RELATÓRIOS DE CAMPANHA

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

"IBERAS0920"

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

INSTITUTO ESPAÑOL DE OCEANOGRAFÍA

IPMA
Instituto Português do Mar e da Atmosfera

IBERAS0920
SURVEY REPORT

INSTITUTO ESPAÑOL DE OCEANOGRAFÍA
INSTITUTO PORTUGUÊS DO MAR E DA ATMOSFERA

INDEX

TECHNICAL SUMMARY

Institution:	INSTITUTO ESPAÑOL DE OCEANOGRAFÍA/INSTITUTO PORTUGUÊS DO MAR E DA ATMOSFERA
Survey name:	IBERAS0920
Vessel name:	Ramón Margalef (46.70 m length, 10.50 width 988 GRT, 900 kW diesel-electric)
Dates:	09-30/09/2020
Area:	WESTERN IBERIAN COAST (9aCS-9aCN-9aN-8Cw)
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 4/6 nmi apart from 20 to 100 isobath
Main sampling procedures	EK-80 at 18-38-70-120-200 kHZ acoustic frequencies. 882 nmi prospected. Only day time Pelagic fishing stations: 40 Hydrological characterisation. 48 stations
Personnel 1st leg Vigo/Vigo Dates: 05 to 21/09	CARRERA LÓPEZ, PABLO AMORIM, PEDRO DA CONCEIÇAO, ANTONIO PEDRO BARRA, JORGE IGLESIAS GARCÍA, LUISA PASTOR, JOÃO SÁNCHEZ BARBA, M JOSÉ LORENA RODRIGUEZ FERNANDEZ CÓRDOBA SELLÉS, PILAR[1]
2nd leg Lisboa/Cádiz Dates: 22-27/09	CARRERA LÓPEZ, PABLO AMORÍN, PEDRO DA CONCEIÇAO, ANTONIO PEDRO BARRA, JORGE IGLESIAS GARCÍA, LUISA PASTOR, JOÃO SÁNCHEZ BARBA, M JOSÉ PAMPILLÓN LORENZO, Mº DOLORES
Report author	Pablo Carrera
Other collaborators	Pedro Amorim Ana Moreno Isabel Riveiro

INTRODUCTION

IBERAS is a new acoustic-trawl time series aiming at to estimate the strength of the sardine recruitment in Atlantic Iberian waters. The survey is carrying out over the main potential distribution area of the Iberoatlantic sardine stock recruitment. The first survey was undertaken in 2018 in November. Due to the poor weather conditions and in order to make a synoptic coverage with JUVENA which is also covering the Bay of Biscay, the timing was sifting to September.

This shift did no change the recruit availability and, in fact, the abundance of recruits estimated was really high which has been corroborated by the spring acoustic-trawl survey PELAGO. Unfortunately, due to the Covid-19 the Spanish survey PELACUS was cancelled so the real strength of the 2019 sardine cohort would have been underestimated.

For this reason, instead of covering from Cape Fisterra southwards, this year the survey started at the Atlantic/Cantabrian sea corner in order to verify the strength of the 2019 cohort and its potential distribution area.

The rationality of this new time series is based on the low productivity level of the sardine stock in this area. Although sardine is not considered a short-lived species, the lack of good incoming year classes, 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.

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.

OBJECTIVES

i. Acoustic estimates by echointegration of the strength of the sardine in Atlantic waters of the Iberian Peninsula, between Cape Ortegal and São Vicente

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 Ramón Margalef, a similar vessel of Angeles Alvariño, used in the previous survey IBERAS0919, from 9th until 30th September, departing from the port of Vigo and arriving to Cádiz harbour in the morning 1st October. A scale was scheduled in Vigo on 21st . Two first days were used to calibrate the transducers. For this purpose, the vessel moored in the Pontevedra Bay. h.

Working Area

From Ortegal cape until São Vicente cape, from shoreline (20 m) to 100 m isobath over an adaptive grid with 86 tracks distanced between 4-6 nmi on account the potential recruitment distribution area of both sardine and anchovy. Tracks were enlarged or shortened accordingly. Figure 1 show the foreseen survey track and table 1 the expected survey coverage and time.

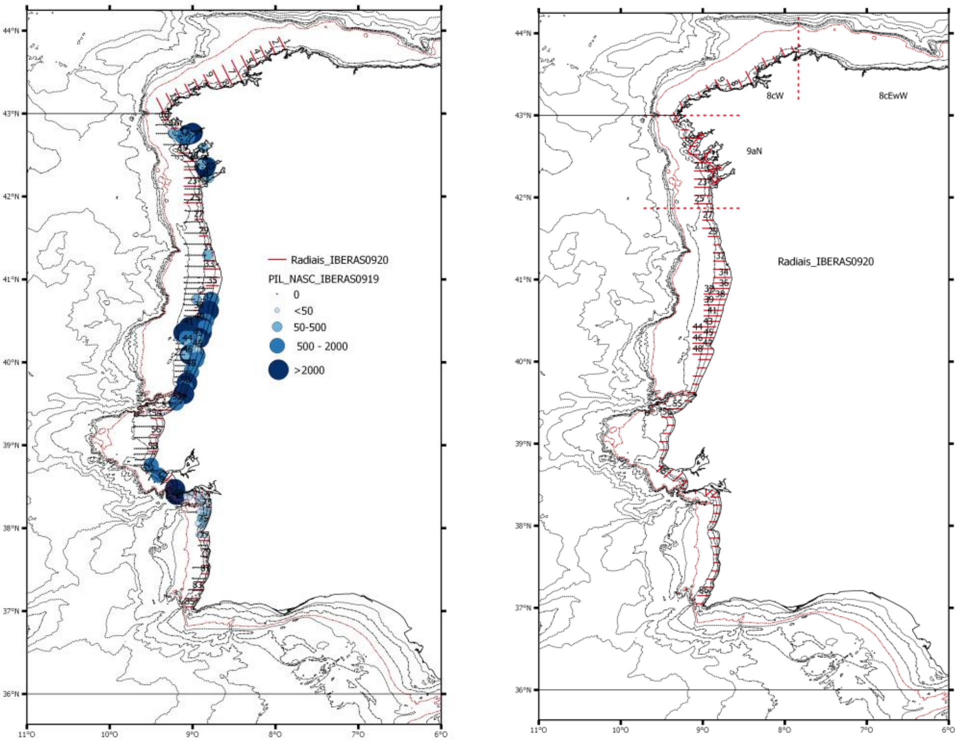


Figure 1: Survey track and NASC distribution obtained last year and the proposed track for 2020

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
Rías Baixas (9a-N)	23	112	0	8-1	12-0.86	20-2
8cW continental self	14	146	81	22.7-2	6-12-0.86	14-16-2
9a N continental self	9	83	75	15-1	12-0.86	27-2
O. Norte (9a-CN): Caminha-Porto	8	39	48	9-1	4-10.86	24-2
O. Norte (9a-CN): Porto-nazaré	19	149	96	25.4-2.2	9-18-1.3	43.4-3.5
O Sul (9a-CS): Nazaré-Roca	8	37	43	8-0.67	4-8-0.57	16-1.2
O Sul (9a-CS): Roca-Espichel	6	29	29	5.6-0.46	4-8-0.57	12-1
O Sul (9a-CS): Espichel-São Vicente	19	78	95	18.65-1.55	4-8-0.57	37-3
Total	85-23	831	437	127-10.5	45-6-86	212.23-(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.

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).

1 NASC allocation

A pelagic gear gloria HOD 352 together with a 63.5/51 were 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 logL_T+ b_{20} (Simmonds and MacLennan, 2005), where L_T is the length class. The b_{20} values for the most important species present in the surveyed area are shown in table 3:

Table 3.- b_{20} values from the length target strength relationship of the main fish species assessed in IBERAS survey (WHB is blue whiting; MAC-mackerel; HKE- hake; HOM- horse mackerel; PIL-sardine; JAA-blue jack mackerel ; BOG-bogue ; VMA-chub mackerel ; BOC-boar fish ; and HMM-Mediterranean horse mackerel

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 together with a 63.5/51 pelagic fishing nets with a vertical opening of about 13 m and 16 m respectively were 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 100 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 performed during daytime.

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

Plankton and hydrological characterisation

Continuous records of SSS, SST and SSF (fluorometry) were taken using a SBE21 Thermosalinograph coupled with a Turner fluorometer. 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.

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 specimens 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

Weather conditions were similar to those observed in the previous year, with predominant northern winds and only a period of 3 days of low pressures in the middle of th survey.

Sea surface temperature ranged between 13 and 20ºC, with cold waters located in the northern part (8cW and 9aN), the Ericeira area (north Lisbon), and the southern part. Warmest waters were found round Figueira da Foz and Sado area.

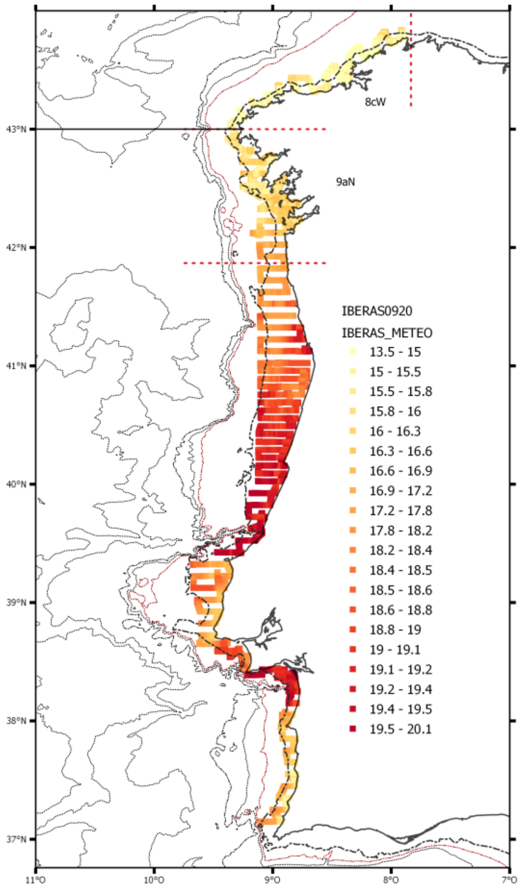


Figure 2: SST during IBERAS 0920

ACOUSTIC

School extraction and total backscattering energy

A total of 3616 echotraces were extracted, accounting for a total NASC (s_A) of 796880 m^2 nmi^{-2}. On tracks, NASC values were 608124 m^2 nmi^{-2}, which was much higher than that recorded in 2019 (430069). Figure 3 shows the sum of NASC per track along the surveyed area.

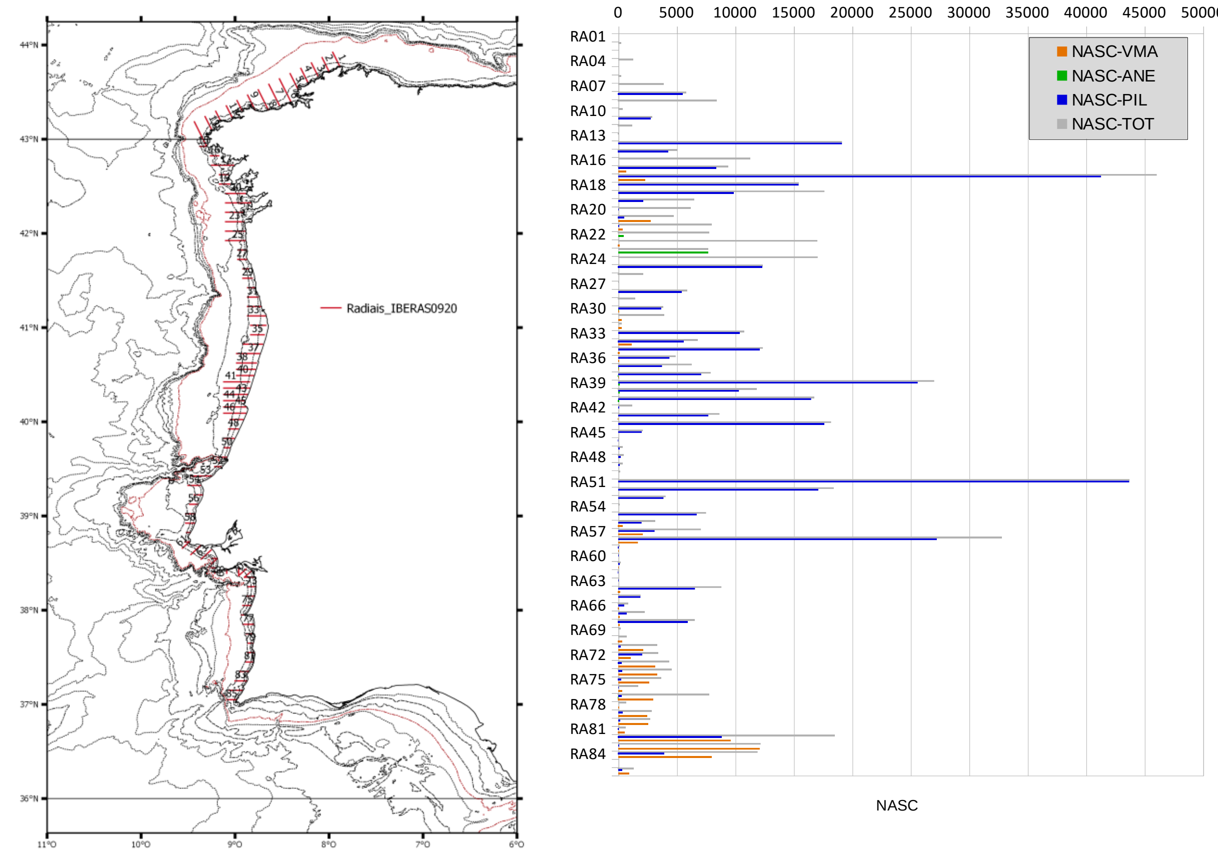


Figure 3. Cumulated NASC(sardine -PIL-, chub mackerel -VMA-, and anchovy -ANE-) values per track

Fish schools occurred more or less in the same areas as recorded last year, with some areas (e.g. Ría de Muros or north Figueira da Foz) having an important contribution to the total backscattering. It should be noticed the amount of sardine found north Nazaré.

Bathymetric distribution of schools is significantly different from that recorded last year when the mode was located at 47.5 whereas this year was found at 27.5 m, as shown in figure 4. The weighting average (weighting factor, s_A) shifted from 37.53 (c.v. 0.38) to 32.35 (c.v. 0.36).

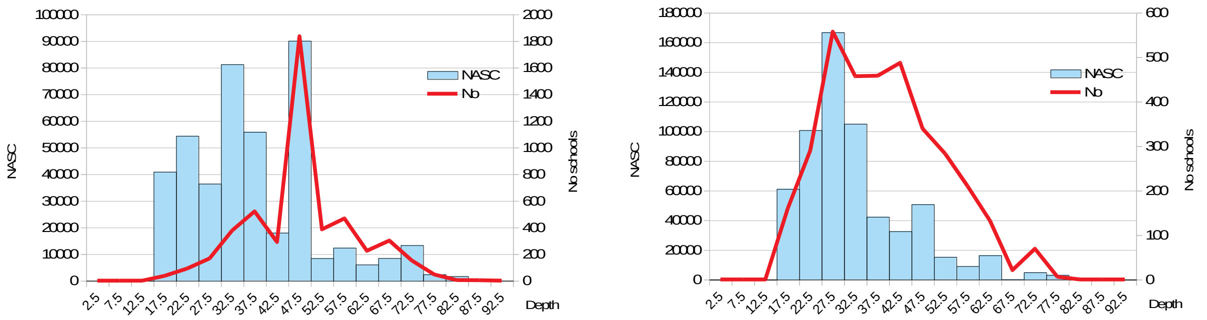


Figure 4. Number of schools and their cumulated NASC values per depth strata (5 m) – Left IBERAS0919; right IBERAS 0920

Besides, this year schools were more dense, with some schools with mean s_V higher than -18 dB, and, although the number was also lower, the backscattering energy was higher than in 2019.

Fishing station and echotrace allocation

As stated last year, to perform fishing stations near shore was a challenging task as long as most of the area was occupied by static fishing gears, thus restricting the available areas to carry out these and increasing the searching time for doing it. Of 40 fishing station performed, 3 were done for setting up the fishing gears; 2 were interrupted due to accidental catch of ghost octopus traps lines; other 2 had problems due to presence of fishing gears and rough bottom and other was considered nil as the net crashed due to the rough bottom. In spite this, close to 29 mt were caught corresponding to more than 9.2E+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
WHB	103	2836	1	4	101	17.87	2.78	0.36	0.31
MAC	2803	47671	26	82	1210	20.73	72.22	9.70	5.16
HKE	5	108	3	4	68	17.81	8.33	0.02	0.01
HOM	2585	45617	26	124	1944	19.22	72.22	8.95	4.94
PIL	17970	456780	30	128	2700	17.40	83.33	62.20	49.48
JAA	1	13	1	0	1	21	2.78	0.00	0.00
SNS	2602	335927	4	2	210	12	11.11	9.01	36.39
BOG	163	1281	14	39	302	23.71	38.89	0.56	0.14
VMA	1400	13814	21	115	870	24.08	58.33	4.85	1.50
BOC	11	239	3	1	18	12.61	8.33	0.04	0.03
SEAB	1086	4729	19	163	835	28.37	52.78	3.76	0.51
ANE	162	14222	6	9	507	12.93	16.67	0.56	1.54
Total	**28892**	**923237**	**36**	**670**	**8766**				

This year, sardine accounted more than 50% of the total catch in weight, and was present in 83% of the hauls. It should be also noticed the low presence of anchovy(only 17% of the hauls).

1 Chub mackerel echotrace identification

There has been an important change in the aggregation pattern of chub mackerel schools from last year. While in 2019 mainly occurred in the southern part in epipelagic aggregations, not particularly dense but wide (figure 5), this year was recorded as very dense near bottom schools . In the southern part, thick schools were recorded. The distribution was very patchy, and some of them would be also sardine shoals, as long as the fishing station done over these concentrations gave both species. However due to the presence of fishing gears and particularly the roughness of the bottom, fishing station, although gave length distribution for both species did no clarify the proportion between both species

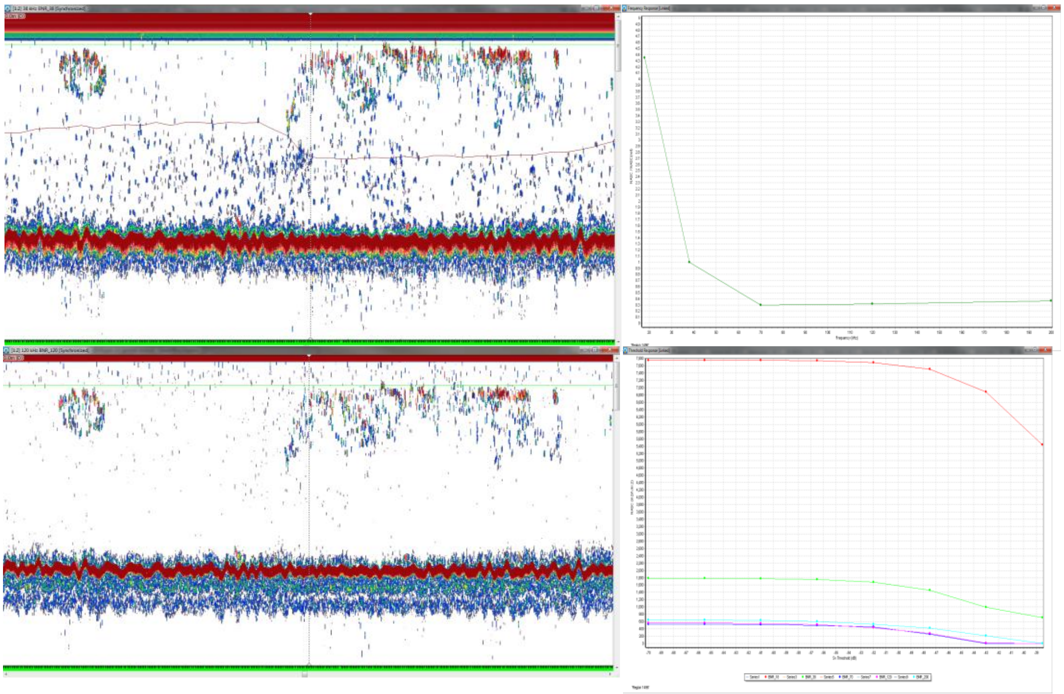


Figure 5. Echogram showing echotraces attributed to chub mackerel (38 kHz above, 120 kHz below) and its characteristic frequency and threshold responses (ground truthed by fishing station)

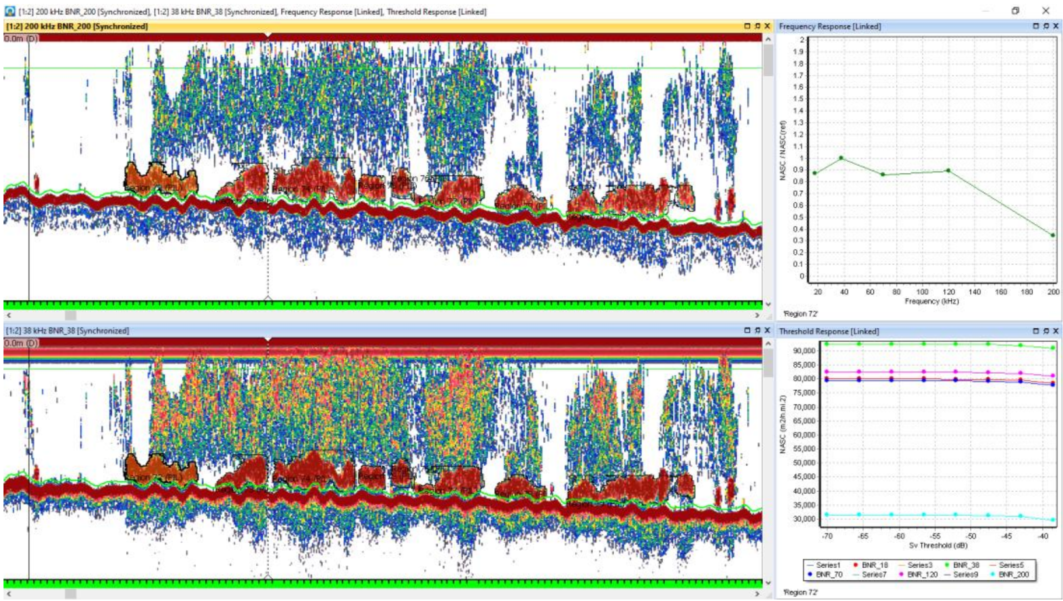


Figure 6.a Echogram showing echotraces attributed to chub mackerel and sardine (200 kHz above, 38 kHz below) and its the frequency and threshold responses gave by the first school

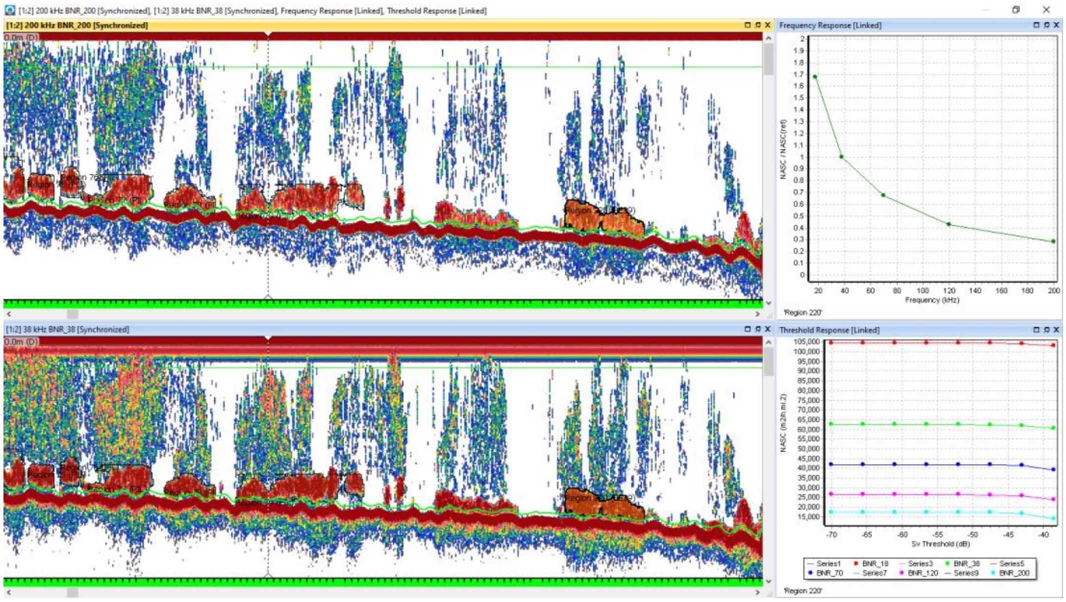


Figure 6.b. Similar to 6a, but different frequency and threshold responses, more similar to that expected for chub mackerel

This mega-concentration of fish was also observed in 2018, but in this case main fish species was anchovy, as shown in figure 7. Whether these high concentrations are exceptional in terms of fish aggregation and distribution patterns but plausible every survey and independently of the period, should be studies as long as they achieve a high contribution to both surveys estimates and its variance.

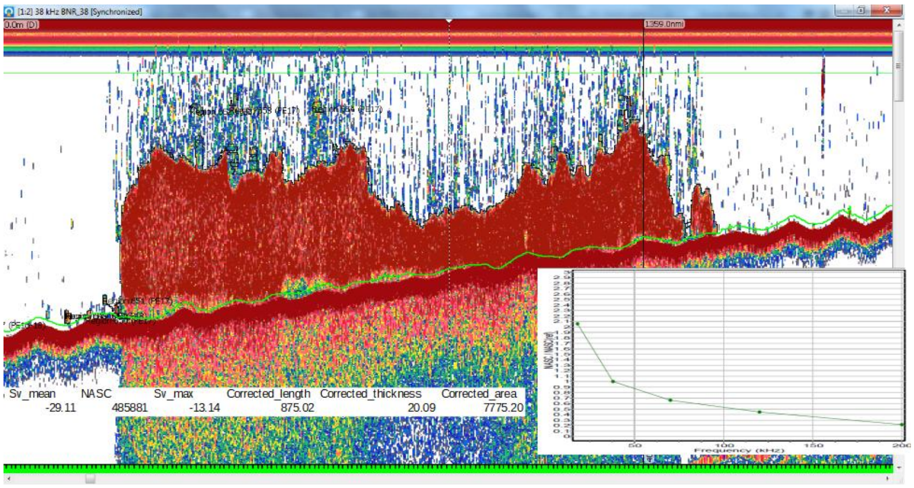


Figure 7. Mega-school recorded in november 2018 during IBERAS1118, mainly composed by anchovy

2 Longspine snipe fish echotrace identification

As in the previous year, 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. They did not occur isolate. At the fishing station, although being dominant, sardine, sea breams, chub mackerel and horse mackerel among other fish species were also caught.

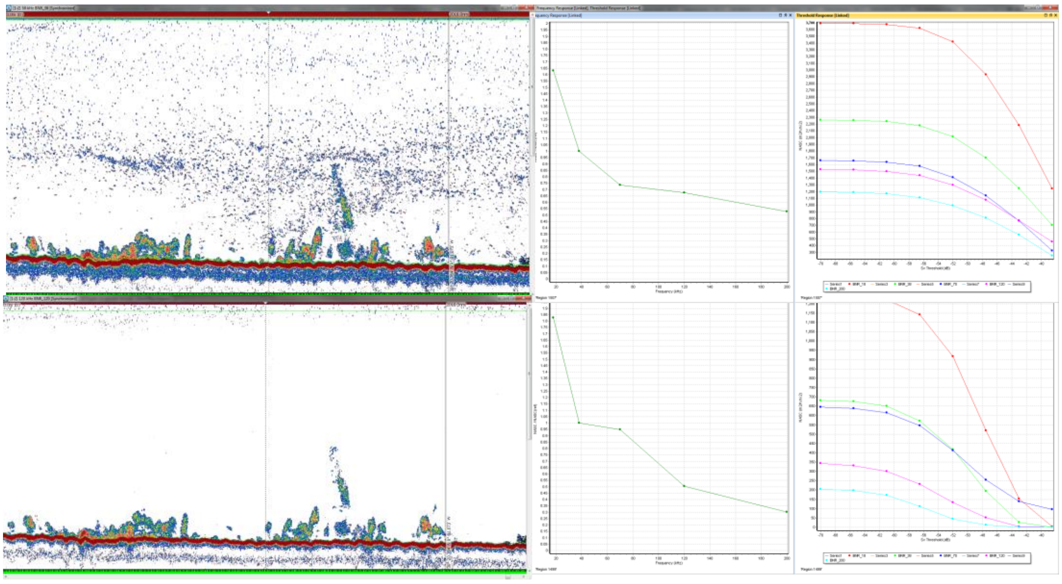


Figure 8. Echogram showing echotraces with longspine snipe fish as main species (38 kHz above, 120 kHz below)

3 Sardine echotrace identification

As observed for chub mackerel, sardine also occurred in dense schools. In fact, some of the schools had as s_{Vmax} values higher than -15 dB, which are unusual and never recorded in such quantity. Besides some of them were also very small. In Galicia the bulk of the schools were recorded in the northern part (8cW and 9aN), mainly within the Ria de Muros. It should be noticed that in spite the fishing station performed gave almost pure sardine, frequency response had a higher value to 18 kHz and lower than expected for 200 kHz, as shown in figure 9. Same schools were also recorded in 8cW (figure 10). However, in this area those schools were found either in rough bottom or in areas with high presence of static fishing gears: instead, a sample obtained by a bottom trawl survey done in the same period over this area was used to characterise the length distribution of those sardine

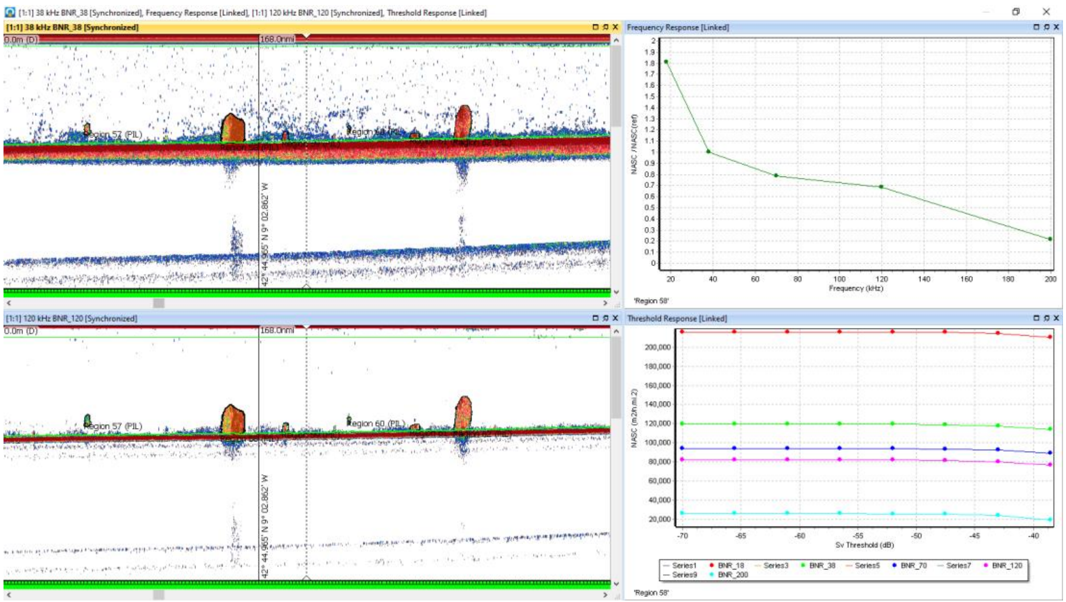


Figure 9. Echogram showing echotraces attributed to sardine (38 kHz above, 120 kHz below) and its frequency and threshold responses within the Ria de Muros (north 9aN)

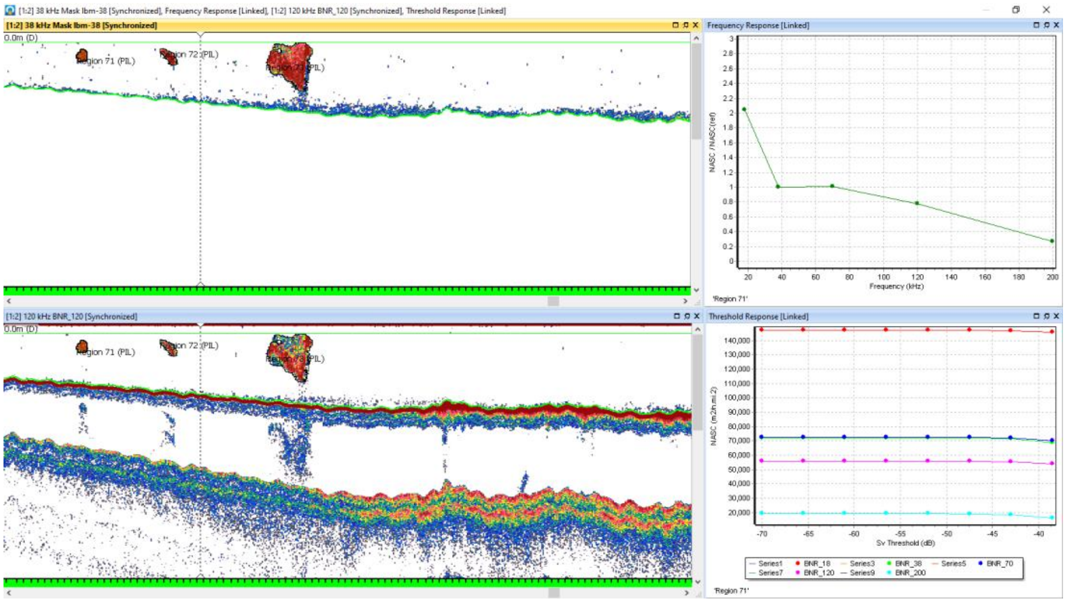


Figure 10. Echogram showing echotraces attributed to sardine (38 kHz above, 120 kHz below) and its frequency and threshold responses in 8cW, corroborated by a bottom trawl survey carried out during the survey period

Over the main distribution area (9aCN between Aveiro and Nazaré), sardine occurred rather near coast, although some schools were also recorded round 100 m isobath. Near coast, most of the schools were located close to the bottom and pelagic in the rest of the distribution area, as shown in figure 11. In this later case, as stated, some of the schools although very dense, were, in general small. It was often usual no observed those schools not directly but in the second echo (e.g. once the acoustic signal reached to the surface/hull and travelled again downwards, giving a second echo of those targets located in the acoustic beam, wider now than in the first echo; figure 12).

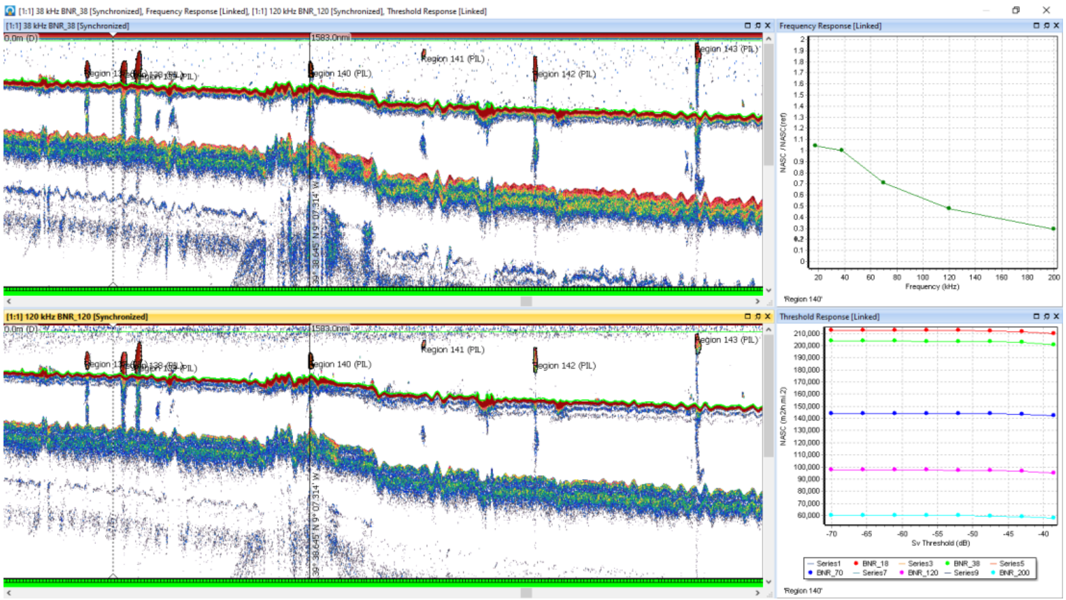


Figure 11. Echogram showing echotraces attributed to sardine (38 kHz above, 120 kHz below) and its frequency and threshold responses in 9aCN, corroborated by fishing station.

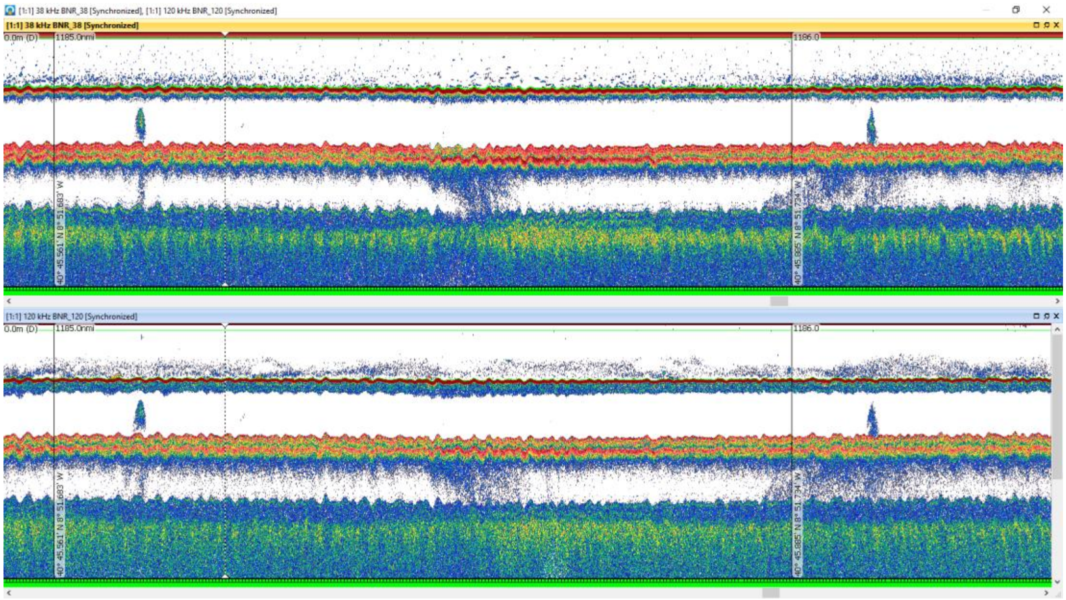


Figure 12. Echogram showing two schools recorded only in the second echo. (38 kHz above, 120 kHz below).

Although no school was recorded in the first echo, a fishing station performed in this situation gave pure sardine. The explanation is related with the small width of the acoustic beam 83-5 m)in relation to the horizontal opening of the fishing gear (25-30 m).

4 Anchovy echotrace identification

This survey, anchovy was found in the outer part of the surveyed area (e.g. close to the slope). It occurred in epipelagic schools, rather dense (figure 13). A fishing station performed on those echotrace gave pure anchovy with two modes located at 7 and 13 cm. This is the first time this near slope aggregation are recorded. Whether this behaviour is similar to that observed in the Bay of Biscay where pre-recruits anchovy mainly occur offshore and then are approaching to the coast, once the size of the of fish is increasing, to finally recruit to the area located on the continental self, should be studied. However, given the complementarity between sardine and anchovy recruitment areas, it seems difficult to cover both during IBERAS given the duration of the survey.

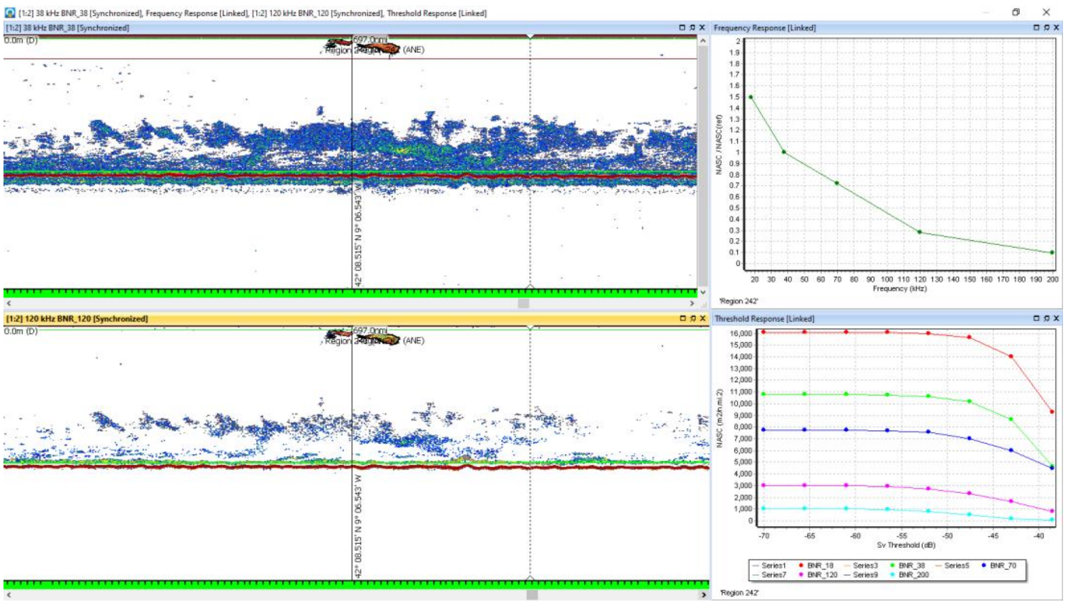


Figure 13. Echogram showing echotraces attributed to anchovy (38 kHz above, 120 kHz below) and its frequency and threshold responses in 9aN, corroborated by fishing station

5 Mackerel echotrace identification

In the previous IBERAS surveys, juvenile mackerel were normally caught although it was difficult to observe any echotrace to be likely attributed to this species as long as the density seemed to be really scarce and in spite the very different frequency response in relation to the rest of the fish species. However, this year, within the Tagus bay, important concentrations were recorded, which were corroborated by fishing station. It should be also mentioned that juvenile mackerel were caught in the 70% of the fishing station.

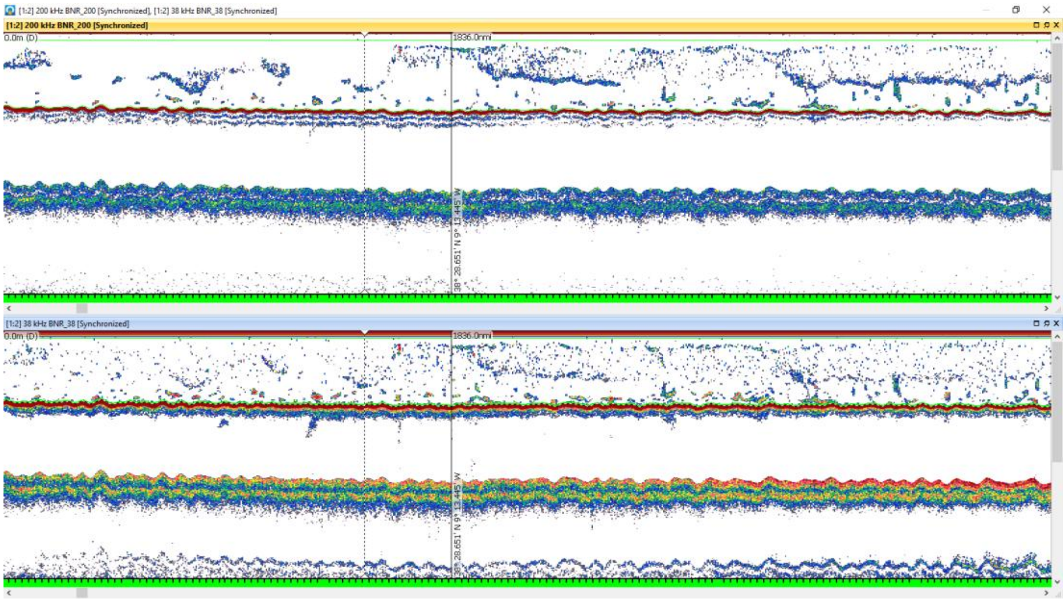


Figure 14. Echogram showing echotraces attributed to juvenile mackerel (200 kHz above, 38 kHz below) in 9aCN (Tagus bay), corroborated by fishing station

6 Krill echotrace identification

As the previous IBERAS surveys, important krill swarms were mainly recorded in 9aN (figure 15). However due to the Covid-19, no marine mammals observers were on board, but the presence of whales in this area was also noticeable.

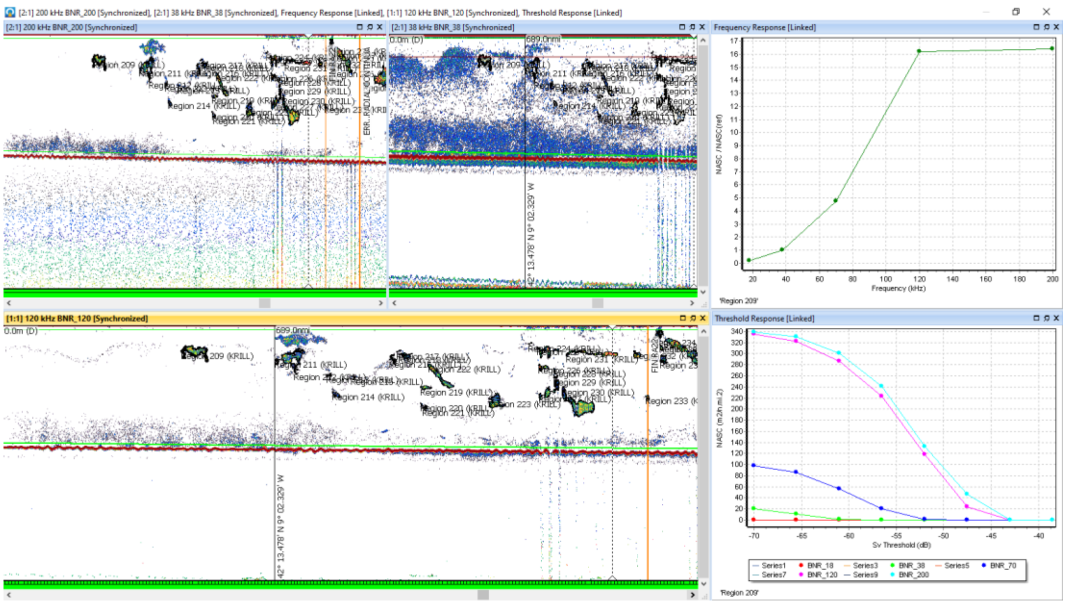


Figure 15. Echogram showing echotraces attributed to juvenile mackerel (200 and 38 kHz above, 120 kHz below) and its frequency and thershold response in 9aN

7 Fishing station used for echotrace allocation

On survey tracks, from the total of 608124 m^2 nmi^{-2}, 421472 were directly allocated to fish species (69% of the total attributed backscattering energy). 391177 m^2 nmi^{-2} were allocated to sardine (78% of them directly allocated) and 65702 m^2 nmi^{-2} to chub mackerel (27% directly allocated). The remained energy (186618 m^2 nmi^{-2}) was allocated accounting the results fo the fishing station. It should be also note that 29782m^2 nmi^{-2} were left as unallocated (5% of the total backscattering energy) as has been recorded in a potential multi-specific environment in which no fishing station was undertook. Figure 16 shows the spatial distribution of the fishing stations and the proportion for each species estimated using the Nakken and Dommasnes method.

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.

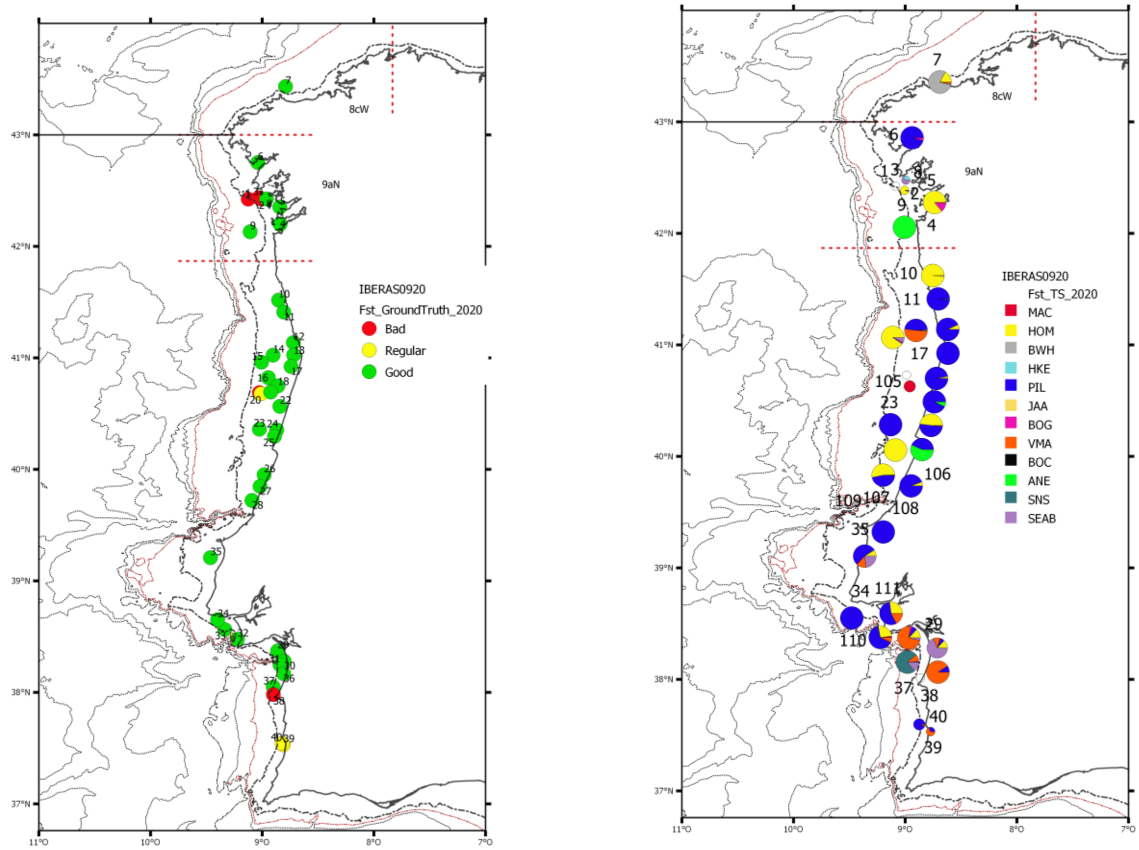


Figure 16. Left panel: location of the fishing station and traffic-light quality control. Right panel: Fish proportion accounting the Nakken and Dommaness method (BWH, blue whiting; MAC, mackerel; HKE, hake; HOM, horse mackerel; PIL, sardine; JAA, bluejack mackerel; BOG, bogue; VMA, chub mackerel; SEAB, seabreams; ANE, anchovy; SNS, longspine snipe fish)

Length weight-relationship

Length weight relationships for the target species were calculated using individual weights (0.001 g) and measurement (mm). Besides, grouped weights for length classes were also recorded but not used for the present estimates. The relations were estimated by ICES sub-Divisions, but only the overall relationship was used for assessment purposes.

1 Sardine WLR

Off 1023 individuals, 152 were measured in 9aN; 602 in 9aCN; and 269 in 9aCS. There was no measurement in 8cW. Figure 17 shows the length distribution for each area.

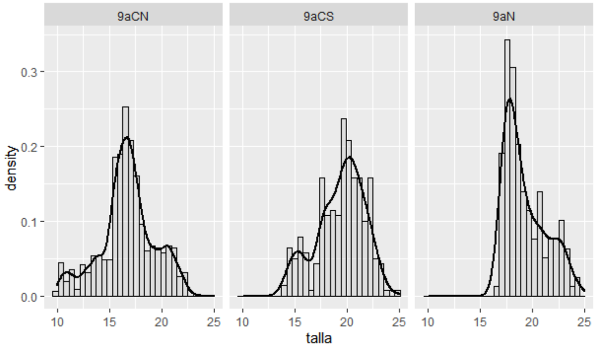


Figure 17. Sardine length distribution by ICES sub-Division from those specimens to obtain length-weight relationship

Either the differences in number of measured fish and also in the range of length distribution made difficult to compare WLR by area. The well represented small sizes in 9aCN and, in contrast the lack of bigger sizes, led to this area to have a different relation compared to both 9aN and 9aCS, as shown in figure 18.

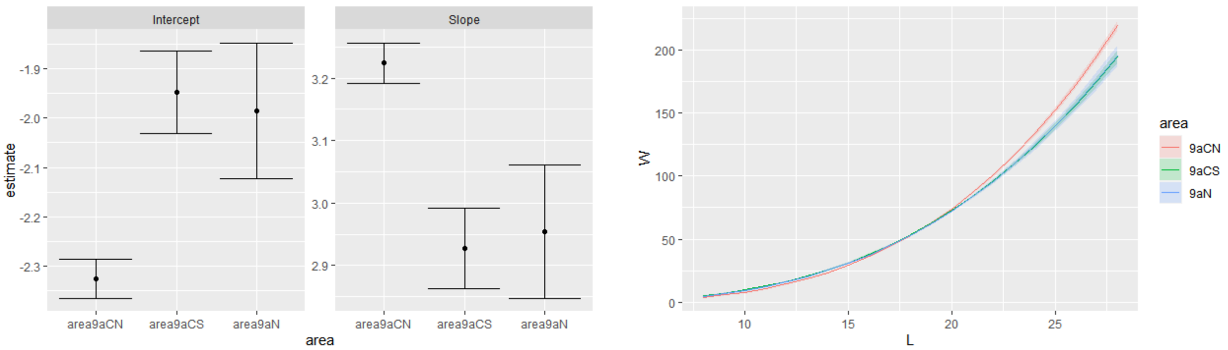


Figure 18. Length Weight Relationship for sardine by ICES sub-Division. Left panels a (log scale) and b parameters and their confidence intervals (%); right panel, plot with the LWR

Given this discrepancies in both length range and number of observations, a single LWR for the whole data was calculated with 0.00578 (0.005386-0.006246) and 3.15148 (3.1257-3.1773) as a and b parameters respectively with their 95% confidence intervals (figure 19).

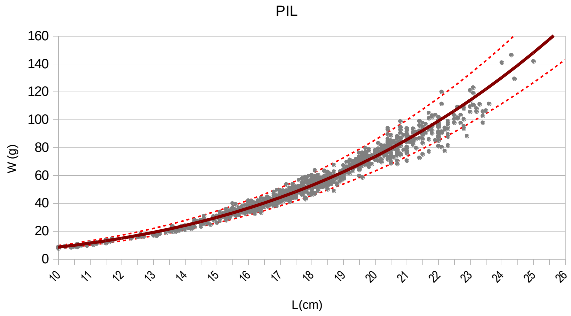


Figure 19. Length Weight Relationship for sardine used for assessment purposes (grey dots individual measurements; dotted lines, 95% confidence intervals)

2 Chub mackerel WLR

For the rest of the species between 271 and 365 were measured. For chub mackerel, there was a sample in every ICES sub-division. The WLR parameters for the whole area were 0.006957 (0.005713-0.008471) and 3.063983 (3.003135-3.12483) respectively (figure 20).

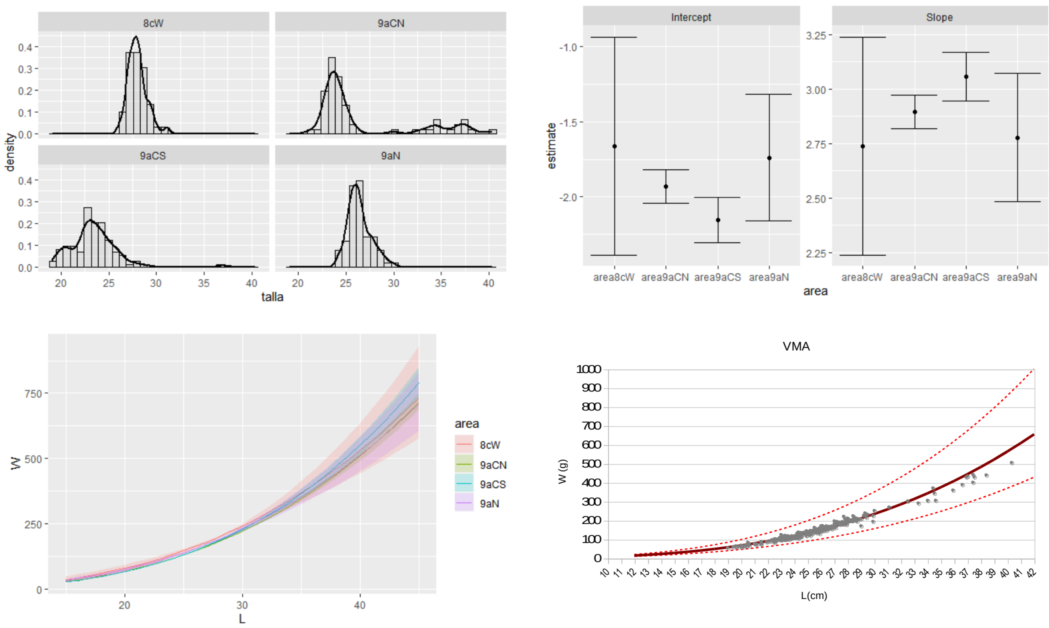


Figure 20. Chub mackerel Length Weight Relationship. Upper left, length distribution by area; right a and b parameter by ICES sub-division. Lower left, lwr by ICES sub-division and right overall lwr (grey dots individual measurements; dotted lines, 95% confidence intervals)

3 Mackerel WLR

As for chub mackerel, there was a sample in each ICES sub-division, although the length distributions, as for sardine were different. WLR parameters were 0.002438 (0.002083-0.00285) and 3.356366 (3.305204-3.407528) respectively (figure 21).

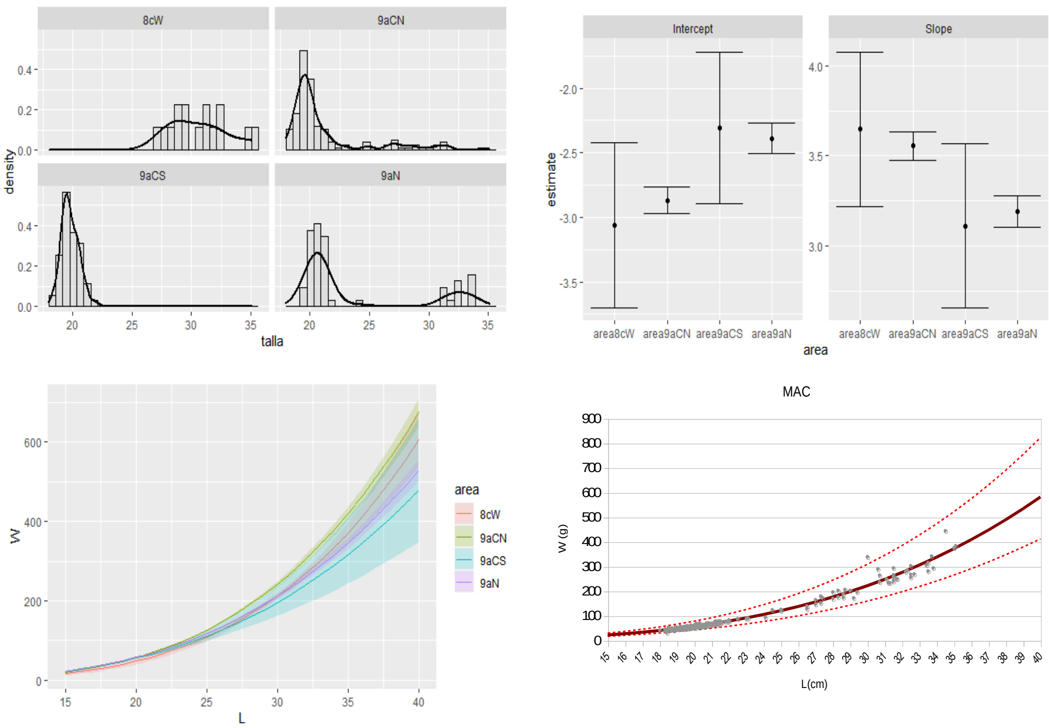


Figure 21. Mackerel Length Weight Relationship. Upper left, length distribution by area; right a and b parameter by ICES sub-division. Lower left, lwr by ICES sub-division and right overall lwr (grey dots individual measurements; dotted lines, 95% confidence intervals)

4 Horse Mackerel WLR

Only in 9aN and 9aCN samples for horse mackerel were available. WLR parameters were 0.0085524 (0.007618-0.009602) and 3.00676 (2.967583-3.045936) respectively (figure 22).

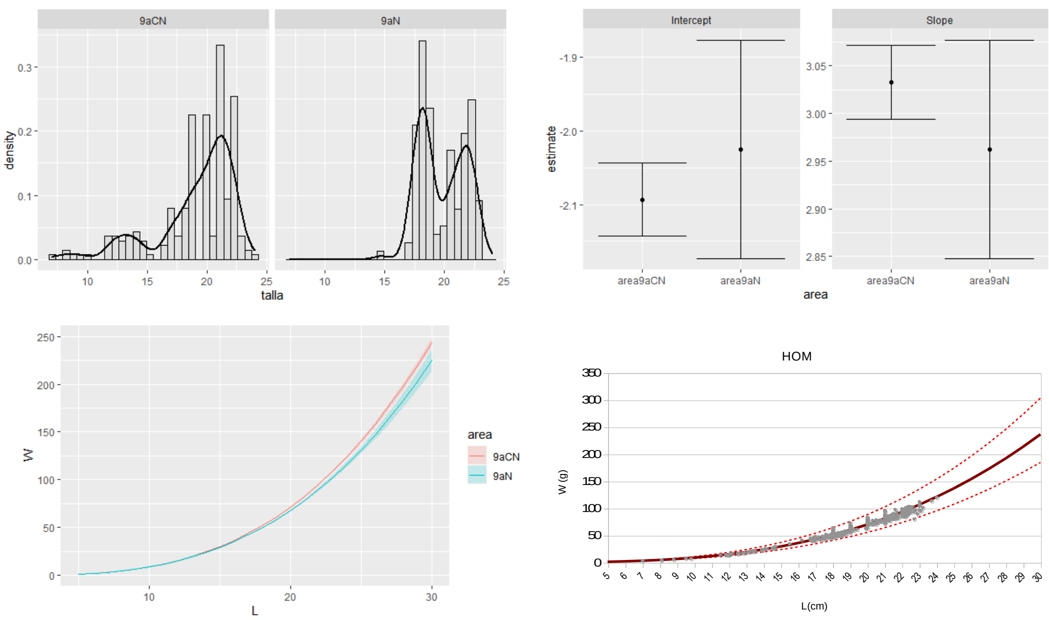


Figure 22. Horse Mackerel Length Weight Relationship. Upper left, length distribution by area; right a and b parameter by ICES sub-division. Lower left, lwr by ICES sub-division and right overall lwr (grey dots individual measurements; dotted lines, 95% confidence intervals

5 Anchovy WLR

Only in 9aN and 9aCN samples for anchovy were available, with different length distributrion. WLR parameters were 0.0027775 (0.002472-0.0031202) and 3.32119 (3.277857-3.364515) respectively (figure 23).

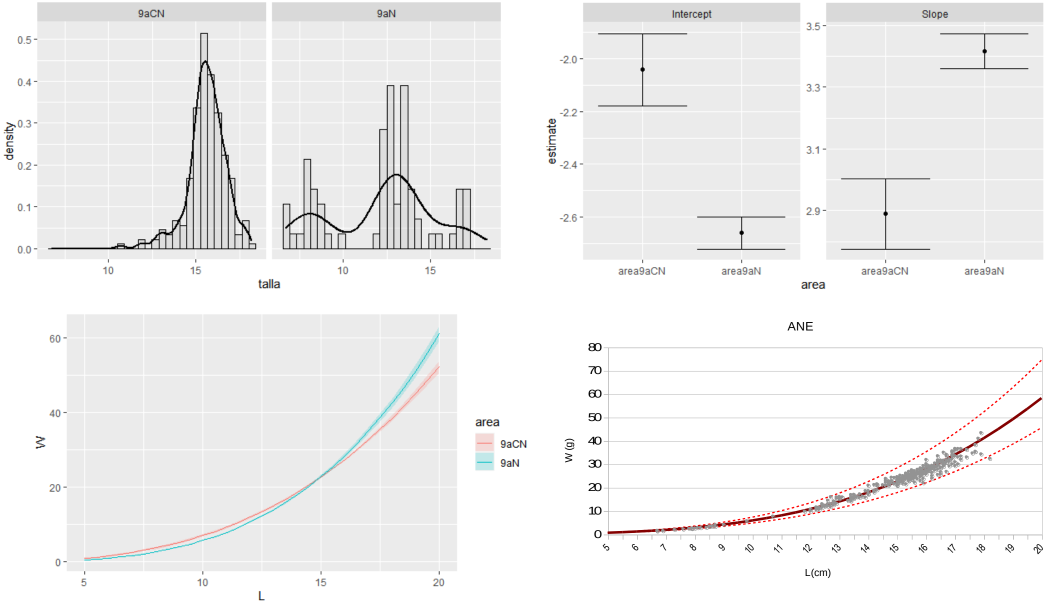


Figure 23. Anchovy Length Weight Relationship. Upper left, length distribution by area; right a and b parameter by ICES sub-division. Lower left, lwr by ICES sub-division and right overall lwr (grey dots individual measurements; dotted lines, 95% confidence intervals

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 2019 cruise is the important increase in sardine and the decrease in anchovy backscattering energy, whose center of gravity sifted northwards due to the schools recorded in 9aN close to the slope.

Table 6. Total NASC allocated to the main pelagic species together with the location of the coordinates of the centre of gravity (WHB, blue whiting; MAC, mackerel; HOM, horse mackerel; PIL, sardine; SEB, sea breams; VMA, chub mackerel; ANE, anchovy; SNS, longspine snipefish, KRILL, euphausidae)

	WHB	MAC	HOM	PIL	SEAB	ANE	SNS	krill
NASC	36	900	95312	391177	6844	8573	6118	76
Depth	67.28	33.88	26.26	22.39	30.29	61.16	43.96	48.28
s.d.	0.00	6.40	5.70	5.16	4.43	7.03	3.21	6.75
ic	0.00	0.84	0.75	0.68	0.59	0.93	0.42	0.89
Dist	382.05	104.36	295.45	228.81	123.91	303.30	66.23	360.40
s.d.	0.00	21.89	32.79	44.83	21.05	10.48	3.66	18.38
ic	0.00	2.89	4.33	5.92	2.78	1.38	0.48	2.43

Figure 24 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, and similar to that found in 2019 (areas 2 to 4). Chub mackerel has moved southwards while sardine was sifted northwards although was mainly located in 9aCN. Horse mackerel and anchovy are clearly located in 9aN whereas mackerel was mainly located in the Tagus bay.

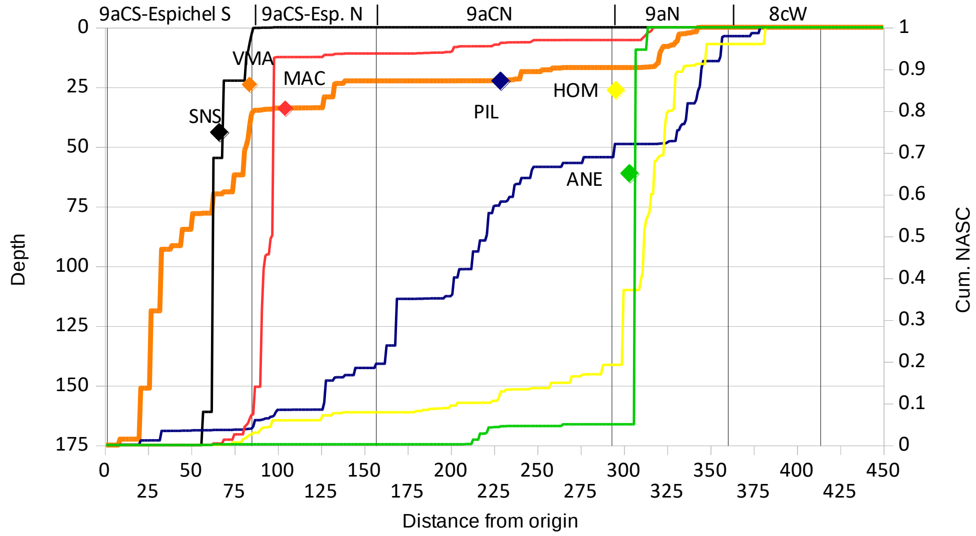


Figure 24. Center of gravity and cumulated NASC for the most important pelagic species (ANE, anchovy-green-; PIL, sardine -blue-; HOM, h. mackerel -yellow-; MAC, mackerel -red-; VMA, C. mackerel -orange-; and SNS, longspine snipe fish-black-)

1 Sardine assessment

Accounting the length distributions obtained at the fishing station and the NASC spatial distribution, sardine was divided in 6 strata, one for each ICES sub-division (8cW, 9aN and 9aCN) and 3 for 9aCS (Ericeira, Lisbon, Alentejo). For each strata fishing station were weighted using the sardine backscattering values attributed to each fishing station. In 9aCN, where the bulk of the hauls were performed, mean length ranged from 10.95 to 17.55, the later located offshore with only few schools within them, thus little influence on the overal length distribution (0.79%). Figure 25 shows the length distribution in each area.

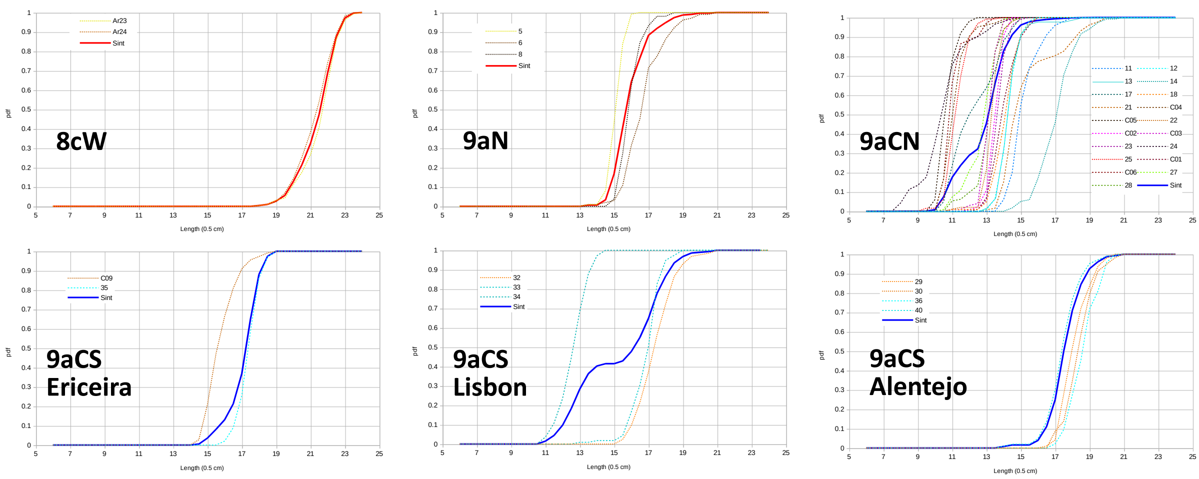


Table 7 summarises the sardine assessment. A total of 328911 tonnes, corresponding to 10529 million fish were estimated. The bulk of the distribution was found in 9aCN (160.7*10^3 tonnes).

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 0920 SARDINE						
ICES-Div	**Region**	**No**	**Mean**	**Surface**	**Fishing st.**	**PDF**	**No (million fish)**	**Biomass (tonnes)**	**Density (Tn/nmi-2)**
8cW	8cW	9	921.56	43	P06	S01	122	11754	271
	Total	**9**	***921.56***	**43**			**122**	**11754**	**271**
9aN	9aN	176	644.81	447	P05-P06-P08	S02	1422	64272	144
	Total	**176**	***644.81***	**447**			**1422**	**64272**	**144**
9aCN	Oc North	306	645.25	1462	P-11P12-P13-P17-P18-CE04-CE05-PE22-CE02-CE03-PE23-PE24-PE25-C06-PE27-PE28	S03	7601	160688	110
	Total	**306**	***645.25***	**1462**			**7601**	**160688**	**110**
9aCS	Ericeira	86	457.34	455	C09-PE35	S04	784	53964	119
	Lisbon	26	601.81	119	PE32-PE33-PE34	S05	320	17385	146
	Alentejo	67	253.40	308	PE29-PE30-PE36-PE40	S06	280	20847	68
	Total	**179**	***401.99***	**882**			**1384**	**92196**	**105**
	Total Spain	***185***	***658***	***490***			***1544***	***76026***	**155**
	Total Portugal	***485***	***555***	***2344***			***8986***	***252884***	**108**
	TOTAL	**670**	***584***	**2834**			**10529**	**328911**	**116**

The assessment was clearly dominated by young fish, with young of the year fish (YOY)accounted for 41.32% of the total biomass and the 64.42 % of the abundance and age group 1 for the 35% and 26% respectively. In relation with that estimated in previous years there was a significant increasing trend, from 14x10^3 mt estimated in 2018; 101x10^3 mt in 2019; and 136x10^3 mt in 2020. Length and age distribution by ICES sub-divisions are shown in figure 27. Interesting, in each area both and age distribution are different and complementary and the whole gave an idea of the population structure in length and age.

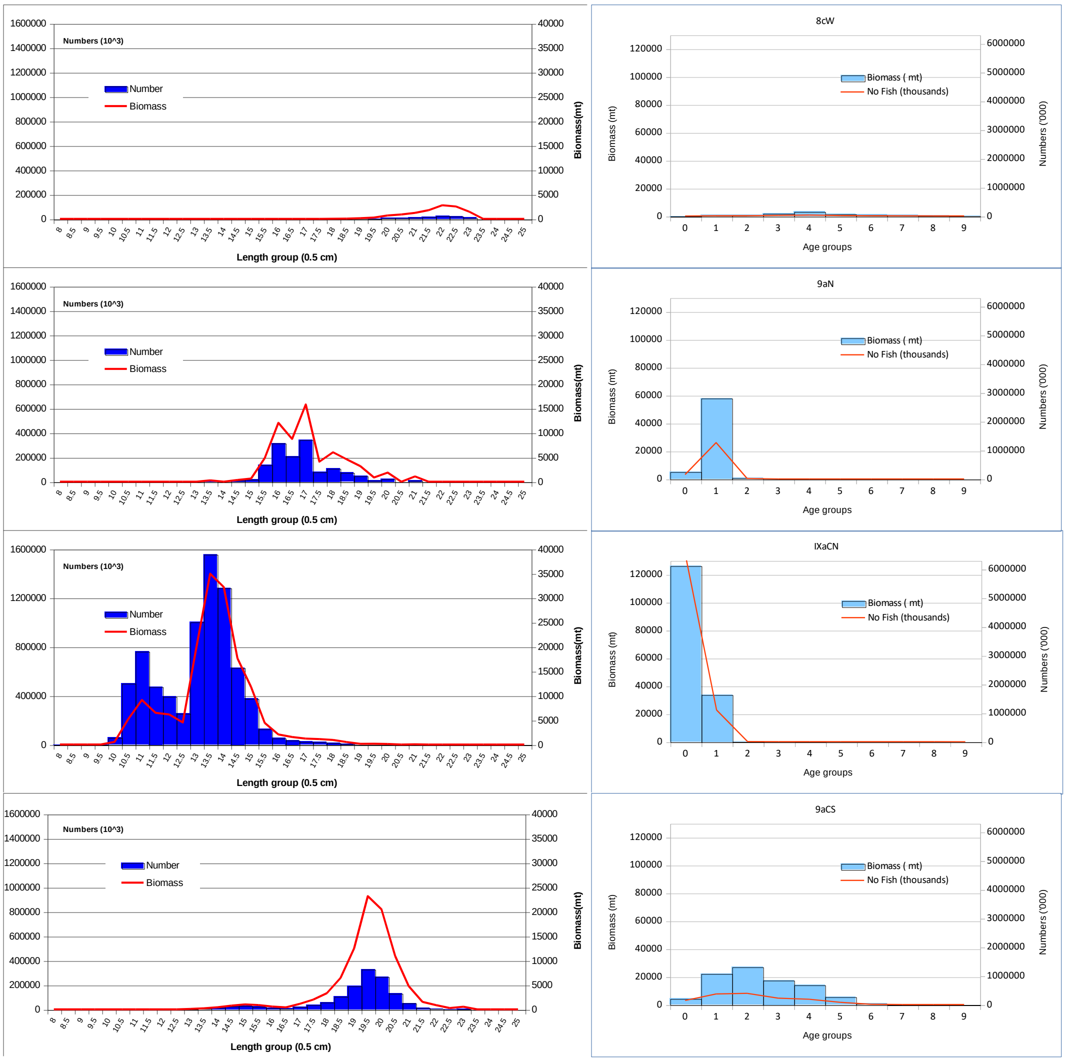


Figure 27. Sardine biomass and abundance estimates by ICES sub-division. Left panels in length classes; right panels in age groups

Figure 28 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, the gap towards Galicia observed last year was small where fish were only located inside the Rias. The same perception of the sardine distribution, having a rather continuity in the distribution.

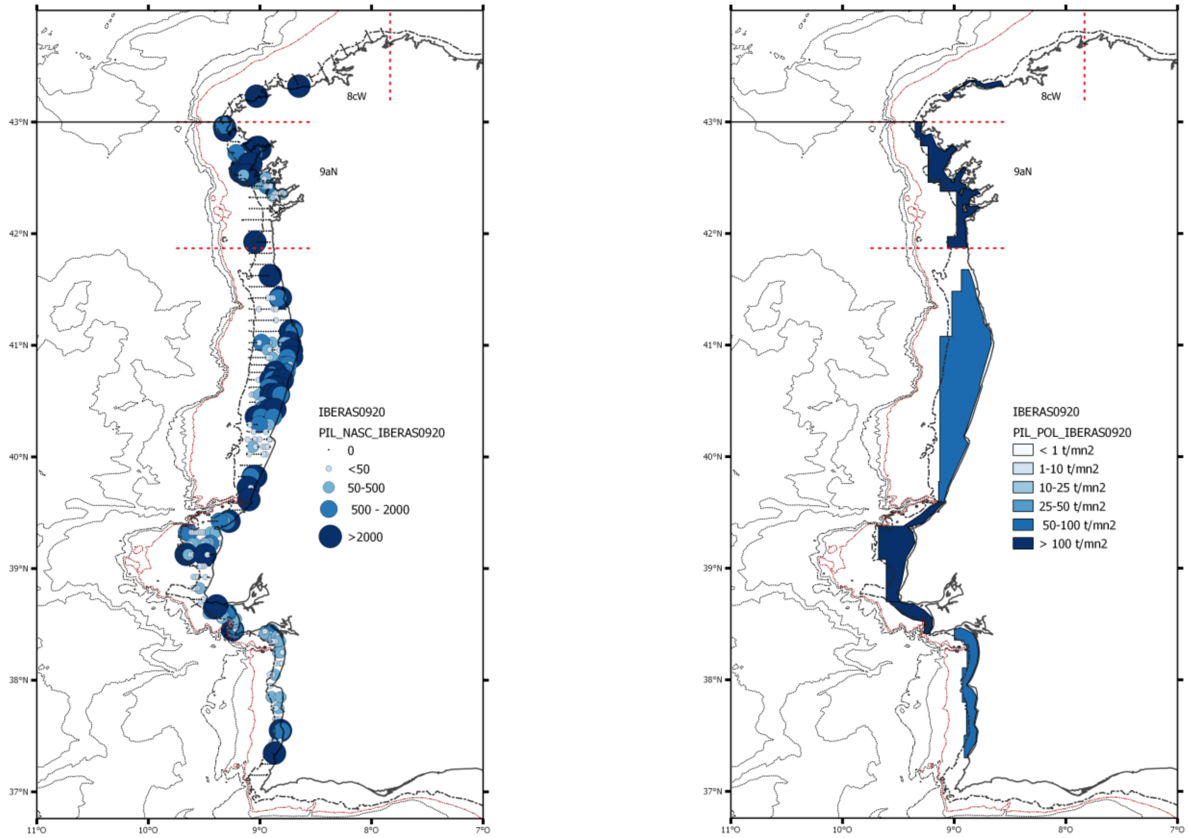


Figure 28. Sardine spatial distribution in IBERAS 0920. Dots represent the NASC values attributed to sardine and the polygons the strata together with the relative density

Table 8a-g 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. In the same way age distribution in 8cW should be taken as provisional as long as age/length key should be updated and, therefore, age structure could change.

Table 8a: Sardine assessment in 8cW

	AGE GROUPS											
Length	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Total**	**No fish (thousands)**
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												
17.5												
18	1	26	1								27.80	508
18.5		37	6								43.36	727
19		85	47	3	6						141.32	2182
19.5		47	59	30	101	12					248.68	3542
20		165	165	132	177	33		11			683.99	9004
20.5		170	170	212	276	21	42				891.85	10872
21		177	133	222	532	22	89	22	22		1218.64	13782
21.5		80		402	402	482	322	80			1768.37	18585
22		71	356	285	570	570	427	427	71		2777.86	27177
22.5				583	972	194	194	194	194	194	2527.85	23058
23		84	84	168	335	251	84	168	168	84	1424.53	12134
23.5												
24												
24.5												
25												
Biomass (mt)	1	943	1021	2037	3370	1586	1158	903	455	278	11754.24	121572
%	0.01	8.02	8.69	17.33	28.67	13.50	9.85	7.68	3.87	2.37		
M. weight	52.41	77.43	83.74	92.66	92.90	97.35	96.37	100.87	105.84	108.02	15.41	
No Fish (thousands)	27	11585	11639	21067	34756	15672	11568	8623	4149	2487	121572	
%	0.02	9.53	9.57	17.33	28.59	12.89	9.52	7.09	3.41	2.05		
M. length	18.00	20.37	20.89	21.57	21.59	21.91	21.84	22.16	22.50	22.64	21.56	
s.d.	0.00	1.20	1.11	0.93	0.97	0.68	0.58	0.56	0.51	0.23	1.04	

.

Table 8b: Sardine assessment in 9aN

	AGE GROUPS											
Length	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Total**	**No fish (thousands)**
8												
8.5												
9												
9.5												
10												
10.5												
11												
11.5												
12												
12.5												
13												
13.5	275										275.13	12268
14												
14.5	272	82									353.90	12648
15	280	373									652.43	20992
15.5	1749	3060									4809.27	139781
16	1951	10079									12029.75	316849
16.5	728	8004									8731.12	209020
17		15794									15793.87	344626
17.5		4089									4088.86	81537
18		6017									6016.64	109922
18.5		4565									4564.55	76584
19		3164									3163.62	48854
19.5		643	214								857.47	12214
20		1624	232								1855.53	24427
20.5												
21		540	540								1079.97	12214
21.5												
22												
22.5												
23												
23.5												
24												
24.5												
25												
Biomass (mt)	5254	58032	986	0	0	0	0	0	0	0	64272.11	1421935
%	8.17	90.29	1.53									
M. weight	32.91	43.44	77.45								42.62	
No Fish (thousands)	150623	1259099	12214	0	0	0	0	0	0	0	1421935	
%	10.59	88.55	0.86									
M. length	15.53	16.96	20.38								16.84	
s.d.	0.78	1.06	0.65								1.17	

Table 8c: Sardine assessment in 9aCN

Length	0	1	2	3	4	5	6	7	8	9	Total	No fish (thousands)
						AGE GROUPS						
8	0										0.07	16
8.5	0										0.14	27
9	0										0.05	8
9.5	1										0.61	80
10	521										520.72	58601
10.5	5186										5186.34	502312
11	9108										9108.38	764418
11.5	6480										6479.85	474174
12	6147										6147.31	394477
12.5	4513										4513.28	255314
13	18438	1603									20041.09	1004284
13.5	34933										34933.49	1557685
14	27046	5152									32197.60	1282847
14.5	10583	7056									17638.89	630409
15	2710	9034									11743.84	377863
15.5	552	3861									4412.61	128253
16		2057									2056.92	54177
16.5		1539									1538.79	36838
17		1206									1206.41	26324
17.5		1101									1101.49	21965
18	92	782	46								919.74	16803
18.5		353	141								494.12	8290
19		62	57	5	10						133.68	2064
19.5		19	34	24	78	5					160.44	2285
20		18	27	20	34	7		2			108.09	1423
20.5												
21		6	4	9	20		4	1	1		44.32	501
21.5												
22												
22.5												
23												
23.5												
24												
24.5												
25												
Biomass (mt)	126311	33849	309	58	141	12	4	3	1	0	160688.29	7601439
%	78.61	21.07	0.19	0.04	0.09	0.01	0.00	0.00	0.00			
M. weight	18.85	30.22	61.94	73.73	73.06	73.40	88.42	79.80	88.42		20.54	
No Fish (thousands)	6491801	1101698	4976	784	1923	158	42	44	14	0	7601439	
%	85.40	14.49	0.07	0.01	0.03	0.00	0.00	0.00	0.00			
M. length	13.01	15.12	18.98	20.06	20.00	20.03	21.25	20.57	21.25		13.32	
s.d.	1.28	1.05	0.59	0.54	0.52	0.25		0.47			1.47	

Table 8d: Sardine assessment in 9aCS

Length	AGE GROUPS 0	1	2	3	4	5	6	7	8	9	Total	No fish (thousands)
8												
8.5												
9												
9.5												
10												
10.5												
11												
11.5												
12												
12.5												
13	94										94.03	4712
13.5	211										211.34	9424
14	426										425.73	16962
14.5	765										764.65	27328
15	1007										1007.04	32402
15.5	875										875.40	25444
16	561										561.15	14780
16.5	401										400.74	9594
17		1117									1117.16	24377
17.5		2002									2002.13	39925
18		3312									3312.04	60510
18.5		6424									6424.02	107782
19		3127	9382								12508.97	193170
19.5		4634	9268		4634	4634					23169.59	330020
20			6823	10234	3411						20468.00	269450
20.5		1363	1363	5454	2727						10907.08	132962
21		317	317	950	2534	317	317				4752.09	53742
21.5				763	763						1525.96	16038
22					122	367	367				857.20	8386
22.5				138		138					275.24	2511
23						268	268				536.58	4570
23.5												
24												
24.5												
25												
Biomass (mt)	4340	22297	27152	17539	14192	5724	952	0	0	0	92196.14	1384088
%	4.71	24.18	29.45	19.02	15.39	6.21	1.03					
M. weight	28.96	57.82	67.29	76.17	74.75	71.23	96.71				60.10	
No Fish (thousands)	140645	367093	386905	221229	182032	76721	9462	0	0	0	1384088	
%	10.16	26.52	27.95	15.98	13.15	5.54	0.68					
M. length	14.91	18.57	19.49	20.27	20.15	19.84	21.86				19.03	
s.d.	0.87	0.87	0.46	0.41	0.63	0.89	0.78				1.67	

Table 8e: Sardine assessment in Spanish area (8cW+9aN)

					AGE GROUPS						
Length	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Total**	**No fish (thousands)**
8												
8.5												
9												
9.5												
10												
10.5												
11												
11.5												
12												
12.5												
13												
13.5	275										275	12268
14												
14.5	272	82									354	12648
15	280	373									652	20992
15.5	1749	3060									4809	139781
16	1951	10079									12030	316849
16.5	728	8004									8731	209020
17		15794									15794	344626
17.5		4089									4089	81537
18	1	6042	1								6044	110430
18.5		4602	6								4608	77311
19		3248	47	3	6						3305	51037
19.5		690	274	30	101	12					1106	15756
20		1789	397	132	177	33		11			2540	33431
20.5		170	170	212	276	21	42				892	10872
21		717	673	222	532	22	89	22	22		2299	25995
21.5		80		402	402	482	322	80			1768	18585
22		71	356	285	570	570	427	427	71		2778	27177
22.5				583	972	194	194	194	194	194	2528	23058
23		84	84	168	335	251	84	168	168	84	1425	12134
23.5												
24												
24.5												
25												
Biomass (mt)	5256	58975	2008	2037	3370	1586	1158	903	455	278	76026.35	1543508
%	6.91	77.57	2.64	2.68	4.43	2.09	1.52	1.19	0.60	0.37		
M. weight	32.91	43.69	80.48	92.66	92.90	97.35	96.37	100.87	105.84	108.02	44.77	
No Fish (thousands)	150650	1270684	23852	21067	34756	15672					1543508	
%	9.76	82.32	1.55	1.36	2.25	1.02	0.75	0.56	0.27	0.16		
M. length	15.53	16.99	20.62	21.57	21.59	21.91	21.84	22.16	22.50	22.64	17.21	
s.d.	0.78	1.11	0.94	0.93	0.97	0.68	0.58				1.72	

Table 8f: Sardine assessment in Portuguese area (9aCN+9aCS)

Length	0	1	2	3	4	5	6	7	8	9	Total	No fish (thousands)
8	0										0	16
8.5	0										0	27
9	0										0	8
9.5	1										1	80
10	521										521	58601
10.5	5186										5186	502312
11	9108										9108	764418
11.5	6480										6480	474174
12	6147										6147	394477
12.5	4513										4513	255314
13	18532	1603									20135	1008995
13.5	35145										35145	1567109
14	27472	5152									32623	1299809
14.5	11348	7056									18404	657737
15	3717	9034									12751	410265
15.5	1427	3861									5288	153696
16	561	2057									2618	68957
16.5	401	1539									1940	46432
17		2324									2324	50701
17.5		3104									3104	61890
18	92	4094	46								4232	77313
18.5		6777	141								6918	116072
19		3189	9439	5	10						12643	195234
19.5		4653	9302	24	4712	4639					23330	332305
20		18	6850	10254	3445	7		2			20576	270873
20.5		1363	1363	5454	2727						10907	132962
21		323	320	959	2554	317	320	1	1		4796	54243
21.5				763	763						1526	16038
22					122	367	367				857	8386
22.5				138		138					275	2511
23						268	268				537	4570
23.5											0	
24											0	
24.5											0	
25											0	
Biomass (mt)	130651	56146	27462	17597	14333	5736	956	3	1	0	252884.42	8985527
%	51.66	22.20	10.86	6.96	5.67	2.27	0.38	0.00	0.00			
M. weight	17.93	34.69	67.18	76.15	74.70	71.22	96.66	76.79	85.19		25.85	
No Fish (thousands)	6632447	1468790	391881	222013	183955	76880					8985527	
%	73.81	16.35	4.36	2.47	2.05	0.86	0.11	0.00	0.00			
M. length	12.81	15.79	19.48	20.27	20.14	19.84	21.86	20.32	21.00		13.99	
s.d.	1.31	1.89	0.47	0.41	0.63	0.89	0.78				2.62	

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

	AGE GROUPS											
Length	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Total**	**No fish (thousands)**
8	0										0.07	16
8.5	0										0.14	27
9	0										0.05	8
9.5	1										0.61	80
10	521										520.72	58601
10.5	5186										5186.34	502312
11	9108										9108.38	764418
11.5	6480										6479.85	474174
12	6147										6147.31	394477
12.5	4513										4513.28	255314
13	18532	1603									20135.12	1008995
13.5	35420										35419.96	1579377
14	27472	5152									32623.34	1299809
14.5	11620	7137									18757.44	670386
15	3997	9407									13403.31	431257
15.5	3176	6921									10097.29	293477
16	2512	12136									14647.83	385806
16.5	1128	9542									10670.65	255452
17		18117									18117.45	395327
17.5		7192									7192.48	143427
18	93	10136	47								10276.21	187743
18.5		11379	147								11526.05	193383
19		6438	9486	8	16						15947.58	246271
19.5		5344	9575	54	4812	4651					24436.17	348061
20		1807	7247	10387	3622	40		13			23115.61	304305
20.5		1533	1533	5666	3003	21	42				11798.93	143834
21		1040	993	1181	3086	339	409	23	23		7095.01	80239
21.5		80		1165	1165	482	322	80			3294.33	34623
22		71	356	285	692	937	795	427	71		3635.06	35563
22.5				721	972	332	194	194	194	194	2803.09	25569
23		84	84	168	335	520	352	168	168	84	1961.11	16704
23.5												
24												
24.5												
25												
Biomass (mt)	135907	115121	29469	19633	17703	7322	2114	906	457	278	328911	10529035
%	41.32	35.00	8.96	5.97	5.38	2.23	0.64	0.28	0.14	0.08		
M. weight	20.04	42.02	70.89	80.77	80.94	79.11	100.34	104.59	109.71	111.86	31.24	
No Fish (thousands)	6783096	2739474	415733	243080	218711	92552	21072	8666	4163	2487	10529035	
%	64.42	26.02	3.95	2.31	2.08	0.88	0.20	0.08	0.04	0.02		
M. length	12.87	16.35	19.54	20.38	20.37	20.19	21.85	22.15	22.49	22.64	14.46	
s.d.	1.36	1.69	0.58	0.60	0.87	1.16	0.00	0.00	0.00	0.00	2.76	

Sardine stock indicators

These stock indicators are a series of metrics comparing results from 2018 to 2020. However, it should be take into account that there is a gap of two month between 2018 and 2019 and 2020 surveys which have to take into account when the results of this comparison are analysed.

Spatial distribution

Figure 29 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. 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).

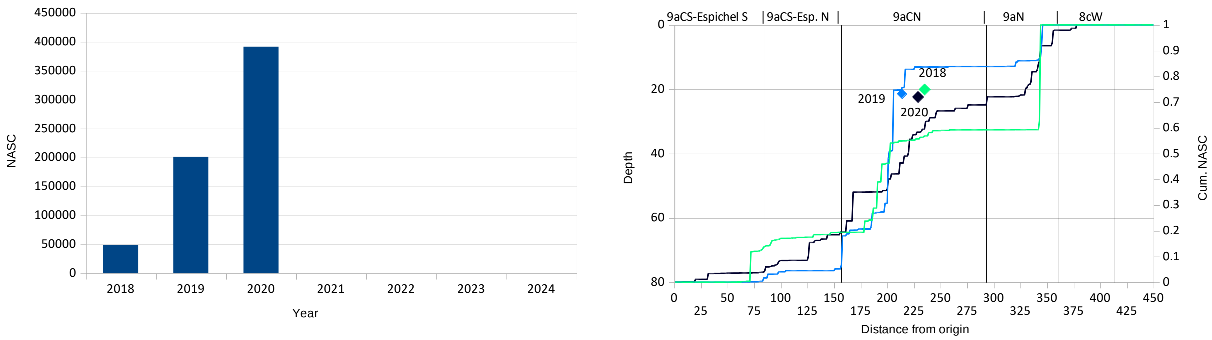


Figure 29: Relative cumulative NASC values of sardine along the coast (from south to north) and center of gravity (above right) and the total backscattering energy attributed to sardine (below right). Numbers in the cumulative plot correspond to the areas in the map (left)

Length and weight evolution (2018-20)

As expected, both mean length and weight decreased from 2018 to 2019 mainly due to the gap in time, as shown in figure 30. In addition the strength of the 2019 cohort led to a decrease in both mean length and weight-at-age.

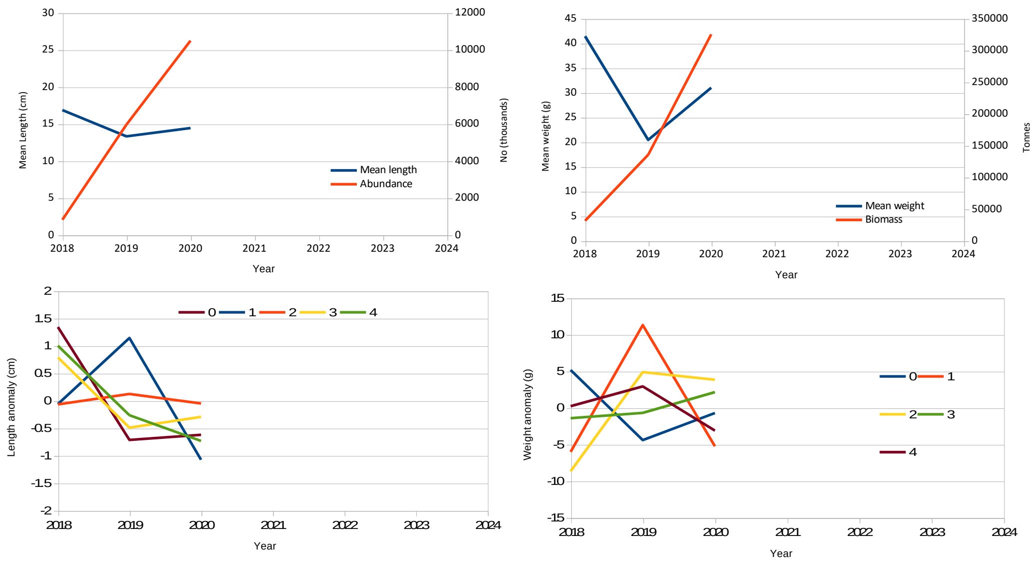


Figure 30: Above: mean length (cm) and abundance (thousand of fish) and mean weight (gr) and biomass /mt) of sardine estimated in IBERAS (2018-20) (left and right respectively); below: mean length and weight anomalies (differences from the mean value) for age groups 0 to 4

In relation to 2019, the estimated biomass in 2020 gave similar results (e.g $4*10^3$ mt and $5*10^3$ mt respectively), far from the estimation obtained in 2018 when $182*10^3$ mt were assessed to only. The summary of the assessment is shown in table 9. The assessment is still in progress and age structure is not available for the time being. Figure 30 shows the spatial distribution

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

Zone	Area	No	Mean	Area	Fishing st.	PDF	No (million fish)	Biomass (tonnes)	Density (Tn/nmi-2)
9aCS	Sines	8	1.75	40	P14	S01	1	8	0
	Total	***8***	***1.75***	***40***			***1***	***8***	**0**
9aCN	Figueira	69	6.01	320	P14	S01	12	289	1
	Total	***69***	***6.01***	***320***			***12***	***289***	**1**
9aN	Rbaixas	11	740.73	62			570	4879	78
	Total	**11**	**741**	**62**			***570***	***4879***	78
	Portugal	***77***	***6***	***360***			***12***	***297***	**1**
	Spain	***11***	***741***	***62***			***570***	***4879***	**78**
	TOTAL	**88**	***97.47***	**422**			**583**	**5176**	**12**

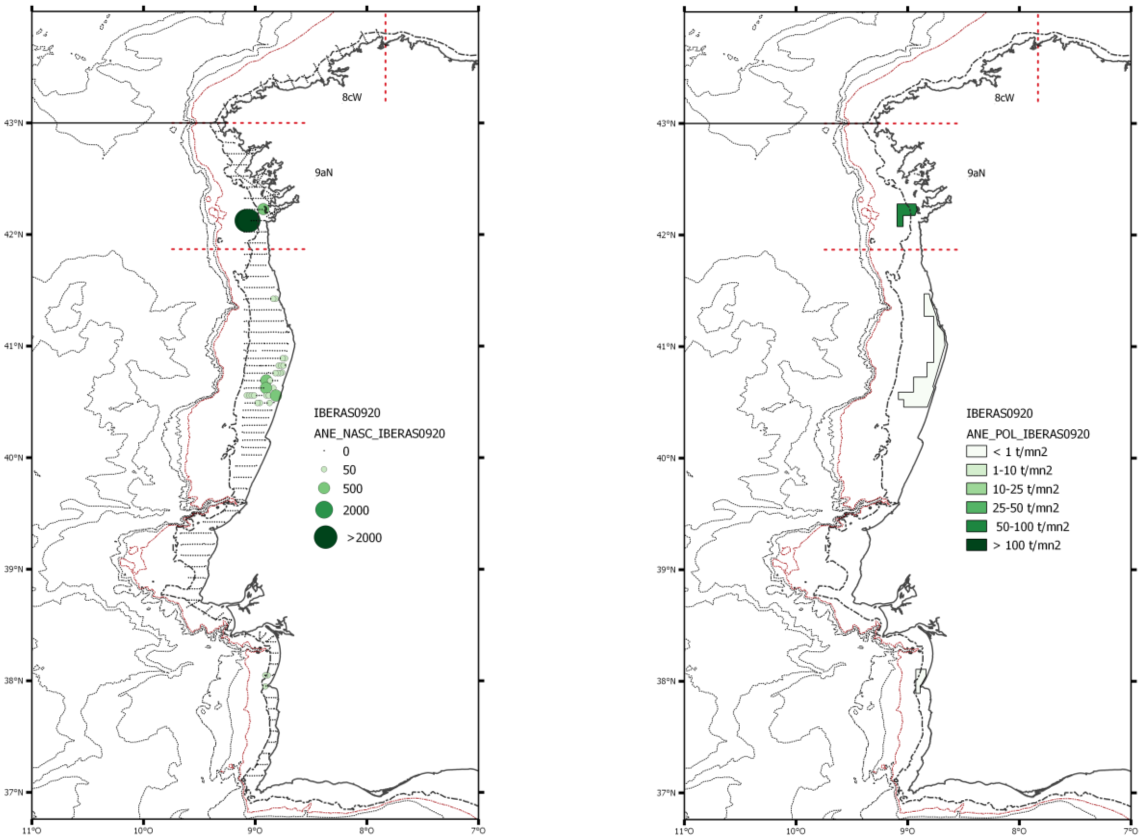
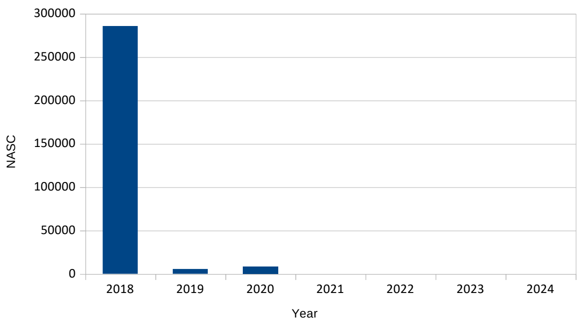


Figure 30. Anchovy spatial distribution in IBERAS 0920. Dots represent the NASC values attributed to anchovy and the polygons the strata together with the relative density

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 provide a comprehensive length and age distributions. Even backscattering energy is very low, and the center of gravity is highly influenced by the presence of (relative) high values (figure 31).



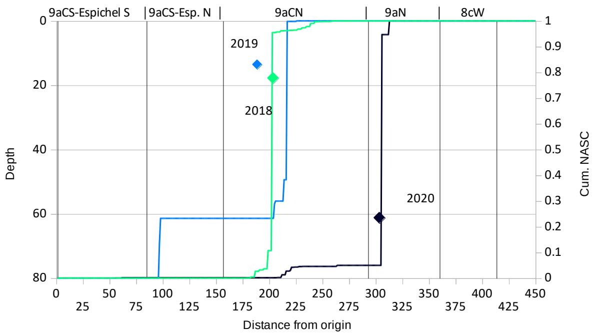


Figure 31: Relative cumulative NASC values of anchovy along the coast (from south to north) and center of gravity (above right) and the total backscattering energy attributed to anchovy (below right). Numbers in the cumulative plot correspond to the areas in the map (left)

3 Chub mackerel assessment

As for anchovy, the assessment is still in progress and no age information is available for the time being. Table 11 summarises the chub mackerel assessment. $54*10^3$ mt tonnes, corresponding to $323*10^6$ fish, were assessed. Length distribution was very similar in the southern part, with the mode located at 22 while in the northern part the mode was locted at 25 cm. There was a decrease compared to the results obtained in 2019.

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

Zone	Area	No	Mean	Surface	Fishing st.	PDF	No (million fish)	Biomass (tonnes)	Density (Tn/nmi-2)
9aCS	Alentejo	78	674.45	378.62	P09-P10-P14-P16	ST01	24	2521	7
	Lisboa	26	17.04	119.19	P13-P14-P15	ST02	2	229	2
	Ericeira	75	56.83	394.04	P09-P10-P14-P16	ST01	276	28746	73
	Total	***179***	***320***	***892***			***302***	***31496***	35
9aCN	9aCN	238	8.77	1117.11	P09-P10-P14-P16	ST01	10	1168	1
	Total	***238***	***9***	***1117.1***			***10***	***1168***	1
9aN	9aCN	150	41.88	308.33	P09-P10-P14-P16	ST01	11	1605	5
	Total	***150***	***42***	***308***			***11***	***1605***	5
	Total Portugal	***417***	***142***	***2009***			***312***	***32664***	16
	Total Spain	***150***	***42***	***308***			***11***	***1605***	5
	Total 9a	***567***	***116***	***2317***			***323***	***34268***	15

As stated, chub mackerel had a wider distribution all along the surveyed area, as shown in figure 32. 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.

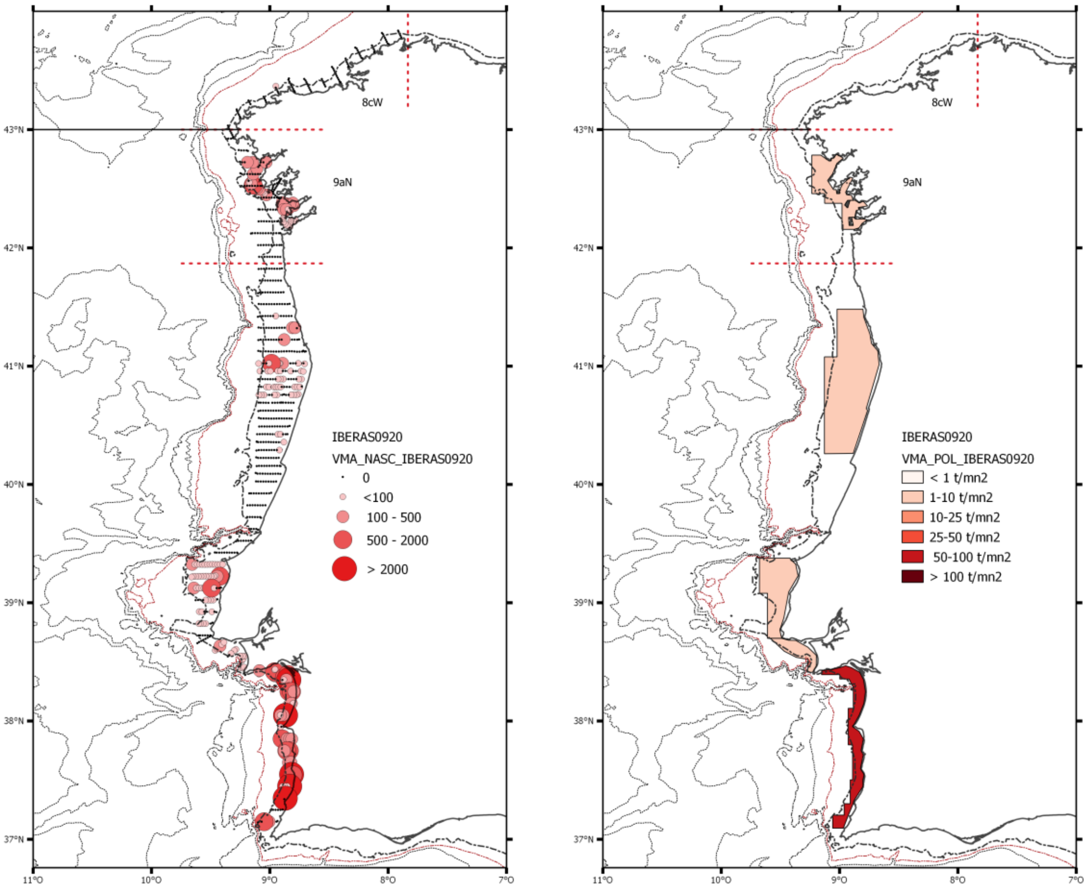


Figure 32. Chub mackerel spatial distribution in IBERAS 0920. Dots represent the NASC values attributed to chub mackerel and the polygons the strata together with the relative density

Chub mackerel stock indicators

As the age/length key is still not available, no comparison among ages between 2018 and 2020 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 33.

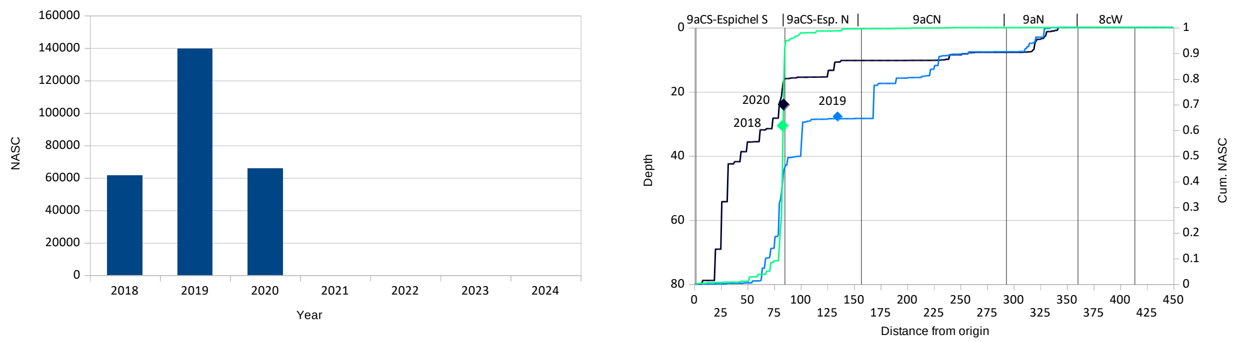


Figure 33: Relative cumulative NASC values of chub mackerel along the coast (from south to north) and center of gravity (above right) and the total backscattering energy attributed to anchovy (below right). Numbers in the cumulative plot correspond to the areas in the map (left)

DISCUSSION AND CONCLUSIONS

In spite this is the third year this survey is carried out, sardine recruitment area seems to be quite stable and, for the time being, independent of the strength of the recruitment. The change from from November to September (two months 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 still available.

The fish distribution was wider than that observed in 2019 and it seems, the amount of fish has increased. As consequence, the number of fishing stations has also increased. The change from 8 to 6 nmi together with keeping 4 nmi between transect in the main recruitment area has also improved the estimates. Besides, this intertransect distance allows the hotspot (e.g. areas with high fish concentration) be recorded.

Concerning sardine recruitment, it seems the productivity is now increasing and the last two recruitment were significantly better than that estimated in 2018. In addition, although the potential distribution area is not fully covered, sardine availability has increased. Interesting, both length distribution and age composition seems to be complementarity among ICES sub-divisions. The bulk of the recruitment is distributed in 9aCS, the younger (age group 1) in 9aN, middle ages in 9a CS and the older ages in 8cW. For this reason, a single wlr for the whole surveyed area was used instead a specific by ICES sub-division.

It should be also highlighted the strength of the mackerel recruitment, mainly found in Lisbon area. The strength of this recruitment would be confirmed during the spring surveys.

ACKNOWLEDGEMENT

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