WD to WGHANSA 2019 (25-28/11/2019), Madrid

PELAGIC ECOSYSTEM ACOUSTIC-TRAWL SURVEY PELACUS 0319: SARDINE AND ANCHOVY ABUNDANCE ESTIMATES

Instituto Español de Oceanografía

Funded by the EU through the European Maritime and Fisheries Fund (EMFF) within the National Program of collection, management and use of data in the fisheries sector and support for scientific advice regarding the Common Fisheries Policy.

Unión Europea
Fondo Europeo Marítimo y de Pesca (FEMP)

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TECHNICAL SUMMARY

Institution:	INSTITUTO ESPAÑOL DE OCEANOGRAFÍA
Survey name:	PELACUS 0319 (Spanish Area)
Vessel name:	Miguel Oliver (70 mn length, 2x1000 kW diesel-electric)
Dates:	27/03/2019-19/04/2019
Area:	NW-Spanish coast (9a-N, 8c)
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 8 nmi apart from 30 to 1000 isobath
Main sampling procedures	EK-60 at 18-38-70-120-200 kHZ acoustic frequencies. 1118 nmi prospected. Only day time CUFES, Intake at 5 m depth, 600 l min^{-1}. 3 nmi/sample, 374 samples (sardine, anchovy and mackerel eggs) Pelagic fishing stations: 37 Marine mammals and birds observations (not yet determined) Manta trawl hauls (microplastics).XX tows mostly done at the same time as the fishing tows Hydrological characterisation. 125 stations

Personnel
1st leg
Santander/A Coruña
Dates: 26/03 to 06/04

CARRERA LÓPEZ	PABLO	LAGO ROUCO	MARÍA JESÚS
GAGO PIÑEIRO	JESÚS MANUEL	SÁNCHEZ BARBA	MARÍA
MURCIA ABELLÁN	JOSÉ LUIS	IGLESIAS ÁLVAREZ	EVA
SANCHO MARTÍNEZ	PAULA	MALLOU TATO	GLORIA
ANTOLÍNEZ BOJ	ANA	VIDAL RODRÍGUEZ	ANA
SÁNCHEZ HERMOSÍN	PABLO	POLO SAINZ	JULIA
LOPEZ DÍAZ	EDUARDO	NAVARRO RODRÍGUEZ	MARIA ROSARIO
RODRÍGUEZ RAMOS	TAMARA	ARMESTO LÓPEZ	Mª ANGELES
FERNÁNDEZ LAMAS	ANGEL	GONZÁLEZ GONZÁLEZ	ISABEL CRISTINA
GÓMEZ GONZÁLEZ	ANTONIO	OTERO PINZÁS	ROSENDO
SOLLA COVELO	ANTONIO JOSÉ		

2nd leg
A Coruña/Vigo
Dates: 07-18/04

GUTIÉRREZ MUÑOZ	PAULA	DUEÑAS LIAÑO	CLARA
CARRETERO PERONA	OLGA	NOGUEIRA FUERTES	RAQUEL
SANCHO MARTÍNEZ	PAULA	OLMO BALLESTEROS	CRISTINA
COSTAS SELAS	CECILIA	GONZÁLEZ DEQUIDT	JAVIER
SÁNCHEZ HERMOSÍN	PABLO	FERRAZ CASTIÑEIRAS	DIEGO
GARCÍA BARCELONA	SALVADOR	BLANCO GINER	Mª ANGELES
VARELA ROMAY	JOSÉ	SALINAS AGUILERA	MIREN ITXASO
FERNÁNDEZ LAMAS	ANGEL	GONZÁLEZ GONZÁLEZ	ISABEL C
SOLLA COVELO	ANTONIO JOSÉ	OTERO PINZÁS	ROSENDO
REPARAZ	MARÍA		
CARRERA LÓPEZ	PABLO		

Report authors — Pablo Carrera, Isabel Riveiro

INTRODUCTION

The Spanish acoustic-trawl times series PELACUS started in 1991 when R/V Cornide de Saavedra was rebuilt and a new EK-500 was also purchased. Since that and until 1996, all cruises were carried out on board this vessel except that of 1995, called IBERSAR, which has been undertook on board R/V Noruega. In 1997 the series changed from R/V Cornide de Saavedra to the new R/V Thalassa (TH), a French/Spanish research vessel specially conceived for fish surveys.

This vessel was also used for the French acoustic survey (PELGAS). Survey strategy methods and analysis were established at the Planning Group for Acoustic Surveys in ICES Sub-Areas 8 and 9 met for the first time in 1986. Since 1998 the Planning Group, only attended until then by Spanish and Portuguese members, incorporated French scientists. As a first joint recommendation, the Planning Group agreed that acoustic data will be only recorded during day time, living the night time available for physical, chemical and plankton characterisation of the water column. This recommendation was implemented in 1998. In 2000, under the frame of the DG FISH, PELASSES project started, and the spring acoustic surveys incorporated the Continuous Underwater Fish Egg Sampler (CUFES) together with the routinely collection of other systematic measurements (SSS, SST, Flourometry, CTD+rossete casts, plankton hauls to determine primary production or dry weight at different sizes among other biological descriptors of the water column, etc.). In addition, the 120 khz frequency started to be used to help discriminate between different fish species. During this period, acoustic estimates were also provided for non commercial species such as bogue or boar fish. In 2007, a new team used the survey as a platform to obtain data on presence, abundance and behaviour of top predators (marine mammals and seabirds). Since 2007 data are also routinely collected on floating litter (type, number and position) and on other human pressures such as fishing (number of boats, type, activity, etc.).

Since the beginning of the time series (1982), biological data (length, weight, sex, maturity, etc.) and samples have been taken from individual fish taken by the hauls to provide biological data and to construct length-weight and age-length relationships needed for the assessment of first sardine and later, all the other target species. Fish stomachs have also been routinely examined to quantify the trophic relationships between species and isotope analysis of muscle of sardine and anchovy have been also carried out the study their trophic position.

Overall the evolution of this time series made it an essential platform for integrated data collection following the requirements posed by the Ecosystem Approach to Fisheries Management (EAFM), the Marine Strategy Framework Directive (2008/56/CE) and the revised CFP .

In 2013 R/V is substituted by the Spanish vessel Miguel Oliver (MO), built in 2007. In addition the surveyed area was extended from the 200 m isobath to the 1000 m one in order to make available the bulk of the blue whiting distribution. Intercalibration done in 2014 (acoustic and fishing trawl devices) gave rather similar results for both vessels although a slight difference between fishing gear performance was noticed. That used by R/V Miguel Oliver had a small rockhooper which made accessible much fish located close to the sea bed (such as demersal species together with more horse mackerel) than that of the R/V Thalassa. In order to make comparable both fishing gears, the rockhooper was substituted in 2015 by a footrope chain, similar to that of the R/V Thalassa.

In 2018, on account the Spanish duties related to DCF, the IEO has joined the International Blue Whiting Spring Survey (IBWSS). Therefore, the ICES Working Group of International Pelagic Surveys acknowledged this new collaborator and agreed B/O Miguel Oliver will cover the off-core spawning area located southwest of Porcupine Bank (e.g. Porcupine Seabight). This area was surveyed between 14th and 20th March, when the vessel sailed towards Santander harbour to start the normal PELACUS coverage. Nevertheless, it should be noted that due to time constraint, the grid was anticlockwise prospected, thus optimizing survey time but covering in opposite way as normally performed.

This WD provides acoustic estimates, distribution and mean size for four of the eleven main pelagic species found in northern and northwestern Spanish waters (sardine, anchovy, horse mackerel and chub mackerel) and assessed within the frame of the ICES WGHANSA.

OBJECTIVES

Main objective of this survey was to achieve a biomass estimates by echointegration of the main pelagic fish distributed in the Spanish Cantabrian and NW waters (sardine, anchovy, horse mackerel, mackerel, blue whiting, bogue, boar fish, chub mackerel). Together with this, the following objectives were also foreseen:

- Determine the distribution area and density of the main fish species
- Determine the main biological characteristics (length, sex, maturity stage and age) of the main fish species
- Estimate the relative abundance and distribution area of sardine and anchovy eggs by means of CUFES
- Estimate the adults parameters needed to apply the Daily Egg Production Method to sardine. To achieve this objective, de survey has also cover the southern part of the French contiental shelf, up to 45ºN..
- Characterise the main oceanographic conditions of the surveyed area
- Determine the distribution pattern, taxonomic diversity and dry biomass by size classes of the plankton population presented in the surveyed area.
- Determine the natural abundance of N15 in sardine, anchovy and mackerel and their trophic position.
- Determine the distribution area and density of apical predators
- Determine the distribution area and density of marine microplastics litter

MATERIAL AND METHODS

The methodology was similar to that of the previous surveys and is summarised in ICES Cooperative Research Report No. 332. 268 pp. https://doi.org/10.17895/ices.pub.4599, . Survey design consisted in a grid with systematic parallel transects with random start, separated by 8 nm, perpendicular to the coastline, covering the continental shelf from 30 to 1000 m depth and from Spanish -French border to the Portuguese-Spanish one. (Figure 1).

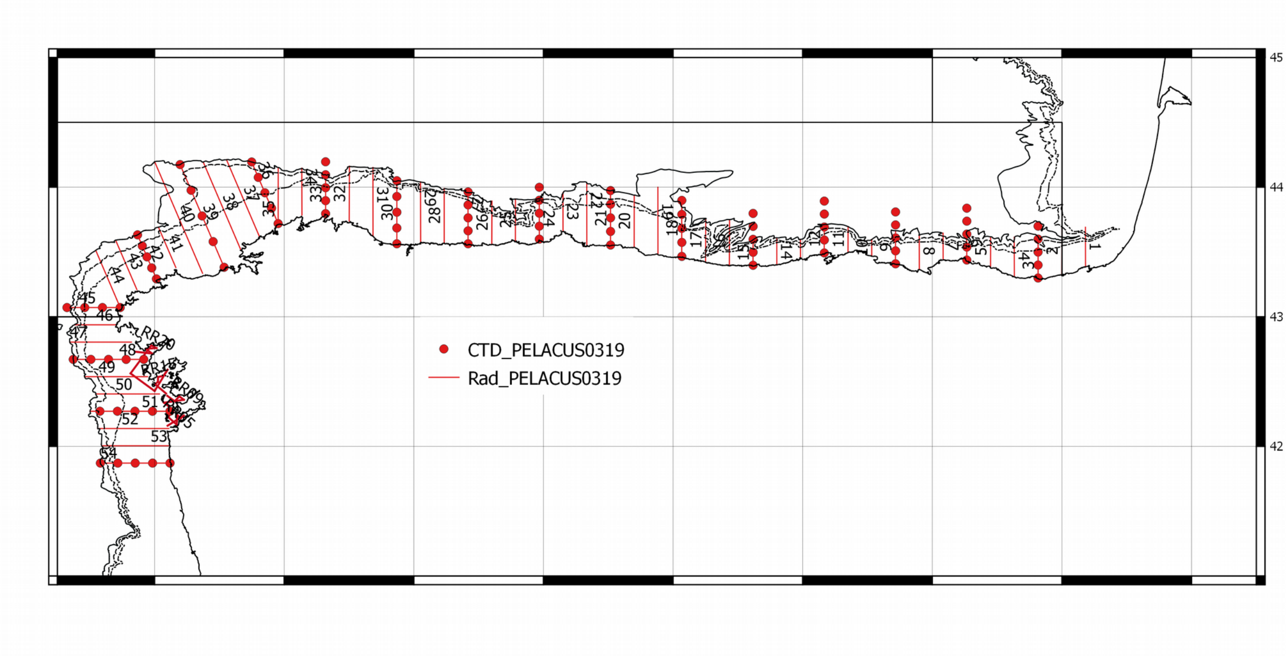

Figure 1 Survey track (foreseen CTD and plankton stations included)

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

Sampling procedures

Acoustic

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

This year, due to the bad weather conditions, a previous filter to remove bubble sweepdown (Honkalehto et al. 2011) has been applied (see appendix 1 for further details).

Main echosounder settings are shown in table 2

Transducer power	2000/2000/1000/200/90 W for 18/38/70/120/200 kHz
Pulse duration	1.024 ms
Ping rate	Maximum, in case of ghost echo-bottom, change to time interval starting at 0.30 ms
Range (echograms, files)	200 m in shallower area (i.e. depth<100m); 500 when depth is between 100-200m; and 1000 when depth is>500m

Table 2: Main echosounder settings.

Acoustic tracks were steamed at 10 knots.

Fishing stations

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

Two fishing gears were used. An adaptation of a "grandes mailles", with a vertical opening of about 20 m and around 30 m horizontal one,was used as main fishing gear. As general rig, 400 kg of clump weight were put at each side of the set back (2 m lower wing). Dyneema bridles (wings) had 100 m, but shorten to 50 m in shallower waters. Besides a set of Apollo 4.0 m^2 and 1400 kg weight polyice doors (Thyborøn) were used; in shallower waters, these were substituted by similar ones with only 3.5 m^2 and 750 kg weight. Gear performance was controlled using a wired Simrad Sonar FS20 net sounder. Close to the codend a MARPORT Trawl speed Exploreer SPE155 with the Scala system was placed in order to ensure that flux at high towing speed (I.e. 4.5-5 knots) is good and no fish school is escaping below the footrope or at the end of the fishing station.

CUFES

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

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

Plankton and hydrological characterisation

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

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

Water samples were stored at -20°C for further dissolved nutrients analysis (NO_3, NO_2, P, NH_4^+, SiO_4).

Top predator observations

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

Marine Microplastic Litter characterisation

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

Fish Biological sampling

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

Data analysis

NASC Allocation

A pelagic gear has been 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 is always attempted. The quality of the hauls for ground-truthing of the acoustic data was classified on account of weather condition, haul performance and the catch composition in numbers and the length distribution of the fish caught as follows (table 3):

	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 following table:

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

* day and night respect.

Table 4.- b_{20} values from the length target strength relationship of the main fish species assessed in PELACUS survey (WHB is blue whiting; MAC-mackerel; HKE- hake; HOM- horse mackerel; PIL-sardine; JAA-blue jack mackerel (*Trachurus picturatus*); BOG-bogue (*Boops boops*); VMAS-chub mackerel (*Scomber colias*); BOC-board fish (Capros aper); and

HMM-Mediterranean horse mackerel (Trachurus mediterraneus))

When possible, direct allocation was also done, accounting for the shape of the schools and also the relative frequency response (Korneliussen and Ona, 2003, De Robertis et al, 2010). Due to the aggregation pattern found in the surveyed area, fish schools were extracted using the following settings:

Sv threshold	-60/-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 m
Distance mode	Vessel log
Main frequency for extraction	38/120 kHz

Table 5: Main morphological and backscattering energy characteristics used for schools detection

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

Echointegration estimates

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

LFD were obtained for all positive hauls for a particular species (either from the total catch or from a representative random sample of 100-200 fish). For the purpose of acoustic assessment, only those LFD which were based on a minimum of 30 individuals were considered. Differences in probability density functions (PDF) were tested using Kolmogorov-Smirnov test. PDF distributions without significant differences were joined, providing a homogeneous PDF strata. Spatial distribution was then analysed within each stratum and finally mean s_A value and surface (square nautical miles) were calculated using a GIS based system (Q-gis). These values, together with the length distributions, are used to calculate the fish abundance in number as described in Nakken and Dommasnes (1975) (see previous section for further details). Estimatesfor each species was carried out on each strata (polygon) using the arithmetic mean of the backscattering energy (NASC, s_A) attributed to each fish species and the surface expressed in square nautical miles using the following formula:

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

$$N_l = \rho_l * A_p$$

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

Numbers were converted into biomass using the length weight relationships derived from the fish measured on board. For purposes of comparison, results are given by ICES Sub-Divisions (9aN, 8cW, 8cEw , 8cEe and 8b)

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

Centre of gravity

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

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

RESULTS

As in 2018, due to the participation in the International Blue Whiting Spawning Stock Survey, the area was covered anti clockwise, i.e., from the eastern part (Spanish-French border) to the southwestern part (Spanish-Portuguese border). Besides, as expected, bad weather conditions had an impact on survey and some of the foreseen tracks (25-27 and from 31 to 33 and from 37 to 41) were partially covered (e.g. outer part)

Fishing stations and NASC allocation

Bad weather conditions resulted in poor conditions for prospecting the expected grid. Besides some foreseen tracks were not steamed and others were cut once reached 200 m depth in order to safe time. Moreover, some of the track ought to be steamed with the stern to the swells in order to mitigate the number of pings lost and to decrease de attenuation due to bubbles sweptdown.

Besides fish were mainly located close to the coast, avoiding the areas of rough weather conditions. This, together with the lack of available time decreased the total number of fishing stations. Only 46 valid hauls were done. Figure 2 is showing the location and the catch composition of these hauls.

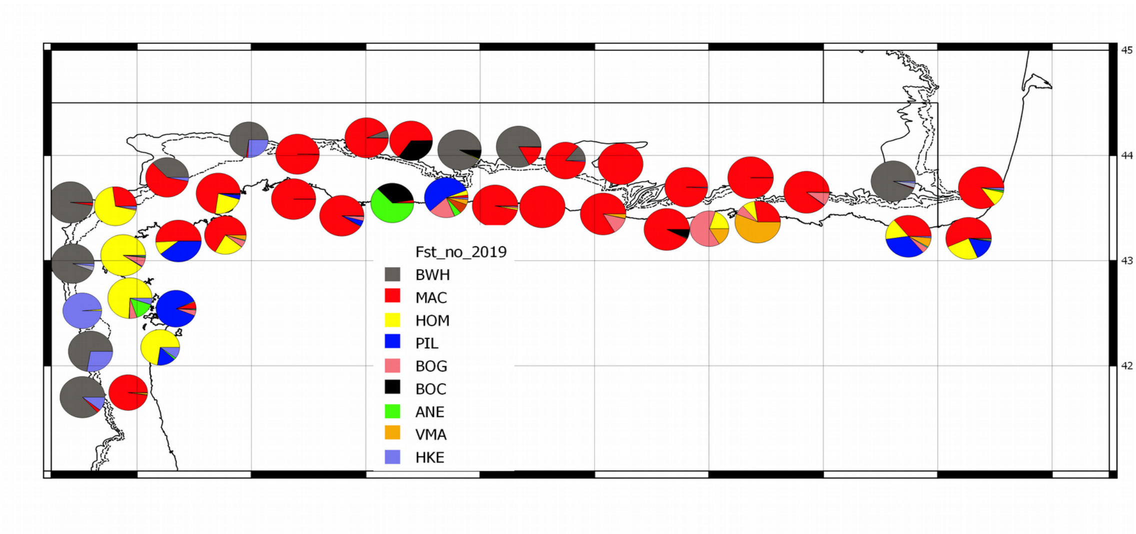

Figure 2: Fishing stations and catch composition (% in number of fish caught). MAC-mackerel; PIL-sardine; BOC-boarfish; HOM-horse mackerel; WHB-blue whiting; ANE-anchovy; BOG-bogue; HKE-hake; VMA-chub makcerel; MAV-müller's pearlside; SEAB-seabream and similar species.

60 mt of fish were caught corresponding to $273*10^3$ fish (table 6). Mackerel, was present in 80% of the fishing stations, representing 83% in weight and 52%. Sardine catches distribution is rather similar to that found last year, mainly concentrated in outer parts of the surveyed areas (e.g. inner part Bay of Biscay, IXa)

	TOTAL CAP (Kg)	No ind.	No Fishing st	Sample weight (kg)	Measured fish	Mean length	%PRES	% Catch_W	% Catch_No
WHB	1287	19825	16	103	1544	22.10	34.78	2.14	7.27
MAC	49743	142221	37	1616	4880	35.41	80.43	82.56	52.16
HKE	133	1379	37	123	1267	23.41	80.43	0.22	0.51
HOM	2590	33258	30	213	2637	19.98	65.22	4.30	12.20
PIL	4095	51905	19	163	2222	20.29	41.30	6.80	19.04
NOO	0	3	1	0	3	10	2.17	0.00	0.00
BOG	1147	7650	25	406	2205	25.01	54.35	1.90	2.81
VMA	603	3400	20	179	1036	26.86	43.48	1.00	1.25
BOC	306	5410	6	27	465	14.16	13.04	0.51	1.98
SEAB	109	376	13	100	355	26.15	28.26	0.18	0.14
ANE	211	6948	12	26	933	15.66	26.09	0.35	2.55
MAC-S	28	298	1	23	252	23.13	2.17	0.05	0.11
Total	**60251**	**272673**	**46**	**2979**	**17799**				

Table 6: Summary of catch composition

Contrary to that observed last year the amount of pearlside has significantly decreased, but in turn, it should be highlighted the presence of krill, specially in the western part.

On the other hand, the weather conditions may led to a change in both spatial distribution and aggregation patterns of mackerel, occurring near close, close to the bottom and often mixed with some other species: frequency response analysis revealed that the increase in strength of backscattering energy through high frequencies was lower than expected for an isolated mackerel school. In such circumstances, rather than direct direct allocation, most of the backscattering energy was allocated on account the results of the fishing stations (82% from 210113.76 m^2 mni^{-2}). 37 different combination of fishing station were used to allocate backscattering energy, as shown in figure 3 and table 7.

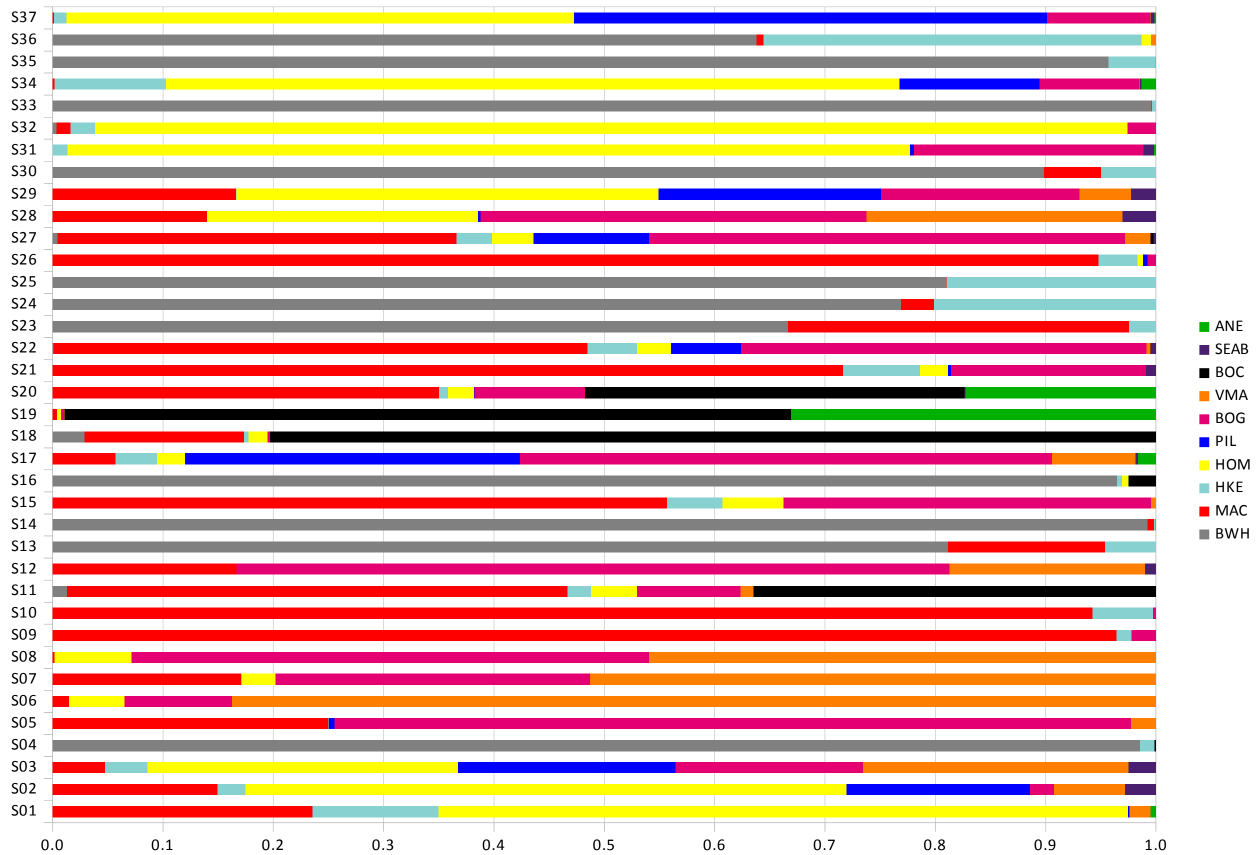

Figure 3: Proportion of backscattering energy allocated to main fish species on fishing station used for allocation purposes (see table 7 for further explanation)

Fst-synt	Fst-comb	NASC	Species	NASC
S01	PE01	1353.28	PIL	26573.08
S02	PE02	4636.99	ANE	1084.65
S03	PE03	1232.35	HOM	4988.39
S04	PE04	8241.57	MAC	692.68
S05	PE05	973.53	MAV	4436.66
S06	PE06	1489.22	KRILL	712.45
S07	PE06-PE07	5236.10		
S08	PE06-PE08	2040.16		
S09	PE07	1313.04		
S10	PE07-PE09	1186.73		
S11	PE10	1339.44		
S12	PE11	4370.50		
S13	PE13	4991.29		
S14	PE15	1365.73		
S15	PE16	4614.31		
S16	PE17	2907.43		
S17	PE18	2638.43		
S18	PE19	2370.62		
S19	PE20	657.15		
S20	PE20-PE21	1020.34		
S21	PE21	462.18		
S22	PE21-PE26	252.42		
S23	PE22	1782.58		
S24	PE22-PE23	1330.14		
S25	PE23	5601.75		
S26	PE24	1579.61		
S27	PE26	6281.06		
S28	PE27	78.05		
S29	PE27-PE28-PE29	4901.55		
S30	PE30	1743.97		
S31	PE31	4090.72		
S32	PE32	2437.87		
S33	PE33	23049.23		
S34	PE34-PE37-PE40-PE46	18565.67		
S35	PE35-PE39	13891.41		
S36	PE36-PE38-PE41-PE42	12915.71		
S37	PE43-PE44-PE45	18683.73		
TOTAL		**171625.85**		**38487.91**

Table7: Total energy allocated using fishing stations or directly allocated to single species (Fst-comb, denotes the fishing stations using in a particular region).

Center of gravity

Figure 4 is showing the center of gravity of the main fish species. For sardine is located at 63.03 m depth and in the western part 9a. For horse mackerel it is also located in shallower waters (71.24) and very near of that of sardine: for anchovy, the center has shifted towards the eastern part and is located at 99.46 m. Mackerel remains in the center of the Cantabrian sea at a or even mackerel at a 99.57 m depth. Blue whiting is close to the slope (282.98 m) and in the western part, too.

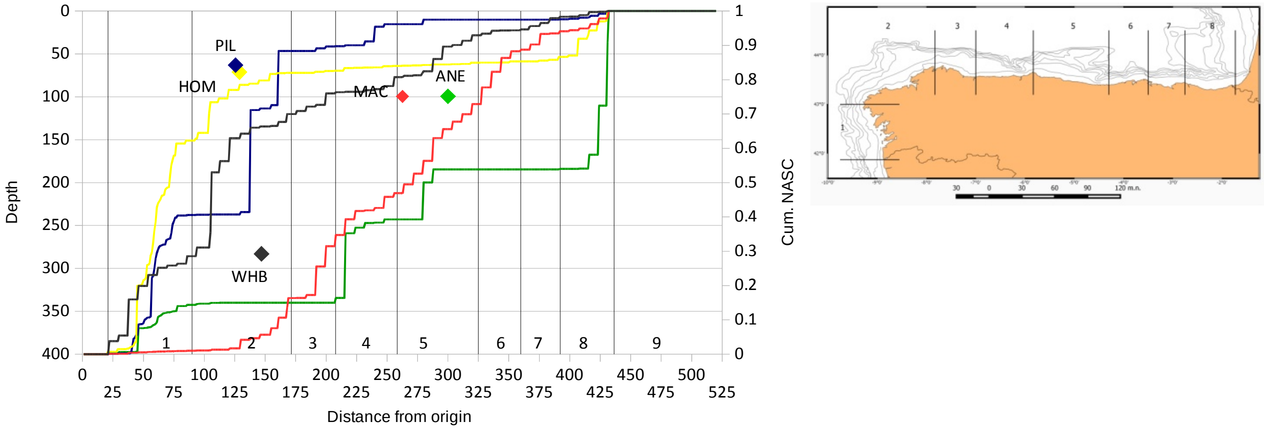

Figure 4: Cumulated NASC frequency along the coast and center of gravity for the main pelagic species. The plot is accomplished by a map showing the different areas labelling with a number from 1 (9a from Spanish-Portuguese) to 9 (French continental shelf in 8b)

Sardine Assessment

<u>Adult distribution</u>

The bulk of the sardine NASC distribution was recorded in the western area (i.e. Atlantic waters). Figure 5 is showing the evolution of the center of gravity. The lasst two years, the amount of backscattering energy allocated to sardine is the highest of the time series in Spanish waters, which also shows an increasing trend since 2013 when de minimum was achieved. Besides, as the amount of fish (e.g. backscattering energy) is increasing, the center of gravity is moving towards the western area (Galician area), and consistently going to shallower waters.

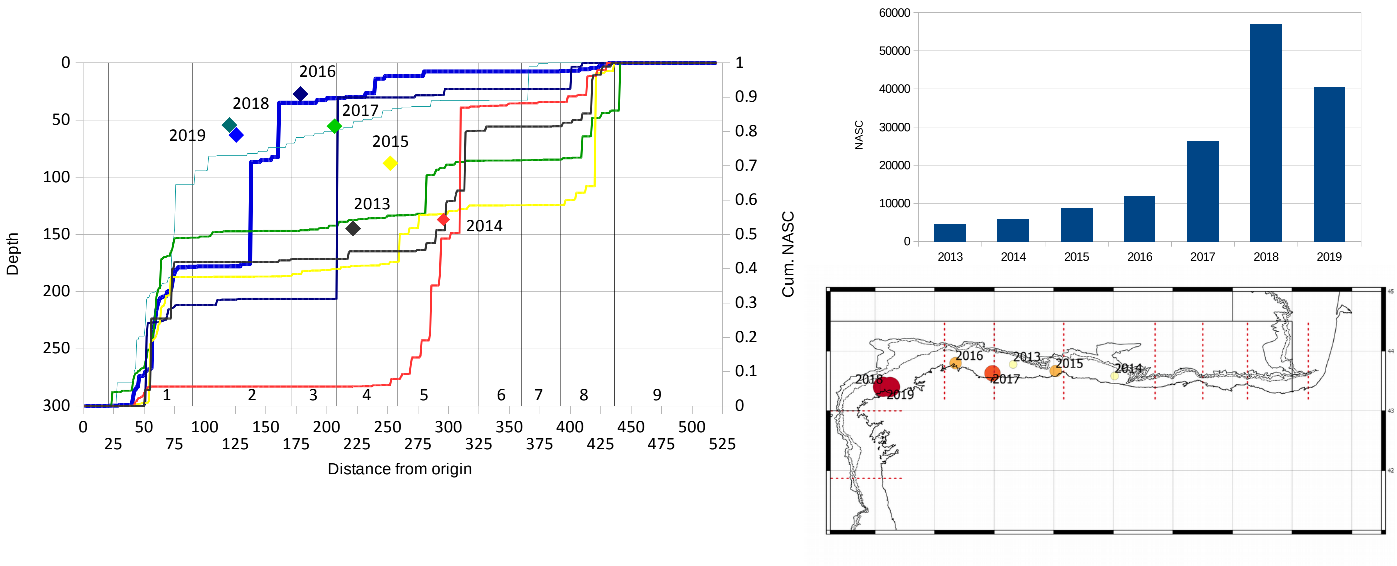

Figure 5: Cumulated NASC frequency along the coast and center of gravity for sardine since 2013. Right panel, total backscattering energy (NASC) attributed to sardine since 2013 in the Spanish waters and the plot of the location of the center of gravity (circles encompassed the biomass estimates)

Figure 6 shows the sardine spatial distribution (NASC) and mean abundance.

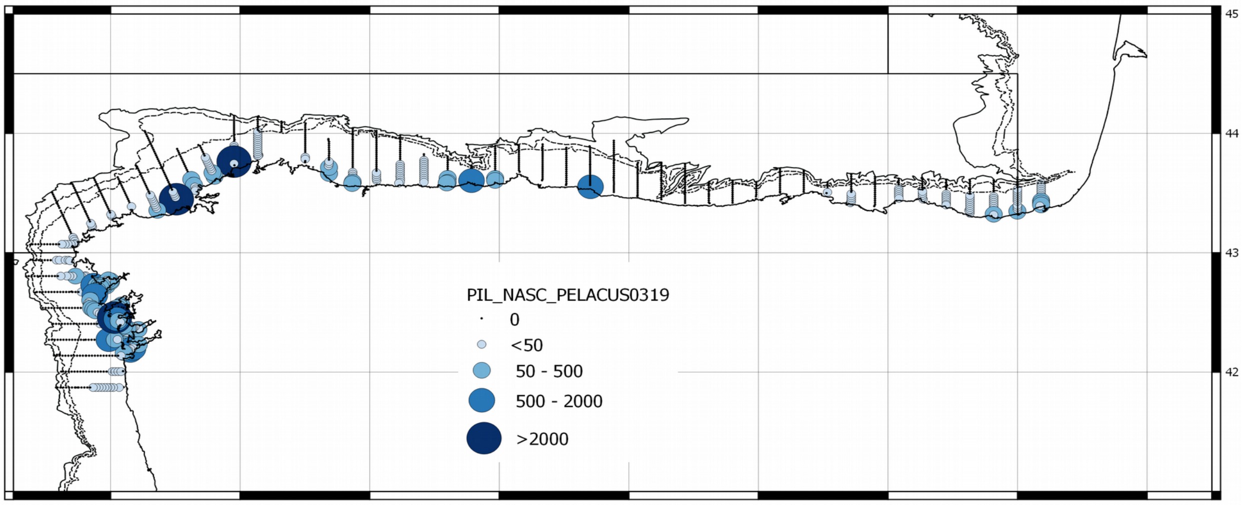

Figure 6: Sardine spatial distribution

Abundance estimates

A total of 71 thousand tonnes, corresponding to 713 million fish were estimated, most of them, as expected in the western part (Galicia) (table 8). Although the significant increase in biomass in relation to that estimataed in 2018, age group 1 only accounted for less than 1% of the total biomass , but mainly located off the main distribution area located in Galician waters. (figure 12). It is also noticeable that the increase in biomass is only due to a vegetative increase (e.g. individual growth) and not for an increase in biomass. In fact the number of fish decreased. Age group 3 is dominant, accounted for the 48% of the total biomass and number.

		1	2	3	4	5	6	7	8	9	10	Total	No fish (thousands)
8cEe	Biomass (mt)	100	800	197	26	2	0	0	0	0	0	1125.71	25751
	%	8.92	71.08	17.47	2.31	0.21							
	M. weight	37.27	41.87	53.95	61.30	71.59						#VALOR!	
	No Fish (thousan	2683	18997	3615	422	33	0	0	0	0	0	25751	
	%	10.42	73.77	14.04	1.64	0.13							
	M. length	17.01	17.61	19.00	19.74	20.67						17.78	
	s.d.	0.67	0.76	0.94	0.85	0.50						0.98	
8cEw	Biomass (mt)	13	1406	4698	1571	394	44	7	0	0	0	8134.29	119974
	%	0.17	17.29	57.75	19.32	4.84	0.55	0.09					
	M. weight	40.88	60.26	67.41	72.01	80.47	88.05	106.12				67.43	
	No Fish (thousan	328	23087	69406	21701	4879	504	68	0	0	0	119974	
	%	0.27	19.24	57.85	18.09	4.07	0.42	0.06					
	M. length	17.49	19.64	20.30	20.71	21.41	21.99	23.25				20.29	
	s.d.	0.34	1.10	0.75	0.86	0.67	0.45					0.96	
8cW	Biomass (mt)	6	5142	23975	13058	5242	894	166	0	0	0	48482.40	618925
	%	0.01	10.61	49.45	26.93	10.81	1.84	0.34					
	M. weight	47.16	70.59	75.77	81.74	85.78	91.34	106.12				77.73	
	No Fish (thousan	121	72347	315108	159043	60960	9778	1568	0	0	0	618925	
	%	0.02	11.69	50.91	25.70	9.85	1.58	0.25					
	M. length	18.25	20.59	21.03	21.51	21.82	22.23	23.25				21.20	
	s.d.	0.00	0.94	0.78	0.81	0.67	0.53					0.88	
9aN	Biomass (mt)	326	1819	5134	4307	1063	205	728	0	0	0	13581.44	182433
	%	2.40	13.39	37.80	31.71	7.83	1.51	5.36					
	M. weight	44.38	62.06	71.89	81.37	86.17	92.55	91.59				70.02	
	No Fish (thousan	7264	29112	71153	52586	12172	2187	7959	0	0	0	182433	
	%	3.98	15.96	39.00	28.82	6.67	1.20	4.36					
	M. length	17.92	19.81	20.70	21.48	21.85	22.32	22.25				20.83	
	s.d.	0.99	0.90	0.74	0.96	1.33	1.24					1.26	
TOTAL	Biomass (mt)	445	9167	34003	18963	6701	1143	901	0	0	0	71323.84	947084
	%	0.62	12.85	47.67	26.59	9.40	1.60	1.26					
	M. weight	42.38	62.83	73.67	80.68	85.49	91.42	93.97				73.88	
	No Fish (thousan	10396	143543	459283	233752	78045	12470	9594	0	0	0	947084	
	%	1.10	15.16	48.49	24.68	8.24	1.32	1.01					
	M. length	17.68	19.88	20.85	21.42	21.80	22.24	22.42				20.92	
	s.d.	0.98	1.35	0.83	0.88	0.81	0.71	0.00	0.00	0.00	0.00	1.15	

Table 8:Sardine assessment

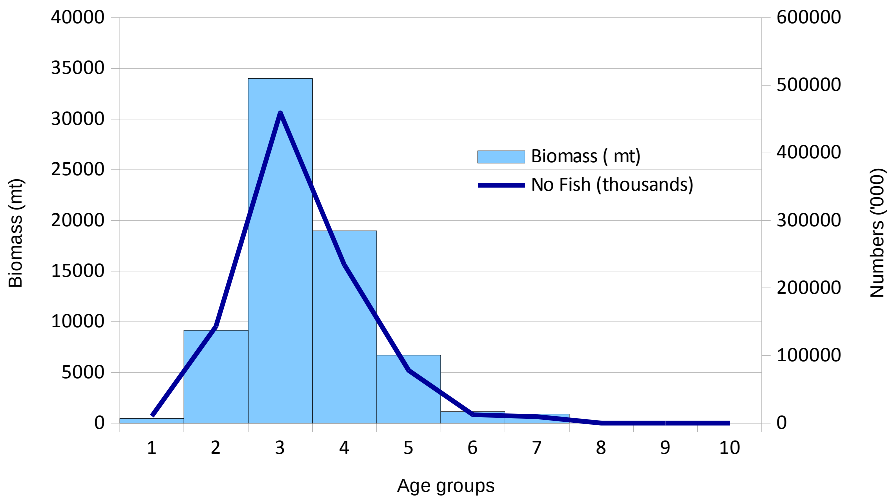

Figure 7:Sardine abundance by age group estimated in PELACUS 0319

Egg distribution

Sardine egg distribution (number of eggs per cubic meter) collected by CUFES is similar to that recorded from the acoustic (figure 8), with most of the egg being concentrated in the western part, and only few eggs just at the inner part of the Bay of Biscay were adult occurrence was also negligible. 367 samples were collected. Of those, only 121 (33%) were positive for sardine, lower than in previous year, although the number of eggs was slightly higher accounted 2930, with an average density over the positive stations of f 2.17 eggs/m^3.

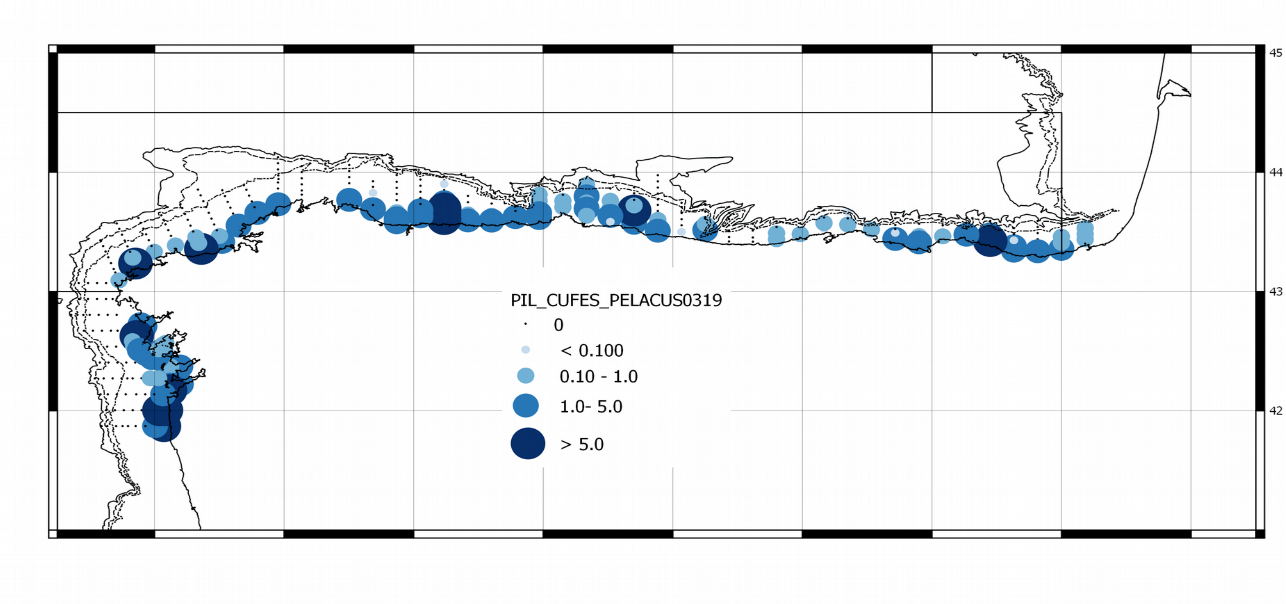

Figure 8:Sardine egg abundance (number per cubic meter) from CUFES

Other metrics

Figure 9 is showing the evolution of the mean weight and length in both 9aN and 8c since 2013

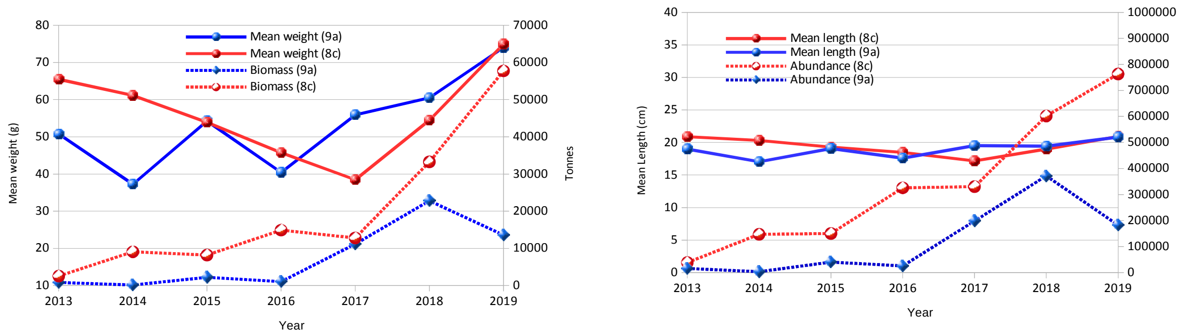

Figure 9:Trends (2013-19) in mean weight and length together with biomass and estimates in number of sardine in 8c and 9aN.

Mean weight has a clear increasing trend, which would not be related with and increase in the mean length, although is also increasing. This trend has been observed this year in catches. This trend is clear for age groups 2 to 4 as shown in figure 10.

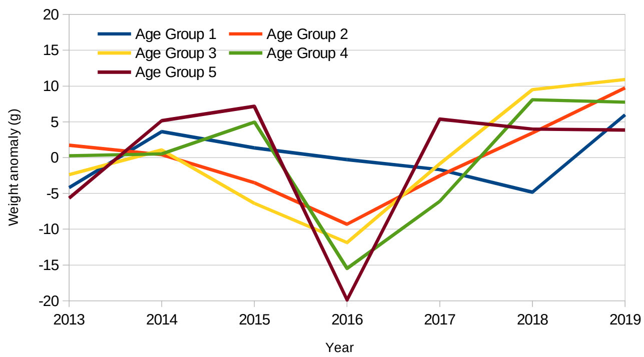

Figure 10:Trends (2013-19) in mean weight at age (whole area) for sardine

Conclusions on sardine assessment

The situation found is similar to that of the previous year, with sardine mainly located in Atlantic waters. Weight-at-age is increasing since 2016 an in spite the number of estimated fish has decreased, total biomass was increased,. This has been also observed in horse mackerel and also in mackerel. This increase in main weight has been also observed in catches, excluding, therefore, any problem due scale measurement.

The last two cohorts seems to be weak, specially that of 2018 whose presence in the surveyed area was almost negligible. As consequence, age group 3 clearly dominated the age structure of the population.

9a Anchovy Assessment

Adult distribution

In general, anchovy has a very scarce presence in 9a. Only in 2018, as outcome of an important outburst, anchovy had an important contribution to the pelagic fish community, and its distribution was mainly around the continental shelf, between 50 and 125 m depth.

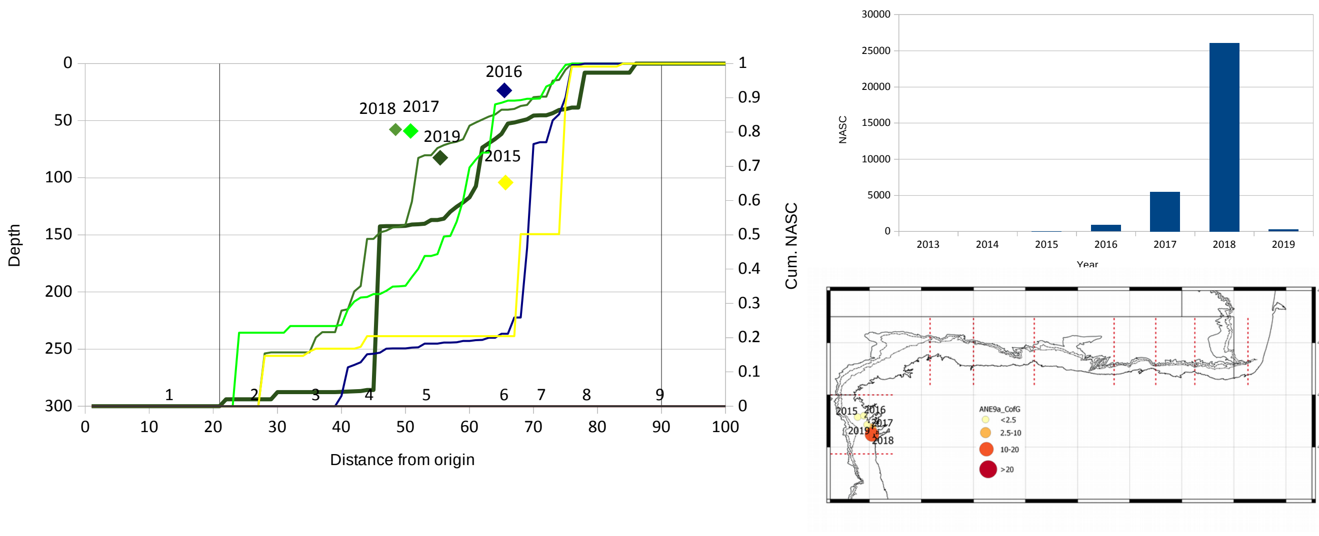

Figure 11: Cumulated NASC frequency along the coast and center of gravity for anchovy since 2013. Right panel, total backscattering energy (NASC) attributed to anchovy since 2013 in 9aN and the plot of the location of the center of gravity (circles encompassed the biomass estimates)

Figure 12 shows the spatial distribution accounting the allocated backscattering energy per ESDU. Few anchovies have been caught in most of the fishing statio.

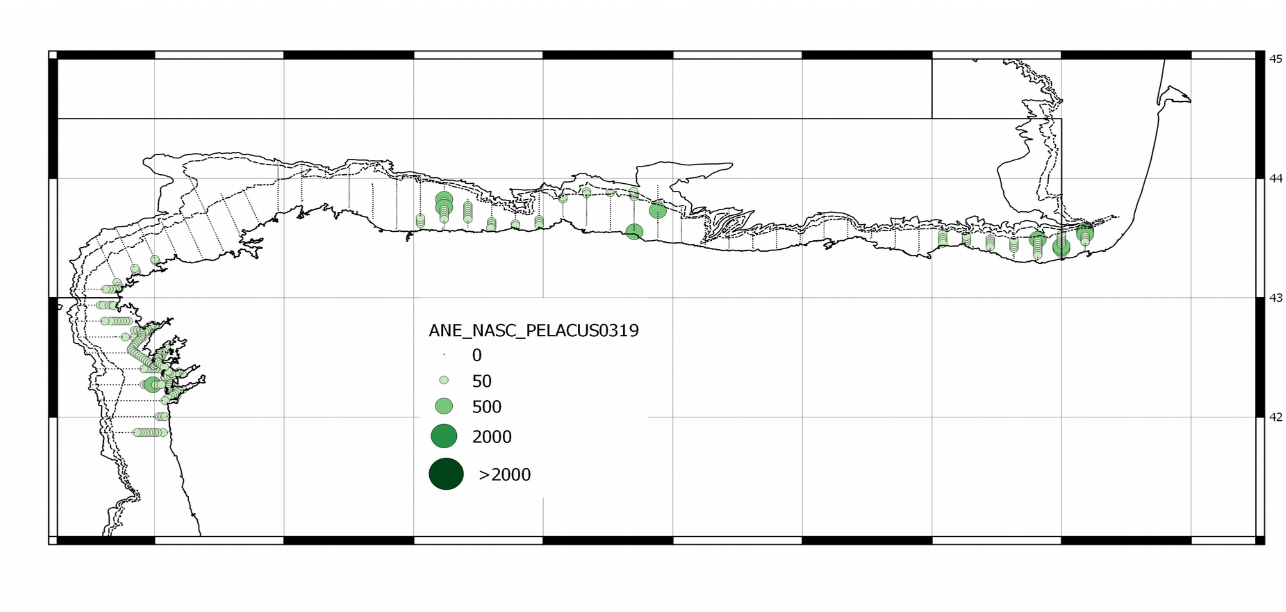

Figure 12: Anchovy spatial distribution

Abundance estimates

Only 142 tonnes, corresponding to 5 millions fish were assessed in 9a. Age 2 accounted for the 72% of the total biomass, corresponding to 65% in number.

	1	2	3	4	Total	No fish ('000)
Biomass (mt)	36	103	3	0	141.98	5084
%	25.30	72.44	2.26			
M. weight	20.52	31.00	43.55		27.64	
No fish ('000)	1721	3289	74	0	5084	
%	33.86	64.70	1.45			
M. length	14.52	16.43	18.19		15.81	
s.d.	0.94	0.78	0.47		1.26	

Table 9: Anchovy in 9aN assessment

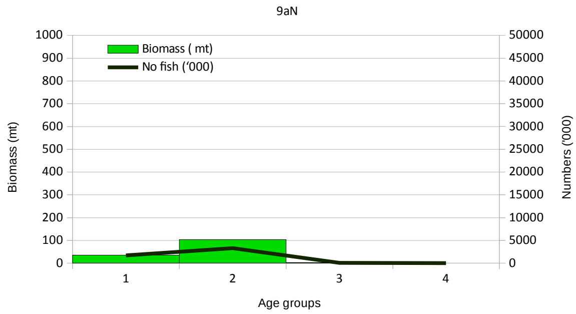

Figure 13: Anchovy in 9aN abundance by age group estimated in PELACUS 0319

Egg distribution

In 9a 41.51% of the station were positives (44 of 106), with a mean density on positive stations of 5.57 egg m^{-3}.

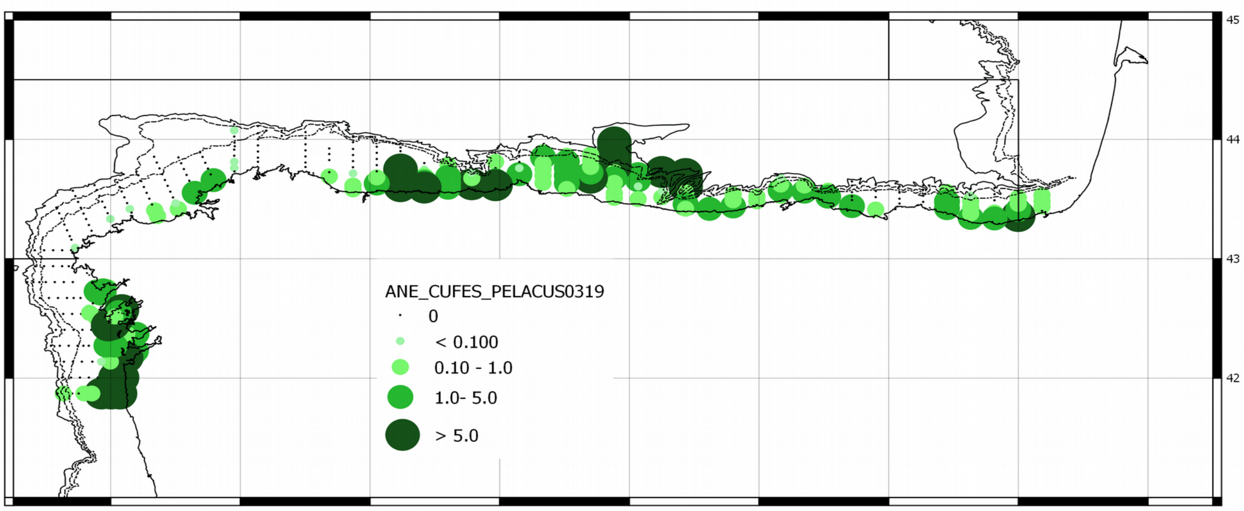

Figure 14: Anchovy egg abundance (number per cubic meter) from CUFES

Other metrics

In 9a trends in number, biomass or length and weight are difficult to track due to the very low abundance, except the 2018 outburst. In this case it seems this outburst caused a density-depend in growth, as shown in figure 15 and 16

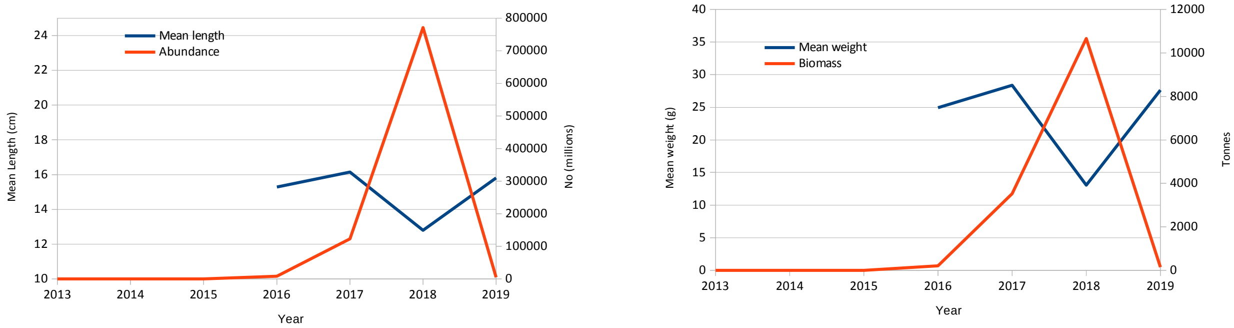

Figure 15: Trends (2013-19) in mean weight and length , abundance and biomass estimates in 9aN Anchovy

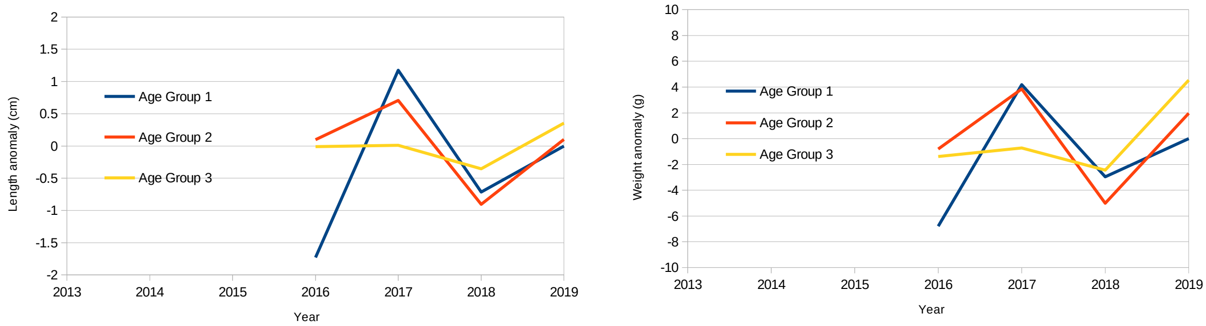

Figure 16: Trends (2013-19) in mean weight and length at age in 9aN Anchovy

Conclusions on anchovy assessment in 9aN

The observed anchovy biomass was very low. The number of eggs, relatively high would probably due to the presence of old fish (age 2 and 3). This low value agrees with the normal presence of this species where only in particular years outburst.

8c Anchovy Assessment

Adult distribution

As observed in 9a, in earlier spring, the presence of anchovy is very scarce, expect a particular year (2016) when the estimates was very high. Its is also remarkable the increasing trend of anchovy presence in mid-western part of the Cantrabrian sea.

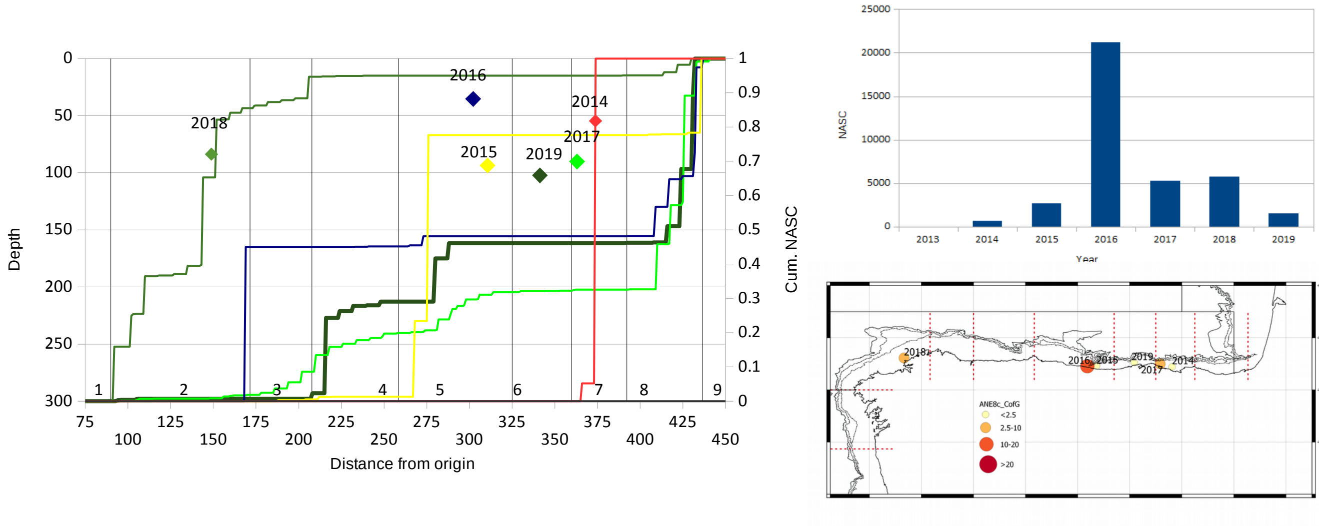

Figure 17: Cumulated NASC frequency along the coast and center of gravity for anchovy since 2013. Right panel, total backscattering energy (NASC) attributed to anchovy since 2013 in 9aN and the plot of the location of the center of gravity (circles encompassed the biomass estimates)

Figure 18 shows the spatial distribution accounting the allocated backscattering energy per ESDU. In middle Cantabrian sea, anchovy occurred in schools, some of them offshore, marking two locations (e.g. inner part of Bay of Biscay and central Cantabrian Sea), with a gap between both

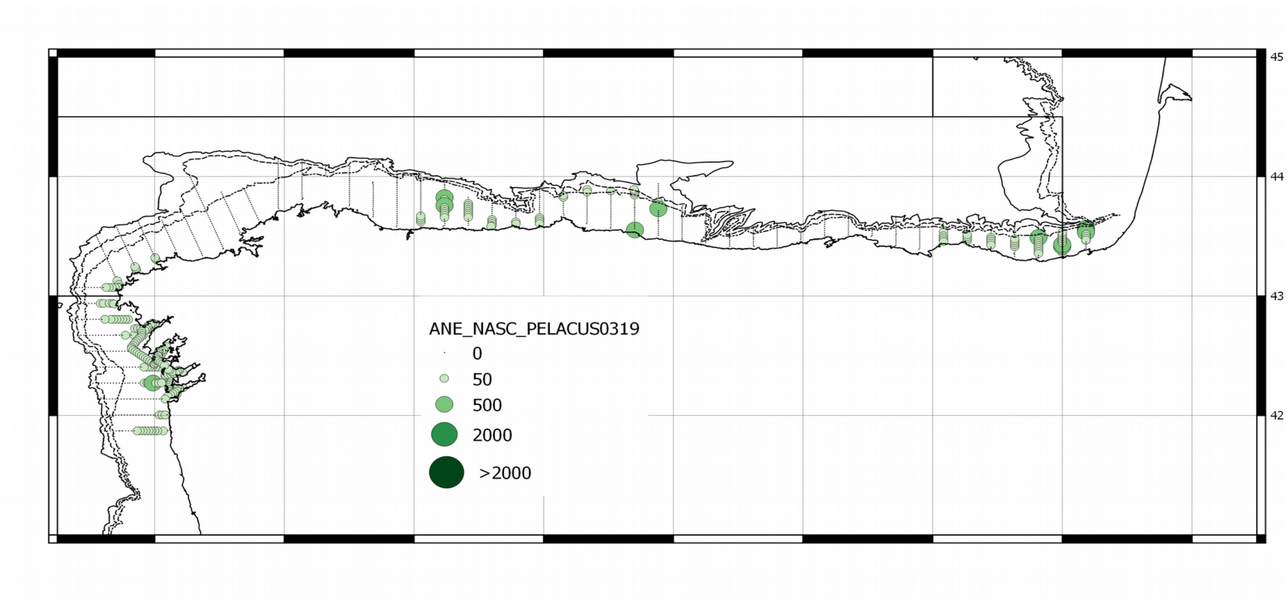

Figure 18: Anchovy spatial distribution

Abundance estimates

1.4 thousand tonnes, corresponding to 63 millions fish were assessed in 8c. Age 2 is still more abundant but recruits from 2018 yielded 53 % in number.

	1	2	3	4	Total	No fish ('000)
Biomass (mt)	545	779	14	0	1339.21	63170
%	40.72	58.20	1.08			
M. weight	15.45	28.30	38.08		21.61	
No fish ('000)	33229	29446	494	0	63170	
%	52.60	46.61	0.78			
M. length	13.34	15.99	17.47		14.60	
s.d.	2.14	0.86	0.54		2.13	

Table 11 Anchovy in 9aN assessment

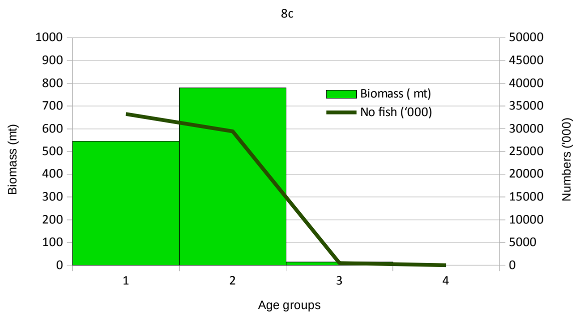

Figure 19: Anchovy in 8c abundance by age group estimated in PELACUS 0319

Egg distribution

The percentage of positive CUFES stations in 8c was slightly higher than in (45.59% to 41.51% respectively), with 119 of of 261 being positives. However, mean egg density per station was half of that obseved in 9aN (2.51 to 5.57 egg m^{-3}).

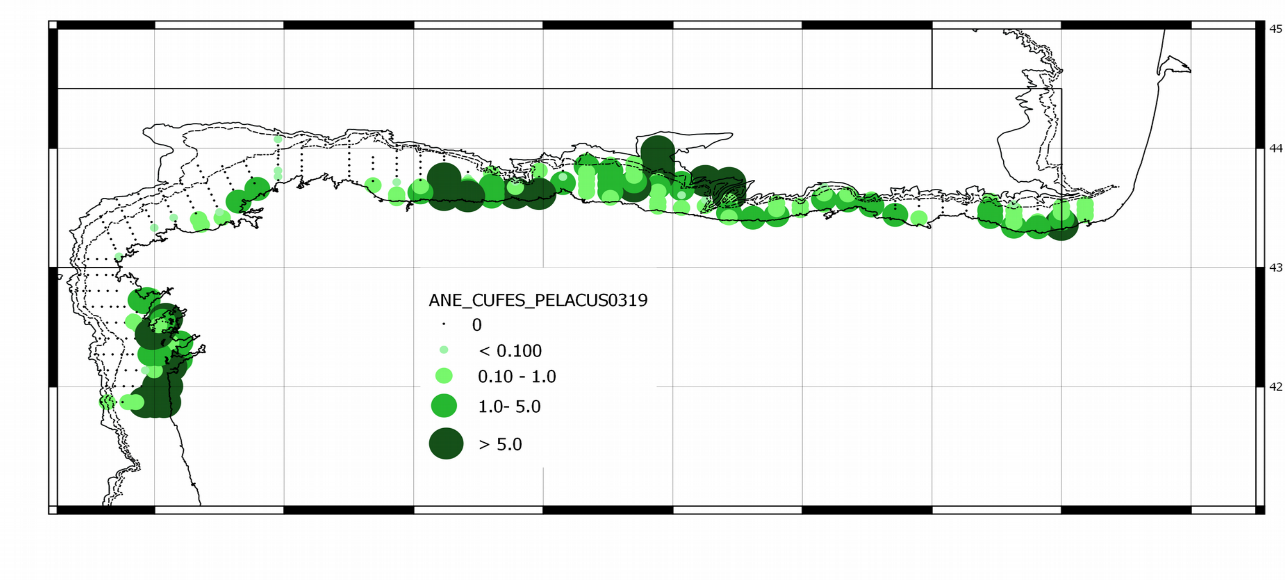

Figure 20: Anchovy egg abundance (number per cubic meter) from CUFES

Other metrics

In 8c, as observed in 9aN, trends in number, biomass or length and weight are difficult to track due to the very low abundance, except the abundance detected in 2016. It should be noted the decrease in weight-at-age for age group 1, as this trend agrees with that observed in sardine in 8ab

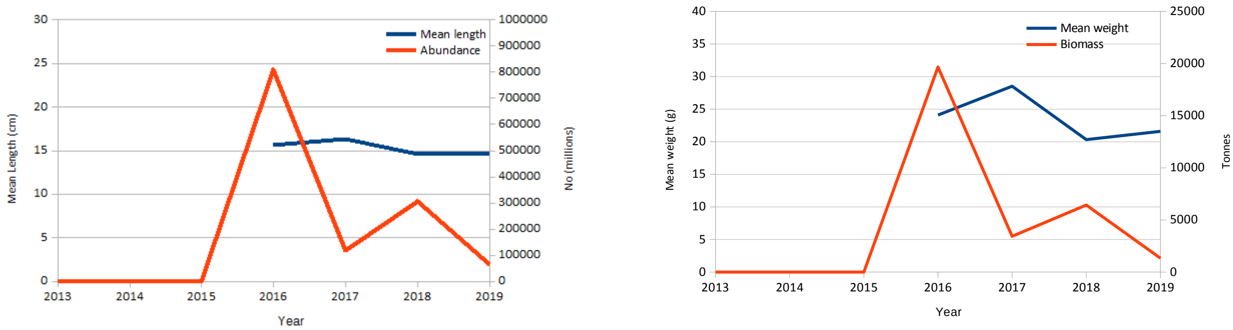

Figure 21: Trends (2013-19) in mean weight and length , abundance and biomass estimates in 9aN Anchovy

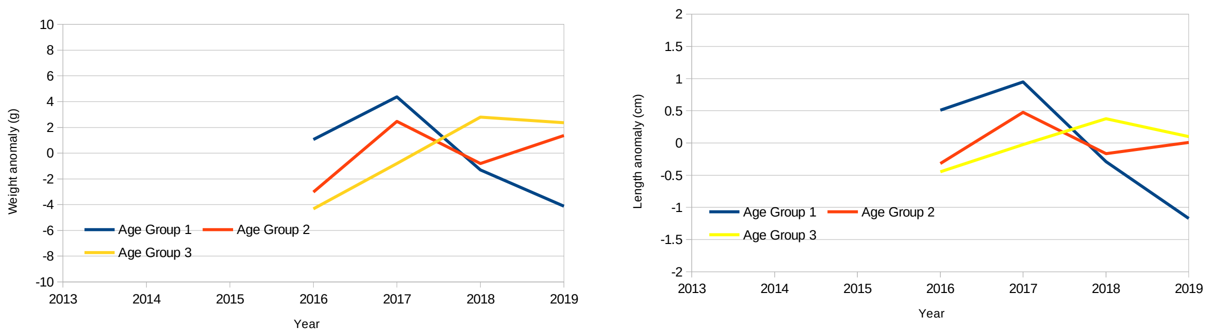

Figure 22: Trends (2013-19) in mean weight and length at age in 9aN Anchovy

Conclusions on anchovy assessment in 8c

The change of the survey steam occurred in 2018 when the area started to be prospected anti-clock wise (e.g. westwards instead eastwards) may have influenced the results in 8c as the anchovy tends to move westwards in April-May from the inner part of the Bay of Biscay, thus after this area is surveyed. Nevertheless, the estimates in 2018and 2019 were of the same order of that of 2017. The different trajectories observed in weight-at-age in Bay of Biscay and Atlantic waters should analysed in depth.

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