RELATÓRIOS DE CAMPANHA

INTERNATIONAL SURVEY FOR THE ASSESSMENT OF THE STRENGTH OF THE SARDINE AND ANCHOVY RECRUITMENT IN ATLANTIC IBERIAN WATERS

"IBERAS1118"

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INTERNATIONAL SURVEY FOR THE ASSESSMENT OF THE STRENGTH OF THE SARDINE AND ANCHOVY RECRUITMENT IN ATLANTIC IBERIAN WATERS

IBERAS1118
SURVEY REPORT

INSTITUTO ESPAÑOL DE OCEANOGRAFÍA
INSTITUTO PORTUGUÊS DO MAR E DA ATMOSFERA

INDEX

TECHNICAL SUMMARY

Institution:	INSTITUTO PORTUGUÊS DO MAR E DA ATMOSFERA/INSTITUTO ESPAÑOL DE OCEANOGRAFÍA
Survey name:	IBERAS1118
Vessel name:	Ramón Margalef (46.70 m length, 10.50 width 988 GRT, 900 kW diesel-electric)
Dates:	1/11-/2018-18/04/2018
Area:	WESTERN IBERIAN COAST (9aCS-9aCN-9aN)
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 random start, tracks 4/8 nmi apart from 30 to 100 isobath
Main sampling procedures	EK-80 at 18-38-70-120-200 kHZ acoustic frequencies. 1118 nmi prospected. Only day time (except in north 9aCN and south 9aN)
	CUFES, Intake at 5 m depth, 600 l min^{-1}. 3 nmi/sample, 239 samples (sardine, anchovy eggs)
	Pelagic fishing stations: 25
	Marine mammals and birds observations (not yet determined)
	Manta trawl hauls (microplastics).4 tows
	Hydrological characterisation. 10 stations

Personnel 1st leg Cadiz/Leixões Dates: 01 to 07/11	AMORIM, PEDRO	IGLESIAS GARCÍA, LUISA
	SILVA, ANDREIA	LÓPEZ DE IPIÑA, HIART
	ANGELICO, MARIA MANUEL	MATOS, RITA
	BARRA, JORGE	MILHAZES, RAQUEL
	CARRERA LÓPEZ, PABLO	PASTOR, JOÃO
	DÍAZ CONDE, PAZ	SÁNCHEZ BARBA, M JOSÉ
2nd leg Leixões/Vigo Dates: 11-19/11	BARRA, JORGE	MORENO, ANA
	CARRERA LÓPEZ, PABLO	MILHAZES, RAQUEL
	FEIJÓ, DIANA	OTERO PINZÁS, ROSENDO
	LÓPEZ DE IPIÑA, HIART	PASTOR, JOÃO
	LÓPEZ DÍAZ, EDUARDO	POMBAL, EMANUEL
	MATOS, RITA	

Report authors	Pablo Carrera, Pedro Amorim, Vítor Marques, Ana Moreno

INTRODUCTION

According to ICES, the sardine biomass of age 1 and older fish has decreased since 2006; it has been below B_{lim} since 2009; and it has stabilized to a historical low since 2012. Recruitment has been below the long-term average since 2005 and in 2017 it was estimated as the lowest in the time-series. Fishing mortality has been above F_{lim} for most of the time-series but has been decreasing from a peak in 2011. In 2017, it is the lowest in the time-series and around F_{pa}. Although sardine is not considered a short-lived species, the lack of enough adults, resulted in a very low presence of older ages (e.g. very low expectation for reaching ages older than 5 due to the high natural mortality), being the bulk of the population composed by younger fish, which in turn, make this species looks like a short-lived species.

In such conditions, any recovery of the biomass will likely be triggered by the strength of the recruitment. Thus when juveniles can be assessed at age 0, the estimates can be used to predict the relative strength of the future recruitment to the fisheries. This strategy is of special interest to manage the fisheries for short-lived species because of the short time between spawning and the exploitation of subsequent emerging recruits.

On the other hand, in coincidence with the decrease of sardine, off north Portugal and South Galicia, anchovy population has sharply increased. Monitoring this outburst is, therefore of interest as this species would partially compensate the recent lack of sardine.

Attending the experience achieved by IPMA through JUVESAR time series, an acoustic survey targeted on sardine recruitment, and by Azti and IEO in the JUVENA survey to improve the assessment and management of the Bay of Biscay anchovy together with ECOCADIZ recruit survey conducted by IEO in the Gulf of Cadiz, IBERAS will try to get a recruitment index for both species in Atlantic waters of the Iberian peninsula, aiming at to improve the estimation of the strength of the recruitment of both Iberoatlantic sardine and the western component of the south anchovy population.

OBJECTIVES

i. Acoustic estimates by echointegration of the strength of the anchovy and sardine recruitment off Portugal and south Galicia
ii. Oceanographic (physical -CTD- and biological _bongo nets) characterization of the surveyed area
iii. Charting the subsurface microplastic distribution along the surveyed area
iv. Charting the subsurface sardine egg distribution along the surveyed area
v. Charting the relative abundance of apical predator along the surveyed area

MATERIAL AND METHODS

Survey was carried out on board R/V Ramón Margalef from 31st October until 19th November, departing from the port of Cadiz on 31st noon and arriving to Vigo harbour on the evening of 19th.

A scale is scheduled in Leixões (Matosinhos) on 12th November, but finally, due to adverse weather conditions, the survey remained at harbour from 7th to 11th November.

Working Area

From São Vicente cape until Fisterra cape, from shoreline (20 m) to 100 m isobath over an adaptive grid with tracks distance between 4-8 nmi on account the potential recruitment distribution area of both sardine and anchovy. Tracks were enlarged or shorted accordingly. Figure 1 is showing the foreseen survey track:

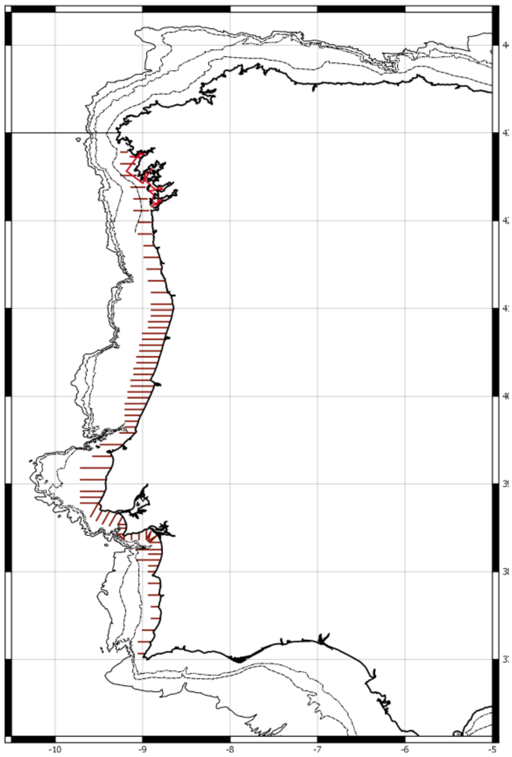


Figure 1: Survey track

Zone	No tracks	Number of nautical miles		Steaming time (hours-days)
		track	Unión	
Ocidental sul (9a-cs)	22	125.9	98.6	22.5-3.7
Lisboa (9a-cn)	14	120	165	20.1-3.3
Ocidental norte (9a-n)	32	292.4	165	45.7-7.6
Rías Baixas (9a-n)	29	147.2	53.2	20-3.33
Total	97	685.3	397.4	108.3-18

Table1. Expected survey coverage and time in each ICES Sub-Division

The backscattering acoustic energy from marine organisms was measured continuously during daylight except in the northern area where some tracks were steamed at night. Pelagic trawls were carried out whenever possible to help identify the species (and size classes) that reflect the acoustic energy.

A continuous underway fish egg sampler with an internal water intake located at 5 m depth and mounted with a mesh size of 335 µm was used to sample the composition of the ichthyoplankton.

During daylight hours, concurrently to acoustics, a trained observer recorded marine mammal, seabird, floating litter and vessel presence and abundance.

At night, when acoustics surveying is not running, CTDF profiles for hydrography and zooplankton samples (Bongo 60 and Manta trawl nets) are collected, opportunistically, in some of the transects.

Acoustic

Acoustic equipment consisted on a Simrad EK-80 scientific echosounder, operating at 18, 38, 70, 120 and 200 kHz, working in CW mode. All frequencies were calibrated according to the standard procedures (ICES-CRR) during the previous acoustic-trawl survey ECOCADIZ-Reclutas. 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, although, some tracks were also steamed at night. Data were them stored in raw format and post-processed using SonarData Echoview software (Myriax Ltd.) (Higginbottom et al, 2000). All echograms were first scrutinized, the bottom line incorporated, and also background noise was removed according to De Robertis and Higginbottom (2007). Fish abundance was calculated with the 38 kHz frequency as recommended at the PGAAM (ICES 2002), although echograms from 18, 70, 120 and 200 kHz frequencies were used to visually discriminate between fish and other scatter-producing objects such as plankton or bubbles, and to distinguish different fish species according to the frequency response. The 18, 70, 120 and 200 kHz frequencies were used to create a mask allowing a better discrimination between swim bladder fish species and other organisms. The threshold used to scrutinize the echograms was –70 dB. The integration values were expressed as nautical area scattering coefficient (NASC) units or s_A values (m^2 nm^{-2}) (MacLennan et al., 2002).

1 NASC allocation

A pelagic gear gloria HOD 352 was used to identify the species and size classes responsible for the acoustic energy detected and to provide samples. Haul duration was variable and ultimately depended on the number of fish that enters the net and the conditions where fishing takes place although a minimum duration of 20 minutes was 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 (table 2):

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

Table 2.Ground-truth criteria for fishing stations

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 was 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 or 0.5 cm length classes) has been used, as follows:

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

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

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

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

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

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

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

Sp	b_{20}	Ref	Observations	Otherb_{20}	Ref.
PIL	-72.6	Degnbol et al., 1985	TS for clupeids	-71.2 -70.4 -74.0 -72.5	ICES ,1982 Patti et al., 2000 Hannachi et al., 2005 Georgakarakos et al., 2011
ANE	-72.6	Degnbol et al., 1985	TS for clupeids	-71.2 -76.1 -71.6 -74.8	ICES 1982 Barange et al., 1996 Zhao et al., 2008 Georgakarakos et al., 2011
HKE	-67.5	Foote et al., 1986; Foote, 1987		-68.5 -68.1	Lillo et al., 1996 Henderson, 2005; Henderson and Horne, 2007
BOG	-67.5	Foote et al., 1986	Adapted from gadoids		
BOC	-66.2	Fässler et al., 2013			
MAC	-84.9	Edwards et al., 1984; ICES, 2002		-86.4 -88.0	Misund and Betelstad, 1996 Clay y Castonguay, 1996
HOM	-68.7	Lillo et al., 1996		-68.15 -66.8 -66.5/-67.0(*)	Gutiérrez and McLennan, 1998 Barange et al. (1996) Georgakarakos et al., 2011
VMA	-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; HKE- hake; HOM- horse mackerel; PIL-sardine; JAA-blue jack mackerel (Trachurus picturatus); BOG-bogue (Boops boops); VMAS-chub mackerel (Scomber colias); BOC-board fish (Capros aper); and HMM-Mediterranean horse mackerel (Trachurus mediterraneus))

When possible, direct allocation was done, accounting for the shape of the schools and also the relative frequency response (Korneliussen and Ona, 2003, De Robertis et al, 2010).

Fish schools were extracted using the following settings:

Sv threshold	-60/-70 dB for all frequencies
Minimum total school length	2/20 m
Min. total school height	1/5 m
Min. candidate length	1 m
Min. candidate height	0.5 m
Maximum vertical linking distance	2/5 m
Max. horizontal linking distance	10/25 m
Distance mode	Vessel log
Main frequency for extraction	38/120 kHz

Table 4: Main morphological and backscattering energy characteristics used for schools detection

For all school candidates, several of variables were extracted, among them the NASC (s_A, m^2/nmi^2) together with the proportioned region to cell (ESDU, 1 nmi) NASC and the s_V mean and s_V max and geographic position and time. PRC_NASC values were summed for each ESDU and distances were referenced to a single starting point for each transect. Results for 38 and 120 kHz were compared. Besides, the frequency response for each valid school (i.e. those with length and s_V which allows them be properly measured) was calculated as the ratio $s_{A(fi)}/s_{A(38)}$, being f_i the $s_A$values for 18, 70, 120 and 200 kHz.

2 Echointegration estimates

Once backscattering energy is allocated to fish species, the spatial distribution for each species is 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 be 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 are based on a minimum of 30 individuals will be considered. Differences in probability density functions (PDF) will be tested using Kolmogorov-Smirnov test. PDF distributions without significant differences will be joined, providing a homogeneous PDF strata. Spatial distribution will be then analysed within each stratum and finally mean s_A value and surface (square nautical miles) will be calculated using a GIS based system (Q-gis). These values, together with the length distributions, will be used to calculate the fish abundance in number as described in Nakken and Dommasnes (1975) (see previous section for further details). Estimates for each species will be done on each strata (polygon) using the arithmetic mean of the backscattering energy (NASC, s_A) attributed to each fish species and the surface expressed in square nautical miles using the following formula:

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

$$N_l = \rho_l * A_p$$

where $\rho_l$is the areal density of fish (numbers per square nautical mile in length group l); the total number for length group l (N_l) within each strata is calculated as the product of ρ_l times the total surface of the strata (A_p) expressed in square nautical miles.

Numbers were converted into biomass using the length weight relationships derived from the fish measured on board. For purposes of comparison, results are given by ICES Sub-Divisions (9aS, CS, CN and N).

3 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, instead longitude and latitude, we have used depth and a new variable called "distance from the origin", where the distance (nautical miles) is calculated as (Lat-37.0)*60, being *Lat* the latitude of the middle point of any particular EDSU.

Fishing stations

Fishing stations were used for both NASC allocation and length analysis. Therefore, they will be located on account the results obtained during the acoustic prospection (i.e. opportunistic accounting the echotraces).

A gloria HOD 352 with a vertical opening of about 14 m and around 30 m horizontal one was used. As general rig, 200/400 kg of clump weight were put at each side of the set back (2 m lower wing). Dyneema bridles (wings) have 70 m, but shorten to 50 m in shallower waters. Besides a set of Apollo polyice doors with 3.5 m^2 and 750 kg weight will be used. Besides, gear performance will be controlled using a wired Simrad Sonar FS20 net sounder.

Fishing station were mainly performed during daytime but, exceptionally, some tows were conducted at sunset.

CUFES:

CUFES system uses an internal pumping system with the intake located at 5 m depth. Samples were collected every three nmi while acoustically prospecting the transects. Once the sample is taken it is fixed in a buffered 4% formaldehyde solution. Samples will be analysed after the survey.

Plankton and hydrological characterisation

Continuous records of SSS, SST and flourometry are taken using a SeaBird Thermosalinograph coupled with a Turner Flourometer. Plankton. CTD cast down were performed once the acoustic and fishing operations are finished (i.e. from sunset). Four stations are placed over the transects, which are those of the acoustic prospection but that are extended in order to ensure a minimum distance of 6 nmi between stations. The stations are evenly distributed over the surveyed area at a distance of 16-24 nmi. See appendix II.

Zooplankton will be sampled using Bongo net, fitted with 200 and 500 µm nets. The samples will be stored for further analysis at lab.

Top predator observations

A single observer was placed at the bridge of the vessel at a height of 16 m above sea level work. Observations are carried out with the naked eye although binoculars are used (7x50) to confirm species identification and determine predator behaviour. Observations were carried out during daylight while the vessel prospects the acoustic transects. Observer recorded 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.).

Subsurface Marine Microplastic Litter characterisation

A “manta net neuston sampler” will be used. This trawl device has a collector of 350µm. Tows were performed for 15 min at 4 knots speed. Due to the adverse weather conditions, only few hauls were made.

Fish 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); and, sampling for estimation of fecundity adult parameters (sardine). Besides, specific sampling will be done on sardine for pollution and genetic purposes.

1 Catch and length distribution per specie

Once sorted the catch, for all species, a length distribution was estimated. If the number of specimen caught was above 100, a random sample was selected. This sample was weighted and the specimen were measured to length class. This was 0.5 for sardine and anchovy and 1 cm for the rest of the species. Catch length distribution was estimated by raising the sample length distribution according to the weighting factor TCW/TSW (total catch weight vs total sampling weight).

2 Weight Length relationship

To all assessed species, a weight length relationship was calculated, either from the results of the biological sampling (see below) or from a specific sampling procedure. In the latter case, a stratified random sampling scheme was, with the length class (i.e. 0.5 or 1 cm) as stratum.

3 Biological sampling

For main target species caught in each trawl haul (e.g. anchovy and sardine), a biological sampling was conducted. Data collected were: Length (mm); Weight (g); Sex; Maturity stage; otolith release; fat content; Stomach colour and repletion state. For sardine, the tale will be also collected for further genetic analysis.

RESULTS

Due to a successive storm fronts, the survey was stopped from 7th to 11th November. This made difficult to achieve all the expected goals. Namely, acoustic tracks north Porto (tracks number 63 to 68) and other two north Aveiro (tracks no 56 and 57) were steamed from sunset and tracks 72 and 73 were not surveyed.

ACOUSTIC

School extraction and total backscattering energy

A total of 7652 echotraces were extracted, accounting for a total NASC (s_A) of 476837.09 m^2 nmi^{-2}. Figure 1 shows the sum of NASC per track along the surveyed area.

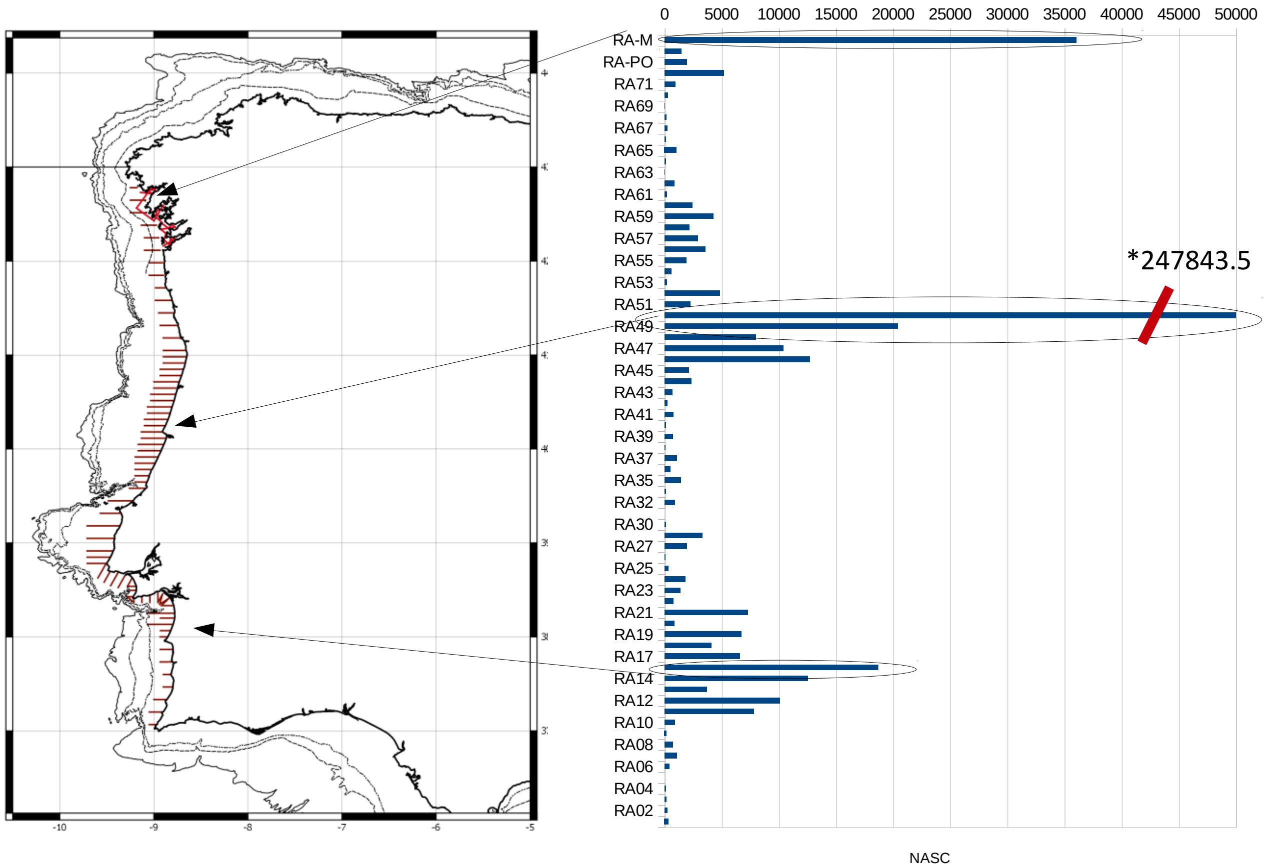


Figure 1. Cumulated NASC values per track

Fish were mainly located in three areas. Between Setúbal canyon and cape Roca; between the mouths of the Mondego and Douro rivers; and within the Rias Baixas. Yet, up to 52% of the total echointegrated energy was found in a single track, round Tocha Beach. The characteristics of these high concentrations will be further analysed.

Most of the schools occurred at 30 m depth, although the maximum cumulated NASC values was found at 22.5 m as shown in figure 2.

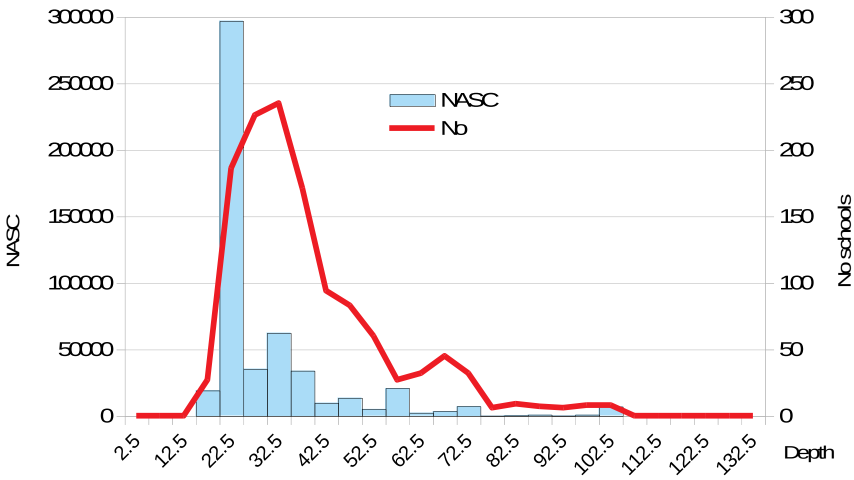


Figure 2. Number of schools and their cumulated NASC values per depth strata (5 m)

It seems the main school distribution area was covered as long as only few schools were found in very shallower waters.

Fishing station and echotrace allocation

To perform fishing stations near shore was a challenging task as long as most of the area was occupied by static fishing gears, thus dramatically restricting the available areas to carry out these and increasing the searching time for doing it. In spite this, a total of 26 fishing station were done, accounting a total of 17.4 mt and more than 5.0E+5 specimen as shown in table 5.

	TOTAL CAP (Kg)	No ind.	No Fishing st	Sample weight (kg	Measured fish	Mean length	%PRES	% Catch_W	% Catch_No
WHB	2	41	1	2	41	19.40	3.85	0.01	0.01
MAC	996	14076	11	17	213	22.48	42.31	5.71	2.64
HKE	2	34	4	2	34	19.00	15.38	0.01	0.01
HOM	3681	70778	22	72	1096	19.65	84.62	21.11	13.28
PIL	1507	32352	18	40	847	17.68	69.23	8.64	6.07
JAA	7	36	1	4	20	0.00	3.85	0.04	0.01
BOG	244	3611	12	28	274	22.43	46.15	1.40	0.68
VMA	4748	73655	18	45	555	22.03	69.23	27.24	13.82
BOC	421	11696	3	10	259	12.44	11.54	2.41	2.20
SEAB	41	128	7	34	109	29.09	26.92	0.24	0.02
ANE	5785	326294	10	7	423	13.71	38.46	33.18	61.24
SNS	2	108	1	1	40	14	3.85	0.01	0.02
Total	**17434**	**532809**	**26**	**260**	**3911**				

Table 5. Summary of the fishing stations (WHB, blue whiting; MAC, mackerel; HKE, hake,; HOM, horse mackerel; PIL, sardine; JAA, bluejack mackerel; BOG, bogue; VMA, chub mackerel; SEAB, seabreams; ANE, anchovy; SNS, longspine snipe fish)

Horse mackerel was found in 85% of the trawl haul, being also noticeable the presence of sardine and chub mackerel. Anchovy, although was only found in 39% of the stations, accounted for 33% of the total catch in weight (61% in number). That is, had a lower distribution area but was clearly dominant in this. Younger mackerel was also important in the northern part.

Fishing station 26 was not taking into account for allocation purposes. On the other hand, 4 fishing stations were almost monospecific, allowing to identify echotraces.

1 Chub mackerel echotrace identification

Chub mackerel mostly occurred in the southern part. In general, the schools were bigger, isolated, located on the bottom, and very dense. Nevertheless in shallower water, it also occurred in smaller schools. Typical chub mackerel echotrace and its frequency response is shown in figure 3.

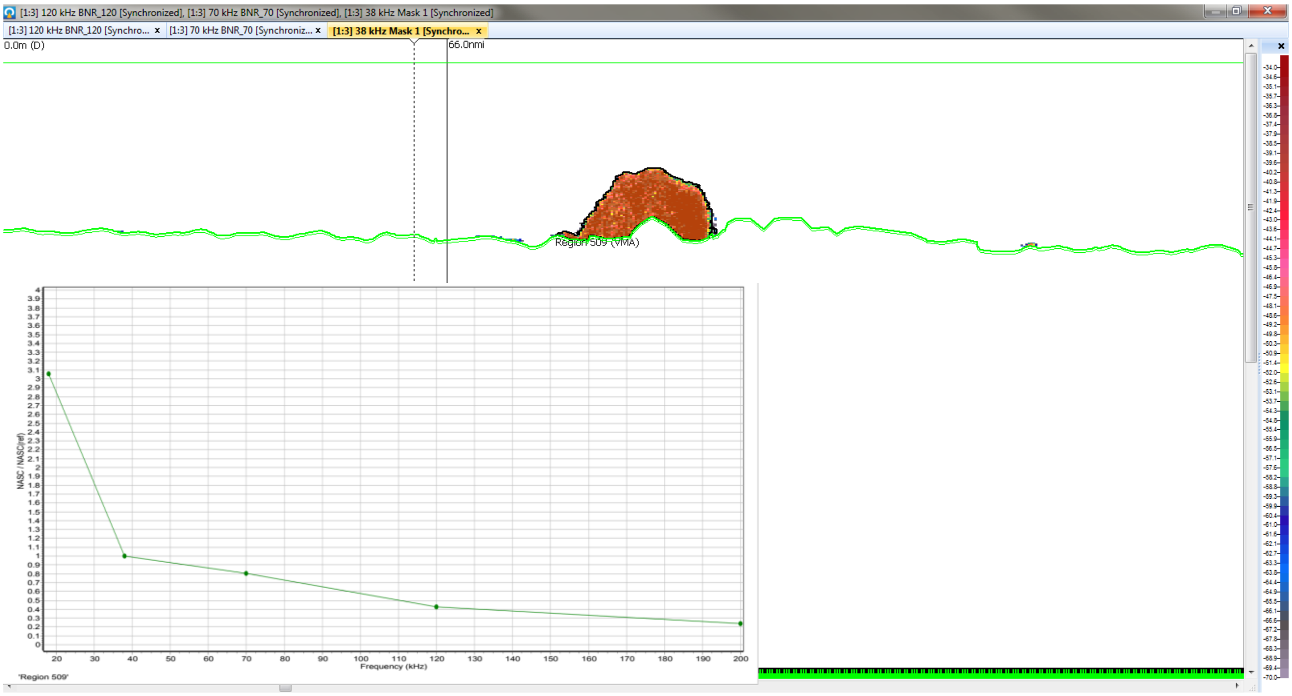


Figure 3. Cleaned echogram showing an isolated echotrace attributed to chub mackerel and its characteristic frequency response

11 schools were identified, accounting for a total of 11719 m^2 nmi^{-2}. It should be noted that the frequency response together with the schools size and energy descriptors matched with those found during the PELACUS survey.

2 Boar fish echotrace identification

Boar fish was mainly located around the Setúbal canyon. The echotraces, as already seen in the spring surveys in the Spanish area, occurred either close to the bottom, and rising towards middle waters, in isolated schools. On the bottom, it may occur with horse mackerel and sardine.

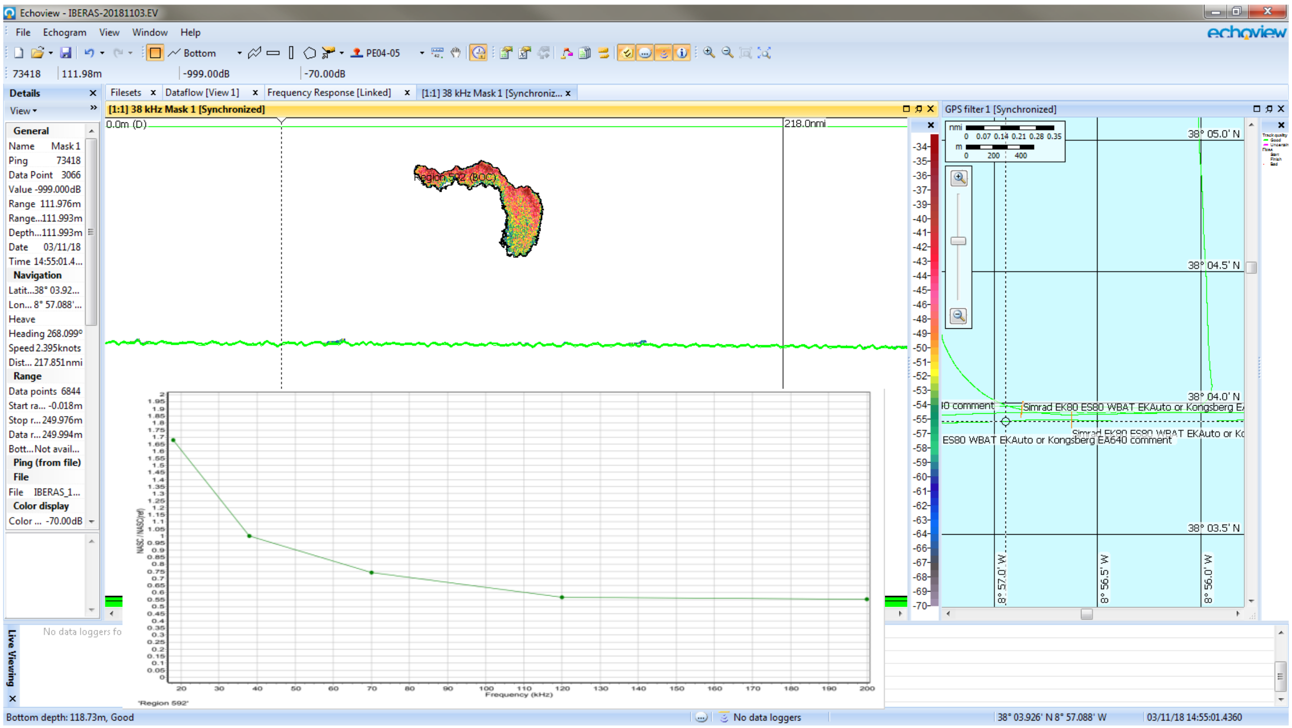


Figure 4. Cleaned echogram showing an isolated echotrace attributed to boarfish l and its characteristic frequency response

In this case, 10 schools were identified, accounting for a total of 13704 m^2 nmi^{-2}.

3 Anchovy echotrace identification

Typically, anchovy occurs in small, continuous echotraces, near bottom, with other fish species. This make difficult to isolate them, and, therefore, rather than direct allocation, fishing stations are used to assign NASC values. In this survey, a big echotrace was detected near Tocha beach. This was a mega-school, recorded in two consecutive tracks, one steamed at sunset and the other in the morning. It has more than 4 nmi long and almost 1 nmi width with a height of about 17 m (i.e. from bottom to sea surface and very thick, as shown in figure 5. The trawl haul performed on this was almost anchovy monospecific with few sardine probably caught in small schools detected before the mega-school (figure 5).

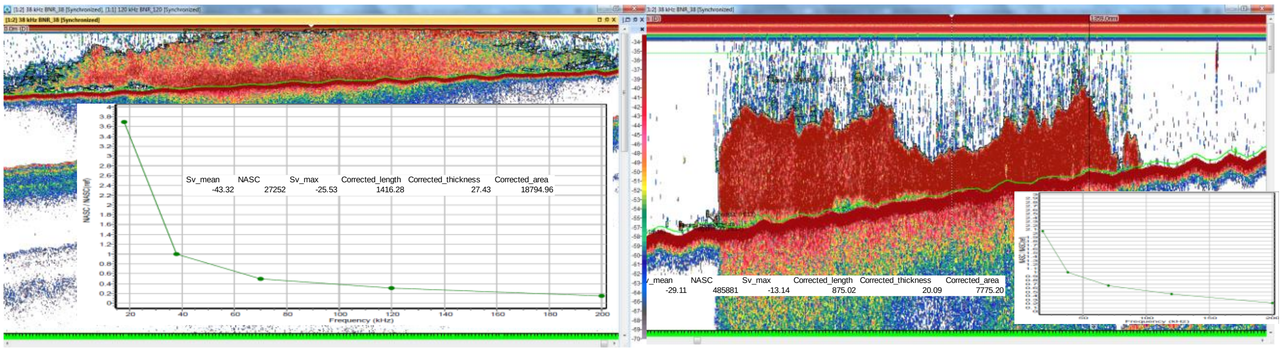
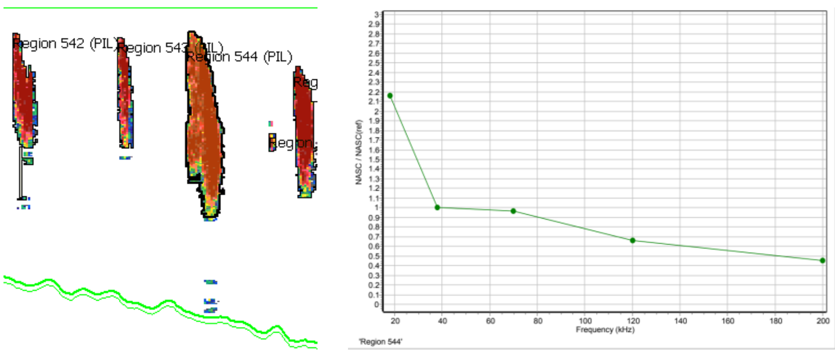


Figure 5. Echogram showing the mega-school at sunset (left) and in the morning (right)

In this case, given that sardine would be also within this school, no direct allocation was done and the energy was split into both species accounting the proportion found at the fishing station

4 Sardine fish echotrace identification

Few echotraces looking like sardine schools in terms of their morphological and energy descriptors were found. The biggest were located in the northern part, within the Muros rías.



Sv_mean	NASC	Sv_max	Height	Length	Thickness	Area
-29.78	356668.71	-16.24	7.87	18.66	14.14	139.18
-32.40	194293.25	-17.40	7.84	10.85	9.13	78.37
-30.43	448386.01	-14.74	11.48	29.96	15.85	328.48
-28.96	292669.81	-17.71	5.34	33.89	10.96	169.21
-34.70	108718.40	-22.22	7.45	16.85	9.17	117.33

Figure 6. Echogram showing several echotraces attributed to sardine

12 sardine schools were identified, accounting for a total 36796 m^2 nmi^{-2}.

5 Fishing station used for echotrace allocation

From the total of 476837 m^2 nmi^{-2} , 75733 were directly allocated to fish species, of which 250346 corresponded to the mega-school, split into fish species on account the result of the fishing station

17, and the rest of the NASC values (150379) were distributed through the species on account the fish proportion found at the fishing stations. Figure 7 shows the spatial distribution of the fishing stations and the proportion for each species estimated using the Nakken and Dommasnes method.

The 9aCS was dominated by chub mackerel while in 9aCN anchovy was predominant and in 9aN horse mackerel which was also important in northern part of 9aCS (near Peniche and Nazaré).

For allocation purposes, the area was split in different strata, on account the ***echotypes***. These are areas in which the echotraces were similar and the species proportion found at the fishing station performed on each stratum were also similar. Accordingly, the surveyed area was divided in 11 strata on account echotypes as follows:

1. Near shore community in Algarve, composed by several species, being bogue and chub mackerel dominant (fishing stations 1 and 5)
2. Shelf community in Algarve, mainly composed by boarfish and sardine with a small amount of horse mackerel (fishing station 2)
3. Near shore community in Sado area, with big variety of species but dominated by chub mackerel (fishing stations 4, 5, 6 and 7)
4. Shelf community in Sado, mainly composed by boarfish and sardine with a small amount of horse mackerel (fishing station 8)
5. Near shore community in Lisboa-Caparica area, similar to the Sado community but with bogue as important species. (fishing stations 9 and 10)
6. Community between Ericeira and Nazaré, with sardine and horse mackerel as main species (fishing stations 12 and 13).
7. Community between Nazaré and Figueira da Foz, with anchovy and horse mackerel as main species (fishing stations 11 and 12).
8. Near shore community in Figueira da Foz Porto area with pelagic schools of sardine, horse mackerel and anchovy together with other close to the bottom (fishing stations 11 and 14 and 15). Results from the fishing station 11 were used instead those of number 19 because this was horse mackerel monospecific and thus would likely overestimate the presence of this specie.
9. Shelf community in Figueira da Foz north Aveiro with rather near bottom schools of anchovy and sardine (fishing stations 16, 18 and 20).
10. Shelf community in north Aveiro north Porto with rather near bottom schools of anchovy and sardine, including schools of small sardine (fishing stations 18, 20 and 21).
11. Community in Galician waters, mainly composed by horse mackerel (fishing stations 22, 23, 24 and 25).

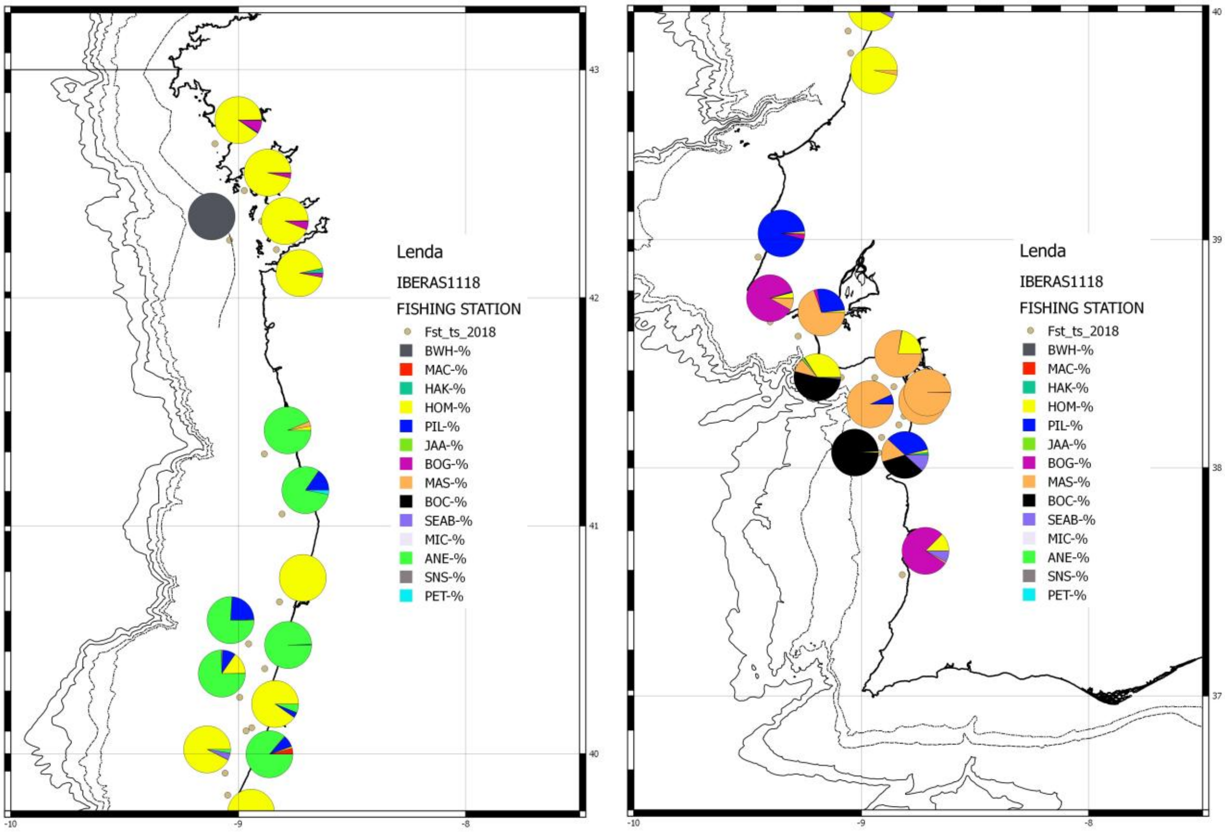


Figure 7. Fish proportion accounting the Nakken and Dommaness method (BWH, blue whiting; MAC, mackerel; HAK, hake,; HOM, horse mackerel; PIL, sardine; JAA, bluejack mackerel; BOG, bogue; MAS, chub mackerel; SEAB, seabreams; ANE, anchovy; SNS, longspine snipe fish; PET, small sardine)

Figure 8 shows the amount of energy per echotype as well as the number of nautical miles in which these were found and also the % of energy allocated to each main species. On overall, 29% of the total energy was allocated to horse mackerel, while for chub mackerel this percentage was a 33% and for anchovy a 24%. For sardine the percentage was a 7%. Echotype 3 (the one characterised by the fishing stations 4, 5, 6 and 7), accounted for more than the 30% of the total energy being the bulk of this allocated to chub mackerel; in the same way in north Portugal, main echotypes were mainly characterised by anchovy while in the central part and in Galicia, the major contribution was due to horse mackerel.

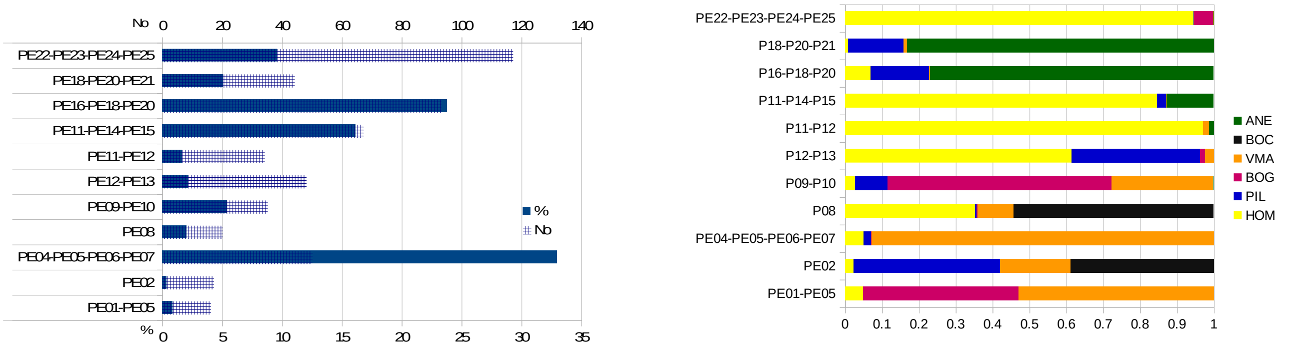


Figure 8. Left, in solid blue bars, NASC allocated (%) to each echotype and in dashed bars, the number of nautical miles for each echotype. Rifht, fish proportion accounting the Nakken and Dommaness method to each echotype (ANE, anchovy; BOG, bogue; VMA, chub mackerel; PIL, sardine; and HOM horse)

Figure 9 shows the spatial distribution of each echotype strata.

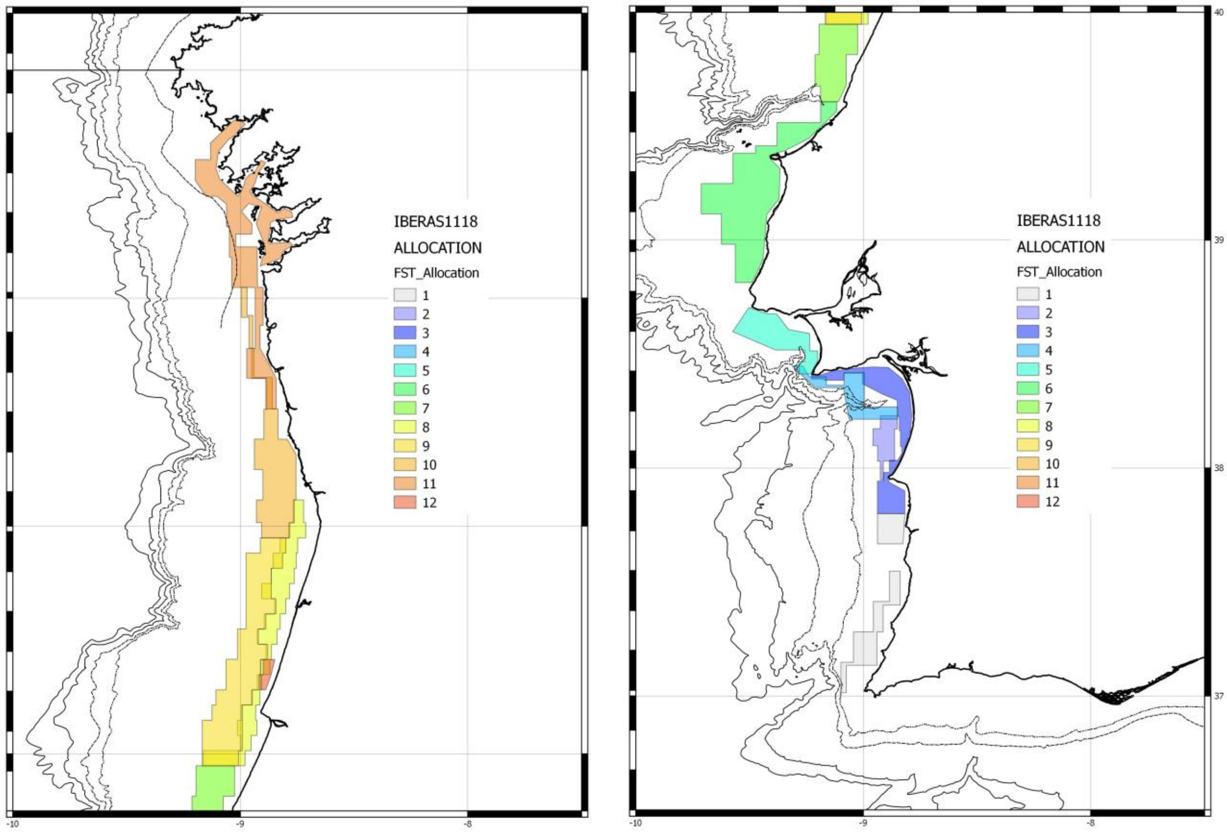


Figure 9. Spatial distribution of each echotype strata. Numbers reflect the same numbering of the echotype description. Number 12 deals with the area of the mega-school

Acoustic assessment

Table 6 shows the total energy attributed to the main species as well as the center of gravity, using as coordinates the distance from the origin, located at 37°N, and depth. As expected, most of the integrated backscattering energy was attributed to anchovy, being also important those for horse mackerel, chub mackerel and sardine. 76% of the sardine NASC was directly allocated. It was also important the direct allocation done for boar fish (88%) while for the rest of the species this % was lower than 25%.

	MAC	HOM	PIL	JAA	BOG	VMA	BOC	ANE	SNS	PET
NASC	278	57152	48423	45	6335	61378	15493	285688	18	302
Depth	27.07	31.54	20.04	69.04	31.28	30.53	76.62	17.72	69.04	26.73
s.d.	3.24	54.17	23.51	1.13	18.35	48.32	37.14	31.36	0.72	1.10
ic	0.52	8.66	3.76	0.18	2.93	7.73	5.94	5.01	0.12	0.18
Dist	225.46	250.74	234.98	78.52	114.40	82.88	87.14	203.40	78.52	210.66
s.d.	11.43	298.61	335.28	0.45	94.84	53.19	58.48	62.58	0.29	5.55
ic	1.83	47.75	53.61	0.07	15.16	8.50	9.35	10.01	0.05	0.89

Table 6. Total NASC allocated to the main pelagic species together with the location of the coordinates of the centre of gravity (MAC, mackerel; HOM, horse mackerel; PIL, sardine; JAA, blue jack mackerel; BOG, bogue; VMA, chub mackerel; BOC, boarfish, ANE, anchovy; SNS, longspine snipefish, PET, small sardine)

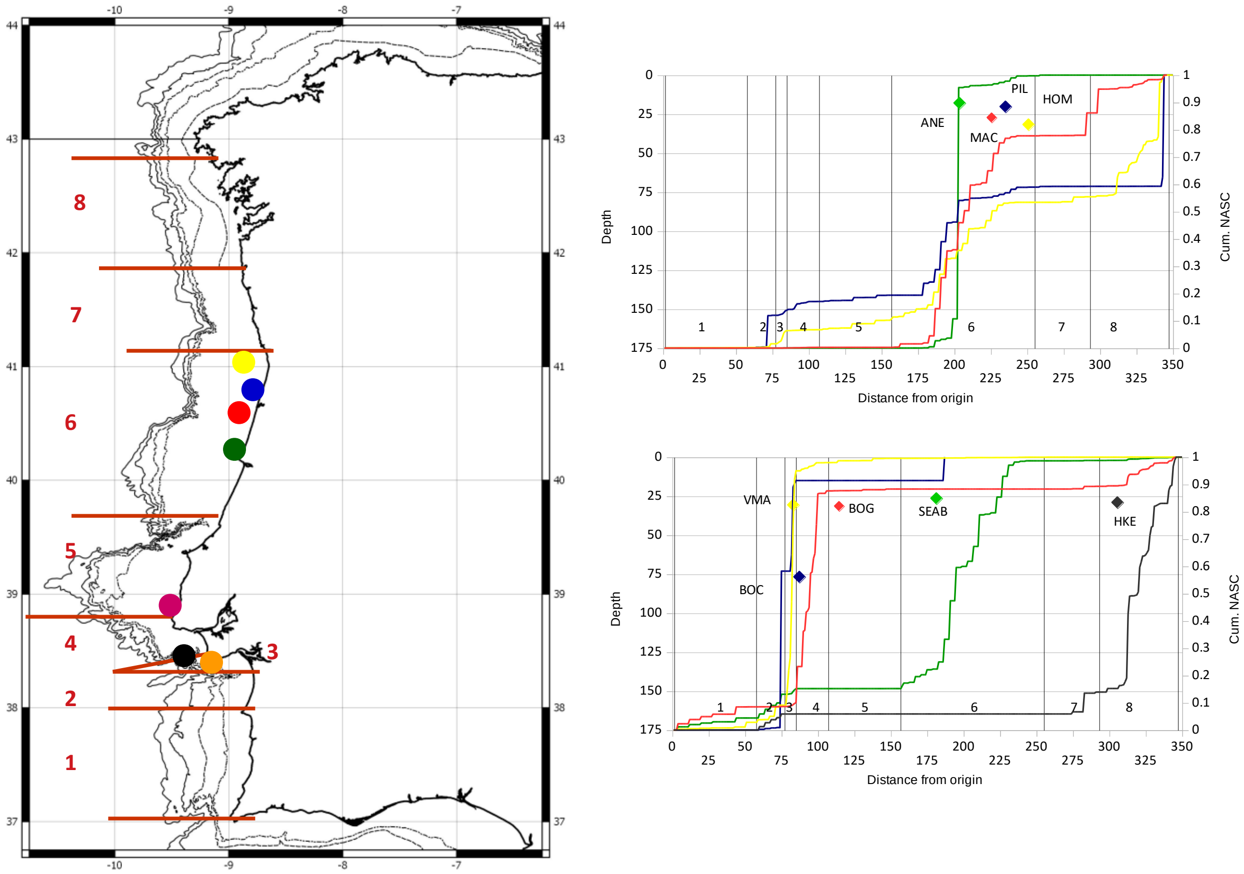


Figure 10. Center o f gravity and cumulated NASC for the most important pelagic species (ANE, anchovy-green-; PIL, sardine -blue-; HOM, h. mackerel -yellow-; MAC, mackerel -red-; VMA, C. mackerel -orange-; BOC, boarfish -black-; and BOG, bogue -magenta-)

Figue 10 shows the spatial distribution of the center of gravity as well as the cumulated NASC along distance from the origin. Chub mackerel and bogue were mainly located in 9aCS, round Setúbal area, together with boarfish which has its center of gravity in the outer area (deeper waters). Those of sardine, anchovy, mackerel and horse mackerel were found closer each other, and located in 9aCN, between Mondego and Douro rivers, where it seems their main recruitment area is placed.

1 Sardine assessment

Accounting the length distributions obtained at the fishing station and the NASC spatial distribution, sardine was divided in 6 strata, 4 in 9aCS and a single stratum in both 9aCN and 9aN. In the Setúbal strata, mean length was lower than those of the surrounding areas (north and south) and also length distribution was significantly different. Besides there was a discontinuity between Ericeira and Lisboa strata (with only 2 positive miles with NASC values lower than 1 m^2 nmi^{-2}); both the difference in mean length/length distribution and the discontinuities in the fish distribution explained the strata. In 9aCN all fishing station gave a lower mean length than those estimated in 9aN and in Ericeira area.

Table 7 summarises the sardine assessment. A total of 35701 tonnes, corresponding to 819 million fish were estimated. The bulk of the distribution was found in 9aCN ($16.6*10^3$ tonnes).

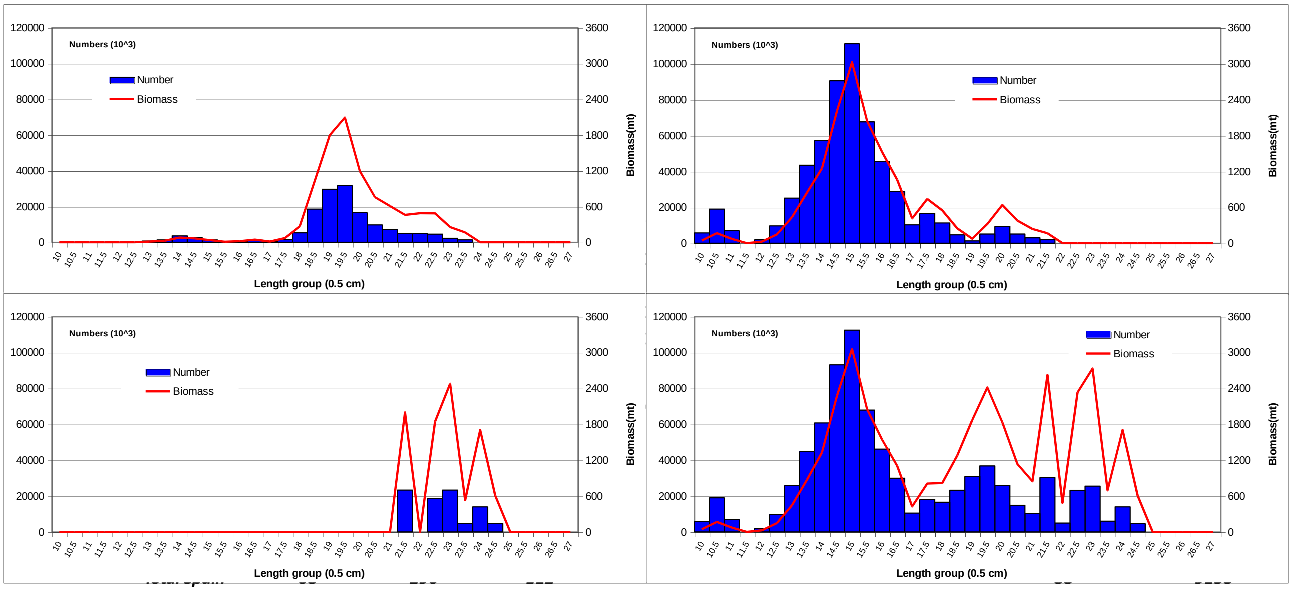
SURVEY: IBERAS 1118 SARDINE

ICES-Div	Region	No	Mean	Surface	Fishing st.	PDF	No (million fish)	Biomass (tonnes)	Density (Tn/nmi-2)
9aCS	Sines	44	132.04	181	P02-P04-P07-P09-P10-P11	S01	86	6035	33
	Setúbal	37	25.03	105	P07-P08	S02	14	515	5
	Lisboa	42	35.93	138	P02-P04-P07-P09-P10-P11	S01	18	1249	9
	Ericeira	52	21.53	394	P02-P04-P07-P09-P10-P11	S01	31	2144	5
	Total	**175**	***53.51***	**818**			**149**	**9944**	12
9aCN	9aCN	178	110.13	856	P14-15-P16-P17-P18-P20	S03	581	16604	19
	Total	**178**	***110.13***	**856**			**581**	**16604**	19
9aN	Rias Baixas	68	290.37	112	P22	S04	88	9153	82
	Total	**68**	**290**	**112**			**88**	**9153**	**82**
	Total Portugal	***353***	***82***	***818***			***730***	***26548***	32
	Total Spain	***68***	***290***	***112***			***88***	***9153***	82
	TOTAL 9a	**421**	***115.71***	**930**			**819**	**35701**	38

Table 7. Summary of the sardine assessment, with the name of the strata, number of positive nmi, mean NASC value (m^2 nmi^{-2}), surface (nmi^2), fishing station used for the estimation and number and biomass estimated

Length distribution were quite complementary among areas, with the younger fish located in 9aCN, the older in 9aN and the intermediate lengths in 9aCS, as shown in figure 11.

Figure 12 shows the spatial distribution accounting the NASC values. Main distribution area seems to be located around Figueira da Foz, being similar that observed for sardine. Yet, two second areas were located around Setúbal and within the Rías Baixas (9aN) in Spain, in which anchovy was almost absent. Between Aveiro and Porto, the distribution extended off shallower waters, and the outer limit of the sardine distribution was not reached.



TOTAL 9a 421 115.71 930 819 35701

Figure 11. Sardine estimated abundance and biomass per length class in 9aCS (above left), 9aCN (above right), 9aN (below left) and for the total area (below right)

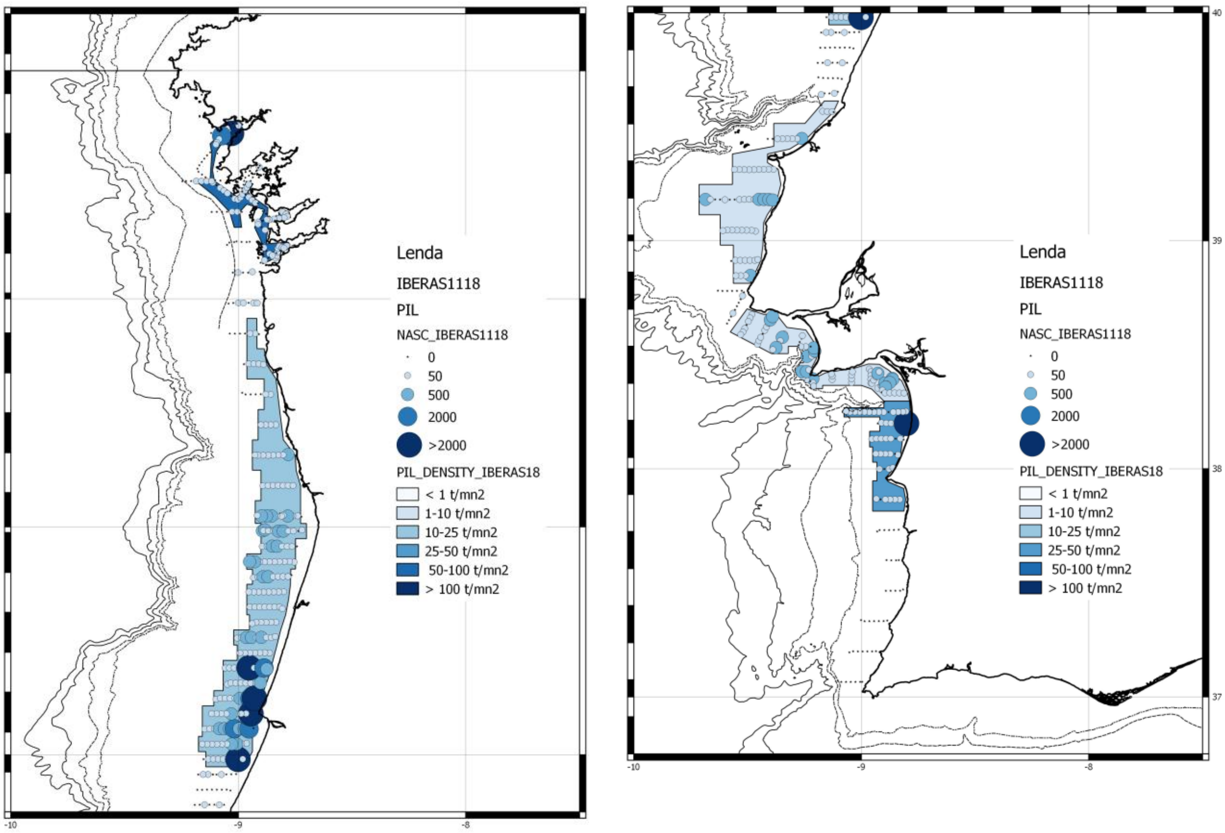


Figure 12. Sardine spatial distribution in IBERAS 1118. Dots represent the NASC values attributed to sardine and the polygons the strata together with the relative density

On the other hand, sardine adult distribution matched quite well with the egg distribution derived from the CUFES samples, as shown in figure 13.

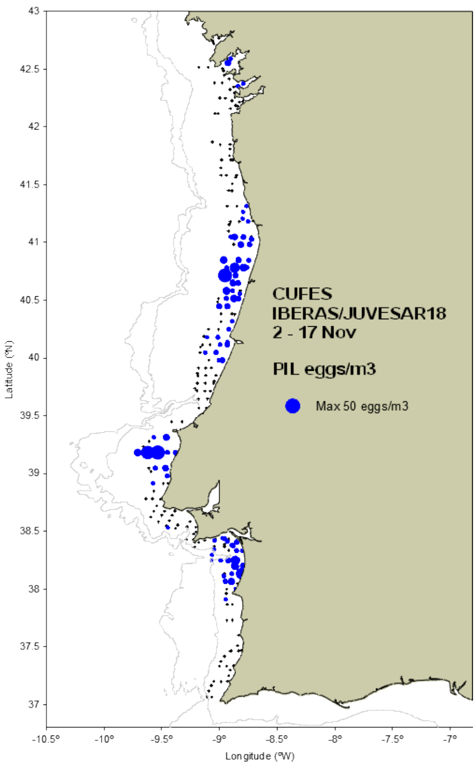


Figure 13: Sardine egg spatial distribution in IBERAS 1118 obtained from CUFES samples

Table 8a-e is shown the sardine assessment by length group and age classes per ICES Sub-Division and by country. All recruit (age group 0) were found in the Portuguese area, accounting for the 73.44% of the total fish estimates in this country. Moreover, the bulk of them were recorded in 9aCN where juveniles accounted up to 90% of the total estimates in number. O group mean length was 14.83 in 9aCN, similar to that found in 9aCS (14.80), although in 9aCN a small second mode was also recorded at 10.5 cm.

Age group 1 was almost negligible, confirming, thus, the very weak strength of this cohort.

In 9aN (Spain), only older fish were observed, without younger fish. It should be noticed that in this area the lack of time together with the bad weather conditions found at the end of the survey made difficult to obtain extra trawl hauls samples in order to verify the true length structure.

SURVEY: IBERAS 0318. Sardine

BIOMASS (tonnes). ZONE: 9aCS

						AGE GROUPS						
Length	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Total**	**No fish (thousands)**
10												
10.5												
11												
11.5												
12												
12.5												
13	11										11.09	644
13.5	25										25.12	1288
14	78										77.92	3542
14.5	64										63.66	2576
15	36										35.61	1288
15.5	8										7.62	247
16	18										17.83	520
16.5	43										43.32	1142
17	11										11.45	273
17.5			69								69.17	1500
18		38	229								267.27	5276
18.5		33	962	33							1028.07	18528
19			1638	157							1795.22	29606
19.5		35	1672	279	70	35					2090.48	31620
20			1052	137							1189.46	16537
20.5			520	189	47						755.93	9680
21			217	173	87	43	87				607.09	7174
21.5			66	197		131	66				458.76	5012
22					70	139	209		70		486.61	4925
22.5					138	69	207	69			484.07	4545
23					85	85		85			253.85	2215
23.5					82		82				164.06	1332
24												
24.5												
25												
25.5												
26												
26.5												
27												
Biomass (mt)	294	106	6424	1166	578	502	650	154	70	0	9943.66	149472
%	2.95	1.07	64.61	11.72	5.81	5.05	6.54	1.55	0.70			
M. weight	25.01	56.29	63.74	72.59	93.55	94.66	100.19	110.76	98.81		66.08	
No Fish (thousands)	11522	1878	100221	15937	6091	5266	6466	1388	704	0	149472	
%	7.71	1.26	67.05	10.66	4.07	3.52	4.33	0.93	0.47			
M. length	14.80	18.83	19.54	20.31	21.89	21.97	22.34	23.02	22.25		19.59	
s.d.	1.00	0.61	0.74	0.88	1.33	0.94	0.70	0.25			1.84	

Table 8a: Sardine assessment in 9aCS

SURVEY: IBERAS 0318. Sardine

BIOMASS (tonnes). ZONE: 9aCN

	AGE GROUPS											
Length	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Total**	**No fish (thousands)**
10	43										43.12	5715
10.5	167										167.07	18983
11	71										71.01	6967
11.5												
12	26										25.98	1936
12.5	147										147.23	9641
13	434										433.83	25091
13.5	846										845.53	43388
14	1195	54									1249.48	57130
14.5	2211										2210.74	90428
15	3023										3022.79	111023
15.5	2041										2040.90	67543
16	1523										1522.81	45558
16.5	777	283									1059.50	28742
17	296	118									414.08	10215
17.5	415	277	46								737.85	16598
18	299	100	150								548.40	11277
18.5		93	155								247.89	4671
19			75								74.62	1292
19.5		29	146	146							321.76	5127
20			300	263	75						638.20	9380
20.5		47	47	236	47						377.30	5125
21			119	79	40						238.46	3000
21.5				55	111						165.90	1936
22												
22.5												
23												
23.5												
24												
24.5												
25												
25.5												
26												
26.5												
27												
Biomass (mt)	13513	1001	1038	780	273	0	0	0	0	0	16604.46	580767
%	81.38	6.03	6.25	4.70	1.64							
M. weight	24.89	40.51	59.74	70.43	76.87						27.75	
No Fish (thousands)	524781	24200	17209	11041	3535	0	0	0	0	0	580767	
%	90.36	4.17	2.96	1.90	0.61							
M. length	14.83	17.25	19.45	20.47	21.03						15.21	
s.d.	1.48	1.33	1.02	0.55	0.63						1.91	

Table 8b: Sardine assessment in 9aCN

SURVEY: IBERAS 0318. Sardine

BIOMASS (tonnes). ZONE: 9aC

	AGE GROUPS											
Length	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Total**	**No fish (thousands)**
10												
10.5												
11												
11.5												
12												
12.5												
13												
13.5												
14												
14.5												
15												
15.5												
16												
16.5												
17												
17.5												
18												
18.5												
19												
19.5												
20												
20.5												
21												
21.5				665	1330						1995.26	23282
22												
22.5					461	461	461			461	1845.61	18626
23								2475			2474.82	23282
23.5					530						530.17	4656
24				425		425		425		425	1701.22	13969
24.5				303		303					605.71	4656
25												
25.5												
26												
26.5												
27												
Biomass (mt)	0	0	0	1393	2322	1190	461	2900	0	887	9152.79	88472
%				15.22	25.37	13.00	5.04	31.69		9.69		
M. weight				101.32	93.07	113.00	99.09	108.23		108.42	103.02	
No Fish (thousands)	0	0	0	13581	24834	10477	4656	26774	0	8149	88472	
%				15.35	28.07	11.84	5.26	30.26		9.21		
M. length				22.91	22.31	23.69	22.75	23.38		23.39	23.01	
s.d.				1.35	0.79	0.86		0.34		0.74	0.94	

Table 8c: Sardine assessment in 9aN (Spain)

SURVEY: PELACUS 0318. Sardine

BIOMASS (tonnes). ZONE: 9aCS-CN

	AGE GROUPS											
Length	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Total**	**No fish (thousands)**
10	43										43.12	5715
10.5	167										167.07	18983
11	71										71.01	6967
11.5												
12	26										25.98	1936
12.5	147										147.23	9641
13	445										444.91	25735
13.5	871										870.65	44676
14	1273	54									1327.40	60673
14.5	2274										2274.40	93005
15	3058										3058.40	112312
15.5	2049										2048.52	67790
16	1541										1540.64	46079
16.5	820	283									1102.82	29884
17	307	118									425.53	10488
17.5	415	277	115								807.03	18097
18	299	138	379								815.66	16554
18.5		126	1117	33							1275.95	23199
19			1712	157							1869.84	30898
19.5		64	1819	425	70	35					2412.24	36747
20			1353	400	75						1827.66	25917
20.5		47	567	425	94						1133.23	14805
21			336	253	126	43	87				845.55	10174
21.5			66	252	111	131	66				624.66	6948
22					70	139	209		70		486.61	4925
22.5					138	69	207	69			484.07	4545
23					85	85		85			253.85	2215
23.5					82		82				164.06	1332
24												
24.5												
25												
25.5												
26												
26.5												
27												
Biomass (mt)	13807	1107	7463	1945	851	502	650	154	70	0	26548.12	730239
%	52.01	4.17	28.11	7.33	3.20	1.89	2.45	0.58	0.26			
M. weight	25.91	41.26	58.38	66.20	78.44	82.73	86.95	94.95	85.91		35.00	
No Fish (thousands)	536303	26079	117431	26978	9625	5266	6466	1388	704	0	730239	
%	73.44	3.57	16.08	3.69	1.32	0.72	0.89	0.19	0.10			
M. length	14.83	17.36	19.52	20.37	21.58	21.97	22.34	23.02	22.25		16.11	
s.d.	1.47	1.35	0.79	0.77	1.20	0.94	0.70	0.25			2.59	

Table 8d: Sardine assessment in Portugal (9aCS+9aCN)

SURVEY: IBERAS 0318. Sardine

BIOMASS (tonnes). ZONE: Portugal+Spain

	AGE GROUPS											
Length	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Total**	**No fish (thousands)**
10	43										43.12	5715
10.5	167										167.07	18983
11	71										71.01	6967
11.5												
12	26										25.98	1936
12.5	147										147.23	9641
13	445										444.91	25735
13.5	871										870.65	44676
14	1273	54									1327.40	60673
14.5	2274										2274.40	93005
15	3058										3058.40	112312
15.5	2049										2048.52	67790
16	1541										1540.64	46079
16.5	820	283									1102.82	29884
17	307	118									425.53	10488
17.5	415	277	115								807.03	18097
18	299	138	379								815.66	16554
18.5		126	1117	33							1275.95	23199
19			1712	157							1869.84	30898
19.5		64	1819	425	70	35					2412.24	36747
20			1353	400	75						1827.66	25917
20.5		47	567	425	94						1133.23	14805
21			336	253	126	43	87				845.55	10174
21.5			66	917	1441	131	66				2619.92	30230
22					70	139	209		70		486.61	4925
22.5					600	531	669	69		461	2329.68	23171
23					85	85		2559			2728.66	25497
23.5					612		82				694.24	5989
24				851		851					1701.22	13969
24.5				303		303					605.71	4656
25												
25.5												
26												
26.5												
27												
Biomass (mt)	13807	1107	7463	3764	3172	2117	1112	2629	70	461	35701	818711
%	38.67	3.10	20.90	10.54	8.89	5.93	3.11	7.36	0.19	1.29		
M. weight	25.91	41.26	58.38	77.21	84.28	98.73	88.94	97.66	85.91	91.74	41.43	
No Fish (thousands)	536303	26079	117431	44052	34460	19236	11122	24670	704	4656	818711	
%	65.51	3.19	14.34	5.38	4.21	2.35	1.36	3.01	0.09	0.57		
M. length	14.83	17.36	19.52	21.46	22.11	23.32	22.51	23.24	22.25	22.75	16.86	
s.d.	1.47	1.35	0.79	1.71	0.98	1.18	0.00	0.00	0.00	0.00	3.27	

Table 8e: Sardine assessment in the whole area (9aCS+9aCN+9aN)

Figure 14 shows the sardine assessment by age group and ICES sub-division, in Portugal and for the whole area. There were remarkable difference in age composition among sub-divisions. While in southern Portuguese Atlantic waters (9aCS) age 2 was clearly dominant, in the northern Portuguese region the bulk of the population in the surveyed area was composed by younger fish (e.g. young of the year), while in the Spanish area, only individuals older than 2 were found.

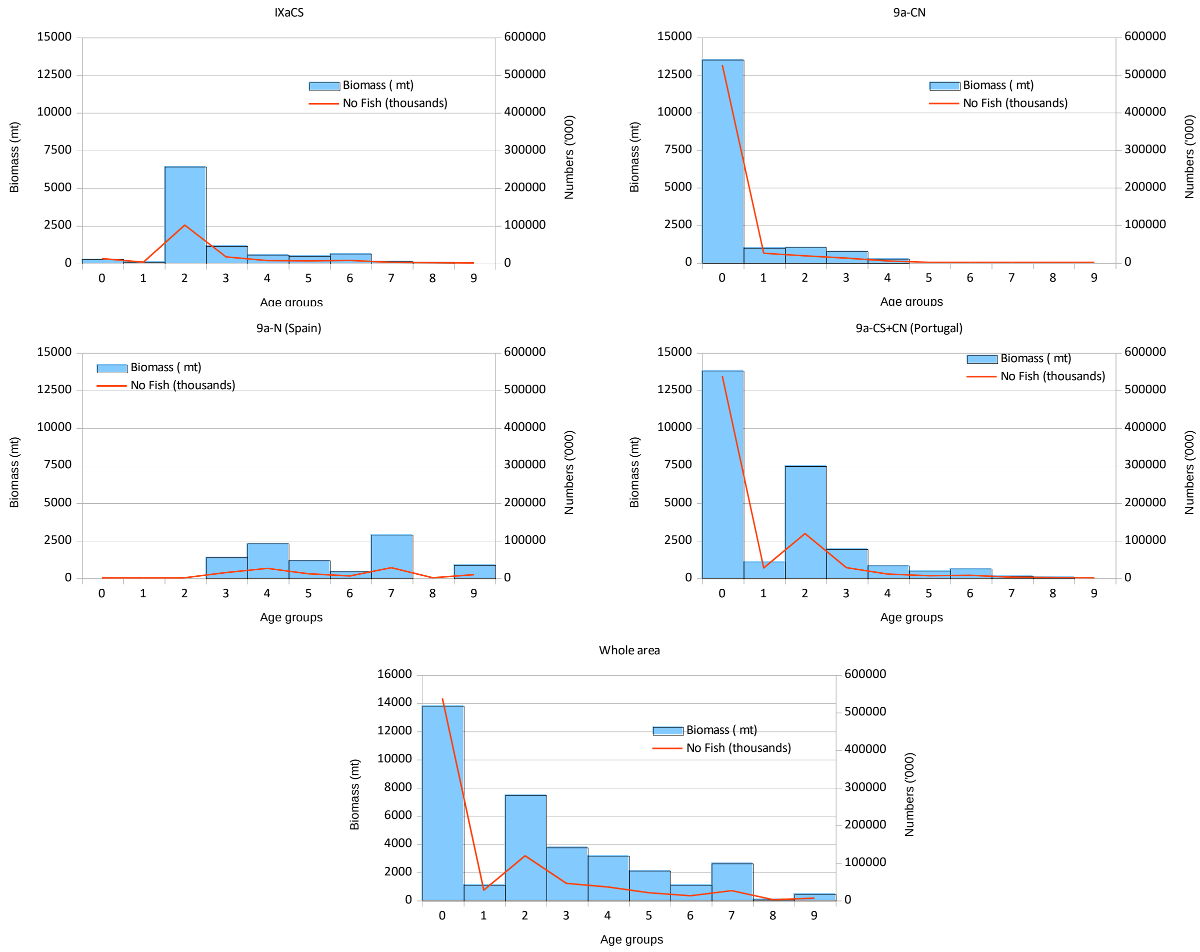


Figure 14: Sardine assessment (abundance and biomass buy age group) by ICES division

2 Anchovy assessment

For anchovy, the 9aCN Sub-Division was divided into 5 strata. 3 of them accounting the differences in length distribution and mean length and the other two to restrict the influence of the mega-school to the adjacent areas; besides, another strata was placed in the northern part of 9a CN because this was mainly steamed during night hours.

Mainly due to the mega-school found north Figueira da Foz, the total biomass estimated was 182 thousand tonnes as shown in table 9. Almost no anchovy was found in 9aN, nor in 9aCS. Main mode was found at 14.5 cm, with a secondary one at 16.5 cm, as shown in figure 15.

SURVEY: IBERAS1118 ANCHOVY

Zone	Area	No	Mean	Area	Fishing st.	PDF	No (million fish)	Biomass (tonnes)
9aCS	Lisboa	39	0.02	134	P14	S01	0	0
	Total	***39***	***0.02***	***134***			***0***	***0***
9aCN	Figueira	54	23.14	224	P14	S01	34	670
	Mira	3	83057.20	15	P16-P17-P18	S02	7568	161674
	Aveiro	81	308.13	341	P16-P17-P18	S02	654	13979
	Porto	69	148.85	357	P20-P21	S03	557	5047
	Viana	9	2.15	72	P20-P21	S03	23	206
	Total	***216***	***1322.55***	***1009***			***8836***	***181576***
9aN	Rbaixas	68	0.04	112	P20-P21	S03	0	0
	Total	**68**	***0.04***	**112**			***0***	***0***
	Portugal	***255***	***1120***	***1142***			***8836***	***181577***
	Spain	***68***	***0***	***112***			***0***	***0***
	TOTAL	**323**	***884.44***	**1254**			**8836**	**181577**

Table 9. Summary of the anchovy assessment, with the name of the strata, number of positive nmi, mean NASC value (m^2 nmi^{-2}), surface (nmi^2), fishing station used for the estimation and number and biomass estimated

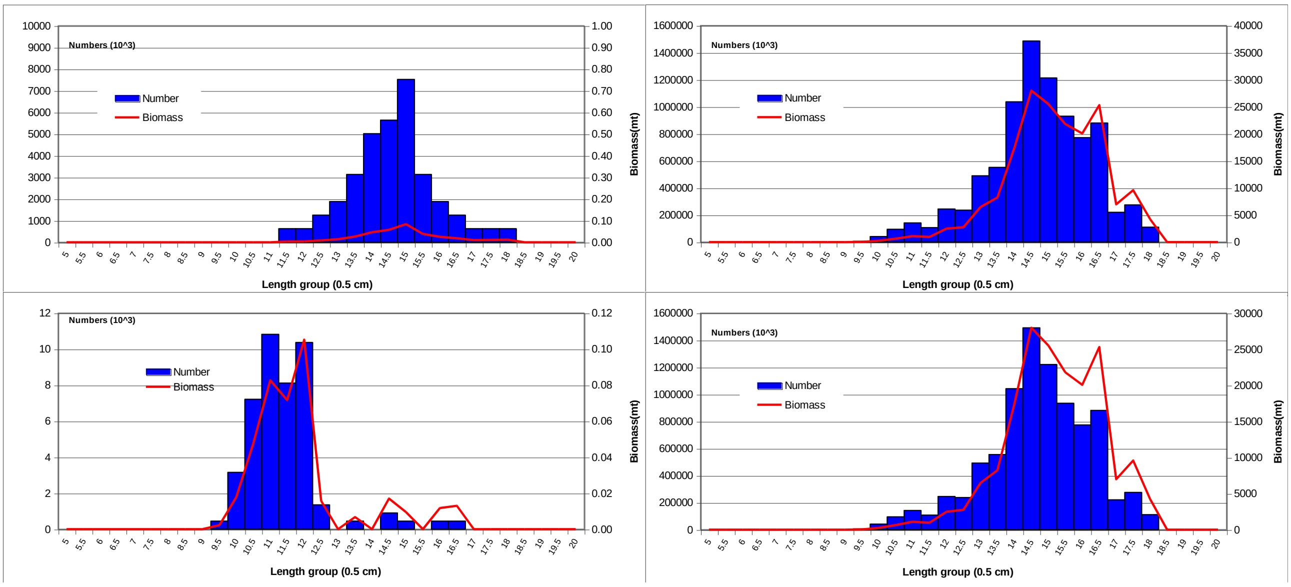


Figure 15. Anchovy estimated abundance and biomass per length class in 9aCS (above left), 9aCN (above right), 9aN (below left) and for the total area (below right), note that scales are different

Regarding ages, it should be noted that although the high abundance compared to that estimated for sardine, only 5.9 kt belonged to age group 0 (recruits), accounted age group 1 for a 84% of the total biomass. Comparing to sardine where recruits represented up 66% of the total abundance and 39% in biomass, juvenile anchovy only accounted for the 7% of the abundance (3% of the total biomass). Given these figures, it seems 2018 recruitment would be very low as compared to that of 2017. Figure 16 and table 10 shows the anchovy assessment by age group.

Length	AGE GROUPS 0	1	2	3	Total	No fish (thousands)
5						
5.5						
6						
6.5						
7						
7.5						
8						
8.5						
9						
9.5						
10						
10.5						
11						
11.5	0.00				0.00	627
12	0.00				0.00	627
12.5	0.01				0.01	1253
13	0.01				0.01	1880
13.5	0.03				0.03	3133
14	0.04	0.01			0.05	5013
14.5	0.05	0.01			0.06	5640
15	0.07	0.02			0.08	7520
15.5	0.02	0.01			0.04	3133
16	0.00	0.02			0.02	1880
16.5	0.00	0.02			0.02	1253
17		0.01			0.01	627
17.5		0.01	0.00		0.01	627
18		0.01			0.01	627
18.5						
19						
19.5						
20						
Biomass (mt)	0.235	0.117	0.003	0	0.355	33840
%	66.23	33.02	0.75			
M. weight	19.09	27.21	38.50		21.15	
No Fish	24591	9092	157	0	33840	
%	72.67	26.87	0.46			
M. length	14.41	16.01	17.75		14.85	
s.d.	1.00	1.12			1.27	

Length	AGE GROUPS 0	1	2	3	Total	No fish (thousands)
5						
5.5						
6						
6.5						
7						
7.5						
8						
8.5						
9						
9.5	28				28.08	5916
10	232				232.16	41414
10.5	622				621.79	94660
11	1085				1085.04	141990
11.5	946				946.03	107119
12	2477				2477.30	244179
12.5	2737				2736.56	236108
13	6453				6452.65	489831
13.5	8223				8222.87	551815
14	11600	5800			17400.15	1036805
14.5	13982	13982			27964.75	1485626
15	25510				25509.85	1212894
15.5	7264	14528			21792.66	930671
16	20058				20057.85	771967
16.5	12644	12644			25288.23	879893
17		6969			6969.36	219882
17.5			9575		9575.35	274696
18			4216		4215.51	110255
18.5						
19						
19.5						
20						
Biomass (mt)	113861	53924	13791	0	181576	8835724
%	62.71	29.70	7.60			
M. weight	19.77	24.64	39.56		21.94	
No Fish (thousands)	6082082	2368691	384951	0	8835724	
%	68.84	26.81	4.36			
M. length	14.56	15.54	17.89		14.97	
s.d.	1.48	1.00	0.23		1.54	

Table 10a: Anchovy assessment in 9aCS (left) and 9aCN (right)

Length	AGE GROUPS 0	1	2	3	Total	No fish (thousands)
5						
5.5						
6						
6.5						
7						
7.5						
8						
8.5						
9						
9.5	28				28.08	5916
10	232				232.16	41414
10.5	622				621.79	94660
11	1085				1085.04	141990
11.5	946				946.04	107746
12	2477				2477.31	244806
12.5	2737				2736.56	237362
13	6453				6452.66	491711
13.5	8223				8222.90	554948
14	11600	5800			17400.20	1041818
14.5	13982	13982			27964.81	1491266
15	25510				25509.93	1220414
15.5	7264	14528			21792.70	933804
16	20058				20057.88	773847
16.5	12644	12644			25288.24	881147
17		6969			6969.37	220509
17.5			9575		9575.36	275323
18			4216		4215.52	110881
18.5						
19						
19.5						
20						
Biomass (mt)	113861	53924	13791	0	181576.53	8869564
%	62.71	29.70	7.60			
M. weight	19.77	24.65	39.55		21.93	
No fish (thousands)	6106673	2377783	385108	0	8869564	
%	68.85	26.81	4.34			
M. length	14.56	15.54	17.89		14.97	
s.d.	1.48	1.00	0.23	0.00	1.54	

Length	AGE GROUPS 0	1	2	3	Total	No fish (thousands)
5						
5.5						
6						
6.5						
7						
7.5						
8						
8.5						
9						
9.5	0.002				0.002	0
10	0.018				0.018	3
10.5	0.047				0.047	7
11	0.083				0.083	11
11.5	0.072				0.072	8
12	0.105				0.105	10
12.5	0.016				0.016	1
13						
13.5	0.006	0.001			0.007	0
14						
14.5	0.015	0.002			0.017	1
15	0.006	0.003			0.009	0
15.5						
16	0.005	0.006			0.012	0
16.5						
17						
17.5						
18						
18.5						
19						
19.5						
20						
Biomass (mt)	0.375	0.026	0	0	0.400	44
%	93.63	6.37				
M. weight	9.21	27.37			9.48	
No fish	43	1	0	0	44	
%	97.70	2.30				
M. length	11.60	16.04			11.70	
s.d.	0.95	7.12			1.16	

Table 10b: Anchovy assessment in Portugal (left) and Spain (right)

	AGE GROUPS					
Length	**0**	**1**	**2**	**3**	**Total**	**No fish (thousands)**
5						
5.5						
6						
6.5						
7						
7.5						
8						
8.5						
9						
9.5	28				28.08	5917
10	232				232.17	41417
10.5	622				621.84	94667
11	1085				1085.12	142001
11.5	946				946.11	107754
12	2477				2477.41	244816
12.5	2737				2736.58	237363
13	6453				6452.66	491711
13.5	8223				8222.90	554949
14	11600	5800			17400.20	1041818
14.5	13982	13982			27964.82	1491267
15	25510				25509.92	1220415
15.5	7264	14528			21792.70	933804
16	20058				20057.86	773847
16.5	12644	12644			25288.26	881147
17		6969			6969.37	220509
17.5			9575		9575.35	275323
18			4216		4215.51	110881
18.5						
19						
19.5						
20						
Biomass (mt)	113862	53924	13791	0	181576.93	8869608
%	62.71	29.70	7.60			
M. weight	19.77	24.65	39.55		21.93	
No fish	610671	23777	38510	0	8869608	
%	68.85	26.81	4.34			
M. length	14.56	15.54	17.89		14.97	
s.d.	1.48	1.00	0.23	0.00	1.54	

Table 10c: Anchovy assessment in the whole area (9aCS+9aCN+9aN)

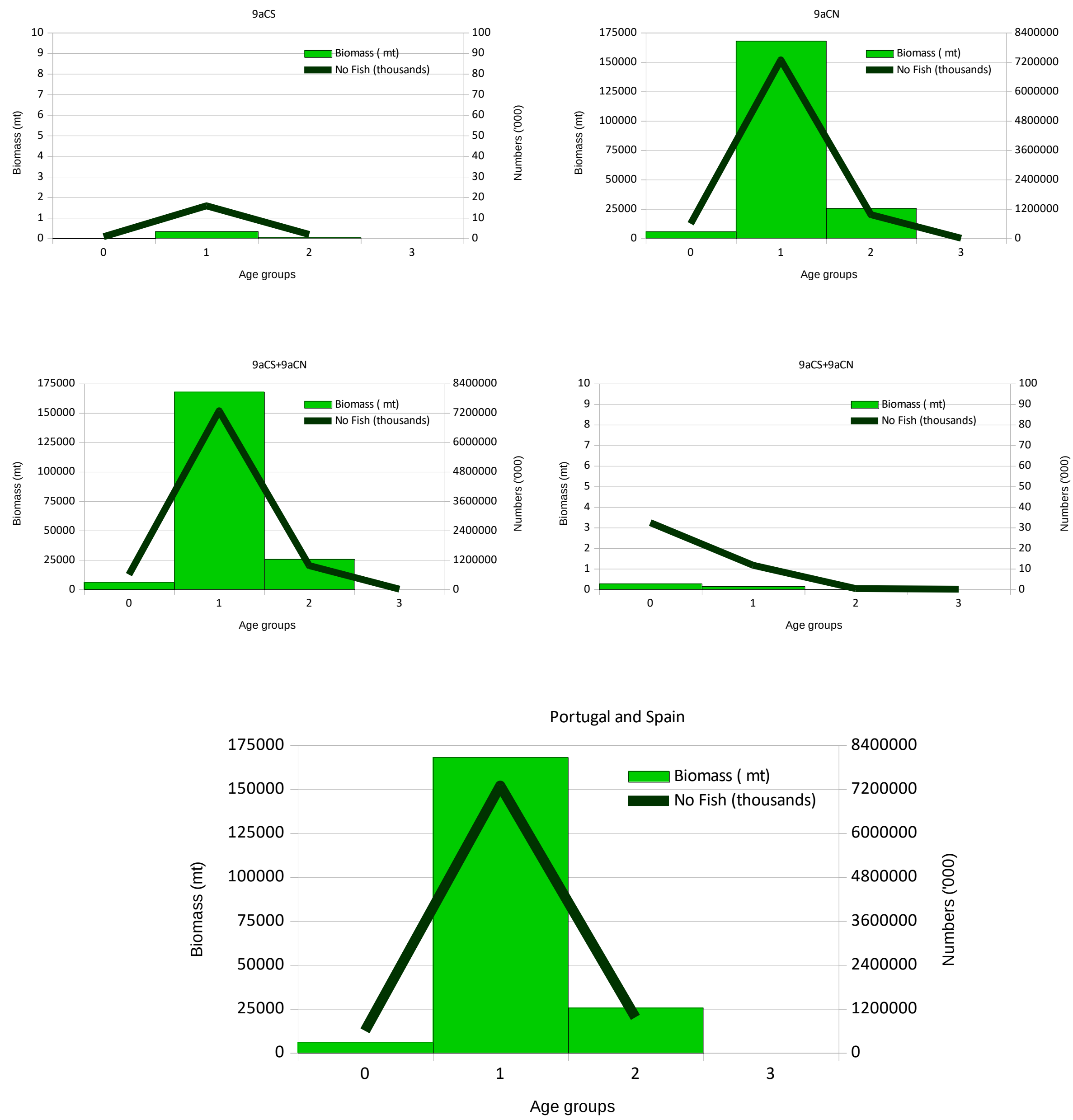


Figure 16: Anchovy assessment (abundance and biomass by age group) by ICES division

Finally, figure 17 shows the spatial distribution.

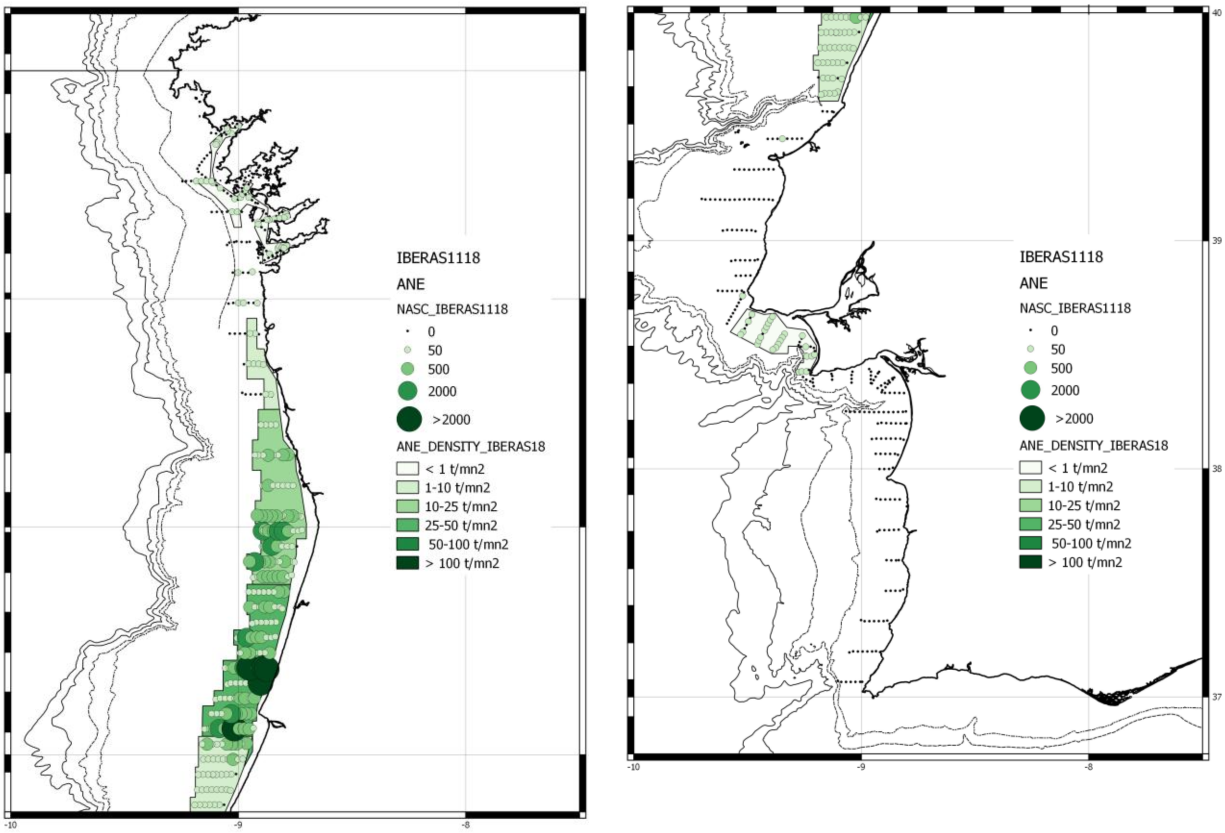


Figure 17. Anchovy spatial distribution in IBERAS 1118. Dots represent the NASC values attributed to anchovy and the polygons the strata together with the relative density

3 Horse mackerel assessment

Horse mackerel was well distributed all around the surveyed area but in in the southern part (Algarve). Length distribution were similar around the surveyed area, noticing the presence of very small juveniles in hauls, especially in 9aCS and 9aN. 9aCS was divided into three strata due to a discontinuities in the spatial distribution, although length distribution were similar throughout the Sub-Division. On the other hand, in 9aCN an extra strata was placed in the northern part as this was mainly steamed at night. Table 11 summarises the assessment. A total of 22 thousand tonnes were estimated, corresponding to 341 million fish.

Most of the younger fish occurred in 9aCN, while only few juveniles were recorded in 9aCS. In 9aN, a mode peaked in 12 cm, not seen in 9aCN was also recorded although most of the fish were bigger than 20 cm. (figure 18)

Figure 19 shows its spatial distribution and the relative density. North Figueira da Foz and within the Rias Baixas, the density was the highest.

Zone	Area	SURVEY: No	IBERAS 1118 HIORSE MACKEREL Mean	Surface	Fishing st.	PDF	No (million fish)	Biomass (tonnes)
9aCS	Alentejo	10	4.22	91.27	-P02-P03-P04-P05-P06-P08-P09-:	ST01	0	49
	Lisboa-Sines	126	30.04	479.79	-P02-P03-P04-P05-P06-P08-P09-:	ST01	16	1841
	Peniche	52	38.09	403.54	-P02-P03-P04-P05-P06-P08-P09-:	ST01	17	1964
	Total	***188***	***31***	***974.60***			***33.88***	***3853.84***
9aCN	Aveiro	197	125.38	899.54	P11-P12-P15-P16-P19-P21	ST02	191	11060
	Viana	23	50.51	183.13	P11-P12-P15-P16-P19-P21	ST02	16	907
	Total	***220***	***118***	***1082.7***			***206.85***	***11967.59***
9aN	Rbaixas	118	215.93	293.68	P22-P23-P24-P25	ST03	100	6511
	Total	***118***	***216***	***294***			***99.81***	***6511.01***
	Total Portugal	***408***	***78***	***2057***			***241***	***15821***
	Total Spain	***118***	***216***	***294***			***100***	***6511***
	Total 9a	***526***	***109***	***2351***			***341***	***22332***

Table 11. Summary of the horse mackerel assessment, with the name of the strata, number of positive nmi, mean NASC value (m^2 nmi^{-2}), surface (nmi^2), fishing station used for the estimation and number and biomass estimated

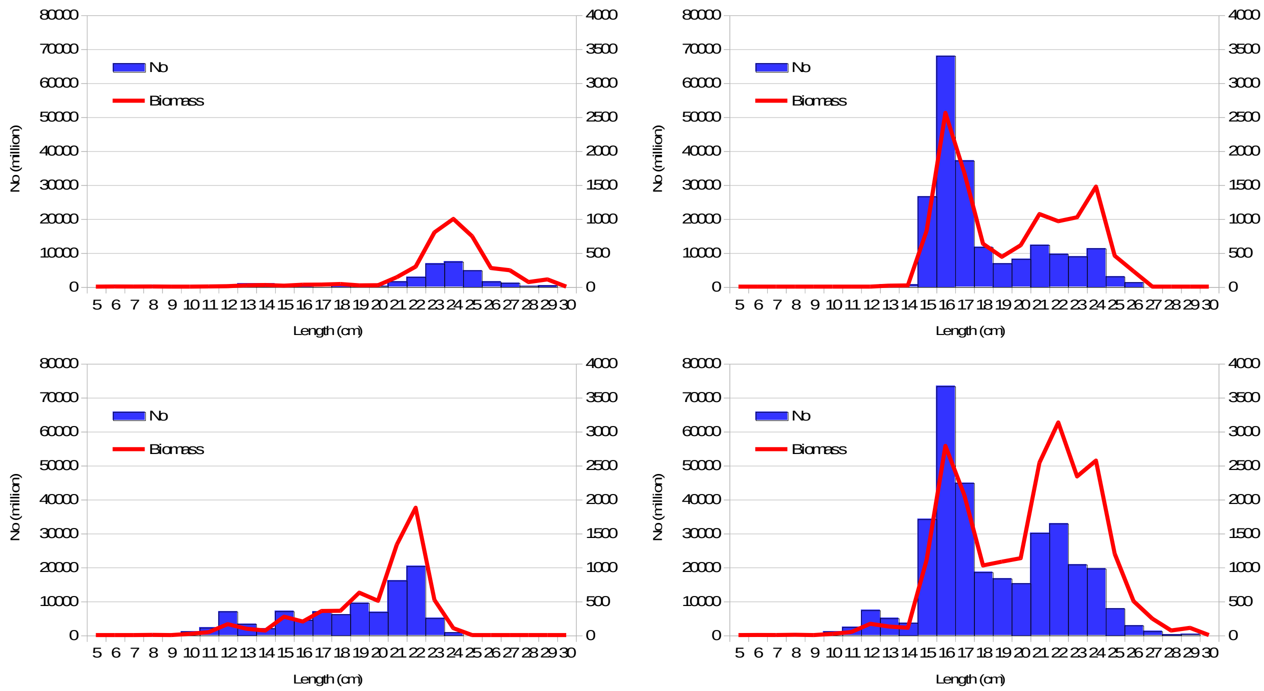


Figure 18. Horse mackerel estimated abundance and biomass per length class in 9aCS (above left), 9aCN (above right), 9aN (below left) and for the total area (below right)

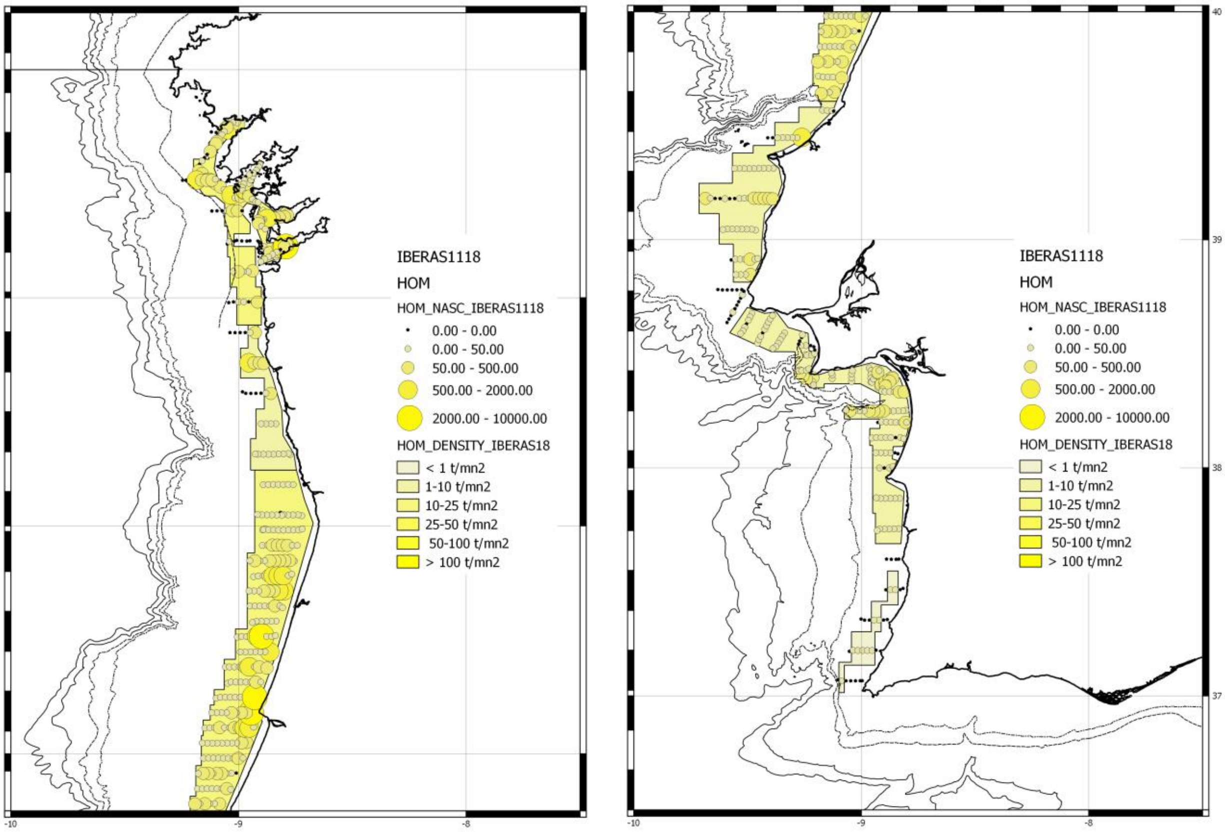


Figure 19. Horse mackerel spatial distribution in IBERAS 1118. Dots represent the NASC values attributed to horse mackerel and the polygons the strata together with the relative density

4 Chub mackerel assessment

Table 12 summarises the chub mackerel assessment. Of 25 thousand tonnes, 99% were found in 9aCS. The distribution was bimodal, with the main mode at 19 cm and the second one at 23 cm (figure 20). Figure 21 shows the spatial distribution, with the bulk of the distribution being located close to the Sado estuary.

		SURVEY:	IBERAS 1118 CHUB MACKEREL					
Zone	**Area**	**No**	**Mean**	**Surface**	**Fishing st.**	**PDF**	**No (million fish)**	**Biomass (tonnes)**
9aCS	Alentejo	10	46.08	91.27	:-P04-P05-P06-P07-P08-P09-P10-I	ST01	5	438
	Lisboa-Sines	126	473.43	479.79	:-P04-P05-P06-P07-P08-P09-P10-I	ST01	274	23674
	Peniche	52	18.19	403.54	:-P04-P05-P06-P07-P08-P09-P10-I	ST01	9	765
	Total	***188***	***325***	***974.60***			***288.08***	***24877.42***
9aCN	Aveiro	197	1.37	899.54	P09-P10-P12	ST02	1	130
	Viana	23	0.40	183.13	P05-P21	ST03	0	10
	Total	***220***	***1***	***1082.7***			***1.48***	***140.34***
9aN	Rbaixas	118	0.10	293.68	P05-P21	ST03	0	4
	Total	***118***	***0***	***294***			***0.02***	***3.90***
	Total Portugal	***408***	***150***	***2057***			***290***	***25018***
	Total Spain	***118***	***0***	***294***			***0***	***4***
	Total 9a	***526***	***117***	***2351***			***290***	***25022***

Table 12. Summary of the chub mackerel assessment, with the name of the strata, number of positive nmi, mean NASC value (m^2 nmi^{-2}), surface (nmi^2), fishing station used for the estimation and number and biomass estimated

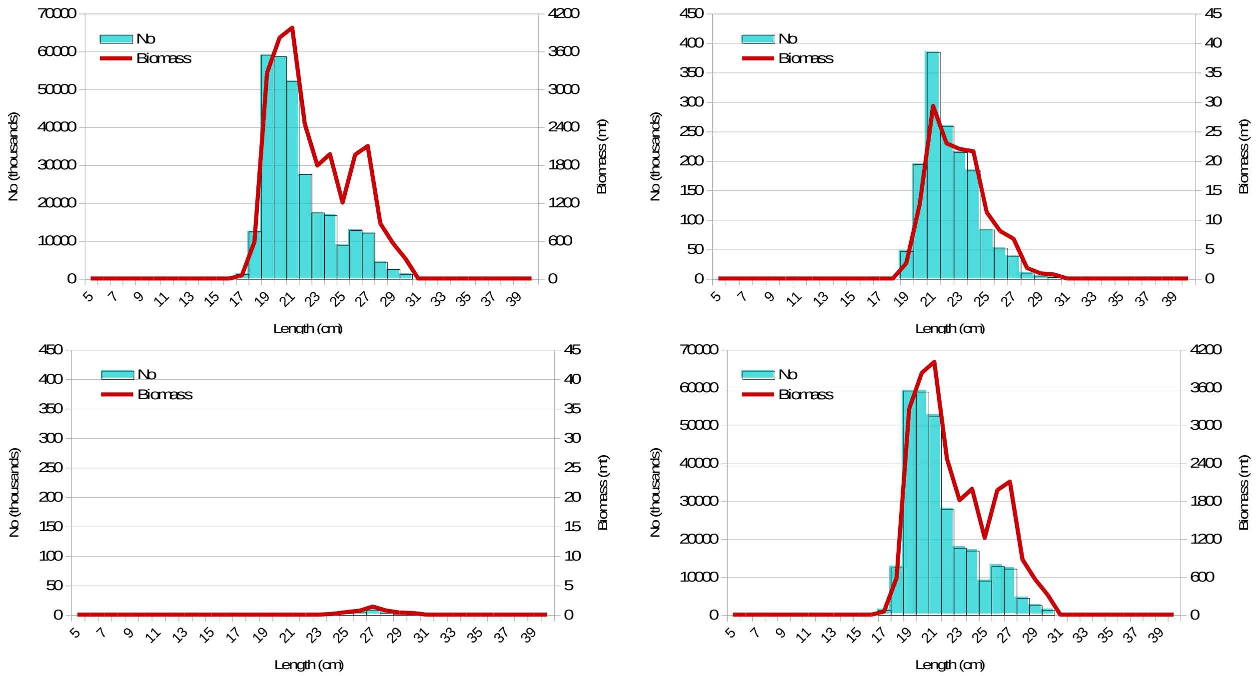


Figure 20. Chub mackerel estimated abundance and biomass per length class in 9aCS (above left), 9aCN (above right), 9aN (below left) and for the total area (below right), note that scales are different

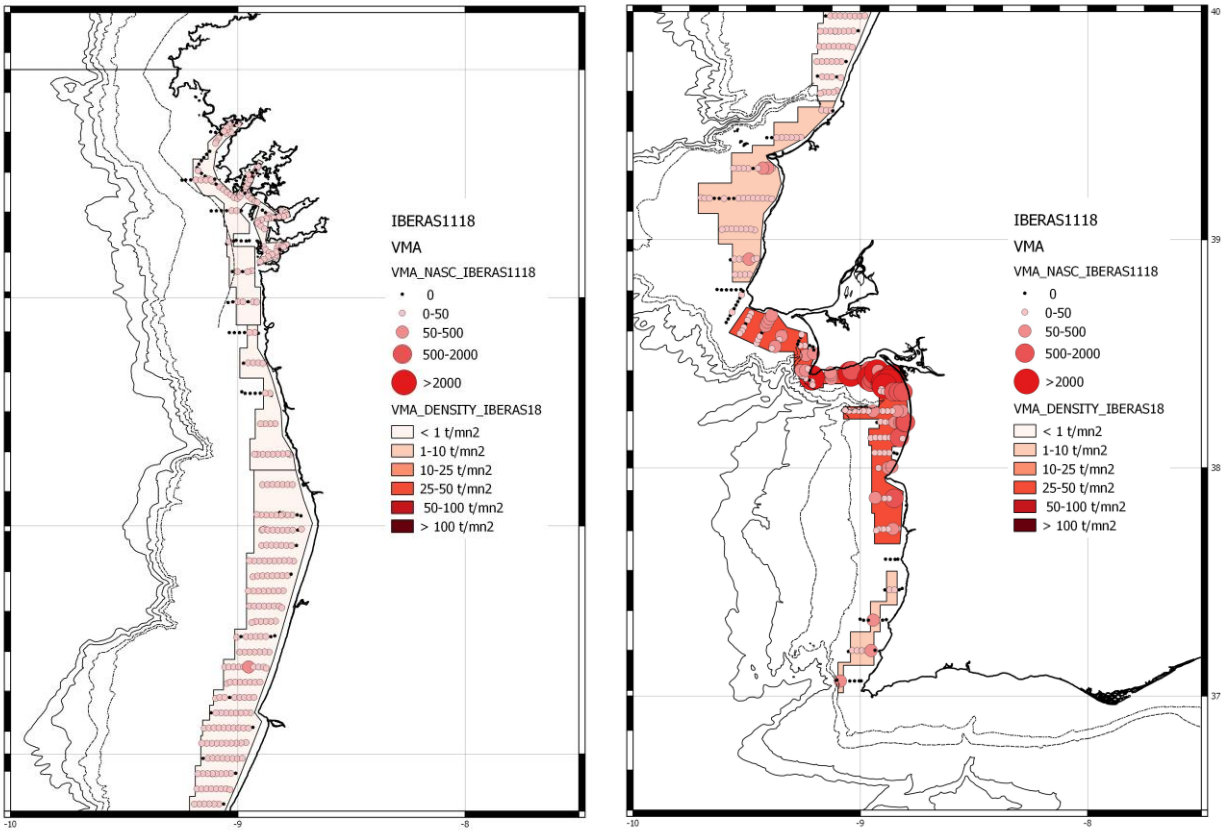


Figure 21. Chub mackerel spatial distribution in IBERAS 1118. Dots represent the NASC values attributed to chub mackerel and the polygons the strata together with the relative density

DISCUSSION AND CONCLUSIONS

IBERAS1118 is the first attempt for surveying the main potential area of the recruitment of the Iberoatlantic stock of sardine using the new EK80 echosounder on board of the Spanish Research vessel Ramón Margalef. The survey was carried out by an integrated team composed by scientists and technician of both IPMA (Portugal) and IEO (Spain) research centres.

In general, weather conditions made difficult to undertake all the foreseen activities. In spite of this, the expected acoustic coverage was performed together with the fishing stations. However, some concerns could arise due to the impossibility for surveying the coastal waters for safety reasons due to the height of the swells. Nevertheless, on account figure 2, the school distribution along depth showed that the bulk of them were located at around 30 m, within the depth range of the surveyed area. Besides, the bad weather conditions, with heavy rain left the coastal waters less salty and fish use to avoid these kinds of waters. In fact, in 9aN, the bulk of the 0 group seemed to be located really far from the coastal areas. Even more, in 2017, mean depth of the sardine abundance was estimated at 25.90 m and 17.09 for anchovy. This year was 20.04 and 17.72, which means, mean depth remained stable for anchovy and more in shallower waters for sardine but still inside the surveyed area. On account these results, it seems only few fish would be located near shore, thus, outside the vessel operative range, so the achieved results are comparable to those of the 2017 survey (JUVESAR).

Comparing both survey, it was a clear change in the distribution pattern of sardine, as shown in figure 22.

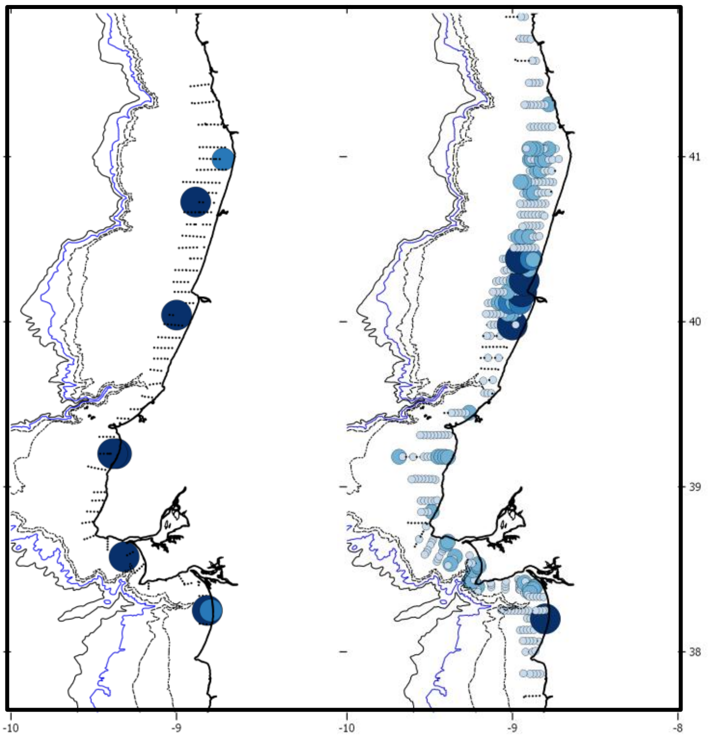


Figure 22. Sardine spatial distribution in JUVESAR 17 (left) and IBERAS 1118 (right). Dots represent the NASC values attributed to sardine

In 2017, sardine showed a very patchy and dense distribution with only few hot spots (six in total), while in 2018, although some dense patches, the distributions was wider, showing a continuity among transects.

For anchovy this feature was even more clear, with a clear expansion of the distribution area. As shown in figure 23.

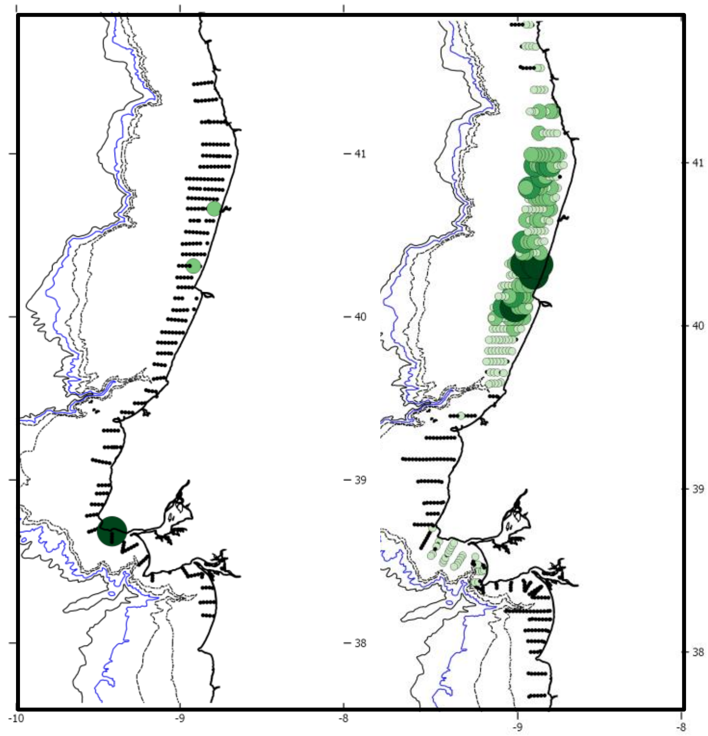


Figure 23. Anchovy spatial distribution inJUVESAR 17 (left) and IBERAS 1118 (right). Dots represent the NASC values attributed to anchovy

Probably, the number of hotspots with high fish concentration is a feature during winter time, with concentrating in smaller areas, and spreading its distribution area towards wider areas in spring time, when food availability increases. In northern areas, herring and mackerel among other species exhibit this kind of behaviour, with most of the fish concentrated in few but big schools (Huse and Ona1996). During this survey anchovy, and in lesser amount chub mackerel, occurred in big and almost isolate schools. These big schools increase the uncertainty by decreasing the precision as long as they have an important impact in both overall mean abundance and its variance estimates. In order to avoid this, it should be better to perform the survey earlier, (i.e. beginning fall, end summer), when fish would occur in a wider area. Besides, if the survey is performed in September instead November, the survey will take place at the same time of the JUVENA survey, thus giving a synoptic coverage of the Iberian Peninsula. In any case, placing the intertransect distance at 4 nmi apart, sounds reasonable given both the aggregation and the spatial distribution patterns.

During IBERAS survey, although the estimated biomass of anchovy was much higher than that of the sardine (round 200 kt and 35 kt respectively), it should be noted that the biomass of the young fish (recruitment) was higher in sardine (round 14 kt) than that assessed for anchovy (only 6 kt). Although the anchovy spawning season takes place later in the year (e.g. March -June), in the Bay of Biscay pre-recruits are found even in September in open waters and accessible to the survey vessel, so the recruitment would be also accessible to the surveyed area unless, as in the northern part, it is unavailable because is located off-survey track.

Comparing with previous juvenile target surveys in Portugal (JUVESAR time series), the number of sardine juveniles in 2018 was higher than those estimated in 2017 (525 million fish in 2018 and 472 million fish in 2017, see table 13), although the biomass was higher in 2017 (1 kt more). In any case, these figures are the lowest of the time series 2013-18. Curiously, the assessed anchovy biomass in

2018 is the highest of the time series but the strength of the recruitment is the weakest of the time series.

The spring surveys PELAGO and PELACUS will confirm in any case the strength of both sardine and anchovy recruitment.

Survey	**Sardine**				**Anchovy**			
	Total (millions)	Total (kt)	**Recruits** (millions)	**Recruits (kt)**	Total (millions)	Total (kt)	Recruits (millions)	Recruits (kt)
Série Juvesar								
JUVESAR13	2 093	22	1 986	19,4	-	-	-	-
JUVESAR15	2 831	45	2 822	44,4	3 870	30,0	3 835	29,0
JUVESAR16	1 264	57	899	28,6	2 836	14,4	2 835	14,4
JUVESAR17*	2 077	120	472	14,6	2 145	38,0	570	4,7
IBERAS/JUV18 +	**629,3**	**20**	**525**	**13,5**	**8 836**	**181,6**	391	2,9
Exetended area								
JUVESAR17**	2 292	132	472	14,6	2145	38,0	570	4,7
IBERAS/JUV18 ++	643,8	20,5	535,3	13,8	8 836	181,6	391	2,9
IBERAS/JUV18+++	818,7	35,7	536,3	13,8	8 836	181,6	391	2,9

Table 13 – Sardine and anchovy abundace and biomass estimates in the November time seires 2013-18 (*only in the area between Espichel Cape and northern boundary; + area between Caminha and Espichel Cape for interannual comparison purposes; ** from Póvoa to Melides; ++ from Caminha to Sagres; +++ whole surveyed area (from Galiza to Sagres). Recruits mean age 0 for sardine and L< 12 cm for anchovy.

CONSULTED IBLIOGRAPHY

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