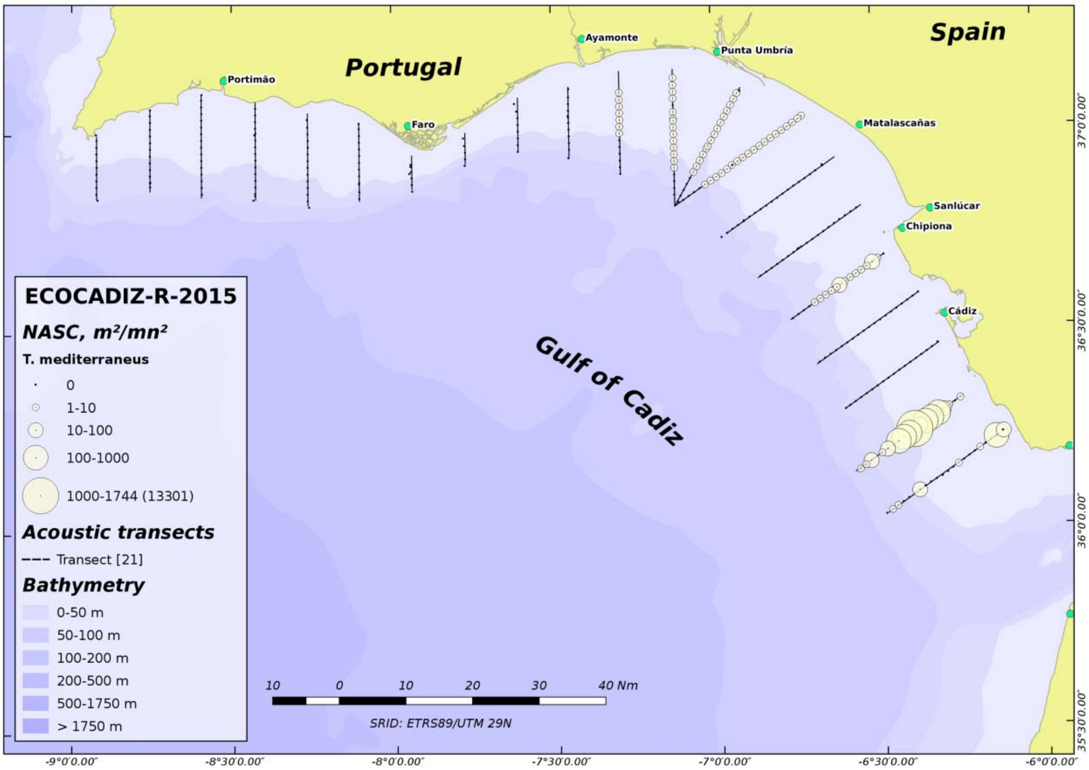


Figure 16. *ECOCADIZ-RECLUTAS 2015-10* survey. Mediterranean horse mackerel (*Trachurus mediterraneus*). Distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species.

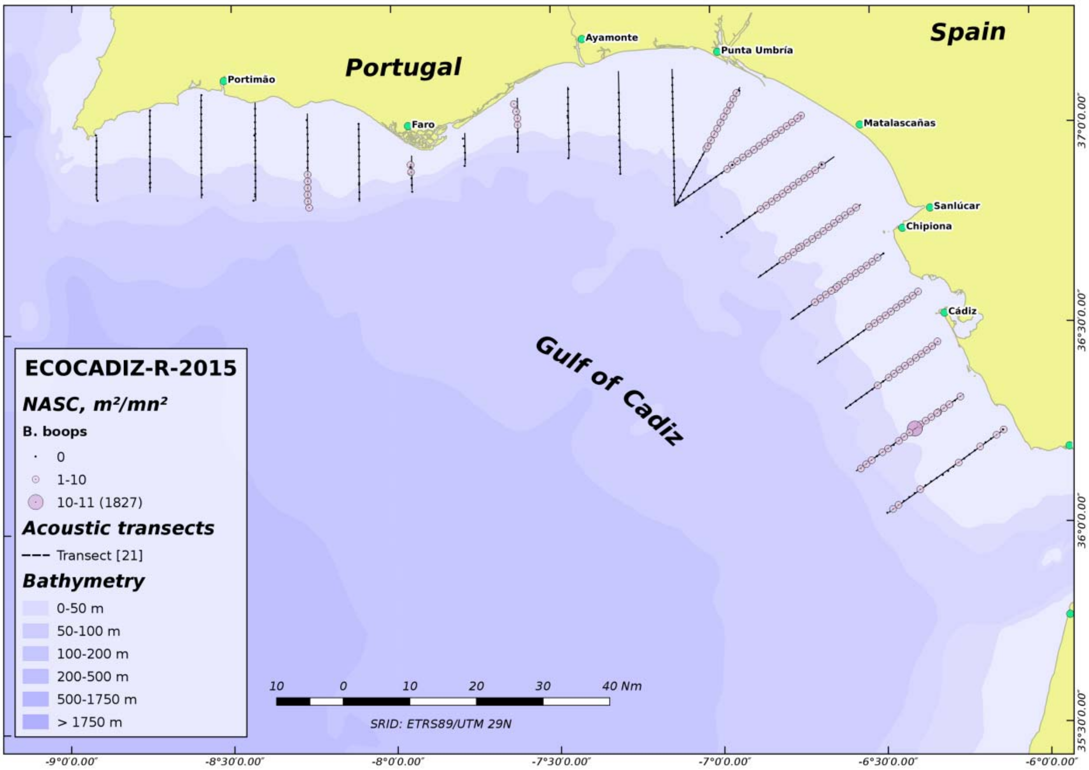


Figure 17. *ECOCADIZ-RECLUTAS 2015-10* survey. Bogue (*Boops boops*). Distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species.

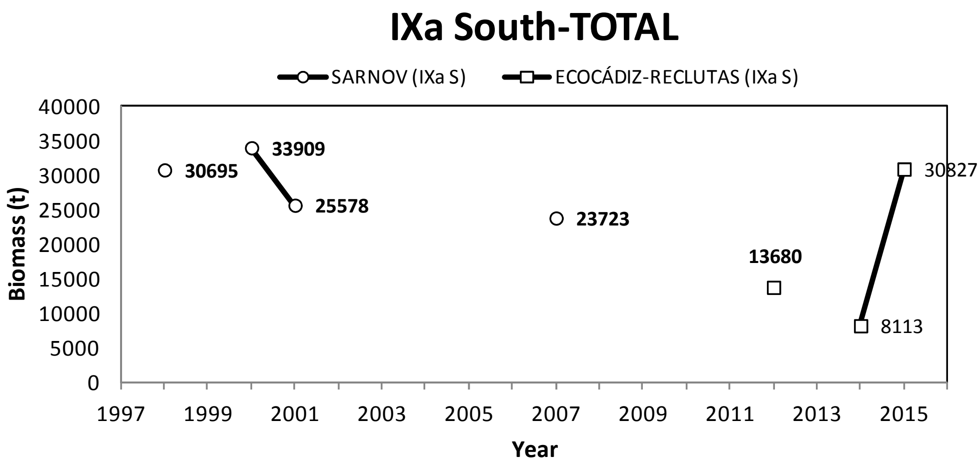


Figure 18. *ECOCADIZ-RECLUTAS* surveys series. Historical series of autumn acoustic estimates of anchovy biomass (t) in Sub-division IXa South. The graph includes the available estimates from both the Portuguese (SARNOV) and Spanish (ECOCADIZ-RECLUTAS) surveys series. The estimates are not differentiated in their regional components since such values are not available for the Portuguese series. The estimates correspond to a not age-structured total biomass of the estimated population.

Physical oceanography conditions during ECOCADIZ 2015 cruises

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December 18, 2015

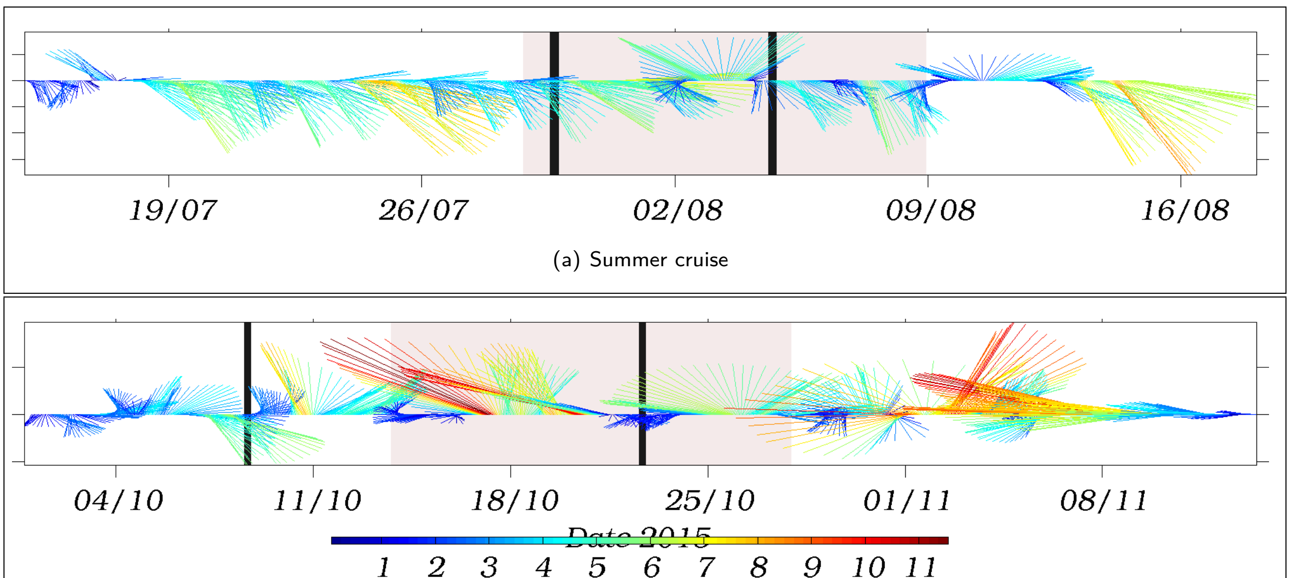
Abstract

IEO conducted two pelagic fish stock assessment cruises by acoustic methods in 2015. These occurred in summer and early fall and provide an unique means to accurately describe the physical settings that hosted the 2015 ecosystem. In both cruises the same methodological set was applied, including $CTDO_2$, LADCP profiles along a number of standard sections as well as underway thermo-fluoro-salinograph and SADCP observations taken underway. The present report describes the data and gives a brief characterization of the physical oceanographic conditions at the times of the cruise based on these *in situ* and other remotely sensed data.

0.1 Remotely sensed fields

0.1.1 Ocean Wind

Puertos del Estado ocean buoy data (Fig. 1) shows that booth cruises were undertaken under opposite wind conditions. The summer cruise started under moderate ($< 6m/s$) westerlies with a brief southerly episode taking place towards the middle of the cruise time-span. On the contrary, the fall cruise was characterized by a general easterly wind setting, including two strong ($< 10m/s$) easterly onsets towards the second half of the cruise time-span.



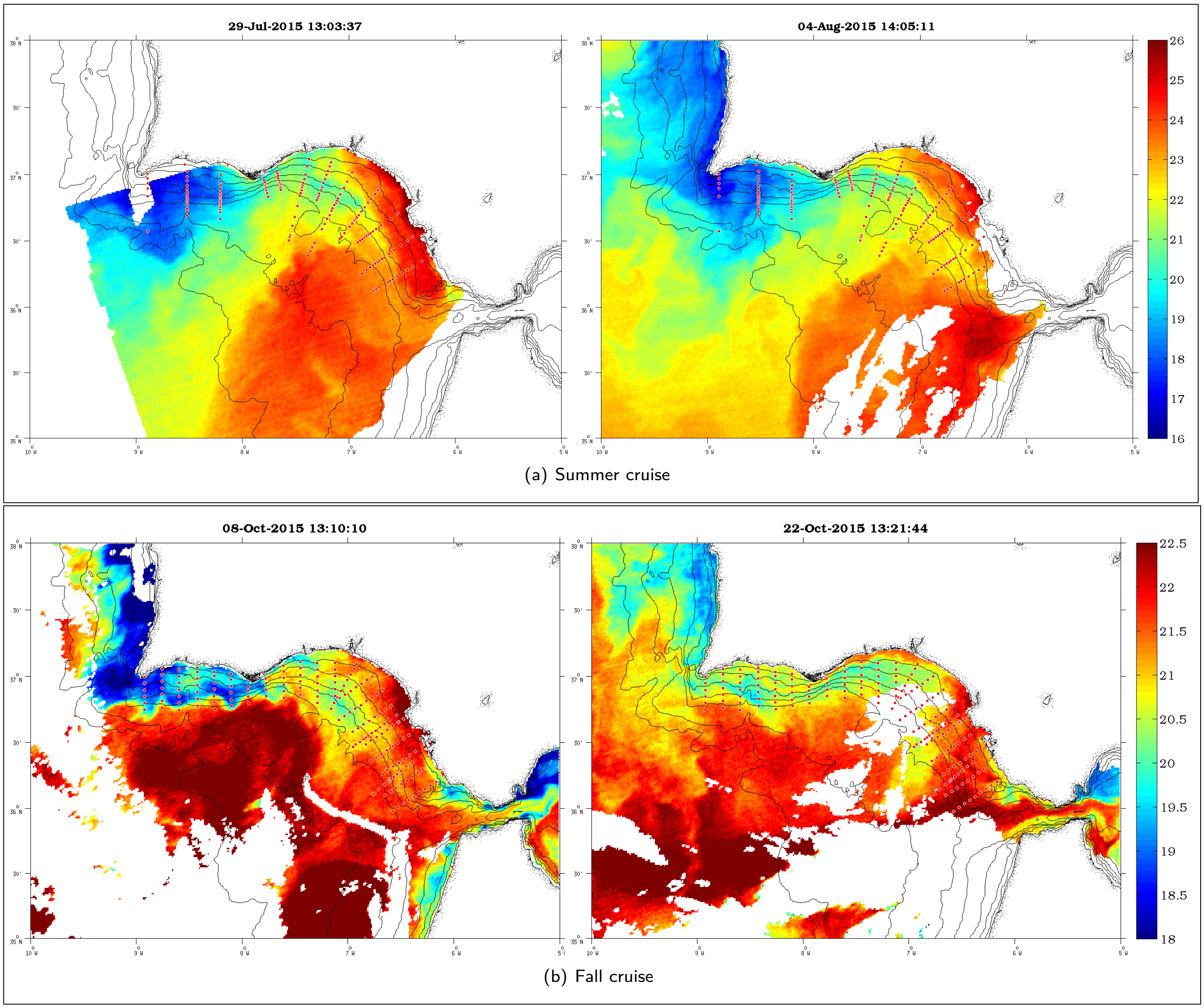
(a) Summer cruise

(b) Fall cruise

Figure 1: Subtinertial wind stick series at RAYO ocean Buoy (Deep-water Network, Puertos del Estado, http://calipso.puertos.es/BD/informes/anuales/2/2342I13.pdf). Sticks align windward (oceanographic convention). A pinky shade indicate the cruise period. Black bands indicate approximately the times of acquisition of satellite images presented below. Abscissa represent date 2015, ordinate wind speed (m/s). Positive to the north.

0.1.2 Ocean Sea Surface Temperature

Fig. 2 show a sequence of satellite SST images taken during each of the ECOCADIZ 2015 cruises. These are very illustrative of the situation along each cruise. The general pattern is that of colder temperatures towards the Cape St. Vincent and warmer to the south east and the inshore band extending from Cape Trafalgar to Cape St. Maria occupied by warm waters. However a number of dissimilarities between both time periods are evident. The summer cruise (Fig. 2(a)), what was conducted under weak westerlies features full development of the coastal upwelling west of Cape St. Maria. Towards the end of the summer cruise we observe the enlargement of the coastal upwelling as a number of coherent upwelling filaments extend offshore from their root spots at Cape St. Vincent and St. Maria. A southward-oriented one appears to contribute to the offshore transport of coastal, cold water. In addition, another upwelling filament extends southwestwards along the shelf-break to near Cape Trafalgar, leaving warmer waters at both its sides. Offshore, warmer waters seem constrained between the contorted upwelling front, the Strait of Gibraltar and the African coastline.



(a) Summer cruise

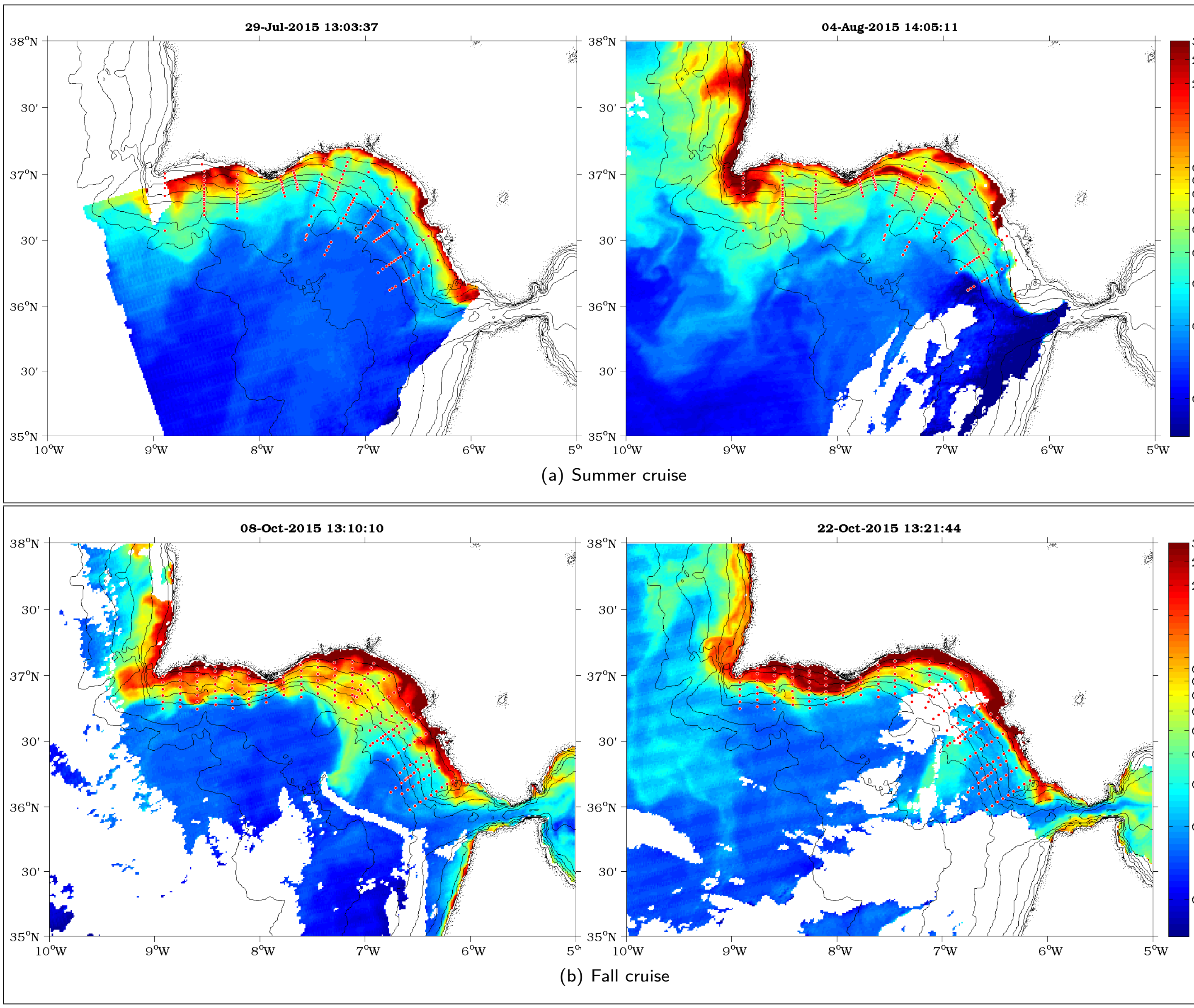
(b) Fall cruise

Figure 2: 1-km spatial resolution Aqua MODIS L2 SST fields during the cruise. Timestamp is indicated in the figure header. 20, 50, 100, 200, 500, 1000 and 2000 m isobaths are also shown. Colorbar is ªC. The location of CTD stations is overlayed in each plot. Note the different colorscale for each cruise images.

The fall cruise sampled a quite different situation (Fig. 2(b)). In this case no upwelling filaments were evident south of Cape St. Vincent although colder waters also extended from the Cape St. Maria southwestwards along the Spanish shelf-break. Short before the cruise started (Fig. 2(b), left panel) an intense, wavy temperature front was seen off the southern Portuguese coast. This feature appeared likely as a result of the confluence of the colder upwelling water with the offshore warm water pool. Indeed, this warmer water seems to push onshore the cold coastal band. This onshore push of the warm oceanic waters seems to have occurred throughout most of the continental shelf. A major consequence seems to have occurred as the colder filament rooted at Cape St. Maria was impeded to proceed towards the Strait of Gibraltar. Unlike the summer in October this filament deflected southwards, leaving the northward intrusion of warm, oceanic water east of 7°W.

The onset of a number of relatively strong easterly wind bursts had a twofold effect on the SST patterns. For one, we noted smoothing of SST gradients, with evident warming of the coastal upwelling area and surface cooling of the warm oceanic water (about 1-2 °C in each case). For another, an onshore shift of the warm water pool was observed specially east of 7°W. As mentioned above, this intrusion was able to approach oceanic waters onto the inner shelf zone, and hence bring together the two warm surface water pools.

0.1.3 Ocean Sea Surface Chlorophyll-*a* and diffuse attenuation coefficient Kd$_{490}$

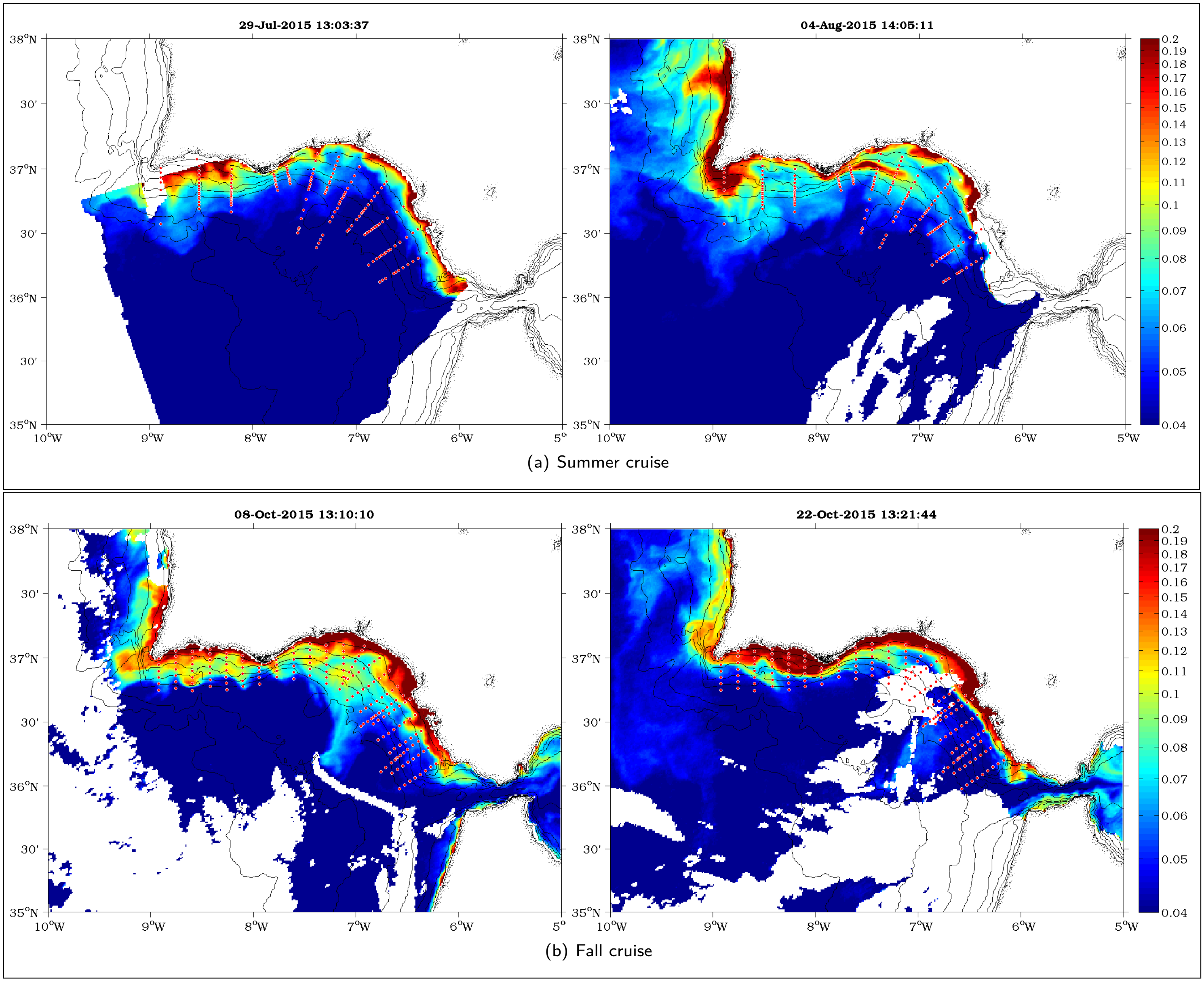


(a) Summer cruise

(b) Fall cruise

Figure 3: 1-km spatial resolution Aqua MODIS L2 Chlorophyll-*a* fields during the cruise. Timestamp is indicated in the figure header. 20, 50, 100, 200, 500, 1000 and 2000 m isobaths are also shown. Colorbar is mg m^{-3}. The location of CTD stations is overlayed in each plot. Al images share the same colorbar.

Both the surface Chl-*a* (fig. 3) and the diffuse attenuation coefficient Kd_{490} (fig. 4) show the two sides of the same pattern. Although they don't show exactly the same information (specially in turbidity plumes), distribution and abundance of phytoplankton cells are well mapped by the MODIS sensor either by their chl-*a* concentration of by the light attenuation through the first optical depth.



(a) Summer cruise

(b) Fall cruise

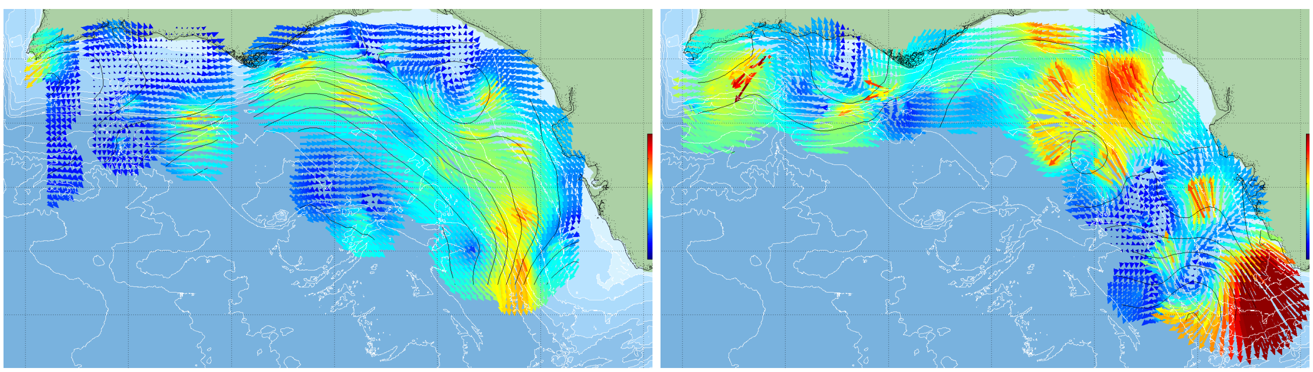
Figure 4: 1-km spatial resolution Aqua MODIS L2 diffuse attenuation coefficient (Kd_{490}) fields during the cruise. From left to right top to bottom: 29 July and 4 August. Timestamp is indicated on the figure header. 20, 50, 100, 200, 500, 1000 and 2000 m isobaths are also shown. Colorbar is m^{-1}

In both cruises a pigment-rich band occurred over the shelf from Cape St. Vincent to Cape Trafalgar. However, in summer a number of discontinuity patches were noted (fig. 0.1.3). The highest chl-*a* concentrations occurred near Cape St. Vincent and off the (Tinto-Odiel, Guadiana and particularly) Guadalquivir river mouths. The cold upwelling filaments rooted at the Portuguese capes had a serious imprint on the distribution of pigment. An intense offshore extension of the Chlorophyll-rich coastal water occurred south of Cape St. Vincent. This indicated seaward transport of coastal nutrient-rich waters. This export mechanism also had a zonal component by the cold Cape St. Maria filament. This featured high chl-*a* concentrations stretching throughout the Spanish shelf-break.

In fall the chl-*a* concentrations were notably higher, particularly near the coast (fig. 0.1.3). This coastal band was rather continuous, as opposed to the summer observations. Another difference is that the chlorophyll-rich filament rooted at the Cape St. Maria stretched in a clockwise manner likely because of the effect of the oceanic intrusion east of 7°W. This is probably clearer in fig. 0.1.3 than by the SST image. From the image of October 8^{th} (short before the cruise started) to October 22^{nd} (towards the middle of the fall cruise) the meandering upwelling front disappeared and the transition from the coastal to offshore waters sharpened. Also, the intrusion inshore of the southward filament enlarged. This event was adequately resolved by the CTD-LADCP sampling scheme, as it will be shown later.

0.1.4 Near-surface ocean velocities

LADCP-derived near-surface velocities (top 100 m of the water column) further illustrate the contrasting oceanographic conditions during each of the 2015 ECOCADIZ cruises (fig. 5). In summer a meandering, clockwise jet gently transported atlantic waters eastwards into the Strait of Gibraltar area (fig. 5(a)). Maximum velocities (averaged through the top 100 m) were less than $0.25\ m \cdot s^{-1}$. These were intensified southeastward of Cape St. Maria and around the Trafalgar banks. This circulation opposed to that observed along the inner shelf. There, the transport was sluggish with a slight westward component, although this latter observation is blurred in the interpolated field of fig. 5(a).



(a) Summer cruise (b) Fall cruise

Figure 5: Lowered-ADCP (LADCP) derived ocean surface velocity vectors. To better illustrate the contrasting summer and fall situations, we present interpolated fields of the top 100 m of the water column velocities. Colorbar scale is $0 - 0.25\ m \cdot s^{-1}$.

As depicted by the satellite images shown before, the oceanographic conditions in fall were quite opposite. For one, most of the transport was westward. A meandering jet extended all along the sampling area with velocities greater than $0.30\ m \cdot s^{-1}$ intensified over the shelf-break. The inner zone was subjected to a more energetic dynamics than in summer, specially in the Spanish shelf. On the other hand, dramatically strong velocities featured the eastward atlantic inflow onto the Strait of Gibraltar. A well-defined mesoscale anti-cyclone took over the Trafalgar banks. This contributed to the cyclonic turn and onshore approach of the westward jet in the vicinity of Cádiz. Off the Guadalquivir river mouth the westward jet spread in a mushroom-shaped structure. The inshore border featuring an anti-cyclonic turn and the offshore one a sharp cyclonyc bend. The location of this bifurcation approximately coincided with the southward Cape St. Maria filament. In the Portuguese shelf, the westward jet approached the Cape St. Maria to exhibit a series of meanders while wading through towards the Cape St. Vincent.

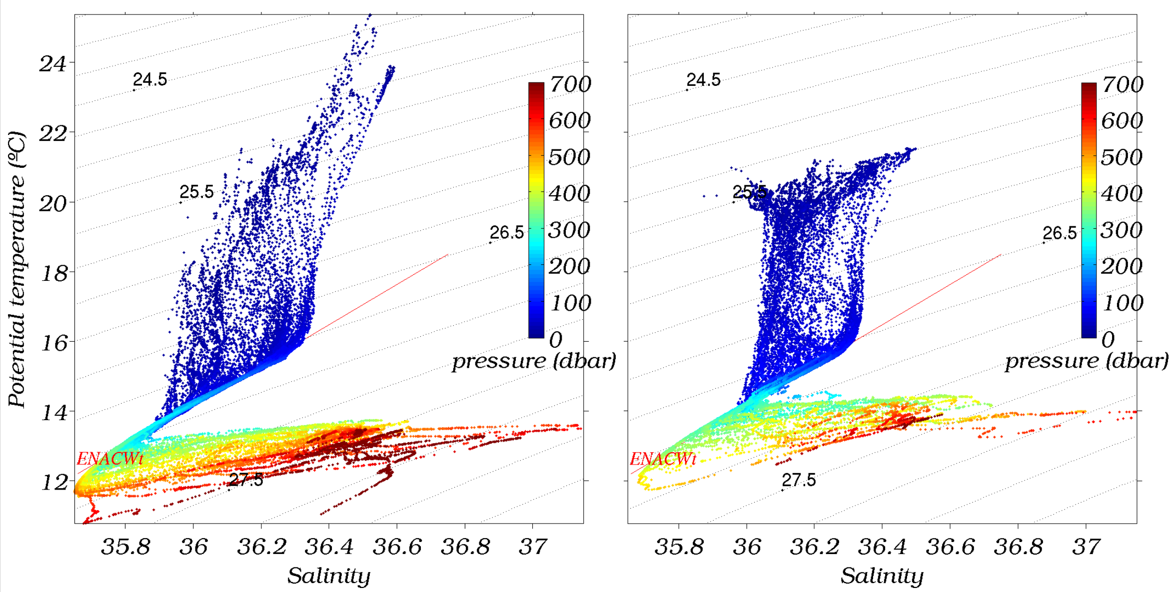
0.1.5 Hydrographic fields from CTD data

In addition to the underway VM-ADCP and Thermo-fluoro-salinometer data, 157 CTD-LADCP profiles were performed during the summer cruise and 172 CTD-LADCP profiles during the fall cruise (see the station distribution in the satellite images of fig. 2 for example). This work was carried out during the evenings and nights after the acoustic tracking works were done for the day. These observations suffice to adequately resolve the shelf and near-surface oceanographic conditions but also to investigate the baroclinic component of the circulation, known to be strongly influenced by the Mediterranean underflow.

T-S plots

Fig. 6 shows the T-S diagrams of all (QC'd) CTD stations taken during both cruises. The number of stations and sampled area differ for each realization but this figure provides a very illustrative overview. Observations taken at grounds shallower than 100 m (inner shelf) exhibit a wider thermohaline range in summer than in winter. This is mostly cause of the enhanced coastal upwelling driving lower temperature and salinity specially for the westernmost observations. Due to seasonal heating, higher near-surface temperatures occur in summer too. Because during this cruise transects extended well offshore, a larger part of the Mediterranean outflow waters was sampled there. This appears as a larger amount of deep, saline T-S pairs.

A shocking feature emerged at the ENACW-MOW confluence in the T-S space. In Summer mixing with the MOW produced mixing types distributed along the ENACWt line with temperature values below 13.5 °C and salinities below 37.9, down to 12 °C and 35.65. This contrasted with the fall observations that exhibited MOW mixing types with temperature values greater than 14 °C and salinities as high as 36.1 along the same line. These also appeared at a shallower depth level. The interpretation is that in fall the ENACW-MOW interface occurred at a shallower depth level smearing high salinities throughout a thicker extent of the water column than in summer. This was probably related to heave of the 27.0 isopycnal (fig. 6).



(a) Summer cruise (b) Fall cruise

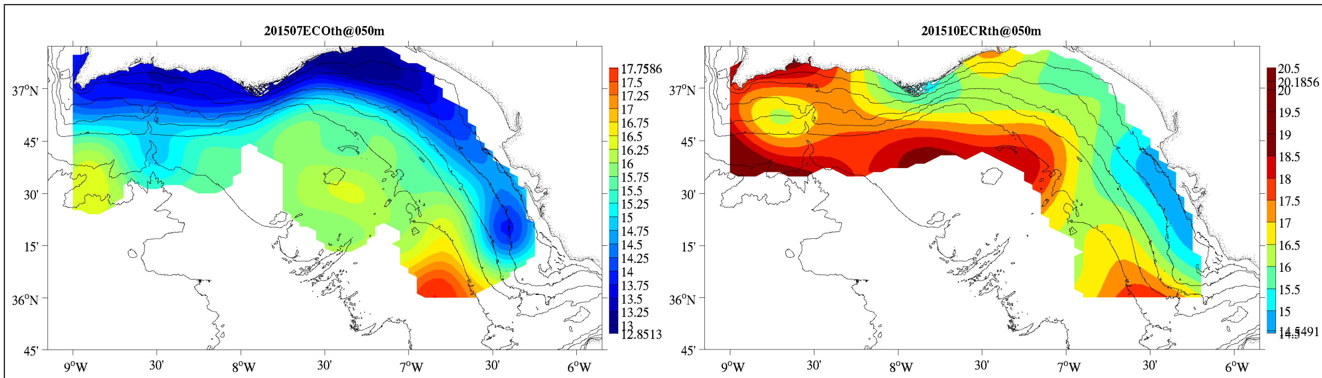
Figure 6: TS with all full-depth CTD observations taken during both cruises. The red straight line represents the linear ENACWt T-S relationship. The colorbar and colorscale refer to the observation pressure.

Horizontal fields

As seen before, the upper thermohaline fields are quite similar for both ECOCADIZ cruises in the sense that all cases showed the following features: 1) The inner shelf invaded by relatively warm, low salinity waters that spread westwards from the Spanish shelf (as noted in fig. 6, it will be seen that these are low salinity coastal waters); 2) colder waters right offshore the warmer inshore band as a response to coastal upwelling specially over the shelf between capes St. Maria and St. Vicente; and (3) an eastward extension of a cold filament rooted at Cape St. Maria.

Sub-surface observations illustrate that away from the satellite penetration depth (usually the top meters of the water column) significant differences between summer and fall emerge. The strong dissimilarities between both sets of observations was the relative strength and the geographical extension of each of the above mentioned zones, as a response to a particular set of oceanographic conditions in each case. Horizontal temperature, salinity and dissolved oxygen maps below the surface are plotted in (Figs. 7 through 15).

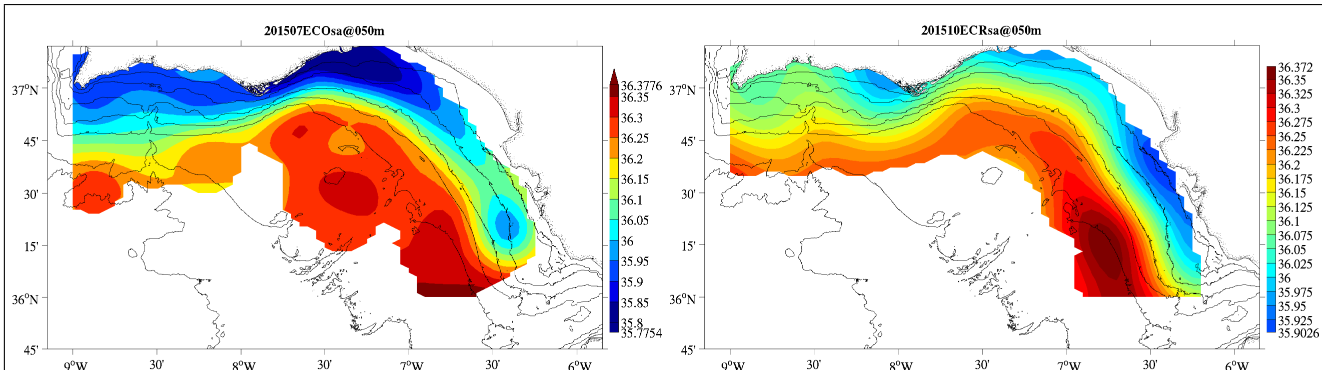
Figs. 7-9 plot the thermohaline and dissolved oxygen fields at 50 m. Following the current pattern described in fig. 5, the summer cruise (left panels in figs. 7-9) featured a relatively strong coastal upwelling that, away the innermost shelf (where the warm counter-current prevails) occupied most shelf grounds shallower than 200 m. This band was characterized by low-salinty and dissolved oxygen concentrations than offshore. In summer this band appeared clearly following the equatorward jet described in fig. 5. Due to this upwelling-like situation, the offshore warmer, saltier water masses appeared rather cornered towards the southeastern part of the study area, leaving also space for the extrusion of cold, low salinity upwelling filaments south of Cape St. Vicente.



(a) Summer cruise (b) Fall cruise

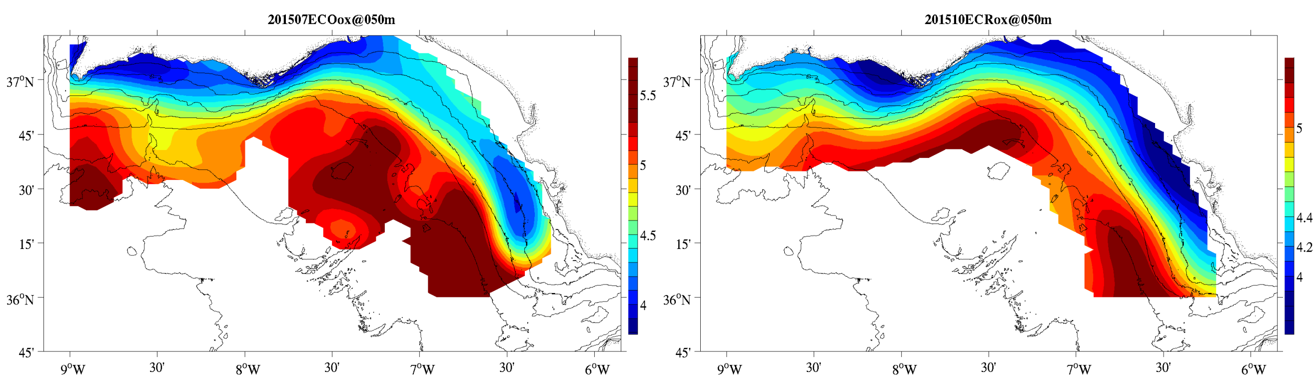
Figure 7: Horizontal distribution of potential temperature at 50 dbar.

A number of dissimilarities emerge in the fall situation. It will be shown later that the lack of upwelling-favorable wind does not seem to be the only cause for the generalized westward flow. The upper-layer response is the onshore approach of the warm, more saline offshore water. Parts of the shelf are invaded by this oceanic water and in general more saline water occupies the continental shelf. Particularly dramatic is the shift occurred between capes St. Vincent and St. Maria as below the surface no traces of coastal upwelling are left in fall.



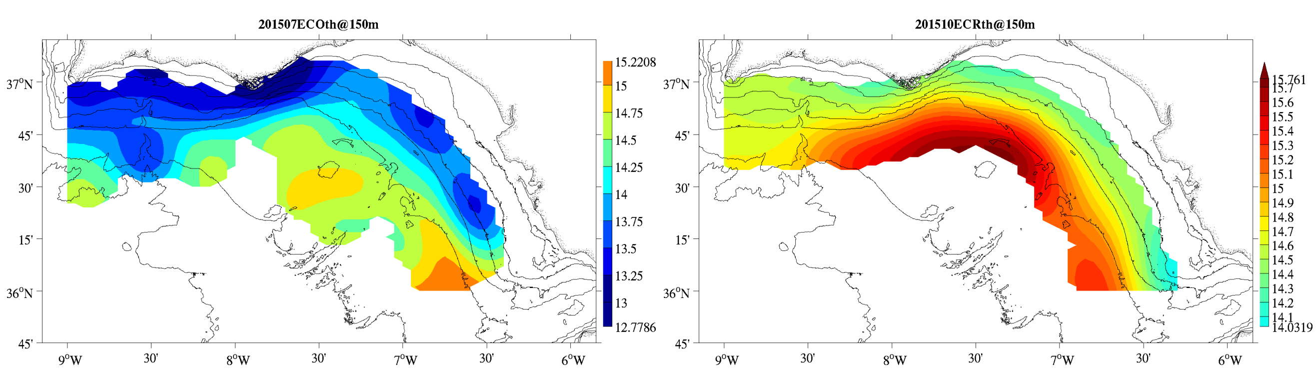
(a) Summer cruise (b) Fall cruise

Figure 8: Horizontal distribution of salinity at 50 dbar.



(a) Summer cruise (b) Fall cruise

Figure 9: Horizontal distribution of dissolved oxygen at 50 dbar.

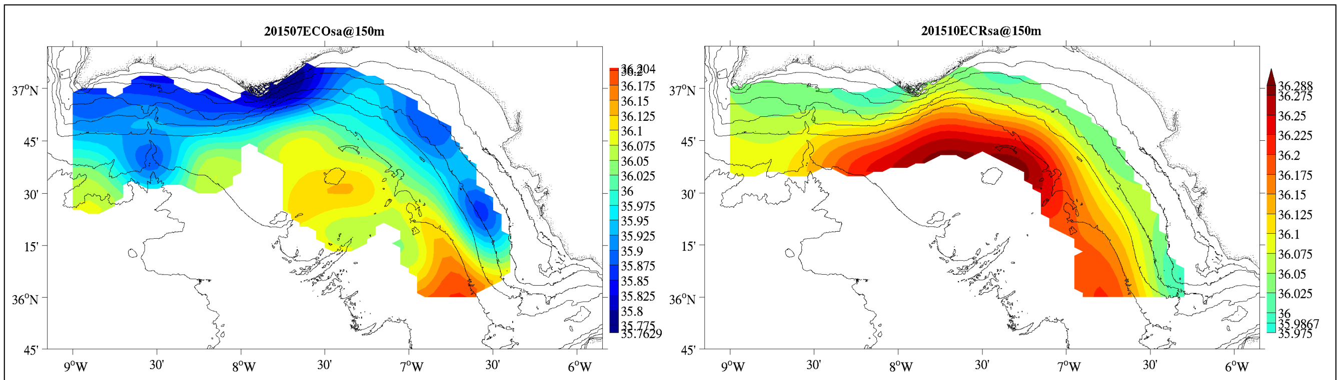


(a) Summer cruise (b) Fall cruise

Figure 10: Horizontal distribution of potential temperature at 150 dbar.

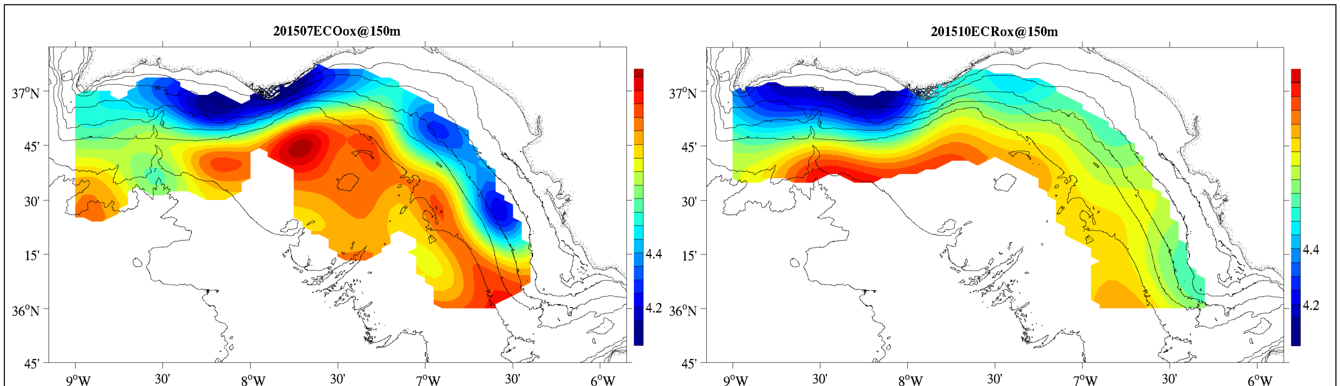
Figs. 10-12 illustrate the sub-surface situation. At 150 m the picture resembled that observed above. In summer shelf regions appeared invaded by colder and relatively less saline NACW, contrasting with warmer and more saline shelf-break waters at the same depth level. This situation is compatible with the transport of an equatorward coastal upwelling jet, as discussed before. The coldest temperatures are noted in the lee of Cape St. Maria (values below 13 °C). In fall the shelf was invaded by wamer and saltier waters that, as suggested by the T-S plot of fig. 6, may be the result of enhanced NACW-MOW mixing associated with a shallow MW vein. This seems supported by the onshore approach of warmer, more saline oceanic water towards the shelf (see figs. 10, right panels).

The shallower MOW traces are noted at 300 m as depicted by figs. 13-15. The images are self-explicative and illustrate the generalized westward invasion of warm, saline MOW from the Strait of Gibraltar in fall. This brusque input has an effect on, not just the thermohaline setting, but also on the transport pattern all along the continental shelf and slope. Hence, whereas in spring a horizontal (and likely vertical) recirculating scheme is envisioned, in fall due to the dramatic outburst of the shallow MOW as well as the relaxation of upwelling-favorable winds, the general transport pattern is thought to be westwards. This could have an implication of the transport of planctonic material from the well-known spanning areas close to the Guadalquivir river mouth towards the portuguese continental shelf.



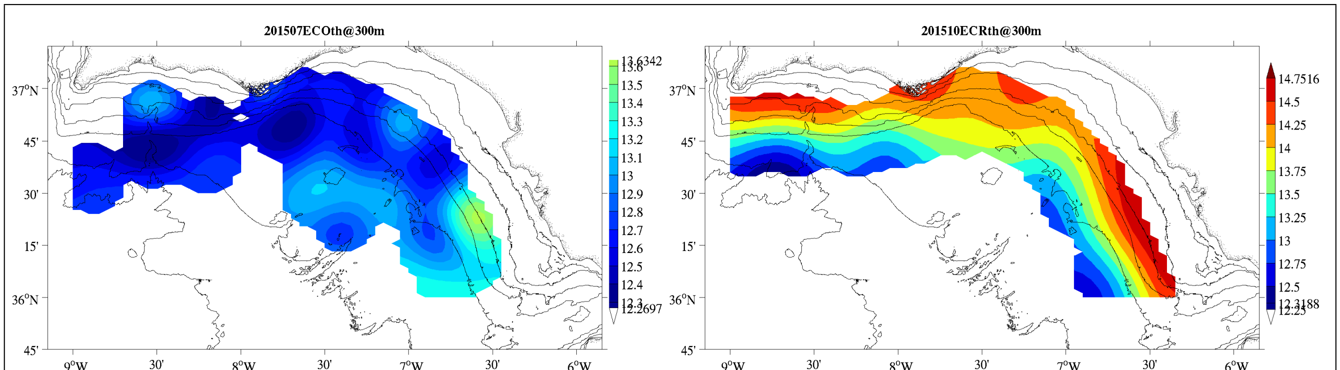
(a) Summer cruise (b) Fall cruise

Figure 11: Horizontal distribution of salinity at 150 dbar.



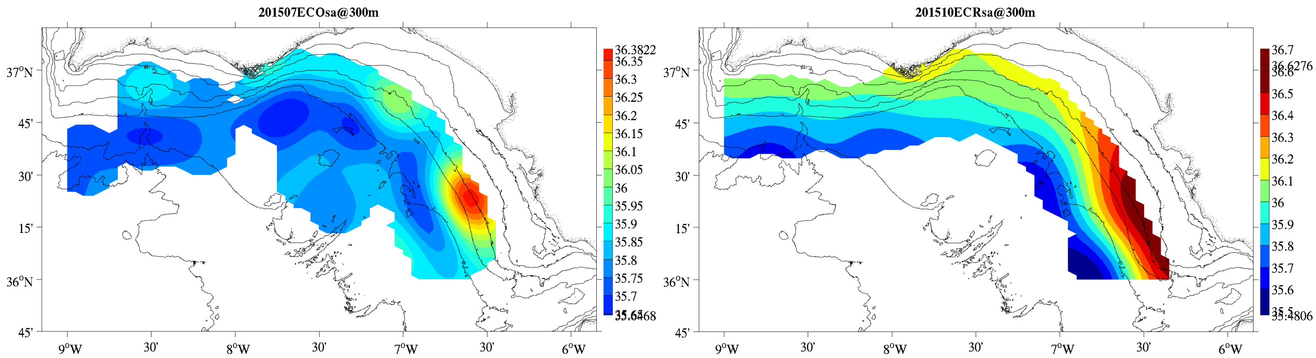
(a) Summer cruise (b) Fall cruise

Figure 12: Horizontal distribution of dissolved oxygen at 150 dbar.



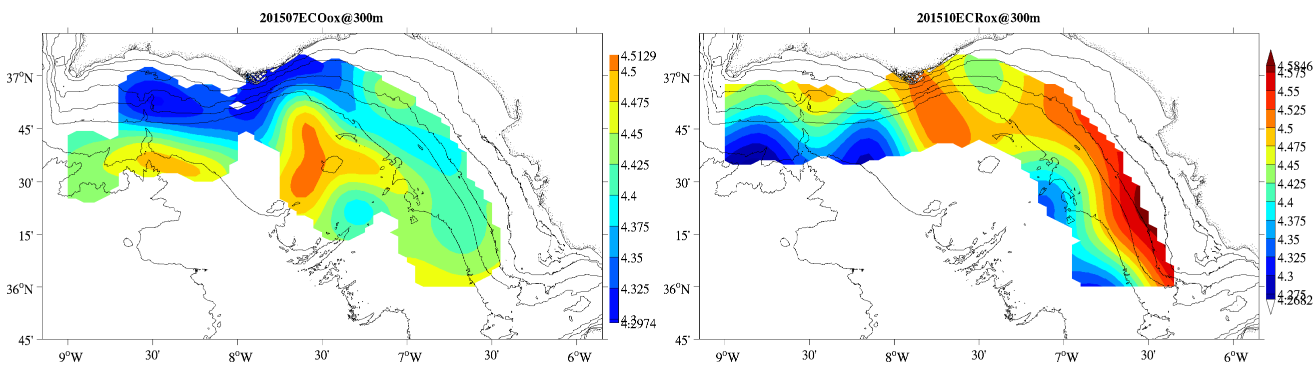
(a) Summer cruise (b) Fall cruise

Figure 13: Horizontal distribution of potential temperature at 300 dbar.



(a) Summer cruise (b) Fall cruise

Figure 14: Horizontal distribution of salinity at 300 dbar.



(a) Summer cruise (b) Fall cruise

Figure 15: Horizontal distribution of dissolved oxygen at 300 dbar.

Acknowledgements

We are indebted to the Captain, crew and technicians of R/Vs Ramón Margalef and Miguel Oliver. Horizontal fields were interpolated with the Data-Interpolating Variational Analysys (DIVA, `http://modb.oce.ulg.ac.be/mediawiki/index.php/DIVA`). We thank projects PELCOSAT3, INGRES3 and SeVaCan.

DRAFT Survey report CEND22_15

PELTIC15: Small pelagic fish in the coastal waters of the western Channel and Celtic Sea

Jeroen van der Kooij, Elisa Capuzzo, Joana Silva, Mike Bailey

Survey report CEND22_15

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1. Outline of the survey

STAFF:

Part 1 (3rd -13th of October)	Part 2 (13– 21st of October)
1. Jeroen van der Kooij (SIC)	Jeroen van der Kooij (SIC)
2. Elisa Capuzzo (2IC)	Elisa Capuzzo (2IC)
3. Joana Silva (2IC)	Joana Silva (2IC)
4. John Pinnegar	Dave Brown
5. Dave Brown	Ken May
6. Buster Rook Bishop	Richard Humphreys
7. Richard Humphreys	Matt Eade
8. Matt Eade	Paul Bouch
9. Paul Bouch	James Pettigrew
10. James Pettigrew	Phil Lamb (PhD student)
11. Samantha Barnett	Mike Bailey (observer)
12. Philip Lamb (PhD student)	Pete Akers (observer)
13. Mike Bailey (observer)	Jack Lucas (observer)
14. Pete Akers (observer)	
15. Jack Lucas (observer)	

1.2. **Duration**: 3rd –21st 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 third in a series of five annual multidisciplinary pelagic survey of the Western Channel and Celtic Sea waters to map, 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 (stomach will be extracted frozen for future work)

2. To collect plankton samples using 2 different mesh ringnets (80 µm, and 270 µm mesh) at fixed stations along the acoustic transects at night and at a subset of trawl stations during the day. Samples will be processed aboard:
   a. Ichtyoplankton (eggs and larvae, 270 µm) of pelagic species will be identified and counted onboard and combined with information from maturity to identify spawning areas.
   b. Zooplankton will be stored for further analysis back in the lab.
3. Water column sampling. At fixed stations along the acoustic transect, 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. To record the locations, species, numbers and activities of seabirds and marine mammals in the survey area during daylight hours.
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 collect water samples for nutrient and TA/DIC analysis in support of a programme on ocean acidification (Naomi Greenwood) to continue autumn time-series in area.
10. To map the acoustically derived zooplankton densities using the new 333 kHz frequency and compare it with data collected under 2 (and where possible 7) as part of Defra project HAZARD.
11. To collect genetic samples of gut contents and jellyfish for a UEA PhD studentship aiming to identify and quantify predation of jellyfish (Philip Lamb)
12. To collect and freeze samples of jellyfish for isotope work (Clive Trueman, NOC)
13. To quantify the size, biomass, distribution of the gelatinous species as part of a collaboration with the Nerc-Defra funded Marine Ecosystem Research Programme (MERP)

1.5 Narrative

Cefas staff joined the RV Cefas Endeavour in the afternoon of Friday the 2nd of October. The vessel left Portland the following morning at 6:00 AM of the 3rd of October and steamed straight to the calibration site off Portland Head (50° 36.180 N, 002° 35.762 W), to calibrate the echosounders. During the first calibration attempt which commenced at 9:00, slack tide was just missed and currents rapidly became too strong (+0.8 knots) so the attempt was interrupted until next the next slack tide at ~14:30. Instead a toolbox talk, muster drill and safety walks with all scientific staff were conducted before lunch. The aim was to use the two hours between lunch and scheduled resumption of the calibration to conduct shakedown tows with the ESM2, and plankton nets. However as those gears were prepared for deployment, a distress call came in at 13:30 requiring the RV Cefas Endeavour to abandon all planned operations and leave the calibration site to aid a yacht which had engine issues and could not move due to lack of wind. Despite the fact that there was no threat to life and the engine was working again, the RV's searider had to act as safety vessel and escort the yacht back into port. At approximately 16:30 the searider was back onboard the RV. However by this time the slack tide window was missed again rendering the calibration futile; even a shakedown tow with the pelagic trawl was by this point not possible due to specialist fishing staff on deck (bowson) being out of their 12 hours. The next slack tide was due after sunset and as the calibration spheres had not been located and previous experience had demonstrated that doing that in darkness was pointless, it was decided to postpone the calibration until a suitable future window and start the first of the primary stations that evening continuing through the night.

On Saturday morning the 4th of October survey started proper commencing with the eastern most of the acoustic transects. Similar to last year's survey, fisheries acoustic transects, trawling and bird and mammal observations were conducted during daylight hours only, and CTD and plankton stations were covered during the night. The first trawl of the survey took a bit of time; firstly after the trawl was shot it appeared that the wrong trawl rigged. Secondly after the correct trawl was rigged on the netdrum 1½ hours later, the crew needed to get familiar with the gear. After only a few trawl operations this improved notably and before long the quickest recorded time to the survey series was achieved consistently to shoot and retrieve the trawl gear. 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 23 valid tows were made, the highest for the survey series.

On the morning of 13th October, after completing all but two transects in the western Channel and most of the Isles of Scilly sub-area, the Endeavour steamed to Falmouth for a planned staff changeover which commenced at 8:00. J. Pinnegar, S. Barnett and B. Rook Bishop left the vessel, whilst K. May joined.

After changeover, at 10:15 BST the Endeavour sailed to the start of the last two transects left in the Channel subarea which were completed that day. After completion of the necessary CTD and plankton stations the Endeavour steamed overnight to complete the last of the Isles of Scilly subarea on the 14th of October and set an eastwards course to begin the survey of the Bristol Channel sub-area. Between the 15th and the 18th of October all but four of the south-west to north east running transects were completed in the Bristol Channel sub-area and on the night of the 18th saw the last of the primary CTD and zooplankton stations completed. This year distinct "bands" of fish biomass were present parallel to the coast both halfway along the transects and at the end of the transects. Prior to completing the last four of the conventional Bristol Channel transects, the excellent forecast for the Monday lead to a decision to run the 100 nmi transect from the inner Bristol Channel to the Celtic Deep on the 19th of October. Two planned transects were completed on the 20th of October and deteriorating weather conditions meant that only one trawl could be performed in the morning.

Weather conditions throughout the survey were exceptionally favourable with the worst conditions on the 5th of October not exceeding much beyond 30 knots of wind. Unusually most of the wind was from an easterly direction.

On the morning of the 21st the Endeavour completed the final two transect which ran from the north Devon coast into Swansea bay where the pilot was booked for 13:00. The RV Cefas Endeavour docked at 15:00 in Swansea port.

2. Material and Methods

2.1. Study area

The survey were conducted according to the PELTIC survey grid (Figure 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.

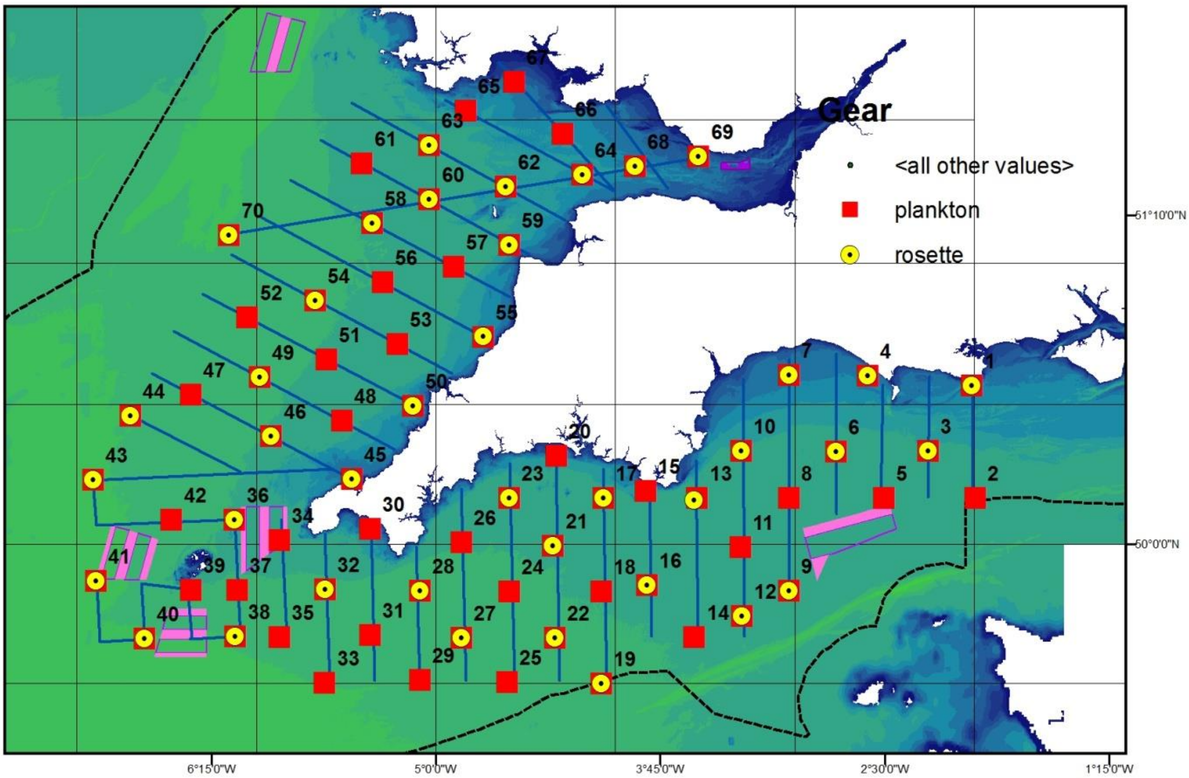

Figure 1. Overview of the survey area, with the acoustic transect (blue lines), plankton stations (red squares) and hydrographic stations (Yellow circles).

2.2 Fisheries acoustics

2.2.1. Acquisition

Due to the lack of a successful calibration at the start of the survey, the calibration settings from the previous survey were loaded. This excluded calibration settings for the 333 kHz which was not available for calibration at the time.

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}. Due to the exceptionally favourable weather conditions, acoustic data were of very high standard. Poor quality surface data due to aeration was only encountered on the 5th and 21st of October and at no time was it necessary to hold acoustic data collection altogether. 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.

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.

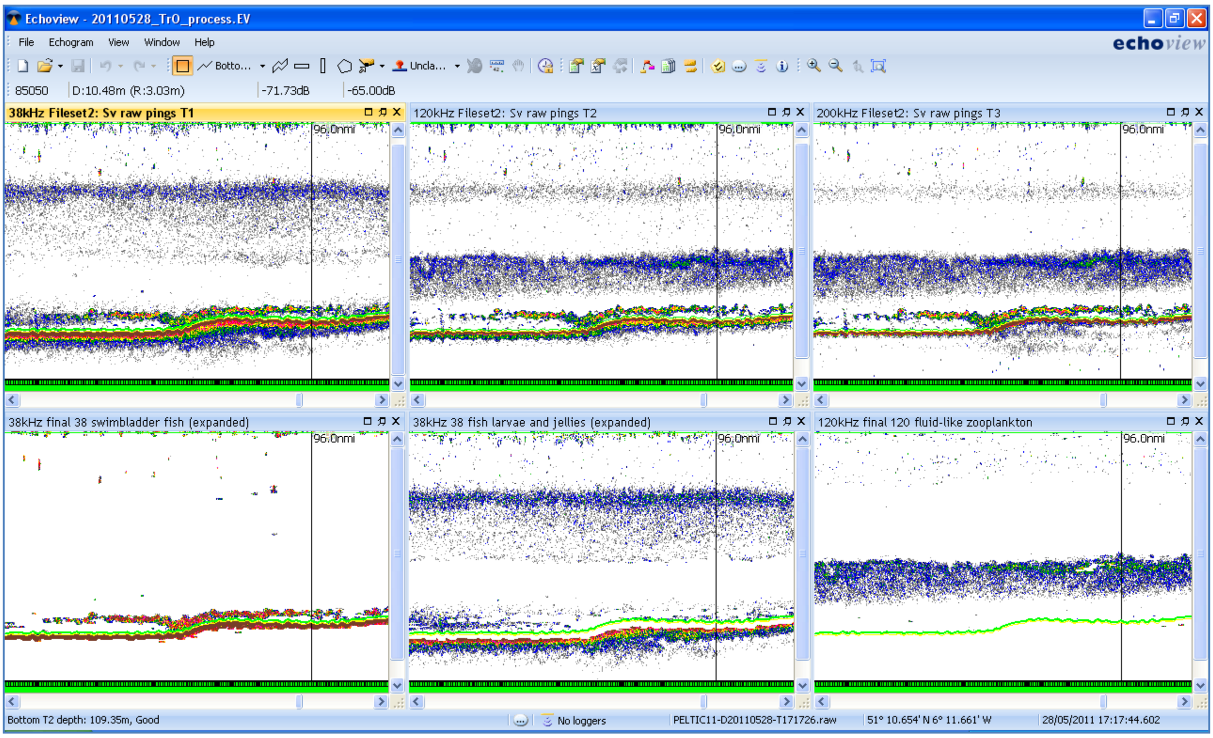

Figure 2. Dataflow of algorithm (top) used to divide the acoustic data by echotype. Screen-shot example (bottom) with raw echograms of 38, 120 and 200 kHz (top panels) and three examples of extracted echotypes (bottom panel from left to righ): fish with swimbladder (sardine schools at surface and myctophids layer near seabed), fish larvae/ jellyfish and zooplankton (dense krill layer).

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. The trawl was tested and tuned during the morning of the 2nd of October by experimenting with different weights, speeds and warp. 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. In general, the trawl performed well and caught a broad range of species and size classes.

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 10 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.

2.4 Zooplankton

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 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.

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. In addition, this year at 40 stations surface samples of zooplankton were taken using the new 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.

2.5 Oceanography

Physical, chemical and biological properties of the water column were investigated using different platforms of observations (Ferrybox, CTD, remote sensing) and by collecting of discrete water samples at the subsurface.

The Ferrybox provided continuous measurements in real time at the subsurface of different variables including temperature, salinity, fluorescence and dissolved oxygen concentration. Daily and weekly maps of chlorophyll concentration (OC5 algorithm), sea surface temperature and frontal systems were downloaded 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 nanoplankton populations. A pCO2 analyser carried out continuous measurements of the dissolved carbon dioxide in water and air during the whole survey.

Vertical profiles of temperature, salinity, fluorescence, optical backscatter, dissolved oxygen and Photosynthetically Available Radiation (PAR) were collected at 39 sampling stations using an ESM2 profiler. At 18 of these stations, water samples were collected at the surface from the continuous water pump that supplies the Ferrybox, for analysis of salinity, dissolved inorganic nutrients (for this project), samples for flow cytometry and pigments analysis, as well as for analysis of phytoplankton and microzooplankton communities.

Surface samples for determination of Total Alkalinity (TA), dissolved inorganic nutrients and dissolved organic matter (for PML, Shelf Sea Biogeochemistry project), and samples for dissolved oxygen analysis were collected from a Niskin bottle connected to the hydrowire of the ESM2 logger.

Samples for analysis of dissolved oxygen concentration, salinity and chlorophyll will be used for calibrating the sensors on the ESM2 profiler and on the Ferrybox.

A summary of the samples collected and of the CTD casts carried out during the survey is given in Table 1.

Table 1. Samples collected during the survey and number of vertical casts carried out.

	Total
Salinity	21
Dissolved oxygen	24
TA/DIC	13
Dissolved inorganic nutrients (PML)	13
Dissolved organic nutrients (PML)	13
Dissolved inorganic nutrients (Cefas)	18
Chlorophyll/Pigments analysis	38
Flow Cytometry	38
Phytoplankton	18
Microzooplankton	18
CTD casts with ESM2	39

2.6 Top predators

Effort-related surveys were made for top predators daily during all daylight hours whenever the ship was moving on or between transects. This year, 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 employed an effort-based distance sampling straight-line transect survey following strict ESAS methodology, whilst on the other Bridge wing, a single volunteer MARINElife surveyor 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 continuously during daylight hours, including all transit cross-lines, and with the additional coverage provided by the MARINElife surveyor, a 180° scan area was surveyed almost continually throughout the entire survey. Furthermore, observations were conducted during the net-retrieval stage of each trawl to identify species of birds associated with the fishing activity of the survey vessel. 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. Fortunately, the weather conditions during the entire 2015 Peltic survey rarely reached sea state 5 or above, facilitating almost constant useable data gathering.

Special attention was given to gathering data on Balearic Shearwaters, as the waters off south west England are considered an increasingly important habitat for this globally critically endangered seabird.

3. Preliminary results

3.1. Pelagic Ichthyofauna

After removing the off-transect data a total of ~1400 nautical miles of acoustic sampling units were collected for further analysis (Fig. 3). A total of 23 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.

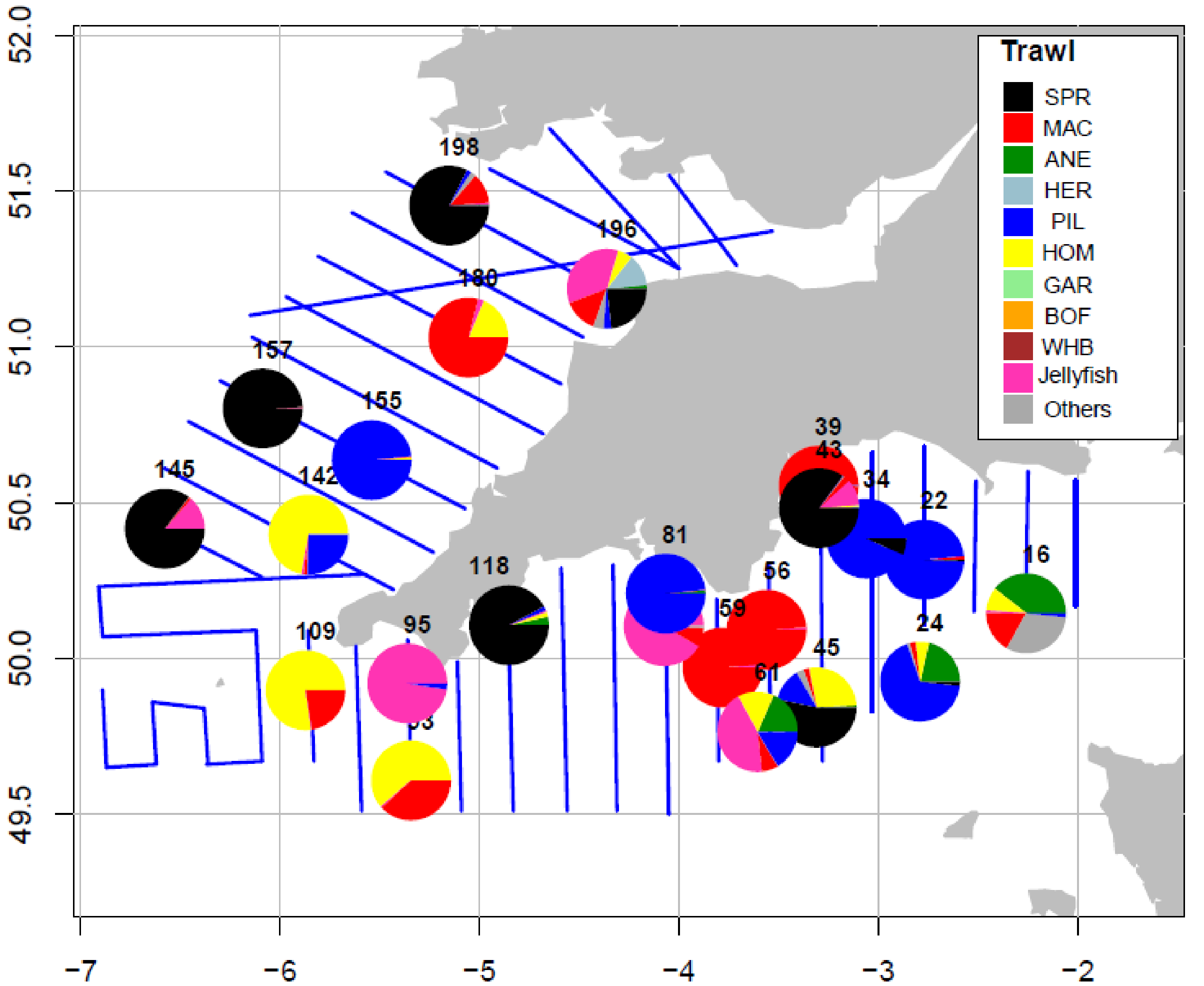

Figure 3. Overview map and detail of the survey area. Acoustic transects (blue lines) and trawl catches (pies) with relative catch composition by key species. Three letter codes: SPR=sprat, MAC=mackerel, ANE=anchovy, HER=herring, PIL=sardine, HOM= horse mackerel, GAR=garfish, BOF=Boarfish, WHB=Blue whiting.

Several trawls included jellyfish of at least three species. Sprat (*Sprattus sprattus*) dominated the inshore waters of the English Channel. In the Bristol Channel distinct schooling aggregations were found offshore in the deeper waters and, as in previous years in inshore waters further east of the Birstol Channel. Sprat in the Bristol Channel consisted nearly entirely of small specimens, whereas those from the Lyme Bay area were more mature (fig. 4).

Sardines (*Sardina pilchardus*) were much more widespread than in previous years according to the trawl stations (fig. 3), with specimens found in most hauls (fig. 3). Despite the large numbers caught, very few specimens larger than 20 cm were caught (Fig 4).

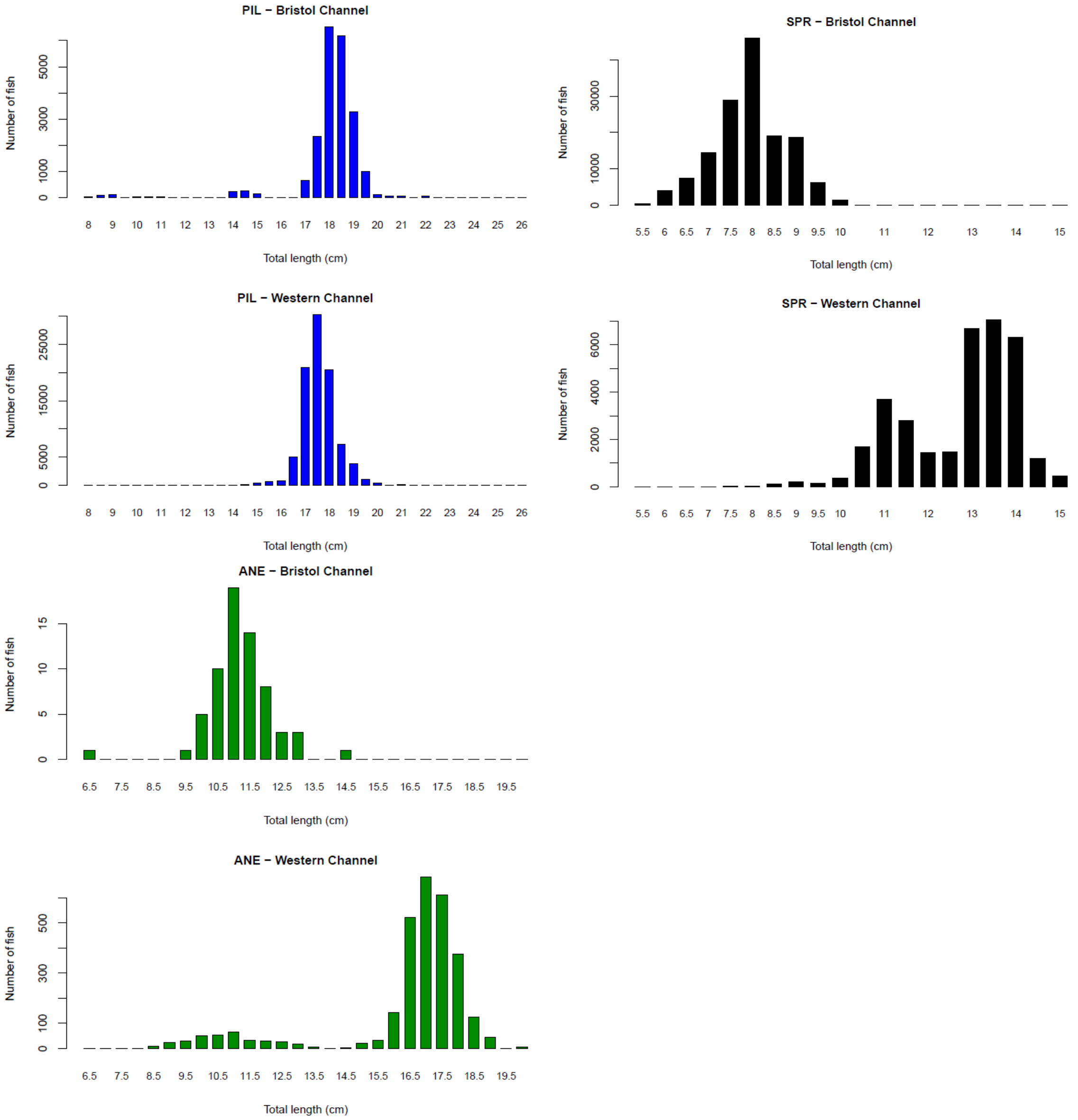

Figure 4. Trawl-caught numbers by length of sardine (*Sardina pilchardus*) (top left) sprat (*Sprattus sprattus*) (top right) and anchovy (*Engraulis encrasicolus*) by subarea. Please note that these numbers were not yet raised by the acoustic data.

Mackerel (*Scomber scombrus*) observations appeared to be in line with those in 2012 and 2014 when only small numbers of juvenile mackerel were found. None of the very large mackerel schools as seen in 2013 were observed in the western channel this year despite the large overlap in timing of the surveys. Horse mackerel (*Trachurus trachurus*) was found in most trawls suggested wide distribution, although apparently preferring the deeper waters. Both mackerel and horse mackerel displayed two distinct length classes (fig. 5).

This year, anchovy appeared more widespread than in previous years although main densities were in Lyme Bay trawl stations (Fig 3). For the first time small anchovy was found also in the inner Bristol Channel. Herring (*Clupea harengus*) were found in the study area in small numbers (fig. 3). It appeared to be mixed in with juveniles of the other small pelagic species and mainly in the inner Bristol Channel.

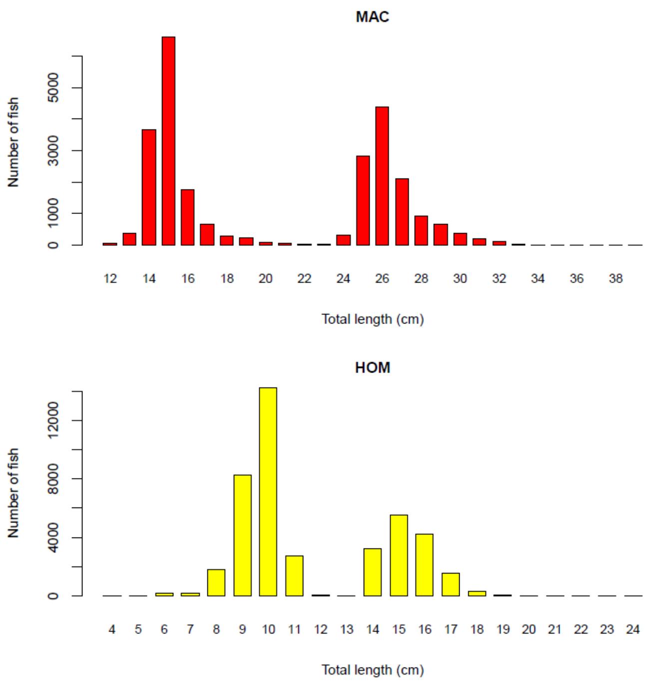

Figure 5. Trawl caught numbers by length of mackerel and horse mackerel for survey.

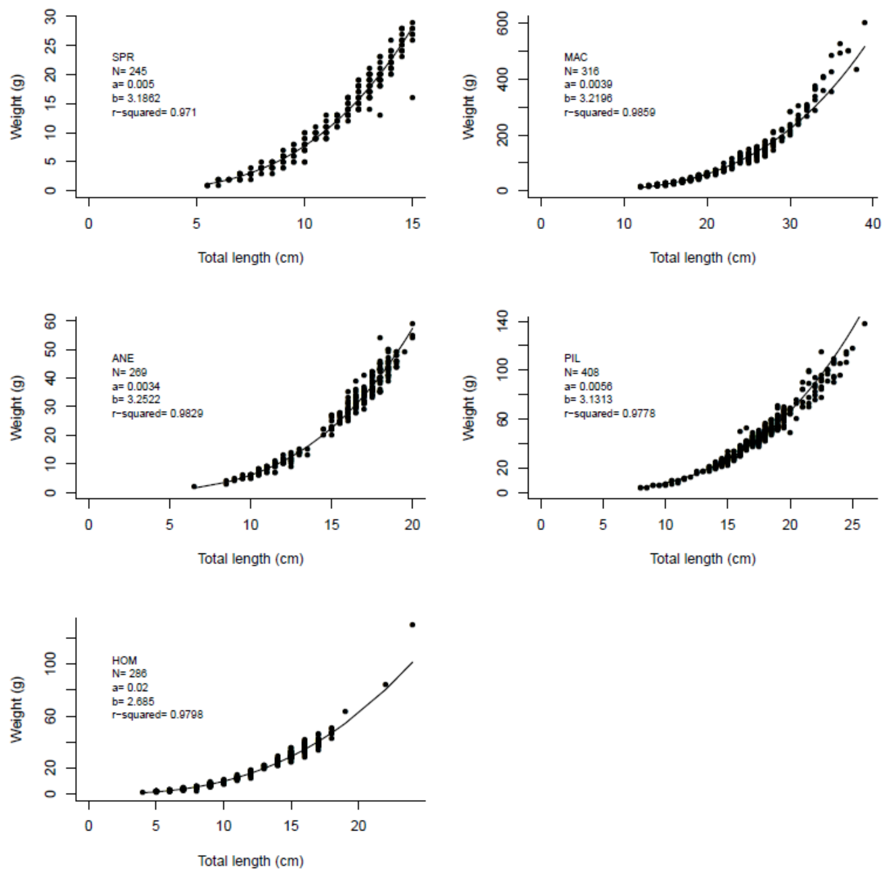

Figure 6. Length weight relationships of dominant pelagic species across the survey area.

3.2. Plankton data

Zooplankton samples were collected at 70 stations with the two ringnets. Whilst water samples were taken from 39 stations, only a subset of 18 “key” stations will be further analysed to extract micro-zooplankton. Onboard ichthyoplankton processing revealed that the bulk of eggs were sardine, with small numbers of sprat, lemon sole and sandsol making up the remaining categories. Most abundant were sardine eggs and larvae and “unidentified clupeid” larvae the vast majority of which were thought to comprise of sardine as few other clupeid species are spawning at this time of year. Sardine eggs were patchily distributed predominantly in the western part of the English Channel with smaller numbers in the Isles of Scilly. This year for the first time small numbers of eggs were found in the Bristol Channel. A detailed size based (zooscan) and taxonomic analysis of the zooplankton will be undertaken on return to the laboratory.

3.3. Oceanographic data

3.3.1. Temperature and salinity

With temperatures up to 16°C, surface waters of the Western English Channel were warmer than surrounding waters of the Celtic and Irish Seas (Figures 7 and 8). The average, minimum and maximum temperatures recorded at the 39 sampling stations during this survey (Table 2) were comparable with temperatures recorded during the survey in 2013 (Cend20_13); however, they were lower than temperatures measured in 2014 (Cend20_14). Particularly, the maximum temperature recorded in 2015 (15.95°C) was approximately 2°C lower than the maximum temperature measured in 2014 (18.14°C). Salinity of surface water at the different sampling stations was similar except for the inner stations in the Bristol Channel, which had a lower salinity as result of increased freshwater influence from the river Severn. The salinity range was comparable with the other three surveys (Table 2).

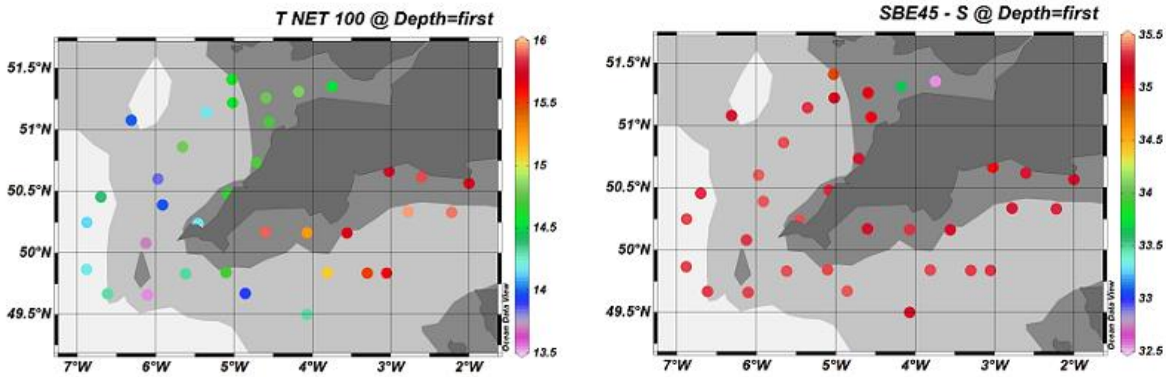

Figure 7. Temperature (T Net 100, °C) and salinity (SBE45) at 4 m depth measured by the Ferrybox at the 39 oceanographycal sampling stations between 3rd October and 19th October.

Remote sensing images (Figure 7) showed that a patch of slightly cooler water (approximately 14°C (Figures 7 and 8) was located south of Eddystone Bay and the Isles of Scilly south to the France coast. During the course of the survey the location of this patch of cooler water did not change, likely as result of the calm weather conditions and sea state. A similar patch of cooler water was also clearly visible in the remote sensing images from the 2014 survey, althought in 2014 it extended westward during the course of the survey.

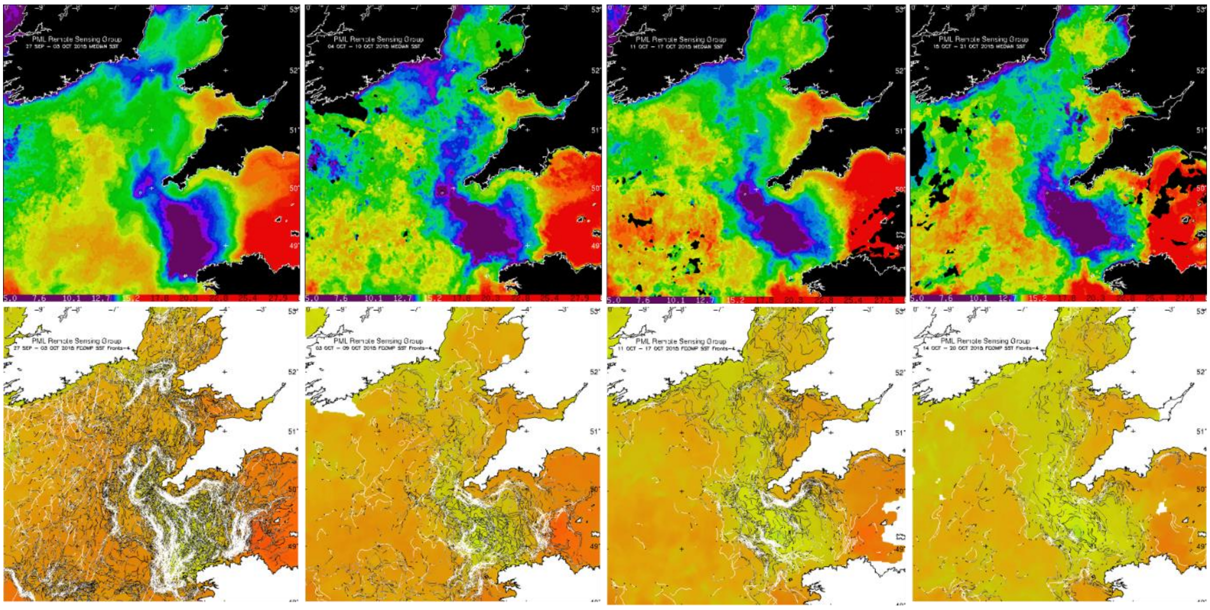

Figure 8. Composite surface maps for the periods 27 September - 3 October, 4 – 10 October, 11 – 17 October and 14-20 October 2015 of temperature (upper row of images) and thermal frontal systems (lower row) from Neodaas.co.uk.

The northern, eastern and western boundaries between the cool water patch and the warmer waters of the English Channel and the Celtic Sea was marked by a series of frontal systems (Figure 7), clearly visible particularly in the composite image for the week 27 September – 3 October. The frontal systems were present throughout the survey although they became weaker over time (Figure 7).

Table 2. Average, minimum and maximum values at 4 m depth of temperature, salinity and fluorescence, measured by the Ferrybox at the 39 oceanographycal sampling stations, during surveys in 2015 (Cend22_15), 2014 (Cend20_14) and 2013 (Cend20_13).

Survey	**Average**	**Minimum**	**Maximum**
Cend22_15 – Temperature (°C)	14.72	13.53	15.95
Cend22_15 – Salinity	35.14	32.53	35.14
Cend22_15 – Fluorescence	1.17	0.46	2.32
Cend20_14 – Temperature (°C)	15.98	14.62	18.14
Cend20_14 – Salinity	35.09	33.33	35.37
Cend20_14 – Fluorescence	0.19	0.08	0.44
Cend20_13 – Temperature (°C)	14.91	13.65	16.15
Cend20_13 – Salinity	35.28	33.36	35.61

Vertical profiles of temperature and salinity (carried out with a SAIV Mini CTD mounted on the zooplankton sampling nets) were plotted using the software Ocean Data View (ODW). Surface maps from CTD measurements (Figure 7) showed a temperature distribution similar to the one observed from the satellite-derived maps. The surface maps of the Western English Channel (Figure 10) show the presence of a gradient from cooler and saltier waters towards the Scilly Isle to warmer and less salty waters in Lyme Bay. Stations in the Bristol Channel showed a similar gradient (warm and less salty waters in the inner Bristol Channel, cooler and saltier waters in the outer Channel; Figure 10), although waters in the Bristol Channel were not as warm as in Lyme Bay (16.33 and 18.08 °C respectively; Table 2).

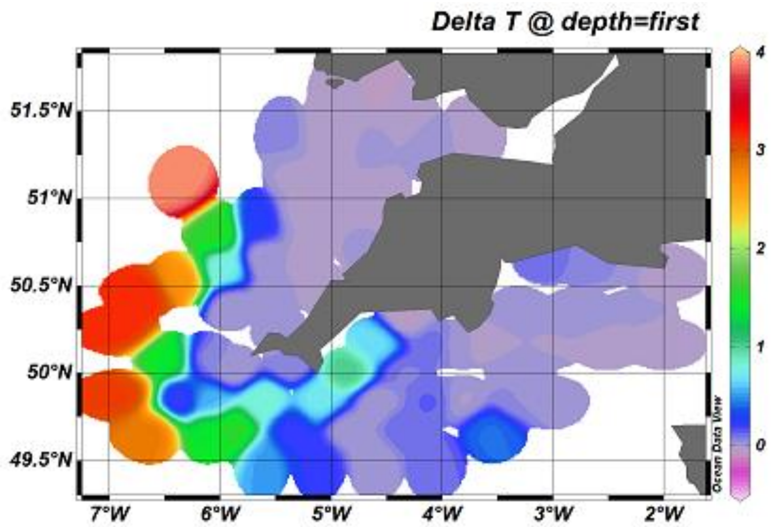

Figure 9. Values of ΔT (surface temperature – bottom temperature; °C) at the 69 sampling stations, as measured by the SAIV MiniCTD. The water column is considered stratified when ΔT > 0.5 (°C).

3.3.2. Chlorophyll and fluorescence

Higher levels of chlorophyll concentration were observed offshore, south of Edddystone Bay and around the Scilly Isles (Figure 10), corresponding with the frontal systems around the cool patch of water in the Western English Channel. In these frontal systems, nutrient-rich waters are mixed with nutrient-depleted surface waters leading to an observed increase in phytoplankton biomass.

Chlorophyll concentration was higher south of Lyme Bay and off the Scilly Isles, as shown by the Ferrybox raw fluorescence (Figure 11). Remote sensing images also indicated high level of chlorophyll concentration in Bristol Channel. However, this observation was not supported by the Ferrybox fluorescence measurements which were generally low (compare Figure 4 and 5). This was likely due to the higher level of suspended solids in the inner Bristol Channel affecting the reliability of the remote sensing algorithm for calculating chlorophyll concentration.

Remote sensed images (Figure 10) shows that the autumn bloom was well developed during the week before the survey (27 September - 3 October); however high level of fluorescence were recorded throughout the survey in different areas. On average, fluorescence measurements at the different sampling stations, recorded by the Ferrybox during this survey, were 6 time higher than average fluorescence measured during the previous year survey (Cend20_14).

Analysis of phytoplankton samples at the inverted microscope, and of samples for HPLC and flow cytometry in the laboratory will provide details of the pico-, nano- and phytoplankton community as well as their abundance and pigment composition.

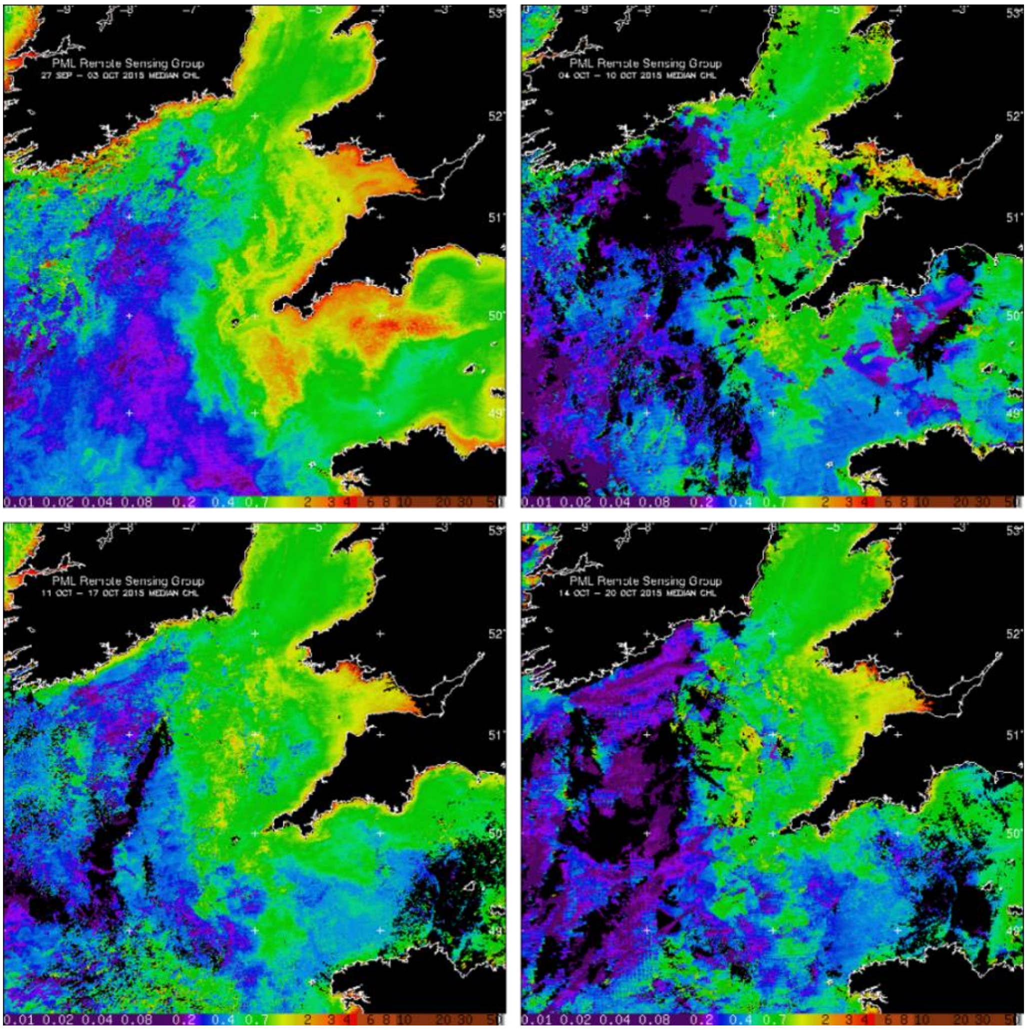

Figure 10. Composite surface maps for the periods 27 September - 3 October, 4 – 10 October, 11 – 17 October and 14-20 October 2015 of surface chlorophyll from Neodaas.co.uk.

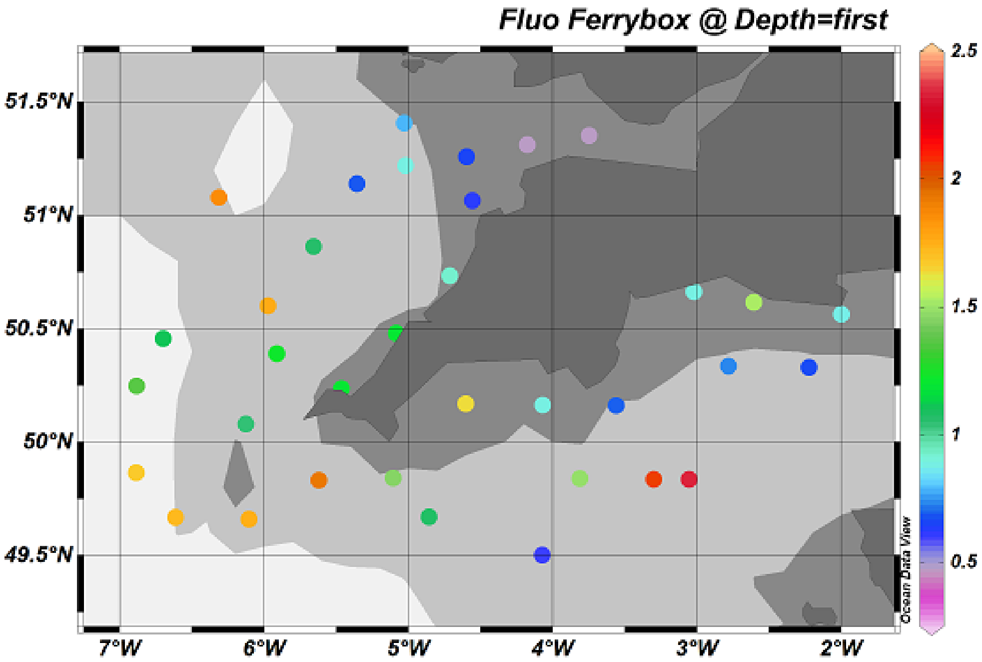

Figure 11. Fluorescence values at 4 m depth, at 18 sampling stations, as recorded by the Ferrybox.

3.4. Marine Mammals and birds

This year, as in 2014, all transects were run in daylight, and with more sea time in the survey area and better weather, almost complete coverage was achieved in all sections of the survey. Visibility during effort surveys was generally good to excellent, and rain was infrequent and fog absent.

In total, there were 170 sightings (96 in 2014) of seven cetacean species (same as in 2014), with significantly more individual animals counted (1790 compared to 1520 in 2014).

The most abundant cetacean species encountered throughout was Common Dolphin *Delphinus delphis* with 129 (76 in 2014) sightings of 1,650 animals (1520 in 2014), chiefly but not exclusively in deeper waters (>50m) in the west and northwest of the survey area. The White-beaked Dolphin *Lagenorhynchus albirostris* were encountered in the western section of Lyme Bay as in previous years; Long-finned Pilot Whales *Globicephala melas* were found south of Plymouth and all nine Fin Whale *Balaenoptera physalus* sightings (22 confirmed individuals) were located to the north west of the Cornwall and Devon coasts. Rorqual whale encounters where the animals were too distant to see their dorsal fins were logged as Unidentified rorqual sp., although they were all presumed to be Fin Whale. A single sighting of two animals at approximately 3 km distance from the vessel whose distinctly different blows were seen well and photographed, were thought to be humpback whales. However as no diagnostic views were obtained these were logged as unidentified baleen whales.

Detailed results of the bird observations were not available at the time of writing and only a brief summary is provided here. A total of 50 species of birds were recorded during the survey. A notable observation included a flock of at least 115 Storm Petrels *Hydrobates pelagicus*, feeding in the RV Endeavour's wake during net retrieval operations, south of Portland Bill, Dorset.

Some evidence of visible migration was noted, particularly along the Dorset coast, with a steady stream of Meadow Pipits Anthus pratensis overhead. A Richard's Pipit Anthus richardi and an Alpine Swift Apus melba seen off south Devon and south Dorset respectively were both vagrant individuals presumably blown off course by the easterly airflow which dominated the weather for most of the survey period.

Unexpectedly high numbers of Balearic Shearwaters, *Puffinus mauretanicus*, chiefly in the Bristol Channel in 2013 (79) and 2014 (205) provided an important focus again for 2015. This species is the UKs only critically endangered seabird, having declined by ~95% since 1970s. UK waters are at the edge of their non-breeding range however, distinct northward shifts in range have been noted in recent years so it is likely that the UK will become increasingly important. This year a minimum of 90 specimens were counted (subject to analysis of the two datasets recorded), the majority of which in the same general area to the west of Lundy Island in the Bristol Channel, as was the case in the previous two years. Behaviours noted include shallow plunge diving, surface pecking and active searching, particularly around feeding groups of Common Dolphin and occasionally investigating the RV Endeavour's wake during net retrievals. These data will be further analysed as part of a Defra funded project to establish the importance of the Bristol Channel as an important feeding area, and will be used to inform future conservation measures.

4. Summary

The fourth in the series of Pelagic Ecosystem Surveys in the western English Channel and Eastern Celtic Sea took place between the 3rd and 21st of October 2015. The oceanographic conditions were similar to those observed in 2013 and represented a typical autumn bloom scenario, in contrast to the much warmer 2014 survey and the winter conditions encountered in 2012. Primary production was high, 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 had increased in both abundance and distribution. Western English Channel sprat was distributed further west than the traditional Lyme Bay region and was found also in good numbers in coastal waters off Plymouth. In the Bristol Channel, the usual small but dense surface schools stretched for many miles along the coast in the inner parts. In addition, this year very large schools were also prevalent in the deeper (>80 m) offshore waters of the western and central parts of the Bristol Channel which appeared to be associated with several aggregations of feeding fin whales. In contrast to the sprat in the western Channel which consisted of predominantly adult specimens (age 1-3), in-and offshore sprat in the Bristol Channel were predominantly age 0 (with a unimodal length distribution around 8 cm). Given the consistent occurrence of these very large juvenile sprat aggregations in this area it is clearly an important nursery area.

As in 2014, anchovy was found in large numbers in the western English Channel, this time extending further west than observed in previous years. Noticeably in this area were the larger number of 2 year old (and older) specimens than in previous years. This year for the first time, anchovy was also observed in the inner Bristol Channel, where the predominantly smaller specimens were mixed with several other small clupeids in what is clearly an important nursery area.

Sardine numbers also appeared to have increased, as has their distribution. 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 contrast to 2014, very few large specimens (> 20cm) were present in the trawls. 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 both in terms of magnitude and distribution although in 2015 for the first time (small numbers of) eggs were also observed in the Bristol Channel.

Although mackerel were observed throughout the survey area, both in and offshore, highest densities were found in the western parts of the English Channel and Bristol Channel and particularly around the Isles of Scilly. Young of the year made up more than half of the mackerel population in the area. Horse mackerel were prevalent in the survey area although they dominated the offshore areas of the western Channel and around the Isles of Scilly. To distinct modes were observed in the length data, one at around 10cm and one at 15cm, generally associated with 0 and 1 year old fish.

Working Document to WGACEGG meeting 16-20 November 2015 at Lowestoft, UK

Acoustic surveying of anchovy Juveniles in the Bay of Biscay:

JUVENA 2015 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 2015 is around 460,000 tonnes, which represents the third 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 2015 took place between the 1st and 30th of September onboard the chartered R/V Ramon Margalef and the R/V Emma Bardán, both equipped with scientific echosounders. The acoustic equipment included three split beam echo sounders Simrad EK60 (Kongsberg Simrad AS, Kongsberg, Norway; Table 1) calibrated using Standard procedures (Foote *et al.* 1987). In the Ramon Margalef, the 38 kHz, 120 kHz and 200Khz transducers were installed looking vertically downwards, 3 m deep, at the end of a tube attached to the side of the boat, where as at the R/V Emma Bardan the same transducers were installed at the hull. For acoustic data processing the IFREMER Movies+ software was used.

The water column was sampled to depths of 200 m. Acoustic back-scattered energy by surface unit (S_A, MacLennan *et al.* 2002) was recorded for each geo-referenced ESDU (Echointegration Sampling Distance Unit) of 0.1 nautical mile (185.2 m). Fish identity and population size structure was obtained from fishing hauls and echotrace characteristic using a pelagic trawl (Table 1). Acoustic data, thresholded to -60 dB, was processed using Movies+ software (Ifremer) for biomass estimation and the processed data was represented in maps using ArcGIS. Hydrographic recording was made with CTD casts.

Sampling strategy

The sampling area covered the waters of the Bay of Biscay (being 8º40’ W and 47º30’ N the limits, Figure 1). Sampling was started from the Southern part of the sampling area, the Cantabrian Sea, moving gradually to the North to cover the waters in front of the French Coast. The acoustic sampling was performed during the daytime, when the juveniles are supposed to aggregate in schools (Uriarte 2002 FAIR CT 97-3374) and can be distinguished from plankton structures.

The vessels followed parallel transects, spaced 15 n.mi., perpendicular to the coast along the sampling area, taking into account the expected spatial distribution of anchovy juveniles for these dates, that is, crossing the continental shelf in their way to the coast from offshore waters (Uriarte et al. 2001).

During the summer, information from the commercial live bait tuna fishery was collected (Table 7), in order to have knowledge about the spatial distribution and relative abundance of anchovy previous to the beginning of the survey.

Data analysis

Biological processing

Each fishing haul was classified to species and a random sample of each species was measured to produce size frequencies of the communities under study. A complete biological sampling of the anchovy juveniles collected is performed in order to analyze biological parameters of the anchovy juvenile population, as the age, size or size-weight ratio. Using these and other environmental parameters we will try to obtain, in a long term, indexes of the state of condition of the juvenile population, in order to be able to improve the prediction of the strength of the recruitment.

Acoustic data processing

Acoustic data processing was performed by layer echo-integration by 0.1 nautical mile (s_A) of the first 65 m of the water column with Movies+ software, after noise filtering and bottom correction, increasing or decreasing this range when the vertical distribution of juveniles made it necessary.

The hauls were grouped by strata of homogeneous species and size composition. Inside each of these homogeneous strata, the echo-integrated acoustic energy s_A was assigned to species according to the composition of the hauls. Afterwards, the energy corresponding to each specie-size was converted to biomass using their corresponding conversion factor.

Each fish species has a different acoustic response, defined by its scattering cross section that measures the amount of the acoustic energy incident to the target that is scattered backwards. This scattering cross section depends upon specie *i* and the size of the target *j*, according to:

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

Here, L_j represents the size class, and the constants a_i and b_i are determined empirically for each species. For anchovy, we have used the following TS to length relationship:

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

The composition by size and species of each homogeneous stratum is obtained by averaging the composition of the individual hauls contained in the stratum, being the contribution of each haul weighted to the acoustic energy found in its vicinity (2 nm of diameter). Thus, given a homogeneous stratum with M hauls, if E_k is the mean acoustic energy in the vicinity of the haul *k*, w_i, the proportion of species *i* in the total capture of the stratum, is calculated as follows:

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

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

In order to distinguish their own contribution, anchovy juveniles and adults were separated and treated as different species. Thus, the proportion of anchovy in the hauls of each stratum (w_{ij})

was multiplied by a age-length key to separate the proportion of adults and juveniles. Then, separated w_i were obtained for each.

Inside each homogeneous stratum, we calculated a mean scattering cross section for each species, by means of the size distribution of such specie obtained in the hauls of the stratum:

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

Let s_A be the calibration-corrected, echo-integrated energy by ESDU (0.1 nautical mile). The mean energy in each homogeneous stratum, $E_m = < s_A >$, is divided in terms of the size-species composition of the haul of the stratum. Thus, the energy for each species, E_i, is calculated as:

$$E_i = \frac{w_i \langle \sigma_i \rangle E_m}{\left(\sum_i w_i \langle \sigma_i \rangle \right)}$$

Here, the term inside the parenthesis sums over all the species in the stratum. Finally, the number of individuals F_i of each species is calculated as:

$$F_i = H \cdot l \frac{E_i}{\langle \sigma_i \rangle}$$

Where l is the length of the transect or semi-transect under the influence of the stratum and H is the distance between transect (about 15 n.mi.). To convert the number of juveniles to biomass, the size-length ratio obtained in each stratum is applied to obtain the average weight of the juveniles in the stratum:

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

Thus, the biomass is obtained by multiplying F_i times $< W_i >$.

3. Results

Checking and calibrations

Calibration was performed in Vigo during the first days of the survey following the sphere method (Foote et al. 1987). The inter-ship calibration between EB and RM was performed along a 80 nautical miles transect over a pure juvenile distribution just after the sunset. 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 2015 took place between the 31st of August and 30th of September (see Table 2). The survey sampled 2,200 n.mi. that provided a coverage of about 33,000 n.mi.2 along the continental shelf and shelf break of the Bay of Biscay, from the 9º10’ W in the Cantabrian area up to 47º 30’ N at the French coast (Figure 1). Seventy nine hauls were done during the survey to identify the species detected by the acoustic equipment, 58 of which were positive of anchovy (Figure 2, Tables 3, 4, 5 and 6).

The survey was covered by both vessels in coordination, in the Spanish region both vessels followed alternate transects, while in the French part they concentrated the sampling effort of each vessel in the most appropriate areas according to their efficiency: this is, oceanic and slope waters for the RM and continental shelf for the smaller pelagic trawler EB (Figure 1).

Spatial Distribution

This year, as usual, we have found anchovy distributed along two different strata: a pure juvenile anchovy stratum, located at the outer part of the continental shelf and slope waters, and a mixed juvenile-adult stratum located at the inner part of the continental shelf and coastal waters (Figure 4):

- **Pure juvenile stratum**: In this stratum, anchovy was located in the uppermost part of the water column forming the typical superficial aggregations of pure juvenile anchovy (Figure 4), mixed in occasions with smaller proportions of juvenile horse mackerel, gelatinous species and krill. In order to simplify description, we can divide this stratum in two areas, Cantabric and French.
    - **Cantabric sub-stratum**: in this area, anchovy juveniles were extended along a strip around the shelf break edge, from 9º10’ W to 1º30’ W (Figure 4). Mean sizes ranged between 4 and 7 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 12 and 16 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 2015 is 426,000 tones (Table 7). This value, is the third maximum biomass of the JUVENA series, well above the average (Figure 5). The area of distribution of juvenile anchovy this year was also among the highests 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 2015
by Maite Louzao, Isabel García-Barón, José Luis Murcia, Iñigo Krug, Iñaki Oyarzabal and Mikel Basterretxea

As a part of the ecological activities conducted during the JUVENA survey, we assessed the spatial distribution of marine top predators in the Bay of Biscay, considering interactions within the community as well as with human activities. For that, we investigated the distribution and abundance of seabirds and marine mammals collecting information on the species present, number and behaviour of individuals sighted during at-sea observations.

Apart from recording information on seabirds and cetaceans, we also recorded other marine organisms such as tuna, ocean sunfish (Mola mola) or jellyfish, among others. Likewise, we also record and typify human activities such as fishing (the presence of fishing boats and their activity, fishing buoys, etc.), commercial vessels and various types of wastes and debris, in addition to registering the presence of oceanographic features such as fronts or slicks.

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

Two observers were placed over the bridge of R/V Ramón Margalef, 10 meters high from the sea surface (Figure 8). Observers scanned the water to the front of the boat covering an area of 90º from the trackline to port or starboard, respectively continuously while the vessel was sailing at constant heading and speed during daytime. The temporal observations resolution was one minute. Observers recorded the environmental conditions that could affect sightings (i.e. wind speed and direction, sea state, swell height, glare intensity, visibility, etc. and they estimated the distance to the sightings and the angle of the sightings with respect to the trackline. Additional data collected from each sighting included: species, group size, movement direction, behaviour, presence of calves and/or juveniles, etc. All sightings were made with the naked eye while the identifications were supported with 10X42 binoculars.

A total of 220 observations periods (legs) were performed, travelling a total of 2522 km during 150 hours of observation. We observed an average of 6.36 hours per day (range: 2.88 – 10.07) and travelled an average of 105 km per day (range: 48 - 186). We recorded a total of 5451 seabirds, 1238 cetaceans, 480 of human activities and 49 of land birds. A complete list is given in Table 1.

Regarding marine mammals, we observed 7 different species and the spatial distribution of the most abundant species can be observed in Figure 2. The most abundant species where the common dolphin with 92 sightings (group size = 9.91 ± 24.17, total of 912 individuals), followed by fin whales with 45 sightings (group size = 1.33 ± 0.52, total of 60 individuals), stripped dolphins with 13 sightings (group size = 7.69 ± 8.46, total of 100 individuals) and long-finned pilot whales with 13 sightings (group size = 7.69 ± 5.82, total of 100 individuals). We also observed bottlenose dolphins, sperm whales and Cuvier's beaked whales (Table 1).

Regarding seabirtds, we observed 25 different species and the spatial distribution of the most abundant species can be observed in Figure 3. The most abundant species where the northern gannet with 379 sightings (group size = 2.39 ± 13.51, total of 905 individuals), followed by lesser black-backed gull with 270 sightings (group size = 2.57 ± 5.42, total of 694 individuals), yellow-legged gulls with 211 sightings (group size = 5.32 ± 24.7, total of 1122 individuals) and great shearwaters with 146 sightings (group size = 3.17 ± 7.62, total of 463 individuals). We also observed Sabine's gulls with 119 sightings (group size = 2.92 ± 6.33, total of 347 individuals), great skuas with 77 sightings (group size = 1.18 ± 0.74, total of 91 individuals), common terns with 44 sightings (group size = 2.3 ± 2.75, total of 101 individuals), sooty shearwaters with 38 sightings (group size = 1.76 ± 2.33, total of 67 individuals) and Balearic shearwaters with 36 sightings (group size = 1.94 ± 3.99, total of 70 individuals) (Table 1). We also observed bottlenose Arctic skua, Manx shearwater, Pomarine skua, European storm-petrel, Cory's shearwater, Great black-backed gull, Little gull, Razorbill, Northern fulmar, Black Tern, Artic tern, Black-headed gull, Leach's storm-petrel, Great cormorant, Gull-billed tern (Table 1).

In the other hand, we have collected opportunistic predator observations 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 behavior of the most abundant species.

Conclusions

- Good survey spatial coverage
- Good general performance of the equipment and different acoustic configurations for different tasks-scenarios.
- The survey maintains or even increases its recently acquired ecological scope
- The positive area of anchovy this year was the largest in the temporal series.
- The biomass estimate of this year (426,000 tones) is the third maximum of the JUVENA series, well above the average.
- Since last 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

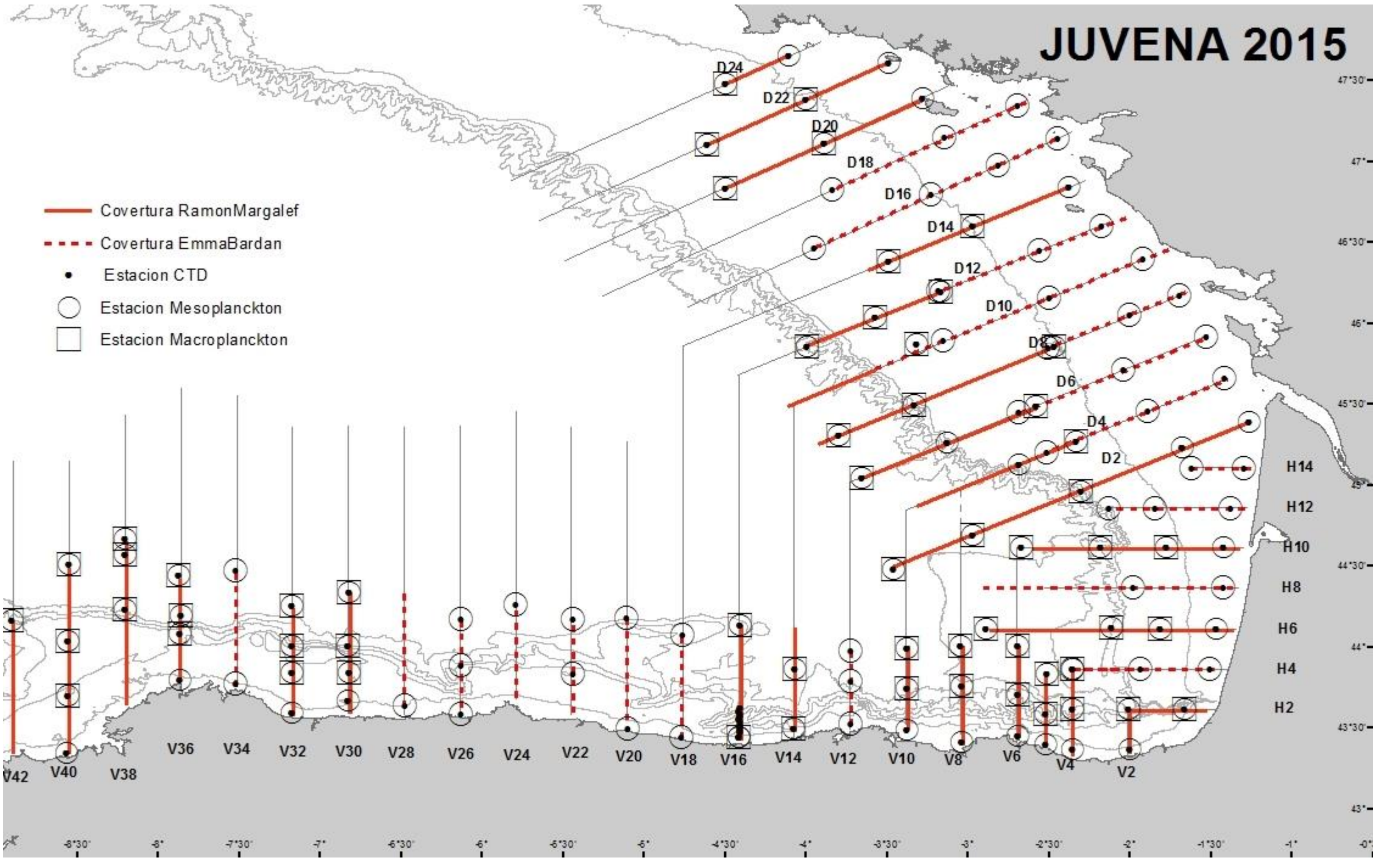


Figure 1. Visited transects (red solid line for the RM and dashed line for the EB) and stations of hydrography / plankton by the R/V Ramon Margalef and R/V Enma Bardán.

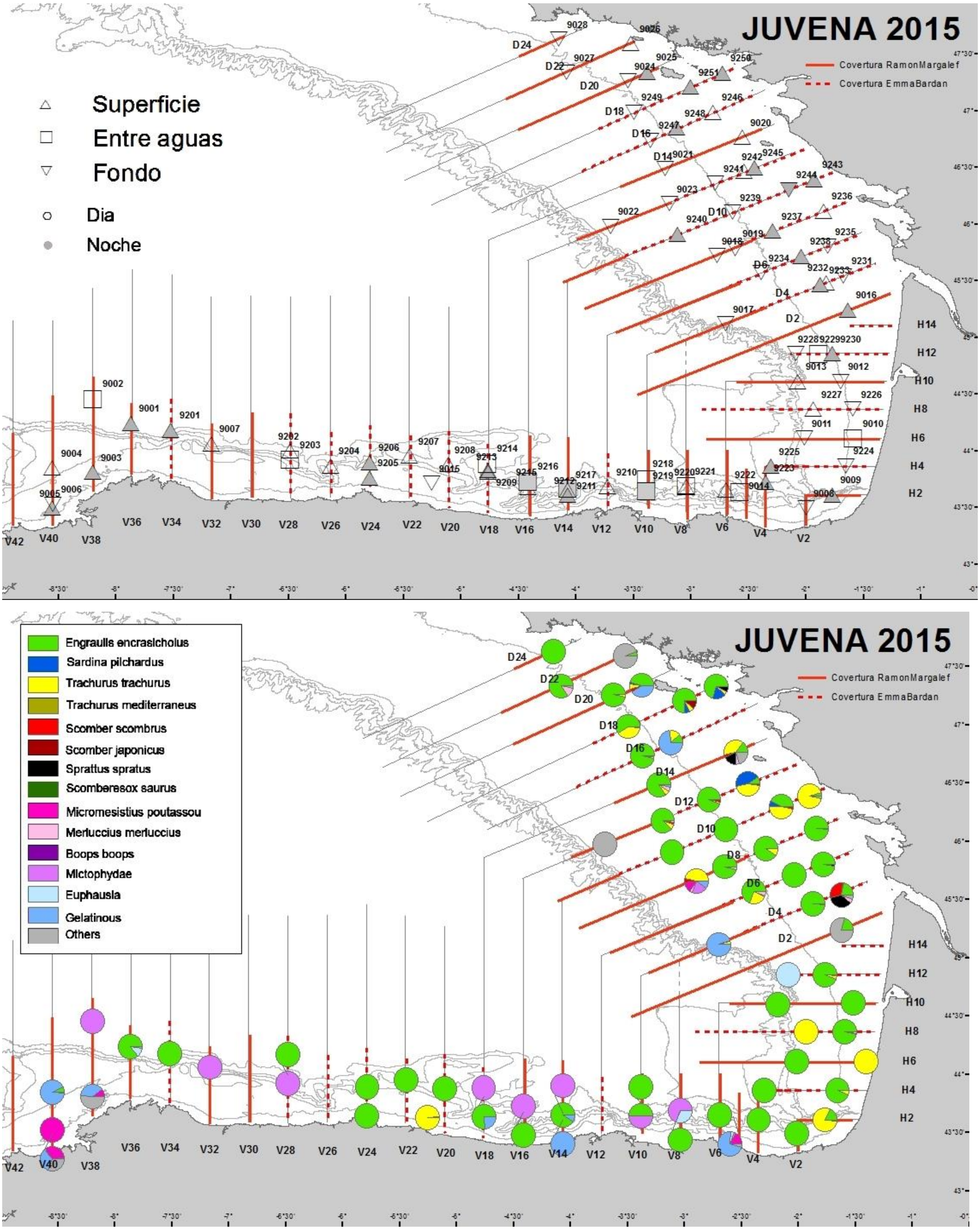


Figure 2. Top panel: position of the fishing stations. Hauls performed by RM are numbered from 9001 to 9031 and the transects are marked with dashed lines; hauls performed in the EB are numbered from 9201 to 9235 and the transects are marked with solid lines. Bottom panel: Species composition of the hauls.

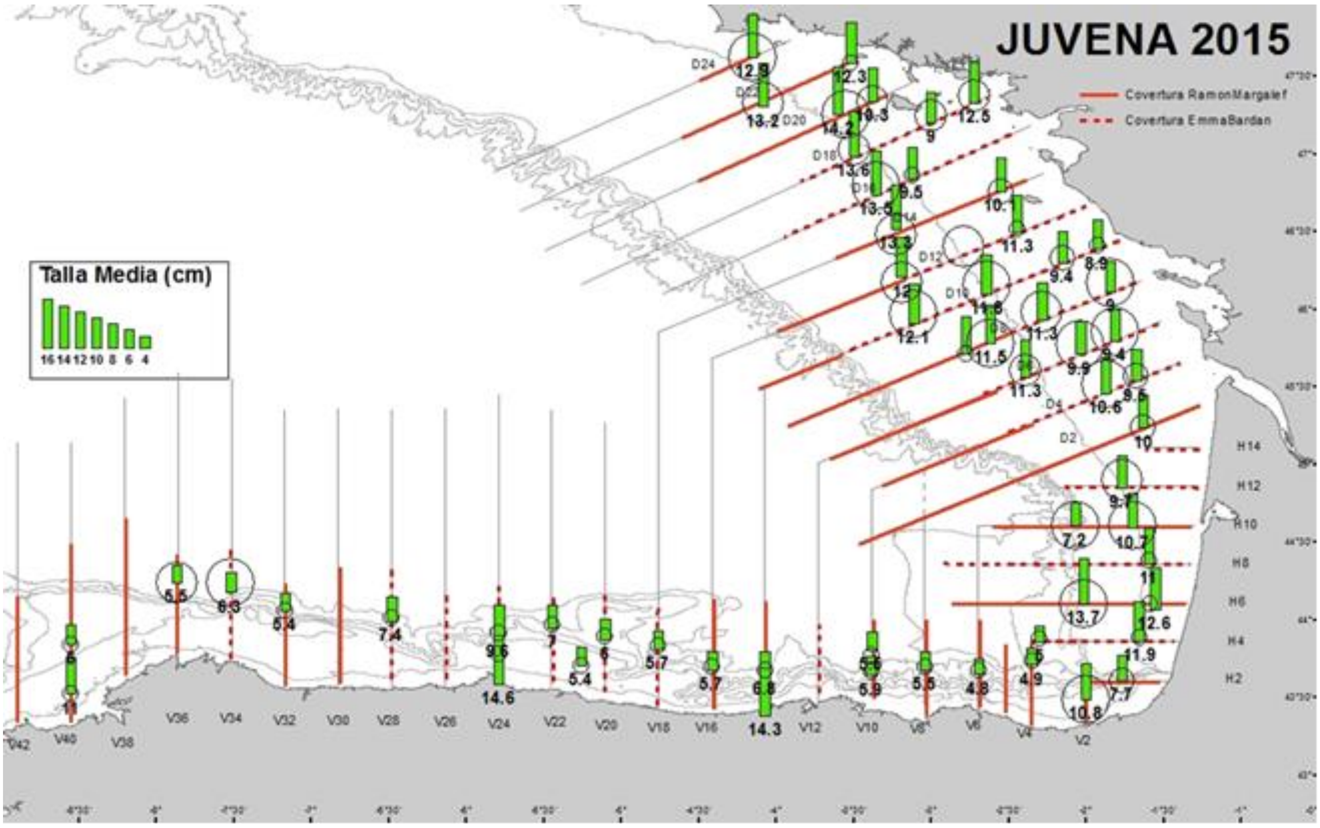


Figure 3: Top panel: Size of anchovy in the positive anchovy hauls. The length of the bars is proportional to the mode of the size (Standard length) of the captured anchovy. Bottom panel: Anchovy size distribution in the different areas distinguished.

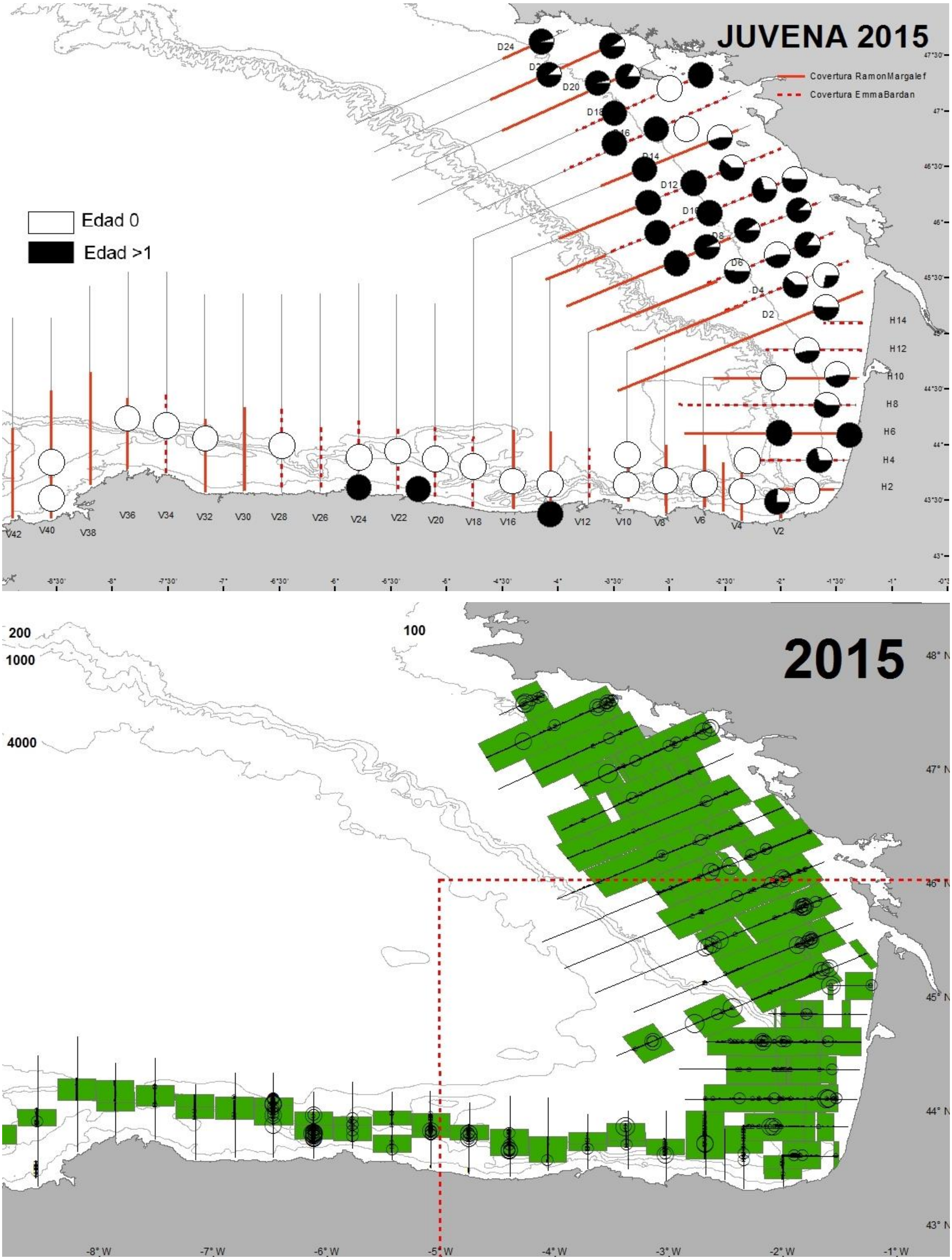


Figure 4: Top: positive area of distribution of anchovy. The pie charts show the percentage of juveniles (white) and adults (black) in the fishing hauls. Bottom: total acoustic energy (NASC) of all the identified species and the three subareas of the positive area of anchovy.

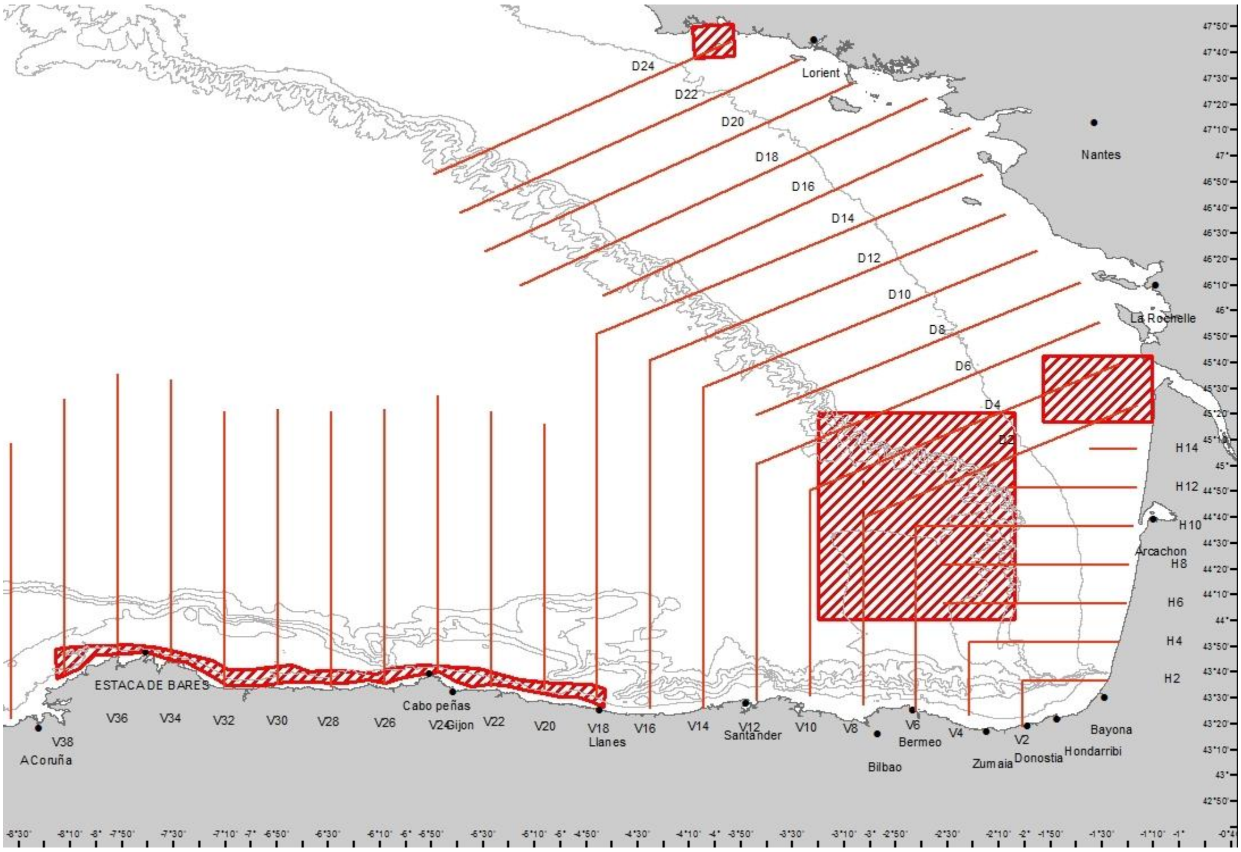


Figure 5. Approximated regions of presence of anchovy in the Bay of Biscay according to the reports of the live bait tuna fishery one week before the start of the survey.

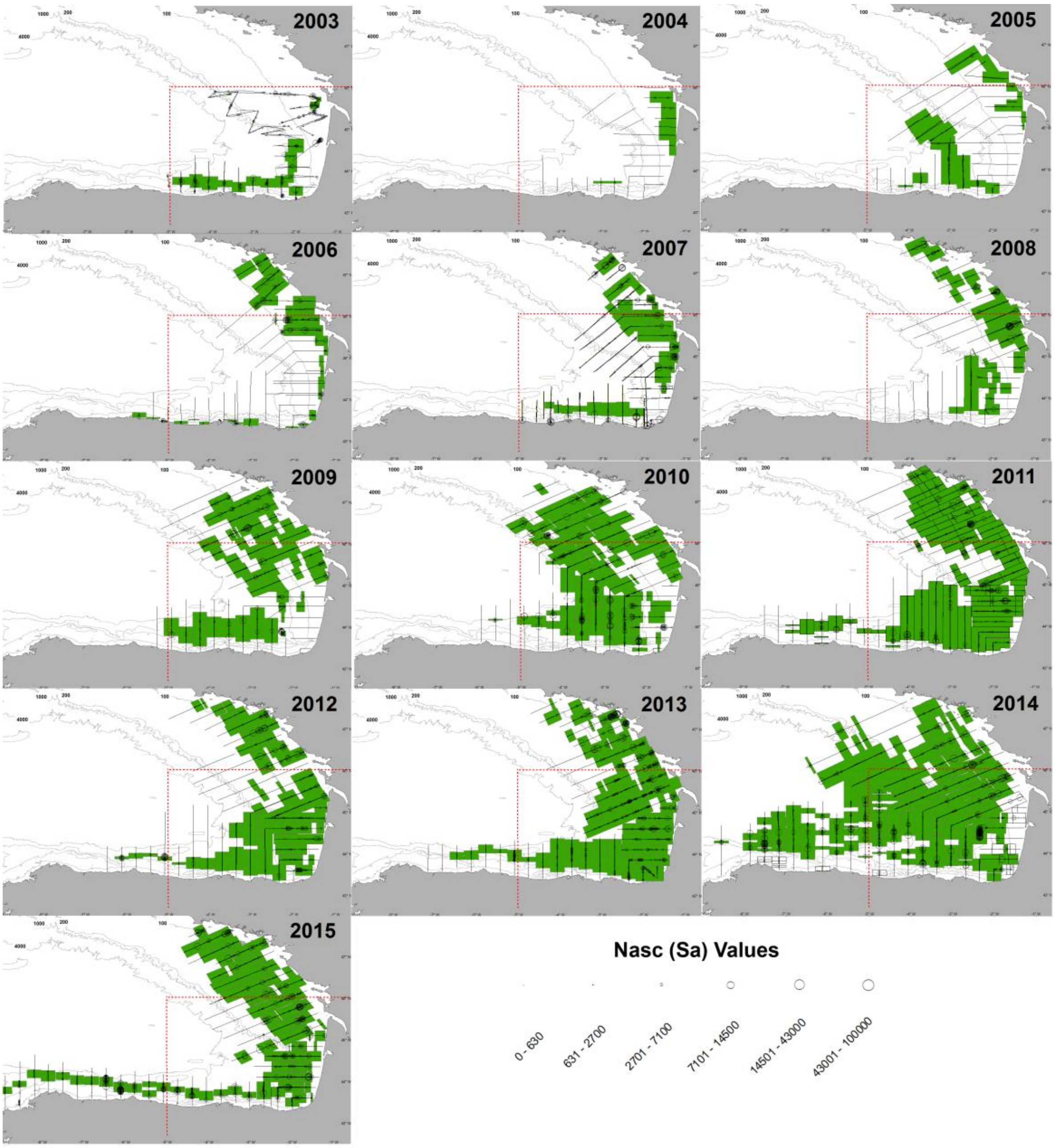


Figure 6: Positive area of presence of anchovy and total acoustic energy echo-integrated (from all the species) for the eight years of surveys. The area delimited by the dashed line is the minimum or standard area used for inter annual comparison.

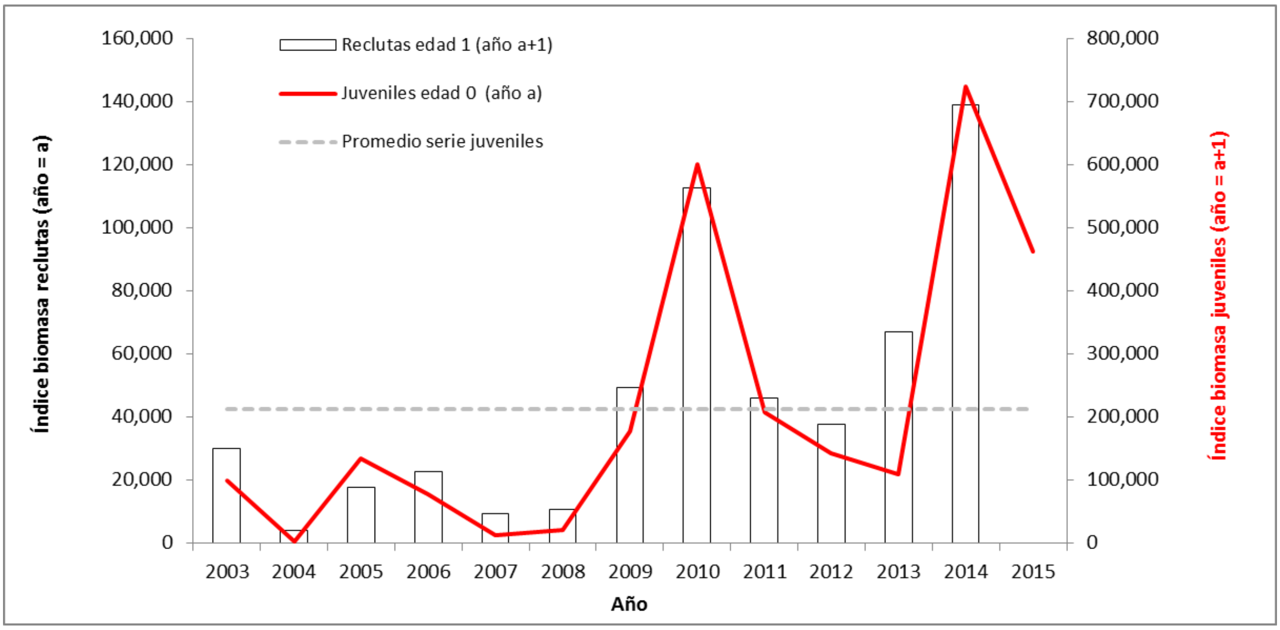
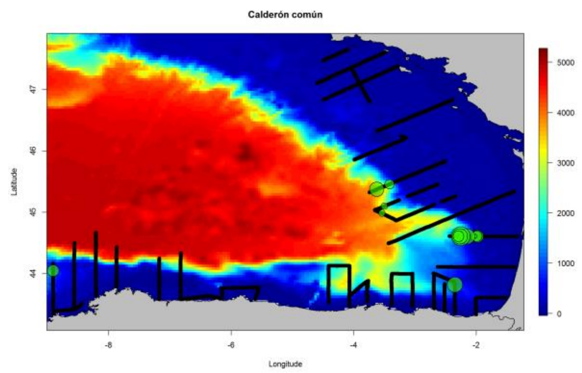


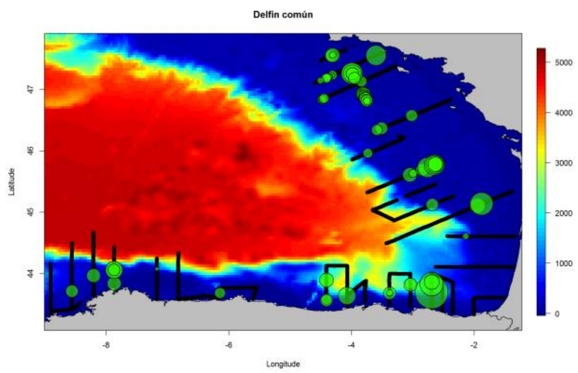
Figure 7: Temporal series of the estimated abundances of anchovy juveniles (blue) against the CBBM synthetic estimated abundances of age 1 anchovy next spring (red), based on PELGAS and BIOMAN surveys plus the catches.

Figure 8. Observation platform onboard R/V Ramón Margalef showing observer activities when they measure the distance and angle to an object or animal.

(a)



(b)



(c)

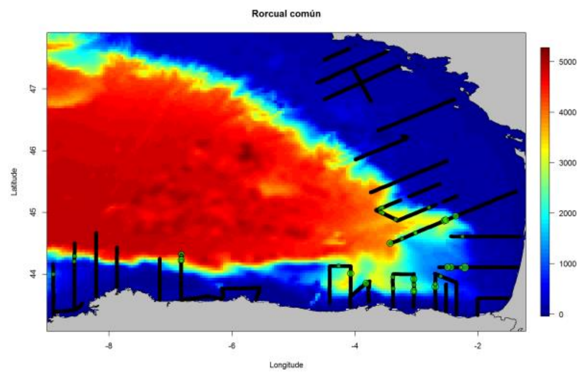


Figure 9. Distribution of the most abundant marine mammal species during JUVENA 2015, (a) long-finned pilot whales *Globicephala melas* (b) common dolphin *Delphinus delphis*, (c,d) fin whale *Balaenoptera physalus*. Black points represent the effort while the size of the green circles is proportional to observed abundances.

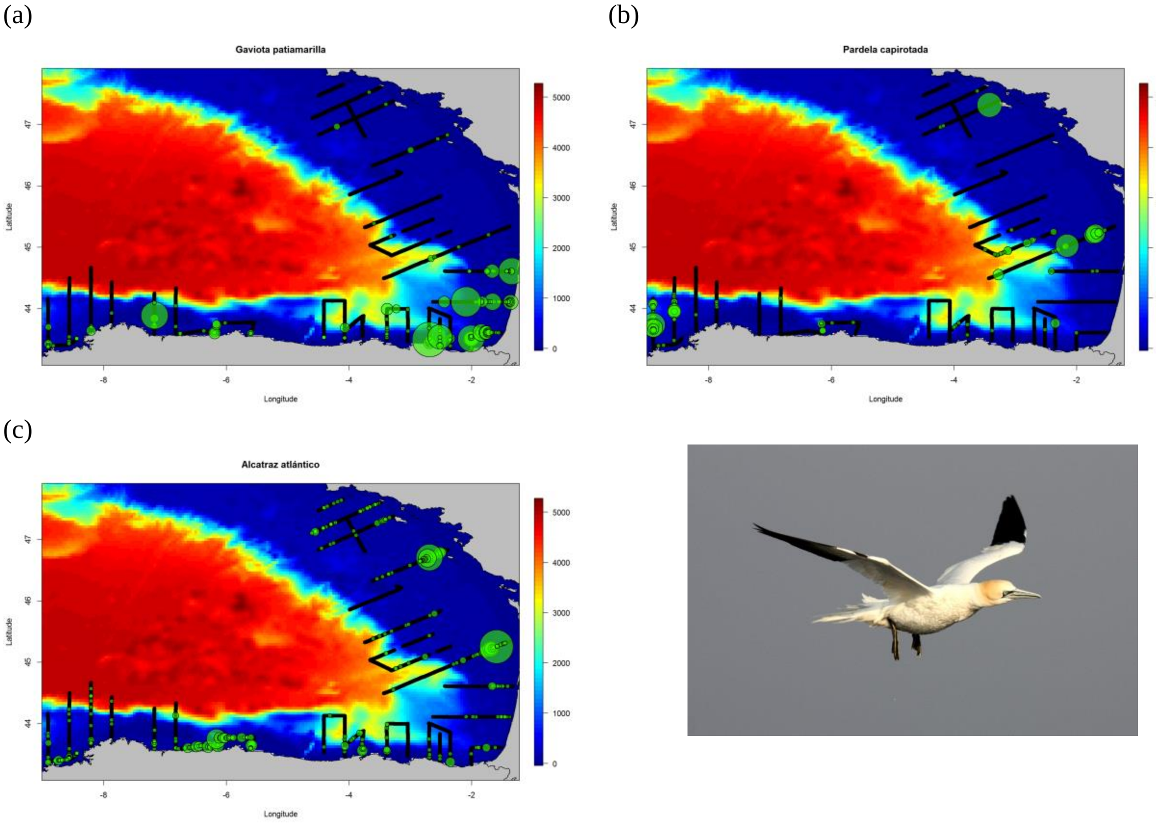


Figure 10. Distribution of the most abundant seabird species during JUVENA 2015, (a) yellow-legged gull *Larus michahellis*, (b) great shearwater *Puffinus gravis*, (c,d) northern gannet *Morus bassanus*. Black points represent the effort while the size of the green circles is proportional to observed 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

Actividad	**Puerto**	**Fecha**	**Observaciones**
Instalación RM y EB	Vigo	27 agosto	
Puesta a punto RM y EB	Vigo	28-30 agosto	Pruebas de equipos. Calibración. Intercalibración
Inicio campaña		31 agosto	
Escala EB	Santander	4 septiembre	
Escala RM	Pasaia	10 septiembre	
Escala EB	Pasaia	10 septiembre	
Escala RM	Pasaia	14-16 septiembre	Mal tiempo
Escala EB	Pasaia	14-16 septiembre	Mal tiempo
RCAN RM		17-19 septiembre	
Escala RM	Gijón	20 septiembre	
Escala EB	La Pallice	22 septiembre	Mal tiempo
Final campaña EB		28 septiembre	Descarga material
Final campaña RM	Pasaia	30 septiembre	Descarga material

Table 3:
Relation of fishing catches performed by Ramon Margalef

Estación	Fecha	Radial	Hora GMT	Lat	Long	Sonda
1	30/08/15	V36	12:00	43.7927	-7.8695	65
2	30/08/15	V36	15:02	44.0773	-7.8703	268
3	30/08/15	V36	18:10	44.4358	-7.8733	4860
4	30/08/15	V36	22:33	44.1932	-7.8592	3705
5	31/08/15	V38	5:34	44.6678	-8.2068	4883
6	31/08/15	V38	10:31	44.5642	-8.2065	4882
7	31/08/15	V38	13:37	44.2307	-8.2078	2042
8	01/09/15	V40	5:01	44.5040	-8.5548	4895
9	01/09/15	V40	9:53	44.0288	-8.5593	348
10	01/09/15	V40	16:06	43.6933	-8.5623	187
11	01/09/15	V40	19:56	43.3420	-8.5677	58
12	02/09/15	V42	5:03	44.1572	-8.9068	680
13	03/09/15	V32	5:04	43.5900	-7.1732	53
14	03/09/15	V32	8:13	43.8395	-7.1743	154
15	03/09/15	V32	13:18	44.0009	-7.1783	775
16	03/09/15	V32	15:17	44.2515	-7.1748	3931
17	04/09/15	V30	6:05	44.3342	-6.8232	4826
18	04/09/15	V30	8:47	44.0008	-6.8270	2136
19	04/09/15	V30	11:21	43.8332	-6.8245	127
20	05/09/15	V14	6:10	43.6655	-6.8255	80
21	05/09/15	V14	9:36	43.4923	-4.0723	2360
22	05/09/15	V14	11:30	43.8560	-4.0717	3000
23	05/09/15	V16	14:20	44.1302	-4.4102	1900
24	05/09/15	V16	19:30	43.4372	-4.4128	72
25	05/09/15	V16	20:30	43.4397	-4.4152	195
R16_1	06/09/15	V16T	14:07	43.6155	-4.4100	1360
R16_2	06/09/15	V16T	13:00	43.5960	-4.4153	1110
R16_3	06/09/15	V16T	15:47	43.5828	-4.4097	680
R16_4	06/09/15	V16T	16:30	43.5670	-4.4097	277
R16_5	06/09/15	V16T	16:51	43.5495	-4.4108	218
R16_6	06/09/15	V16T	17:11	43.5333	-4.4100	185
R16_7	06/09/15	V16T	15:32	43.5167	-4.4097	160
R16_8	06/09/15	V16T	18:30	43.5005	-4.4085	150
R16_9	06/09/15	V16T	18:52	43.4833	-4.4102	142
R16_10	06/09/15	V16T	19:12	43.4665	-4.4100	132
26	07/09/15	V10	5:30	43.4842	-3.3793	60
27	07/09/15	V10	7:46	43.7397	-3.3800	2000
28	07/09/15	V10	10:25	43.9905	-3.3798	2000
29	07/09/15	V08	13:05	43.9997	-3.0420	1800
30	07/09/15	V08	15:46	43.7512	-3.0395	1900

Estación	Fecha	Radial	Hora GMT	Lat	Long	Sonda
31	07/09/15	V08	19:20	43.4075	-3.0417	60
32	08/09/15	V06	5:30	43.4480	-2.6910	46
33	08/09/15	V06	8:00	43.7010	-2.6932	1800
34	08/09/15	V06	11:00	44.0040	-2.6923	1200
35	08/09/15	V04	14:00	43.8600	-2.3498	800
36	08/09/15	V04	15:45	43.6103	-2.3500	667
37	08/09/15	V04	18:00	43.3602	-2.3505	70
38	10/09/15	V02	5:30	43.3623	-2.0003	60
39	10/09/15	V02	12:26	43.6097	-2.0075	1124
40	10/09/15	H02	15:45	43.6122	-1.6623	108
41	11/09/15	H06	5:00	44.1112	-1.4680	52
42	11/09/15	H06	10:26	44.1093	-1.8138	124
43	11/09/15	H06	15:14	44.1132	-2.1123	518
44	11/09/15	H06	19:40	44.1090	-2.8907	1468
45	12/09/15	H10	5:00	44.6095	-1.4238	53
46	12/09/15	H10	10:56	44.6100	-1.7705	117
47	12/09/15	H10	16:06	44.6107	-2.1775	494
48	12/09/15	H10	19:30	44.6105	-2.6718	2400
49	13/09/15	H05	4:59	43.8328	-2.5148	1114
50	13/09/15	H05	11:13	43.5835	-2.5167	512
51	13/09/15	H05	13:27	43.3920	-2.5177	50
52	21/09/15	D2	4:53	44.4790	-3.4612	3824
53	21/09/15	D2	8:54	44.6897	-2.9697	3086
54	21/09/15	D2	12:09	44.9602	-2.3015	246
55	21/09/15	D2	18:48	45.3855	-1.2628	29
56	21/09/15	D2	21:11	45.2258	-1.6757	70
57	22/09/15	D4	5:09	45.2672	-2.3312	117
58	22/09/15	D4	8:43	45.1203	-2.6868	166
59	22/09/15	D6	13:56	45.2548	-3.1287	521
60	22/09/15	D6	18:24	45.4805	-2.5803	124
61	23/09/15	D4	12:03	45.8678	-3.3173	3439
62	23/09/15	D6	14:56	45.0370	-3.6578	3898
63	24/09/15	D8	4:49	45.3037	-3.7973	3746
61	24/09/15	D8	8:00	45.4952	-3.3323	190
65	24/09/15	D8	18:27	45.8538	-2.4658	105
66	25/09/15	D14	5:07	46.8353	-2.3795	23
67	25/09/15	D14	11:20	46.5937	-2.9713	103
68	25/09/15	D14	16:47	46.3805	-3.4920	126
69	26/09/15	D12	4:49	45.8538	-3.9922	1662

Estación	Fecha	Radial	Hora GMT	Lat	Long	Sonda
70	26/09/15	D12	10:33	46.0303	-3.5710	139
71	26/09/15	D12	16:32	46.1947	-3.1692	120
72	27/09/15	D20	5:03	46.8308	-4.4995	150
73	27/09/15	D20	9:40	47.1118	-3.8867	116
74	27/09/15	D20	16:57	47.3843	-3.2758	36
75	28/09/15	D22	5:16	47.6080	-3.4872	39
76	28/09/15	D22	4:33	47.3788	-4.0007	107
77	28/09/15	D22	17:05	47.1017	-4.6115	140
78	29/09/15	D24	5:00	47.4742	-4.5007	117
79	29/09/15	D24	9:02	47.6533	-4.1077	65

Table 4:
Relation of fishing catches performed by Emma Bardan

Estación	Fecha	Radial	Hora Local	Lat	Long	Sonda
1	30/08/15	V34	15:26	43.7688	-7.5183	103
2	30/08/15	V34	20:34	44.4653	-7.5182	4500
3	31/08/15	V28	8:10	43.6347	-6.4788	102
4	01/09/15	V26	7:50	43.5800	-6.1292	50
5	01/09/15	V26	10:27	43.8797	-6.1300	300
6	01/09/15	V26	15:24	44.1670	-6.1298	3500
7	01/09/15	V24	17:25	44.2550	-5.7893	4200
8	02/09/15	V22	10:11	43.8300	-5.4400	160
9	02/09/15	V22	17:37	44.1668	-5.4400	2800
10	02/09/15	V20	19:30	44.1765	-5.1028	2650
11	03/09/15	V20	13:56	43.4937	-5.0998	48
12	03/09/15	V18	15:41	43.4413	-4.7643	35
13	03/09/15	V18	20:57	44.0717	-4.7613	1500
14	05/09/15	V12	10:09	43.5193	-3.7200	59
15	05/09/15	V12	14:06	43.7808	-3.7198	750
16	05/09/15	V12	15:53	43.9688	-3.7200	3000
17	11/09/15	H4	11:23	43.8605	-1.5050	51
18	11/09/15	H4	16:22	43.8610	-1.9353	132
19	11/09/15	H4	19:17	43.8600	-2.3500	2300
20	12/09/15	H8	8:23	44.3605	-1.4195	48
21	12/09/15	H8	13:43	44.3610	-1.9772	138
22	19/09/15	h12	8:02	44.8545	-2.1308	391
23	19/09/15	h12	11:14	44.8507	-1.8453	110
24	19/09/15	h12	15:44	44.8507	-1.3723	
25	19/09/15	H14	18:22	45.1000	-1.2915	30
26	19/09/15	H14	20:10	45.0998	-1.6178	71
27	20/09/15	d4	8:11	45.6577	-1.4158	27
28	20/09/15	d4	16:02	45.4558	-1.8850	73
29	20/09/15	d4	20:07	45.1998	-2.5130	130
30	21/09/15	d6	7:57	45.4500	-2.6860	130
31	21/09/15	d6	13:56	45.7078	-2.0405	76
32	21/09/15	d6	19:46	45.9120	-1.5297	30
33	23/09/15	D8	14:20	46.1697	-1.6913	30
34	23/09/15	D8	17:40	46.0463	-2.0002	51
35	23/09/15	D8	20:40	45.8430	-2.5017	105
36	24/09/15	D10	9:28	46.3913	-1.9153	29
37	24/09/15	D10	12:54	46.1562	-2.4995	83
38	24/09/15	D10	18:40	45.8922	-3.1498	130

Estación	Fecha	Radial	Hora Local	Lat	Long	Sonda
39	25/09/15	D12	7:37	46.1988	-3.1832	118
40	25/09/15	D12	15:11	46.4477	-2.5598	73
41	25/09/15	D12	17:35	46.5997	-2.1737	33
42	26/09/15	D16	7:30	47.1417	-2.4443	33
43	26/09/15	D16	12:38	46.9750	-2.8155	50
44	26/09/15	D16	15:10	46.7920	-3.2285	105
45	26/09/15	D16	20:28	46.4635	-3.9495	138
46	27/09/15	D18	7:45	46.8243	-3.8335	130
47	27/09/15	D18	15:35	47.1440	-3.1402	66
48	27/09/15	D18	18:15	47.3410	-2.6953	31

Table 5:
Species composition of the fishing performed by Ramon Margalef**.**

STATION	BOARDING WEIGHT (kg)	BOARDING WEIGHT/ SPECIES (kg)	*SPECIES*
9001	42.2382	36.1	Engraulis encrasicholus
		0.03	Myctophidae
		5.1	Euphasiacea
		0.1	Thalia democratica
		1.0	Others
9002	0.848	0.8	Myctophidae
9003	0.1394	0.01	Micromesistius poutassou
		0.06	Loligo vulgaris
		0.03	Thalia democratica
		0.03	Rhopilema spp
		0.02	Others
9004	0.3792	0.03	Engraulis encrasicholus
		0.001	Trachurus trachurus
		0.004	Loligo vulgaris
		0.0002	Capros aper
		0.001	Thalia democratica
		0.35	Rhopilema spp
9005	1.3	0.02	Trachurus trachurus
		0.44	Micromesistius poutassou
		0.004	Loligo vulgaris
		0.02	Merluccius merluccius
		0.42	Rhopilema spp
		0.40	Others
9006	461.3035	0.8	Engraulis encrasicholus
		0.02	Trachurus trachurus
		453.8	Micromesistius poutassou
		2.4	Merluccius merluccius
		1.3	Trisopterus luscus
		0.1	Myctophidae
		0.3	Euphasiacea
		2.6	Others
9007	1.5587	0.01	Engraulis encrasicholus
		0.0004	Capros aper
		1.6	Myctophidae
9008	150	148.7	Engraulis encrasicholus

STATION	BOARDING WEIGHT (kg)	BOARDING WEIGHT/ SPECIES (kg)	*SPECIES*
		0.01	Scomber scombrus
		1.2	Trachinus draco
		0.1	Others
9009	40.35	7.1	Engraulis encrasicholus
		32.5	Trachurus trachurus
		0.01	Loligo vulgaris
		0.7	Myctophidae
		0.03	Euphasiacea
		0.03	Others
9010	5.75	0.05	Engraulis encrasicholus
		5.7	Trachurus trachurus
9011	218.1368	216.2	Engraulis encrasicholus
		0.1	Trachurus trachurus
		0.6	Scomber scombrus
		0.5	Loligo vulgaris
		0.8	Rhopilema spp
9012	273.35	272.2	Engraulis encrasicholus
		1.2	Scomber scombrus
9013	63.6	63.6	Engraulis encrasicholus
9014	2.4369	0.4	Micromesistius poutassou
		0.01	Loligo vulgaris
		0.1	Myctophidae
		0.1	Euphasiacea
		1.8	Rhopilema spp
		0.1	Others
9015	263.8065	3.7	Engraulis encrasicholus
		0.8	Sardina pilchardus
		257.9	Trachurus trachurus
		0.1	Scomber scombrus
		0.9	Scomber Japonicus
		0.2	Micromesistius poutassou
		0.2	Merluccius merluccius
9016	200	41.3	Engraulis encrasicholus
		1.0	Sardina pilchardus
		0.5	Trachurus trachurus
		0.2	Scomber scombrus
		157.0	Others
9017	3.1542	0.1	Trachurus trachurus

STATION	BOARDING WEIGHT (kg)	BOARDING WEIGHT/ SPECIES (kg)	*SPECIES*
		0.04	Myctophidae
		3.0	Rhopilema spp
9018	66.5297	0.03	Engraulis encrasicholus
		30.8	Trachurus trachurus
		4.0	Scomber scombrus
		8.6	Micromesistius poutassou
		2.3	Merluccius merluccius
		0.4	Capros aper
		14.0	Myctophidae
		6.6	Rhopilema spp
9019	185.0335	175.7	Engraulis encrasicholus
		1.7	Trachurus trachurus
		0.1	Scomber Japonicus
		6.7	Merluccius merluccius
		0.0	Capros aper
		0.9	Rhopilema spp
		0.1	Others
9020	75	11.5	Engraulis encrasicholus
		0.4	Sardina pilchardus
		28.1	Trachurus trachurus
		3.3	Scomber scombrus
		13.4	Sprattus spratus
		0.7	sarda sarda
		9.2	Loligo vulgaris
		2.8	Merluccius merluccius
		0.6	Trisopterus luscus
		5.0	Others
9021	221.63435	185.7	Engraulis encrasicholus
		15.3	Trachurus trachurus
		0.003	Scomber scombrus
		0.1	Sprattus spratus
		0.2	Micromesistius poutassou
		0.2	Loligo vulgaris
		13.9	Merluccius merluccius
		0.2	Myctophidae
		6.0	Rhopilema spp
9022	1500	0.3	Trachurus trachurus
		51.4	Capros aper
		1448.3	Others
9023	253.4436	222.1	Engraulis encrasicholus

STATION	BOARDING WEIGHT (kg)	BOARDING WEIGHT/ SPECIES (kg)	*SPECIES*
		17.1	Trachurus trachurus
		6.1	Scomber scombrus
		0.2	Loligo vulgaris
		6.5	Merluccius merluccius
		0.1	Trisopterus luscus
		0.7	Zeus faber
		0.3	Thalia democratica
		0.3	Others
9024	103.816	99.5	Engraulis encrasicholus
		3.1	Trachurus trachurus
		0.7	Scomber scombrus
		0.1	Sprattus spratus
		0.1	Merluccius merluccius
		0.4	Rhopilema spp
9025	36.2888	16.8	Engraulis encrasicholus
		0.6	Sardina pilchardus
		2.8	Trachurus trachurus
		1.3	Scomber scombrus
		14.7	Thalia democratica
		0.2	Others
9026	1000	55.5	Engraulis encrasicholus
		0.7	Sardina pilchardus
		0.1	Thalia democratica
		943.6	Others
9027	600	503.5	Engraulis encrasicholus
		0.6	Trachurus trachurus
		0.3	Scomber scombrus
		1.4	Sprattus spratus
		0.3	Micromesistius poutassou
		74.4	Merluccius merluccius
		9.1	Dicentrarchus labrax
		7.7	Trisopterus luscus
		2.7	Rhopilema spp
9028	300	294.5	Engraulis encrasicholus
		2.4	Sardina pilchardus
		0.1	Trachurus trachurus
		0.8	Scomber scombrus
		0.4	Sprattus spratus
		2.3	Rhopilema spp

Table 6:
Species composition of the fishing performed by Emma Bardan**.**

STATION	BOARDING WEIGHT (kg)	BOARDING WEIGHT/ SPECIES (kg)	*SPECIES*
9201	0.005	0.01	Engraulis encrasicholus
9202	6.35	6.4	Engraulis encrasicholus
9203	0.75	0.75	Myctophidae
9205	1.15	0.1	Engraulis encrasicholus
		1.1	Trachurus trachurus
9206	18.4	18.4	Engraulis encrasicholus
9207	2.15	2.2	Engraulis encrasicholus
9208	1	1.0	Engraulis encrasicholus
9210	20.01	0.01	Trachurus trachurus
		20.0	Thalia democratica
9211	0.5	0.5	Myctophidae
9212	5	0.01	Engraulis encrasicholus
		5.0	Others
9213	2.1	1.6	Engraulis encrasicholus
		0.5	Thalia democratica
9214	1	1.0	Myctophidae
9215	2	2.0	Engraulis encrasicholus
9216	1	1.0	Myctophidae
9217	5.5	5.0	Engraulis encrasicholus
		0.5	Thalia democratica
9218	66.85	66.9	Engraulis encrasicholus
9219	23.5	2.5	Engraulis encrasicholus
		21.0	Myctophidae
9220	23.7	23.7	Engraulis encrasicholus
9221	2.5	1.75	Myctophidae
		0.8	Euphasiacea
9222	2.7	2.7	Engraulis encrasicholus
9223	120	115.0	Engraulis encrasicholus

STATION	BOARDING WEIGHT (kg)	BOARDING WEIGHT/ SPECIES (kg)	*SPECIES*
		5.0	Euphasiacea
9224	570	533.7	Engraulis encrasicholus
		35.1	Trachurus trachurus
		1.2	Merluccius merluccius
9225	45.7	45.7	Engraulis encrasicholus
9226	1200	1167.4	Engraulis encrasicholus
		16.3	Scomber scombrus
		16.3	Merluccius merluccius
9227	0.8	0.8	Trachurus trachurus
9228	31.4	31.4	Myctophidae
9230	300	282.9	Engraulis encrasicholus
		13.1	Trachurus trachurus
		4.0	Scomber scombrus
9231	153.95	33.7	Engraulis encrasicholus
		1.6	Sardina pilchardus
		47.7	Scomber scombrus
		0.5	Scomber Japonicus
		53.7	Sprattus spratus
		3.2	sarda sarda
		7.2	Merluccius merluccius
		1.8	Dicentrarchus labrax
		3.7	Trisopterus luscus
		0.9	Others
9233	500	491.0	Engraulis encrasicholus
		7.0	Trachurus trachurus
		2.0	Scomber scombrus
9234	176.01	119.8	Engraulis encrasicholus
		42.1	Trachurus trachurus
		2.8	Trachurus mediterraneus
		1.1	Scomber scombrus
		8.9	Merluccius merluccius
		1.1	Zeus faber
		0.1	Capros aper
		0.2	Myctophidae
9235	1500	1447.8	Engraulis encrasicholus
		0.1	Sardina pilchardus
		12.4	Scomber scombrus
		39.5	Sprattus spratus

STATION	BOARDING WEIGHT (kg)	BOARDING WEIGHT/ SPECIES (kg)	*SPECIES*
		0.2	Merluccius merluccius
9236	86.2	84.9	Engraulis encrasicholus
		1.1	Sardina pilchardus
		0.3	Trachurus trachurus
9237	200	181.3	Engraulis encrasicholus
		17.0	Trachurus trachurus
		1.7	Scomber scombrus
9238	350	210.1	Engraulis encrasicholus
		0.1	Sardina pilchardus
		137.7	Trachurus trachurus
		2.1	Scomber scombrus
9239	700	689.6	Engraulis encrasicholus
		6.9	Trachurus trachurus
		3.4	Scomber scombrus
		0.0	Myctophidae
9240	170	169.2	Engraulis encrasicholus
		0.8	Scomber scombrus
9241	170	158.1	Engraulis encrasicholus
		5.0	Trachurus trachurus
		5.0	Scomber scombrus
		1.4	Sprattus spratus
		0.5	Merluccius merluccius
9243	200	9.1	Engraulis encrasicholus
		183.1	Trachurus trachurus
		7.8	sarda sarda
9244	88.77	37.9	Engraulis encrasicholus
		6.3	Sardina pilchardus
		41.5	Trachurus trachurus
		2.9	Scomber scombrus
		0.2	sarda sarda
9245	150	14.2	Engraulis encrasicholus
		65.8	Sardina pilchardus
		66.5	Trachurus trachurus
		3.5	Scomber scombrus
9247	1500	1438.6	Engraulis encrasicholus

STATION	BOARDING WEIGHT (kg)	BOARDING WEIGHT/ SPECIES (kg)	*SPECIES*
		35.2	Trachurus trachurus
		25.6	Scomber scombrus
		0.6	Sprattus spratus
9248	100	11.8	Engraulis encrasicholus
		13.8	Trachurus trachurus
		0.9	Scomber scombrus
		73.5	Thalia democratica
9249	150	88.7	Engraulis encrasicholus
		58.8	Trachurus trachurus
		1.8	Scomber scombrus
		0.1	Sprattus spratus
		0.6	Merluccius merluccius
9250	350	244.6	Engraulis encrasicholus
		64.7	Sardina pilchardus
		14.1	Trachurus trachurus
		2.1	Scomber scombrus
		24.6	Sprattus spratus
9251	200	151.3	Engraulis encrasicholus
		13.5	Sardina pilchardus
		12.7	Trachurus trachurus
		22.5	Scomber scombrus

Table 7:

Synthesis of the abundance estimation (acoustic index of biomass) for Juvena 2015 by main strata

	E acust (m2/ n.m.2)	Area (n.m.2)	Talla media (cm)	Biomasa (t)
Juvenil pura	665	10380	6.7	408,658
Plataforma	198	9232	10.0	24,090
Garona	809	2232	9.3	29,593
Total		21845	6.8	462,341

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	

Table 9:
List of commercial vessels of the live bait fleet that reported detections of anchovy.

Barco	Puerto
Izaskun	Getaria
Santana Berria	Getaria
Itsas Lagunak	Hondarribia
Beti Piedad	Getaria
Attona Domingo	Hondarribia
Kukuarri	Hondarribia
Almirante Berria	Hondarribia
Gure Gogoa	Orio

Table 10
List of taxa observed during JUVENA 2015.

Group	Common name	Scientific name	Number of sightings	Group size	Total sum
Marine mammal	Common dolphin	Delphinus delphis	92	9.91 ± 24.17	912
Marine mammal	Fin whale	Balaenoptera physalus	45	1.33 ± 0.52	60
Marine mammal	Long-finned pilot whale	Globicephala melas	13	7.69 ± 5.82	100
Marine mammal	Striped dolphin	Stenella coeruleoalba	13	7.69 ± 8.46	100
Marine mammal	Bottlenose dolphin	Tursiops truncatus	7	7.86 ± 8.69	55
Marine mammal	Balaenopterid sp.	Balaenopteridae sp.	3	1 ± 0	3
Marine mammal	Sperm whale	Physeter macrocephalus	2	2 ± 1.41	4
Marine mammal	Cetacean sp.	Large Cetacean	2	1 ± 0	2
Marine mammal	Cuvier's beaked whale	Ziphius cavirostris	2	1 ± 0	2
Sea Bird	Gannet	Morus bassanus	379	2.39 ± 13.51	905
Sea Bird	Lesser black-backed gull	Larus fuscus	270	2.57 ± 5.42	694
Sea Bird	Yellow-legged gull	Larus michahellis	211	5.32 ± 24.7	1122
Sea Bird	Great shearwater	Puffinus gravis	146	3.17 ± 7.62	463
Sea Bird	Sabine's gull	Xema sabini	119	2.92 ± 6.33	347
Sea Bird	Skua	Stercorarius skua	77	1.18 ± 0.74	91
Sea Bird	Common Tern	Sterna hirundo	44	2.3 ± 2.75	101
Sea Bird	Sooty shearwater	Puffinus griseus	38	1.76 ± 2.33	67
Sea Bird	Balearic shearwater	Puffinus mauretanicus	36	1.94 ± 3.99	70
Sea Bird	Arctic skua	Stercorarius parasiticus	25	1.24 ± 0.52	31
Sea Bird	Manx shearwater	Puffinus puffinus	24	1.54 ± 0.93	37
Sea Bird	Gull sp	Larus sp	20	64.45 ± 174.55	1289
Sea Bird	Pomarine skua	Stercorarius pomarinus	17	1.12 ± 0.33	19
Sea Bird	European storm-petrel	Hydrobates pelagicus	15	3.6 ± 5.07	54
Sea Bird	Cory's shearwater	Calonectris diomedea	14	1.07 ± 0.27	15
Sea Bird	Larid sp	Laridae spp	7	5.29 ± 10.9	37
Sea Bird	Great black-backed gull	Larus marinus	5	14.2 ± 20.57	71
Sea Bird	Little gull	Hydrocoloeus minutus	4	1.75 ± 0.96	7

Sea Bird	Shearwater sp.	Puffinus spp	4	1 ± 0	4
Sea Bird	Razorbill	Alca torda	3	1.33 ± 0.58	4
Sea Bird	Northern fulmar	Fulmarus glacialis	3	1.33 ± 0.58	4
Sea Bird	Black Tern	Chlidonias niger	2	1 ± 0	2
Sea Bird	Artic tern	Sterna paradisaea	2	1 ± 0	2
Sea Bird	Sandwich Tern	Thalasseus sandvicensis	2	2 ± 0	4
Sea Bird	Tern sp.	Sterna spp	2	1 ± 0	2
Sea Bird	Black-headed gull	Chroicocephalus ridibundus	1		3
Sea Bird	Leach's storm-petrel	Oceanodroma leucorhoa	1		1
Sea Bird	Great cormorant	Phalacrocorax carbo	1		1
Sea Bird	Gull-billed tern	Gelochelidon nilotica	1		3
Sea Bird	Jaeger sp.	Stercorarius spp	1		1
Other Marine Wildlife	Fish sp	Ostéichiens	2	1 ± 0	2
Other Marine Wildlife	Sunfish	Mola mola	20	1.3 ± 0.73	26
Other Marine Wildlife	Tuna / Bonito	Thunnus spp. / Sarda spp.	34	3.88 ± 4.06	66
Human activity	Plastic trash	Plastic trash	148	1.01 ± 0.08	149
Human activity	Fishing boat (professional)	Fishing boat (professional)	53	1 ± 0	53
Human activity	Merchant ship (containership, cargo, tanker)	Merchant ship (containership, cargo, tanker)	43	1.02 ± 0.15	44
Human activity	Fishing buoy, setnet	Fishing buoy, setnet	39	1.18 ± 0.6	46
Human activity	Trawler	Trawler	32	1 ± 0	32
Human activity	Pleasure boat	Pleasure boat	26	2.5 ± 5.35	65
Human activity	Sailing boat	Sailing boat	26	1 ± 0	26
Human activity	Trash (plastic, wood, oil)	Trash (plastic, wood, oil)	16	1 ± 0	16
Human activity	Fishing trash (net part, buoy…)	Fishing trash (net part, buoy…)	14	1.07 ± 0.27	15
Human activity	Unnatural wood	Unnatural wood	10	1 ± 0	10
Human activity	Longliner	Longliner	7	1 ± 0	7
Human activity	Pair trawler	Pair trawler	6	1 ± 0	6

Human activity	Non identified ship	Non identified ship	3	1 ± 0	3
Human activity	Ferry	Ferry	3	1 ± 0	3
Human activity	Platform	Platform	2	1 ± 0	2
Human activity	Tanker (oil, gaz, chemical)	Tanker (oil, gaz, chemical)	2	1 ± 0	2
Human activity	Research vessel (science)	Research vessel (science)	1		1
Land Bird	Common Chiffchaff	Phylloscopus collybita	5	1 ± 0	5
Land Bird	Grey heron	Ardea cinerea	4	2.75 ± 2.06	11
Land Bird	White Wagtail	Motacilla alba	3	1.67 ± 0.58	5
Land Bird	Yellow Wagtail	Motacilla flava	3	1.33 ± 0.58	4
Land Bird	Passerine bird	Passeriformes	3	1 ± 0	3
Land Bird	Eurasian hobby	Falco subbuteo	2	1 ± 0	2
Land Bird	Pipit sp	Anthus spp	1		12
Land Bird	Sanderling	Calidris alba	1		2
Land Bird	Dunlin	Calidris alpina	1		3
Land Bird	Rock Pigeon	Columba livia	1		1
Land Bird	Barn swallow	Hirundo rustica	1		1
Other	Tidal front	Tidal front	37	1 ± 0	31

Annex 8.9. WGACEGG presentations during the meeting

1) 2014 Sardine DEPM survey Iberian Peninsula (9a and 8c) (PT-DEPM14-PIL/SAREVA-0414) - update

Paz Díaz, A. Lago de Lanzós, MM Angélico, C. Franco, J. R. Pérez, C. Nunes, E. Henriques, P. Cubero and L. Iglesias

IPMA, IEO

(Section 5.2.2.2, Annex 8.9)

2) Anchovy DEPM and sardine egg abundances in Bay of Biscay 2015 : BIOMAN SURVEY

M. Santos, L. Ibaibarriaga, A. Uriarte

AZTI

(Section 5.2.2.3, Annex 8.9)

3) PELTIC15 - Pelagic ecosystem survey in western Channel and eastern Celtic Sea

Jeroen van der Kooij

Cefas

(Section 5.2.6, Annex 8.9)

4) PELGAS15 acoustic survey - Abundance indices by acoustics in the Bay of Biscay

E. Duhamel, M. Doray, M. Huret, F. Sanchez, P. Bergot, M. Authier

Ifremer

(Section 5.2.1, Annex 8.9)

5) PELACUS

(Section 5.2.1, Annex 8.9)

The Spanish acoustic-trawl times PELACUS 0315 was carried out on board RV Miguel Oliver from 14 March to 14 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 nautical mile apart and equally spaced. Acoustic, fishing stations, fish egg counting, microplastic, and apical predators observations were done during daytime while the oceanographic characterization was done during night-time. A total of 3979 nautical miles were steamed, 1190 corresponding to the survey track. Besides, 66 fishing stations were performed.

PELACUS 0315 was characterized by a relative high strength of NE winds which led to change the survey sampling schedule. The area is typically covered continuously from the Spanish/Portuguese border to the French/Spanish one, but due to the wind the NW corner was steamed from the north-eastern part to the southwestern one and also in the Cantabrian Sea, the inner part (i.e. Euskadi) was covered westward. Besides, this weather condition, together with the change in the strategy, would have been affected the mackerel fish distribution and abundance estimates: this was the first time in the time-series that adult mackerel occurred in high quantities in 9aN while 8c-West was almost empty. Nevertheless, as compared with the biomass assessed in 2014 when the weather conditions were better and the therefore the stability would have increased the mackerel availability either for a change in the behaviour (i.e. spatial pattern distribution) or for an increase in the food availability, the estimated biomass in 2015 was lower. On the other hand, the increase in horse mackerel observed in 2014 was corroborated this year. In the case of anchovy, although during 2014 an important amount of new juveniles (young of the year) were detected during the JUVENA survey undertook in September in the Cantabrian waters, the anchovy distribution found at PELACUS was scarce in this area.

During PELACUS 0315 blue whiting has been observed performing nictimeral migration towards the surface. This is the first time this movement has been recorded and described.

6) Portuguese acoustic survey PELAGO15

Vitor Marques, Maria Manuel Angélico, Cristina Nunes, Eduardo Soares, Sílvia Rodríguez-Climent, Andreia Silva, Paulo Oliveira, Raquel Marques, Luís Sobrinho-Gonçalves, Elisabete Henriques, Alexandra Silva

IPMA

(Section 5.2.1, Annex 8.9)

7) JUVENA 2015 SURVEY REPORT

G. Boyra, U. Martinez and M. Louzao

AZTI, IEO

(Section 5.2.5, Annex 8.9)

8) IPMA Acoustic surveys onboard purse-seiners 2014-2015:

Acoustic survey SARECOOP1014 - Onboard purse-seiner "AVÔ VARELA" (October 2014)

Acoustic survey SARECOOP0215 - Onboard purse-seiners "Jonas David", "Flor da Beira"and "Mário Luis" (February 2015)

Acoustic survey SARECOOP0715 - Onboard purse-seiners (July 2015) "JESUS NAS OLIVEIRAS", "AVÔ VARELA" and "ANÉLLIO"

Vítor Marques *et al.*

IPMA

The SARECOOP Project "Sardine recruitment evaluation for the sustainable purse-seiner fisheries – cooperation between the stakeholders" was set up by IPMA with the

Portuguese purse-seiners associations as partners in order to get the sardine fishing sector involved in the process of data acquisition to complement the information collected during the scientific acoustic surveys. Four surveys using purse-seiners and an echosounder (Simrad EK60 echosounder with 38KHz and 120KHz frequencies) with pole mounted transducers on the vessel´s side were organized in the coastal waters of north-western Portugal (two occasions), Algarve and western Bay of Biscay. The main objectives of these coastal surveys were to assess sardine recruitment and to analyse the distribution of the juveniles in relation to environmental descriptors (sea temperature and salinity). The sounder performed well with good weather and good results were obtained. The major challenges while working on the purse-seiners were the lack of continuity in surveying due to the need to come to port every night and the limited conditions for many days of work.

9) Preliminary assessment of Bay of Biscay anchovy - WGHANSA 2015

AZTI

The results of the preliminary assessment for the Bay of Biscay anchovy conducted by WGHANSA in June were presented. This assessment is not used by ICES to provide advice but it allows analysing the results of the spring surveys (BIOMAN and PELGAS) and the fishery in the previous year. The final assessment and subsequent advice will be based on the stock assessment conducted by correspondence at the end of November including the latest results from BIOMAN and JUVENA surveys and the fishery during the second half of the year.

10) Sardine assessment -WGHANSA, June 2015

IEO, IPMA

Results of the 2015 sardine assessment from WGHANSA were presented during WGACEGG meeting.

Since 2012, sardine is assessed with Stock Synthesis (SS3), by means of data from commercial landings (1978–2014) and from surveys (acoustic and DEPM).

Results of the last assessment showed the bad situation of the Iberian sardine population. The stock biomass shows a downward trend since 2006 due to the lack of strong recruitments and high fishing mortality. The stock is at the lowest historical level, therefore, the development of the stock and the fishery is currently mainly dependent on the strength of the incoming recruitment. In addition to the low biomass the stock spawning area appears to be shrinking when compared to 2011 (ICES, 2015a). The stock and the catches are largely dominated by young individuals with low reproductive potential. The survival of incoming year classes until older ages may be important to improve the stock reproductive potential.

In addition, some unresolved issues related to the acoustic and egg surveys, relevant to the next sardine benchmark (proposed for 2017), and pending the advice of the WGACEGG, were raised. One of these issues is the catchability at age of the surveys. Recent decrease was signalled in acoustic surveys 1–2 years before than in DEPM surveys. The consequence for assessment is an overestimation of stock biomass was and underestimation of fishing mortality, for some years. The consequence for advice was a higher level of recommended catches in 2010-2011, leading F to unsustainable levels.

11) Iberian Peninsula P0 Estimations for Sardine from HOM/MAC Egg surveys - Benchmark Assessment proposed for 2017

Paz Díaz, MM Angélico, A. Lago de Lanzós and E. Henriques

IEO, IPMA

(Section Annex 8.5.1)

12) Implementing an external egg mortality model to estimate egg production for anchovy in the Gulf of Cadiz

Paz Díaz, Paz Jiménez, and MM Angélico

IEO, IPMA

(Section Annex 8.5.2)

13) Comparing Egg and Acoustic estimates

Pierre Petitgas *et al.*

Ifremer

Section Annex 8.6

14) Comparison between egg and acoustic survey indices - Compilation of previous work addressing this issue for sardine (2009-2015)

IPMA, IEO

Section Annex 8.6

15) First approach – small pelagics data from CGFS French bottom-trawl survey in the Channel

E. Duhamel, M. Doray, M. Travers

Ifremer

A bottom-trawl survey, called CGFS, occurred onboard Thalassa in the English Channel for the first time, in September 2015. This short presentation presents a first approach on location, catches and sizes of small pelagic fish (sardine and anchovy) during this survey. It constitutes the first pictures of small pelagics in the Channel (particularly Eastern) at this period. Despite the problem of catchability (pelagics vs. bottom trawl), in near future, some more biological data will be needed (age, maturity) to improve the knowledge of these species in that area.

16) Spatial dynamics of juvenile anchovy in the Bay of Biscay

Guillermo Boyra, Marian Peña, Unai Cotano, Xabier Irigoien, Anna Rubio and Enrique Nogueira

AZTI, IEO

In autumn 2009, the implementation of two successive acoustic surveys targeting juvenile anchovy (*Engraulis encrasicolus*) in the Bay of Biscay allowed monitoring the changes in the spatial distribution and aggregation patterns of juveniles of this species during 45 days under fairly stable meteorological conditions. Juvenile anchovy changed its biological condition and behavior in a different manner in two distinct areas. In the Spanish sector, the juveniles migrated 20 nautical mile. Toward the coast, but they remained off-the-shelf and near the surface during the whole surveyed period. As the coastward advance compressed them against the shelf break, their area of distribution decreased, their density increased and the juveniles spread in fewer but heavier shoals. In the French sector, the juveniles migrated also from slope waters toward the coast at similar velocity, but they crossed the shelf break into the continental shelf, where they increased significantly their mean depth until gradually adopting the typical nyctemeral migrations of adult anchovy. The mean length of the juveniles that adopted the nyctemeral migrations was significantly higher than that of the juveniles remaining at the surface, suggesting that body size is relevant to accomplish this change. The stronger temperature gradients between shelf and oceanic waters in the Spanish sector, favored by a narrow shelf, may have acted as a barrier influencing the distinct observed spatial patterns in the two areas.

17) Acoustics and DEPM biomass estimations: comparisons, issues and plans for future work

María Santos, Andrés Uriarte, Guillermo Boyra

18) On Target Strength - Depth effect on TS and Biomass

Mathieu Doray

Ifremer