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PRELIMINARY RESULTS OF THE PELACUS0316 SURVEY: ESTIMATES OF SARDINE, ANCHOVY AND HORSE MACKEREL ABUNDANCE AND BIOMASS IN GALICIA AND CANTABRIAN WATERS

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Abstract

PELACUS 0316 has been carried out between 13th March and 16th April, covering the north Spanish continental self between the Miño river (Spanish/Portuguese border) and the Bidasoa one (Spanish/French border). Unexpectedly, weather and oceanographic conditions found were those of the winter time rather than the incipient spring ones. Consecutive deep W/NW storm fronts have affected the survey plan; five days were lost due to the bad weather conditions and even during part of the survey either strong south wind (up to 45 knots) or a persistent swell of about 2-4 m height have also made problems to achieve clean echograms (i.e. without bubbles) and good performance at the fishing station. These conditions might have been also affected the availability of the fish. This seems clearer in the southern part (IXaN), where a stronger winter poleward current led the continental self almost empty of plankton and with a very scarce concentration of fish.

Abundance of the main pelagic fish species was lower than that of the previous year. For sardine the abundance was very low, practically below of an acceptable threshold for an acoustic assessment. Only the presence of a very thick school with acoustic and morphological characteristics being compatibles to those of sardine, thus being possible sardine but not ground truthed. In total the assessed biomass was very low, and excluding this school only 3 thousand tons were estimated, the lowest record in the time series (13 thousand tons including this school but still at a very low level) Horse mackerel showed also an important decrease while anchovy has been mainly detected at the inner part of the Bay of Biscay, although as it was observed for sardine, the presence of thick schools in the western part, presumably being anchovy, had an important impact in the final assessment.

Introduction

PELACUS 0316 is the latest of the long-time series (started in 1984) of spring acoustic surveys carried out by the Instituto Español de Oceanografía to monitor pelagic fishery resources in the north and northwest shelf of the Iberian Peninsula (ICES divisions IXa – South Galicia and VIIIc – Cantabrian Sea). Since 2013, the survey is carried out in the R/V Miguel Oliver.

We present the results obtained on spatial distribution and abundance estimates of sardine anchovy and horse mackerel and also the egg spatial distribution of sardine and anchovy obtained from CUFES. We also compare the new values with those obtained in previous years.

Material and methods

The methodology was similar to that of the previous surveys.

Survey was carried out from 13th March to 16th April in the R/V Miguel Oliver and sampling design consisted in a grid with systematic parallel transects equally separated by 8 nm and perpendicular to the coastline (Figure 1) with random start, covering the continental shelf from 30 to 1000 m depth and from Portuguese-Spanish border to the Spanish-French one. Acoustic records were obtained during day time together with egg samples from a Continuous Underwater Fish Egg Sampler (CUFES), with an internal water intake located at 5 m depth. This year CUFES sampling was made in alternate transects. CTD casts and plankton and water samples were taken during night time over the same grid in alternating transects. Besides, pelagic trawl hauls were performed in an opportunistic way to provide ground-truthing for acoustic data.

Acoustic equipment consisted in a Simrad EK-60 scientific echosounder (18, 38, 120 and 200 KHz). The elementary distance sampling unit (EDSU) was fixed at 1 nm. Acoustic data were obtained only during daytime at a survey speed of 10 knots. Data were stored in raw format and post-processed using SonarData Echoview software (Myriax Ltd.). The integration values, obtained each nautical mile (ESDU= 1nmi) are expressed as nautical area scattering coefficient (NASC) units or s_A values (m^2 nm^{-2}) (MacLennan *et al.*, 2002).

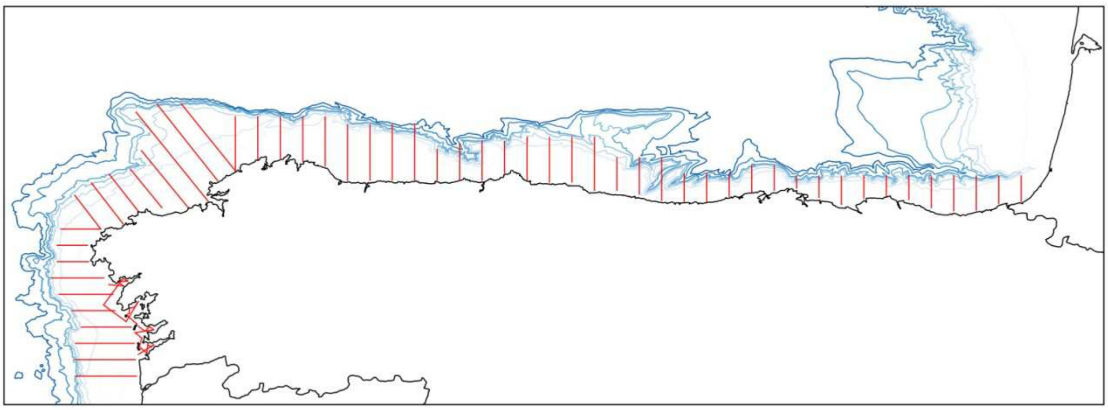


Figure 1. 2016 Survey track

A pelagic gear with vertical opening of 20 m has been used, although, due to a damage in this, a pelagic gloria with 15 m vertical opening has used since the tow number 34. Hauls were mainly performed in depths between 30 m and 1012 m, with an average duration of 26 minutes (and usually with a minimum duration of 20 minutes, although some of the hauls undertook on very dense mackerel layers had a lower duration).

A two steps method was used to assess the pelagic fish community. First, hauls were classified on account the following criteria: weather condition, gear performance and fish behaviour in front of the trawl derived from the analysis of the net sonar (Simrad FS20/25), catch composition in number and length distribution. Each haul was categorised and ranked as follows:

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

These criteria were used as a proxy for ground-truthing. Hauls considered as the best representation of the fish community (i.e. those with higher overall rank on account the four criteria) were used to allocate the backscattering energy got on similar echotraces located in the same area.

Once backscattering energy was allocated, spatial distribution for each species was analysed on account both the NASC values and the length frequency distributions (LFD). These were obtained for all the fish species in the trawl (either from the total catch or from a representative random sample of 100-200 fish). For the purpose of acoustic assessment, only those size distributions which were based on a minimum of 30 individuals and which presented a continuous distribution (either bell shape –normal- or bimodal) were considered. Random subsamples were taken when the total fish caught was higher than 100 specimens. Differences in probability density functions (PDF) were tested using Kolmogorov-Smirnoff (K-S) test. PDF distributions without significant differences were joined, giving a homogenous PDF stratum. Spatial structure and surface (square nautical miles) for each stratum were calculated using QGIS. Fish abundance was calculated with the 38 kHz frequency as recommended at the PGAAM (ICES 2002). Nevertheless, echograms from 18, 70, 120 and 200 kHz frequencies were used to better scrutinize and discriminate among the different backscattering targets. The threshold used to scrutinize the echograms was –70 dB. Backscattered energy (s_A) was allocated to fish species either by direct assignation of echotrace to a specific fish species or according to the proportions found at the fishing stations (Nakken and Dommasnes, 1975). For this purpose, the following TS values were used: sardine and anchovy, -72.6 dB (b_{20}); horse mackerels (*Trachurus trachurus, T. picturatus* and *T. mediterraneus*), –68.7 dB, bogue (*Boops boops*), –67 dB, chub mackerel (*Scomber colias*), -68.7, mackerel (*Scomber scombrus*), –84.9 dB and blue whiting (*Micromesistius poutassou*), -67.5 dB. Biomass estimation was 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.

Besides each fish was measured and weighed to obtain a length-weight relationship. Otoliths were also extracted from anchovy, sardine, horse mackerel, blue whiting, chub mackerel, Mediterranean horse mackerel and mackerel in order to estimate age and to obtain the age-length key (ALK) for each species for each area.

Results

A total of 3650 nautical miles were steamed, 1248 corresponding to the survey track.
In the area surveyed, a total of 49 fishing stations were performed, 3 of them considered null (Figure 2).

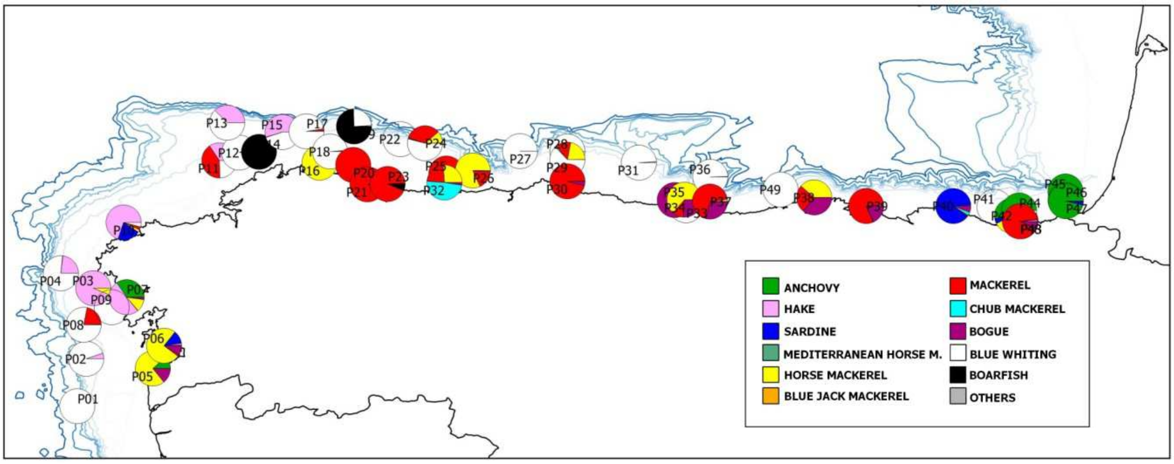


Figure 2: PELACUS0316 Fish proportion (abundance) at each fishing station

Of 49 tows performed, 44 were considered valid. Comparing with the previous year, the number of hauls shows a sharp decrease of a 33%. This was mainly due to the very scarce fish abundance found this year, especially on the self of IXa Subdivision. The reason of this low fish availability could be related with the strong poleward current occurred this year. Table 1 shows the overall species composition of the fishing stations.

Table 1. PELACUS0316 Catch composition.

SPECIES	Weight (kg)	Number of hauls	% (total weight)
Scomber scombrus	36232.03	31	84.2207647
Micromesistius poutassou	1963.1	25	4.56315002
Trachurus trachurus	1756.0	29	4.08188421
Boops boops	1578.8	18	3.66992291
Capros aper	685.2	4	1.59268985
Engraulis encrasicolus	271.0	9	0.62996301
Scomber colias	220.5	13	0.51256728
Merluccius merluccius	133.4	35	0.30999083
Sardina pilchardus	108.2	11	0.25147893
Trachurus mediterraneus	25.8	5	0.06007396
Mola mola	12.7	2	0.02943959

Trachurus picturatus	7.5	1	0.01750336
Sarda sarda	7.1	4	0.01642945
Spondyliosoma cantharus	6.0	4	0.01394225
Zeus faber	4.0	2	0.0092468
Diplodus vulgaris	1.9	2	0.00443047
Meganyctiphanes norvegica	1.4	2	0.0033612
Polybius henslowi	1.3	9	0.00302648
Pagellus erythrinus	1.0	1	0.00227799
Cymbulia peronii	0.6	1	0.00139469
Salpa spp.	0.6	5	0.00131333
Loligo vulgaris	0.5	2	0.00107856
Diplodus sargus sargus	0.4	1	0.00099488
Illex coindetii	0.4	2	0.00088795
Maurolicus muelleri	0.3	3	0.00076011
Notoscopelus spp.	0.2	3	0.00043468
Chelidonichthys cuculus	0.1	1	0.00032543
Pagellus acarne	0.1	1	0.00027894
Alloteuthis spp.	0.1	3	0.00027661

Table 2 summarises the main results of the fishing station for the principal pelagic species. As in previous years, mackerel, horse mackerel, blue whiting and hake were the most representative species. A total of 14508 individuals were measured Mackerel was the most important species in catches, with the 84% in weight, followed by far for the blue whiting (that represents only the 4.5% in weight of the PELACUS catch). Anchovy was caught in 9 hauls, with a 0.6% in weight of the catches and sardine was very scarce, with 0.25% of the catches.

Table 2. PELACUS0316 Catch composition.

	Tot. Catch	No ind.	No F.st.	No meas. Ind.	Mean length	%PRES	% weight	% number
WHB	1943	59964	25	2308	19.64	56.82	4.52	24.27
MAC	36232	119504	31	4071	35.69	70.45	84.31	48.36
HAK	133	1378	35	1300	23.02	79.55	0.31	0.56
HOM	1756	29734	29	2239	20.73	65.91	4.09	12.03
PIL	110	2383	11	859	18.64	25.00	0.26	0.96
JAA	8	32	1	32	30.81	2.27	0.02	0.01
BOG	1582	5583	18	1602	27.55	40.91	3.68	2.26
MAS	218	2392	13	676	24.29	29.55	0.51	0.97
BOC	685	11224	4	439	14.05	9.09	1.59	4.54
Sparidae	9	29	2	29	27.53	4.55	0.02	0.01
ANE	271	14699	9	861	14.70	20.45	0.63	5.95
HMM	26	196	5	92	27.95	11.36	0.06	0.08
Total	***42973***	***247118***		***14508***				

On the other hand, 215 CUFES stations, comprising 3 nautical miles each were taken, as shown in Figure 3. This number is considerably lower than last year because, due to lack of staff, alternate transects were sampled during PELACUS in 2016.

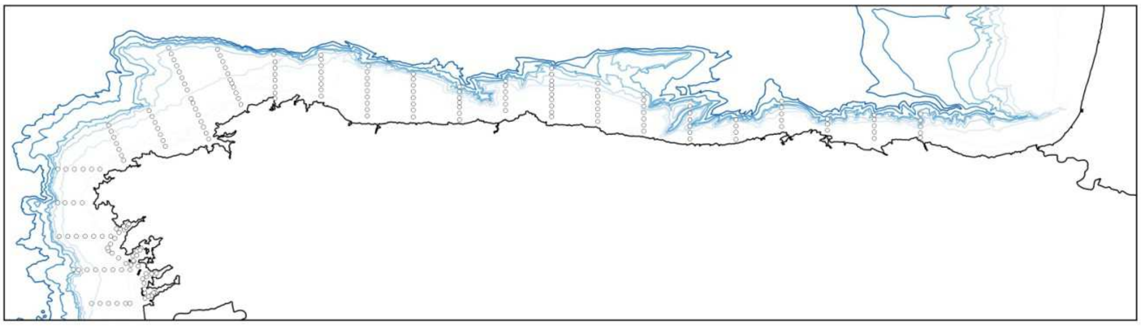


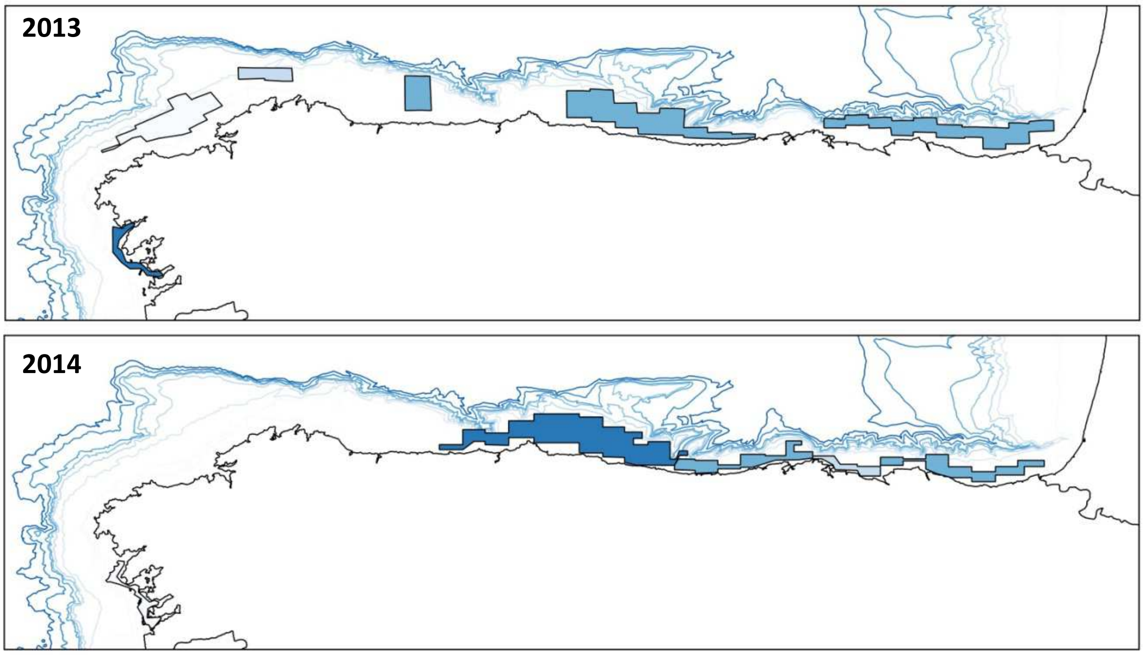
Figure 3. PELACUS0316 CUFES stations.

Results

Acoustic

Sardine distribution and assessment

Sardine distribution was very scarce in both occupied area and density. Sardine occurred in isolated nuclei without, and as it has been already observed in previous years, no clear echotrace of sardine schools have been detected, with sardine occurring in very small echotraces, thus the energy attributed to this species was in general very low (Figure 4). In such circumstances, with sardine observed in a mixed layer with other fish species (mainly mackerel, horse mackerel or bogue) no direct allocation from scrutinization is feasible, being the backscattering energy attributed to sardine derived from the results obtained at the ground-truth fishing stations (length distribution and catch in number). Even in this case, giving its low abundance compared with the other fish species, it is very difficult to get representative samples of sardine; in this case, no length distribution has been got from VIIIc-Ew.



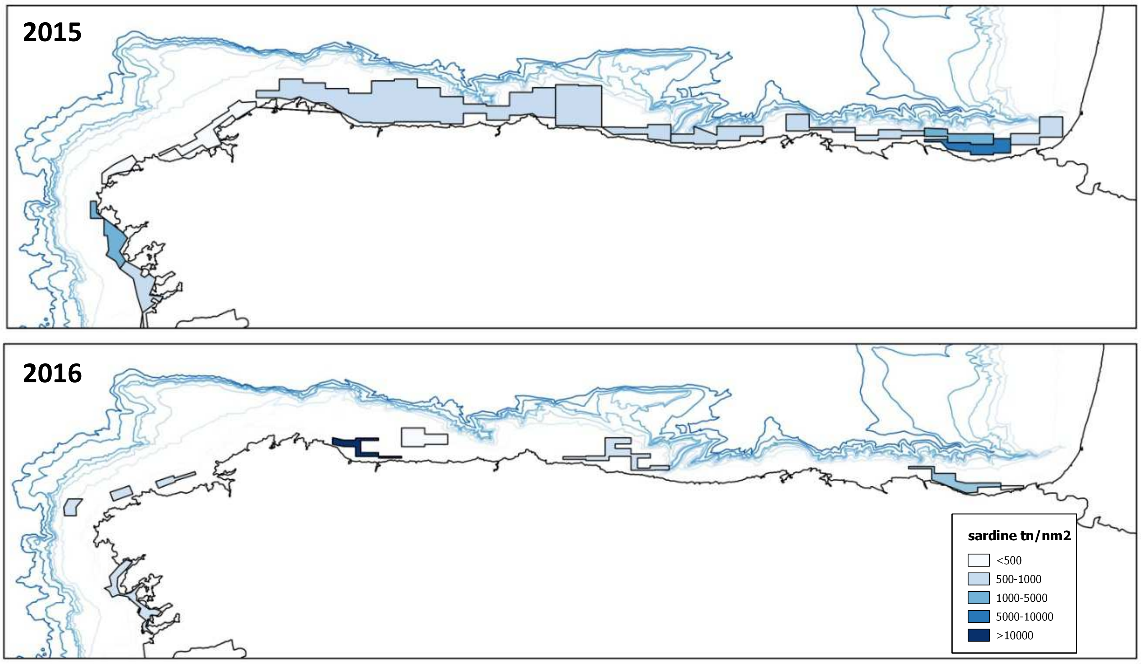


Figure 4. Sardine: spatial distribution of energy allocated to sardine during 2013-2016 PELACUS surveys. Polygons are drawn to encompass the observed echoes, and polygon colour indicates sardine density in nm^2 within each polygon.

At the end of the track number 26, in the coastal area and in very shallower waters, a echotrace corresponding to a school has been detected. This particular school, although not fished, had energetic and morphological characteristics compatible with those of the sardine (s_V mean= -30.15 dB, s_V max= -18.85 db; length= 23 m length; height=7.6 m; NASC=6982.75 m^2/nmi^2) (figure 5). This single school accounted the 59% of the total backscattering energy allocated to sardine. For this reason, the assessment has been done accounting and without accounting this possible sardine school in the estimation of the biomass.

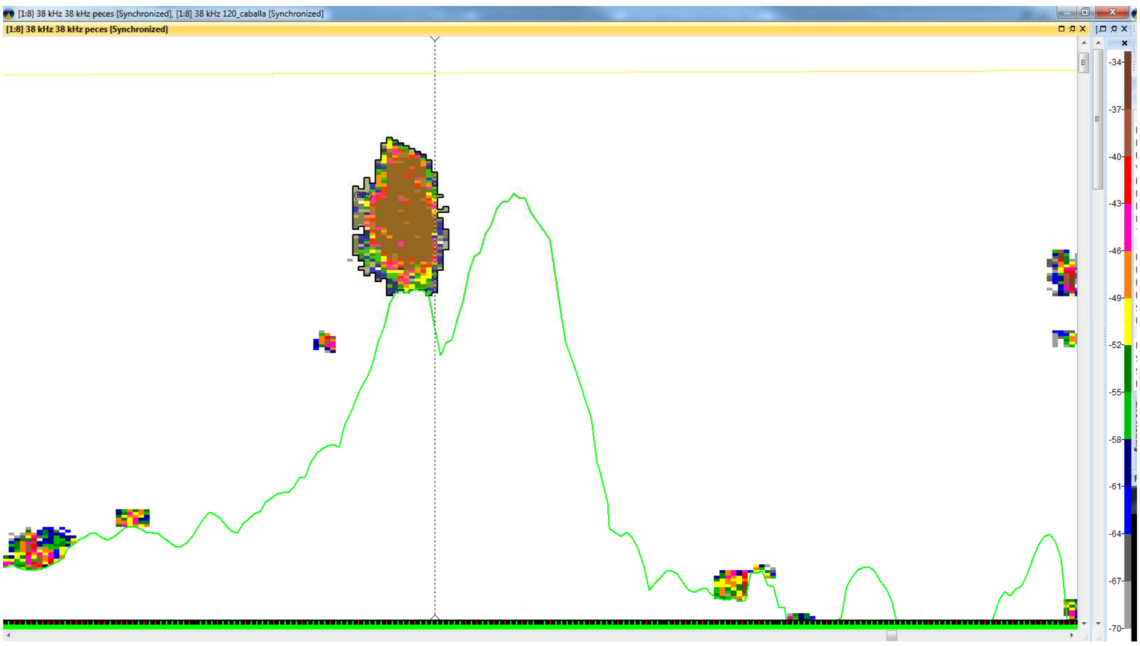


Figure 5. Echotrace attributed to a sardine school. A Mask, to remove other backscatters than those belonging to swimbladder fish, has been applied

Table 2 shows the sardine abundance estimation without including this school. Overall, 3205.5 tonnes have been estimated, corresponding to 70.3 million fish, the lowest value ever recorded.

Table 2. Sardine acoustic assessment

Zone	Area	No	Mean	Area	Fishing st.	PDF	No (million fish)	Biomass (tonnes)	Density (Tn/nmi-2)
IXa	Rias Baixas	75	46.83	118	P06	S01	26	1032	9
	Total	*75*	*47*	*118*			*26*	*1032*	9
VIIIc-W	Fisterra	4	5.12	35	P10	S02	1	40	1
	Artabro_1	4	38.89	32	P10	S02	4	272	9
	Artabro_2	4	7.05	31	P10	S02	1	49	2
	Total	*12*	*17.02*	*98*			*5*	*362*	4
VIIIc-Ew	Masma	6	0.12	56	P40-P42-P47	S03	0	1	0
	Asturias_oc	15	0.24	110	P40-P42-P47	S03	0	5	0
	Asturias_or	16	18.54	140	P40-P42-P47	S03	11	500	4
	Total	**37**	*8.14*	**307**			*11*	*506*	2
VIIIc-Ee	Euskadi	14	63.92	105	P40-P42-P47	S03	29	1298	12
	Total	**14**	*63.92*	**105**			**29**	**1298**	12
VIIIb	Euskadi	2	3.20	12	P40-P42-P47	S03	0	8	1
	Total	*2*	*3.20*	*12*			*0*	*8*	1
	Total IXa	*75*	*47*	*118*			*26*	*1032*	9
	Total VIIIc	*63*	*22*	*510*			*45*	*2166*	4
	Total VIIIb	*2*	*3*	*12*			*0*	*8*	1
	Total Spain	*140*	*35.13*	*640*			*70*	*3205*	5

If this school is included, the biomass increased up to 13960 tonnes (a 77% more), corresponding to 308 million fish, which is still at the

Table 3. Sardine acoustic assessment

Zone	Area	No	Mean	Area	Fishing st.	PDF	No (million fish)	Biomass (tonnes)	Density (Tn/nmi-2)
IXa	Rias Baixas	75	46.83	118	P06	S01	26	1032	9
	Total	*75*	*47*	*118*			*26*	*1032*	9
VIIIc-W	Fisterra	4	5.12	35	P10	S02	1	40	1
	Artabro_1	4	38.89	32	P10	S02	4	272	9
	Artabro_2	4	7.05	31	P10	S02	1	49	2
	Total	*12*	*17.02*	*98*			*5*	*362*	4
VIIIc-Ew	Masma	6	0.12	58	P40-P42-P47	S03	0	1	0
	Masma_2	1	6982.75	8	P40-P42-P47	S03	237	10754	1344
	Asturias_oc	15	0.24	110	P40-P42-P47	S03	0	5	0
	Asturias_or	16	18.54	140	P40-P42-P47	S03	11	500	4
	Total	**38**	*191.68*	**317**			*249*	*11261*	36
VIIIc-Ee	Euskadi	14	63.92	105	P40-P42-P47	S03	29	1298	12
	Total	**14**	*63.92*	**105**			**29**	**1298**	12
VIIIb	Euskadi	2	3.20	12	P40-P42-P47	S03	0	8	1
	Total	*2*	*3.20*	*12*			*0*	*8*	1
	Total IXa	*75*	*47*	*118*			*26*	*1032*	9
	Total VIIIc	*64*	*131*	*520*			*282*	*12920*	25
	Total VIIIb	*2*	*3*	*12*			*0*	*8*	1
	Total Spain	*141*	*84.41*	*650*			*308*	*13960*	21

Sardine ranged in length from 14 to 24 cm, with a mode at 18.5 cm (Figure 6) which corresponds to quite large fish. Most fish in the entire surveyed area were assigned as belonging to the age 2 (45% of the abundance and 43% of the biomass), age 3 (25% of the abundance and 28% of the biomass) and age 1 (21% of the abundance and 17% of the biomass) years classes (Table 4, Figure 6), thus with a weak signal of recruitment.

By sub-area, VIIIcEast-West subdivision represents 83.2%, VIIIcEast- East 8.2%, IXa North 7.2% and VIIIc West 1.4 of the total abundance. Age group 1 was dominant in IXaN, while it was absent in VIIIcW, were age group 4 was dominant. In VIIIcE, age group 2 was the most abundant (Figure 7).

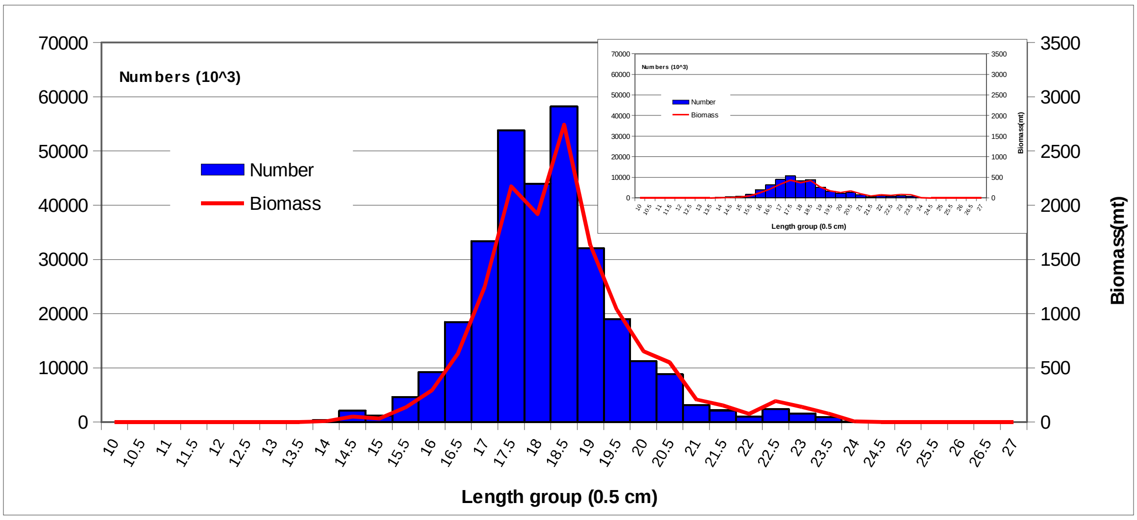


Figure 6. Sardine: fish length distribution in biomass and abundance during PELACUS0316 survey (including VIIIb subdivision). In the small chart, the estimates when excluded the schools accounted as probably sardine.

Table 4. Sardine abundance in number (thousand fish) and biomass (tons) by age group and ICES sub-area in PELACUS0316.

AREA VIIIcE											
AGE	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (Tonnes)	2289	6482	4291	1304	102	7	28	28			14532
% Biomass	15.8	44.6	29.5	9.0	0.7	0.0	0.2	0.2			100
Abundance (N in '0(	62246	147708	84936	23374	1851	79	346	346			320886
% Abundance	19.4	46.0	26.5	7.3	0.6	0.0	0.1	0.1			100
Medium Weight (gr	36.78	43.88	50.52	55.80	55.07	86.01	82.08	82.08			45.29
Medium Length (cm	17.12	18.25	19.19	19.88	19.76	23.25	22.86	22.86			18.42

AREA VIIIcW											
AGE	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (Tonnes)		38	84	126	39	15	31	28			362
% Biomass		10.4	23.2	35.0	10.9	4.2	8.7	7.7			100
Abundance (N in '000)		575	1194	1674	495	183	352	325			4798
% Abundance		12.0	24.9	34.9	10.3	3.8	7.3	6.8			100
Medium Weight (gr)		65.5	70.2	75.6	79.4	83.3	88.9	85.4			75.4
Medium Length (cm)		21.1	21.6	22.1	22.6	23.0	23.5	23.2			22.1

AREA IXaN											
AGE	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (Tonnes)	408	375	132	78	18	2	11	8			1032
% Biomass	39.5	36.3	12.8	7.5	1.8	0.2	1.0	0.8			100
Abundance (N in '0(	12249	9179	2419	1204	240	29	120	100			25540
% Abundance	48.0	35.9	9.5	4.7	0.9	0.1	0.5	0.4			100
Medium Weight (gr	33.30	40.85	54.59	64.40	76.94	76.05	89.21	84.47			40.42
Medium Length (cm	16.5	17.8	19.7	20.9	22.3	22.3	23.6	23.1			17.6

TOTAL SPAIN											
AGE	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (Tonnes)	2697	6894	4507	1508	160	24	70	65			15926
% Biomass	16.94	43.29	28.30	9.47	1.00	0.15	0.44	0.41			100
Abundance (N in '0(	74495	157462	88549	26253	2586	291	818	771			351225
% Abundance	21.21	44.83	25.21	7.47	0.74	0.08	0.23	0.22			100
Medium Weight (gr	36.21	43.78	50.90	57.46	61.75	83.34	86.06	83.79			45.34
Medium Length (cm	17.02	18.23	19.24	20.07	20.53	22.98	23.25	23.02			18.41

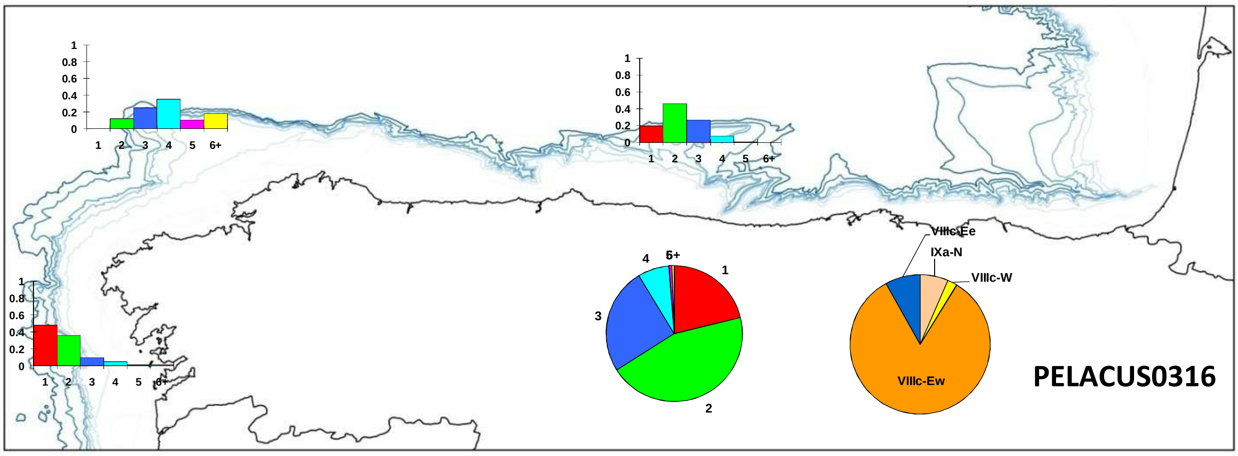
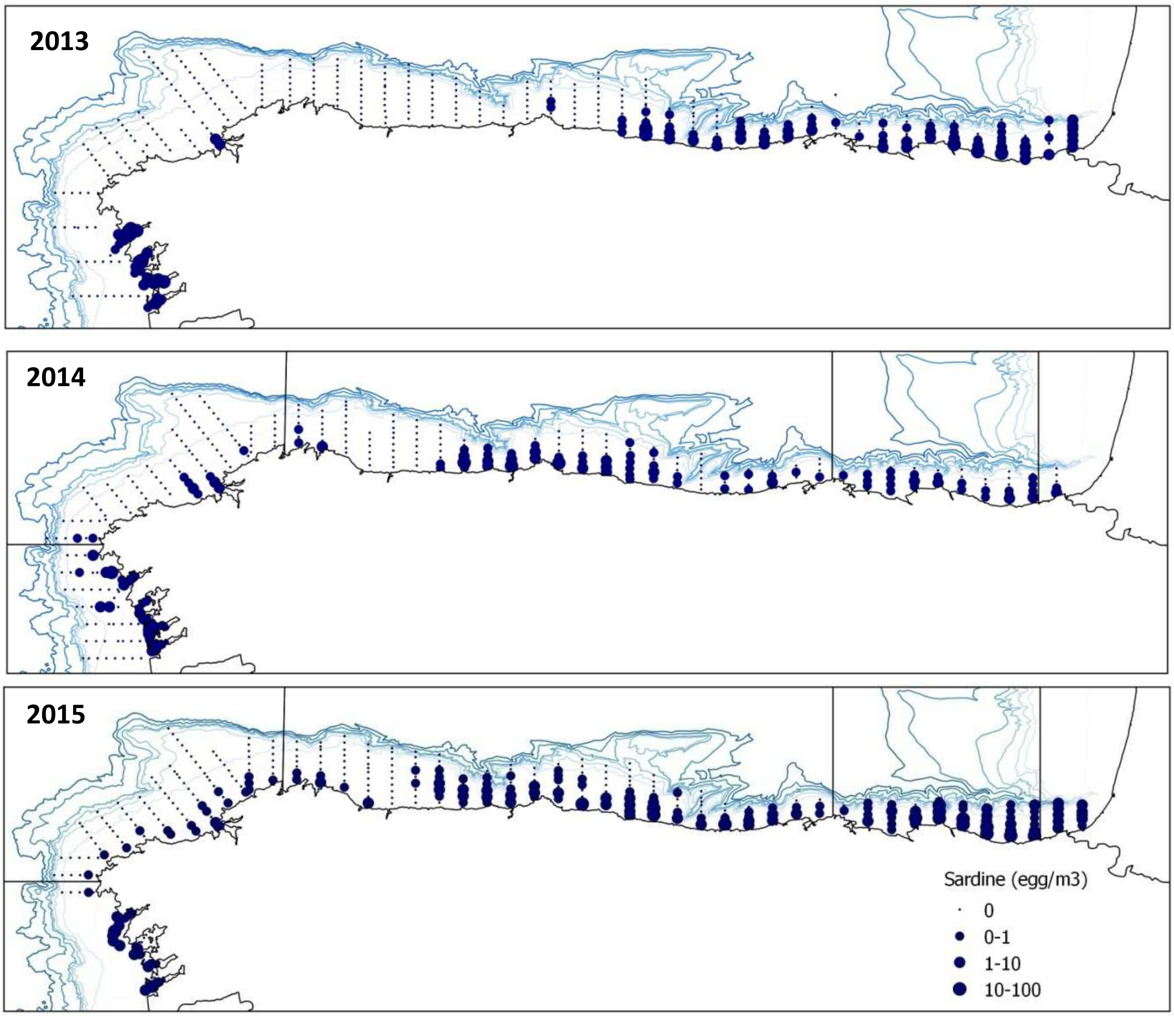


Figure 7. Sardine: relative abundance at age in each sub-area estimated in the PELACUS0316. The pie chart shows the contribution of each sub-area and each age group to the total stock numbers.

Sardine egg abundance

The distribution of sardine eggs (obtained from the analysis of 215 CUFES stations) indicates a coastal distribution, agreeing with that observed in previous years (Figure 8). Total number of sardine eggs detected in Spanish waters was 1696, which represents an important decrease from the 2015 value (7588 in 355 CUFES stations), although the number of stations was lower. For this reason, we compared mean egg abundance in 2015 with that obtained this year. While inside the Rias Baixas (coastal waters of IXaN) mean egg abundance, expressed as number of egg/m^3, remained quite similar (2.32 in 2015 and 2.5 this year), the highest differences were found in the VIIIc Division where the mean egg abundance decreased from 4.74 to only 1.35 eggs/m3, which is in agreement with the lower fish abundance estimated by echo-integration. Besides, the number of positive stations is still very low (37% in 2016, 45% in 2015, 33% in 2014, 28% in 2013).



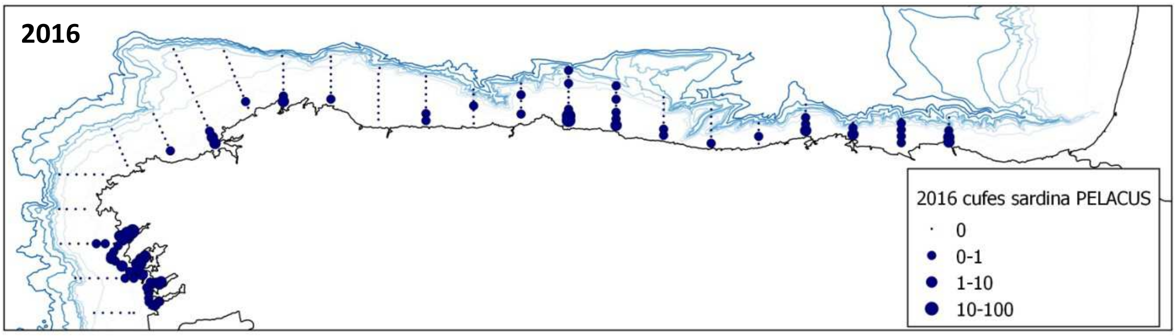


Figure 8.. Sardine: distribution of sardine eggs (CUFES samples) in 2013-2016 PELACUS surveys. Blue circles indicate positive stations with diameter proportional to egg density.

Acoustic Anchovy distribution and assessment

In spite during the acoustic-trawl JUVENA survey, which take place every September covering all the Bay of Biscay, pre-juveniles (round 6 month old) are evenly distributed off-shore (i.e. outside the continental self) from Galicia to Brittany, only few anchovy are routinely recorded along the Spanish continental self in spring. During PELACUS 0316, as in previous years, anchovy mainly occurred around Cape Peñas and at the inner part of the Bay of Biscay. Besides, and also in coincidence with that observed during the PELAGO survey carried out off Portuguese coasts, anchovy was also recorded in IXa, namely within the rías, although the biomass was low (205 tonnes corresponding to 8 million fish).

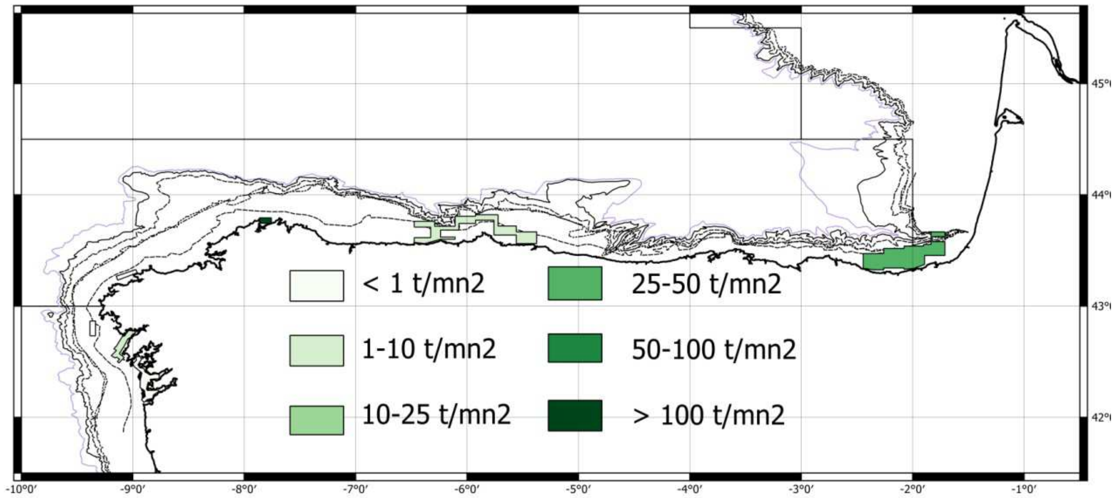


Figure 9. Spatial distribution of energy allocated to anchovy during PELACUS0316 survey. Polygons are drawn to encompass the observed echoes, and polygon colour indicates density in mt/ nm^2 within each polygon.

Table 6 shows the anchovy assessment for the whole surveyed area. Total biomass was estimated to be 19 870 mt corresponding to 817 million fish. As observed in sardine, the bulk of the biomass in the wetern area was located in only few schools. In the case of anchovy, these schools were located within the Ria of Ortigueira, near Ortegal Cape. They occurred close to the coast, in roughly hard bottom (i.e. difficult to fish); this together with the bad weather conditions did not allow a haul be performed. Nevertheless, as shown in figure 10 schools characteristics were those compatibles with a thick anchovy school.

Table 6. Anchovy acoustic assessment

Zone	Area	No	Mean	Area	Fishing st.	PDF	No (million fish)	Biomass (tonnes)	Density (Tn/nmi-2)
IXa	Rias Baixas	59	2.92	79	P05	S01	3	21	0
	Muros	30	23.78	47	P07	S02	6	184	4
	Total	***89***	***9.95***	***126***			***8***	***205***	2
VIIIc-W	Fisterra	2	1.75	18	P10	S02	0	4	0
	Artabro	2	0.30	17	P10	S02	0	1	0
	Total	***4***	***1.02***	***35***			***0***	***5***	0
VIIIc-Ew	Masma	3	3267.26	17	P40-P42-P47	S03	329	7999	466
	Asturias	28	23.78	252	P40-P42-P47	S03	35	856	3
	Total	**31**	***337.67***	**269**			***364***	***8855***	33
VIIIc-Ee,VIIIb	Euskadi	45	237.81	318	P40-P42-P47	S03	444	10804	34
	Total	**45**	***237.81***	**318**			**444**	**10804**	34
	Total IXa	***89***	***10***	***126***			***8***	***205***	2
	Total VIIIbc	***80***	***265***	***623***			***809***	***19665***	32
	Total Spain	***169***	***130.52***	***749***			***817***	***19870***	27

Figure 10. Echotraces attributed to anchovy schools. A mask, to remove other backscatters than those belonging to swimbladder fish, has been applied

In IXa, two clear modes were observed. The first, at 11 cm, was mainly located in the southern part, while the second, at 17.5 cm, was mainly found in the northern part (Muros). A third mode of 13.5 cm was also detected. Most of the fish belonged to age group 3 (53% in number and 77% in weight), as shown in table 7 and figures 11 and 12.

Table 7. Anchovy assessment in IXa-N

Length	1	2	3	4	Total	No fish (thousands)
10	2				1.92	356
10.5	4				4.10	644
11	6				6.08	813
11.5	3				3.25	373
12	1				0.85	85
12.5	1				1.02	88
13	2				2.14	161
13.5	6				5.70	377
14						
14.5	2	1			3.07	158
15	3	1			3.45	158
15.5	4				4.27	175
16			5		4.85	178
16.5	12		12		23.30	770
17			40		39.71	1184
17.5			60		59.86	1615
18			24		24.20	592
18.5			10		9.67	215
19			8		7.96	161
19.5						
20						
20.5						
Biomass (mt)	45	2	158	0	205.40	8105
%	22.11	1.02	76.87			
M. weight	10.92	20.26	36.25		24.57	
No Fish (thousands)	3671	103	4331	0	8105	
%	45.29	1.27	53.44			
M. length	12.53	14.94	17.64		15.29	
s.d.	2.10	0.24	0.64		2.93	

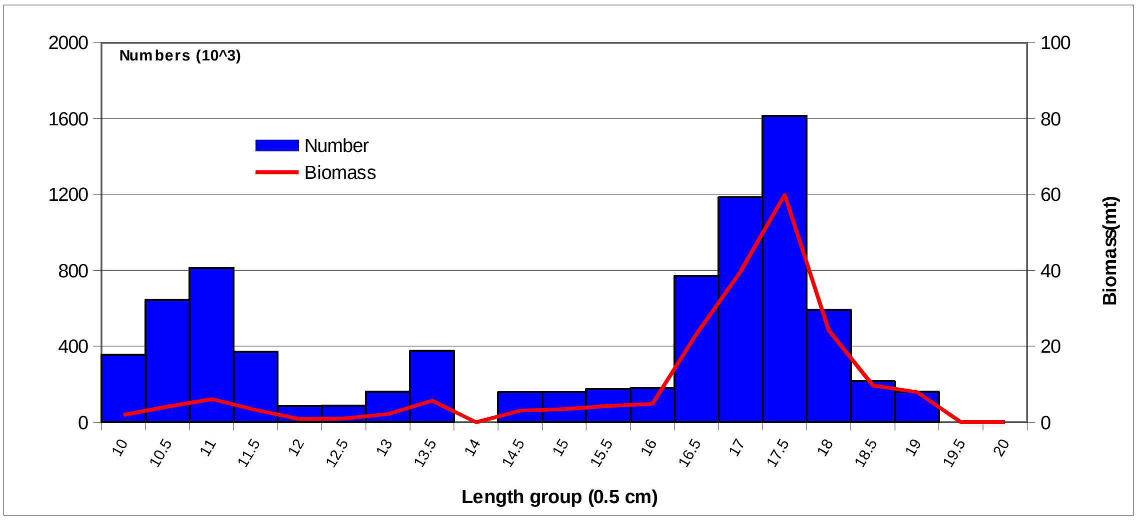


Figure 11. Anchovy fish length distribution in biomass and abundance during the PELACUS0316 survey in IXa-N

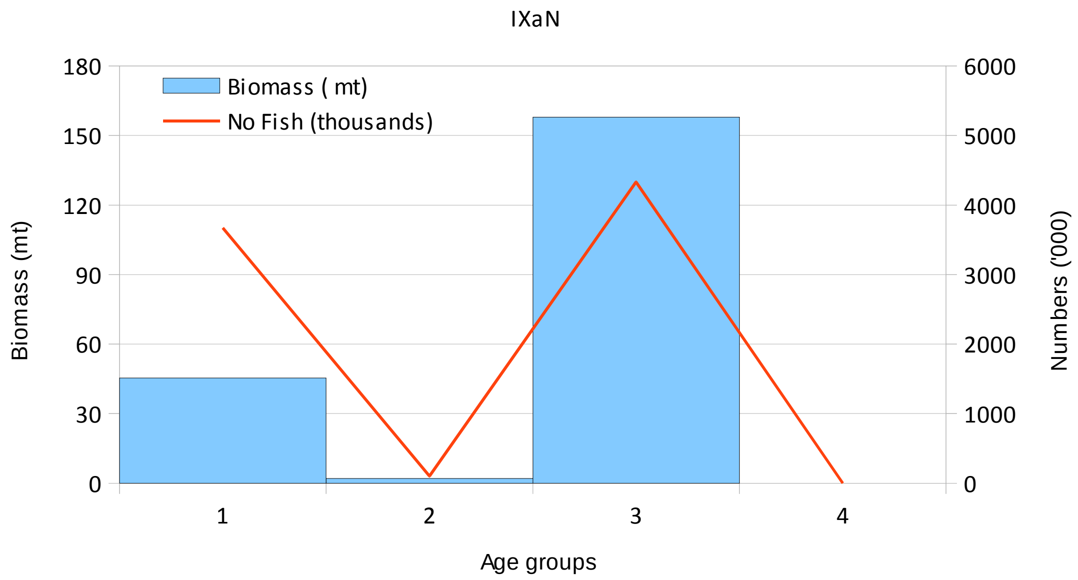


Figure 12. Anchovy fish age distribution in biomass and abundance during PELACUS0316 survey in IXa-N

In VIIIc, and as it was previously stated, 8 of the 19.7 thousand tonnes estimated for the whole area were detected in a single, dense patch located at the Ortigueira inlet. Contrary to that observed in IXa-N, the length structure only showed a single mode located at 15 cm (figure 13)

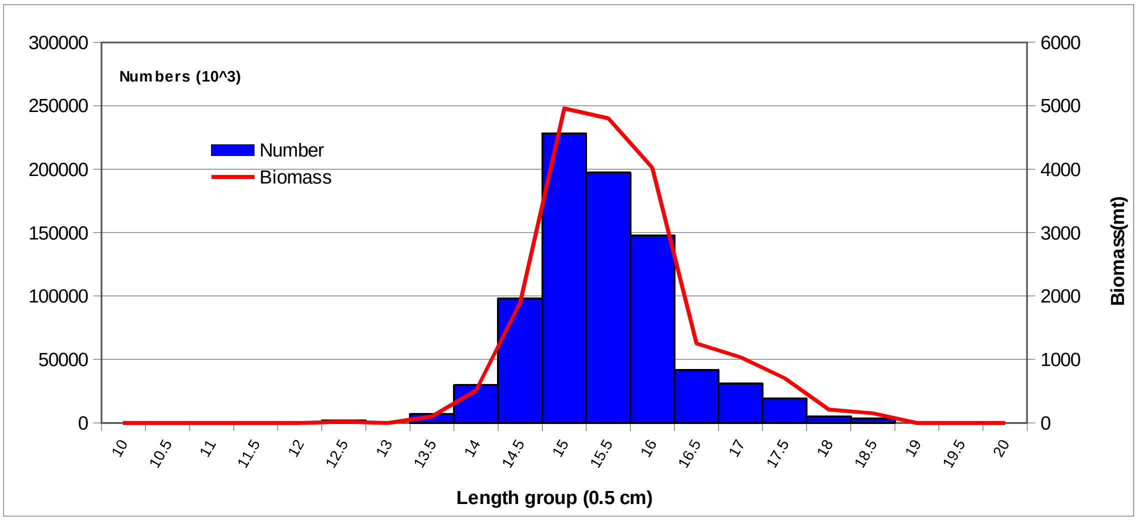
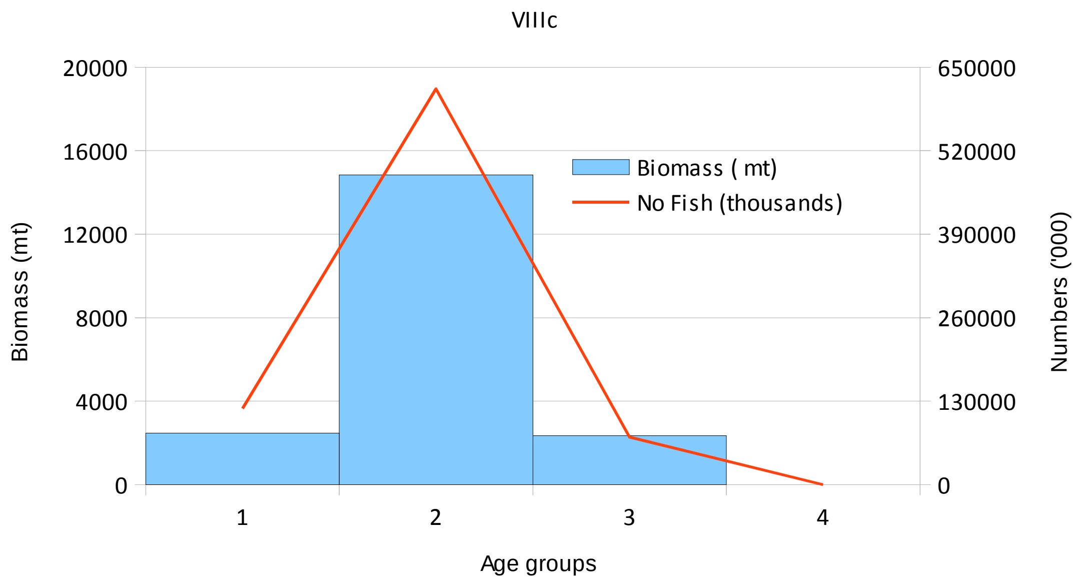


Figure 13. Anchovy fish length distribution in biomass and abundance during PELACUS0316 survey in VIIIc

Excluding the dense patch detected in the western part, the bulk of the fish were found at the inner part of the Bay of Biscay. The age structure, as show in figure 14, is complementary to that observed in IXa-N, being age group 2 the most abundant. Moreover, the behaviour observed to these school detected close to the French-Spanish border, suggested a westward movement along the Spanish coast.

Figure 14. Anchovy fis



h age distribution in biomass and abundance during PELACUS0316 survey in VIIIc

Table 8 shows the assessment of anchovy in VIIIc. More than 75% in both number and weight belonged to age group 2, while age group 1 remained more or less at the same level of age group 3. From these results, although the large presence of pre-recruits of the Spanish coasts in late summer, it seems the recruitment process to the area for anchovy in the Bay of Biscay takes mainly place on the French continental self.

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Length	1	2	3	4	Total	No fish (thousands)
10						
10.5						
11						
11.5						
12						
12.5	20				19.93	1717
13						
13.5	52	52			103.59	6848
14	340	170			510.41	29765
14.5	474	1423			1897.02	98014
15	1026	3763	171		4959.85	227958
15.5	379	4297	126		4802.53	197093
16	175	3493	349		4017.50	147743
16.5		954	298		1252.77	41421
17		518	518		1035.75	30886
17.5		176	529		704.93	19014
18			208		207.94	5088
18.5			152		152.43	3392
19						
19.5						
20						
Biomass (mt)	2466	14846	2352	0	19664.64	808939
%	12.54	75.50	11.96			
M. weight	20.63	23.90	31.37		24.10	
No Fish (thousands)	118636	616363	73940	0	808939	
%	14.67	76.19	9.14			
M. length	15.02	15.66	16.93		15.68	
s.d.	0.64	0.66	0.95		0.82	

Anchovy egg abundance

Figure 15 shows the anchovy eggs count from CUFES since 2013. Although the survey takes place out of the main spawning period (May), eggs are routinely collected in March-beginning April, but in very low density as compared with that of May. Comparing with the previous years, in 2016 the egg distribution was lower than that of 2015, especially in the center part of the Cantabrian Sea, where in 2015 an important amount of anchovy eggs were found. Given the oceanographic conditions found during the survey, more related with winter conditions than those of an incipient spring, the egg production was still lower, far from the spawning activity expected at this period.

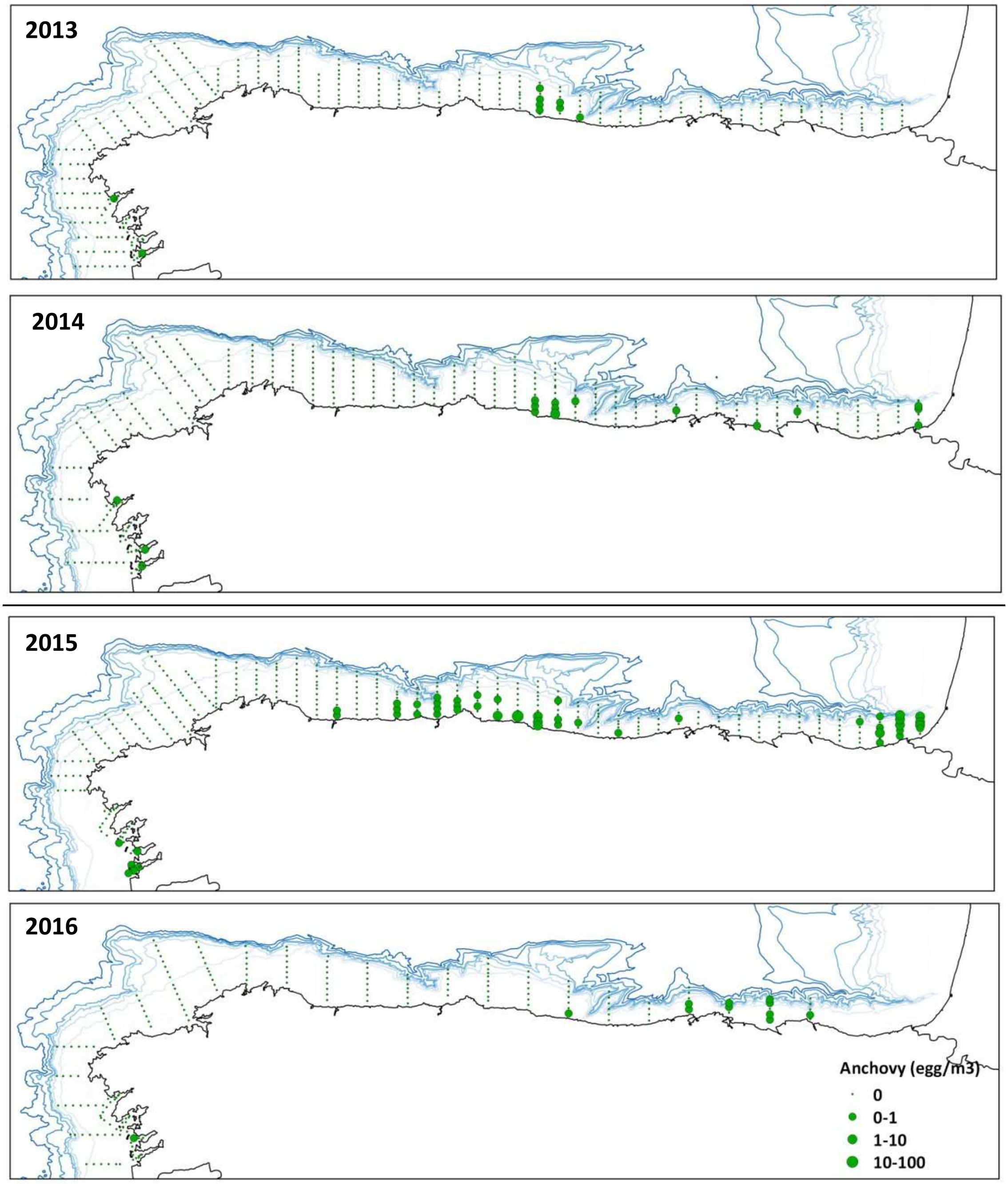


Figure 15. Anchovy: distribution of anchovy eggs (CUFES samples) in 2013-2016 PELACUS surveys. Green circles indicate positive stations with diameter proportional to egg density.

Acoustic Horse mackerel distribution and assessment

Figure 15 shows the horse mackerel distribution and density estimated during PELACUS 0316. The strong poleward current has also affected the horse mackerel availability in the self of IXaN, and only within the Rias and in coastal waters, the horse mackerel density was higher but less than that observed in the previous year.

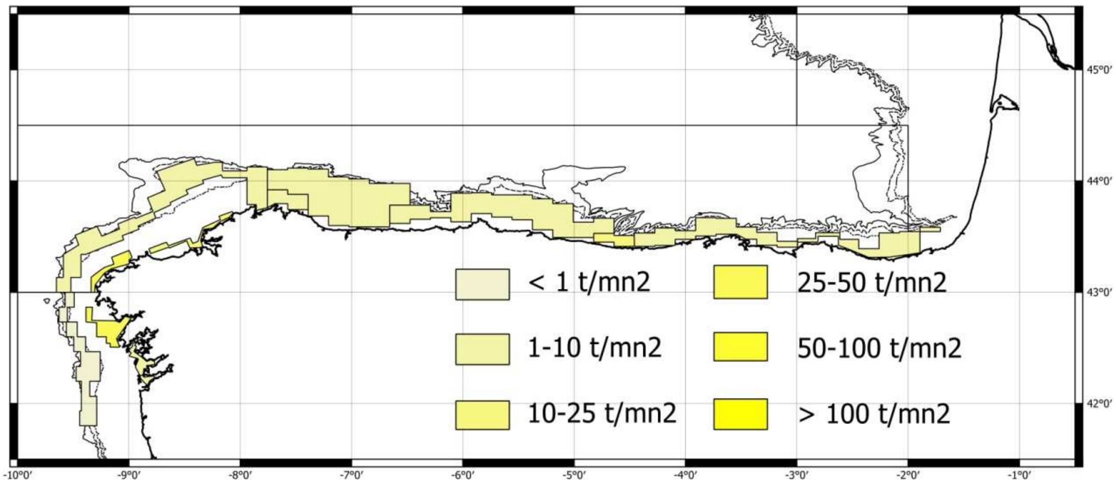


Figure 15. Spatial distribution of energy allocated to horse mackerel during PELACUS0316 survey. Polygons are drawn to encompass the observed echoes, and polygon colour indicates density in mt/ nm² within each polygon.

The assessment of this fish species is shown in table 9. In IXa, only 5.3 thousand tons, corresponding to 122.5 million fish, were estimated. This quantity is much lower than that recorded last year (27 thousand tons, corresponding to 203 million fish). However, it should be noted that 2015 was an extraordinary year where the fish availability in IXa was highest ever recorded for both mackerel and horse mackerel

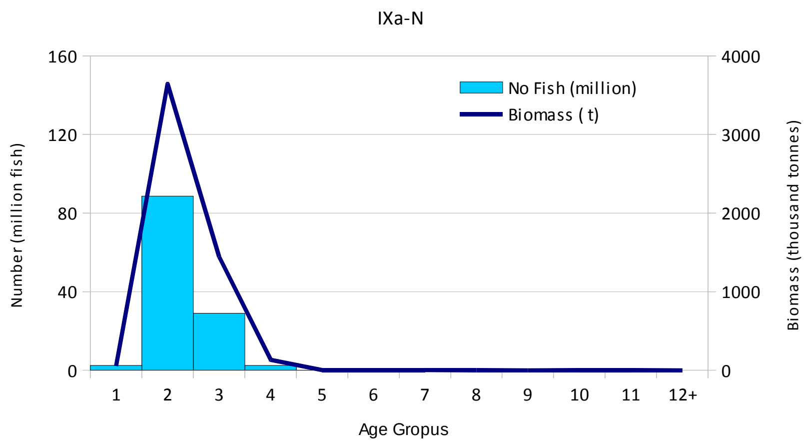
Table 9. Summary of the horse mackerel assessment

Zone	Area	No	Mean	Surface	Fishing st.	PDF	No (million fish)	Biomass (tonnes)
IXa-N	RIA VIGO	19	74.15	15.18	P05	ST01	2	68
	PONTEV-AROUSA	41	126.84	57.43	P06	ST02	15	424
	MUROS	48	509.90	143.17	P07	ST03	106	4782
	IXa-off	52	0.36	399.76	P21-P24	ST04	0	12
	Total	***160***	***194***	***615.53***			***122.54***	***5285.89***
VIIIc-w	COSTA MORTE	10	525.18	84.48	P07	ST03	64	2906
	VIIIc-West	117	87.65	977.33	P21-P24	ST04	83	6680
	ARTABRO	11	59.00	80.43	P16	ST05	6	336
	Total	***138***	***117***	***1142.2***			***153.13***	***9922.67***
VIIIc-E	ESTACA	15	127.08	128.11	P16	ST05	19	1086
	MASMA	141	24.13	1095.17	P21-P24	ST04	21	2035
	ASTURIAS	132	193.81	993.34	P25-P26-P29-P32	ST06	329	11417
	LLANES	11	70.38	85.23	P35	ST07	18	302
	VIIIc-East	102	137.59	781.41	P38-P39-P42-P43	ST08	101	7818
	Total	***401***	***114***	***3083***			***488.25***	***22658.23***
	Total VIIIc	***539***	***115***	***4225***			***641***	***32581***
	Total Spain	***699***	***133***	***4841***			***764***	***37867***

Age group 2 was the most abundant in IXa, comprising the 69% in weight and the 72% in number (table 10, figure 16), with almost absence of fish older than 3.

Table 10. Horse mackerel assessment in IXaN

	AGE GROUPS													
Length	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12+**	**Total**	**No fish (million)**
10	0.21												0.21	0
11	0.27												0.27	0
12	1.36												1.36	0
13													0.00	0
14	11.00												11.00	1
15	20.13	8.81											28.94	1
16	17.16	195.61											212.77	8
17	4.02	176.76											180.77	6
18		457.43											457.43	13
19		1196.87	265.97										1462.84	36
20		1176.44	316.73	45.25									1538.42	33
21		398.46	677.38										1075.84	20
22		32.64	184.97	87.05									304.66	5
23		0.00	0.08	0.12									0.20	0
24			0.12	0.26	0.12								0.49	0
25			0.08	0.49	0.33	0.04							0.94	0
26			0.04	0.48	1.17	0.66							2.34	0
27					1.55	2.03							3.58	0
28					0.07	1.05	0.91	0.07					2.10	0
29						0.11	0.42	0.11					0.63	0
30								0.24		0.08			0.32	0
31										0.25			0.25	0
32										0.11	0.11		0.22	0
33											0.08		0.08	0
34											0.19		0.19	0
35													0.00	0
36													0.00	0
37													0.00	0
38													0.00	0
39													0.00	0
40													0.00	0
41													0.00	0
42													0.00	0
43													0.00	0
44													0.00	0
Biomass (t)	54.2	3643.0	1445.4	133.6	3.2	3.9	1.3	0.4	0.0	0.4	0.4	0.0	5285.89	122.5
%	1.02	68.92	27.34	2.53	0.06	0.07	0.03	0.01		0.01	0.01			
M. weight	19.94	37.88	46.54	51.61	91.97	99.82	112.48	124.32		144.57	172.81		39.66	
No Fish (million)	2	89	29	2	0	0	0	0	0	0	0	0	123	
%	2.00	72.32	23.63	1.97	0.03	0.03	0.01	0.00		0.00	0.00			
M. length	15.40	19.42	20.93	21.72	26.77	27.58	28.80	29.86		31.53	33.64		19.75	
s.d.	1.25	1.38	0.95	1.02	0.88	0.77	0.48	0.94		0.80	1.21		1.60	



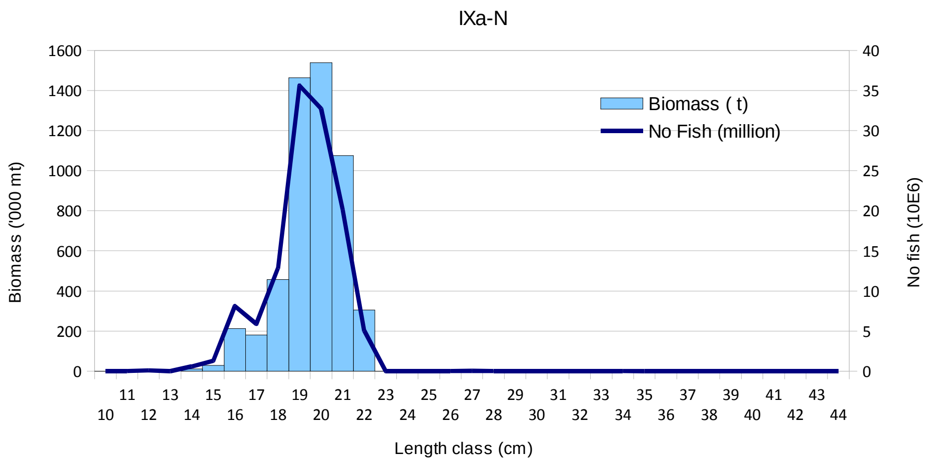


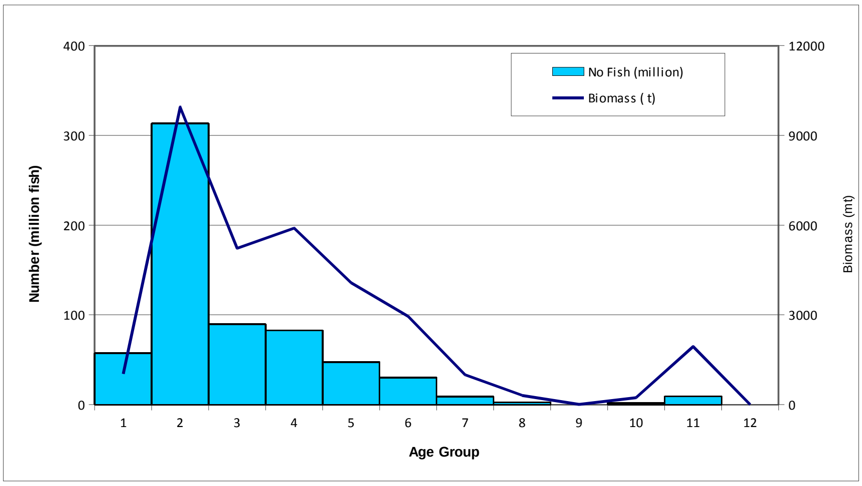
Figure 16. Horse mackerel fish age (above) and length (below) distributions in biomass and abundance during PELACUS0316 survey in IXaN

In VIIIc, the horse mackerel biomass was estimated to be 32.6 thousand tons (641 million fish), which roughly was half of that estimated in 2015 (66.7 thousand tons, 1069 million fish, table 11)

Table 10. Horse mackerel assessment in VIIIc

						AGE GROUPS								
Length	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Total**	**No fish (million)**
10														
11	53												53	6
12	103												103	9
13	27												27	2
14	95												95	6
15	484	212											696	34
16	206	2351											2557	106
17	58	2566											2625	92
18		1271											1271	38
19		1241	276										1517	38
20		1294	348	50									1693	36
21		734	1247										1981	38
22		211	1198	564									1973	34
23		67	1211	1817									3095	47
24			677	1510	677								2863	39
25			226	1432	980	113							2750	34
26			41	530	1305	734							2610	29
27					1069	1394							2463	25
28					39	589	510	39					1177	11
29						120	481	120					722	6
30								145		48			193	1
31										45			45	0
32										135	135		271	2
33											225		225	1
34											130		130	1
35											567		567	3
36											408		408	2
37											219		219	1
38														
39											253		253	1
40														
41														
42														
43														
44														
Biomass (t)	1026	9948	5224	5902	4069	2950	991	305	0	229	1937	0	32580.90	641
%	3.15	30.53	16.03	18.11	12.49	9.05	3.04	0.93		0.70	5.95			
M. weight	17.39	30.52	55.92	69.88	85.64	97.81	114.26	123.70		148.07	203.21		44.60	
No Fish (million)	57	313	90	83	47	30	9	2	0	2	9	0	641	
%	8.90	48.85	13.96	12.89	7.35	4.67	1.34	0.38		0.24	1.42			
M. length	14.66	17.96	22.36	24.24	26.09	27.38	28.96	29.80		31.81	35.67		20.61	
s.d.	1.71	1.63	1.50	1.20	1.07	0.87	0.50	0.71		0.84	1.90		4.48	

Age group 2 was also de the most important, although both length and age distribution were wider than those observed in IXaN (figure 17). In any case, results confirm the strength of the 2014 year class in both stocks.



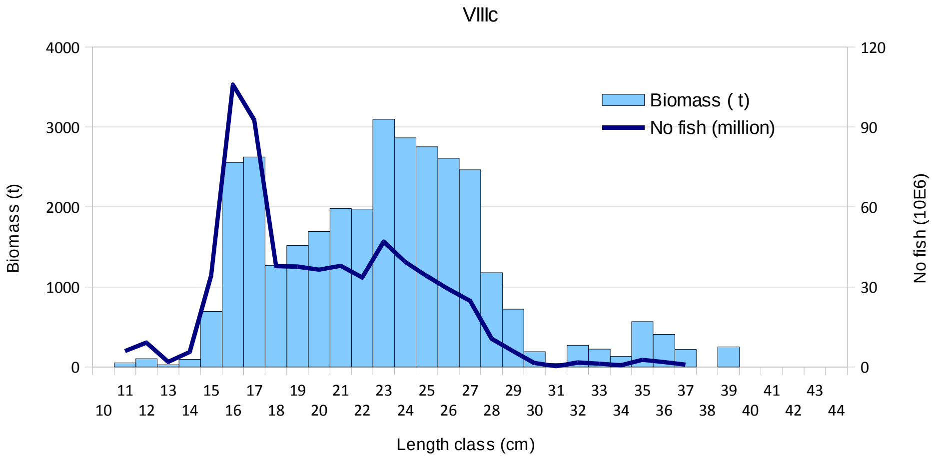


Figure 17. Horse mackerel fish age (above) and length (below) distributions in biomass and abundance during PELACUS0316 survey in VIIIc

Main conclusions

The weather and oceanographic conditions found during the survey time might have been affected the availability of the fish. This seems clearer in the southern part (IXaN, where the water column in the continental self was almost empty and also the plankton concentration was scarce, and only at the break some fish has been observed. Besides March was characterised by the presence of consecutive deep W/NW storms that have affected the survey plan. Five days were lost due to the bad weather conditions and even during part of the survey either strong south wind (up to 45 knots) or a persistent swell of about 2-4 m height have also made problems to achieve clean echograms (i.e. without bubbles) and good performance at the fishing station. As a consequence, the overall conditions were more related to winter ones than the incipient spring ones. These unexpected weather conditions could also be behind the very coastal shoals of sardine and anchovy found in teh western part of the Cantabrian sea. Due to the rough and hard bottom and the very shallower waters, it was not possible to undertake fishing haul for ID purposes, thus allocated as possibly sardine and anchovy. But the high s_A values of those schools as compared with the rest of the values obtained along the surveyed area, have led to trait them as statistic outliers. It has been observed in most of the pelagic fish species the occurrence of very thick and dense schools that have a big impact on both the mean abundance and its c.v. Any attempt for modelling the spatial distribution of these big schools uses to fall due to its scarcity. Therefore, neither the aggregation pattern nor the spatial distribution are known, being a challenge to estimate the abundance and its precision. In our case, we kept them for the assessment but given the low chance for getting a sample to full identify the species and the length structure no extrapolation to adjacent areas was done, being isolated in order to minimize their impact on the final assessment.

Acknowledgements

We would like to thank all the participants and crew of the PELACUS surveys.

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