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## MULTIDISCIPLINARY ACOUSTIC SURVEY PELACUS0313: PRELIMINARY RESULTS ON FISH ABUNDANCE ESTIMATES AND DISTRIBUTION

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**Abstract**

The PELACUS 0313 survey was undertook this year on board R/V Miguel Oliver, an oceanographic research stern trawler vessel similar to R/V Thalassa. The survey was characterised by a very bad weather conditions during the first two weeks which did not allow working properly. Moreover, the weather conditions during the rest of survey were almost similar. As a consequence, most of the coastal pelagic fish community remained very close to the coast, thus not accessible to the pelagic gear samplers. (33% of the total acoustic energy –NASC- was unable to be properly allocated into fish species).

Outside the coastal area (>90 m depth) main abundance fish species was mackerel with 380.000 tonnes, corresponding to 1.725 million fish. On the contrary, sardine distribution was scarce, and occurred in small schools (probably as a consequence of the bad weather condition), with only 3.343 tonnes corresponding to 54.0 million fish. Age group 2 was the most abundant, which confirms the high abundance found last year at age group 1 of the 2011 cohort.

**Introduction**

PELACUS 0313 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).

This year the survey was carried out on board R/V Miguel Oliver. This ship, built in 2007, is similar to the Thalassa, a French/Spanish research vessel traditionally used for the survey since

1997 (i.e. a 70 m length stern trawler with diesel-electric power and fixed pitch propeller, within the standard ship underwater radiated noise recommended in ICES CRR 209). Before the cruise, the ship was tested, including acoustic calibration (Foote *et al*., 1987), during a small survey performed in February in Galician waters. Moreover, an additional effort has been undertook by increasing the length of the survey track up to 1000 isobath in order to cover the main distribution area of blue whiting

We present the results on the mackerel, horse mackerel, blue whiting and board fish distribution together with the estimated values of adult fish abundance and biomass obtained in the survey. 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 (see Iglesias et al. (2010) for further details). Survey 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 40 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. 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 are expressed as nautical area scattering coefficient (NASC) units or $s_A$ values ($m^2$ $nm^{-2}$) (MacLennan *et al*., 2002).

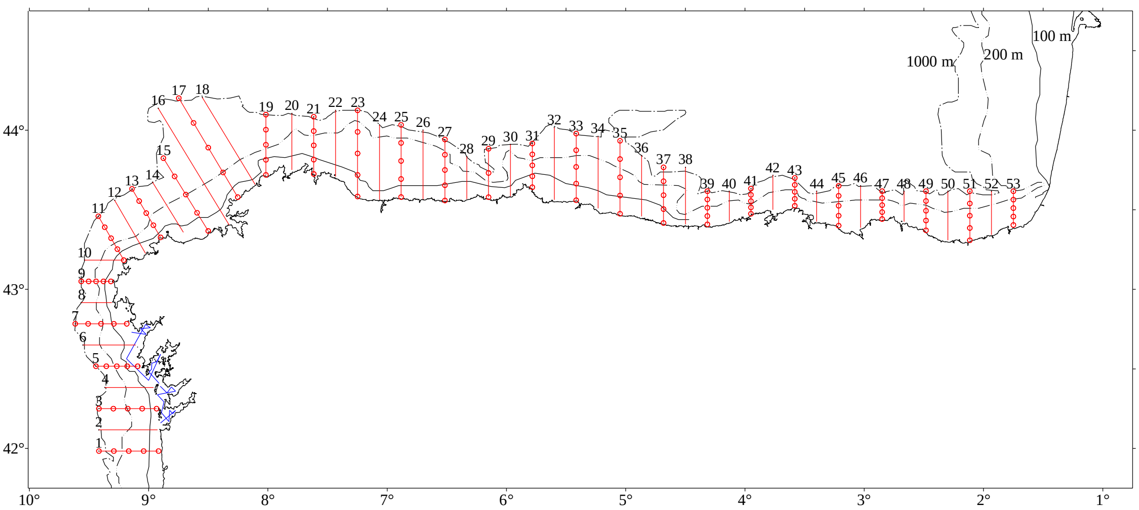


*Figure 1 Survey track*

Two different pelagic gears were used. Nevertheless, due to the bad weather condition and the specific characteristics of those trawls, hauls were mainly performed in depths higher than 90 m (coastal areas with hard, rough bottoms were inaccessible when fish schools occurred close to the seabed). In general, hauls had a minimum duration of 20 minutes, except those done in areas with high mackerel abundance, where the duration was lower. 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) records, 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<br>Fish escaping | Bad geometry<br>No escaping | God geometry<br>No escaping |
| **Weather conditions** | Swell >4 m height<br>Wind >30 knots | Swell: 2 -4 m<br>Wind: 30-20 knots | Swell: 1-2m<br>Wind 20-10 knots | Swell <1 m<br>Wind < 10 knots |
| **Fish number** | total fish caught <100 | Main species >100<br>Second species <25 | Main species > 100<br>Second species< 50 | Main species > 100<br>Second species > 50 |
| **Fish length distribution** | No bell shape | Main species bell shape | Main species bell shape<br>Seconds: almost bell shape | Main species bell shape<br>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 stations (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 bell shape (normal) distribution 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 EVA and SURFER packages. Fish abundance was calculated with the 38 kHz frequency as recommended at the PGAAM (ICES 2002). Nevertheless, echograms from 18, 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 according to the strength of their echo. Also these frequencies have been used to create a mask allowing a better discrimination among fish species and plankton. The threshold used to scrutinize the echograms was –70 dB. Backscattered energy ($s_A$) was allocated to fish species according to the proportions found at the fishing stations (Nakken and Dommasnes, 1975). For this purpose, the following TS values were used:

| Specie | WHB | MAC | HOM | PIL | JAA | BOG | MAS | BOC | SBR | HMM |
|---|---|---|---|---|---|---|---|---|---|---|
| $b_{20}$ | -67.5 | -84.9 | -68.7 | -72.6 | -68.7 | -67.0 | -68.7 | -72.6 | -68.7 | -68.7 |

Where WHB is blue whiting; MAC-mackerel; HOM- horse mackerel; PIL-sardine; JAA-blue jack mackerel; BOG-bogue; MAS-chub mackerel; BOC-board fish; SBR-sea breams and similar specie; and HMM-mediterranean horse mackerel. When possible, direct allocation was also done. 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.

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-41.5)*60, being *I.Lat* the latitude 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 129.5+(Lon+5.8755324052)*60, being *Lon* the corrected longitude (longitude multiplied by the cosine of 43.50) of the middle point of any particular EDSU within this region.

Besides each fish was measured and weighed to obtain a length-weight relationship. Otoliths were also extracted from anchovy, sardine, horse mackerel, blue whiting 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 3642 nautical miles were steamed, 1080 of them corresponding to the survey track. In IXa-N, due to the bad weather conditions, half of the transects were not surveyed and the rest, together with those located in the VIIIc-W Sub-Division, have had to be sternway steamed to avoid bubbles sweep down. This can cause attenuation of sound transmission and reception of backscattering energy, thus an underestimation of the fish population. This phenomenon still persisted and, therefore, acoustic records gathered in the western areas were filtered to remove those pings with a large amount of attenuation. For each ping of the 38 kHz frequency, Sv were tested for deviations (a total of 500 samples-Sv values- in the echogram for each ping). If the maximum value of Sv achieved in the water column was lower than -70dB, we assumed that an important attenuation occurred and therefore the ping was removed. This was applied until the 22nd March when main swell and wind directions were either stern or bow way. The number of pings removed is shown in the following table

| Day | Total ping number | Pings removed | % |
|---|---|---|---|
| 08/03/13 | 35388 | 783 | 2.21 |
| 09/03/13 | 64659 | 1175 | 1.82 |
| 10/03/13 | 22408 | 356 | 1.59 |
| 11/03/13 | 27790 | 1274 | 4.58 |
| 12/03/13 | 44615 | 935 | 2.10 |
| 13/03/13 | 47876 | 955 | 1.99 |
| 14/03/13 | 26872 | 123 | 0.46 |
| 15/03/13 | 32980 | 217 | 0.66 |
| 16/03/13 | 55257 | 451 | 0.82 |
| 17/03/13 | 49619 | 501 | 1.01 |
| 18/03/13 | 33884 | 1516 | 4.47 |
| 19/03/13 | 40805 | 505 | 1.24 |
| 21/03/13 | 93009 | 2140 | 2.30 |
| 22/03/13 | 61923 | 394 | 0.64 |

Sternway steaming has considerable reduced the number of ping removed. However, the coverage in the continental shelf was reduced by a 50%.

A total of 45 fishing station were performed, one of them was removed. Figure 2a-d shows the location and the value for each ground truthing criteria (from 0 to 3).

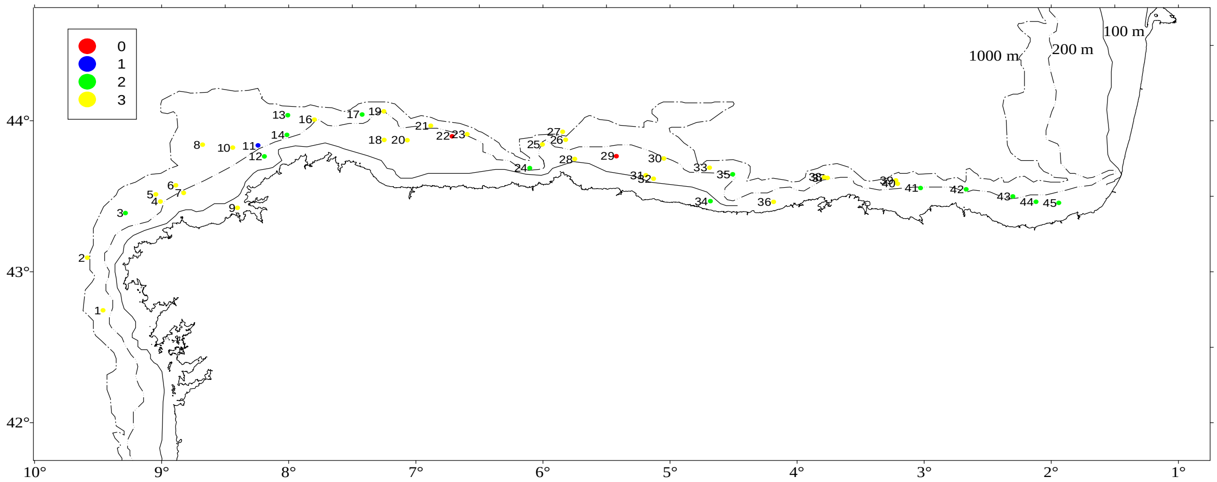



*Figure 2a: Fishing station and colour system according with the Gear performance and fish behaviour criteria*

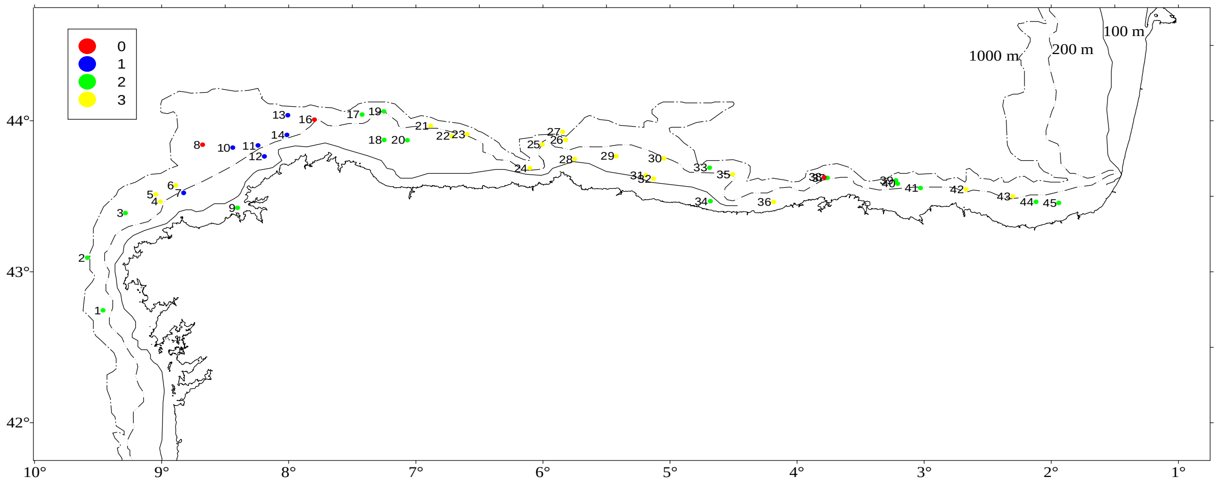



*Figure 2b: Id according with the Weather condition criteria*

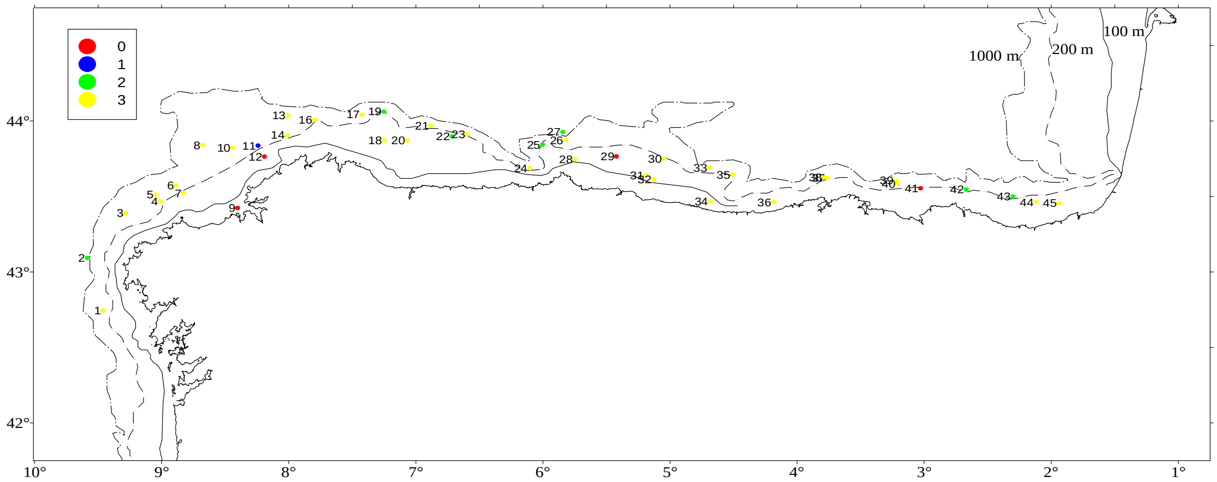



*Figure 2c: Id according with the Fish number criteria*

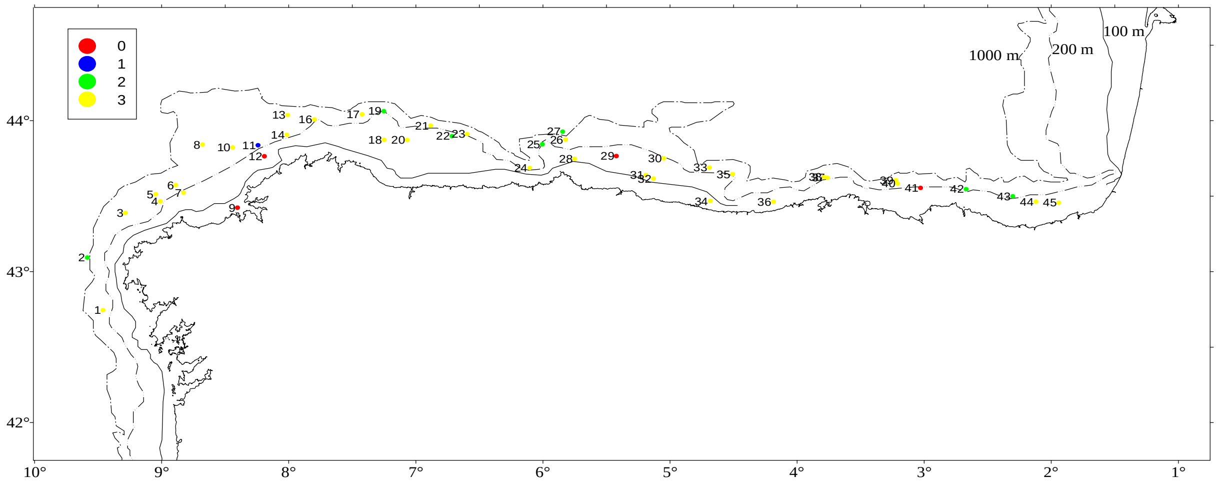



*Figure 2d: Id according with the Fish length distribution criteria*

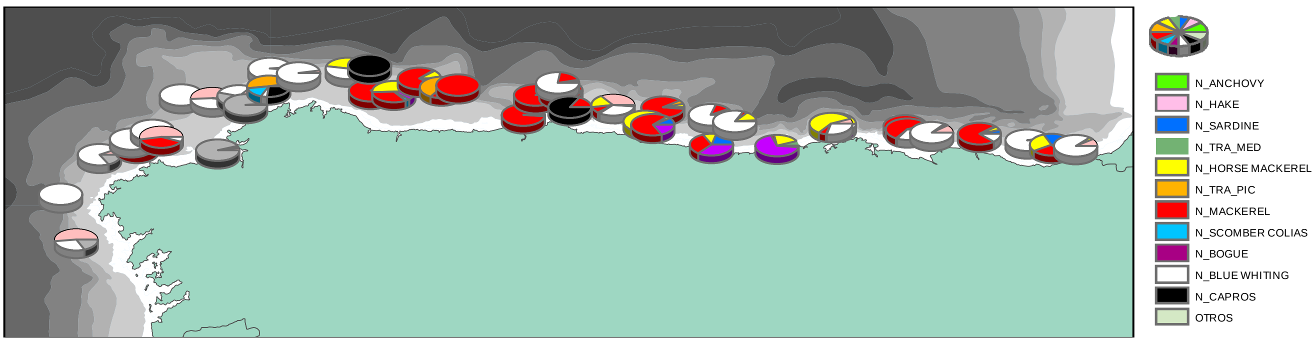



*Figure 2e: Fish proportion at each fishing station*

On the other hand, 381 CUFES stations, comprising 3 nautical miles each were taken, as shown in figure 3.

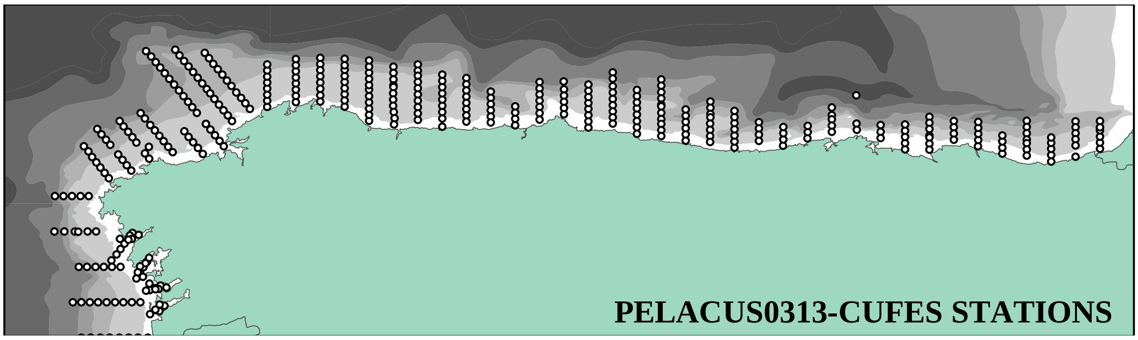


*Figure 3. PELACUS0313 CUFES stations.*

## ***Acoustic***

A total of 105.384,67 $s_A$ were attributed to fish species. Table 1 shows the fishing station used to allocate backscattering energy when echotraces were similar to those found around these fishing station.

*Table 3: Fishing station used for backscattering energy allocation and transects*

| Fishing station | Transects |
|---|---|
| PE02 | RA01, RA03, RA05, RA07, RA09 |
| PE03 | RA11 |
| PE04 | RA12, RA13, RA14, RA15, RA16, RA17 |
| PE05 | RA12, RA13 |
| PE06 | RA14 |
| PE08 | RA16, RA17, RA18 |
| PE13 | RA19 |
| PE14 | RA19, RA20 |
| PE16 | RA21 |
| PE17 | RA22, RA25 |
| PE18 | RA21, RA22, RA23, RA24 |
| PE19 | RA23 |
| PE20 | RA24 |
| PE21 | RA25 |
| PE22 | RA26 |
| PE23 | RA26, RA27 |
| PE24 | RA29 |
| PE25 | RA30 |
| PE26 | RA31 |
| PE27 | RA31 |
| PE28 | RA30, RA31 |
| PE30 | RA34, RA35, RA37 |
| PE31 | RA33, RA34 |
| PE31 | RA35 |
| PE32 | RA33, RA34, RA35, RA36, RA37 |
| PE33 | RA36, RA37 |
| PE34 | RA36, RA37, RA38, RA39, RA40 |
| PE35 | RA38, RA39 |
| PE36 | RA39, RA40 |
| PE37 | RA42, RA43 |
| PE38 | RA40, RA41, RA42, RA43 |
| PE39 | RA44, RA45, RA46, RA47 |

| | |
|---|---|
| PE40 | RA44, RA45, RA46, RA47 |
| PE42 | RA48 |
| PE43 | RA48, RA48, RA49, RA50 |
| PE44 | RA49, RA50, RA51, RA52, RA53 |

Due to the bad weather conditions and gear performance limitations to properly work close to the coast with hard and rough sea bed, a 33% of the total backscattering energy (34.720,97 $s_A$) was no possible to allocate and therefore remained as unallocated. Table 2 shows the backscattering energy distributed by species and ICES subdivision, either by direct allocation (DA) or through the proportion found at de fishing stations (Fst). Direct assignation was feasible accounting for its special acoustic properties, morphology and geographical characteristics for some sardine schools, board fish, horse mackerel and sardine. In IXa-N the 55% of the energy was unallocated (4% of the total energy); in VIIIc-W, the 37 % (5% of the total); in VIIIc-Ew, the 28% (18 % of the total energy); and in VIIIc-Ee, the 41% (6% of the total energy).

*Table 4: Backscattering energy ($s_A$) allocated by species, both by direct allocation (DA) and by the fish proportion found at the ground-truth fishing stations, and by ICES Sub-Division (WHB-blue whiting; MAC-mackerel; HOM- horse mackerel; PIL-sardine; JAA-blue jack mackerel; BOG-bogue; MAS-chub mackerel; BOC-board fish; SBR-sea breams and similar specie; HMM-mediterranean horse mackerel; NEI-unallocated NASC)*

| | | WHB | MAC | HOM | PIL | JAA | BOG | MAS | BOC | SBR | HMM | NEI | total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| IXa | DA | | | 382.8 | 1897.3 | | | | | | | 4188.0 | 6468.1 |
| | Fst | 1214.3 | | 0.7 | | | | | | | | | 1215.0 |
| VIIIc-W | DA | | 28.6 | | | | | | 737.1 | | | 5536.4 | 6302.1 |
| | Fst | 6768.5 | 1419.1 | 122.9 | 4.8 | 120.6 | | 65.4 | 5.6 | 0.4 | | | 8507.4 |
| VIIIc-Ew | DA | | 3424.1 | | 749.0 | | | | 2315.2 | | | 18975.9 | 25464.1 |
| | Fst | 16207.1 | 2631.8 | 8213.8 | 598.6 | 2131.4 | 9647.3 | 921.9 | 2182.3 | 64.6 | 29.3 | | 42628.1 |
| VIIIc-Ee | DA | | 577.2 | | | | | | | | | 6020.6 | 6597.9 |
| | Fst | 3270.9 | 579.2 | 3203.3 | 839.2 | 45.1 | 202.5 | 61.5 | 0.3 | | | | 8202.0 |
| Total | DA | | 4029.9 | 382.8 | 2646.2 | 0.0 | 0.0 | 0.0 | 3052.3 | | | 34721.0 | 44832.2 |
| | Fst | 27460.9 | 4630.0 | 11540.8 | 1442.6 | 2297.0 | 9849.8 | 1048.8 | 2188.2 | 65.0 | 29.3 | | 60552.5 |
| Total | | 27460.9 | 8659.9 | 11923.6 | 4088.8 | 2297.0 | 9849.8 | 1048.8 | 5240.4 | 65.0 | 29.3 | 34721.0 | 105384.7 |

## ***Spatial patterns***

Table 5 and figure 4 summarizes the spatial indices of the main fish species.

*Table 5: Centre of gravity according to the weighting average calculated using Distance to the Origin (D.O.; expressed in nautical miles) and depth (DEPTH, expressed in meters) together with its standard deviation, and the conversion to geographical position of the distance to the origin (Lat/Lon). (WHB-blue whiting; MAC-mackerel; HOM- horse mackerel; PIL-sardine; JAA-blue jack mackerel; BOG-bogue; MAS-chub mackerel; BOC-board fish; MAC-Juvenile (<30 cm length); MAC-Adult (>30 cm length))*

| | Specie | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **WHB** | **MAC** | **HOM** | **PIL** | **JAA** | **BOG** | **MAS** | **BOC** | **MAC-j** | **MAC-a** |
| *D.O.* | 170.87 | 22.04 | 264.34 | 204.98 | 160.35 | 258.35 | 167.51 | 176.99 | 152.96 | 257.09 |
| *s.d.* | 85.32 | 74.78 | 90.97 | 129.71 | 39.79 | 65.51 | 54.95 | 29.33 | 43.68 | 61.74 |
| *Depth* | 191.93 | 184.96 | 165.93 | 144.94 | 152.22 | 160.02 | 162.75 | 161.05 | 159.93 | 197.66 |
| *s.d.* | 85.69 | 135.85 | 81.56 | 141.71 | 32.36 | 102.97 | 53.34 | 32.53 | 114.98 | 147.91 |
| *Lat/Lon* | 7.15 | 5.97 | 5 | 4.6 | 7.4 | 5.142 | 7.2 | 7.0 | 7.57 | 5.137 |

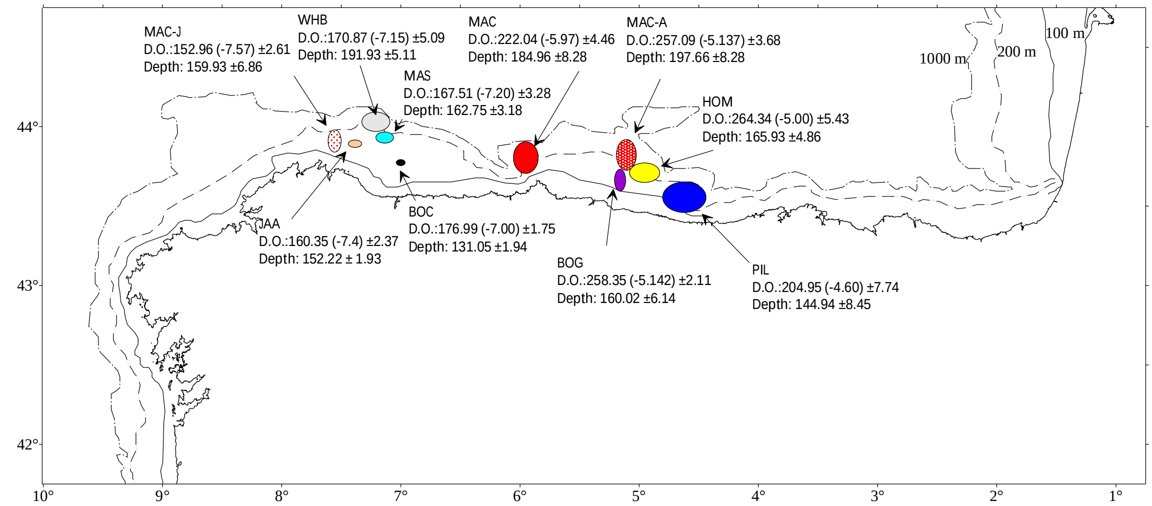



*Figure 4 Centre of gravity of NASC distribution for the main fish species. Ellipses are proportional to the confidence intervals for both variables, Distance to the Origin (D.O.) and Depth*

Excluding mackerel without split into juvenile and adults, it seems that there were two main distribution areas, one located eastward of the Cape Ortegal/Estaca de Bares , with some influence of Atlantic waters (juvenile mackerel, blue whiting, blue jack mackerel, chub mackerel and board fish) and other located between Lastres and Llanes canyons (sardine, horse mackerel, bogue and mackerel). While sardine had the widest distribution area, both in depth distribution and along the coast, board fish and blue jack mackerel were mainly distributed in the center part of the surveyed area. The coincidence in the distribution area of sardine mackerel, horse mackerel and bogue will be deeply discussed further.

## ***Mackerel distribution and assessment***

Mackerel was the most important fish species and was present in 38 of the 44 valid fishing station performed during the survey (a total of 75656 specimen were caught). Almost no mackerel was found in IXa-N, being concentrated in VIIIc. Nevertheless, there was two different areas, the western area where juvenile were predominant (between 100 and 73% of the total number) and the eastern were adults were predominant (97%). Accordingly, the distribution area was divided in four main region. In VIIIc-East mean length was 26 cm without statistical differences among length distribution (K-S test), although the westernmost area had higher density. On the contrary, in VIIIc-West, there were significant differences among length distributions, with a predominant juvenile area with 29 cm as mean length in the westernmost area (Bay of Masma) and the adult area with 35 cm as mean length, without significant differences among length distributions (figure 5)

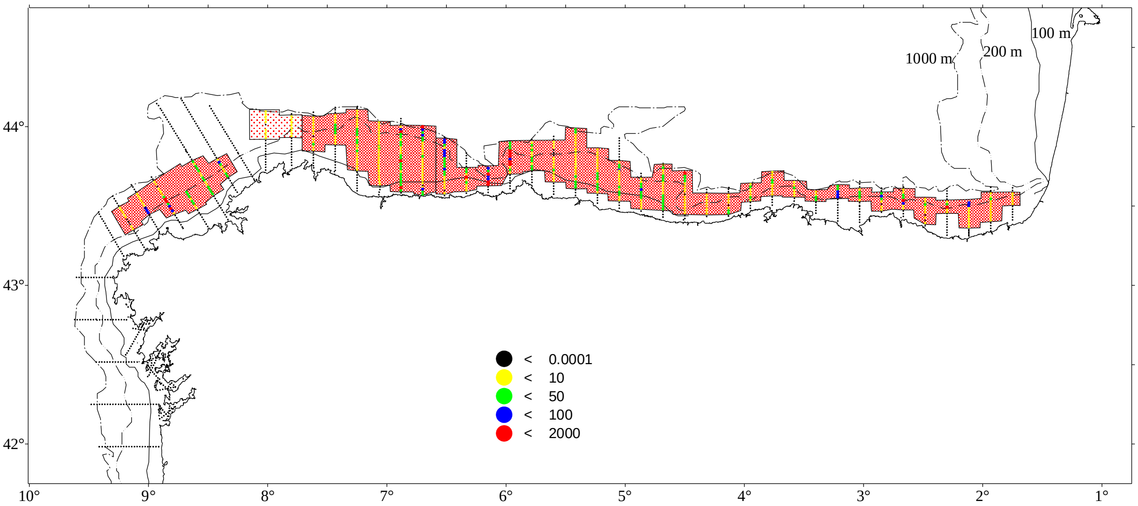


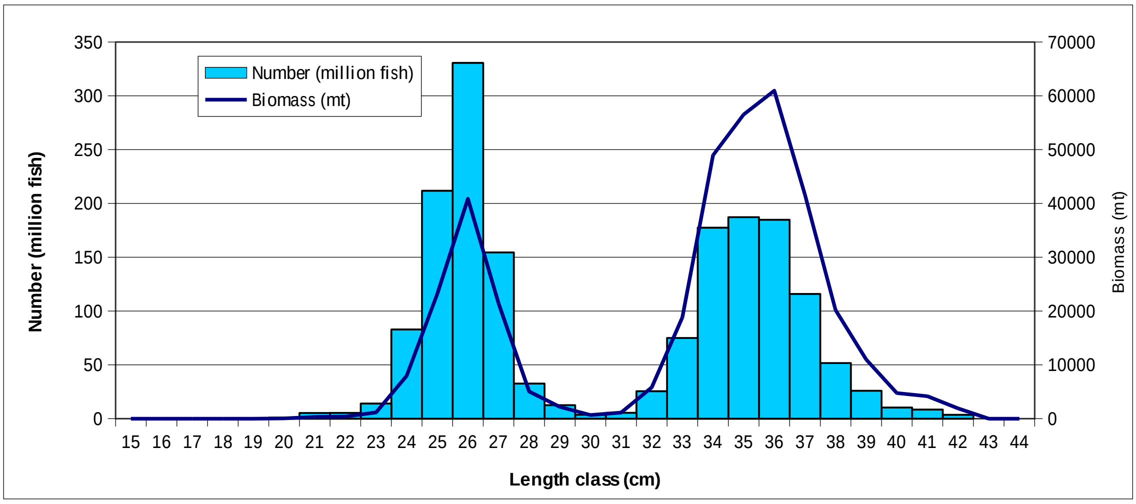

*Figure 5. Mackerel: spatial distribution PELACUS0313 cruise. Polygons are drawn to encompass the observed echoes, and polygon colour indicates the mean integrated energy in $m^2$ within each polygon (>0-10; and 10-100 $s_A$)*

Table 6 shows the mackerel assessment. 379149 mt has been estimated, corresponding to 1.725 million fish. The bulk of the distribution occurred in the central part of the Cantabrian Sea.

*Table 6 Mackerel acoustic assessment*

| Zone | Area | No | Mean | $\sigma^2$ | Model | v* | nugget/model | Area | Fishing st. | PDF | No (million fish) | Biomass (tonnes) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **VIIIc-W** | Artabro | 67 | 21.61 | 1599.73 | 600+sph(1000,7) | 33.63 | 26.66% | 606 | P04-P07-P16 | ST01 | 463 | 58008 |
| | Estaca | 20 | 0.18 | 0.35 | na | na | na | 195 | P04-P07-P16 | ST01 | 1 | 155 |
| | ***Total*** | ***87*** | ***17*** | | | | | ***801*** | | | ***464*** | ***58163*** |
| **VIIIc-E** | Masma | 128 | 15.00 | 1049.07 | 600+sph(600,12) | 450.1666 | 99.00% | 1004 | P18-P20-P22 | ST02 | 452 | 72810 |
| | Cantabrian | 241 | 18.30 | 1180.45 | 800+sph(500,20) | 373.9187 | 70.00% | 2278 | P32-P33-P34-P35-P36-P37-P38-P39-P40-P42-P44 | ST03 | 809 | 248176 |
| | ***Total*** | ***369*** | ***17*** | | | | | ***3282*** | | | ***1261*** | ***320986*** |
| | ***Total VIIIc*** | ***456*** | ***17*** | | | | | ***4083*** | | | ***1725*** | ***379149*** |
| | ***Total Spain*** | ***456*** | ***17*** | | | | | ***4083*** | | | ***1725*** | ***379149*** |

*Figure 5. Mackerel length distribution in both number and biomass during the PELACUS0313 survey.*

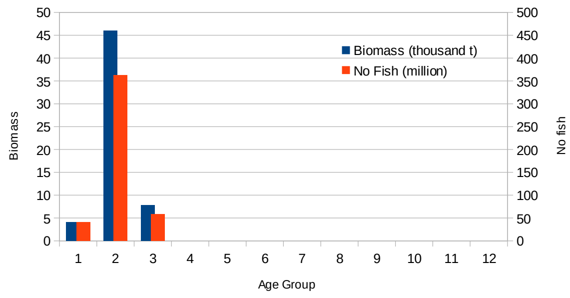


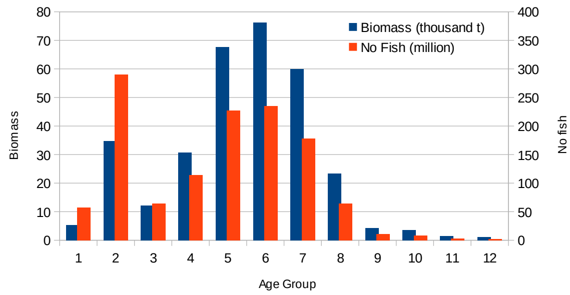

Age groups 2 and 6 were the most abundance (table 7) giving a bimodal distribution as shown in figure 5. Besides, the strength of the age group 2 agreed with the high abundance of age group 1 found in the last year survey (57% of the total fish abundance in 2011).

*Table 7. Mackerel abundance in number (thousand fish) and biomass (tons) by age group and ICES sub-area in PELACUS0313.*

| | AGE GROUPS | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Length** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **Total** | **No fish (milli** |
| **10** | | | | | | | | | | | | | | |
| **11** | | | | | | | | | | | | | | |
| **12** | | | | | | | | | | | | | | |
| **13** | | | | | | | | | | | | | | |
| **14** | | | | | | | | | | | | | | |
| **15** | | | | | | | | | | | | | | |
| **16** | | | | | | | | | | | | | | |
| **17** | | | | | | | | | | | | | | |
| **18** | | | | | | | | | | | | | | |
| **19** | | | | | | | | | | | | | | |
| **20** | | | | | | | | | | | | | | |
| **21** | | | | | | | | | | | | | | |
| **22** | 0.40 | | | | | | | | | | | | 0.40 | 5 |
| **23** | 0.89 | 0.26 | | | | | | | | | | | 1.16 | 14 |
| **24** | 6.50 | 1.46 | | | | | | | | | | | 7.96 | 83 |
| **25** | 0.96 | 21.28 | 0.93 | | | | | | | | | | 23.17 | 211 |
| **26** | 0.71 | 34.55 | 5.55 | | | | | | | | | | 40.80 | 330 |
| **27** | | 16.39 | 5.02 | | | | | | | | | | 21.41 | 154 |
| **28** | | 4.50 | 0.53 | | | | | | | | | | 5.03 | 33 |
| **29** | | 2.11 | 0.08 | | | | | | | | | | 2.20 | 12 |
| **30** | | 0.22 | 0.22 | 0.22 | | | | | | | | | 0.67 | 4 |
| **31** | | | 0.23 | 0.68 | 0.23 | | | | | | | | 1.13 | 5 |
| **32** | | | 0.53 | 3.71 | 1.32 | 0.26 | | | | | | | 5.82 | 26 |
| **33** | | | 2.94 | 7.06 | 6.77 | 1.18 | 0.59 | 0.29 | | | | | 18.83 | 75 |
| **34** | | | 1.97 | 11.17 | 18.73 | 11.17 | 5.26 | 0.66 | | | | | 48.95 | 177 |
| **35** | | | 1.42 | 4.55 | 18.75 | 17.33 | 11.65 | 2.27 | 0.57 | | | | 56.53 | 187 |
| **36** | | | 0.60 | 2.70 | 14.41 | 21.32 | 16.51 | 4.50 | 0.90 | | | | 60.95 | 185 |
| **37** | | | | 0.34 | 5.08 | 17.26 | 12.86 | 5.08 | 0.68 | 0.34 | | | 41.62 | 116 |
| **38** | | | | 0.33 | 1.30 | 5.53 | 7.16 | 5.21 | 0.33 | 0.33 | | | 20.17 | 52 |
| **39** | | | | | 0.76 | 0.76 | 4.54 | 3.03 | 0.38 | 1.14 | 0.38 | | 10.98 | 26 |
| **40** | | | | | 0.37 | 0.73 | 0.73 | 0.73 | 0.73 | 0.73 | 0.37 | 0.37 | 4.76 | 10 |
| **41** | | | | | | 0.42 | 0.42 | 1.25 | 0.42 | 0.83 | 0.42 | 0.42 | 4.17 | 8 |
| **42** | | | | | | 0.27 | 0.27 | 0.27 | 0.27 | 0.27 | 0.27 | 0.27 | 1.91 | 4 |
| **43** | | | | | | | | | | | | | | |
| **44** | | | | | | | | | | | | | | |
| **Biomass (thousand t)** | 9 | 81 | 20 | 31 | 68 | 76 | 60 | 23 | 4 | 4 | 1 | 1 | 379 | 1718 |
| **%** | 2.50 | 21.33 | 5.29 | 8.12 | 17.88 | 20.13 | 15.84 | 6.15 | 1.13 | 0.96 | 0.38 | 0.28 | | |
| **M. weight** | 93.04 | 119.14 | 152.37 | 267.55 | 296.01 | 322.29 | 335.34 | 361.40 | 378.16 | 439.36 | 470.05 | 490.34 | 200.22 | |
| **No Fish (million)** | 99 | 653 | 123 | 114 | 228 | 235 | 178 | 64 | 11 | 8 | 3 | 2 | 1718 | |
| **%** | 5.74 | 37.99 | 7.16 | 6.66 | 13.25 | 13.70 | 10.35 | 3.72 | 0.65 | 0.48 | 0.18 | 0.13 | | |
| **M. length** | 24.49 | 26.47 | 28.61 | 34.17 | 35.28 | 36.24 | 36.69 | 37.57 | 38.11 | 39.96 | 40.82 | 41.37 | 31.19 | |
| **s.d.** | 0.81 | 0.99 | 3.17 | 1.32 | 1.35 | 1.38 | 1.50 | 1.74 | 2.14 | 1.38 | 1.07 | 0.77 | 5.06 | |

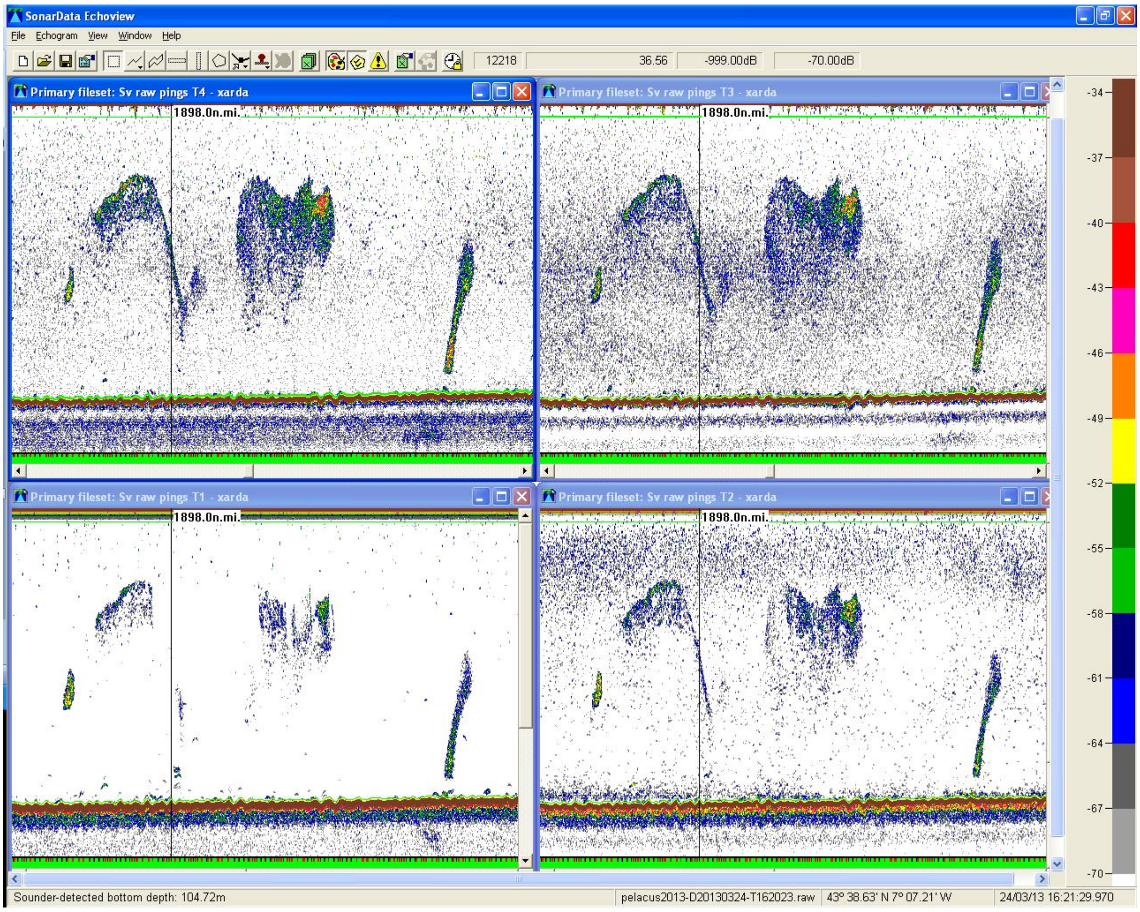
*Figure 6. Mackerel abundance and biomass by age group, left WIIIc-W, right, VIIIc-E.*




## Behaviour:

In most of the cases, mackerel occured in schools which seem to rise from the sea bottom, as shown in figure 7.



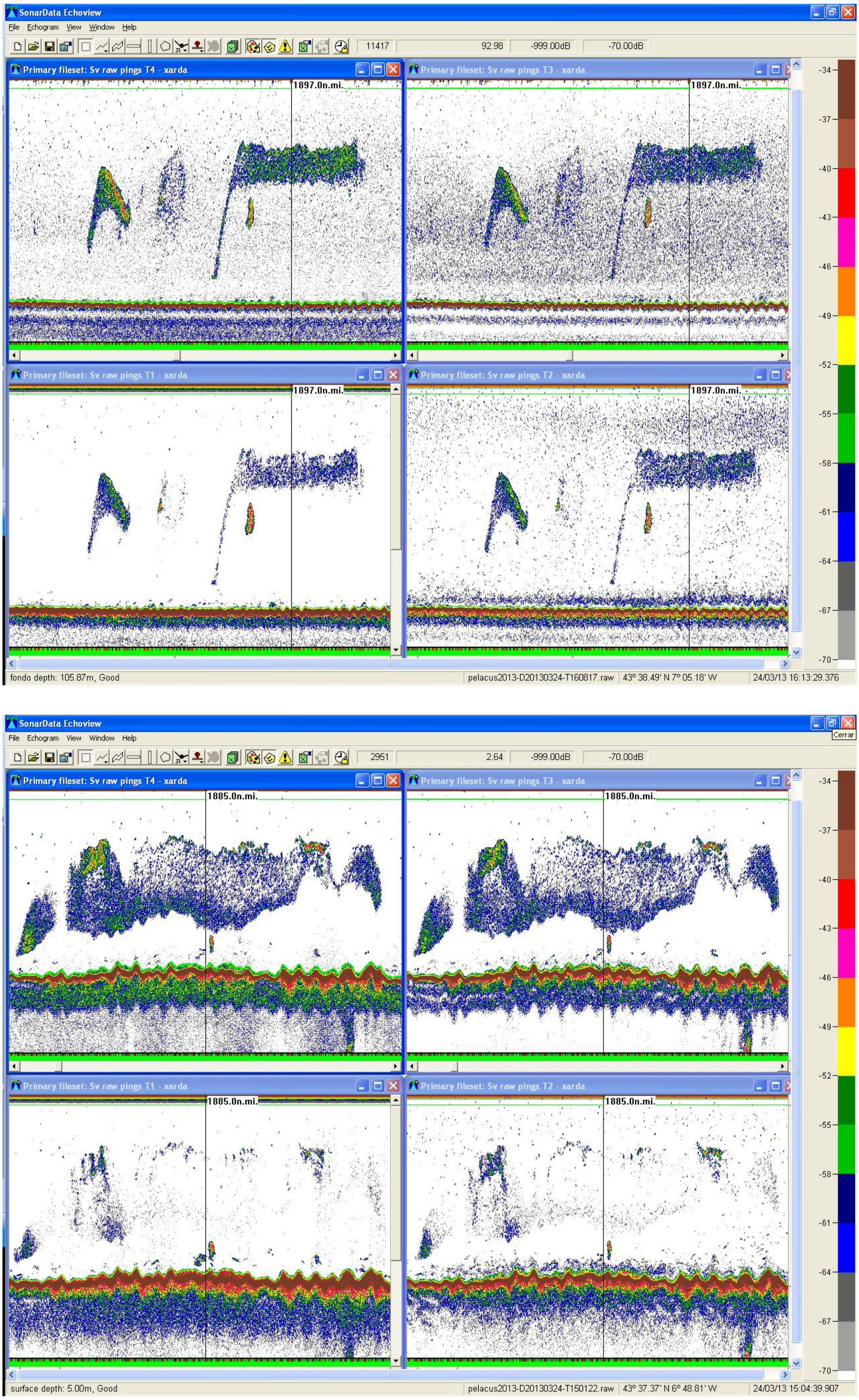



*Figure 7. Mackerel occurrence during PELACUS 0313 at 200 kHz (top left), 120 kHz (top right)., 18 kHz (below left) and 38 kHz (below right)*

Although an analysis of the schools Sv and NASC values showed an increase in both Sv and NASC at higher frequencies similar to that expected for mackerel, the relative frequency response had different patterns, meaning that in some cases the schools could be not monospecific. Midwater hauls performed on these echotraces, mackerel accounted between 78% and 99,72% of the total abundance, with some bogue and sardine. In situ stomach content analysis of these fish species showed a clear prevalence of mackerel eggs as main diet.

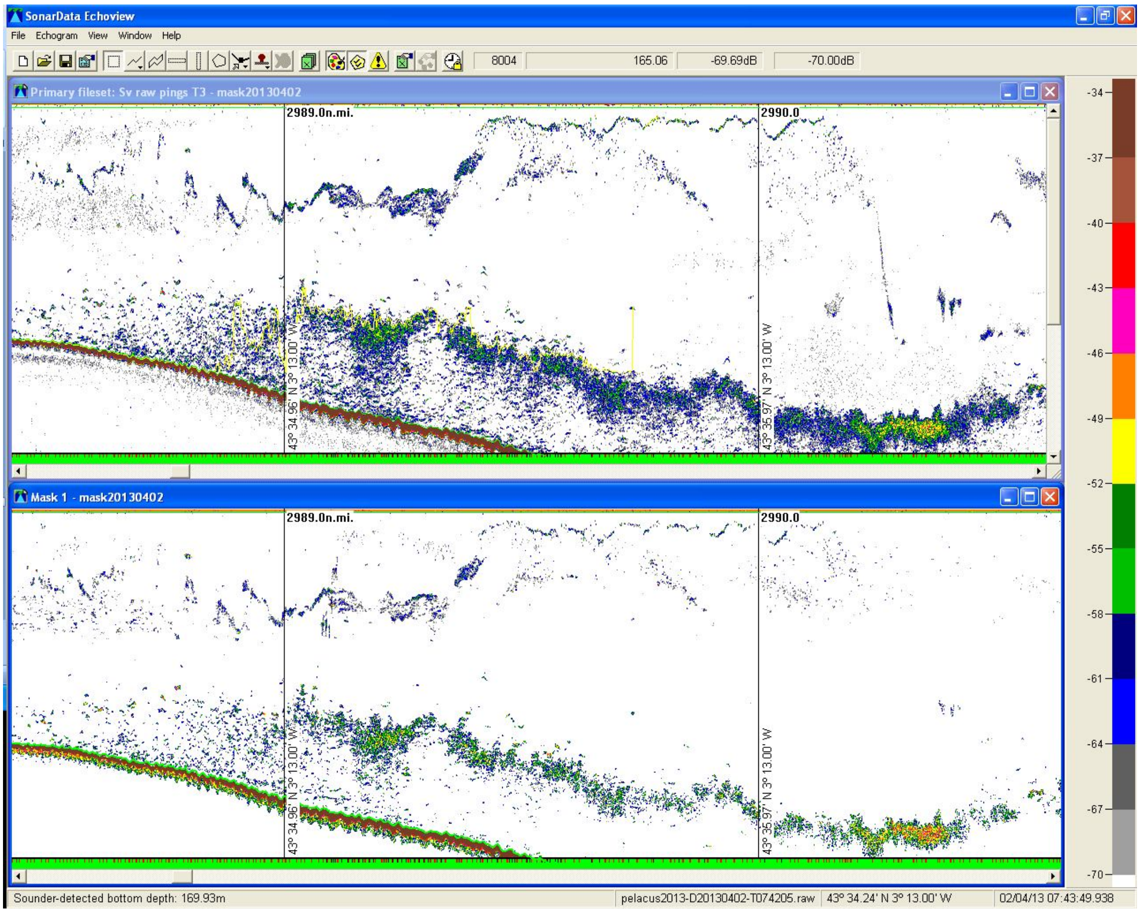



*Figure 8. Mackerel occurrence during PELACUS 0313 at 120 kHz (top). and 38 kHz (with mask, below ) showing a possible migration to the surface.*

## ***<u>Blue whiting distribution and assessment</u>***

The extension of the survey track through deeper water allowed the potential blue whiting distribution be covered. In the self-break, a scattering layer around 400-500 m has been found, although the blue whiting abundance inside this was scarce or even nonexistent. We haven't found the typical aggregation pattern in pelagic layer, ribbon-like as often occurs in northern waters, thus being mainly concentrated close to the self break on the continental platform and in the western part of the surveyed area (figure 4). This distribution was higher than that found for mackerel (figure 9)

In 26 fishing stations the total catch in number was higher than 50 individuals, and mean length ranged from 17.4 to 23.5 cm (the later located in Fisterra –NW- and Machichaco –inner part of the Bay of Biscay- capes and in the central part, resulting in 11 post strata on account the differences in both length distributions (significant differences on account K-S test) and mean density, as shown in figure 9.

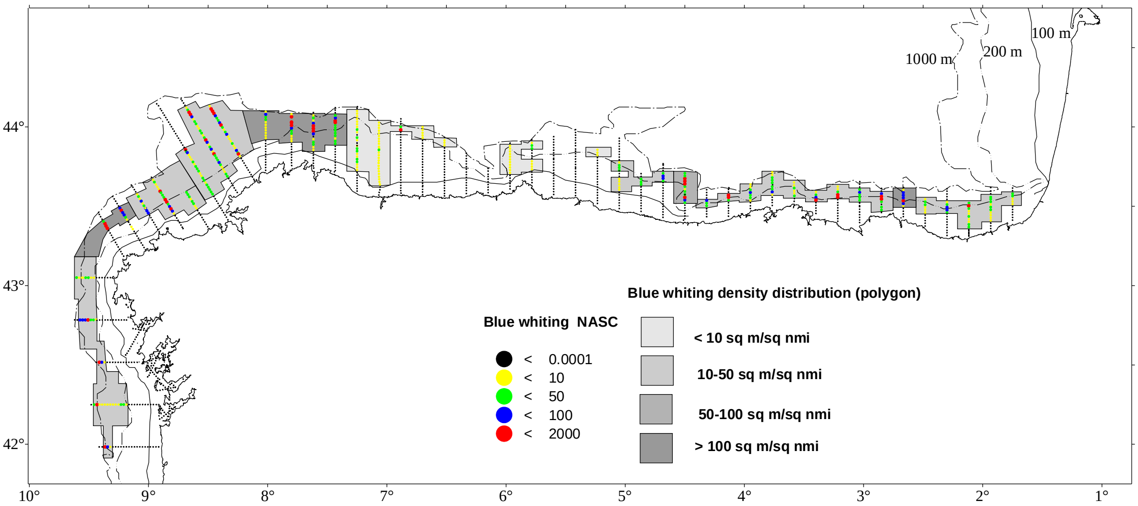



*Figure 9. Blue whiting spatial distribution in PELACUS0313 cruise. Polygons are drawn to encompass the observed echoes, and polygon colour indicates the mean integrated energy in m$^2$ within each polygon (>0-10;10-50; 50-100; and >100 $s_A$)*

Table 7 shows the blue whiting assessment. A total of 13.488 mt has been estimated, corresponding to 299 million fish, which was higher than that assessed the last year (7146 mt corresponding to 123 million fish).

*Table 7: Blue whiting acoustic assessment*

| Zone | Area | No | Mean | Area | Fishing st. | PDF | No (million fish) | Biomass (tonnes) |
|---|---|---|---|---|---|---|---|---|
| **IXa** | Rías Baixas | 36 | 37.72 | 573 | P01-P02 | S01 | 28 | 1091 |
| | ***Total*** | **36** | **37.72** | **573.1** | | | **28** | **1091** |
| **VIIIc-W** | Fisterra | 10 | 122.16 | 151 | P03 | S02 | 15.51 | 1230.31 |
| | Artabro | 34 | 48.81 | 361 | P04-P05-P06-P07 | S03 | 7.25 | 318.32 |
| | Capelada | 76 | 47.02 | 653 | P08-P10 | S04 | 42.88 | 1485.24 |
| | Estaca | 49 | 283.52 | 442 | P13-P14-P16-P17 | S05 | 157.44 | 6542.00 |
| | ***Total*** | ***169*** | ***502*** | ***1606*** | | | ***223*** | ***9576*** |
| **VIIIc-E** | Masma | 61 | 6.70 | 472 | P18-P33-P38-P40-P41 | S06 | 3 | 196 |
| | Peñas | 19 | 4.63 | 151 | P27-P30 | S07 | 1 | 46 |
| | Cachucho | 4 | 2.06 | 34 | P27-P30 | S07 | 0 | 5 |
| | Ribadesella | 17 | 18.74 | 139 | P18-P33-P38-P40-P41 | S06 | 2 | 161 |
| | Llanes | 13 | 71.36 | 106 | P35 | S08 | 8 | 426 |
| | Cantabria | 50 | 44.75 | 410 | P18-P33-P38-P40-P41 | S06 | 17 | 1137 |
| | Machichaco | 7 | 106.33 | 64 | P42 | S09 | 5 | 456 |
| | Euskadi | 38 | 26.86 | 292 | P43-P44-P45 | S10 | 10 | 394 |
| | ***Total*** | ***209*** | ***27.53*** | ***1667*** | | | ***48*** | ***2821*** |
| ***Total IXa*** | | ***36*** | ***38*** | ***573*** | | | ***28*** | ***1091*** |
| ***Total VIIIc*** | | ***378*** | ***239*** | ***3273*** | | | ***271*** | ***12397*** |
| ***Total Spain*** | | ***414*** | ***221.90*** | ***3846*** | | | ***299*** | ***13488*** |

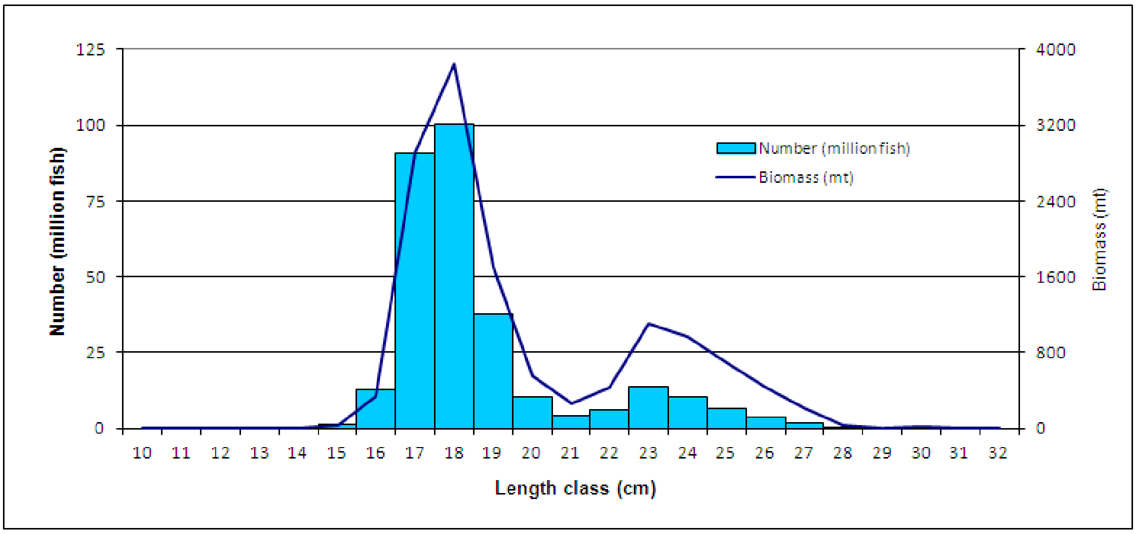



*Figure 10. Blue whiting length distribution in both number and biomass during the PELACUS0313 survey.*

## ***Horse mackerel distribution and assessment***

There is a general declining trend in both biomass estimates and distribution area of horse mackerel. The number of close to bottom schools is scarce as compared to those occurred in the nineties. Besides, only in one fishing station was the most important fish species (57% of the total catch) although it was present in 36 (76%). As observed as well for blue whiting, horse mackerel uses to remain close to the sea bottom, thus less accessible to pelagic fishing gears and probably with a certain degree of underestimation due to the depth zone near the sea floor. In four locations the same mid water haul (i.e. between 5-15 m off bottom) was repeated close to the sea bottom (around 0.5-1 m over the seafloor) giving significant differences in fish species proportion as shown in table 8.

*Table 8: Differences in % obtained in fishing hauls performed in the same area at different depths*

| Area | Haul | % WHB | % MAC | % HOM |
|---|---|---|---|---|
| Cape Peñas | Pelagic | 1.6 | 96.6 | 0.0 |
| | Close bottom | 77.1 | 19.0 | 2.0 |
| Lastres | Pelagic | 0.0 | 73.2 | 3.1 |
| | Close bottom | 0.0 | 17.2 | 61.0 |
| Santander | Pelagic | 7.8 | 55.3 | 29.6 |
| | Close bottom | 29.2 | 6.8 | 57.5 |
| Santoña | Pelagic | 13.6 | 86.0 | 0.0 |
| | Close bottom | 33.1 | 59.1 | 5.9 |

It should be also noted the heterogeneity in length distribution found along the surveyed area. In the central and western area, a bimodal distribution (peaks in 18-19 cm and 30 cm) was found, although the first peak was clearly smaller than the second. On the contrary, in the inner part of the Bay of Biscay, most of the individuals were smaller than 26 cm, with secondary small peaks at around 20-24 and 30 cm. Close to Cape Ortegal, and related with the main bluejack mackerel distribution, a pure juvenile area (17 cm mode) has been found. Complementary, close to Llanes and mainly outside the self-break, no mode at 17 cm nor at 30 cm has found, with de bulk of the distribution ranged between 18-32 cm Accordingly, the distribution area was divided in 9 post strata, as shown in figure 11.

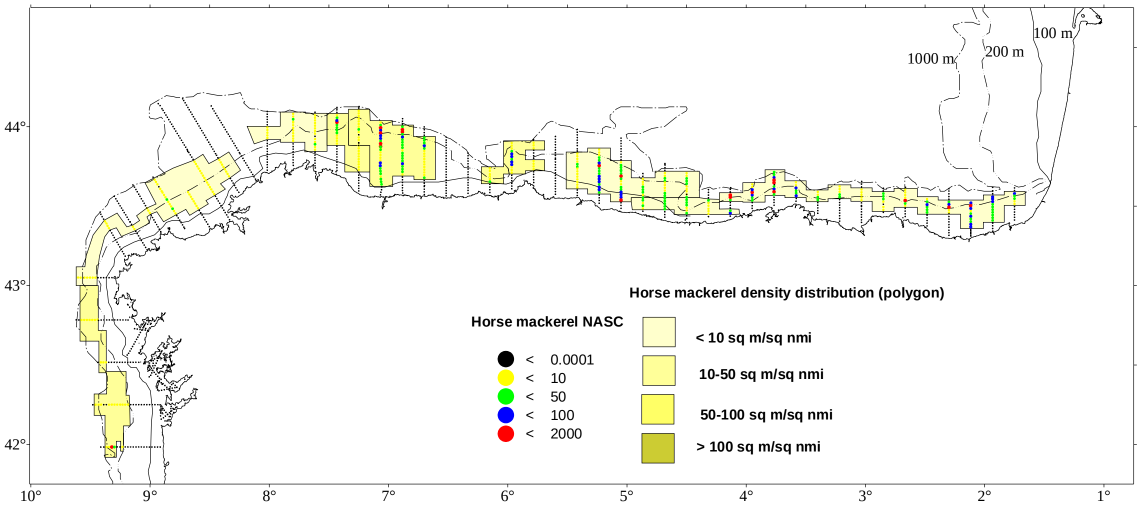



*Figure 11. Horse mackerel spatial distribution in PELACUS0313 cruise. Polygons are drawn to encompass the observed echoes, and polygon colour indicates the mean integrated energy in $m^2/nm^2$ within each polygon (>0-10;10-50; 50-100; and >100 $s_A$)*

Table 9 shows the horse mackerel assessment. A total of 6.372 mt has been estimated, corresponding to 44million fish, which was smaller than that assessed the last year (18264 mt corresponding to 110 million fish).

*Table 9: Horse mackerel acoustic assessment*

| Zone | Area | No | Mean | Area | Fishing st. | PDF | No (million fish) | Biomass (tonnes) |
|---|---|---|---|---|---|---|---|---|
| **IXa** | Rías Baixas | 22 | 13.69 | 460.05 | P20-P30-P31-P33-P35 | S03 | 4 | 840 |
| | ***Total*** | **22** | **13.69** | **460.05** | | | **4** | **840** |
| **VIIIc-W** | Artabro | 64 | 0.59 | 688 | P20-P30-P31-P33-P35 | S03 | 0.29 | 54.40 |
| | Estaca | 31 | 1.61 | 280 | P17-P18-P22 | S01 | 0.83 | 37.48 |
| | ***Total*** | ***95*** | ***2*** | ***968*** | | | ***1*** | ***92*** |
| **VIIIc-E** | Masma | 23 | 19.66 | 186 | P20-P30-P31-P33-P35 | S03 | 3 | 487 |
| | Asturias Occ | 76 | 42.75 | 590 | P20-P30-P31-P33-P35 | S03 | 18 | 3366 |
| | Peñas | 25 | 12.89 | 209 | P20-P30-P31-P33-P35 | S03 | 2 | 359 |
| | Asturias or | 79 | 1.80 | 593 | P20-P30-P31-P33-P35 | S03 | 1 | 142 |
| | Llanes | 24 | 44.77 | 187 | P34-P36 | S04 | 14 | 841 |
| | East. Cant | 91 | 2.73 | 745 | P21-P32-P35-P37-P38-P40-P44-P45 | S02 | 2 | 244 |
| | ***Total*** | ***318*** | ***17.26*** | ***2510*** | | | ***39*** | ***5440*** |
| ***Total IXa*** | | ***22*** | ***13.69*** | ***460.05*** | | | ***4*** | ***840*** |
| ***Total VIIIc*** | | ***413*** | ***14*** | ***3478*** | | | ***40*** | ***5532*** |
| ***Total Spain*** | | ***435*** | ***13.79*** | ***3938*** | | | ***44*** | ***6372*** |

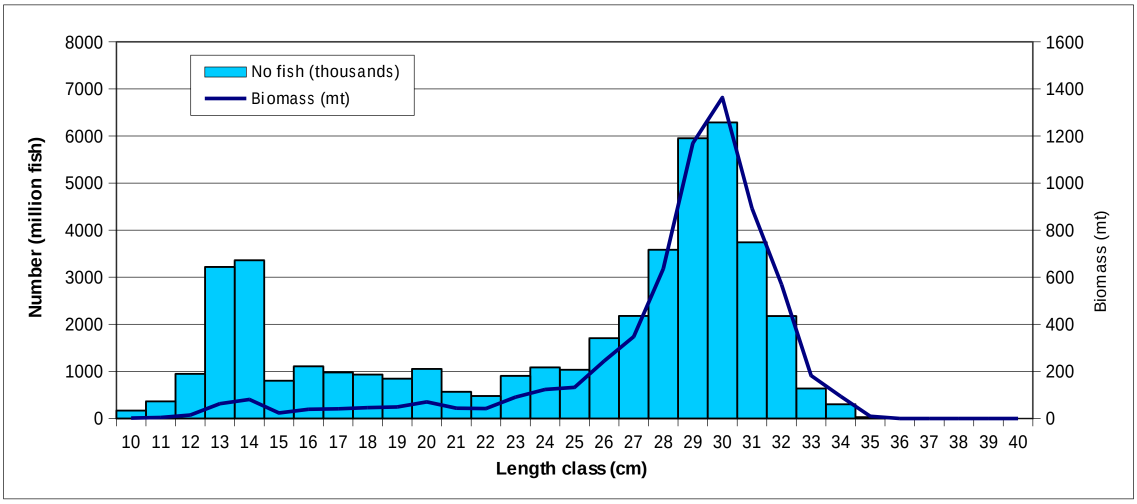



*Figure 12. Horse mackerel length distribution in both number and biomass during the PELACUS0313 survey.*

*Table 10. Horse mackerel abundance in number (thousand fish) and biomass (tons) by age group and ICES sub-area in PELACUS0313.*

| | | | | | | AGE GROUPS | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Length | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15+ | Total | No fish (thou |
| | 10 | 2 | | | | | | | | | | | | | | | 1.55 | 168 |
| | 11 | 4 | | | | | | | | | | | | | | | 4.39 | 363 |
| | 12 | 15 | | | | | | | | | | | | | | | 14.68 | 947 |
| | 13 | 63 | | | | | | | | | | | | | | | 62.62 | 3217 |
| | 14 | 81 | | | | | | | | | | | | | | | 80.76 | 3359 |
| | 15 | 23 | | | | | | | | | | | | | | | 23.47 | 801 |
| | 16 | 39 | | | | | | | | | | | | | | | 39.05 | 1108 |
| | 17 | 41 | | | | | | | | | | | | | | | 40.95 | 977 |
| | 18 | 46 | | | | | | | | | | | | | | | 46.04 | 932 |
| | 19 | 49 | | | | | | | | | | | | | | | 48.83 | 846 |
| | 20 | 55 | 15 | | | | | | | | | | | | | | 70.43 | 1052 |
| | 21 | 31 | 13 | | | | | | | | | | | | | | 43.68 | 567 |
| | 22 | 3 | 16 | 23 | | | | | | | | | | | | | 42.09 | 477 |
| | 23 | | 34 | 42 | 15 | | | | | | | | | | | | 90.69 | 904 |
| | 24 | | | 66 | 53 | 4 | | | | | | | | | | | 123.08 | 1085 |
| | 25 | | | | 95 | 33 | 4 | | | | | | | | | | 132.11 | 1035 |
| | 26 | | | | 20 | 183 | 41 | | | | | | | | | | 244.04 | 1706 |
| | 27 | | | | | 252 | 96 | | | | | | | | | | 347.69 | 2178 |
| | 28 | | | | | 149 | 392 | 95 | | | | | | | | | 635.87 | 3584 |
| | 29 | | | | | 19 | 622 | 434 | 38 | 19 | 38 | | | | 19 | 19 | 1169.29 | 5952 |
| | 30 | | | | | | 122 | 419 | 542 | 175 | | 17 | 87 | 17 | | 87 | 1363.30 | 6288 |
| | 31 | | | | | | | | 128 | 398 | 223 | 64 | 80 | | 16 | 48 | 892.63 | 3742 |
| | 32 | | | | | | | | | 142 | 325 | 81 | 20 | 20 | 20 | 41 | 569.04 | 2175 |
| | 33 | | | | | | | | | 10 | 71 | 81 | 20 | 20 | | 30 | 182.14 | 636 |
| | 34 | | | | | | | | | | | 24 | 71 | 24 | | 24 | 94.06 | 301 |
| | 35 | | | | | | | | | | | | 9 | 9 | | 9 | 9.39 | 28 |
| | 36 | | | | | | | | | | | | | | | | | |
| | 37 | | | | | | | | | | | | | | | | | |
| | 38 | | | | | | | | | | | | | | | | | |
| | 39 | | | | | | | | | | | | | | | | | |
| | 40 | | | | | | | | | | | | | | | | | |
| Biomass (t) | | 451 | 78 | 130 | 183 | 640 | 1277 | 948 | 707 | 745 | 657 | 267 | 288 | 91 | 55 | 258 | 6372 | 44428 |
| % | | 7.08 | 1.23 | 2.04 | 2.87 | 10.05 | 20.05 | 14.88 | 11.10 | 11.68 | 10.31 | 4.19 | 4.51 | 1.43 | 0.87 | 4.05 | | |
| M. weight | | 29.72 | 84.60 | 103.58 | 121.62 | 155.95 | 185.67 | 202.42 | 219.06 | 235.81 | 250.30 | 261.75 | 250.61 | 272.02 | 228.04 | 240.83 | 118.92 | |
| No Fish (million) | | 13.98 | 0.92 | 1.25 | 1.50 | 4.09 | 6.86 | 4.68 | 3.23 | 3.15 | 2.62 | 1.02 | 1.14 | 0.33 | 0.24 | 1.06 | 44.43 | |
| % | | 31.46 | 2.07 | 2.82 | 3.38 | 9.21 | 15.44 | 10.53 | 7.26 | 7.09 | 5.89 | 2.29 | 2.56 | 0.75 | 0.54 | 2.39 | | |
| M. length | | 15.58 | 22.19 | 23.76 | 25.08 | 27.28 | 28.94 | 29.80 | 30.61 | 31.38 | 32.02 | 32.50 | 32.03 | 32.93 | 31.02 | 31.60 | 24.89 | |
| s.d. | | 2.65 | 1.21 | 0.78 | 0.80 | 0.95 | 0.94 | 0.66 | 0.46 | 0.76 | 0.94 | 1.07 | 1.60 | 1.63 | 1.30 | 1.53 | 6.84 | |

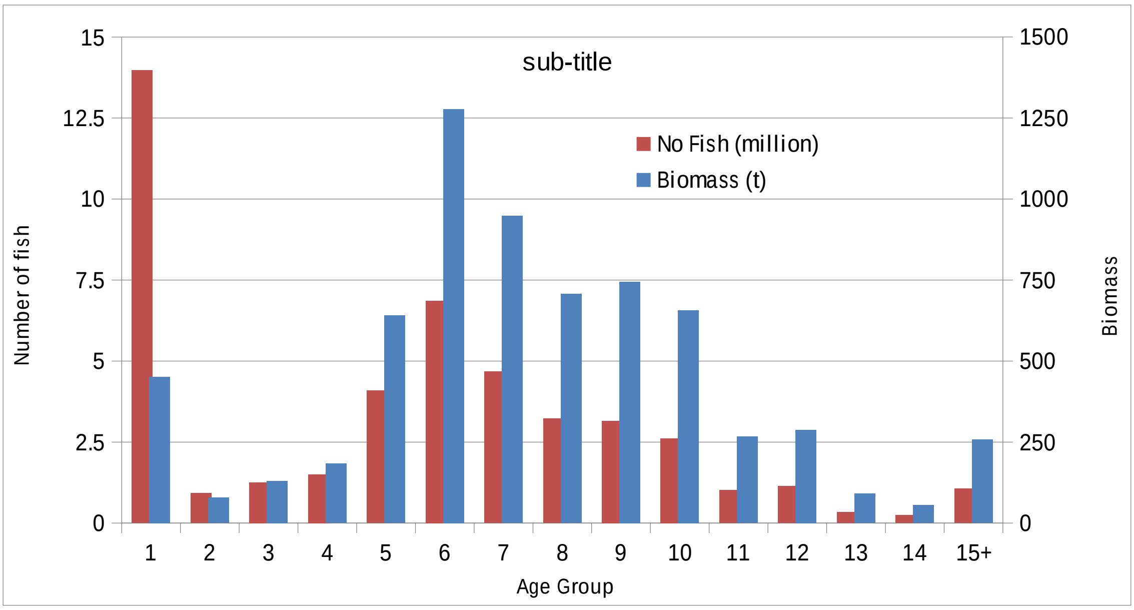



*Figure 13. Horse mackerel abundance and biomass by age group.*

## ***Bluejack mackerel distribution and assessment***

Normally, together with the *T. trachurus*, mediterranean horse mackerel (*T. mediterraneus*) used to be assessed. However, this year, due to the problems for fishing in coastal areas, an important amount of echotraces, most of them in the main mediterranean horse mackerel distribution, where left as unallocated, thus below the assessment acoustic threshold. Complementary, bluejack mackerel has been found in some of the hauls done close to the self-break, especially in the Galician part of the Cantabrian sea (NW).

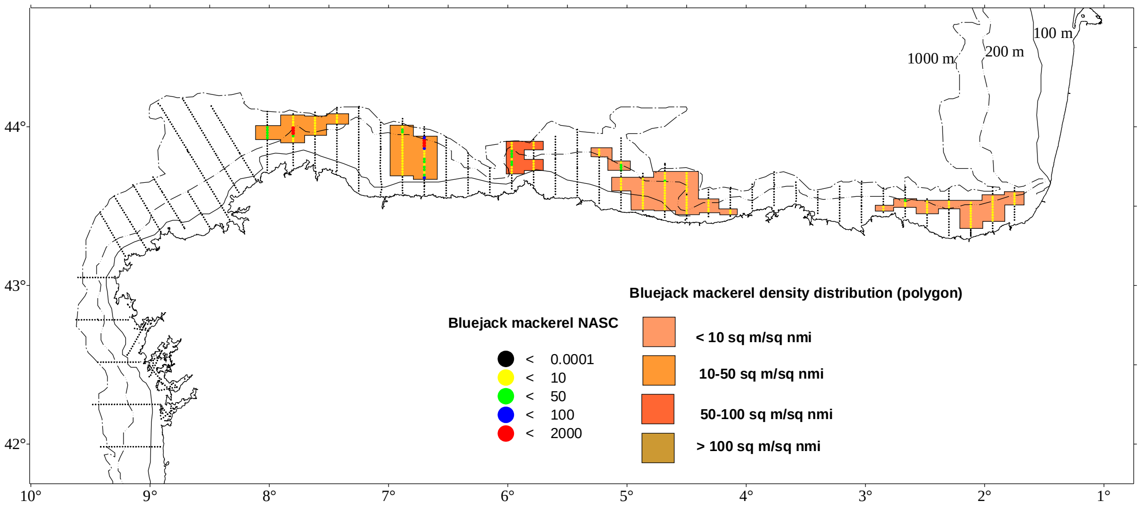



*Figure 14. Bluejack mackerel spatial distribution in PELACUS0313 cruise. Polygons are drawn to encompass the observed echoes, and polygon colour indicates the mean integrated energy in $m^2/nm^2$ within each polygon (>0-10;10-50; 50-100; and >100 $s_A$)*

In spite the length distribution were almost similar, ranging between 13 to 24 cm, and only one fishing station gave significant differences in length distribution, 6 post-strata were needed due to the patchy distribution found in the surveyed area.

Table 11 shows the bluejack mackerel assessment. A total of 1.613 mt has been estimated, corresponding to 31million fish.

*Table 11: Bluejack mackerel acoustic assessment*

| Zone | Area | No | Mean | Area | Fishing st. | PDF | No (million fish) | Biomass (tonnes) |
|---|---|---|---|---|---|---|---|---|
| **VIIIc-W** | Ortegal | 27 | 41.76 | 227 | P14-P22-P34 | S01 | 15 | 800 |
| | ***Total*** | ***27*** | ***42*** | ***227*** | | | ***15*** | ***800*** |
| **VIIIc-E** | Caridad | 35 | 27.11 | 302 | P14-P22-P34 | S01 | 13 | 689 |
| | Peñas | 20 | 4.28 | 135 | P14-P22-P34 | S01 | 1 | 49 |
| | Asturias Or | 56 | 0.59 | 445 | P14-P22-P34 | S01 | 0 | 22 |
| | Cachucho | 6 | 6.52 | 58 | P30 | S02 | 1 | 30 |
| | Euskadi | 56 | 0.59 | 445 | P14-P22-P34 | S01 | 0 | 22 |
| | ***Total*** | ***173*** | ***6.59*** | ***1385*** | | | ***15*** | ***813*** |
| ***Total VIIIc*** | | ***200*** | ***11*** | ***1612*** | | | ***31*** | ***1613*** |
| ***Total Spain*** | | ***200*** | ***11*** | ***1612*** | | | ***31*** | ***1613*** |

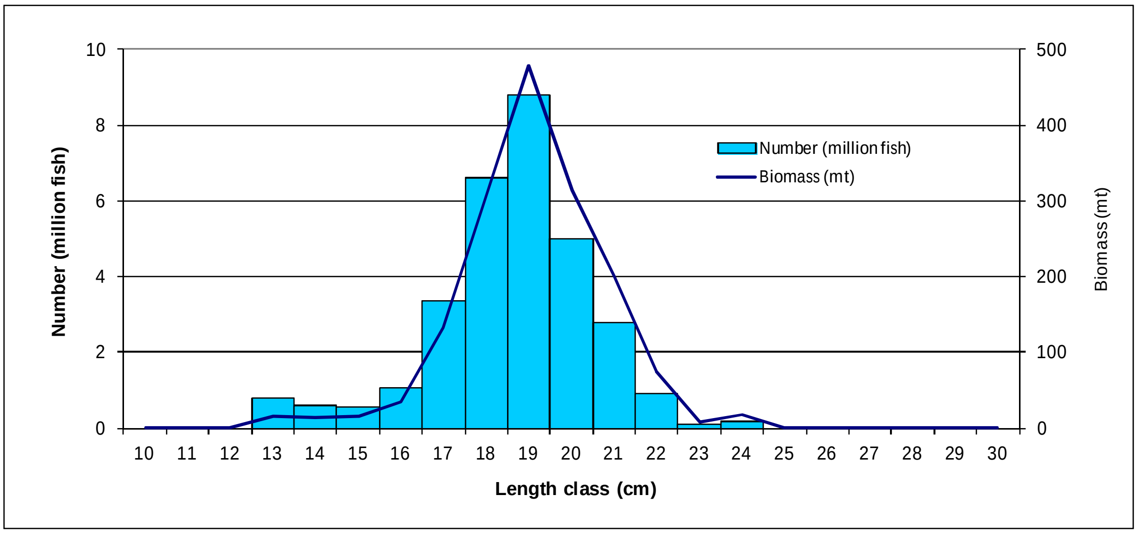



*Figure 15. Bluejack mackerel length distribution in both number and biomass during the PELACUS0313 survey.*

## ***Board fish distribution and assessment***

This year only few board fish were detected, most of them directly assigned accounting its particular school morphometric and backscattering properties.

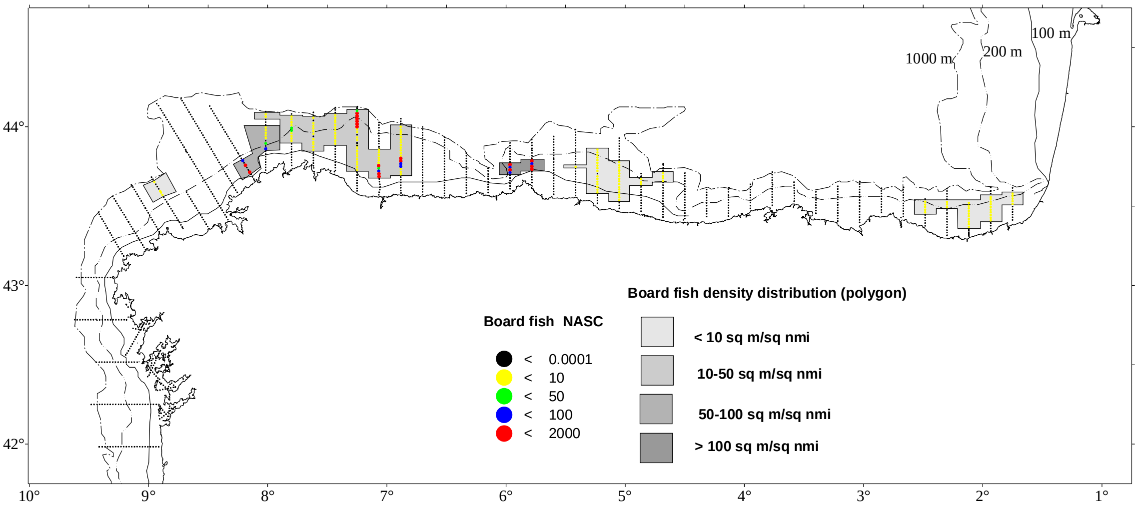



*Figure 16. Board fish spatial distribution in PELACUS0313 cruise. Polygons are drawn to encompass the observed echoes, and polygon colour indicates the mean integrated energy in $m^2/nm^2$ within each polygon (>0-10;10-50; 50-100; and >100 $s_A$)*

A total of 16067 tonnes were estimated, corresponding to 437 million fish (table 12), which represents a drastic decrease since 2011 when more than 220 thousand tonnes were estimated. Last year the total biomass assessed were 33.238 corresponding to 518 million fish.

*Table 12: Board fish acoustic assessment*

| Zone | Area | No | Mean | Area | Fishing st. | PDF | No (million fish) | Biomass (tonnes) |
|---|---|---|---|---|---|---|---|---|
| **VIIIc-W** | Artabro | 7 | 0.00 | 69 | P14 | S01 | 0.0 | 0.07 |
| | Capelada | 15 | 56.16 | 171 | P14 | S01 | 164.58 | 2615.15 |
| | ***Total*** | ***22*** | ***36*** | ***240*** | | | ***165*** | ***2615*** |
| **VIIIc-Ew** | Masma | 94 | 37.17 | 736 | P19 | S02 | 214 | 10315 |
| | Peñas | 9 | 111.40 | 73 | P28 | S03 | 58 | 3132 |
| | Asturias Or | 42 | .03 | 328 | P28 | S03 | 0 | 4 |
| **VIIIc-Ee** | Euskadi | 33 | 0.01 | 280 | P28 | S03 | 0 | 1 |
| | ***Total*** | ***178*** | ***76*** | ***1416*** | | | ***273*** | ***13452*** |
| ***Total VIIIc*** | | ***200*** | ***71.45*** | ***1675*** | | | ***437*** | ***16067*** |
| ***Total Spain*** | | ***200*** | ***71.45*** | ***1675*** | | | ***437*** | ***16067*** |

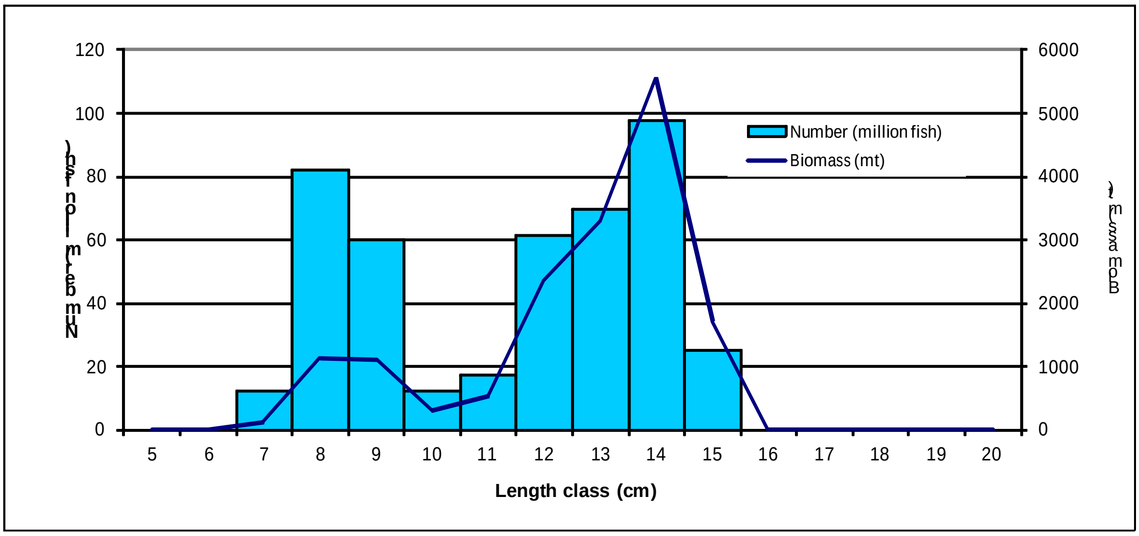



*Figure 17. Board fish length distribution in both number and biomass during the PELACUS0313 survey.*

The main difference between this year assessment and the previous one is the presence os a second mode at 8 cm, which explains the lower difference in number (from 437 to 518 millions fish found last year) as compared with that found in biomass (from 16 thousand tonnes to 32 thousand tonnes).

## ***Other fish species***

Only bogue (Boops boops) has an important contribution to the pelagic community; on the contrary, sardine, anchovy or mediterranean horse mackerel had a lesser contribution, with only few tonnes.

## ***Discussion***

PELACUS 0313 was characterised by both the bad weather conditions and the change of the R/V Thalassa by the R/V Miguel Oliver. In spite, no intercalibration between these ships has been made. This exercise would be done next year. Vessel effect on acoustic assessment is very difficult to achieve when both vessels have similar characteristics (i.e. low noise radiated level). We believe the vessel effect on the total NASC recorded would be negligible since no differences in fish behaviour should be expected due to the similar vessel characteristics. Another source of random error is the fishing stations which could change the species composition and/or proportion of the pelagic community. Again, the pelagic trawl with a vertical opening of about 16-18 m (20-25 in horizontal one) would have had the same performance as the Thalassa one. We had not seen any particular escaping behaviour in front of the gear and we assumed the fishing stations were ground-truthing. Unfortunately, schools close to the coast were inaccessible to the fishing gear, nor it was possible to allocate directly into fish species on account their morphological, acoustic and geographical characteristics.

On account this last feature, we were only able to properly assess the off-shore pelagic community, resulting, therefore, a very low biomass estimation for more coastal species such as sardine with only 3343 metric tonnes.

Nevertheless, an important amount of schools were detected close to the coast, in shallower waters in a very hard and rough sea bed, thus no accessible to the pelagic year, and these represented 33% of the total backscattering energy. Between 1992 and 2002, in coastal waters (depth <90m) sardine achieved up to 67% of the total backscattering energy (12% in deeper waters than 90 m), ranging from 40% up to 75%. If we assume that such proportion of backscattering energy for sardine in coastal waters is stable and independent of the total energy and also assuming that the sardine eggs collected in the CUFES is a good estimator of the sardine spawning biomass distribution, then the biomass estimation including an estimated proportion ranging between 30% to 60 % of the unallocated backscattering energy in coastal waters will increase the estimation in around 7 to 13 thousand tonnes (10-16 thousand tonnes in total), which is still too low.

In spite the lack of fishing stations in coastal waters allowing distributing the backscattering energy into fish species, we can conclude that the sardine biomass would remain in the lowest level of the time series, with no signal of recovery, nor of a good incoming year class in the surveyed area (IXa-North and VIIIc). In the same way, horse mackerel and board fish seems to decrease both in abundance and distribution area. Mackerel, as in the previous years, was the most abundant fish species. The bulk of the juvenile (60 % were inmature) was found in the NW area (i.e. north Galician waters) whilst the adult stock was mainly concentrated in the eastern part. In this area we did two extra egg oblique-tows from sea surface to 50 m depth, controlled by a scanmar sensor put in the wire and monitored through the EK-60.

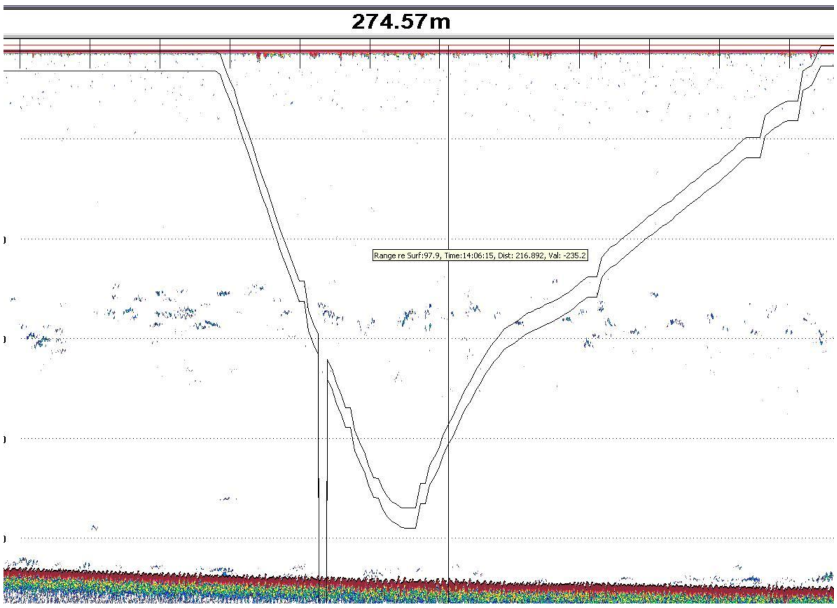



*Figure 18.Example of monitoring an oblique plankton tow, through a scanmar depth sensor integrated in the EK-60.*

In a specific tow, after 15 minutes we collected more than 1000 mackerel eggs together with 21 larvae. It seems that mackerel undertakes vertical migration to upper layers, but, yet, we could not establish a deterministic pattern for this behaviour. Whether there is a specific timing and purpose for this movement should be studied in future surveys. Together with these plankton tows, we have also analysed the bogue and sardine stomach contents. As expected, most of the preys were mackerel eggs. Contrary to the expected normal behaviour, these fish species (and also sometimes horse mackerel) did not occur in shoals or schools, as they seem to be aggregated in small spots, almost dispersed, similar to the night behaviour, as shown in figure 19

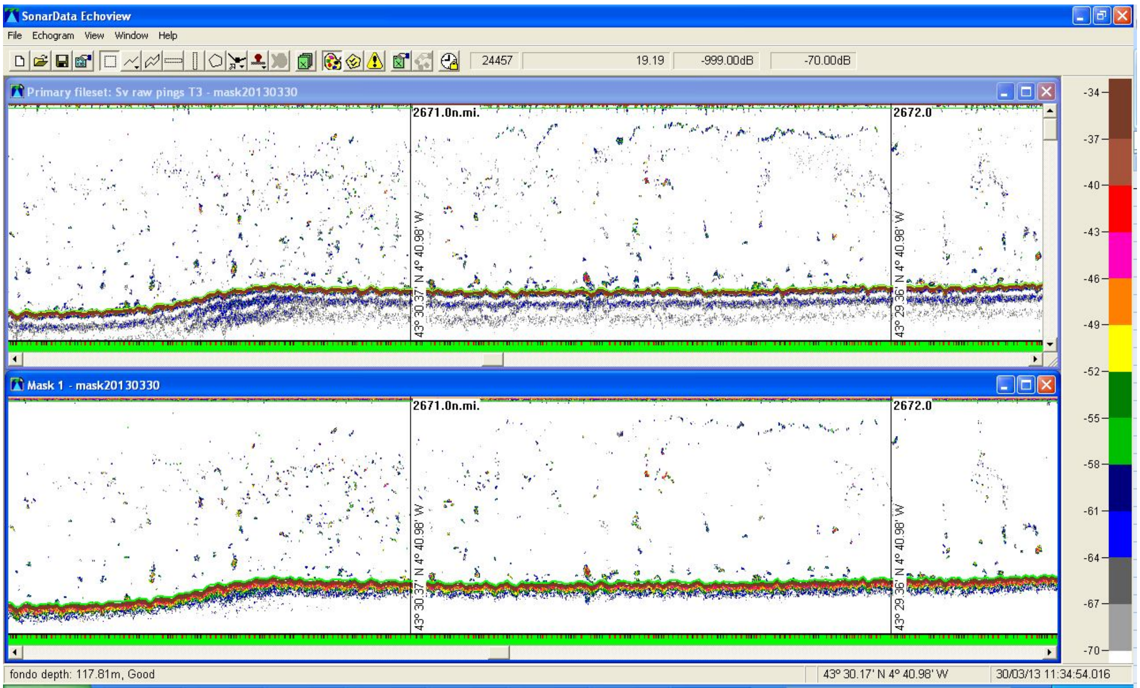


*Figure 19. Dispersed aggregation pattern occurred during day time*

As PELACUS is a multidisciplinary survey series (we collect environmental and biological ancillary information, stomach contents, including CTD cats, plankton tows or continuous records of plankton, eggs, S, T and flourometry), we will try to explain this change of behaviour. Our main hypothesis is that these species could follow mackerel when is undetaking vertical migration, probably related with the spawning activity, just for feeding eggs and, therefore, changing the expected schooling behaviour by the dispersed one, used during the feeding activity.

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