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

IBERAS0919
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:	IBERAS1119	
Vessel name:	Angeles Alvariño (46.70 m length, 10.50 width 988 GRT, 900 kW diesel-electric)	
Dates:	05-27/09/2019	
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 20 to 100 isobath	
Main sampling procedures	EK-80 at 18-38-70-120-200 kHZ acoustic frequencies. 839 nmi prospected. Only day time Pelagic fishing stations: 16 Marine mammals and birds observations (not yet determined) Hydrological characterisation. 48 stations	
Personnel 1st leg Vigo/Lisboa Dates: 07 to 21/09	AMORÍM, PEDRO ANGELICO, MARIA MANUEL CARRERA LÓPEZ, PABLO DA CONCEIÇÃO MENDOZA, ANTONIO PEDRO DÍAZ CONDE, PAZ DOS SANTOS BARRA, JORGE MACHADO DE ABREU, PAULA	MAGALHÃES DA SILVA, ELISABETE MORENO MARQUES, ANA MURCIA ABELLÁN, JOSÉ LUIS SÁNCHEZ BARBA, MARÍA SÁNCHEZ HERMOSÍN, PABLO SANCHO MARTÍNEZ, PAULA
2ndleg Lisboa/Cádiz Dates: 22-27/09	AMORÍN, PEDRO AUTÓN DÍAZ, URBANO CARRERA LÓPEZ, PABLO DA CONCEIÇÃO MENDOZA, ANTONIO PEDRO DÍAZ CONDE, PAZ FEIJÓ, DIANA MAGALHÃES DA SILVA, ELISABETE	MURCIA ABELLÁN, JOSÉ LUIS PASTOR, JOÃO PEREIRA GAMEIRO, CARLA PEREIRA NUNES, CRISTINA SÁNCHEZ BARBA, MARÍA SÁNCHEZ HERMOSÍN, PABLO
Report authors	Pablo Carrera, Pedro Amorim, Ana, Moreno, María Manuel Angélico, Paz Díaz Conde	

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, for the purse-seine fishery, the recent lack of sardine.

IBERAS survey was designed attending the experience achieved by IPMA through the JUVESAR survey (targeting sardine recruitment in northwest Portugal), by Azti and IEO through the JUVENA survey (to improve the assessment/management of the Bay of Biscay anchovy) and by IEO through ECOCADIZ recruit survey (targeting sardine and anchovy recruitment in the Gulf of Cadiz). IBERAS main objective is to get a recruitment index for both species in Atlantic waters of the Iberian Peninsula, aiming to improve the estimation of the strength of the recruitment of the Iberoatlantic sardine and the western component of the south anchovy population.

In 2018 the survey was undertook in November. However both the bad weather conditions, that limited the number of effective survey days, and the aggregation and distribution patterns of the fish, with rather isolate and big schools (figure 1) that made difficult either to find and, specially, to improve the precision of the biomass estimates (figure 2), led to change the period of the survey. Therefore, the survey was shifted to September, at the same time of JUVENA, which in turn allows a synoptic coverage of the Iberian Peninsula at the end of summer, beginning of fall.

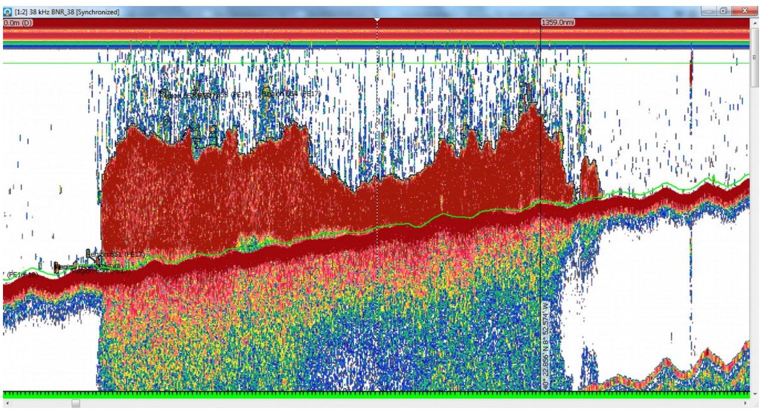

Figure 1: mega-school of anchovy recorded in 2018 during IBERAS north Figueira da Foz

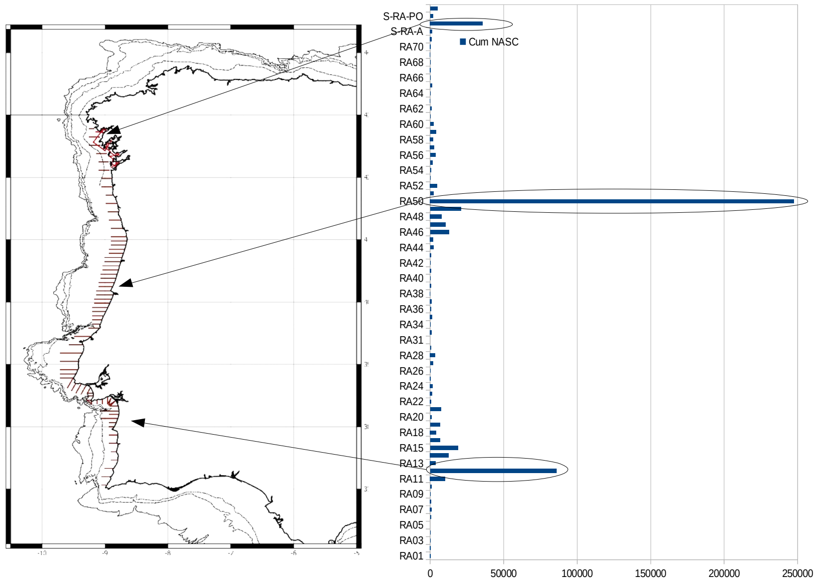

Figure 2: Cumulated backscattering energy per track in IBERAS1118. 3 of them are highlighted due to contribution to the total energy.

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 relative abundance of apical predator along the surveyed area

MATERIAL AND METHODS

Survey was carried out on board R/V Angeles Alvariño, a similar vessel of Ramón Margalef, used in the previous survey IBERAS1118, from 5th until 27th September, departing from the port of Vigo and arriving to Cádiz harbour on the evening of 27th.

A scale was scheduled in Lisbon on 21st . Two first days were used to calibrate the transducers. For this purpose, the vessel moored in the Pontevedra Bay. The wind strength did not to allow the calibration during the first day, which was completed on 6th.

Working Area

From Finisterra cape until São Vicente cape, from shoreline (20 m) to 100 m isobath over an adaptive grid with 73 tracks distanced between 4-8 nmi on account the potential recruitment distribution area of both sardine and anchovy. Tracks were enlarged or shortened accordingly. Figure 3 show the foreseen survey track and table 1 the expected survey coverage and time.

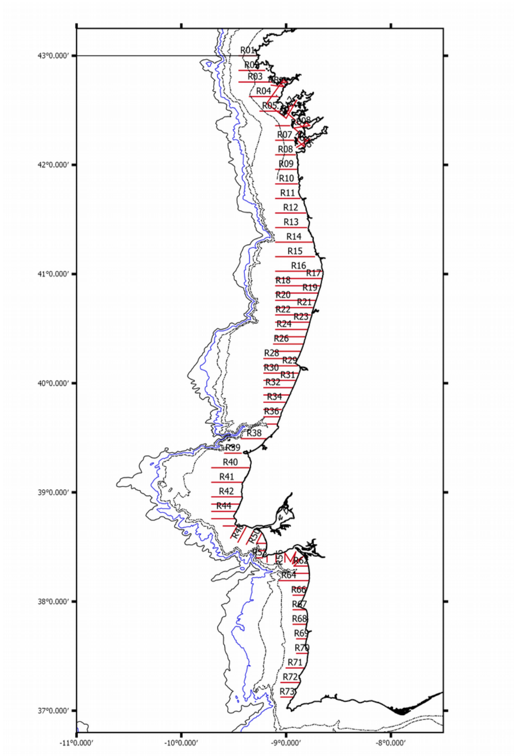

Figure 3: Survey track

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

Zone	No tracks	No of nautical miles		Acoustic	Fishing st.	TOTAL
		track	Unión	hr-days	hr-days	hr-days
Calibration						2
Plataforma 9a N	9	83	75	15-1	12-0.86	27-2
Rías Baixas (9a-N)	23	112	0	8-1	12-0.86	20-2
O. Norte (9a-CN): Caminha-Porto	6	78	48	11.8-1	12-0.86	24-2
O. Norte (9a-CN): Porto-Figueira	12	189	46	23.4-1.67	16-1.14	39.4-3
O Norte (9a-CN): Figueira-Nazaré	10	109	34	14.1-1	8-0.57	22.1-2
O Sul (9a-CS): Nazaré-Roca	9	100	59	15.9-1.14	8-0.57	24-2
O Sul (9a-CS): Roca-Troia	15	141	59	14.09-1	16-1.14	30-3
O Sul (9a-CS): Troia-São Vicente	12	81	78	15.8-1.13	16-1.14	31.8-3
Total	96	831	431	127-10.5	96-6-86	222.23-(17-19)

The methodology was similar to that of the previous surveys and is summarised in ICES Cooperative Research Report No. 332. 268 pp. https://doi.org/10.17895/ices.pub.4599. 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. 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 was not running, CTD profiles for hydrography and zooplankton samples (Bongo 60 and Manta trawl nets) were collected, opportunistically, in some of the transects.

Besides, in specific areas chosen on the core expected distribution area of juveniles, the very shallower waters (15-10 m) were prospected with a portable EK60 with a 120 kHz transducer. For this purpose, the auxiliary dinghy of the vessel was used. As shown in figure 4, the normal tracks (dotted lines) were extended towards the coast (black line), which were prospected by the dinghy. Simultaneously, the vessel steamed the intertrack line (red lines). Results at 120 kHz recorded by both echosounder (EK80 on board Angeles Alvariño and EK60 on board dinghy) were compared.

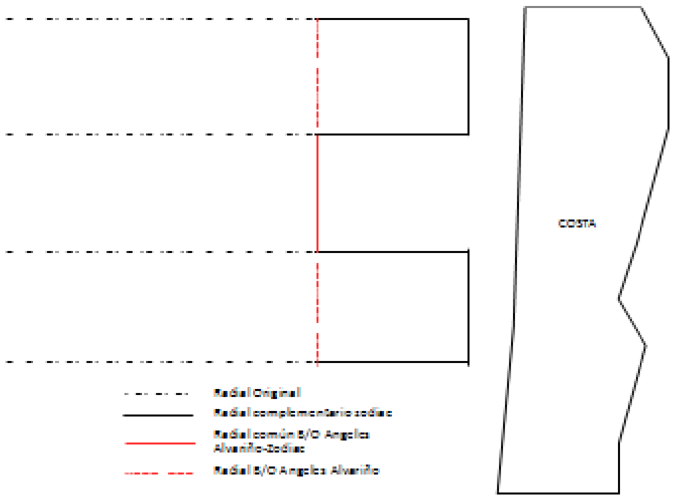

Figure 4: Acoustic scheme in shallower waters

Acoustic

Acoustic equipment consisted of 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-CRR326) during the first two days. The elementary sampling distance 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 then stored in raw format and post-processed using SonarDataEchoview software (Myriax Ltd.) (Higginbottom et al, 2000). All echograms were first scrutinized, the bottom line incorporated, and background noise was also 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 swimbladder 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). The EK60 on board the dinghy had an ES120 7CD. Due to the bad weather conditions this transducer was not calibrated.

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 described in table 2.

Table 2.Ground-truth criteria for fishing stations

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

Hauls considered as the best representation of the fish community for a specific area were used to allocate NASC of each EDSU within this area when no direct allocation 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 table 3:

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))

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.

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 settings in Table 4.

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

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

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 ofρ_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 were located on account the results obtained during the acoustic prospection (i.e. opportunistic accounting the echotraces).

A gloria HOD 352 pelagic fishing net with a vertical opening of about 14 m and 30 m horizontal opening was used. As general rig, 200/400 kg of clump weight were put at each side of the set back (2 m lower wing). The Dyneema bridles (wings) of 70 were shorten to 50 m in shallower waters. A set of Apollo polyice doors with 3.5 m^2 and 750 kg weight were used. Gear performance was controlled using a wired Simrad Sonar FS20 net sounder. For surface tows, a fence buoy was put in upper bridle, opposite to the clumps. Fishing station were mainly performed during daytime but, exceptionally, some tows were conducted at sunset.

Additional biological information was provided by a chartered purse-seiner, who took samples around Aveiro and Figueira da Foz (9aCN).

Plankton and hydrological characterisation

Continuous records of SSS, SST and SSF (flourometry) were taken using a SBE21 Thermosalinograph coupled with a Turner flourometer. Every evening once the acoustic and fishing operations were over, CTD casts and plankton sampling were conducted on some of the acoustics transects. The surveying stations were set at 3nm apart over the transects and the number of stations occupied each night was dependent on the time available (until 24:00 aprox). CTD profiles were obtained with a SBE25 probe and zooplankton sampling was carried out across the top 60m of the water column, using a Bongo net (60 cm diameter, 200µm and 500µm mesh sizes nets); the samples were preserved (200µm: in formalin, 500µm: in ethanol) for further analyses in the laboratory.

Top predator observations

Two observers placed at the bridge of the vessel at a height of 16 m above sea level worked in turns of two prospecting an area of 180° (each observer cover a field of 90°). Observations were carried out with the naked eye although binoculars were used (7x50) to confirm species identification and to determine predator behaviour. Observations were carried out during daylight during the acoustic transects prospection. 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.) were recorded, as well as the 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 share a common database. In addition, an observed from the Portuguese Society for the Study of the Birds, SPEA, has also recorded this information but using the standard methodology for marine birds observation, instead.

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 was 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

The survey was carried out as foreseen. During the first days, NE wind regime was prevalent, which made difficult to perform bongo stations around Galician area; after this episode, compatible with the normal upwelling events in this area, weather was calm and it was only interrupted by an active front with heavy rain during the last weekend. After this front the last 4 days weather was unstable with an increasing strength of the NW wind and swell.

Hydrographic conditions

The month of September 2019 on the Atlantic Iberian region was meteorologically characterized by distinct periods, during the first few days, the atmospheric temperatures were above average for the season, with the influence from a continental air mass, then the wind shifted and blew from N, NW during a short period which was followed by some rather calm days, around the middle of the month; towards the end of the month, in particular during the last 10 days, some cold weather fronts arrived from the west, the atmospheric conditions became unstable and some heavy showers occurred and the air temperature decreased, reaching values below the typical means for late September.

The distributions of sea surface temperature and salinity observed during the IBERAS19 survey (7-26 Sept) shown in figure 5 reflect the weather conditions described above and the usual regional patterns (temperature and salinity increasing from north to south and some regions of fresh water influence).

At the beginning of the survey, in the northern region, the water temperature was between 13 and 14.5ºC, in the Galician rias and across the shelf; to the south of Aveiro the temperatures observed were above 15ºC and reached the highest values, 18-18.5 ºC, in the southern coast off Alentejo. The salinity map shows an interesting plume from Tagus river which resulted from just a couple of showery days that occurred around the days 21 to 23. The usually much more conspicuous Douro river plume was not apparent during the first half of the month (when that area was surveyed) in consequence of the preceding dry summer season.

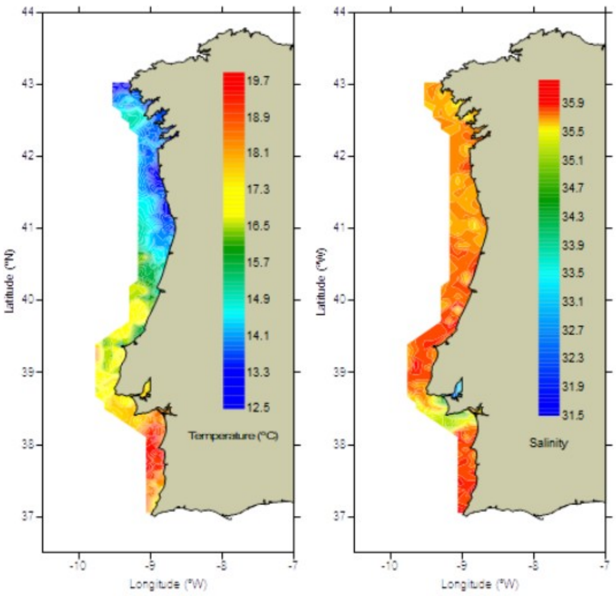

Figure 5: SST and SSS during IBERAS 0919

Sixty plankton stations were analysed and the plankton volumes (ml/10m^3) from the 200 µm mesh size net were determined. The distribution of plankton volume (ml/10m3; from 200 µm net), depicted in figure 6, shows clearly higher biomass on the northern shelf, in particular in the region between Aveiro and Douro, which was also associated to the colder (upwelled) coastal waters and where abundant fish schools, marine mammals and birds were observed. To the south of Aveiro the zooplankton biomass was lower but a clear pattern of richer inshore waters and poorer mid to offshore region was still apparent. The lower values of plankton abundance were observed to the south of Cape Espichel. In the samples collected in the northern area the euphausiid *Nyctiphanes couchi* (adults and larvae) was very abundant and its dense swarms were visible in the echosounder results. The swarms were identified by fishing stations, as shown in figure 7.

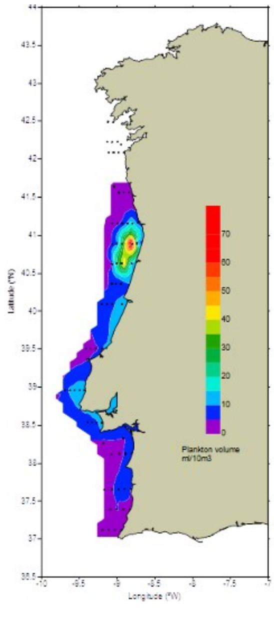

Figure 6: Plankton volume (ml/10m3) distribution derived from the Bongo60 (200 µm mesh) during IBERAS 0919 (the surveying stations (CTD and zooplankton) are represented by black dots.

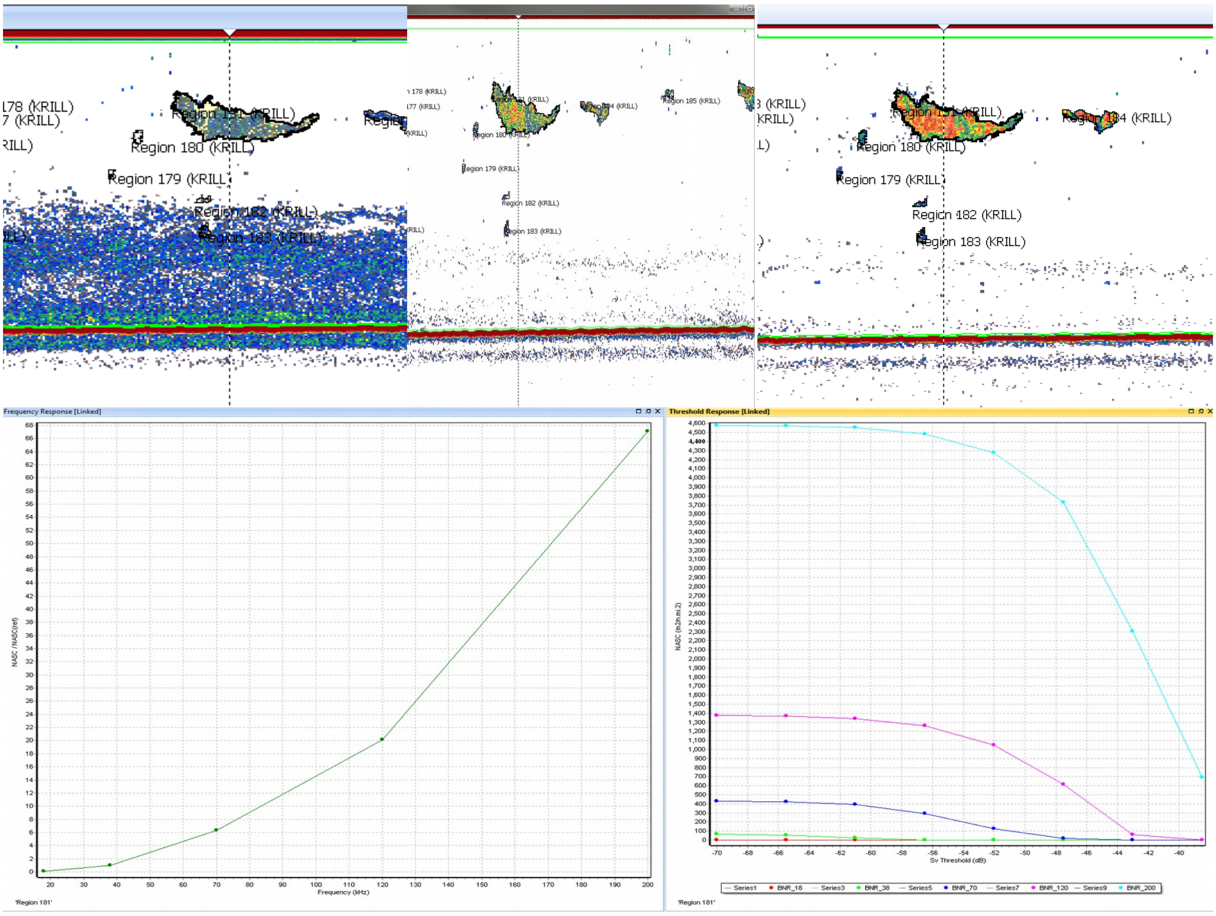

Figure 7: Echogram at 38 (left), 120 (middle) and 200 kHz (right) of a krill school and its frequency and threshold responses (below).

ACOUSTIC

School extraction and total backscattering energy

A total of 6286 echotraces were extracted, accounting for a total NASC (s_A) of 785176 m^2 nmi^{-2}. On tracks, NASC values were 430069 m^2 nmi^{-2}, which was similar to that recorded in 2018 (476837, a 10 % lower). Figure 8 shows the sum of NASC per track along the surveyed area.

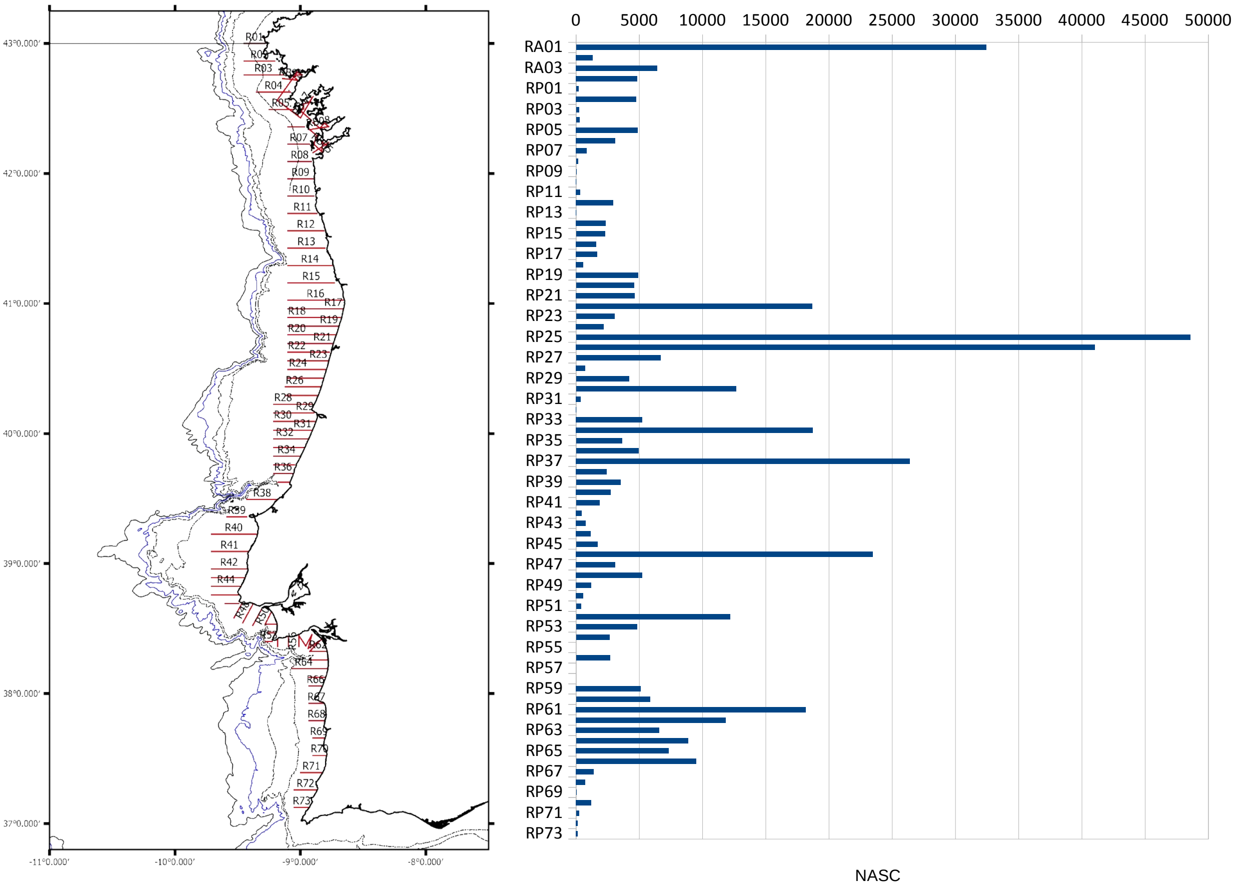

Figure 8. Cumulated NASC values per track

Fish were more evenly distributed than in the previous year, although some tracks (e.g. Ría de Muros or north Figueira da Foz) had an important contribution to the total backscattering, but less than the recorded last year when a single track accounted for the 52% of the total energy.

Bathymetric distribution of schools is significantly different from that recorded last year. The weighting average (weighting factor, s_A) shifted from 30.22 m (c.v. 0.50) to 37.53 (c.v. 0.38), with a mode located at 47.5 m (32.5 m in 2018), as shown in figure 9.

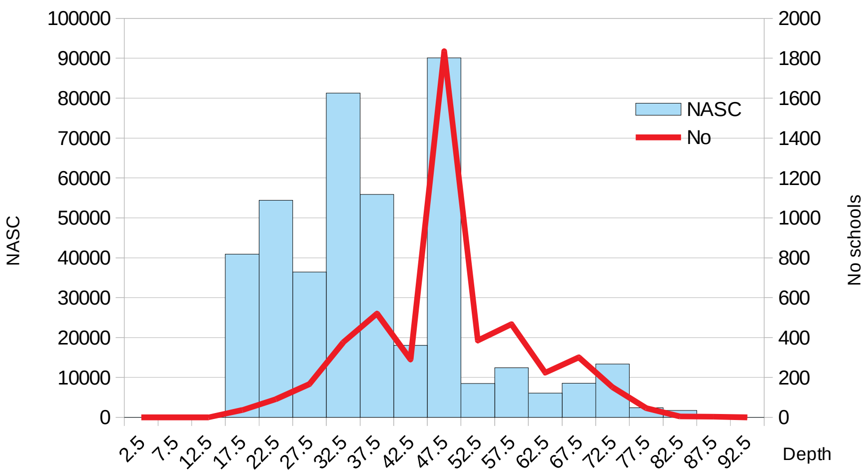

Figure 9. Number of schools and their cumulated NASC values per depth strata (5 m)

As in 2018, it seems the main school distribution area was covered as long as only few schools were found in very shallower waters. In the area covered by the dinghy only few schools were recorded and even the inclusion of coastal inter-transects had little impact on the estimation of the mean NASC value.

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. The situation was even worse than that observed in 2018. In spite this, a total of 16 fishing station were done, accounting a total of 5.1 mt and more than 4.0E+5 specimen as shown in table 5. It should noted that four hauls were qualified as deficient according to the ground-truth criteria described in table 2.

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)

	TOTAL CAP (Kg)	No ind.	No Fishing st	Sample weight (kg)	Measured fish	Mean length	%PRES	% Catch_W	% Catch_No
JAA	8	196	2	8	196	16.54	12.50	0.15	0.05
MAC	73	886	6	27	296	21.94	37.50	1.44	0.22
HKE	3	18	2	3	18	25.72	12.50	0.05	0.00
HOM	490	27871	12	35	772	16.03	75.00	9.67	6.86
PIL	1600	70412	10	25	819	14.55	62.50	31.56	17.33
SNS	2413	279219	4	5	461	13	25.00	47.60	68.71
BOG	7	44	3	2	17	23.79	18.75	0.14	0.01
VMA	319	3677	8	50	556	22.14	50.00	6.29	0.90
BOC	3	17	3	3	74	12.33	18.75	0.06	0.00
SEAB	26	112	4	14	53	24.63	25.00	0.52	0.03
ANE	118	4614	1	3	117	15.10	6.25	2.33	1.14
KRILL	9	19286	1	0	60	2	6.25	0.18	4.75
Total	**5068**	**406352**	**16**	**174**	**3439**				

As in 2018, horse mackerel had the higher presence and was found in 75% of the trawl haul, being also noticeable the presence of sardine (62,5%) and chub mackerel (50%). On the contrary, anchovy was found only in a 6,25% with a small contribution in the total catch (2%). It should be also highlighted the presence of longspine snipe fish, *Macroramphosus scolopax.* Catches have significantly increased since the last year, accounted for 47,6% of the total catch in weight, although was caught in only 4 fishing stations. It was the dominant species at water deeper than 50 m in southern part.

1 Chub mackerel echotrace identification

There has been an important change in both distribution and aggregation patterns of chub mackerel schools. While in 2018 (November) occurred in the southern part in dense near bottom schools, this year (September) the distribution area expanded northward and instead dense school main occurrence was in epipelagic aggregations, not particularly dense, but wide. Two fishing stations were performed to identify it. Chub mackerel echotrace and its frequency response is shown in figure 10.

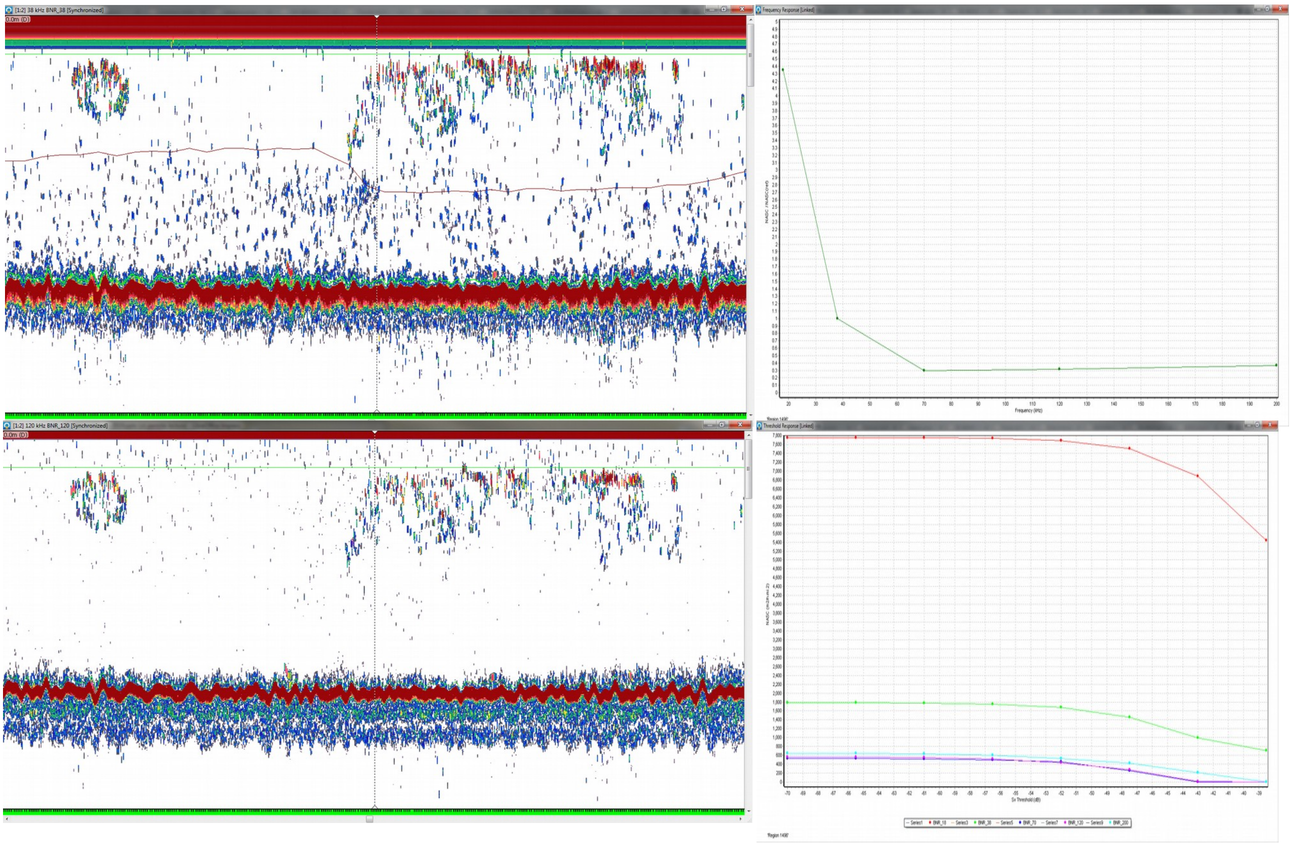

Figure 10. Echogram showing echotraces attributed to chub mackerel (38 kHz above, 120 kHz below) and its characteristic frequency and threshold responses (ground truthed by fishing station)

Although with some variability, frequency response shows a big decrease in backscattering energy from 18 to 38 kHz, with a lesser drop from this later frequency to 70 kHz and then a slight or clear increase from this to 200 kHz.

2 Longspine snipe fish echotrace identification

This fish species was mainly located south cape Roca (e.g. Tagus area and Alentejo). The echotraces were mainly observed close to the bottom and the shape of these were very variable, occurring sometimes as a bottom layer, loose aggregation over the bottom, sometimes raising towards upper layers or in schools in middle waters. It was also very difficult to get a single frequency response pattern as it varied according to the aggregation pattern (e.g dense/loose combined with bottom or middle water occurrence. At fishing station the fish tend to scape diving downwards. In figure 11 shows this variety in occurrence.

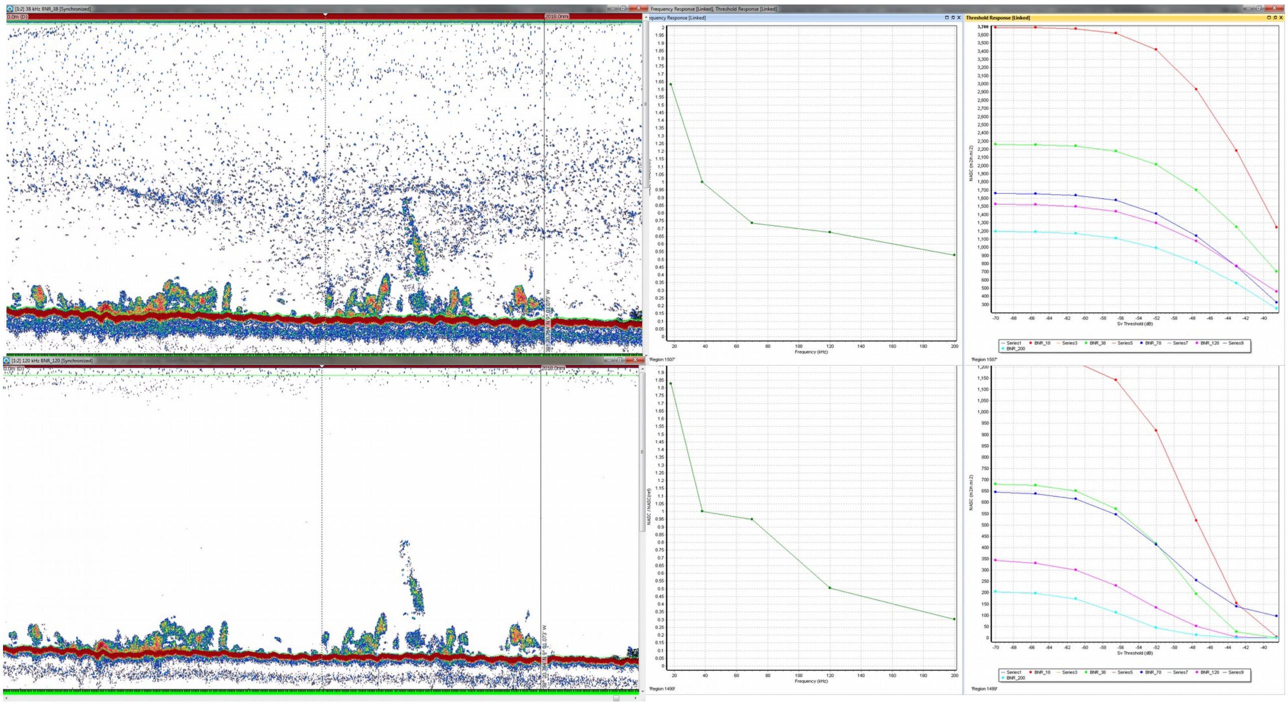

Figure 11. Echogram showing echotraces attributed to longspine snipe fish (38 kHz above, 120 kHz below) and its characteristic frequency and threshold responses for both raising middle water school (above) and bottom aggregation (below)

3 Sardine echotrace identification

Together with coastal echotraces, already observed in the previous survey, sardine occurred in epipelagic different sized schools extending from coastal waters towards the continental shelf. It should be also noted the lack of any kind of reaction from these fish, remained even very close of the active surface of the transducer (e.g. within the near field). They were mainly recorded offshore (40 m of water column onwards) around Figueira da Foz, and in coincidence with the warmer waters (e.g. outside of the influence of the upwelling areas). Sardine, contrary to that observed for chub mackerel and longspine snipe fish, had a very flat threshold response, which means that for all frequencies there is a higher uniformity in s_V values; indicating similar density all around the school volume (figure 12). This behaviour is also observed in the big schools, as those located in Galician waters. Nevertheless the frequency response could vary between a rather flat (e.g. similar energy for lower frequencies and slightly lower for higher frequencies) to a decreasing values from the lower frequency (18 kHz). To illustrate this, figure 13 shows a thick sardine school recorded in Galicia with a threshold response flat and a rather flat for lower and higher frequencies with a jump among these, different from that observed in the case of epipelagic sardine shown in figure 12, where the frequency response is decreasing although the threshold response is very similar in both cases. In both cases the presence of sardine was corroborated with a monospecific catch at the trawl haul stations.

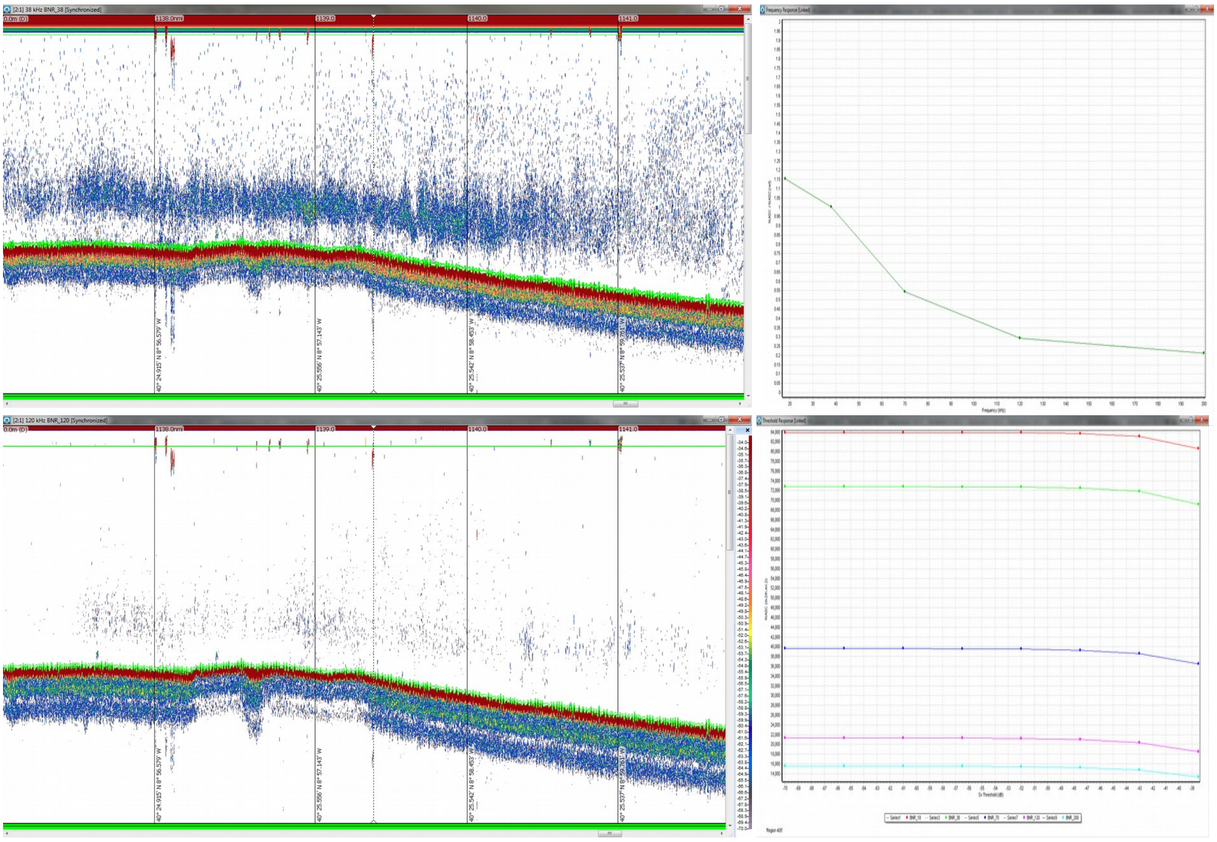

Figure 12. Echogram showing echotraces attributed to sardine (38 kHz above, 120 kHz below) and its frequency and threshold responses in Figueira da Foz area

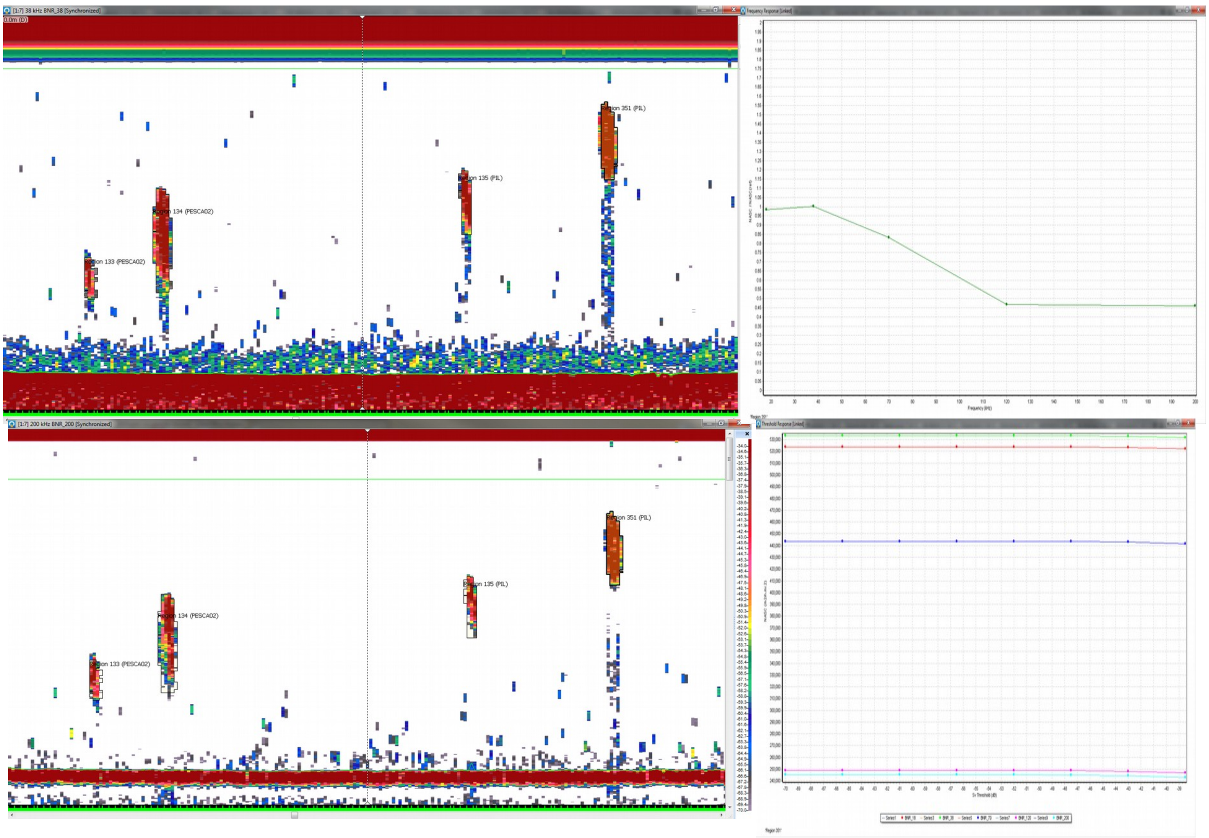

Figure 13. Echogram showing echotraces attributed to sardine (38 kHz above, 200 kHz below) and its frequency and threshold responses in Galicia area

4 Fishing station used for echotrace allocation

On survey tracks, from the total of 430069 m^2 nmi^{-2} , 278322 were directly allocated to fish species (64% of the total attributed backscattering energy). 201171 m^2 nmi^{-2} were allocated to sardine (82% of them directly allocated) and 107718 m^2 nmi^{-2} to chub mackerel (77% directly allocated). The remained energy (1517547 m^2 nmi^{-2}) was allocated accounting the results fo the fishing station. It should be also note that 39013 m^2 nmi^{-2} were left as unallocated (9% of the total backscattering energy) as has been recorded in a potential multi-specific environment in which no fishing station was undertook due to the presence of static fishing gears. Figure 14 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 sardine 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*** and, within echotype, the representative near fishing station . 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.

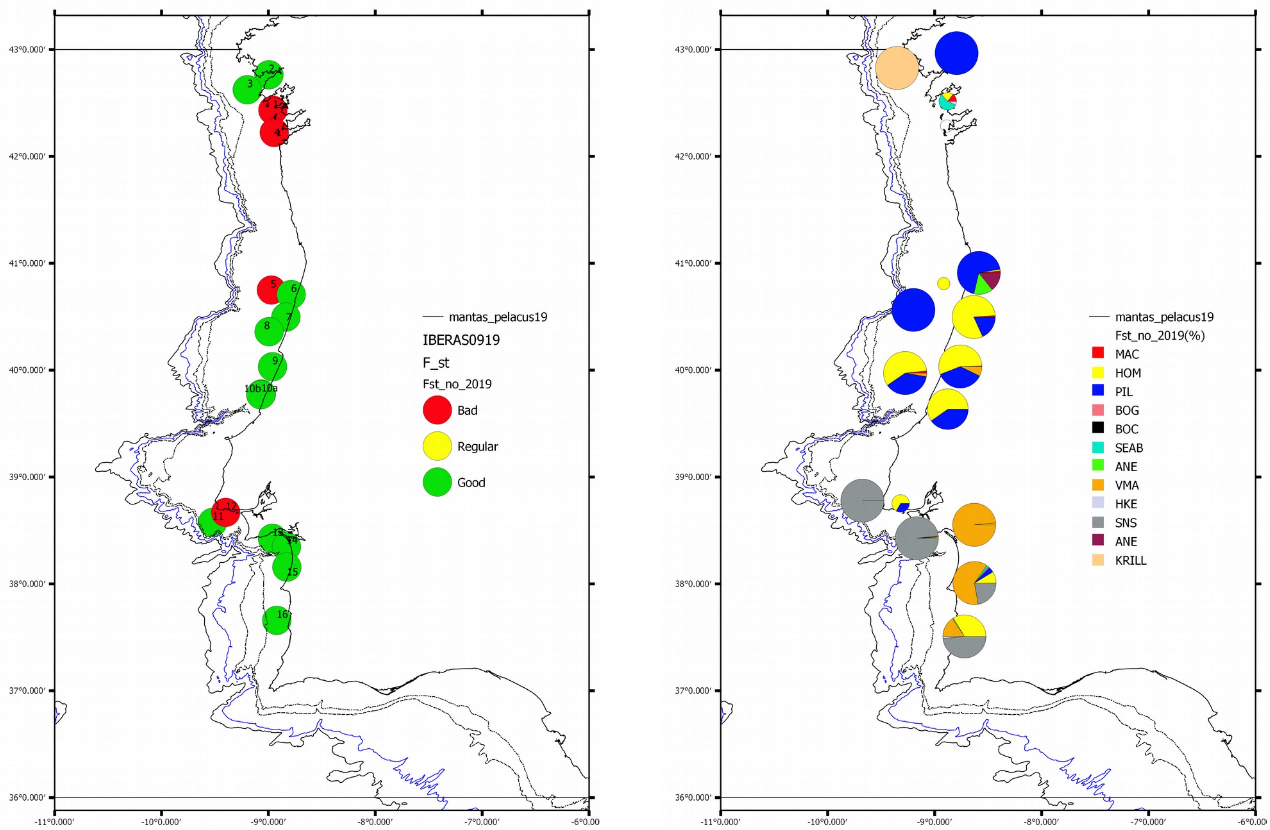

Figure 14. Left panel: location of the fishing station and traffic-light quality control. Right panel: Fish proportion accounting the Nakken and Dommaness method (BWH, blue whiting; MAC, mackerel; HAK, hake,; HOM, horse mackerel; PIL, sardine; JAA, bluejack mackerel; BOG, bogue; MAS, chub mackerel; SEAB, seabreams; ANE, anchovy; SNS, longspine snipe fish)

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. Major changes in relation to 2018 cruise is the important increase in sardine and the decrease in anchovy backscattering energy.

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, KRILL, euphausidae)

	MAC	HOM	PIL	JAA	BOG	VMA	BOC	ANE	SNS	KRILL
NASC	65	23192	201171	4084	859	139600	4	5535	14302	1031
Depth	12.10	33.49	21.39	42.85	42.87	27.67	52.53	13.49	55.30	46.36
s.d.	2.84	10.28	4.26	5.05	4.95	6.14	6.08	3.75	7.72	3.39
ic	0.38	1.39	0.58	0.68	0.67	0.83	0.82	0.51	1.04	0.46
Dist	218.41	212.14	213.63	73.18	74.02	134.48	83.37	188.48	82.71	267.04
s.d.	7.77	49.01	31.54	4.77	4.02	39.69	1.89	25.00	5.50	19.04
ic	1.05	6.63	4.27	0.65	0.54	5.37	0.26	3.38	0.74	2.58

Figure 15 shows the spatial distribution of the center of gravity as well as the cumulated NASC along distance from the origin. Longspine snipe fish is clearly located between Sines and Cabo da Roca (areas 2 to 4). Chub mackerel has a similar main distribution area but has also two other occurrence areas, located between Mondego and Douro rivers (area 6) and also in Galicia. The bulk of the sardine distribution is as well located in area 6, more specific, between Figueira da Foz and Aveiro and second maxima in Galicia. Horse mackerel in spread throughout the whole surveyed area although this central-north part of Portugal is the most suitable. In spite the gap of two months between IBERAS 1118 and IBERAS 0919, sardine, mackerel and horse mackerel seems to have their main recruitment area in 9aCN, between Mondego and Douro rivers.

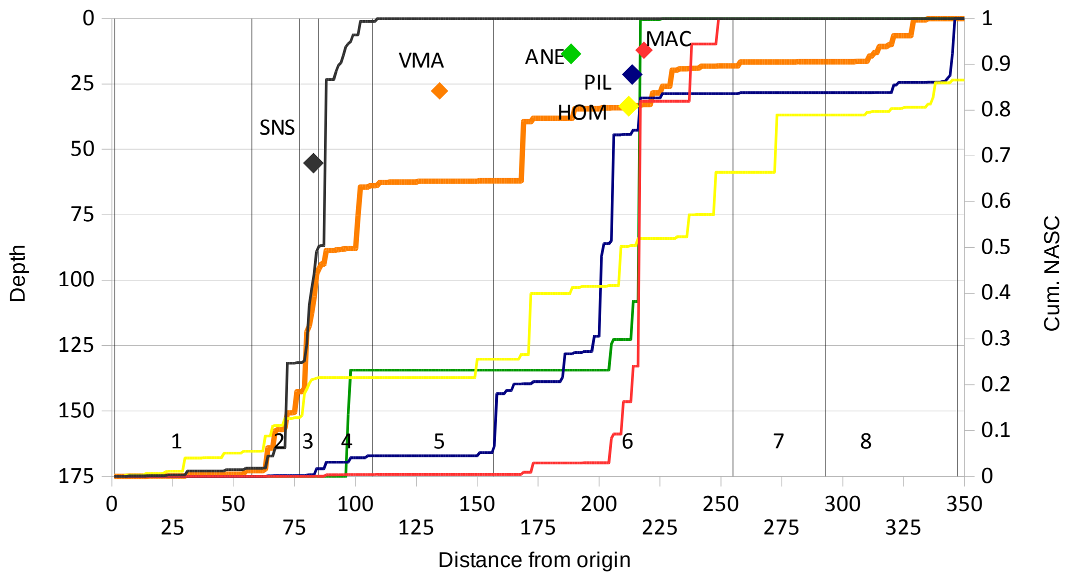

Figure 15. Center of gravity and cumulated NASC for the most important pelagic species (ANE, anchovy-green-; PIL, sardine -blue-; HOM, h. mackerel -yellow-; MAC, mackerel -red-; VMA, C. mackerel -orange-; and SNS, longspine snipe fish-black-)

1 Sardine assessment

Accounting the length distributions obtained at the fishing station and the NASC spatial distribution, sardine was divided in 7 strata, 3 in both 9aCS and 9aCN, and a single stratum in 9aN.

Table 7 summarises the sardine assessment. A total of 135573 tonnes, corresponding to 5962 million fish were estimated. The bulk of the distribution was found in 9aCN (118.5*10^3 tonnes).

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

		SURVEY:	IBERAS 0919 SARDINE						
ICES-Div	**Region**	**No**	**Mean**	**Surface**	**Fishing st.**	**PDF**	**No (million fish)**	**Biomass (tonnes)**	**Density (Tn/nmi-2)**
9a-N	Rias Baixas	87	374.35	157	P37-P40-P43-P44-P46	S01	422	9980	64
	Total	**87**	***374.35***	**157**			**422**	**9980**	**64**
9aCN	Viana Castelo	1	405.83	12	P31	S03	36	792	67
	Aveiro	95	1331.09	398	P26-P28-P29	S04	4594	80912	203
	Nazaré	25	1494.15	106	P26-P28-P29	S04	792	36790	347
	Total	**121**	***1357.14***	**516**			**5422**	**118494**	**230**
9aCS	Ericeira	7	405.51	24	P18	S05	41	2400	100
	Caparica	4	1374.85	12	P18	S05	69	4035	339
	Alentejo	67	10.89	224	P15	S05	9	664	3
	Total	**78**	***116.25***	**260**			**119**	**7099**	**27**
	Total Spain	***87***	***374***	***157***			***422***	***9980***	**64**
	Total Portugal	***199***	***871***	***776***			***5540***	***125593***	**162**
	TOTAL	**286**	***720***	**933**			**5962**	**135573**	**145**

The assessment was clearly dominated by young of the year fish (YOY), which accounted for 75% of the total biomass and the 92 % of the estimated abundance. In relation with that estimated in previous year there was an important increase, from 14x10^3 mt to 101x10^3 mt. Length distribution shows two clear modes, both belonging to YOY, at 9 and 13.5 cm; a third mode is also observed for adult fish peaking at around 18-19 cm as shown in figure 16. In southern part no YOY were observed.

Figure 17 shows the spatial distribution accounting the NASC values. Main distribution area is located around Figueira da Foz, being similar that observed last year but extending towards the continental self. From this area, there is an important gap towrads Galicia where fish were only located inside the Rias. The same perception of the sardine distribution during this month was achieved from the fishermen. Together with these, a third area was between Ericeira and Sines

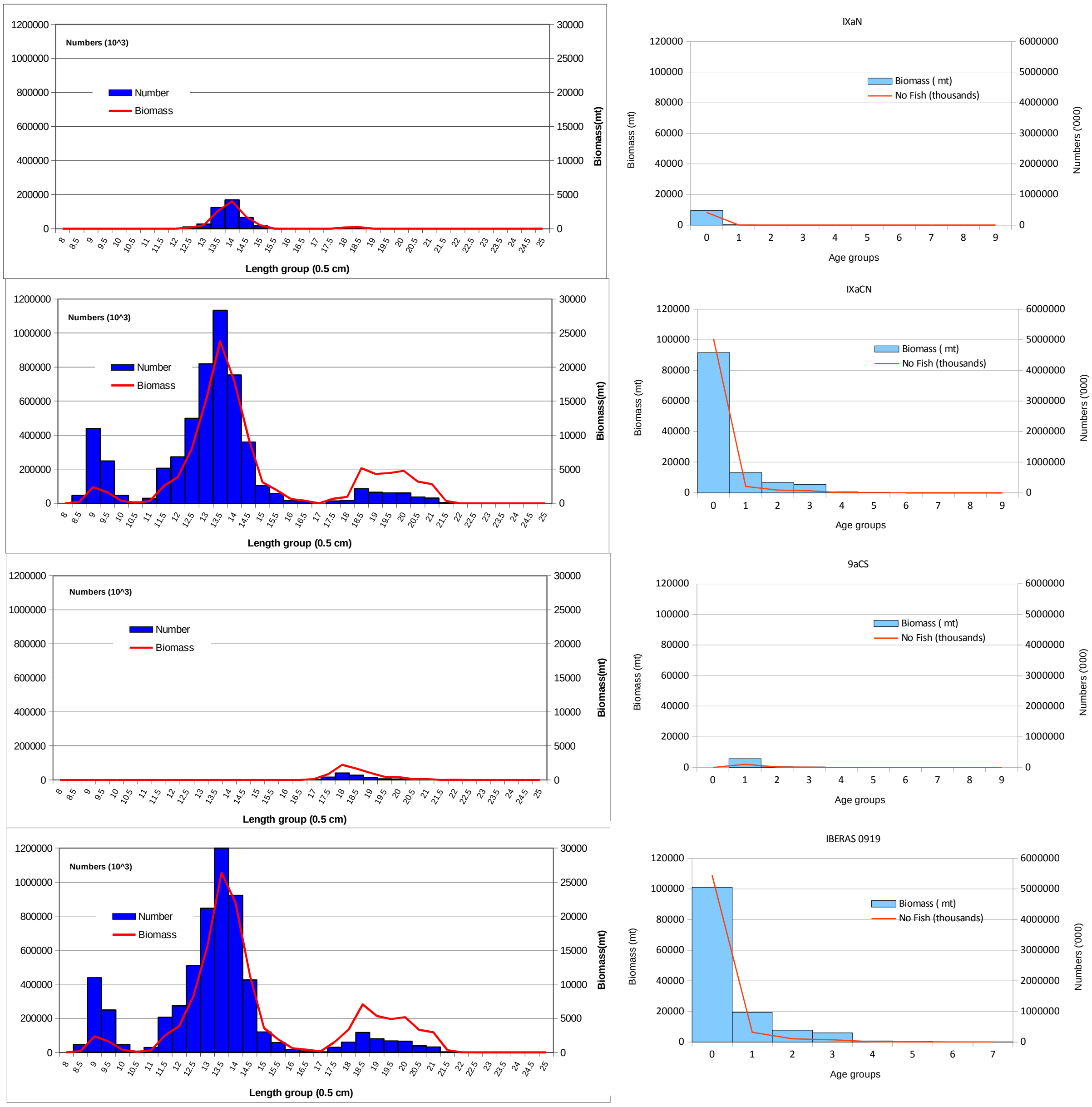

Figure 16. Sardine estimated abundance and biomass per length class (left panels) and age group (right panels) in 9aN, 9aCN , 9aCS and for the total area (below)

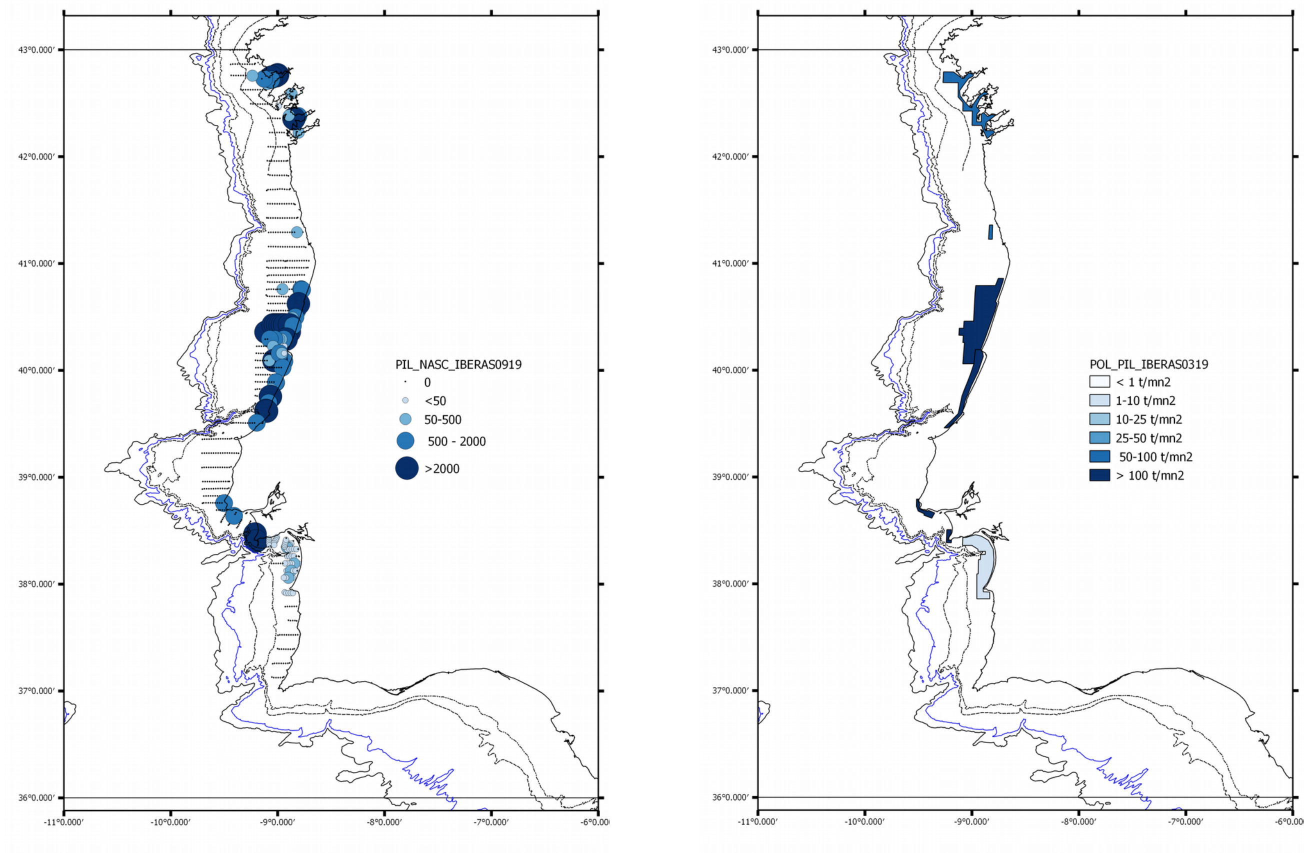

Figure 17. Sardine spatial distribution in IBERAS 1119. Dots represent the NASC values attributed to sardine and the polygons the strata together with the relative density

Table 8a-d is shown the sardine assessment by length group and age classes per ICES Sub-Division and for the whole area. It should be noted that the survey was only targeting on juveniles over its main expected distribution area and, therefore, little information on other ages can be derived from this surveys. All recruit (YOY) were found in northern waters, mainly around Figueira da Foz, (9aCN) with a mean length of 12.94 and two modes, at 9 and 13.5 cm. In Galician waters, mean length of YOY was slight higher (13.87 cm), with a single mode at 14 cm. No recruits were found in 9aCS. Few fish belonging to age group 1 were estimated (5% ot total abundance), but the bulk was located in 9aCS where accounted for the 85% of the total abundance in this sub-division.

Table 8a: Sardine assessment in 9aN

SURVEY: IBERAS 0919. Sardine

BIOMASS (tonnes). ZONE: 9aN (Spain)

						AGE GROUPS						
Length	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Total**	**No fish (thous**
8												
8.5												
9												
9.5												
10												
10.5												
11												
11.5												
12												
12.5	168										168.18	10370
13	512										511.51	27654
13.5	2612										2612.45	124442
14	4018										4017.56	169379
14.5	1753										1752.72	65678
15	517										516.91	17284
15.5												
16												
16.5												
17												
17.5												
18		191									191.00	3457
18.5		196	13								209.48	3457
19												
19.5												
20												
20.5												
21												
21.5												
22												
22.5												
23												
23.5												
24												
24.5												
25												
Biomass (mt)	9579	387	13	0	0	0	0	0	0	0	9979.80	421719
%	95.99	3.88	0.13									
M. weight	21.61	55.17	57.88								22.16	
No Fish (thousands)	414805	6697	216	0	0	0	0	0	0	0	421719	
%	98.36	1.59	0.05									
M. length	13.87	18.24	18.50								13.94	
s.d.	0.51	0.25									0.75	

Table 8b: Sardine assessment in 9aCN

SURVEY: IBERAS 0919. Sardine

BIOMASS (tonnes). ZONE: 9aCN

	AGE GROUPS											
Length	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Total**	**No fish (thous**
8												
8.5	207										206.60	46129
9	2378										2378.40	439186
9.5	1615										1614.91	249096
10	355										354.81	46129
10.5												
11	311										310.70	29386
11.5	2531										2531.29	206342
12	3862										3861.55	272991
12.5	8090										8090.45	498856
13	15156										15155.61	819362
13.5	23787										23786.70	1133057
14	17867										17867.31	753280
14.5	9608										9607.76	360021
15	3093										3093.40	103432
15.5	1923										1923.49	57600
16	635										634.78	17083
16.5	197	197									394.65	9576
17												
17.5		664									663.67	13208
18		943									942.63	17060
18.5		4834	322								5155.95	85080
19		2627	1433	239							4298.44	64828
19.5		2223	1270	953							4445.22	61416
20		1245	2075	1452							4772.38	60535
20.5		454	454	1589	227	454					3178.40	37092
21			1206	1206	402						2813.56	30268
21.5			114	114				114			343.41	3412
22												
22.5												
23												
23.5												
24												
24.5												
25												
Biomass (mt)	91615	13186	6874	5553	629	454	0	114	0	0	118426.06	5414424
%	77.36	11.13	5.80	4.69	0.53	0.38		0.10				
M. weight	17.04	63.51	75.78	81.57	90.15	85.69		100.65			20.75	
No Fish (thousands)	5036738	206234	90202	67841	6973	5299	0	1137	0	0	5414424	
%	93.02	3.81	1.67	1.25	0.13	0.10		0.02				
M. length	12.94	19.01	20.02	20.45	21.06	20.75		21.75			13.40	
s.d.	1.71	0.76	0.74	0.60	0.24						2.38	

Table 8c: Sardine assessment in 9aCS

SURVEY: IBERAS 0919. Sardine

BIOMASS (tonnes). ZONE: 9aCS

	AGE GROUPS											
Length	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Total**	**No fish (thous**
8												
8.5												
9												
9.5												
10												
10.5												
11												
11.5												
12												
12.5												
13												
13.5												
14												
14.5												
15												
15.5												
16												
16.5												
17		144									144.03	3160
17.5		847									846.98	16856
18		2233									2232.53	40405
18.5		1581	105								1686.44	27828
19		630	344	57							1031.67	15559
19.5		224	128	96							448.71	6199
20		107	179	125							410.82	5211
20.5		18	18	64	9	18					127.79	1491
21			64	64	21						149.91	1613
21.5												
22					20						20.28	186
22.5												
23												
23.5												
24												
24.5												
25												
Biomass (mt)	0	5785	839	407	51	18	0	0	0	0	7099.17	118510
%		81.49	11.81	5.73	0.72	0.26						
M. weight		54.61	67.32	74.41	93.02	82.21					56.97	
No Fish (thousands)	0	100691	11867	5216	523	213	0	0	0	0	118510	
%		84.96	10.01	4.40	0.44	0.18						
M. length		18.19	19.34	19.91	21.25	20.50					18.40	
s.d.		0.58	0.65	0.62	0.59						0.78	

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

SURVEY: IBERAS 0919. Sardine

BIOMASS (tonnes). ZONE: Survey (Spain+Portugal)

	AGE GROUPS											
Length	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Total**	**No fish (thous**
8												
8.5	207										206.60	46129
9	2378										2378.40	439186
9.5	1615										1614.91	249096
10	355										354.81	46129
10.5												
11	311										310.70	29386
11.5	2531										2531.29	206342
12	3862										3861.55	272991
12.5	8259										8258.64	509226
13	15667										15667.11	847015
13.5	26399										26399.15	1257499
14	21885										21884.87	922658
14.5	11360										11360.48	425698
15	3610										3610.31	120716
15.5	1923										1923.49	57600
16	635										634.78	17083
16.5	197	197									394.65	9576
17		144									144.03	3160
17.5		1511									1510.65	30064
18		3366									3366.16	60922
18.5		6611	441								7051.88	116365
19		3257	1777	296							5330.11	80387
19.5		2447	1398	1049							4893.94	67616
20		1352	2254	1577							5183.19	65747
20.5		472	472	1653	236	472					3306.19	38583
21			1270	1270	423						2963.48	31880
21.5			114	114				114			343.41	3412
22					20						20.28	186
22.5												
23												
23.5												
24												
24.5												
25												
Biomass (mt)	101194	19358	7726	5960	680	472	0	114	0	0	135505	5954653
%	74.68	14.29	5.70	4.40	0.50	0.35		0.08				
M. weight	16.33	58.58	71.93	77.94	86.98	82.21		96.75			20.41	
No Fish (thousands)	5451543	313623	102285	73057	7497	5512	0	1137	0	0	5954653	
%	91.55	5.27	1.72	1.23	0.13	0.09		0.02				
M. length	12.77	18.56	19.71	20.18	20.84	20.50		21.50			13.31	
s.d.	1.68	0.75	0.75	0.60	0.30		0.00	0.00	0.00	0.00	2.40	

Sardine stock indicators

These stock indicators are a series of metrics comparing results from 2018 and 2019. However, as it was already stated, there is a gap of two month between surveys which have to take into account when the results of this comparison are analysed.

Spatial distribution

Figure 18 is showing the center of gravity derived from the NASC values. There is no important changes on fish relative distribution, although the total echointegrated energy (and therefore abundance estimates) was very different. In both cases the center is located round Figueira da Foz (40 to 60 % of the total cumulated energy) and seems to be independent of the total biomass (e.g. backscattering energy).

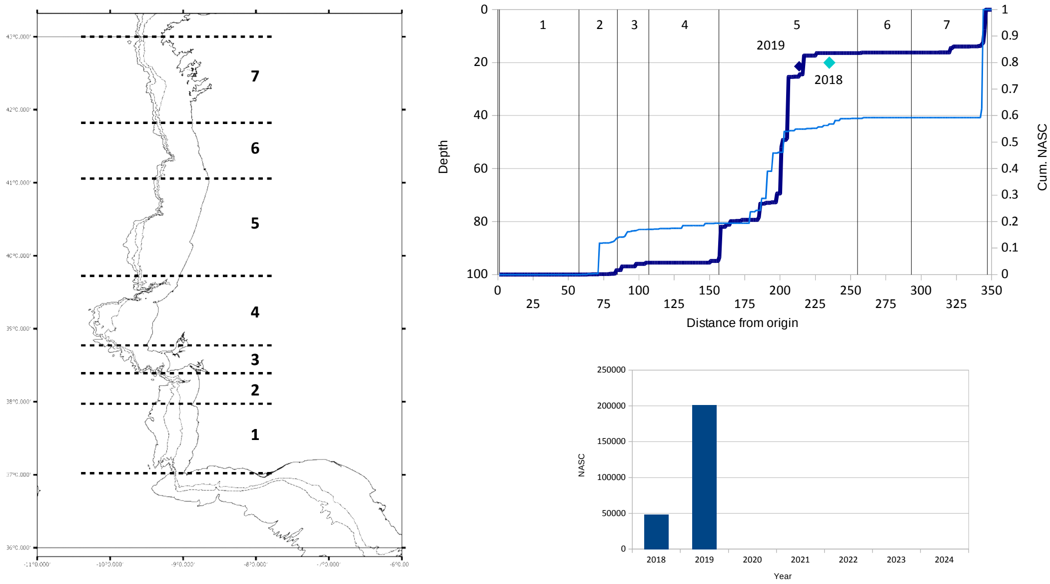

Figure 18: Relative cumulative NASC values of sardine along the coast (from south to north) and center of gravity (above right) and the total backscattering energy attributed to sardine (below right). Numbers in the cumulative plot correspond to the areas in the map (left)

Length and weight evolution (2018-19)

As expected, both mean length and weight decreased from 2018 to 2019 mainly due to the gap in time, as shown in figure 19. However except for the YoY, mean weight at age increased, specially in age groups 1 and 2, as both also shown an increase in mean length

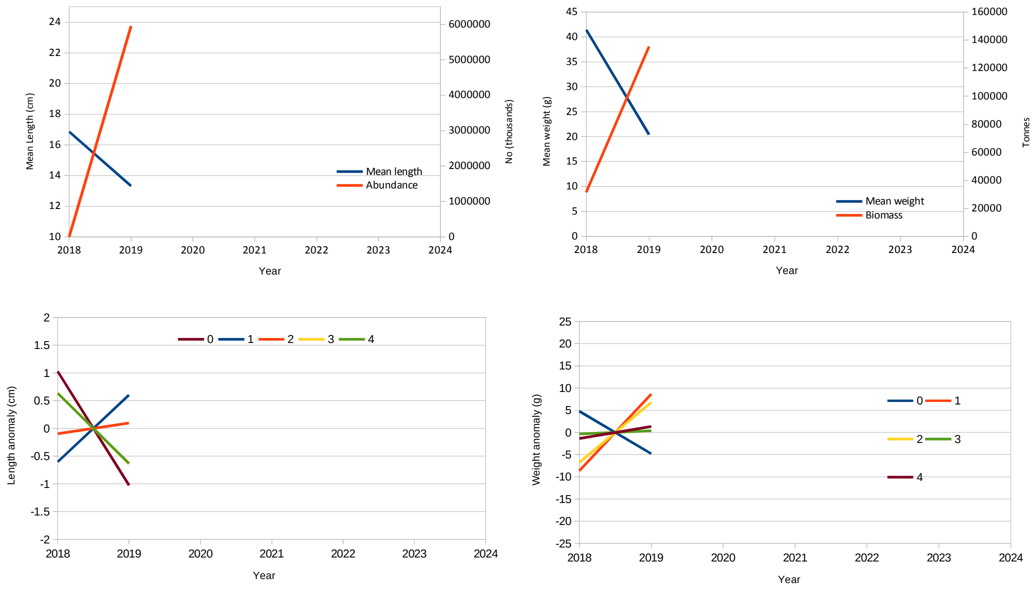

Figure 19: Above: mean length (cm) and abundance (thousand of fish) and mean weight (gr) and biomass /mt) of sardine estimated in IBERAS (2018-19) (left and right respectively); below: mean length and weight anomalies (differences from the mean value) for age groups 0 to 4

2 Anchovy assessment

In relation to 2018, the estimated biomass in 2019 had an important decrease, from 182*10^3 mt to only 4*10^3 mt. The summary of the assessment is shown in table 9. Almost no recruits were assessed, and age group 2 accounted for the 59% of the biomass (57 % in number); this result partially agreed the 2018 assessment when the bulk of the biomass was composed by ages 1 and 2, with little contribution of YOY (figure 20 and table 10). Anchovy occurred in shallower waters, near Figueira da Foz, corroborated by both the purse-seiner and the fishing stations done by the Angeles Alvariño. In Cascais area, although no fishing stations was done (due to the presence of fishing gears), additional information from purse-seiner fleet was used to allocate some echotraces to anchovy (figure 21).

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

		SURVEY:	IBERAS0319 ANCHOVY						
Zone	**Area**	**No**	**Mean**	**Area**	**Fishing st.**	**PDF**	**No (million fish)**	**Biomass (tonnes)**	**Density (Tn/nmi-2)**
9aCS	Cascais	3	428.62	18	P14	S01	42	1232	68
	Total	***3***	***428.62***	***18***			***42***	***1232***	**68**
9aCN	Figueira	16	285.40	70	P14	S01	122	2981	42
	Total	***16***	***285.40***	***70***			***122***	***2981***	**42**
9aN	Rbaixas	0	0.00	0			0	0	0
	Total	**0**	***0.00***	**0**			***0***	***0***	**0**
	Portugal	***19***	***308***	***88***			***164***	***4212***	**48**
	Spain	***0***	***0***	***0***			***0***	***0***	**0**
	TOTAL	**19**	***308.01***	**88**			**164**	**4212**	**48**

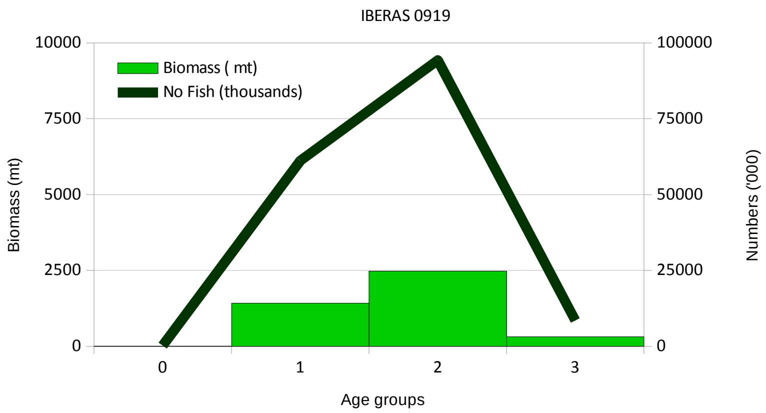

Figure 20. Anchovy estimated abundance and biomass per age group

Table 10: Anchovy assessment in 9a

SURVEY: IBERAS 0319. Anchovy

BIOMASS (tonnes). ZONE: Whole Area

	AGE GROUPS					
Length	**0**	**1**	**2**	**3**	**Total**	**No fish (thous**
5						
5.5						
6						
6.5						
7						
7.5						
8						
8.5						
9						
9.5						
10						
10.5						
11						
11.5						
12						
12.5	3	3			6.81	522
13		8			7.72	522
14		155	155		309.66	16514
14.5		248	310		558.20	26609
15		350	420		770.50	32953
15.5		374	374		748.55	28824
16		239	477		715.74	24896
16.5			464		464.08	14626
17			178	178	355.39	10178
17.5			97	97	193.42	5048
18				39	38.87	927
18.5						
19						
19.5						
20						
Biomass (mt)	3	1421	2475	313	4212.47	164226
%	0.08	33.72	58.76	7.44		
M. weight	13.06	23.03	25.94	36.63	23.49	
No Fish (thousands)	261	61163	94263	8540	164226	
%	0.16	37.24	57.40	5.20		
M. length	12.75	15.18	15.74	17.51	15.62	
s.d.	0.00	0.73	0.91	0.34	0.98	

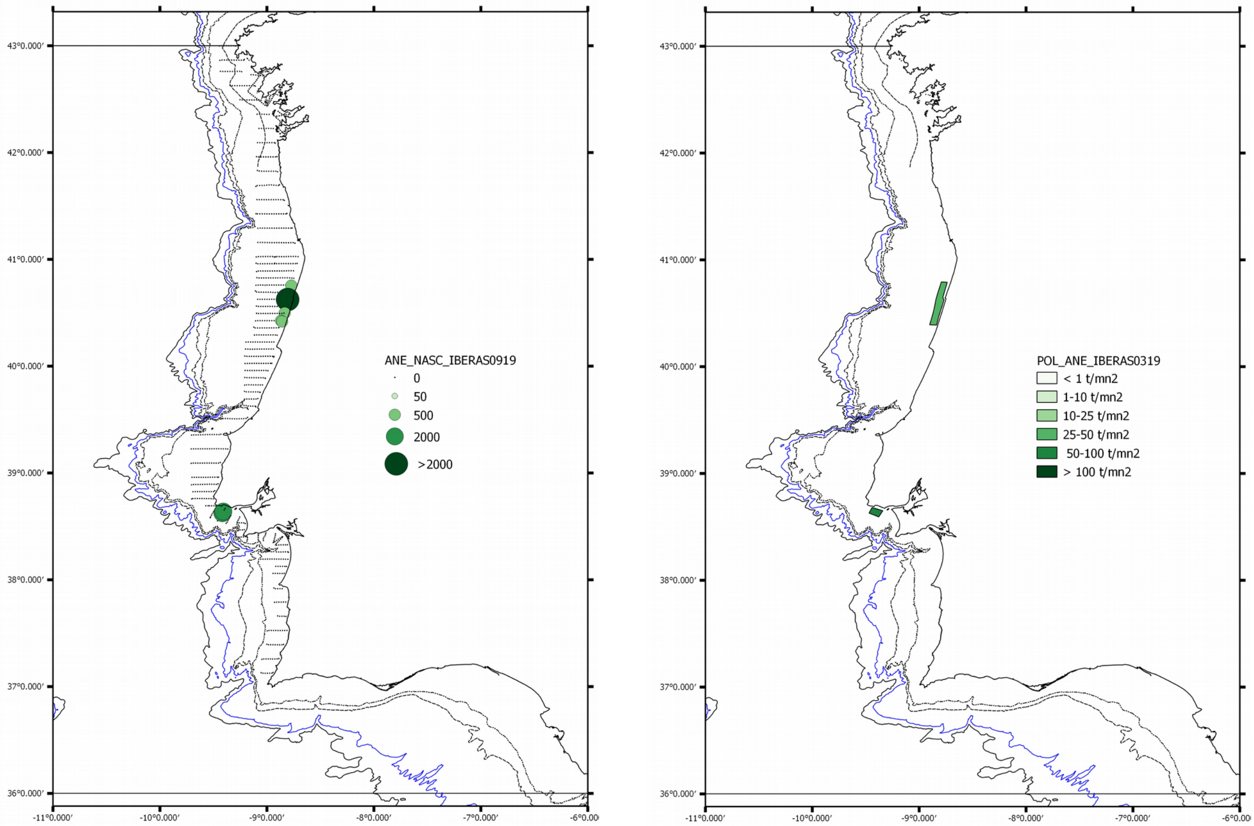

Figure 21. Anchovy spatial distribution in IBERAS 0919. Dots represent the NASC values attributed to anchovy and the polygons the strata together with the relative density

Anchovy stock indicators

In the case of anchovy, only spatial distribution is provided, due to the low biomass estimated this year which made difficult to provided a comprehensive length and age distributions. As observed in sardine, center of gravity remained stable regardless the size of the stock (e.g. backscattering energy) and the gap in time between the surveys. In both years it is located near Figueira da Foz, as shown in figure 22.

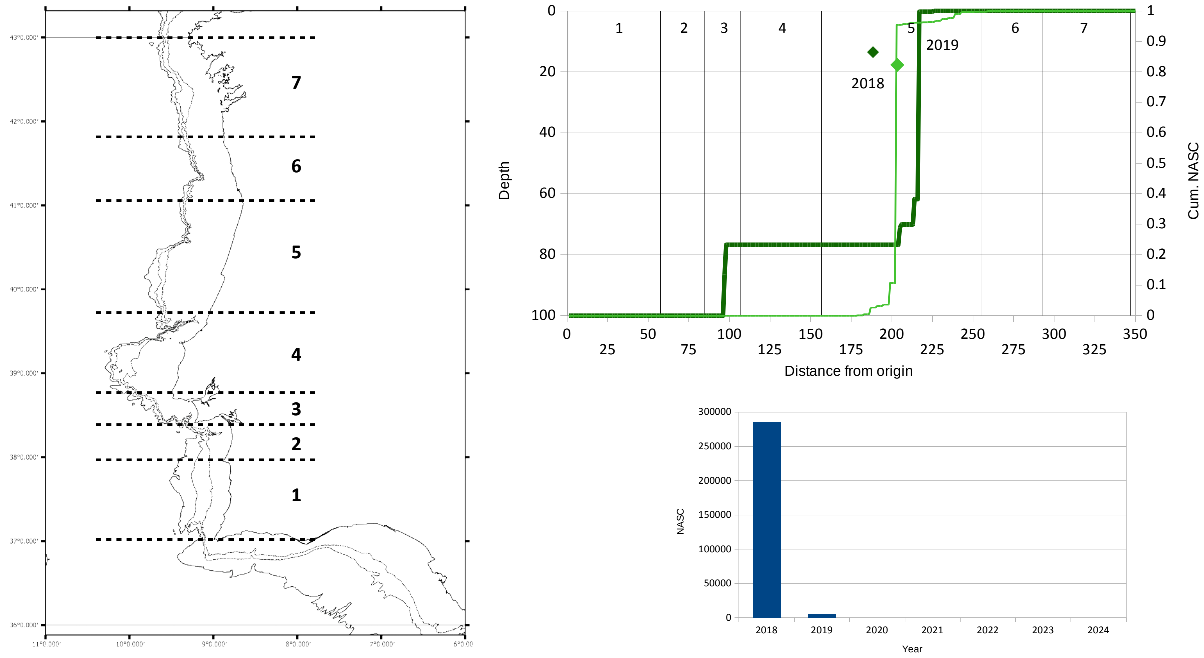

Figure 22: Relative cumulative NASC values of anchovy along the coast (from south to north) and center of gravity (above right) and the total backscattering energy attributed to anchovy (below right). Numbers in the cumulative plot correspond to the areas in the map (left)

3 Chub mackerel assessment

As previously stated, the chub mackerel distribution area was wider in 2019 than that observed in 2018 when the bulk of the stock was located in 9aCS. Table 11 summarises the chub mackerel assessment. $56*10^3$ mt thousand tonnes, corresponding to $702*10^6$ fish, were assessed. Length distribution was very similar around the surveyed area but those located around the Sado estuary, where the bulk of the estimated biomass was located, which had a mode at 20 cm instead 22 cm. Length ranged from 18 to 28 cm, corresponding to younger fish (figure 23). Age length key is still not available but applying the available from 2018, most of the fish would belong to age group 1, and no fish older than 3 was observed. Main difference from 2018 is the increase of the younger fish, as observed in figure 23.

Table 11 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

SURVEY: IBERAS 0919 CHUB MACKEREL

Zone	Area	No	Mean	Surface	Fishing st.	PDF	No (million fish)	Biomass (tonnes)	Density (Tn/nmi-2)
9aCS	Tejo	70	361.15	300.58	P09-P10-P14-P16	ST01	125	10844	36
	Sado	72	890.15	305.65	P13-P14-P15	ST02	350	25624	84
	Alentejo	43	14.82	358.02	P09-P10-P14-P16	ST01	6	530	1
	Total	***185***	***487***	***964***			***481***	***36998***	38
9aCN	Aveiro	195	88.41	916.54	P09-P10-P14-P16	ST01	93	8095	9
	Figueira	19	1061.96	75.71	P09-P10-P14-P16	ST01	93	8032	106
	Total	***214***	***175***	***992.2***			***186***	***16127***	16
9aN	Rbaixas	60	219.24	136.65	P09-P10-P14-P16	ST01	34	2993	22
	Total	***60***	***219***	***137***			***34***	***2993***	22
	Total Portugal	***399***	***319***	***1956***			***667***	***53125***	27
	Total Spain	***60***	***219***	***137***			***34***	***2993***	22
	Total 9a	***459***	***306***	***2093***			***702***	***56117***	27

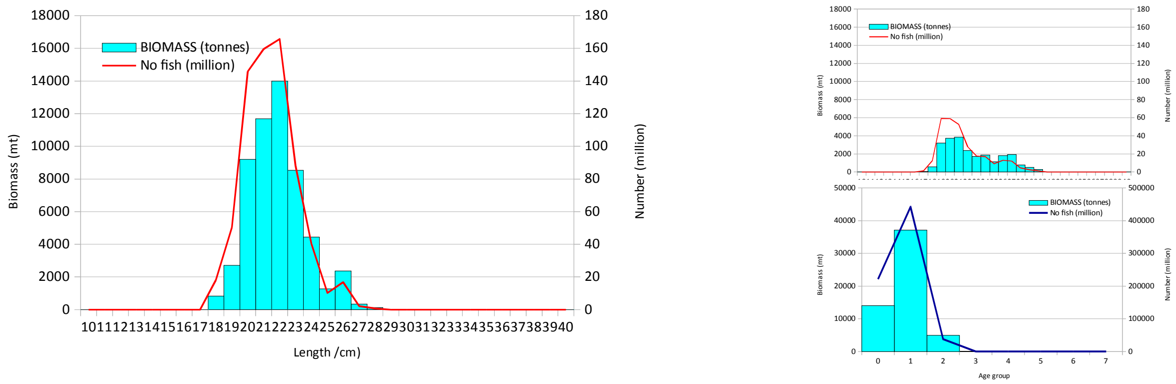

Figure 23. Left: chub mackerel estimated abundance and biomass per length class in IBERAS0919; above right estimated abundance and biomass per length class in IBERAS1119: below right estimated abundance and biomass per age group in IBERAS0919 using the age/length key from 2018

As stated, chub mackerel had a wider distribution all along the surveyed area, as shown in figure 24. In the same way as observed for the other species, there is a gap in the distribution near the Spanish-Portuguese border (e.g. around the Minho river) with tracks with no fish or very scarce.

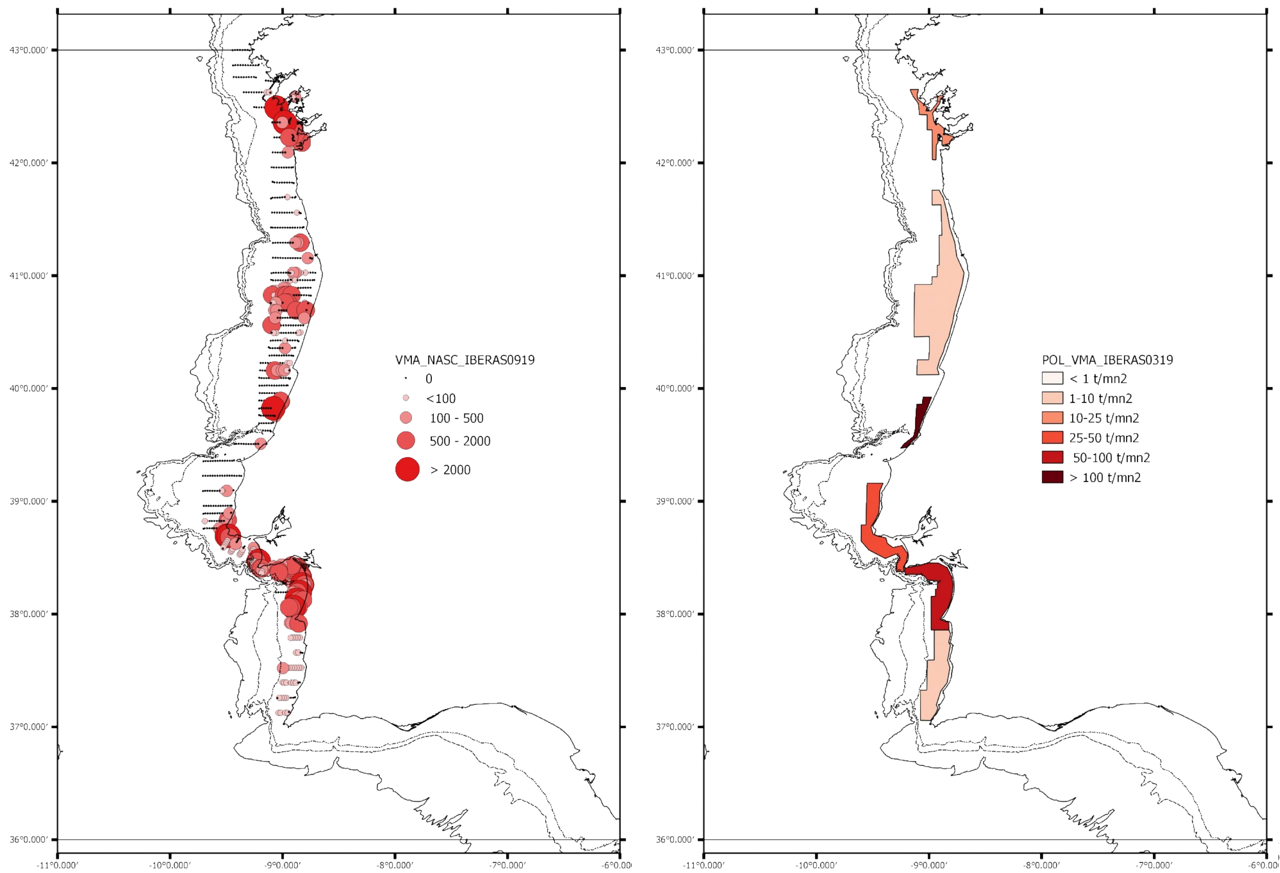

Figure 24. Chub mackerel spatial distribution in IBERAS 1118. Dots represent the NASC values attributed to chub mackerel and the polygons the strata together with the relative density

Chub mackerel stock indicators

As the age/length key is still not available, no comparison among ages between 2018 and 2019 can be done, and only the spatial distribution can be compared. In this case, there seems to be a clear period effect, with a significant northward shift in the center of gravity.- Although the bulk of the distribution is still located near the Sado, in 2018 no fish was observed north this area, as shown in figure 25.

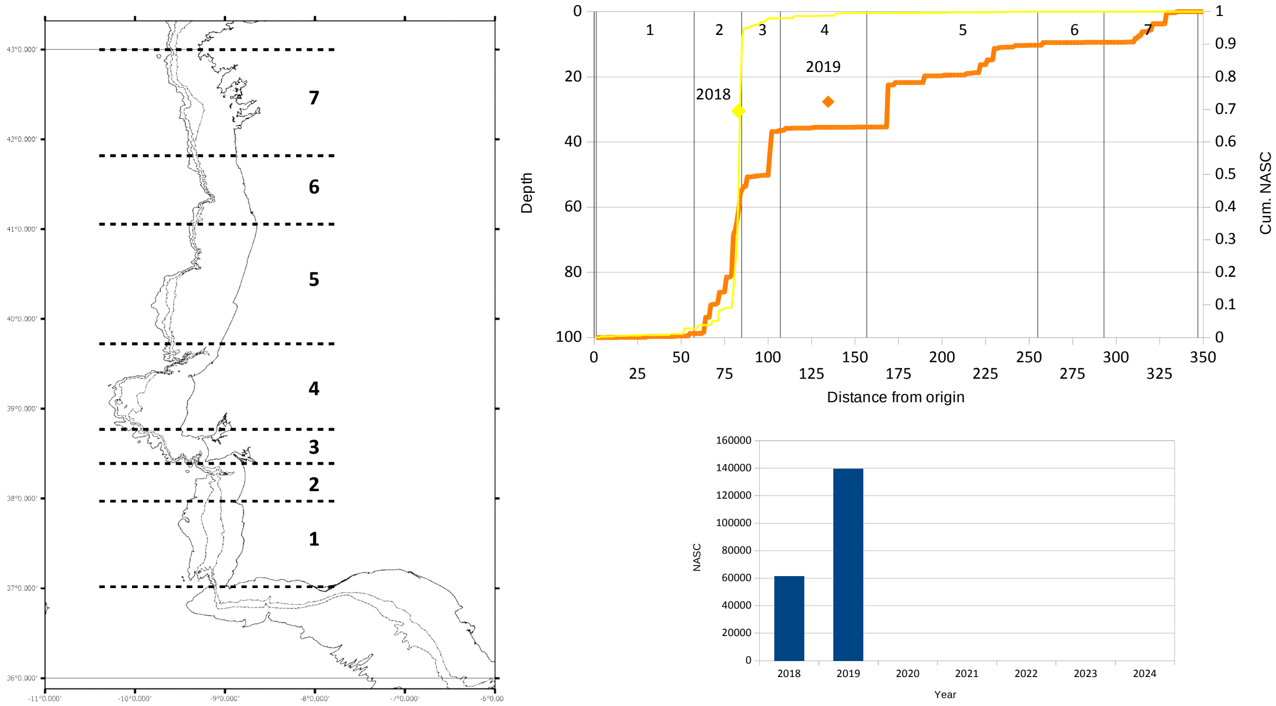

Figure 25: Relative cumulative NASC values of chub mackerel along the coast (from south to north) and center of gravity (above right) and the total backscattering energy attributed to anchovy (below right). Numbers in the cumulative plot correspond to the areas in the map (left)

DISCUSSION AND CONCLUSIONS

In general terms, the change from November to September (two month earlier) improved the survey strategies and the assessment itself. The number of lost days due to bad weather conditions considerably decreased and the bulk of the recruitment is available. The only matter of concern is the amount of static fishing gear all around the shallower waters. From November to September, it seems the number of these fishing devices increased considerably. This drastically reduces the trawleable areas as long as a minimum of 2-3 nmi are required to do a tow haul. The number of fishing stations was low mainly due to lack of available areas.

The fish distribution was more wider than that observed in 2018. It could be either by the better weather condition and also by the increase of the sardine abundance. In such conditions, the proposed survey design matched with de expected distribution area of sardine recruits and no extension towards very shallower waters nor the use of intertransects legs as proxy of the abundance in this area are needed. However, an important amount of fish was observed in particular years within this area; therefore, this has to be prospected in order to ensure a whole coverage of the sardine recruitment area.

On the other hand, it seems that the pelagic fishing gear used in this survey has a very low selectivity and a high catchability, on account the first preliminary analysis of the comparison between the trawl hauls performed by the research vessel and the shots performed by the chartered purse seiner. Although the higher fish diversity observed in the pelagic tows, direct consequence of both the greater water volume filtered in relation to the volume encircled by the purse-seine net and the multispecific pelagic community observed in the survey area, length distribution for those species already caught by both devices, were similar.

Concerning the sardine assessment, there was a significant increase in the strength of the estimated recruitment. More interestingly, the presence of at least two different modes would mean the spawning period, which is relatively long, had several episodes of favourable conditions for the success of the recruitment along this. The occurrence of epipelagic schools, very near of the surface, although without any visible avoidance reaction, would in turn to underestimate the strength of the recruitment. Some of the schools occurred in the near field (Fresnel zone) and others would be located in the blind zone (e.g. between the surface and the active surface of the transducer located at 6.5 m depth). In such circumstances, a underestimation would be expected.

Another issue regarding the survey is the timing. Up to now, all surveys targeting in sardine recruitment were undertook in November over the same area. Given the high natural mortality for age group O (M=0.98, ICES, 2018), an important decrease is expected and no direct comparison between those surveys carried out in November (e.g. two months later) and this survey should be done. The strength of this recruitment should, therefore, be confirmed once the next spring surveys PELACUS and PELAGO were provided the estimates at age 1.

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