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Acoustic assessment and distribution of anchovy and sardine in ICES Subdivision 9a South during the *ECOCADIZ 2018-07* Spanish survey (July-August 2018) with notes on the distribution of other pelagic species.

By

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ABSTRACT

The present working document summarises a part of the main results obtained from the Spanish (pelagic ecosystem-) acoustic survey conducted by IEO between 31st July and 13rd August 2018 in the Portuguese and Spanish shelf waters (20-200 m isobaths) off the Gulf of Cadiz onboard the R/V *Miguel Oliver*. The 21 foreseen acoustic transects were sampled. A total of 25 valid fishing hauls were carried out for echo-trace ground-truthing purposes. This working document only provides abundance and biomass estimates for anchovy and sardine, which are presented with age structure only for anchovy. The distribution of all the mid-sized and small pelagic fish species susceptible of being acoustically assessed is also shown from the mapping of their back-scattering energies. Chub mackerel was the most frequent species in the fishing hauls, followed by sardine, anchovy, mackerel and bogue. *Trachurus* spp. showed a medium relative frequency of occurrence. Pearlside, snipefish and boarfish only occurred in hauls conducted in the deepest limit of the surveyed area. Anchovy was the most abundant species in these hauls, followed by silvery lightfish, sardine and chub mackerel, with the remaining species showing negligible relative contributions. The estimate of total NASC allocated to the "pelagic fish species assemblage" has been the highest one ever recorded within the time series, denoting a high fish density during the survey. Anchovy was widely distributed over the surveyed area, although showing the highest densities in the Spanish shelf waters and in a secondary nucleus located over the western Portuguese shelf. Largest (and oldest) anchovies were distributed both in the westernmost and easternmost waters and the smallest (and youngest) ones were concentrated in the surroundings of the Guadalquivir river mouth and adjacent shallow waters, including those ones in front of the Bay of Cadiz. Anchovy acoustic estimates in summer 2018 were of 3 063 million fish and 34 908 t (i.e. the second historical biomass maximum in the time-series), well above the historical average (ca. 22 kt), but without showing any clear recent trend. Sardine recorded a very high acoustic echo-integration in summer 2018 as a consequence of the occurrence of very dense mid-water schools in the coastal fringe (20-50 m depth) comprised between Tavira and the surroundings of the Guadalquivir river mouth. The distribution pattern of acoustic densities is quite similar to the one provided by the *PELAGO 18* survey in spring although the occurrence of sardine in the surveyed area was more continuous in summer. These facts resulted in summer estimates of 7 955 million fish and 114 631 t, the historical maximum record in terms of abundance and the second maximum in biomass. Spanish waters concentrated the bulk of the population. Such an increasing trend seems to be the result of a greater accessibility of the species to the survey, with the occurrence of many dense schools in the shallowest limits of the surveyed area not usually recorded in the most recent years. In any case, this behaviour should be analysed in more detail between WGACEGG experts.

INTRODUCTION

The *ECOCADIZ* surveys constitute a series of yearly acoustic surveys conducted by IEO in the Subdivision 9a South (Algarve and Gulf of Cadiz, between 20 – 200 m depth) under the "pelagic ecosystem survey" approach onboard R/V *Cornide de Saavedra* (until 2013, since 2014 on onboard R/V *Miguel Oliver*). This series started in 2004 with the *BOCADEVA 0604* pilot acoustic - anchovy DEPM survey. The following surveys within this new series (named *ECOCADIZ* since 2006 onwards) are planned to be routinely performed on a yearly basis, although the series, because of the available ship time, has shown some gaps in those years coinciding with the conduction of the triennial anchovy DEPM survey (the true *BOCADEVA* series, which first survey started in 2005).

Results from the *ECOCADIZ* series are routinely reported to ICES Expert Groups on both stock assessment (formerly in WGMHSA, WGANC, WGANSA, at present in WGHANSA) and acoustic and egg surveys on anchovy and sardine (WGACEGG).

The present Working Document advances some results from the *ECOCADIZ 2018-07* survey. These results will only refer to the acoustic estimates (age-structured ones only for anchovy) and spatial distribution of anchovy and sardine and to inferences on the spatial distribution of other pelagic species from the distribution of the acoustic energy attributed to each of these species.

MATERIAL AND METHODS

The *ECOCADIZ 2018-07* survey was carried out between 31st July and 13rd August 2018 onboard the Spanish R/V *Miguel Oliver* covering a survey area comprising the waters of the Gulf of Cadiz, both Spanish and Portuguese, between the 20 m and 200 m isobaths. The survey design consisted in a systematic parallel grid with tracks equally spaced by 8 nm, normal to the shoreline (**Figure 1**).

Echo-integration was carried out with a *Simrad™ EK60* echo sounder working in the multi-frequency fashion (18, 38, 70, 120, 200 kHz). Average survey speed was about 10 knots and the acoustic signals were integrated over 1-nm intervals (ESDU). Raw acoustic data were stored for further post-processing using *Echoview™* software package. Acoustic equipment was previously calibrated during the *MEDIAS 2018* acoustic survey, a survey conducted in the Spanish Mediterranean waters just before the *ECOCADIZ* one, following the standard procedures (Demer *et al*., 2015).

Survey execution and abundance estimation followed the methodologies firstly adopted by the ICES *Planning Group for Acoustic Surveys in ICES Sub-Areas VIII and IX* (ICES, 1998) and the recommendations given by the *Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES areas 7, 8 and 9* (WGACEGG; ICES, 2006a,b).

Fishing stations for echo-trace ground-truthing were opportunistic, according to the echogram information, and they were carried out using a ca. 15 m-mean vertical opening pelagic trawl (*Tuneado* gear) at an average speed of 4 knots. Gear performance and geometry during the effective fishing was monitored with *Simrad™ Mesotech FS20/25* trawl sonar and a *Marport^{TM} combi TE/TS* (Trawl Eye/Trawl Speed) sensor. Trawl sonar and sensors data from each haul were recorded and stored for further analyses.

Ground-truthing haul samples provided biological data on species and they were also used to identify fish species and to allocate the back-scattering values into fish species according to the proportions found at the fishing stations (Nakken and Dommasnes, 1975).

Length frequency distributions (LFD) by 0.5-cm class were obtained for all the fish species in trawl samples (either from the total catch or from a representative random sample of 100-200 fish). Only those LFDs based on a minimum of 30 individuals and showing a normal distribution were considered for the purpose of the acoustic assessment.

Individual biological sampling (length, weight, sex, maturity stage, stomach fullness, and mesenteric fat content) was performed in each haul for anchovy, sardine (in both species with otolith extraction), mackerel and horse-mackerel species, and bogue.

The following TS/length relationship table was used for acoustic estimation of assessed species (recent IEO standards after ICES, 1998 and recommendations by ICES, 2006a,b):

Species	b_{20}
Sardine (*Sardina pilchardus*)	-72.6
Round sardinella (*Sardinella aurita*)	-72.6
Anchovy (*Engraulis encrasicolus*)	-72.6
Chub mackerel (*Scomber japonicus*)	-68.7
Mackerel (*S. scombrus*)	-84.9
Horse mackerel (*Trachurus trachurus*)	-68.7
Mediterranean horse-mackerel (*T. mediterraneus*)	-68.7
Blue jack mackerel (*T. picturatus*)	-68.7
Bogue (*Boops boops*)	-67.0
Blue whiting (*Micromesistius poutassou*)	-67.5
Silvery lightfish (*Maurolicus muelleri*)	-72.2
Boarfish (*Capros aper*)	-66.2* (-72.6)

*Boarfish b_{20} estimate following to Fässler *et al*. (2013). Between parentheses the usual IEO value considered in previous surveys.

The *PESMA 2010* software (J. Miquel, unpublished) has got implemented the needed procedures and routines for the acoustic assessment following the above approach.

A *Continuous Underway Fish Egg Sampler* (CUFES, 151 stations), a *Sea-bird Electronics™ SBE 21 SEACAT* thermosalinograph and a *Turner™ 10 AU 005 CE Field* fluorometer were used during the acoustic tracking to continuously monitor some hydrographical variables (sub-surface sea temperature, salinity, and *in vivo* fluorescence). Vertical profiles of hydrographical variables were also recorded by night from 161 CTD casts by using *Sea-bird Electronics™ SBE 911+ SEACAT* (with coupled *Datasonics* altimeter, *SBE 43* oximeter, *WetLabs ECO-FL-NTU* fluorimeter and *WetLabs C-Star 25 cm* transmissometer sensors) and *LADCP T-RDI WHS* 300 kHz profilers (**Figure 2**). *VMADCP RDI 150 kHz* records were also continuously recorded by night between CTD stations.

Twenty two (22) *Manta trawl* hauls were also carried out to characterize the distribution pattern of micro-plastics over the shelf (**Figure 3**). These hauls did not follow a pre-established sampling scheme although the main goal was to have samples well distributed both in the coastal and oceanic areas of the shelf. Consequently, the hauls were opportunistically carried out taking the advantage of the conduction of fishing hauls, the start or end of an acoustic transect or whatever discrete station devoted to the sampling of either hydrographical or biological variables which were close to the preferred depths.

Information on presence and abundance of sea birds, turtles and mammals was also recorded during the acoustic sampling by one onboard observer.

RESULTS

Acoustic sampling

The acoustic sampling started on 01st August in the coastal end of the transect RA01 and finalized on 11th August in the oceanic end of the transect RA21 (**Table 1, Figure 1**). Transects were acoustically sampled in the E-W direction. The whole 21-transect sampling grid was sampled. The acoustic sampling usually started at 06:00 UTC although this time might vary depending on the duration of the works related with the hydrographic sampling. The foreseen start of transects RA14 and RA15 by the coastal end had to be displaced into deeper waters in order to avoid the occurrence of open-sea fish farming/fattening cages.

Groundtruthing hauls

Twenty five (25) fishing operations, all of them being considered as valid ones according to a correct gear performance and resulting catches, were carried out (**Table 2**, **Figure 4**).

As usual in previous surveys, some fishing hauls were attempted by fishing over an isobath crossing the acoustic transect as close as possible to the depths where the fishing situation of interest was detected over that transect. In this way the mixing of different size compositions (*i.e.*, bi-, multi-modality of length frequency distributions) was avoided as well as a direct interaction with fixed gears. The mixing of sizes is more probable close to nursery-recruitment areas and in regions with a very narrow continental shelf. This type of hauls is also conducted in depths showing hard and/or very irregular bottoms. Given that all of these situations were not very uncommon in the sampled area, 40% of valid hauls (10 hauls) were conducted over isobath.

Because of many echo-traces usually occurred close to the bottom, all the pelagic hauls were carried out like a bottom-trawl haul, with the ground rope working over or very close to the bottom. According to the above, the sampled depth range in the valid hauls oscillated between 41-185 m.

During the survey were captured 1 Chondrichthyan, 29 Osteichthyes, 5 Cephalopod and 3 Crustacean species. The percentage of occurrence of the more frequent species in the trawl hauls is shown in the enclosed **text table below** (see also **Figure 5**). The pelagic ichthyofauna was the most frequently captured species set and the one composing the bulk of the overall yields of the catches. Within this pelagic fish species set, chub mackerel was the most frequent captured species in the valid hauls (24 hauls, 96% presence index) followed by sardine, anchovy, mackerel and bogue (with relative occurrences between 60-92%). *Trachurus* spp. showed a medium relative frequency of occurrence (ca. 20-48%), whereas silver lightfish (*Maurolicus muelleri*, 16%), snipefish (*Macrorhamphosus scolopax*, 8%) and boarfish (*Capros aper*, 4%) showed either a low or very low occurrence in the whole surveyed area. Round sardinella and blue whiting were absent in the hauls of the present survey.

For the purposes of the acoustic assessment, anchovy, sardine, mackerel species, horse & jack mackerel species, bogue, silver lightfish and boarfish were initially considered as the survey target species. All of the invertebrates, and both bentho-pelagic (*e.g.*, manta rays) and benthic fish species (*e.g.*, flatfish, gurnards, etc.) were excluded from the computation of the total catches in weight and in number from those fishing stations where they occurred. Catches of the remaining non-target species were included in an operational category termed as "*Others*".

According to the above premises, during the survey were captured a total of 20.5 tonnes and 954 thousand fish (**Table 3**). 38% of this fished biomass corresponded to chub mackerel, 31% to sardine, 26% to anchovy, and contributions lower than 1% to the remaining species. The most abundant species in ground-truthing trawl hauls was anchovy (39%) followed by silver light fish (27%), sardine (19%) and chub mackerel (15%), with the remaining species showing lower contributions than 0.1%.

Species	# of fishing stations	Occurrence (%)	Total weight (kg)	Total number
Scomber colias	24	96	7878,981	142227
Sardina pilchardus	23	92	6425,485	183976
Merluccius merluccius	23	92	101,66	874
Engraulis encrasicolus	22	88	5323,439	369728
Scomber scombrus	20	80	84,958	452
Boops boops	15	60	82,441	654
Loligo subulata	15	60	1,606	532
Spondyliosoma cantharus	13	52	51,951	356
Loligo media	13	52	1,696	583
Trachurus trachurus	12	48	74,959	703
Trachurus picturatus	12	48	5,301	76
Loligo vulgaris	9	36	1,427	37
Pagellus erythrinus	8	32	87,247	530
Diplodus bellottii	6	24	9,114	149
Diplodus vulgaris	6	24	47,125	296
Aphia minuta	6	24	0,119	203
Trachurus mediterraneus	5	20	48,755	275
Diplodus annularis	5	20	3,374	55
Spicara flexuosa	5	20	2,381	33
Alosa fallax	4	16	1,583	6
Pagellus acarne	4	16	6,491	33
Trachinus draco	4	16	0,518	4
Maurolicus muelleri	4	16	148,71	253722
Pagellus bellottii	3	12	5,815	31
Mola mola	2	8	13,5	4
Illex coindetii	2	8	0,134	4
Macroramphosus scolopax	2	8	0,056	16
Capros aper	1	4	1,375	304

The species composition, in terms of percentages in number, in each valid fish station is shown in **Figure 5**. A first impression of the distribution pattern of the main species may be derived from the above figure. Thus, anchovy showed a relatively wide distribution over the surveyed area, although the highest yields were recorded in the Spanish waters. The size composition of anchovy catches confirms the usual pattern exhibited by the species in the area during the survey season, with the largest fish inhabiting the westernmost waters and the smallest ones concentrated in the surroundings of the Guadalquivir river mouth and adjacent shallow waters (**Figure 6**). Sardine was also widely distributed in the surveyed area. Juvenile sardines were mainly captured in the shallowest hauls conducted in the coastal fringe between Tinto-Odiel river mouth and the Bay of Cadiz, with a secondary nucleus of occurrence in the surroundings of Cape Santa Maria (**Figure 7**). Chub mackerel, horse mackerel, blue jack mackerel and bogue, although they occurred in a great part of the study area, only showed relatively high yields in the Portuguese waters. Mediterranean horse mackerel was restricted to the easternmost Spanish waters. The size composition of these last species in fishing hauls is shown in **Figures 8** to **15**.

Back-scattering energy attributed to the "pelagic assemblage" and individual species

A total of 335 nmi (ESDU) from 21 transects has been acoustically sampled by echo-integration for assessment purposes. From this total, 218 nmi (11 transects) were sampled in Spanish waters, and 117 nmi

(10 transects) in the Portuguese waters. The enclosed text table below provides the nautical area-scattering coefficients attributed to each of the selected target species and for the whole "pelagic fish assemblage".

S_A (m^2 nmi^{-2})	Total spp.	PIL	ANE	MAC	MAS	HOM	HMM	JAA	BOG	BOC	MAV
Total Area (%)	241648 (100,0)	117882 (48,8)	44153 (18,3)	27 (0,01)	51973 (21,5)	472 (0,2)	1585 (0,7)	41 (0,02)	3585 (1,5)	9 (0,004)	21920 (9,1)
Portugal (%)	65910 (27,3)	20194 (17,1)	4336 (9,8)	5 (19,1)	36521 (70,3)	436 (92,3)	0 (0,0)	34 (83,3)	1276 (35,6)	9 (100,0)	3100 (14,1)
Spain (%)	182864 (72,7)	97688 (82,9)	39817 (90,2)	22 (80,9)	15453 (29,7)	36 (7,7)	1585 (100,0)	7 (16,7)	2309 (64,4)	0 (0,0)	18819 (85,9)

For this "pelagic fish assemblage" has been estimated a total of 241 648 m^2 nmi^{-2}, the highest estimate ever recorded within the time-series (**Figure 16**). Portuguese waters accounted for 27% of this total back-scattering energy and the Spanish waters the remaining 73%. However, given that the Portuguese sampled ESDUs were almost the half of the Spanish ones, the (weighted-) relative importance of the Portuguese area (*i.e.*, its density of "pelagic fish") is actually much higher. The mapping of the total back-scattering energy is shown in **Figure 16**. By species, sardine (49%), chub mackerel (22%) and anchovy (18%) were the most important species in terms of their contributions to the total back-scattering energy. Silvery lightfish (9%), bogue (1.5%) and Mediterranean horse mackerel (1%) were the following species in importance. The remaining species contributed with less than 0.2% only.

Some inferences on the species' distribution may be carried out from regional contributions to the total energy attributed to each species: Mediterranean horse mackerel, anchovy, silvery lightfish, sardine, mackerel and bogue seemed to show greater densities in the Spanish waters, whereas chub mackerel, blue jack mackerel, horse mackerel and boarfish could be considered as typically "Portuguese species" in this survey.

According to the resulting values of integrated acoustic energy, the species acoustically assessed in the present survey finally were anchovy, sardine, mackerel, chub mackerel, blue jack mackerel, horse mackerel, Mediterranean horse mackerel, bogue.

Spatial distribution and abundance/biomass estimates

Anchovy

Parameters of the survey's length-weight relationship for anchovy are given in **Table 4**. The back-scattering energy attributed to this species and the coherent strata considered for the acoustic estimation are shown in **Figure 17**. The estimated abundance and biomass by size and age class are given in **Tables 5** and **6**, and **Figures 18** and **19**.

Anchovy was widely distributed over the surveyed area, although showing the highest densities in the Spanish shelf waters between El Rompido (RA10) and Bay of Cadiz (RA03), and in a secondary nucleus located over the Portuguese shelf, between Alfanzina (RA18) and Cape of Santa Maria (RA15) (**Figure 17**). This distribution pattern differed from the exhibited one during the *PELAGO* spring survey, when anchovy was restricted to a zone comprised between Vila Real Sto. Antonio (easternmost Portuguese waters) and the Bay of Cadiz.

Twelve (12) coherent post-strata have been differentiated according to the S_A value distribution and the size composition in the fishing stations (**Figure 17**). The acoustic estimates by homogeneous post-stratum and total area are shown in **Tables 5** and **6** and **Figures 18** and **19**. Overall acoustic estimates in summer 2018 were of 3 063 million fish and 34 908 tonnes. By geographical strata, the Spanish waters yielded 93%

(2 839 million) and 88% (30 683 t) of the total estimated abundance and biomass in the Gulf, confirming the importance of these waters in the species' distribution. The estimates for the Portuguese waters were 224 million and 4 225 t. The current biomass estimate (34 908 t) becomes in the second historical maximum within the time-series (2006: 35 539 t; 2016: 34 184 t; see **Figure 31**). The *PELAGO 18* spring Portuguese survey previously estimated for this same area 23 473 t (2 157 million): 4 328 t (300 million) in Portuguese waters and 19 145 t (1 857 million) in Spanish waters.

The size class range of the assessed population varied between the 9.0 and 17.0 cm size classes, with one main modal class at 12.0 cm. The size composition of anchovy by coherent post-strata confirms the usual pattern exhibited by the species in the area during the spawning season, with the largest (and oldest) fish being distributed both in the westernmost and easternmost waters and the smallest (and youngest) ones concentrated in the surroundings of the Guadalquivir river mouth and adjacent shallow waters, including those ones in front of the Bay of Cadiz (**Table 5; Figures 18** and **19;** see also **Figure 6**).

The population was composed by fishes not older than 2 years. As it has been happening in the last years, during the 2018 survey some recruitment (age 0 fish) has also been recorded, probably as a consequence of the delayed survey dates. In fact, age 0 fish accounted for 46 and 35% of the total estimated abundance and biomass, respectively. Age 1 fish represented 53% and 62% of the total abundance and biomass (**Table 6**; **Figure 19**).

The Gulf of Cadiz anchovy egg distribution from CUFES sampling is shown in **Figure 20**. Anchovy egg distribution and densities in summer 2018 are quite coincident with that of adults. The estimated total egg density is at the same magnitude than the observed in the most recent years but such estimates are lower than the historical average. Notwithstanding the above, the extension of the spawning area was among the highest one ever recorded (the second historical peak in the series).

Sardine

Parameters of the survey's size-weight relationship for sardine are shown in **Table 4**. The back-scattering energy attributed to this species and the coherent strata considered for the acoustic estimation are shown in **Figure 21**. Estimated abundance and biomass by size and age class are given in **Tables 7** and **8** and **Figures 22** and **23**.

Sardine recorded a very high acoustic echo-integration in summer 2018 as a consequence of the occurrence of very dense mid-water schools in the coastal fringe (20-50 m depth) comprised between Tavira (RA13) and the surroundings of the Guadalquivir river mouth (RA05; see **Annex** figures). The distribution pattern of acoustic densities is quite similar to the one provided by the *PELAGO* survey in spring although the occurrence of sardine in the surveyed area was more continuous in summer (**Figure 21**).

Fourteen (14) size-based homogeneous sectors were delimited for the acoustic assessment (**Figure 21**). The estimates of Gulf of Cadiz sardine abundance and biomass in summer 2018 were 7 955 million fish and 114 631 t, the historical maximum record in terms of abundance and the second maximum in biomass (the historical maximum was reached in 2006: 123 849 t; see **Figure 31**). Spanish waters concentrated the bulk of the population (7 239 million and 90 214 t). The estimates for the Portuguese waters were 716 million and 24 417 t. The *PELAGO 18* spring Portuguese survey previously estimated for this same area 58 561 t (6 680 million): 22 627 t (1 097 million) in Portuguese waters and 35 934 t (5 583 million) in Spanish waters.

Sizes of the assessed population ranged between 8.0 and 20.5 cm size classes. The length frequency distribution of the population was clearly bimodal, with one main mode at 11.5 cm size class and a secondary one at 17.0 cm (**Table 7**; **Figure 22**). The 2018 summer estimate of mean size (122 mm) is among the lowest estimates within the series. This fact might be explained by the relative importance of the juvenile fraction in the estimated population (≤11.5 cm), which was mainly located in relatively shallow waters in front of the Cape Santa Maria and along the coastal fringe comprised between the Guadiana and Guadalquivir river mouths and the Bay of Cadiz (**Table 7**; **Figure 22**; see also **Figure 7**). Such a decrease in mean size was coupled with a similar decreasing trend in the mean weight (14.4 g), which was well below the historical average. The contribution in biomass of the adult fraction in the assessed population (around at a main modal size class at 17.5 cm) may be not enough to compensate the greater relative contribution of juveniles.

Mackerel

Parameters of the survey's length-weight relationship are shown in **Table 4**. The distribution of the back-scattering energy attributed to this species is shown in **Figure 23**.

Atlantic mackerel showed very low acoustic records during the 2018 survey, which were mainly observed all over the shelf located in the central part of the Gulf of Cadiz (**Figure 23**).

Chub mackerel

Parameters of the survey's length-weight relationship are shown in **Table 4**. The distribution of the back-scattering energy attributed to this species is shown in **Figure 24**.

Contrarily to the pattern described for the Atlantic mackerel, the acoustic energy allocated to its close relative, Chub mackerel, accounted for 21.5% of the total acoustic energy attributed to fish in the survey. The population was mainly concentrated in the westernmost waters of the Gulf, between Cape San Vicente and Cape Santa Maria, with a secondary nucleus of fish density in the easternmost waters, from the Bay of Cadiz to the Strait of Gibraltar (**Figure 24**).

Blue jack-mackerel

The survey's length-weight relationship for this species is given in **Table 4**. The distribution of the back-scattering energy attributed to this species is illustrated in **Figure 25**.

The distribution pattern of the very low acoustic densities attributed to Blue jack mackerel closely resembled to the described one for horse mackerel (**Figure 25**).

Horse mackerel

The survey's length-weight relationship for horse mackerel is shown in **Table 4**. The back-scattering energy attributed to this species is shown in **Figure 26**

Horse mackerel showed very low acoustic densities in the surveyed area, with the species being almost absent in the easternmost shelf and showing relatively higher densities in the shelf area comprised between Cape San Vicente and Cape Santa Maria (**Figure 26**).

Mediterranean horse-mackerel

The survey's length-weight relationship for this species is shown in **Table 4**. Back-scattering energy attributed to the species is represented in **Figure 27**.

Mediterranean horse mackerel was restricted, as usual, to the Spanish waters, with the highest densities being recorded in the inner shelf waters of the central part of the Gulf (**Figure 27**).

Bogue

Parameters of the survey's length-weight relationship for bogue are shown in **Table 4**. Back-scattering energy attributed to bogue is shown in **Figure 28**.

Bogue was distributed practically all over the shelf of the surveyed area, although showed its highest densities over the inner shelf of both the central and westernmost waters of the Gulf (**Figure 28**).

Boarfish

The survey's length-weight relationship for this species is shown in **Table 4**. Back-scattering energy attributed to the species is represented in **Figure 29**.

Boarfish showed an incidental occurrence restricted to the outer shelf waters jus to the west of Cape of Santa Maria (**Figure 29**).

Pearlside

The survey's length-weight relationship for this species is shown in **Table 4**. Back-scattering energy attributed to the species is represented in **Figure 30**.

The constant occurrence of pearlside in somewhat shallower waters than usual in the 2018 survey has resulted in its acoustic detection in the surveyed area (9% of the total acoustic energy), just in the transition between outer shelf and upper slope waters. Higher densities were recorded in the Spanish outer shelf (**Figure 30**).

(SHORT) DISCUSSION

The total NASC estimated in this survey for "pelagic fish assemblage", 241 648 m^2 nmi^{-2}, is the highest estimate ever recorded within the time-series (**Figure 16**). Such a sharp increase in acoustic energy may be the result of the combination of several facts, namely, a very high NASC allocated to sardine because the occurrence during this survey of very dense schools in coastal (20-40 m) waters in the central part of the Gulf (see **Annex** figures); a very high NASC allocated to anchovy (mainly in Spanish waters) and chub mackerel (in Portuguese ones); and the high acoustic detection of pearlside in the shelf break, not detected in previous surveys, when its occurrence was occasional and detected in the shallow waters of the upper slope, but not penetrating in the deepest survey limit at 200 m depth.

The current anchovy biomass estimate (34 908 t) becomes in the second historical maximum within the time-series (2006: 35 539 t; 2016: 34 184 t; see **Figure 31**) and denotes a strong increase in relation to the previous year, up to levels well above the historical average (ca. 22 kt), but without showing any clear recent trend. Although the spring *PELAGO 18* survey also estimated increased population levels, such increase was not so pronounced as the estimated by its summer counterpart.

The estimates of Gulf of Cadiz sardine abundance and biomass in summer 2018 were 7 955 million fish and 114 631 t, the historical maximum record in terms of abundance and the second maximum in biomass (the historical maximum was reached in 2006: 123 849 t; see **Figure 31**). As described above, such an increasing trend seems to be the result of a greater availability of the species to the survey, with the occurrence of many dense schools in the shallowest limits of the surveyed area not usually recorded in the most recent years. In any case, these estimates should be analysed in more depth and compared with those ones provided by the Portuguese spring *PELAGO* survey in a standardisation exercise of echograms scrutiny.

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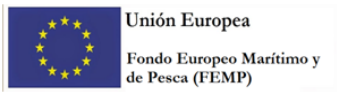

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REFERENCES

Demer, D.A., Berger, L., Bernasconi, M., Bethke, E., Boswell, K., Chu, D., Domokos, R., *et al*. 2015. Calibration of acoustic instruments. *ICES Coop. Res. Rep,* 326, 133 pp.

Fässler, S.M.M., O'Donnell, C., Jech, J.M, 2013. Boarfish (*Capros aper*) target strength modelled from magnetic resonance imaging (MRI) scans of its swimbladder. *ICES Journal of Marine Science*, 70: 1451–1459.

ICES, 1998. Report of the Planning Group for Acoustic Surveys in ICES Sub-Areas VIII and IX. A Coruña, 30-31 January 1998. *ICES CM 1998/G:2*.

ICES, 2006a. Report of the Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES areas VIII and IX (WGACEGG), 24-28 October 2005, Vigo, Spain. *ICES, C.M. 2006/LRC: 01*. 126 pp.

ICES, 2006b. Report of the Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VIII and IX (WGACEGG), 27 November-1 December 2006, Lisbon, Portugal. *ICES C.M. 2006/LRC:18*. 169 pp.

Jiménez, M.P., Tornero, J., González, C., Ramos, F., Sánchez-Leal, R.F. 2017. Anchovy spawning stock biomass of the Gulf of Cadiz in 2017 by the DEPM. Working document presented to the ICES Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas 7, 8 and 9. Cádiz (Spain), 13 – 17 November 2017.

Nakken, O., Dommasnes, A, 1975. The application for an echo integration system in investigations on the stock strength of the Barents Sea capelin (*Mallotus villosus*, Müller) 1971-74. *ICES CM 1975/B:25*.

Torres, M.A., Ramos, F., Sobrino, I., 2012. Length–weight relationships of 76 fish species from the Gulf of Cadiz (SW Spain). *Fish. Res*. (127-128): 171-175.

Table 1. *ECOCADIZ 2018-07 s*urvey. Descriptive characteristics of the acoustic tracks.

Acoustic Track	Location	Date	Start				End			
			Latitude	Longitude	UTC time	Mean depth (m)	Latitude	Longitude	UTC time	Mean depth (m)
R01	Trafalgar	01/08/18	36º 12,968' N	06º 08,805' W	06:22	24	36º 02,075' N	06º 28,864' W	08:29	240
R02	Sancti-Petri	01/08/18	36º 08,505' N	06º 34,300' W	09:25	210	36º 19,420' N	06º 14,410' W	16:14	28
R03	Cádiz	02/08/18	36º 27,223' N	06º 19,149' W	06:03	26	36º 17,589' N	06º 36,655' W	09:31	222
R04	Rota	02/08/18	36º 23,300' N	06º 42,290' W	10:31	240	36º 34,510' N	06º 23,110' W	16:24	23
R05	Chipiona	03/08/18	36º 40,194' N	06º 29,819' W	06:00	24	36º 31,311' N	06º 46,083' W	09:34	188
R06	Doñana	03/08/18	36º 37,740' N	06º 51,950' W	10:37	177	36º 47,050' N	06º 34,916' W	14:02	19
R07	Matalascañas	04/08/18	36º 53,839' N	06º 40,548' W	06:01	22	36º 44,078' N	06º 58,368' W	09:43	200
R08	Mazagón	04/08/18	36º 48,740' N	07º 07,181' W	13:44	228	37º 01,260' N	06º 44,189' W	17:18	21
R09	Punta Umbría	05/08/18	37º 03,767' N	06º 56,501' W	06:01	29	36º 49,549' N	07º 06,669' W	09:58	210
R10	El Rompido	05/08/18	36º 50,130' N	07º 07,250' W	12:06	165	37º 07,233' N	07º 07,255' W	17:31	21
R11	Isla Cristina	06/08/18	37º 07,169' N	07º 16,685' W	06:07	23	36º 53,349' N	07º 16,699' W	08:58	234
R12	V.R. do Sto. Antonio	06/08/18	36º 56,200' N	07º 26,500' W	13:39	135	37º 06,350' N	07º 26,540' W	16:25	19
R13	Tavira	07/08/18	37º 04,820' N	07º 36,049' W	05:59	21	36º 56,959' N	07º 36,100' W	08:17	216
R14	Fuzeta	07/08/18	36º 55,881' N	07º 45,985' W	15:34	161	36º 59,267' N	07º 46,044' W	15:54	60
R15	Cabo Sta. María	08/08/18	36º 55,129' N	07º 55,978' W	06:00	70	36º 52,015' N	07º 55,999' W	06:18	178
R16	Cuarteira	08/08/18	36º 50,130' N	08º 05,910' W	11:29	202	37º 01,389' N	08º 05,842' W	14:28	20
R17	Albufeira	09/08/18	37º 02,494' N	08º 15,452' W	06:12	29	36º 49,338' N	08º 15,499' W	09:33	204
R18	Alfanzina	09/08/18	36º 50,370' N	08º 25,300' W	11:43	202	37º 03,750' N	08º 25,279' W	14:49	29
R19	Portimao	10/08/18	37º 05,785' N	08º 35,372' W	06:04	27	36º 50.381' N	08º 35,398' W	09:40	202
R20	Burgau	10/08/18	36º 52,340' N	08º 45,002' W	12:03	111	37º 03,200' N	08º 45,000' W	13:08	20
R21	Ponta de Sagres	11/08/18	37º 00,038' N	08º 54,980' W	06:01	23	36º 50,790' N	08º 55,000' W	08:12	202

Table 2. *ECOCADIZ 2018-07* survey. Descriptive characteristics of the fishing stations.

FISHING STATION	DATE	POSITION						TIMING				TRAWLED DISTANCE (nmi)	ACOUSTIC TRANSECT	ZONE/LANDMARK
		START			END			START	END	EFFECTIVE TRAWLING	TOTAL MANEOUVRE			
		LAT.	LON.	PROF.	LAT.	LON.	PROF.	UTC	UTC					
PE01	01-08-2018	36º 16.5388 N	6º 19.5235 W	43,4	36º 15.1167 N	6º 22.2324 W	49,85	11:13	11:50	0:37	1:00	2,611	R02	Sancti-Petri
PE02	01-08-2018	36º 12.8734 N	6º 26.3475 W	81,22	36º 11.1748 N	6º 29.4739 W	109,27	13:20	14:03	0:42	1:11	3,046	R02	Sancti-Petri
PE03	02-08-2018	36º 23.8087 N	6º 25.3450 W	56,12	36º 25.5262 N	6º 22.1794 W	45,31	07:05	07:49	0:44	1:05	3,077	R03	Cádiz
PE04	02-08-2018	36º 23.6157 N	6º 39.5761 W	185,48	36º 24.7228 N	6º 40.0975 W	178,73	11:56	12:13	0:17	0:46	1,183	R04	Rota
PE05	02-08-2018	36º 29.9443 N	6º 31.0648 W	61,33	36º 27.5509 N	6º 35.1775 W	91,93	13:54	14:51	0:57	1:21	4,088	R04	Rota
PE06	03-08-2018	36º 33.4984 N	6º 41.9919 W	103,93	36º 35.0322 N	6º 39.2943 W	77,67	07:53	08:31	0:37	1:07	2,659	R05	Chipiona
PE07	03-08-2018	36º 40.7883 N	6º 46.3366 W	93,12	36º 39.2739 N	6º 49.1025 W	115,33	11:37	12:15	0:37	1:02	2,69	R06	Doñana
PE08	03-08-2018	36º 43.6651 N	6º 41.0337 W	42,56	36º 42.1558 N	6º 43.8061 W	68,46	14:44	15:23	0:38	1:00	2,691	R06	Doñana
PE09	04-08-2018	36º 45.7464 N	6º 55.4163 W	115,32	36º 47.5804 N	6º 51.7888 W	89,78	07:54	8:42	0:47	1:14	3,442	R07	Matalascañas
PE10	04-08-2018	36º 45.3789 N	6º 56.0539 W	119,9	36º 47.1727 N	6º 52.6827 W	95,67	11:23	12:08	0:45	1:07	3,247	R07	Matalascañas
PE11	04-08-2018	36º 55.9969 N	6º 50.1088 W	43,19	36º 57.4765 N	6º 51.7540 W	43,34	15:40	16:08	0:27	0:47	1,981	R08	Mazagón
PE12	05-08-2018	36º 57.3658 N	6º 58.5016 W	61,49	36º 58.9450 N	7º 01.6909 W	60,04	07:52	08:34	0:42	1:03	3,003	S/D	Sin Datos
PE13	05-08-2018	36º 55.4889 N	7º 07.2582 W	99,23	36º 52.2136 N	7º 07.2657 W	128,88	13:03	13:49	0:45	1:12	3,271	R10	El Rompido
PE14	05-08-2018	36º 57.6004 N	7º 05.9353 W	82,83	36º 58.5603 N	7º 08.7571 W	80,93	15:41	16:16	0:34	1:00	2,456	R10	El Rompido
PE15	06-08-2018	37º 02.2915 N	7º 14.7397 W	54,41	37º 02.3526 N	7º 16.8729 W	53,8	07:18	07:41	0:23	0:47	1,709	R11	Isla Cristina
PE16	06-08-2018	36º 59.6457 N	7º 26.5813 W	99,83	36º 56.9236 N	7º 26.4835 W	131,28	14:29	15:07	0:38	1:01	2,72	R12	Vila Real do Santo Antonio
PE17	07-08-2018	37º 03.3214 N	7º 34.7989 W	52,5	37º 02.6311 N	7º 36.4885 W	53,06	06:55	07:16	0:21	0:50	1,518	R13	Tavira
PE18	07-08-2018	36º 57.8928 N	7º 36.0870 W	126,24	36º 59.0218 N	7º 36.0957 W	109,91	08:53	09:09	0:15	2:03	1,128	R13	Tavira
PE19	08-08-2018	36º 54.7846 N	7º 56.5828 W	73,27	36º 55.2130 N	7º 54.2592 W	77,05	07:14	07:41	0:27	0:49	1,912	R15	Cabo de Santa María
PE20	08-08-2018	36º 53.4466 N	8º 05.8354 W	96,92	36º 50.6529 N	8º 05.8903 W	123,2	12:24	13:03	0:39	1:10	2,791	R16	Cuarteira
PE21	08-08-2018	36º 58.7931 N	8º 06.8914 W	41,79	36º 58.2543 N	8º 04.7586 W	41,45	15:19	15:44	0:25	0:42	1,792	R16	Cuarteira
PE22	09-08-2018	36º 54.9072 N	8º 15.7515 W	91,9	36º 54.3112 N	8º 13.7479 W	91,7	08:13	08:37	0:24	0:45	1,713	R17	Albufeira
PE23	09-08-2018	36º 54.1354 N	8º 25.2601 W	120	36º 51.6123 N	8º 25.2973 W	135,35	12:36	13:12	0:36	1:02	2,52	R18	Alfanzina
PE24	09-08-2018	36º 59.8305 N	8º 24.4468 W	43,17	37º 00.1414 N	8º 26.8555 W	46,94	15:50	16:18	0:27	0:50	1,954	R18	Alfanzina
PE25	10-08-2018	36º 54.4809 N	8º 35.3532 W	104,35	36º 56.5975 N	8º 35.3839 W	78,75	08:15	08:44	0:28	1:00	2,114	R19	Portimao

Table 3. *ECOCADIZ 2018-07* survey. Catches by species in number (upper panel) and weight (in kg, lower panel) from valid fishing stations.

ABUNDANCE (nº)													
Fishing station	**ANE**	**PIL**	**MAS**	**MAC**	**HOM**	**JAA**	**HMM**	**BOG**	**BOC**	**MAV**	**SNS**	**OTHERS SPP**	**TOTAL**
01	27	490	25920	0	0	0	119	6	0	0	0	185	**26747**
02	19266	0	9887	2	0	0	0	0	0	0	0	36	**29191**
03	15273	8419	408	1	0	0	25	13	0	0	0	230	**24369**
04	0	0	4	26	0	0	0	0	0	253693	0	46	**253769**
05	36523	23	15335	10	0	0	23	11	0	0	0	117	**52042**
06	29669	718	8	11	2	8	0	0	0	0	0	116	**30532**
07	48902	8105	117	32	5	2	0	0	0	4	0	21	**57188**
08	21463	228	5	9	0	0	59	7	0	0	0	37	**21808**
09	25261	4028	189	21	0	1	0	0	0	6	0	31	**29537**
10	32494	3985	452	1	0	0	0	0	0	0	0	1	**36933**
11	9200	4455	1	23	1	0	49	109	0	0	0	273	**14111**
12	7699	56273	5864	112	0	0	0	11	0	0	0	4	**69963**
13	68793	4563	1140	45	0	1	0	0	0	0	0	36	**74578**
14	1308	318	1	15	11	1	0	0	0	0	0	47	**1701**
15	20	46472	9536	15	0	0	0	23	0	0	0	20	**56086**
16	4576	82	151	22	0	0	0	0	0	19	0	137	**4987**
17	272	39164	1100	68	21	1	0	112	0	0	0	72	**40810**
18	2427	25	228	0	0	12	0	0	0	0	0	31	**2723**
19	410	160	0	0	2	0	0	9	0	0	0	62	**643**
20	11413	65	302	14	160	7	0	67	304	0	15	71	**12418**
21	0	3000	2137	0	52	8	0	202	0	0	0	704	**6103**
22	13629	472	2673	17	48	3	0	8	0	0	0	41	**16891**
23	21065	57	578	5	42	6	0	19	0	0	1	29	**21802**
24	0	1591	3258	0	8	0	0	48	0	0	0	17	**4922**
25	38	1283	62933	3	351	26	0	9	0	0	0	9	**64652**
TOTAL	**369728**	**183976**	**142227**	**452**	**703**	**76**	**275**	**654**	**304**	**253722**	**16**	**2373**	**954506**

Table 3. *ECOCADIZ 2018-07* survey. Cont'd.

BIOMASS (kg)													
Fishing station	**ANE**	**PIL**	**MAS**	**MAC**	**HOM**	**JAA**	**HMM**	**BOG**	**BOC**	**MAV**	**SNS**	**OTHERS SPP**	**TOTAL**
01	0,449	23,950	1386,650	0,000	0,000	0,000	20,600	0,761	0,000	0,000	0,000	29,882	**1462,292**
02	344,300	0,000	549,900	0,282	0,000	0,000	0,000	0,000	0,000	0,000	0,000	3,809	**898,291**
03	173,727	117,273	19,590	0,334	0,000	0,000	5,086	2,296	0,000	0,000	0,000	32,878	**351,184**
04	0,000	0,000	0,269	3,140	0,000	0,000	0,000	0,000	0,000	148,661	0,000	4,746	**156,816**
05	584,022	0,302	646,427	1,703	0,000	0,000	4,285	2,144	0,000	0,000	0,000	108,574	**1347,457**
06	296,350	7,200	0,345	1,514	0,040	0,225	0,000	0,000	0,000	0,000	0,000	12,597	**318,271**
07	595,072	97,677	9,850	4,476	0,088	0,061	0,000	0,000	0,000	0,009	0,000	1,633	**708,866**
08	144,720	21,250	0,540	1,558	0,000	0,000	10,284	1,475	0,000	0,000	0,000	3,337	**183,164**
09	314,500	47,514	13,550	3,730	0,000	0,027	0,000	0,000	0,000	0,010	0,000	3,444	**382,775**
10	431,200	48,700	21,350	0,114	0,000	0,000	0,000	0,000	0,000	0,000	0,000	4,000	**505,364**
11	87,450	50,870	0,044	3,838	0,027	0,000	8,500	18,100	0,000	0,000	0,000	33,309	**202,138**
12	96,991	1793,266	265,111	20,200	0,000	0,000	0,000	1,934	0,000	0,000	0,000	1,052	**2178,554**
13	1090,220	63,131	60,710	8,012	0,000	0,026	0,000	0,000	0,000	0,000	0,000	13,210	**1235,309**
14	17,700	6,630	0,040	3,328	0,213	0,039	0,000	0,000	0,000	0,000	0,000	6,531	**34,481**
15	0,246	1860,916	473,984	3,360	0,000	0,000	0,000	3,150	0,000	0,000	0,000	1,795	**2343,451**
16	56,300	1,140	12,400	3,466	0,000	0,000	0,000	0,000	0,000	0,030	0,000	15,950	**89,286**
17	3,572	2012,077	84,041	18,100	2,212	0,156	0,000	15,150	0,000	0,000	0,000	13,142	**2148,45**
18	34,700	0,582	17,900	0,000	0,000	0,353	0,000	0,000	0,000	0,000	0,000	5,200	**58,735**
19	5,610	2,492	0,000	0,000	0,236	0,000	0,000	1,250	0,000	0,000	0,000	10,625	**20,213**
20	187,750	1,143	24,850	2,223	23,312	0,887	0,000	8,700	1,375	0,000	0,052	7,264	**257,556**
21	0,000	119,350	136,850	0,000	4,340	0,225	0,000	19,150	0,000	0,000	0,000	102,678	**382,593**
22	306,100	9,650	166,800	3,966	6,218	0,073	0,000	0,836	0,000	0,000	0,000	5,085	**498,728**
23	551,600	1,439	51,650	0,836	4,967	0,506	0,000	2,632	0,000	0,000	0,004	3,634	**617,268**
24	0,000	77,850	145,100	0,000	0,625	0,000	0,000	4,007	0,000	0,000	0,000	1,279	**228,861**
25	0,860	61,083	3791,030	0,778	32,681	2,723	0,000	0,856	0,000	0,000	0,000	0,856	**3890,867**
TOTAL	**5323,439**	**6425,485**	**7878,981**	**84,958**	**74,959**	**5,301**	**48,755**	**82,441**	**1,375**	**148,710**	**0,056**	**426,510**	**20500,970**

Table 4. *ECOCADIZ 2018-07* survey. Parameters of the size-weight relationships for survey's target species. FAO codes for the species: ANE: *Engraulis encrasicolus*; PIL: *Sardina pilchardus*; MAS: *Scomber colias*; MAC: *Scomber scombrus*; HOM: *Trachurus trachurus*; JAA: *Trachurus picturatus;* HMM: *Trachurus mediterraneus*; BOG: *Boops boops*; BOC: *Capros aper*; SNS: *Macrorhamphosus scolopax*; MAV: *Maurolicus muelleri*.

PARAMETER	ANE	PIL	MAS	MAC	HOM	JAA	HMM	BOG	BOC	SNS	MAV
Size range (mm)	93-182	98-198	157-283	247-355	111-267	115-277	224-366	181-313	47-70	78-99	35-66
n	1028	1223	970	402	283	58	189	358	110	15	238
a	0,002053	0,001571	0,001545	0,000313	0,005194	0,002359	0,044915	0,009061	0,018507	0,002166	0,006447
b	3,447416	3,608874	3,515858	3,943451	3,169538	3,423360	2,468256	3,010727	3,068089	3,410636	3,090835
r^2	0,97	0,98	0,97	0,93	0,99	0,99	0,93	0,95	0,93	0,87	0,97

Table 5. *ECOCADIZ 2018-07* survey. Anchovy (*E. encrasicolus*). Estimated abundance (absolute numbers and million fish) and biomass (t) by size class (in cm). Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figure 17**.

ECOCADIZ 2018-07 . *Engraulis encrasicolus* . ABUNDANCE (in numbers and million fish)																		
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	**POL09**	**POL10**	**POL11**	**POL12**	***n***			**Millions**		
													PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	3092703	0	0	0	3092703	3092703	0	3	3
9,5	0	0	0	0	0	0	0	0	0	24643444	0	0	0	24643444	24643444	0	25	25
10	0	0	0	0	0	0	805120	0	7495873	248690533	0	0	0	256991526	256991526	0	257	257
10,5	0	0	0	279874	0	0	4842219	273907	18776791	238778047	2845438	1142264	279874	266658666	266938540	0,3	267	267
11	0	0	0	0	1695995	1425718	23197540	3933829	142570020	287493489	59691670	5032808	3121713	521919356	525041069	3	522	525
11,5	0	0	0	373165	3502507	6790532	43635623	11221744	210107094	137739025	162033647	7426674	10666204	572163807	582830011	11	572	583
12	0	0	0	2636920	5649342	16094442	88777424	28770876	232594712	88787017	142115578	22451378	24380704	603496985	627877689	24	603	628
12,5	0	86228	0	8144470	2838486	19680783	42357980	18970712	48760283	15288697	56846231	17624068	30749967	199847971	230597938	31	200	231
13	0	1976512	0	14875864	836649	15021479	40522176	15532654	14991746	6129396	45495746	52734027	32710504	175405745	208116249	33	175	208
13,5	309445	4381698	506320	7101674	167695	4644606	28152542	7475060	7495873	0	5690877	33297682	17111438	82112034	99223472	17	82	99
14	1856669	10049423	3037919	3130785	389462	2866133	12482417	6943991	0	0	2845438	38401012	21330391	60672858	82003249	21	61	82
14,5	5413390	5061003	8857496	466938	0	352755	4111361	4889397	0	3036693	0	25449273	20151582	37486724	57638306	20	37	58
15	8043039	8249726	13160181	746812	0	352755	1648760	1191053	0	0	0	9750018	30552513	12589831	43142344	31	13	43
15,5	5259299	2491415	8605370	351044	0	0	0	730000	0	0	0	5190226	16707128	5920226	22627354	17	6	23
16	4021520	771123	6580091	117574	0	0	0	499474	0	0	0	8472777	11490308	8972251	20462559	11	9	20
16,5	928334	428675	1518959	0	0	0	0	0	0	0	0	3378713	2875968	3378713	6254681	3	3	6
17	772981	86228	1264766	117574	0	0	0	0	0	0	0	3378713	2241549	3378713	5620262	2	3	6
17,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL *n*	26604677	33582031	43531102	38342694	15080136	67229203	290533162	100432697	682792392	1053679044	477564625	233729633	224369843	2838731553	3063101396	**224**	**2839**	**3063**
Millions	**27**	**34**	**44**	**38**	**15**	**67**	**291**	**100**	**683**	**1054**	**478**	**234**						

Table 5. *ECOCADIZ 2018-07* survey. Anchovy (*E. encrasicolus*). Cont'd.

ECOCADIZ 2018-07 . *Engraulis encrasicolus* . BIOMASS (t)															
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	**POL09**	**POL10**	**POL11**	**POL12**	**PORTUGAL**	**SPAIN**	**TOTAL**
6	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
6,5	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
7	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
7,5	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
8	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
8,5	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
9	0	0	0	0	0	0	0	0	0	13,596	0	0	**0**	**13,596**	**13,596**
9,5	0	0	0	0	0	0	0	0	0	129,897	0	0	**0**	**129,897**	**129,897**
10	0	0	0	0	0	0	5,042	0	46,946	1557,512	0	0	**0**	**1609,500**	**1609,500**
10,5	0	0	0	2,066	0	0	35,738	2,022	138,58	1762,28	21,000	8,430	**2,066**	**1968,050**	**1970,116**
11	0	0	0	0	14,641	12,308	200,257	33,96	1230,764	2481,844	515,300	43,447	**26,949**	**4505,572**	**4532,521**
11,5	0	0	0	3,742	35,126	68,101	437,616	112,541	2107,137	1381,367	1625,015	74,481	**106,969**	**5738,157**	**5845,126**
12	0	0	0	30,531	65,410	186,346	1027,89	333,117	2693,047	1028,001	1645,454	259,948	**282,287**	**6987,457**	**7269,744**
12,5	0	1,146	0	108,244	37,725	261,567	562,957	252,129	648,046	203,194	755,512	234,232	**408,682**	**2656,070**	**3064,752**
13	0	29,994	0	225,743	12,696	227,952	614,928	235,709	227,501	93,014	690,402	800,244	**496,385**	**2661,798**	**3158,183**
13,5	5,335	75,550	8,730	122,448	2,891	80,083	485,408	128,885	129,244	0	98,122	574,121	**295,037**	**1415,780**	**1710,817**
14	36,208	195,978	59,244	61,055	7,595	55,894	243,425	135,418	0	0	55,490	748,874	**415,974**	**1183,207**	**1599,181**
14,5	118,896	111,157	194,540	10,256	0	7,748	90,299	107,388	0	66,696	0	558,951	**442,597**	**823,334**	**1265,931**
15	198,166	203,259	324,244	18,40	0	8,691	40,623	29,345	0	0	0	240,223	**752,760**	**310,191**	**1062,951**
15,5	144,823	68,605	236,963	9,667	0	0	0	20,102	0	0	0	142,921	**460,058**	**163,023**	**623,081**
16	123,337	23,650	201,806	3,606	0	0	0	15,318	0	0	0	259,853	**352,399**	**275,171**	**627,570**
16,5	31,607	14,595	51,715	0	0	0	0	0	0	0	0	115,034	**97,917**	**115,034**	**212,951**
17	29,126	3,249	47,657	4,430	0	0	0	0	0	0	0	127,310	**84,462**	**127,310**	**211,772**
17,5													**0**	**0**	**0**
18													**0**	**0**	**0**
18,5													**0**	**0**	**0**
TOTAL	**687,498**	**727,183**	**1124,899**	**600,188**	**176,084**	**908,690**	**3744,183**	**1405,934**	**7221,265**	**8717,401**	**5406,295**	**4188,069**	**4224,542**	**30683,147**	**34907,689**

Table 6. *ECOCADIZ 2018-07* survey. Anchovy (*E. encrasicolus*). Estimated abundance (thousands of individuals) and biomass (tonnes) by age group. Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figure 17** and ordered from west to east.

Age class	POL01	POL02	POL03	POL04	POL05	POL06	POL07	POL08	POL09	POL10	POL11	POL12	PT	ES	TOTAL
	N	N	N	N	N	N	Nr	N	N	N	N	N	N	N	N
0	135	705	221	4185	4686	12540	75088	19756	292222	804922	169500	24026	22472	1385513	1407986
I	21702	30463	35509	33232	10272	53845	211646	78746	386744	247267	304962	194840	185024	1424206	1609230
II	4767	2414	7801	926	122	844	3800	1931	3826	1490	3102	14863	16874	29012	45886
III	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	26605	33582	43531	38343	15080	67229	290533	100433	682792	1053679	477565	233730	224370	2838732	3063101

Age class	POL01	POL02	POL03	POL04	POL05	POL06	POL07	POL08	POL09	POL10	POL11	POL12	PT	ES	TOTAL
	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
0	3	12	5	57	49	149	800	225	2818	6150	1731	301	276	12024	12299
I	542	653	887	524	125	746	2885	1143	4356	2549	3635	3479	3479	18047	21526
II	142	62	233	19	2	13	60	37	47	19	41	409	470	613	1083
III	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	688	727	1125	600	176	909	3744	1406	7221	8717	5406	4188	4225	30683	34908

Table 7. *ECOCADIZ 2018-07* survey. Sardine (*S. pilchardus*). Estimated abundance (absolute numbers and million fish) and biomass (t) by size class (in cm). Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figure 21**.

ECOCADIZ 2018-07 . *Sardina pilchardus* . ABUNDANCE (in numbers and million fish)																				
Size class	POL01	POL02	POL03	POL04	POL05	POL06	POL07	POL08	POL09	POL10	POL11	POL12	POL13	POL14	*n*			Millions		
															PORTUGAL	SPAIN	TOTAL	PORTUGAL	SPAIN	TOTAL
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	762681	0	0	0	0	0	0	0	0	762681	0	762681	1	0	1
8,5	0	0	0	0	0	762681	0	0	0	0	0	0	0	0	762681	0	762681	1	0	1
9	0	0	0	0	0	2288043	0	0	0	0	0	0	0	0	2288043	0	2288043	2	0	2
9,5	0	0	0	0	0	26693832	0	0	0	0	0	6208375	22645897	0	26693832	28854272	55548104	27	29	56
10	0	0	0	0	2300	11440214	0	0	0	0	62070	49127140	118366037	0	11442514	167555247	178997761	11	168	179
10,5	0	0	0	0	9199	7626809	0	0	0	0	62070	185130871	388409046	0	7636008	573601987	581237995	8	574	581
11	0	0	0	0	9199	2288043	70670	2812518	0	901486	248278	833809930	911089263	0	5180430	1746048957	1751229387	5	1746	1751
11,5	0	0	1415804	0	11499	7626809	610331	2625017	1529007	4885678	1179323	1343572214	478386991	0	12289460	1829553213	1841842673	12	1830	1842
12	0	0	1415804	0	9199	5338766	1002227	4875032	11082956	4520040	1303462	1303507414	209844468	8254	12641028	1530266594	1542907622	13	1530	1543
12,5	1351	319070	4601364	2950	16098	6864128	1149991	2812518	12841380	6694955	2048297	749698288	60446836	0	15767470	831729756	847497226	16	832	847
13	1351	413563	12034338	2950	27597	11440214	1291331	1687511	19261163	7419927	2917272	234898989	4644563	8254	26898855	269150168	296049023	27	269	296
13,5	4052	3800270	76099490	8849	22998	11440214	539661	187501	8046507	3076401	1365532	77678310	3235128	8254	92103035	93410132	185513167	92	93	186
14	20259	9256076	31147698	44243	13799	7626809	321227	187501	3615393	901486	1489671	20170679	4644563	0	48617612	30821792	79439404	49	31	79
14,5	20259	13879593	25484480	44243	18398	11440214	179887	187501	1275071	359334	2110367	6338665	7879691	8254	51254575	17971382	69225957	51	18	69
15	27012	13081213	7432973	58991	6899	762681	109217	0	849547	0	3475898	0	3235128	8254	21478986	7568827	29047813	21	8	29
15,5	2701	7188060	7432973	5899	0	7626809	0	0	7051645	0	2731063	0	0	105233	22256442	9887941	32144383	22	10	32
16	0	6328816	0	0	0	0	10581205	0	9041739	0	620696	0	0	160944	16910021	9823379	26733400	17	10	27
16,5	0	13590154	0	0	0	0	21155986	0	18084956	0	0	0	0	328079	34746140	18413035	53159175	35	18	53
17	0	28315306	0	0	2300	0	110322077	0	35798430	0	0	0	0	191895	138639683	35990325	174630008	139	36	175
17,5	0	28701776	0	0	0	0	68003680	0	25549634	0	0	0	0	96979	96705456	25646613	122352069	97	26	122
18	0	23156153	0	0	0	0	31737192	0	9748444	0	0	0	0	33014	54893345	9781458	64674803	55	10	65
18,5	0	7316354	0	0	0	0	4535720	0	1446401	0	0	0	0	24761	11852074	1471162	13323236	12	1	13
19	0	2927936	0	0	0	0	0	0	1059163	0	0	0	0	8254	2927936	1067417	3995353	3	1	4
19,5	0	319070	0	0	0	0	0	0	0	0	0	0	0	16507	319070	16507	335577	0,3	0,02	0,3
20	0	567837	0	0	0	0	0	0	0	0	0	0	0	0	567837	0	567837	1	0	1
20,5	0	267217	0	0	0	0	0	0	0	0	0	0	0	8254	267217	8254	275471	0,3	0,01	0,3
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL *n*	76985	159428464	167064924	168125	149485	122028947	251610402	15375099	166281436	28759307	19613999	4810140875	2212827611	1015190	715902431	7238638418	7954540849	**716**	**7239**	**7955**
Millions	**0,1**	**159**	**167**	**0,2**	**0,1**	**122**	**252**	**15**	**166**	**29**	**20**	**4810**	**2213**	**1**	**716**	**7239**	**7955**			

Table 7. *ECOCADIZ 2018-07* survey. Sardine (*S. pilchardus*). Cont'd

ECOCADIZ 2018-07 . Sardina pilchardus . BIOMASS (t)																	
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	**POL09**	**POL10**	**POL11**	**POL12**	**POL13**	**POL14**	**PORTUGAL**	**SPAIN**	**TOTAL**
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
6,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
7,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
8	0	0	0	0	0	2,431	0	0	0	0	0	0	0	0	**2,431**	**0**	**2,431**
8,5	0	0	0	0	0	3,006	0	0	0	0	0	0	0	0	**3,006**	**0**	**3,006**
9	0	0	0	0	0	11,021	0	0	0	0	0	0	0	0	**11,021**	**0**	**11,021**
9,5	0	0	0	0	0	155,482	0	0	0	0	0	36,162	131,904	0	**155,482**	**168,066**	**323,548**
10	0	0	0	0	0,016	79,815	0	0	0	0	0,433	342,746	825,806	0	**79,831**	**1168,985**	**1248,816**
10,5	0	0	0	0	0,076	63,189	0	0	0	0	0,514	1533,832	3218,017	0	**63,265**	**4752,363**	**4815,628**
11	0	0	0	0	0,090	22,337	0,690	27,457	0	8,801	2,424	8139,914	8894,339	0	**50,574**	**17045,478**	**17096,052**
11,5	0	0	16,170	0	0,131	87,106	6,971	29,981	17,463	55,800	13,469	15345,061	5463,701	0	**140,359**	**20895,494**	**21035,853**
12	0	0	18,794	0	0,122	70,870	13,304	64,714	147,122	60,002	17,303	17303,554	2785,604	0,110	**167,804**	**20313,695**	**20481,499**
12,5	0,021	4,893	70,568	0,045	0,247	105,271	17,637	43,134	196,940	102,676	31,413	11497,654	927,035	0	**241,816**	**12755,718**	**12997,534**
13	0,024	7,287	212,048	0,052	0,486	201,579	22,754	29,734	339,386	130,741	51,403	4138,973	81,838	0,145	**473,964**	**4742,486**	**5216,45**
13,5	0,082	76,539	1532,67	0,178	0,463	230,410	10,869	3,776	162,059	61,960	27,502	1564,468	65,157	0,166	**1854,987**	**1881,312**	**3736,299**
14	0,464	212,068	713,632	1,014	0,316	174,740	7,360	4,296	82,833	20,654	34,130	462,135	106,413	0	**1113,89**	**706,165**	**1820,055**
14,5	0,526	360,144	661,264	1,148	0,477	296,847	4,668	4,865	33,085	9,324	54,759	164,474	204,460	0,214	**1329,939**	**466,316**	**1796,255**
15	0,791	382,821	217,525	1,726	0,202	22,320	3,196	0	24,862	0	101,722	0	94,676	0,242	**628,581**	**221,502**	**850,083**
15,5	0,089	236,332	244,384	0,194	0	250,757	0	0	231,847	0	89,793	0	0	3,460	**731,756**	**325,1**	**1056,856**
16	0	232,925	0	0	0	0	389,429	0	332,771	0	22,844	0	0	5,923	**622,354**	**361,538**	**983,892**
16,5	0	557,976	0	0	0	0	868,609	0	742,521	0	0	0	0	13,47	**1426,585**	**755,991**	**2182,576**
17	0	1292,746	0	0	0,105	0	5036,795	0	1634,39	0	0	0	0	8,761	**6329,646**	**1643,151**	**7972,797**
17,5	0	1452,727	0	0	0	0	3441,975	0	1293,183	0	0	0	0	4,909	**4894,702**	**1298,092**	**6192,794**
18	0	1295,63	0	0	0	0	1775,755	0	545,444	0	0	0	0	1,847	**3071,385**	**547,291**	**3618,676**
18,5	0	451,307	0	0	0	0	279,784	0	89,221	0	0	0	0	1,527	**731,091**	**90,748**	**821,839**
19	0	198,603	0	0	0	0	0	0	71,843	0	0	0	0	0,560	**198,603**	**72,403**	**271,006**
19,5	0	23,741	0	0	0	0	0	0	0	0	0	0	0	1,228	**23,741**	**1,228**	**24,969**
20	0	46,241	0	0	0	0	0	0	0	0	0	0	0	0	**46,241**	**0**	**46,241**
20,5	0	23,763	0	0	0	0	0	0	0	0	0	0	0	0,734	**23,763**	**0,734**	**24,497**
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
21,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
TOTAL	**1,997**	**6855,743**	**3687,055**	**4,357**	**2,731**	**1777,181**	**11879,796**	**207,957**	**5944,970**	**449,958**	**447,709**	**60528,973**	**22798,95**	**43,296**	**24416,817**	**90213,856**	**114630,673**

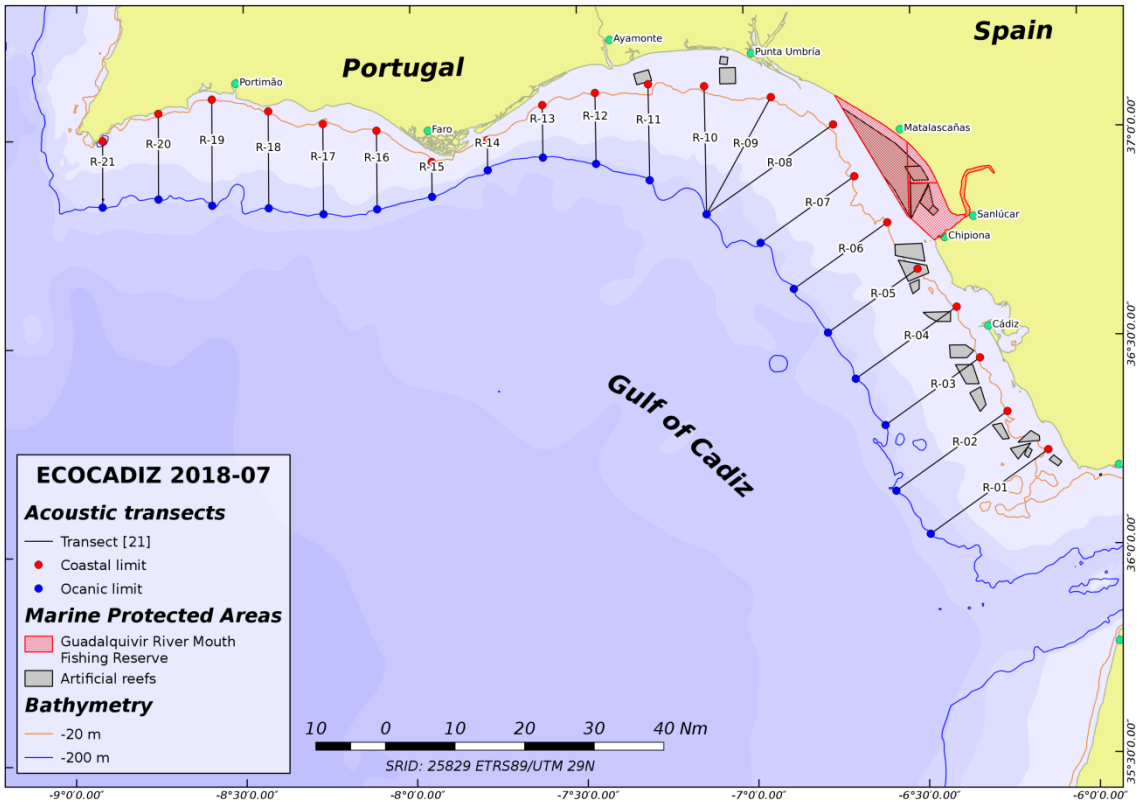


Figure 1. *ECOCADIZ 2018-07* survey. Location of the acoustic transects sampled during the survey. The different protected areas inside the Guadalquivir river mouth Fishing Reserve and artificial reef polygons are also shown.

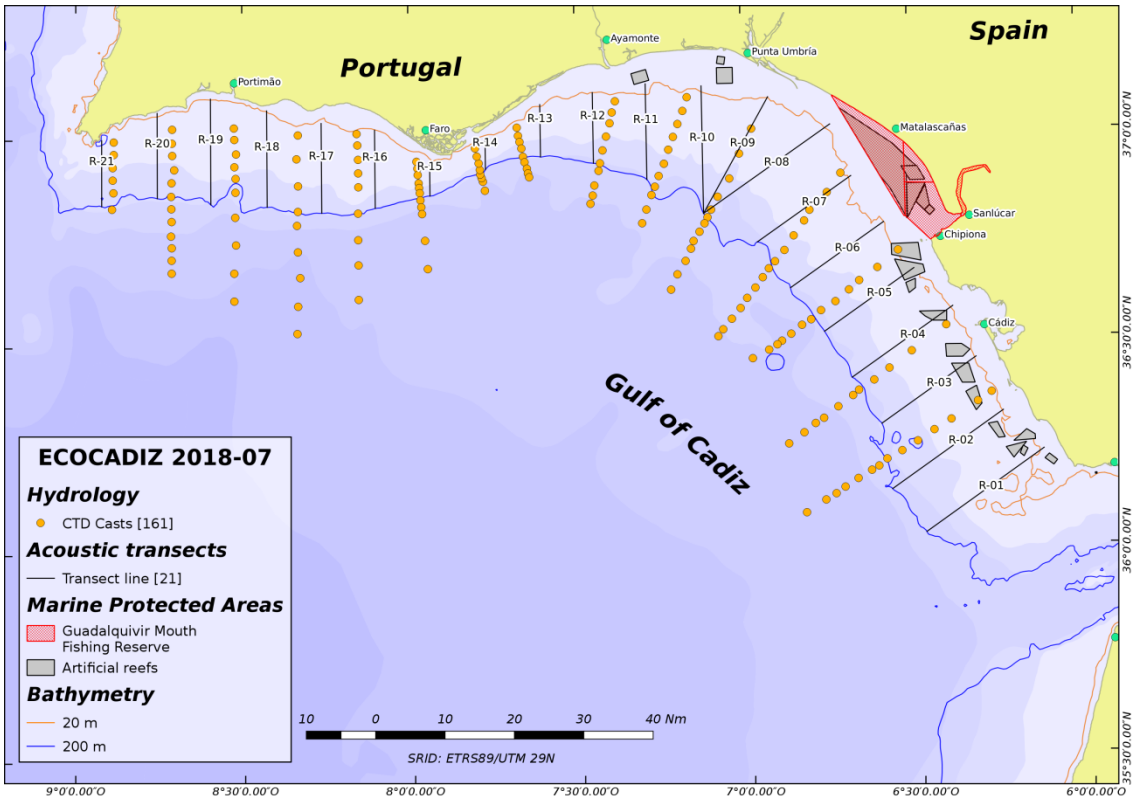


Figure 2. *ECOCADIZ 2018-07* survey. Location of CTD-LADCP stations.

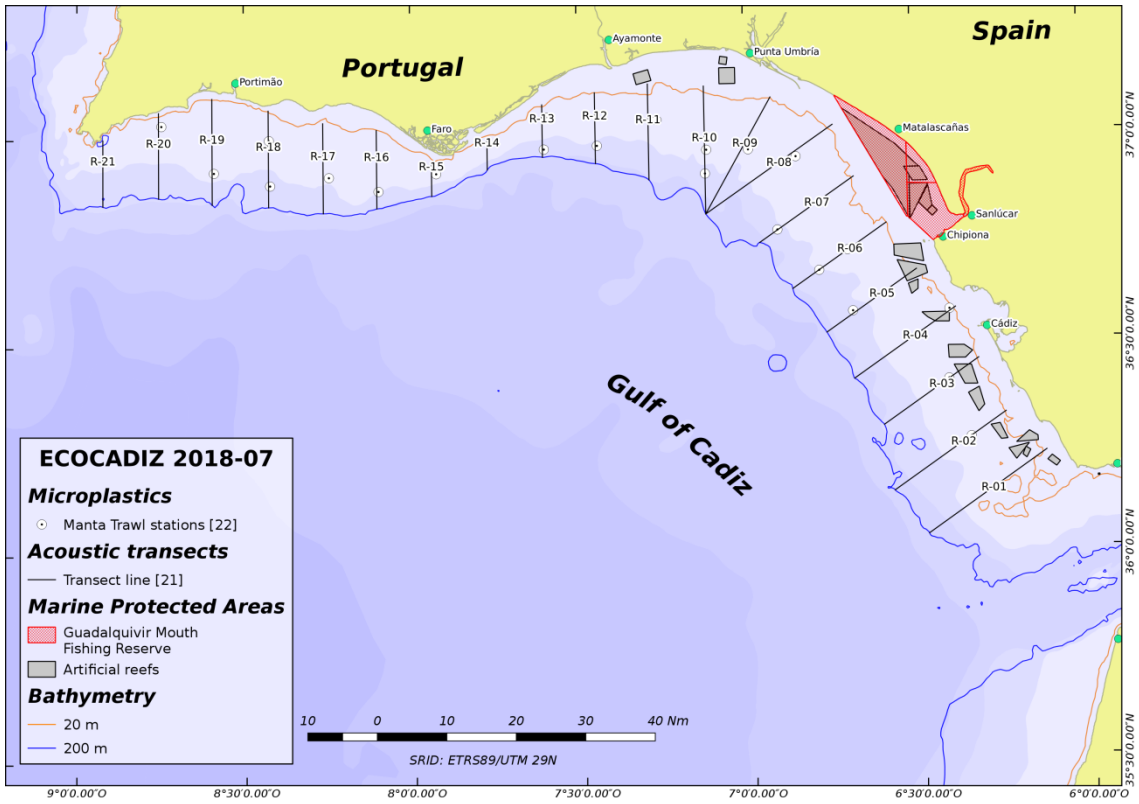


Figure 3. *ECOCADIZ 2018-07* survey. Location of Manta trawl hauls (micro-plastics).

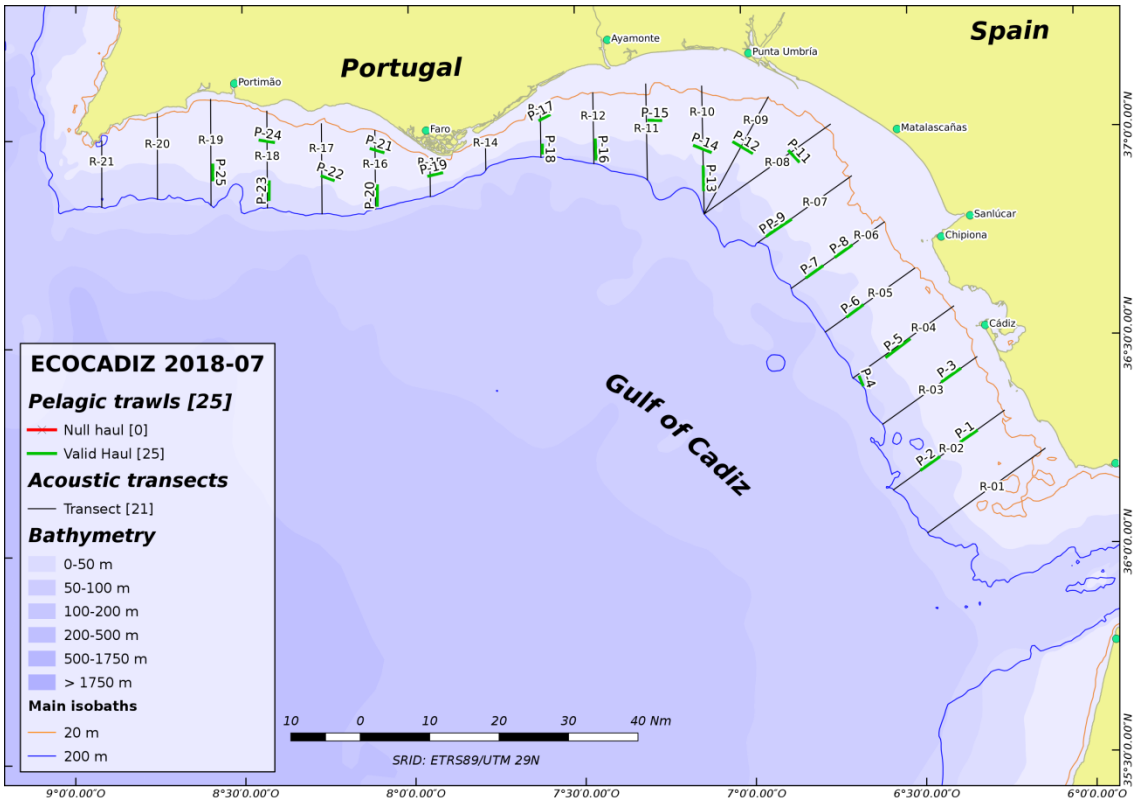


Figure 4. *ECOCADIZ 2018-07* survey. Location of ground-truthing fishing hauls.

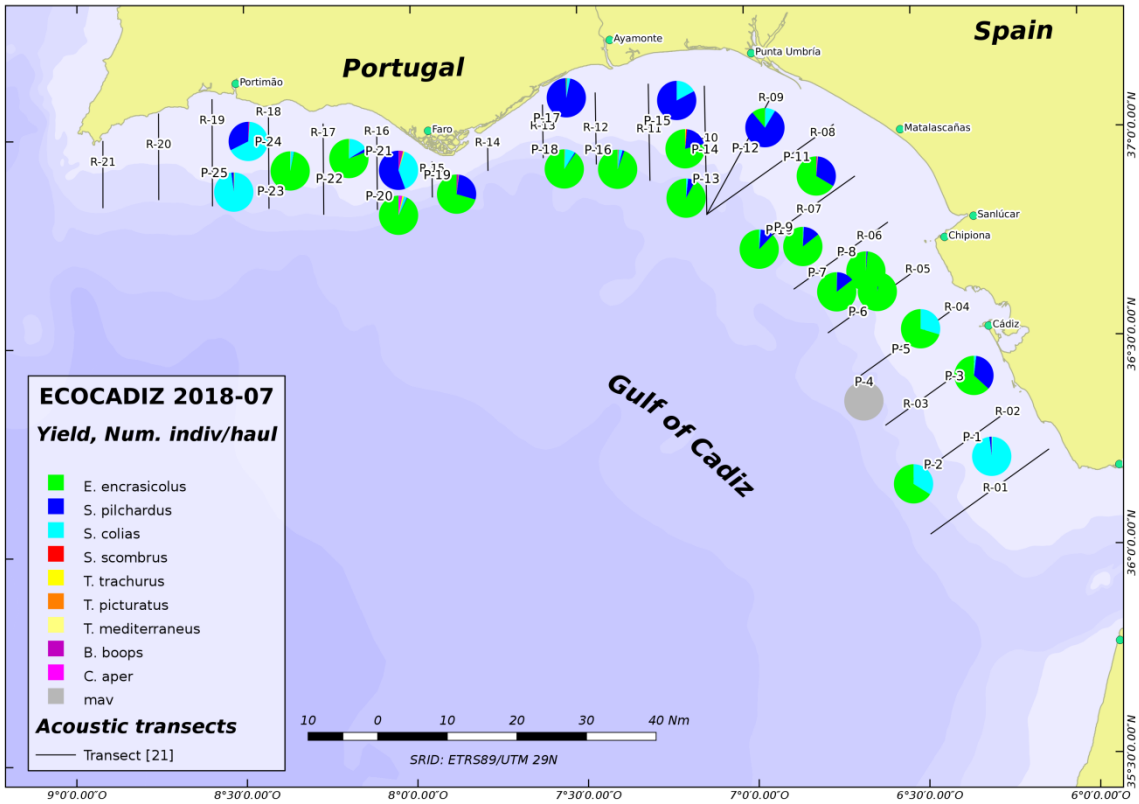


Figure 5. *ECOCADIZ 2018-07* survey. Species composition (percentages in number) in fishing hauls.

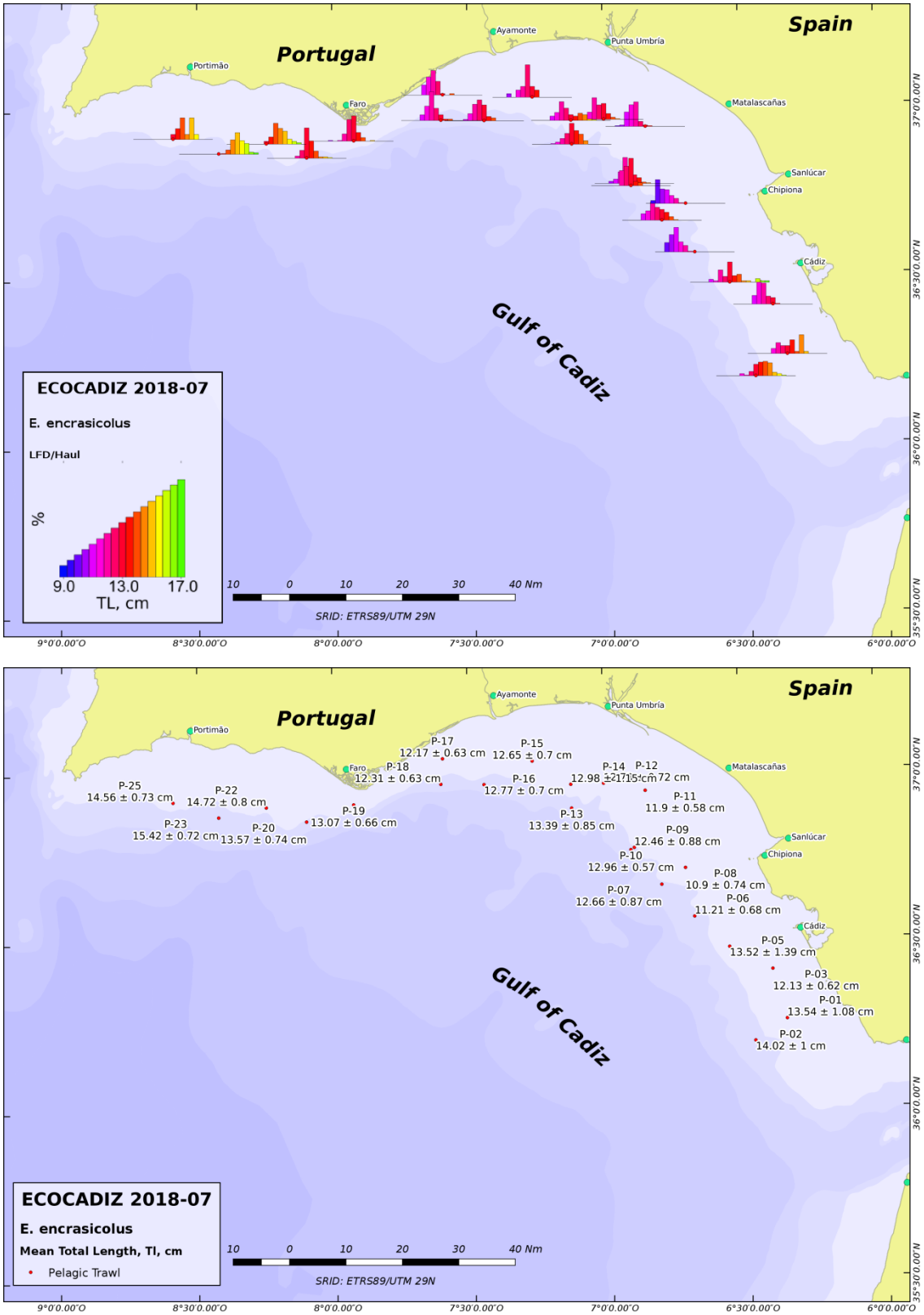


Figure 6. *ECOCADIZ 2018-07* survey. *Engraulis encrasicolus*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

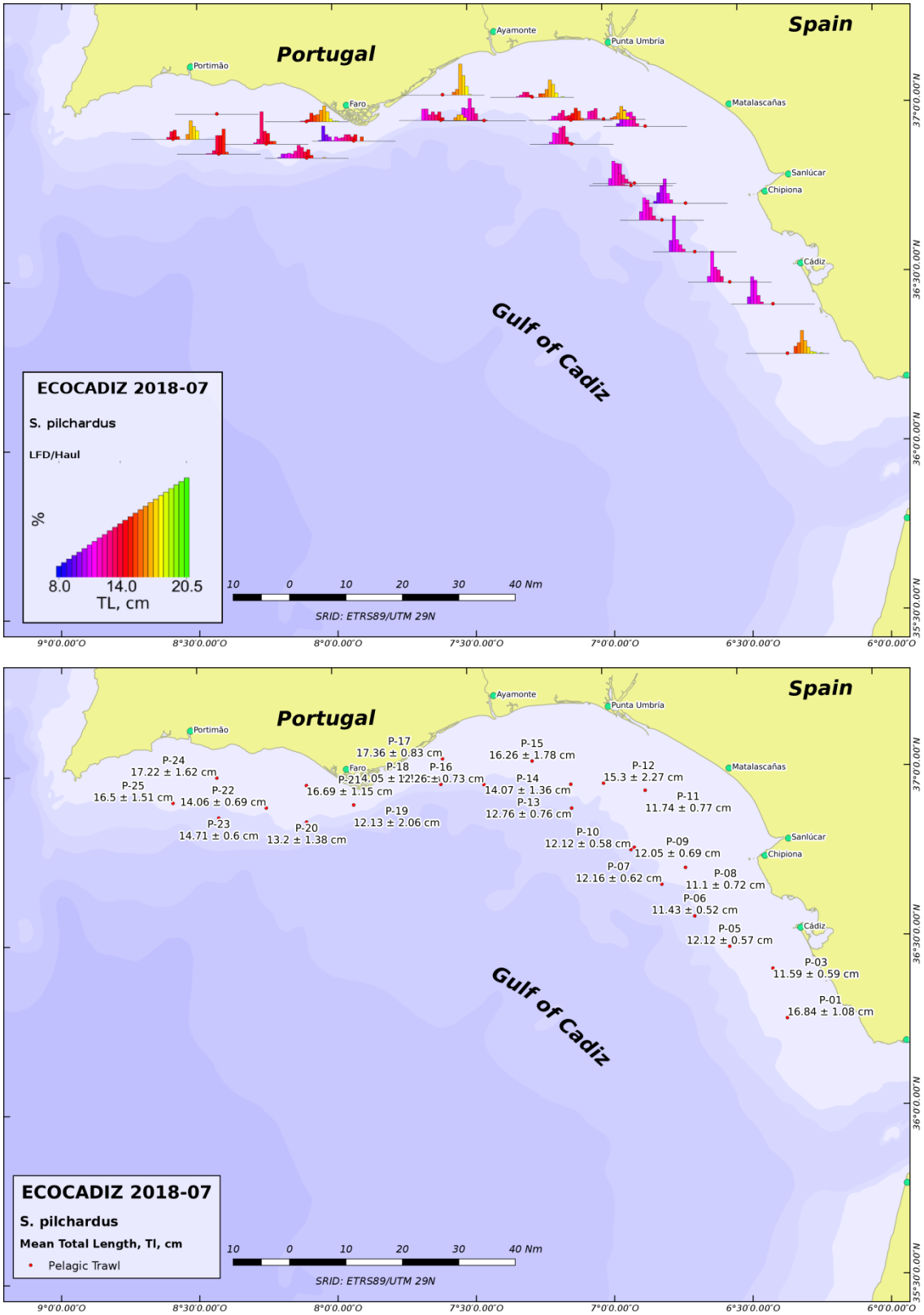


Figure 7. *ECOCADIZ 2018-07* survey. *Sardina pilchardus*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

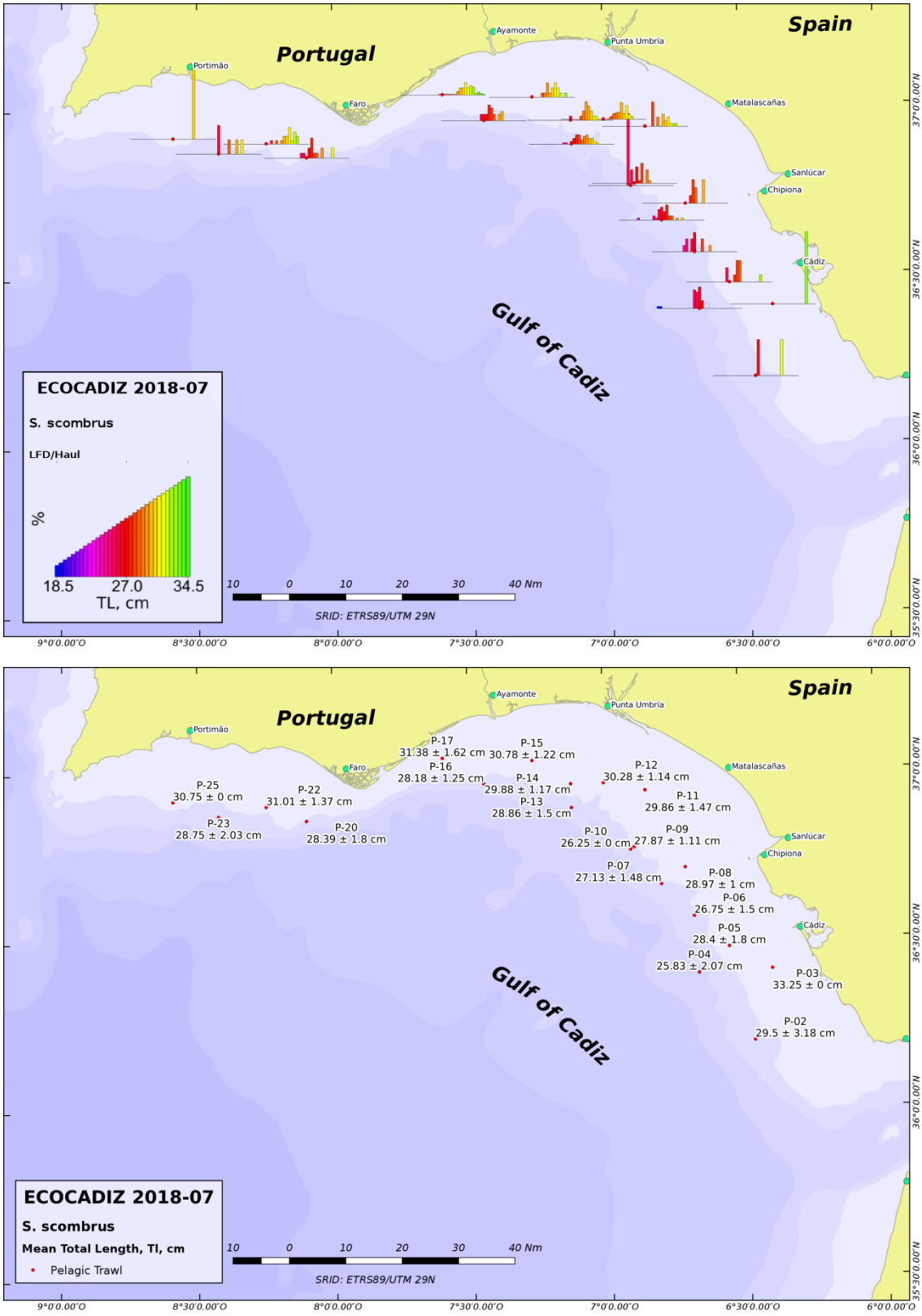


Figure 8. *ECOCADIZ 2018-07* survey. *Scomber scombrus*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

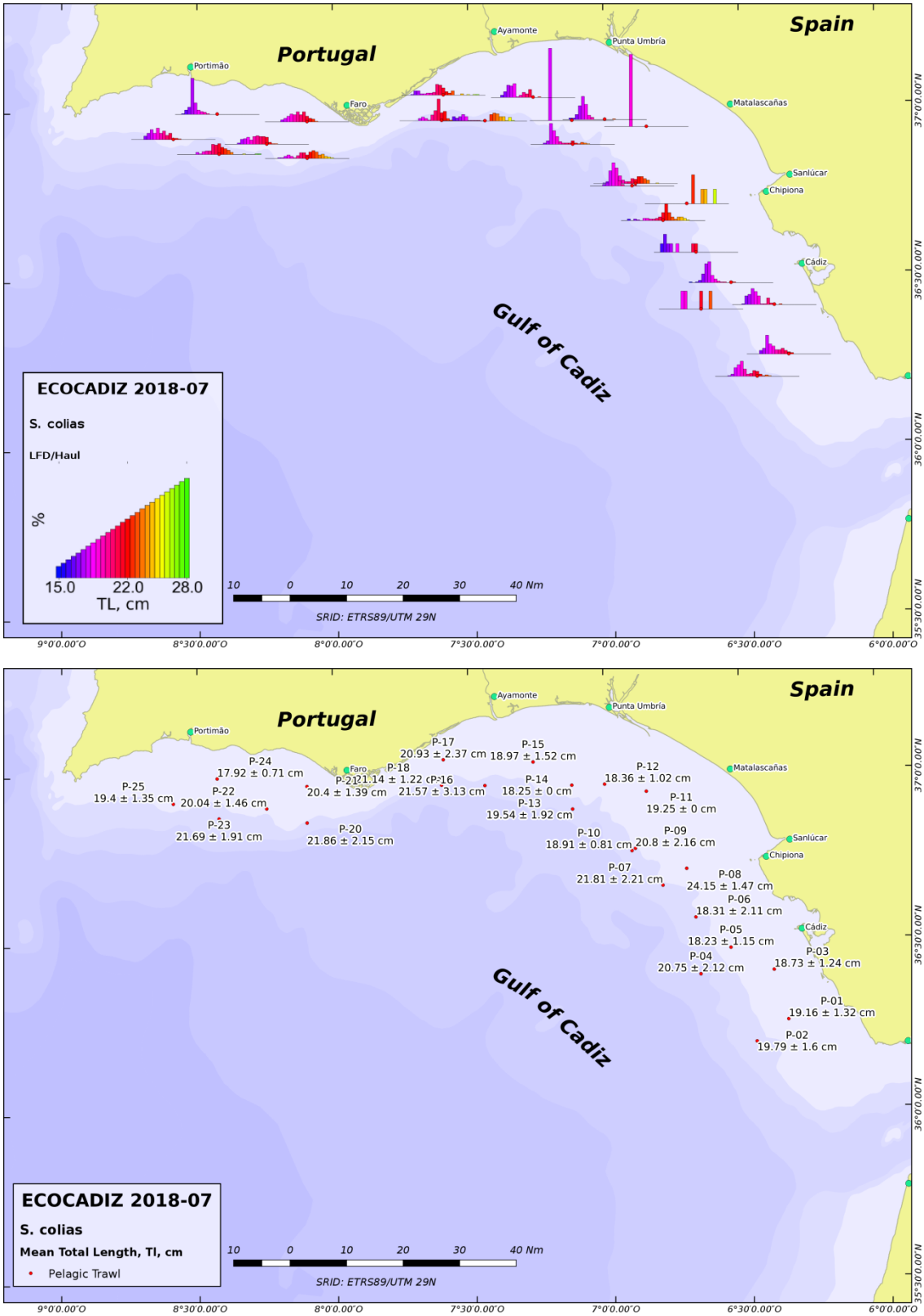


Figure 9. *ECOCADIZ 2018-07* survey. *Scomber colias*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

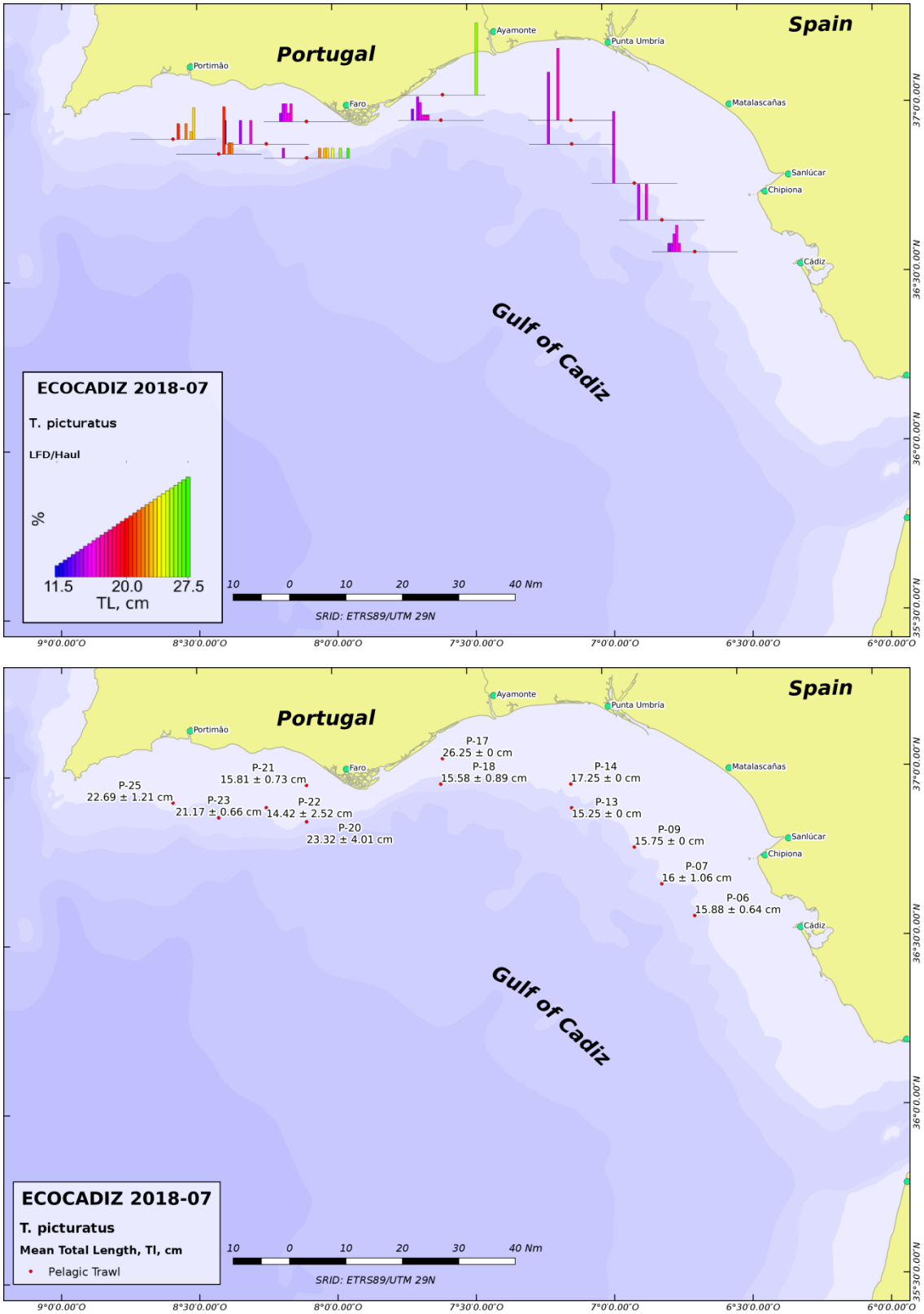


Figure 10. *ECOCADIZ 2018-07* survey. *Trachurus picturatus*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

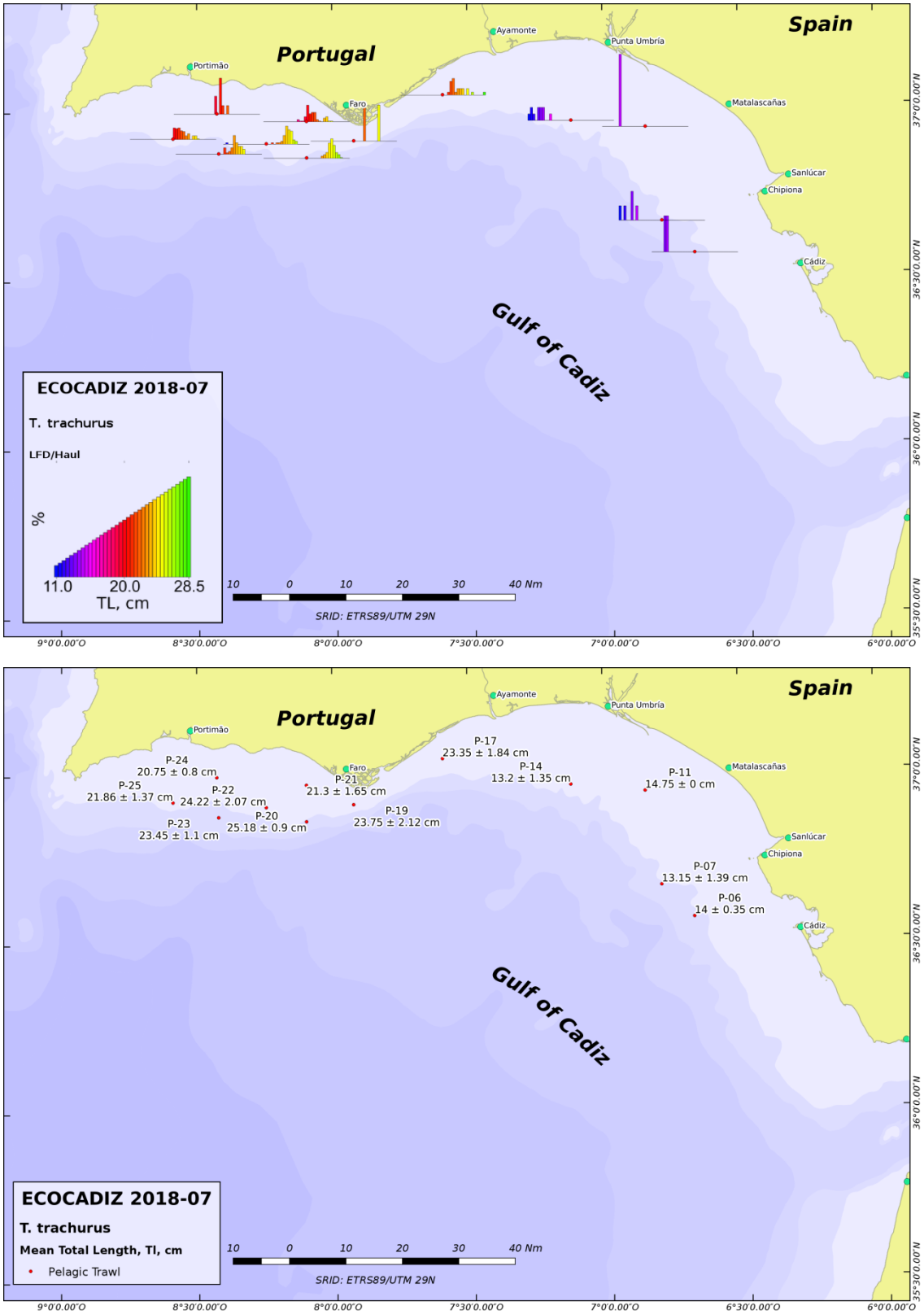


Figure 11. *ECOCADIZ 2018-07* survey. *Trachurus trachurus*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

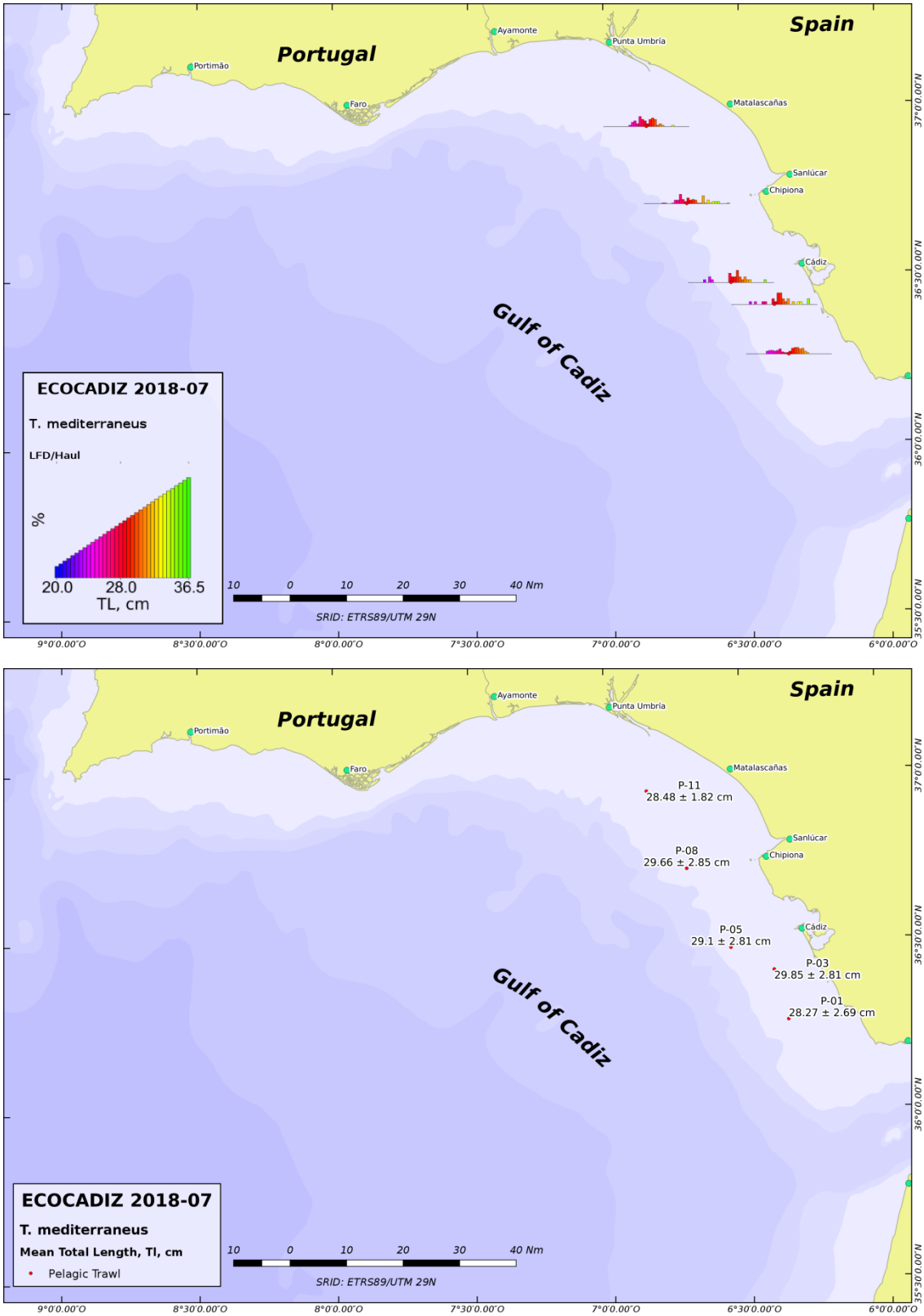


Figure 12. *ECOCADIZ 2018-07* survey. *Trachurus mediterraneus*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

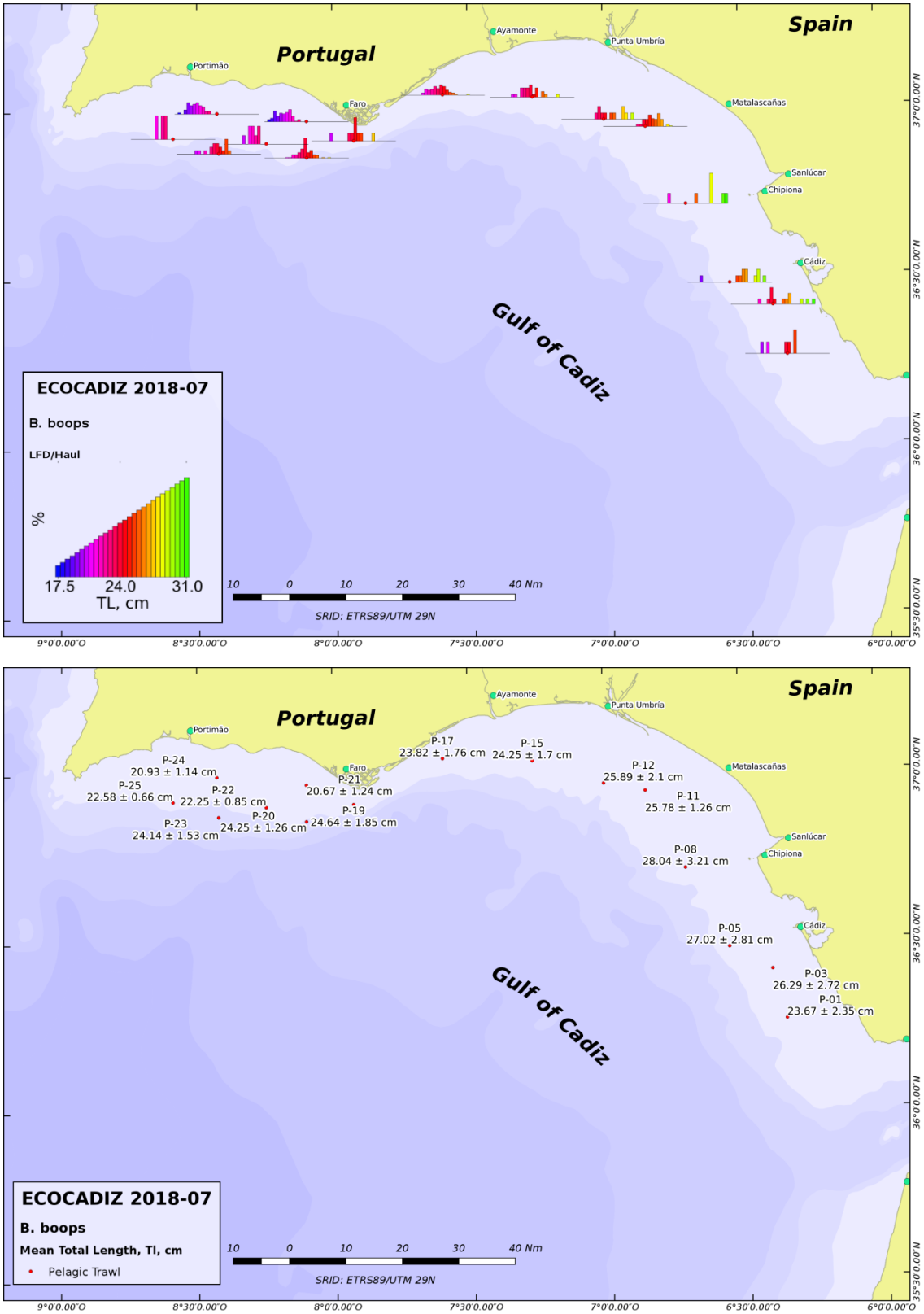


Figure 13. *ECOCADIZ 2018-07* survey. *Boops boops*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

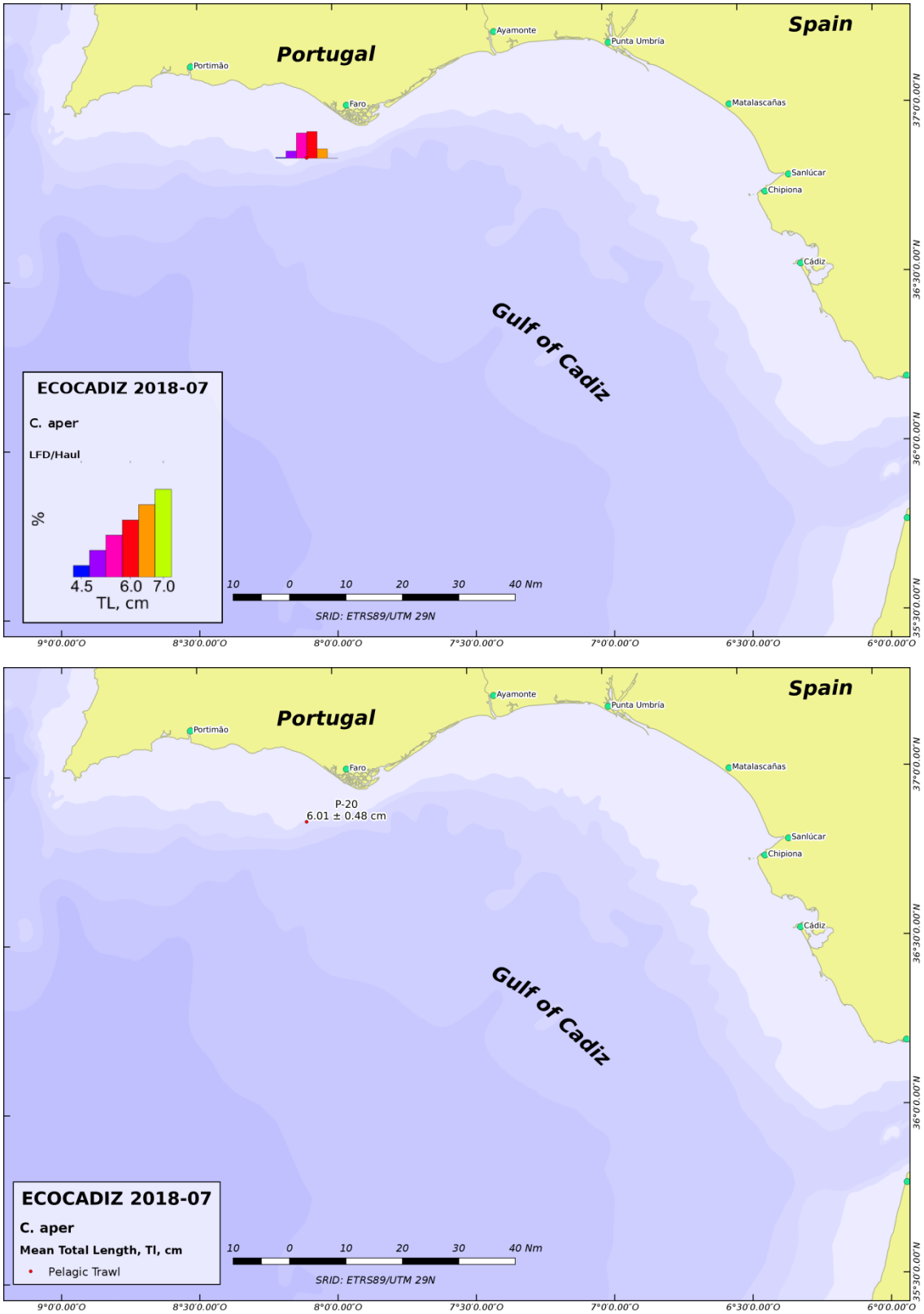


Figure 14. *ECOCADIZ 2017-07* survey. *Capros aper*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

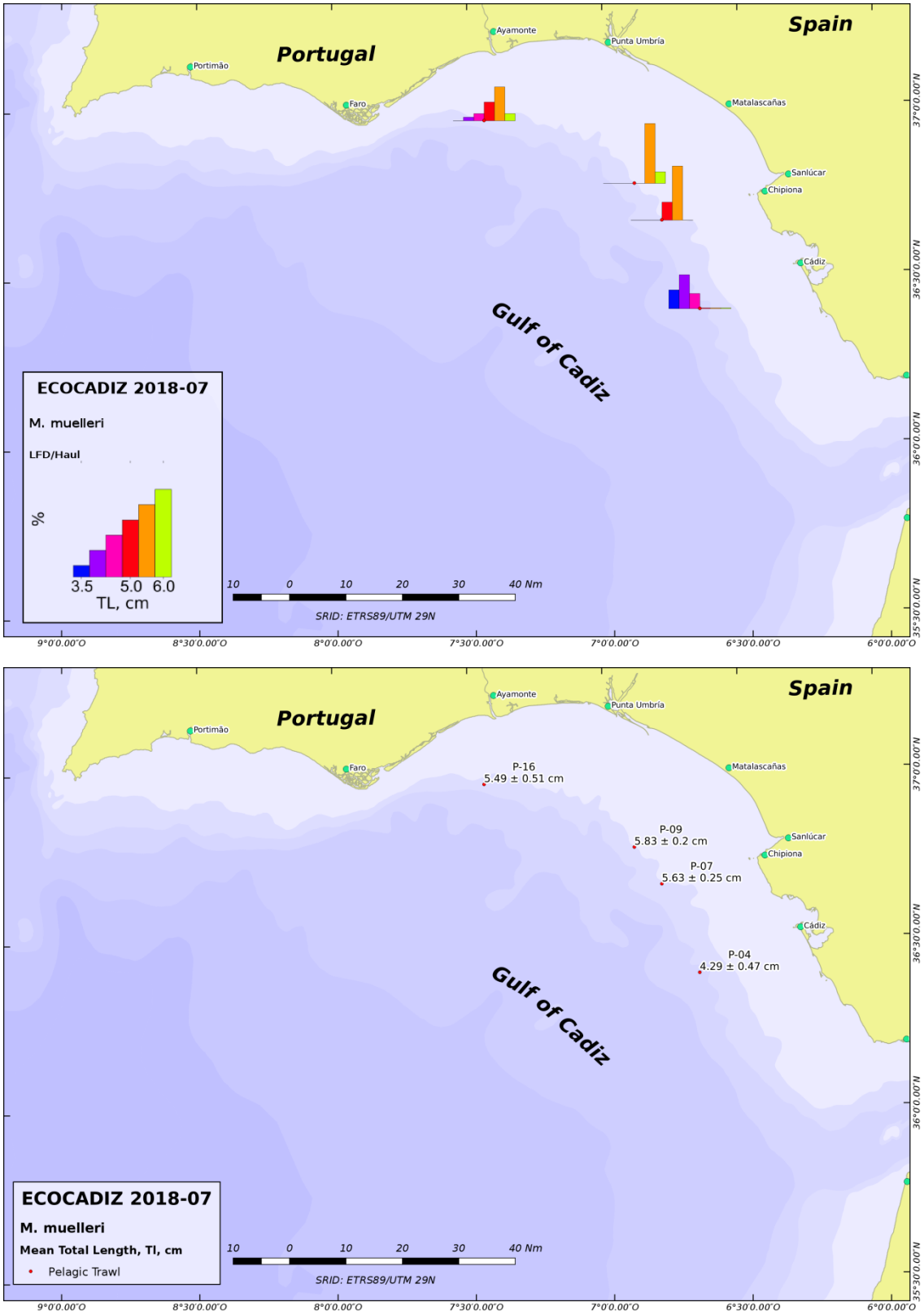


Figure 15. *ECOCADIZ 2017-07* survey. *Maurolicus muelleri*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

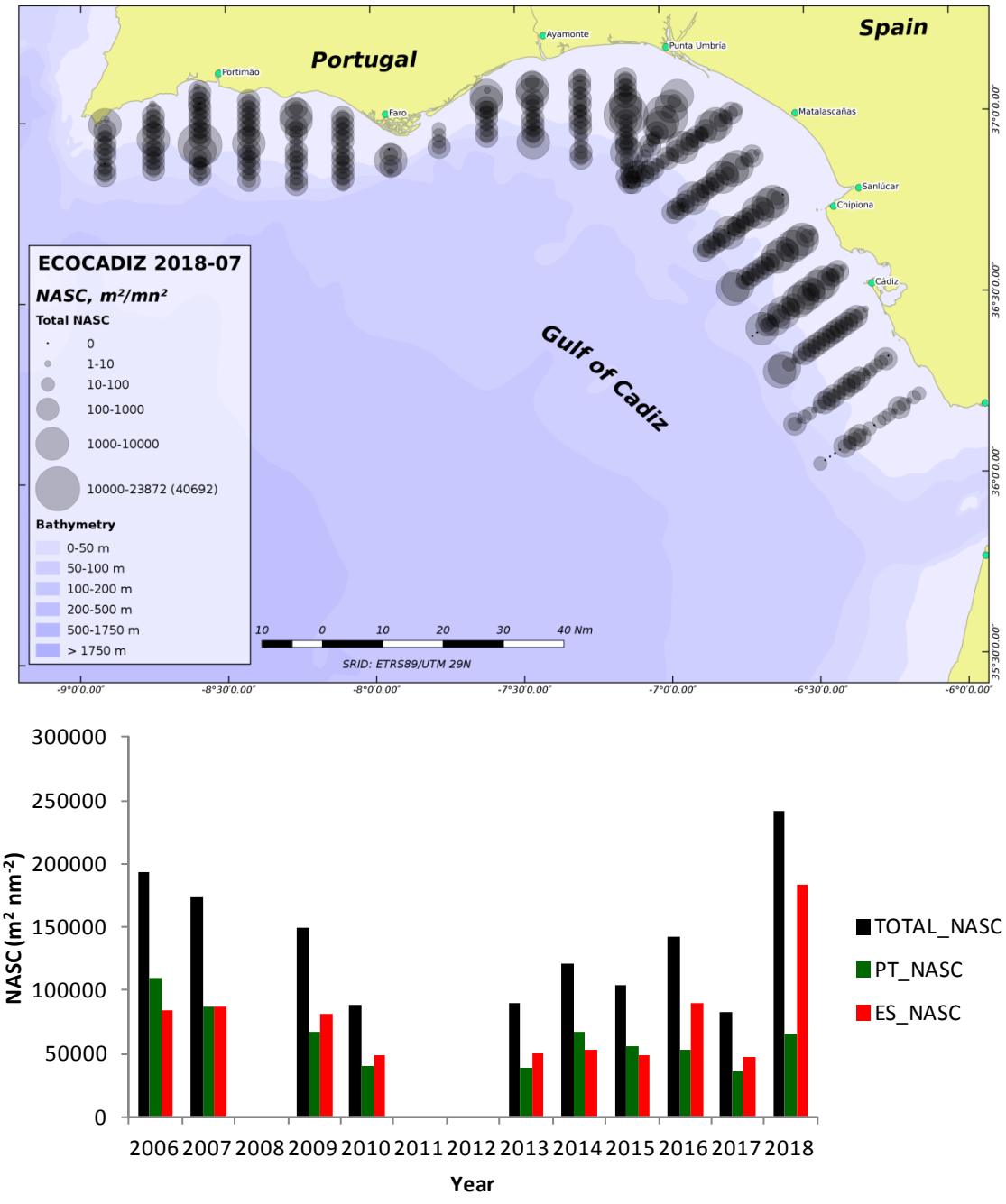


Figure 16. *ECOCADIZ 2018-07* survey. Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the pelagic fish species assemblage. Bottom: time-series of total NASC estimates per survey.

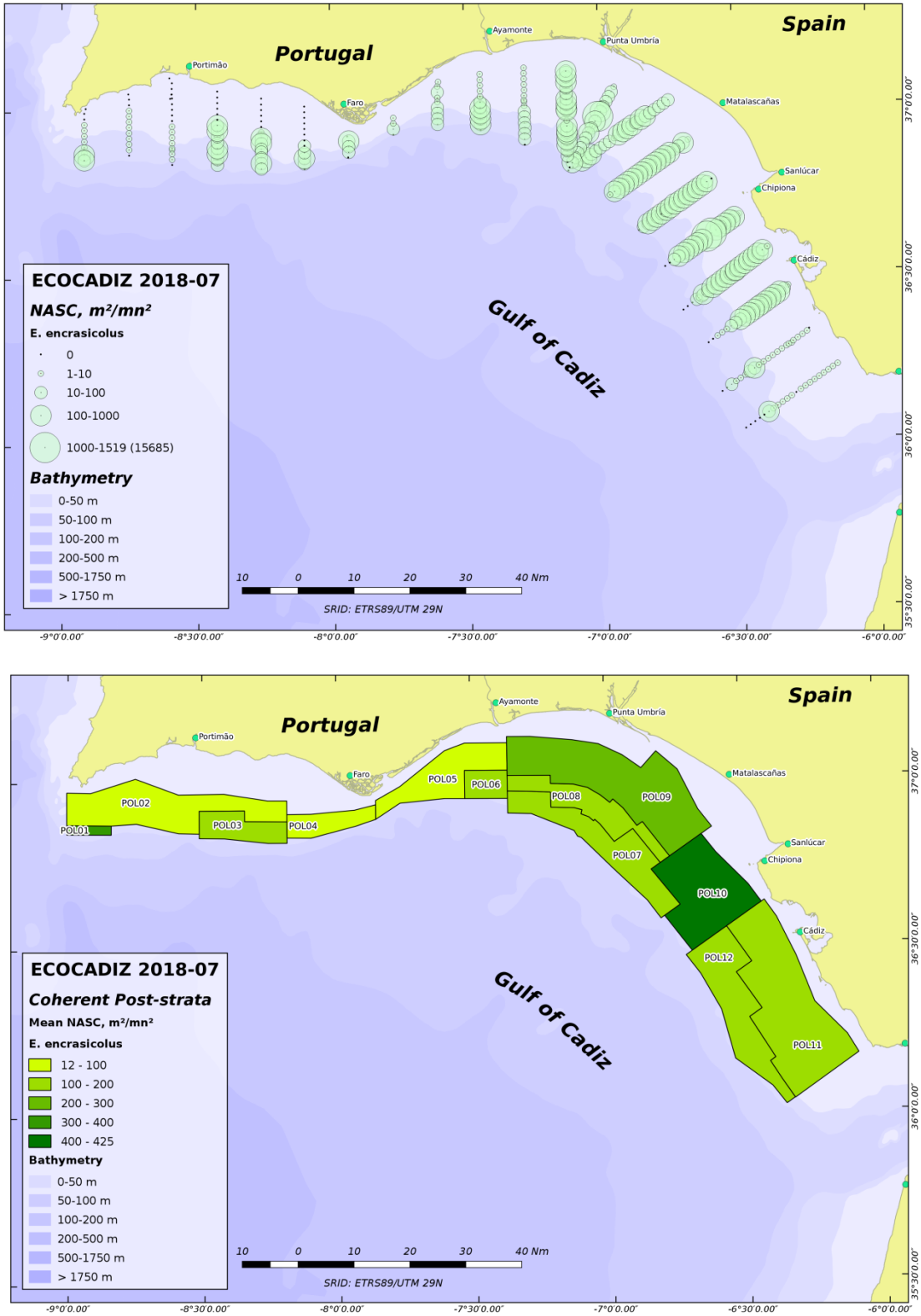


Figure 17. *ECOCADIZ 2018-07* survey. Anchovy (*Engraulis encrasicolus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

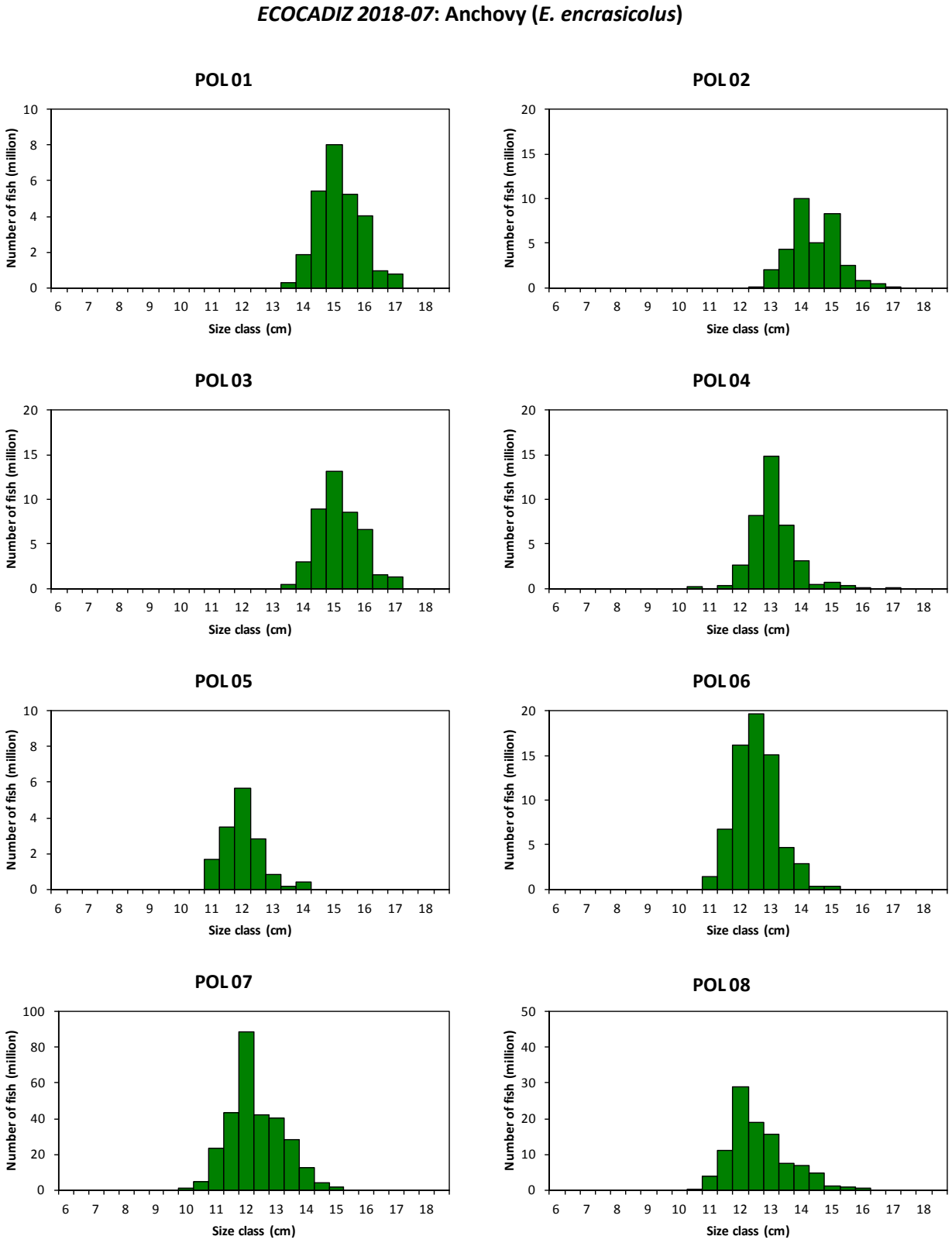


Figure 18. *ECOCADIZ 2018-07* survey. Anchovy (*E. encrasicolus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 17**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

ECOCADIZ 2018-07: Anchovy (*E. encrasicolus*)

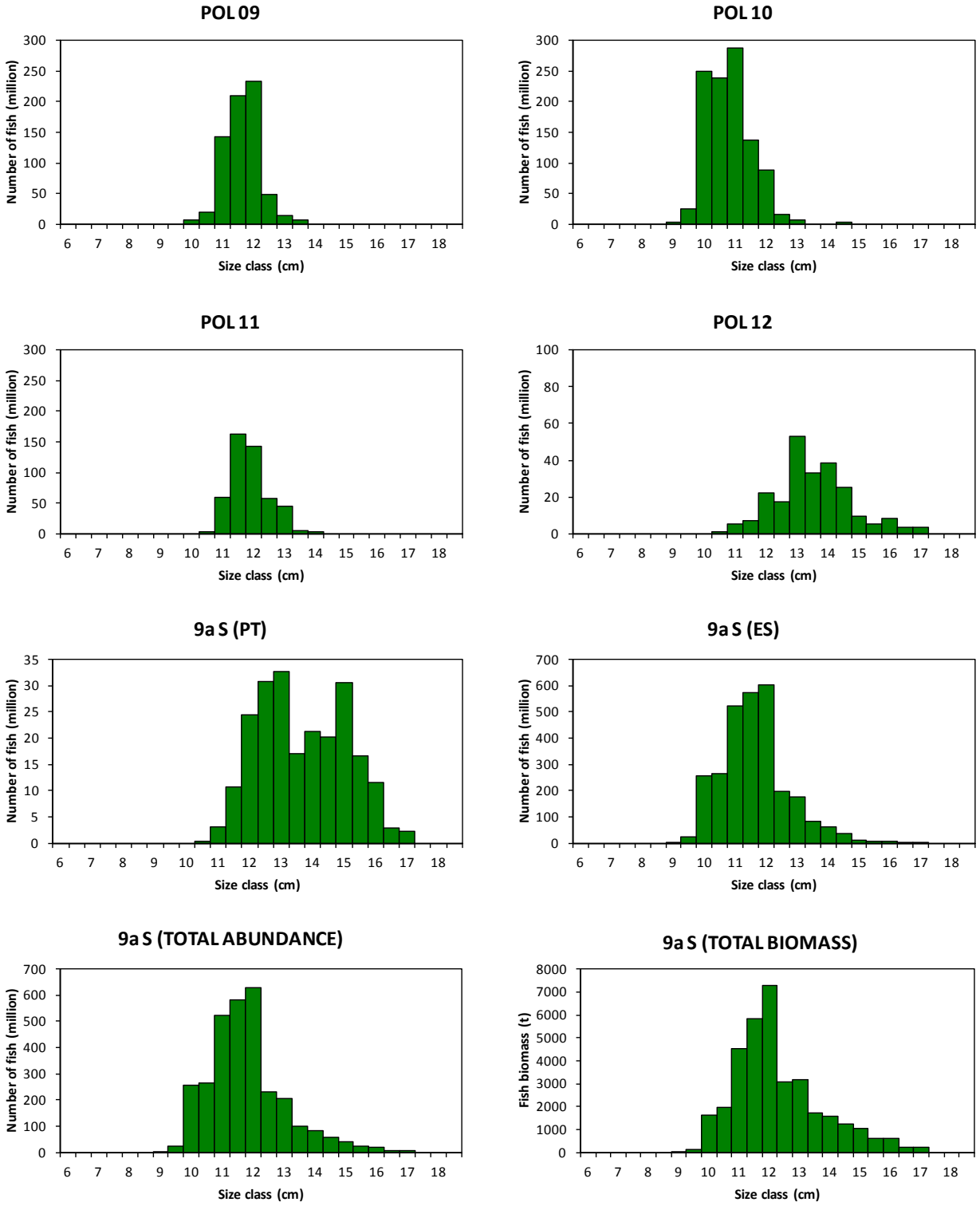


Figure 18. *ECOCADIZ 2018-07* survey. Anchovy (*E. encrasicolus*). Cont'd.

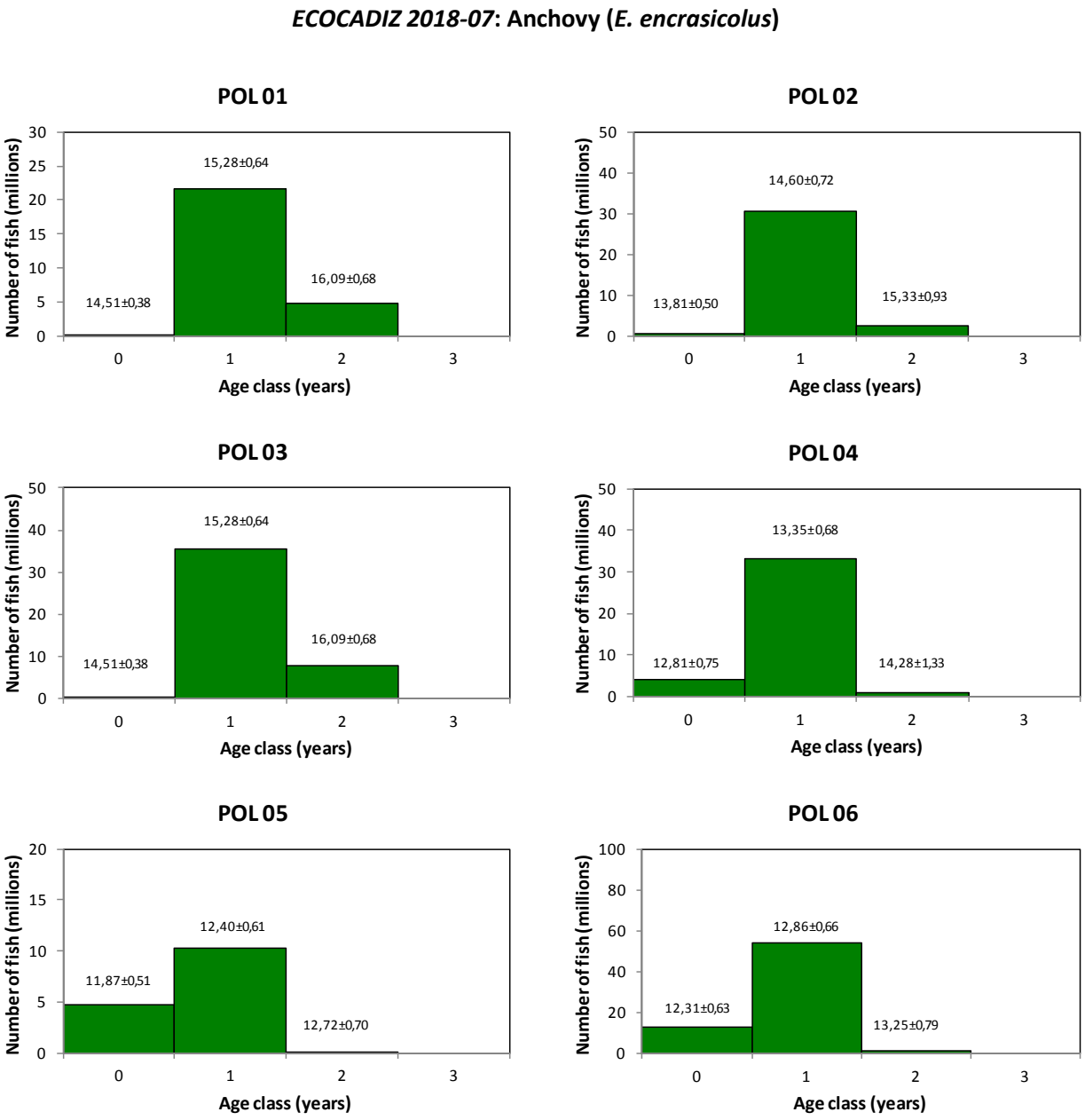


Figure 19. *ECOCADIZ 2018-07* survey. Anchovy (*E. encrasicolus*). Estimated abundances (number of fish in millions) by age group (years) by homogeneous stratum (POL01-POLn, numeration as in **Figure 17**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by age group for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

ECOCADIZ 2018-07: Anchovy (*E. encrasicolus*)

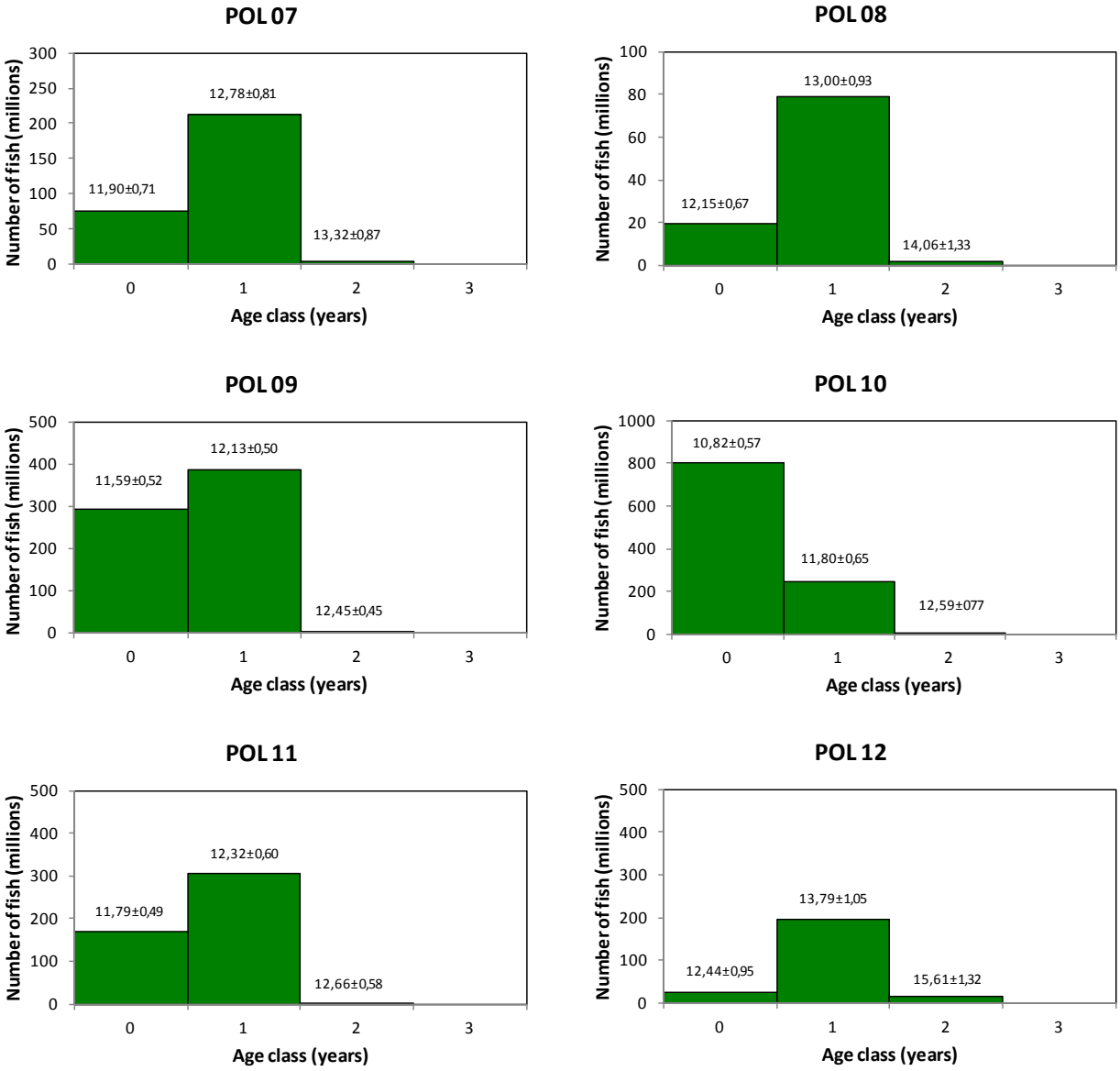


Figure 19. *ECOCADIZ 2018-07* survey. Anchovy (*E. encrasicolus*). Cont'd.

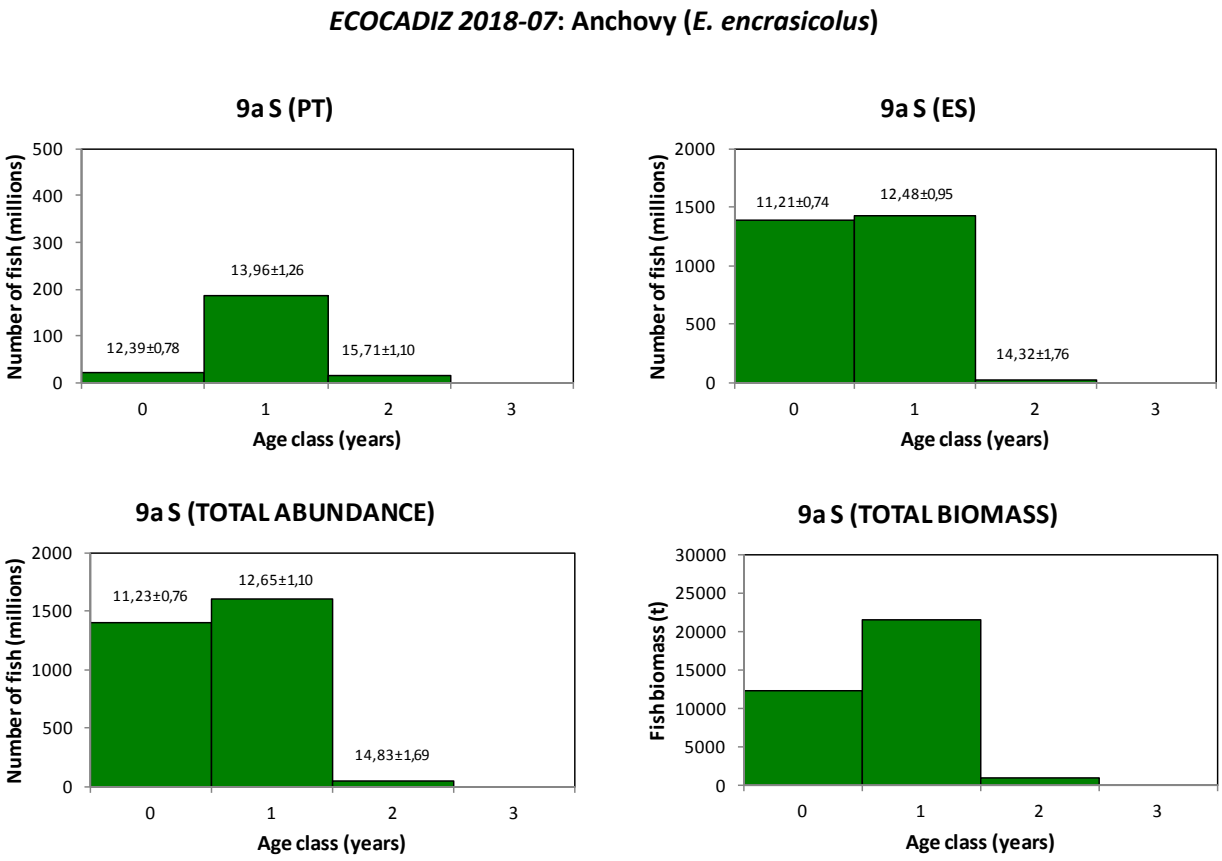
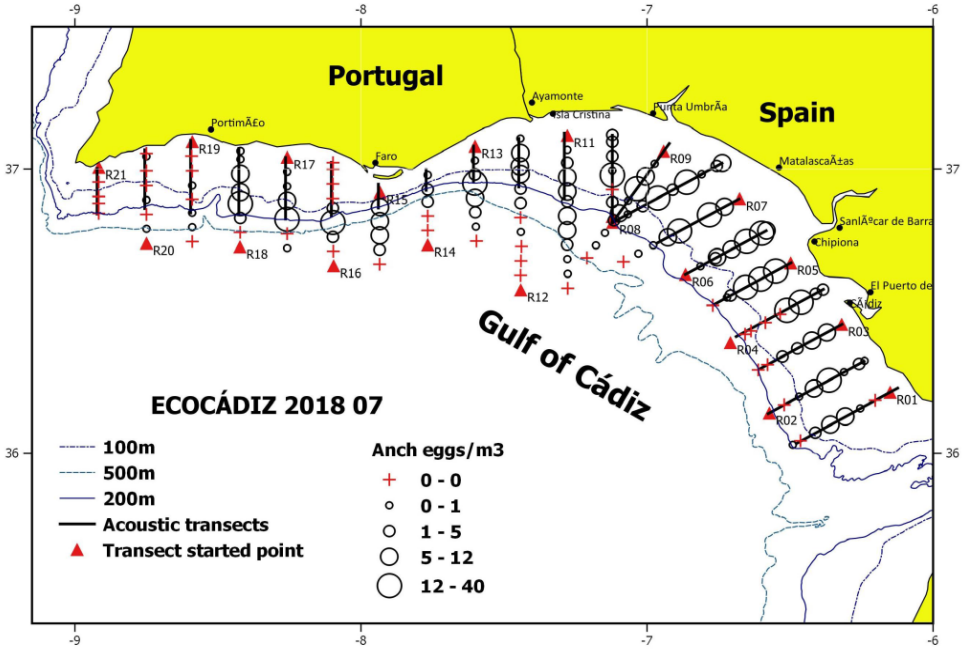
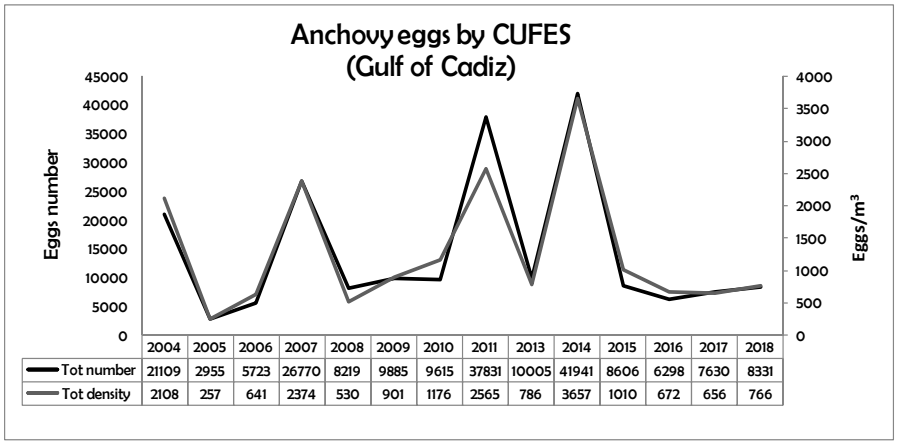


Figure 19. *ECOCADIZ 2018-07* survey. Anchovy (*E. encrasicolus*). Cont'd.

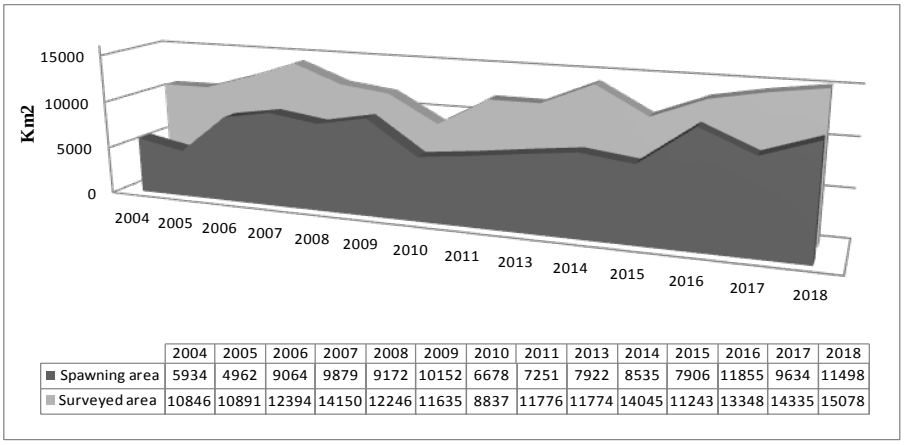


ECOCADIZ 2018-07	
CUFES st	151
Positive anchovy st8	111 (73.5 %)
Max number eggs by st	1453
Total anchovy eggs (in number)	7630
Max density by st (eggs/100 m^3)	122
Total density (eggs/100 m^3)	656

Figure 20. *ECOCADIZ 2018-07* survey. Anchovy (*E. encrasicolus*). Top: distribution of anchovy egg densities sampled by CUFES (eggs m^{-3}). Bottom: main descriptors of the CUFES sampling. Bottom: historical series of GoC anchovy egg densities as sampled by CUFES.



	2004	2005	2006	2007	2008	2009	2010	2011	2013	2014	2015	2016	2017	2018
Tot number	21109	2955	5723	26770	8219	9885	9615	37831	10005	41941	8606	6298	7630	8331
Tot density	2108	257	641	2374	530	901	1176	2565	786	3657	1010	672	656	766



	2004	2005	2006	2007	2008	2009	2010	2011	2013	2014	2015	2016	2017	2018
Spawning area	5934	4962	9064	9879	9172	10152	6678	7251	7922	8535	7906	11855	9634	11498
Surveyed area	10846	10891	12394	14150	12246	11635	8837	11776	11774	14045	11243	13348	14335	15078

Figure 20. *ECOCADIZ 2018-07* survey. Anchovy (*E. encrasicolus*). Cont'd. Top: historical series of GoC anchovy egg total numbers and densities (eggs * m^{-3}) sampled by CUFES. Bottom: historical series of estimates of the extension of the GoC anchovy spawning area (in km^2).

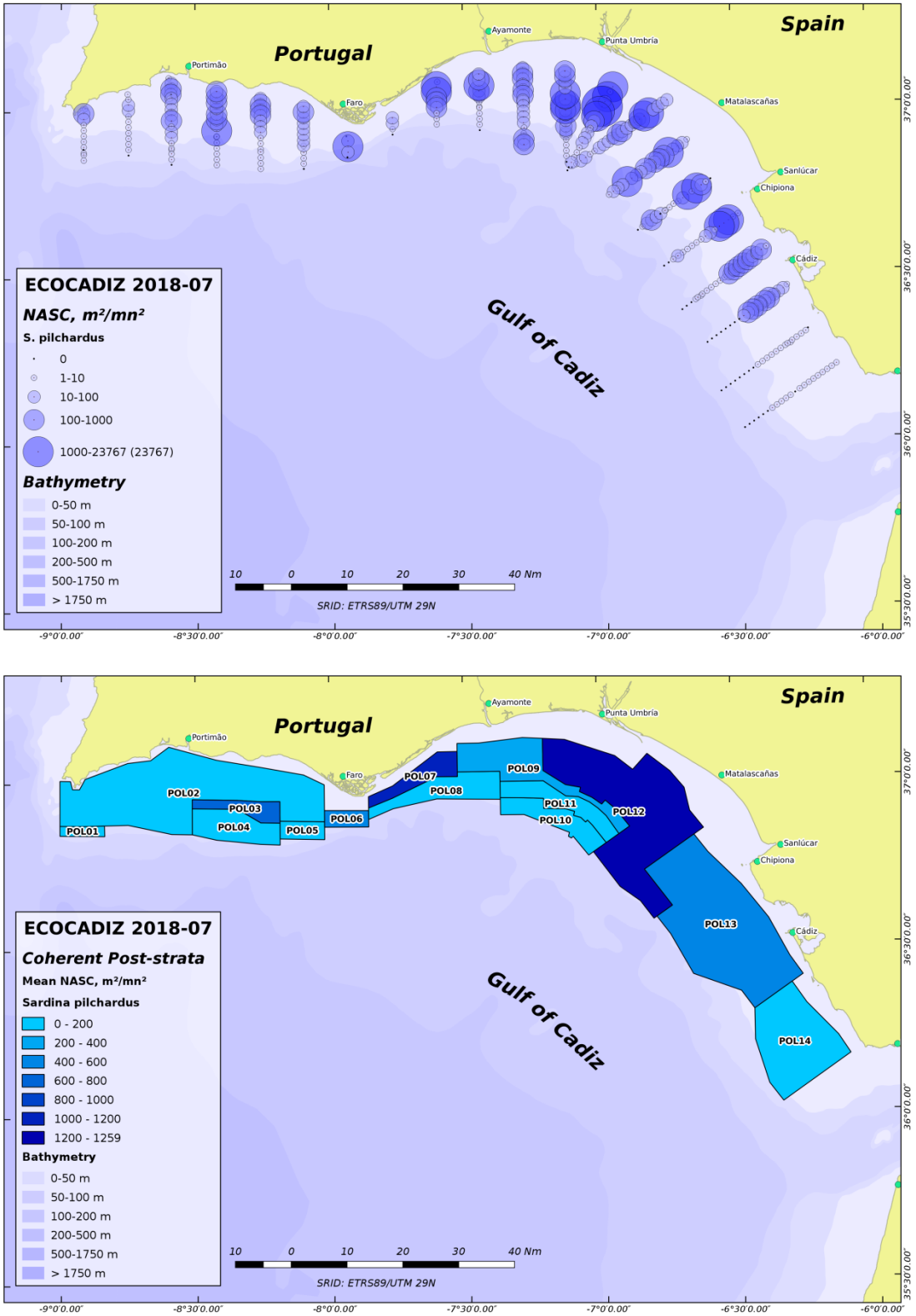


Figure 21. *ECOCADIZ 2018-07* survey. Sardine (*Sardina pilchardus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

ECOCADIZ 2018-07: Sardine (*S. pilchardus*)

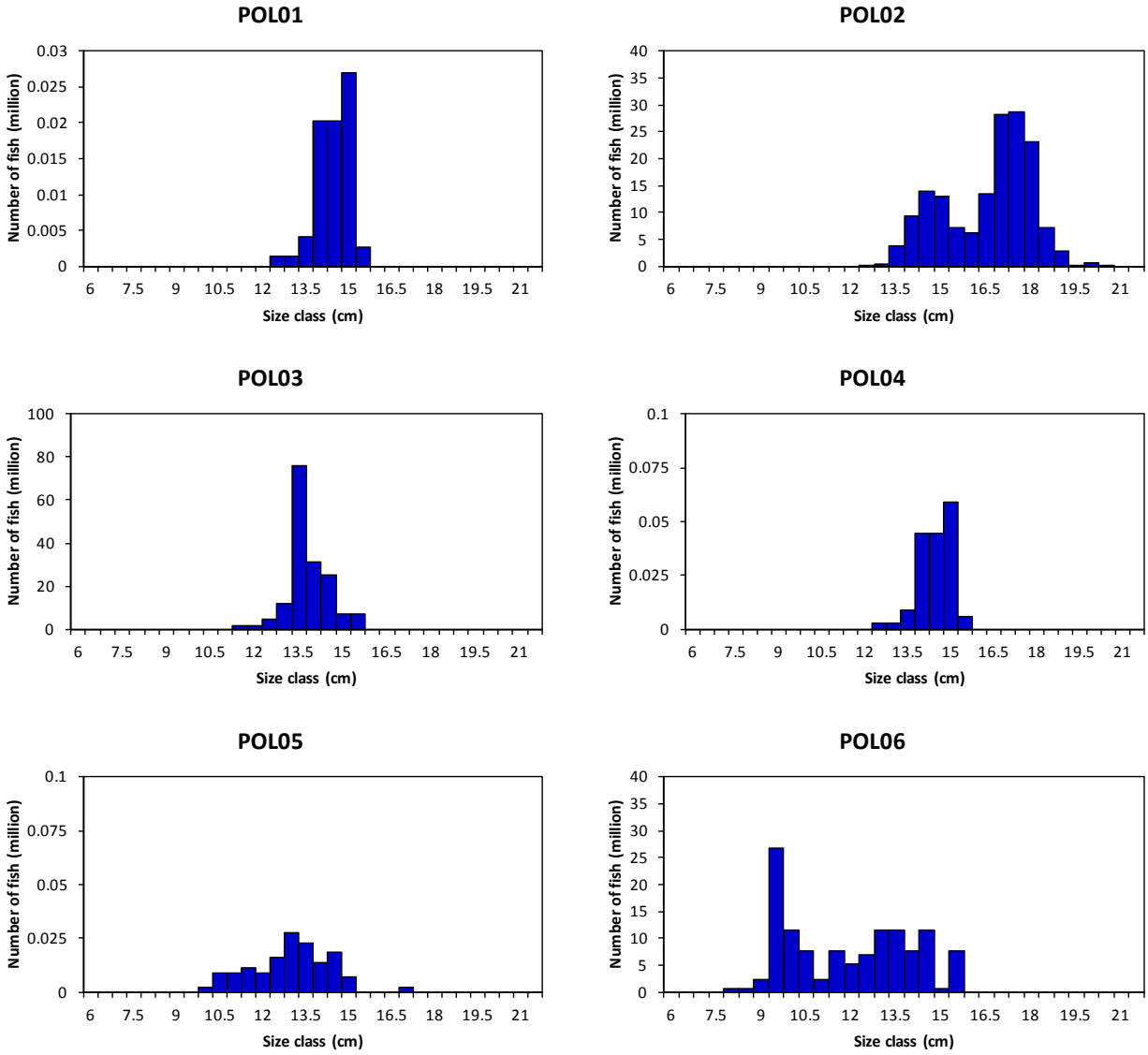


Figure 22. *ECOCADIZ 2018-07* survey. Sardine (*S. pilchardus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 21**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

ECOCADIZ 2018-07: Sardine (*S. pilchardus*)

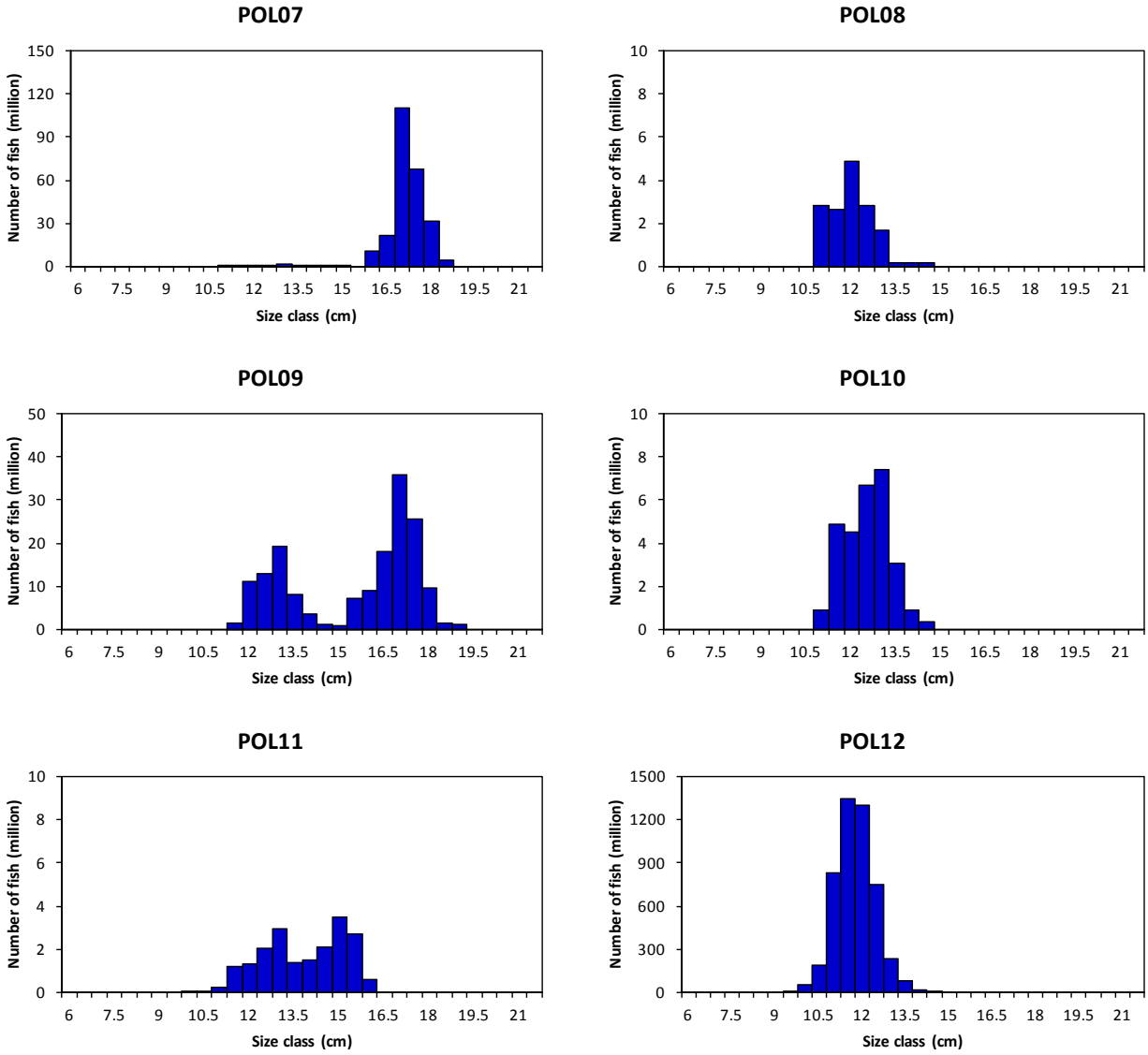


Figure 22. *ECOCADIZ 2018-07* survey. Sardine (*S. pilchardus*). Cont'd.

ECOCADIZ 2018-07: Sardine (*S. pilchardus*)

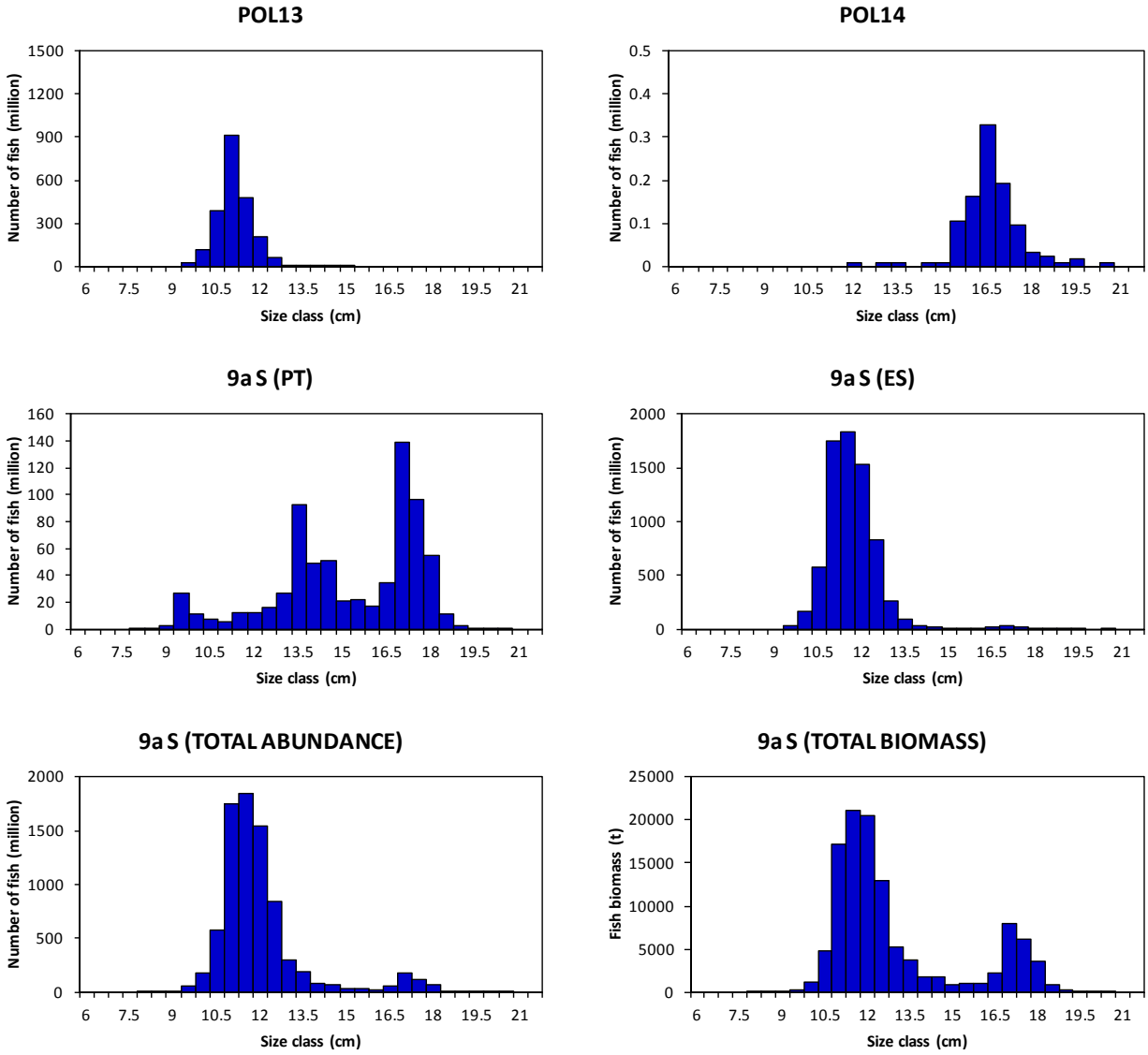


Figure 22. *ECOCADIZ 2018-07* survey. Sardine (*S. pilchardus*). Cont'd.

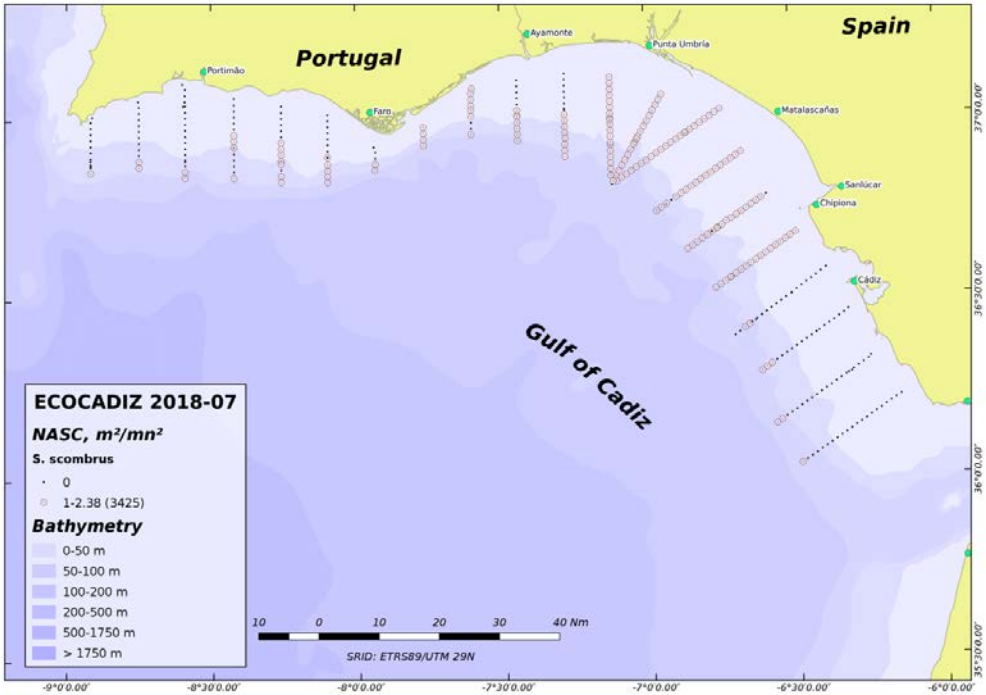


Figure 23. *ECOCADIZ 2018-07* survey. Mackerel (*Scomber scombrus*). Distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species.

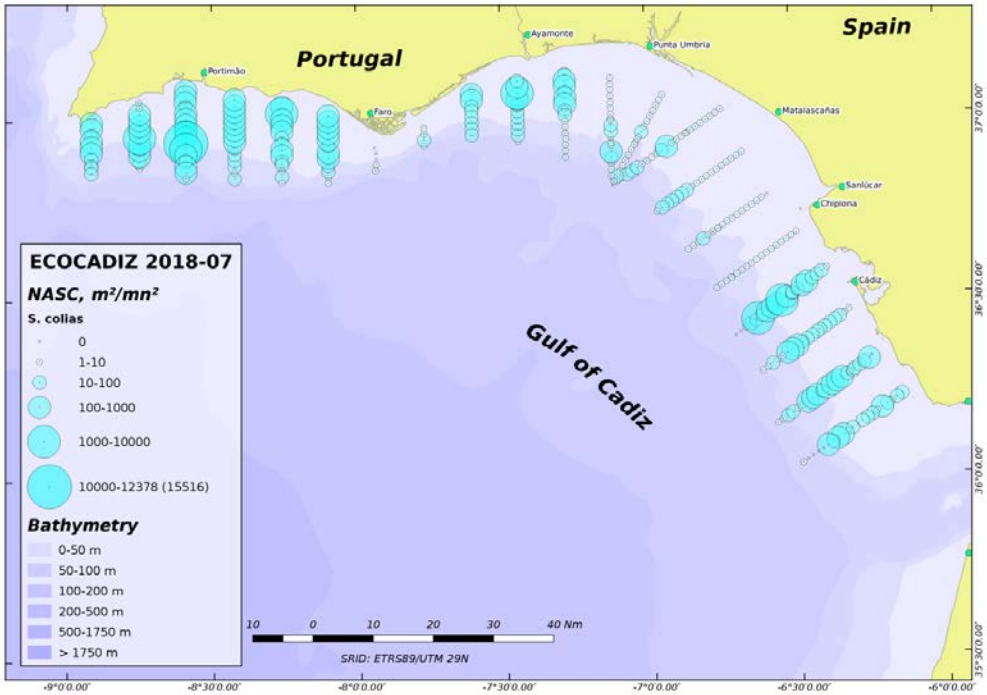


Figure 24. *ECOCADIZ 2018-07* survey. Chub mackerel (*Scomber colias*). Distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species.

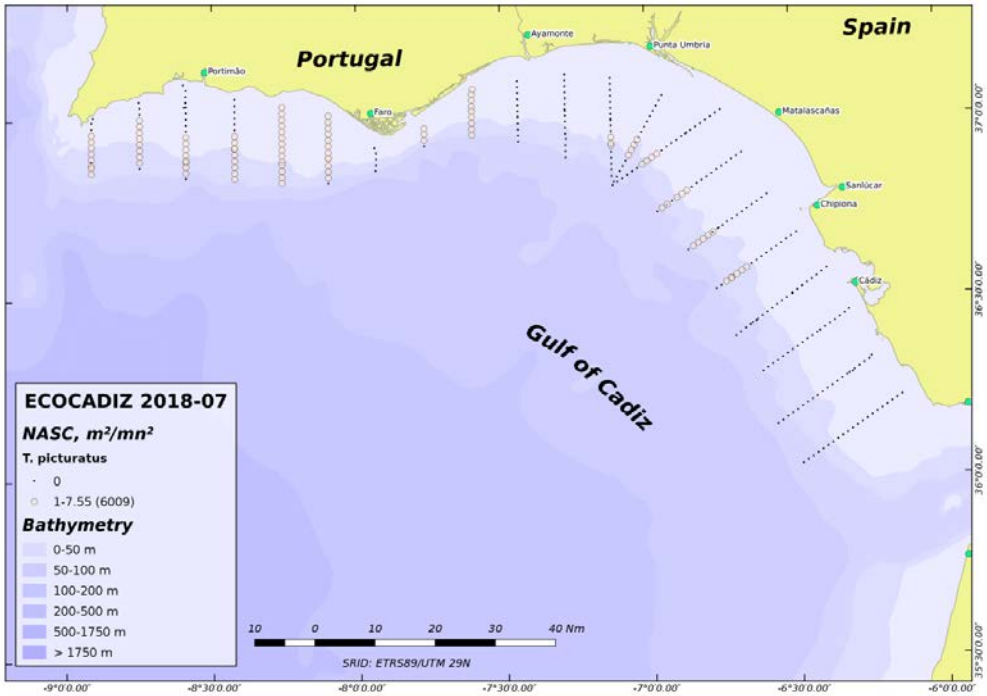


Figure 25. *ECOCADIZ 2018-07* survey. Blue jack mackerel (*Trachurus picturatus*). Distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species.

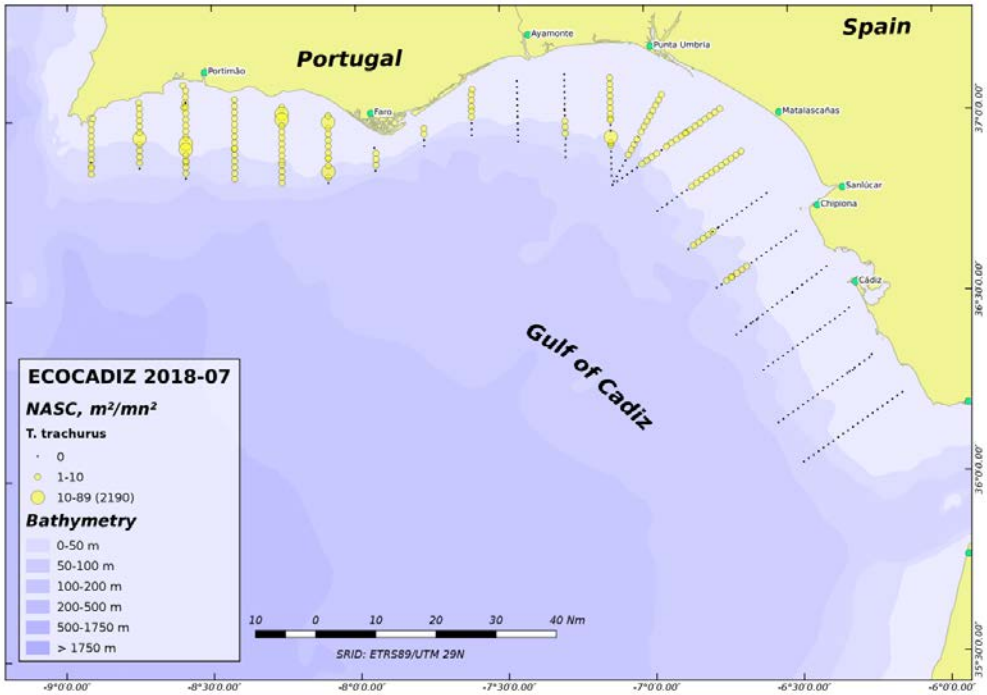


Figure 26. *ECOCADIZ 2018-07* survey. Horse mackerel (*Trachurus trachurus*). Distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species.

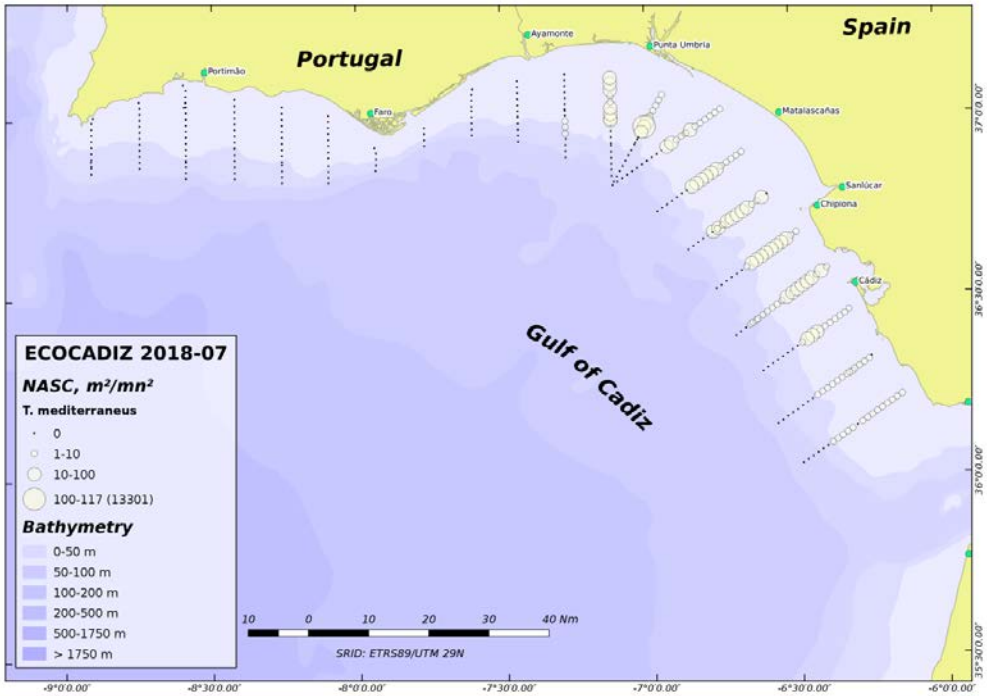


Figure 27. *ECOCADIZ 2018-07* survey. Mediterranean horse mackerel (*Trachurus mediterraneus*). Distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species.

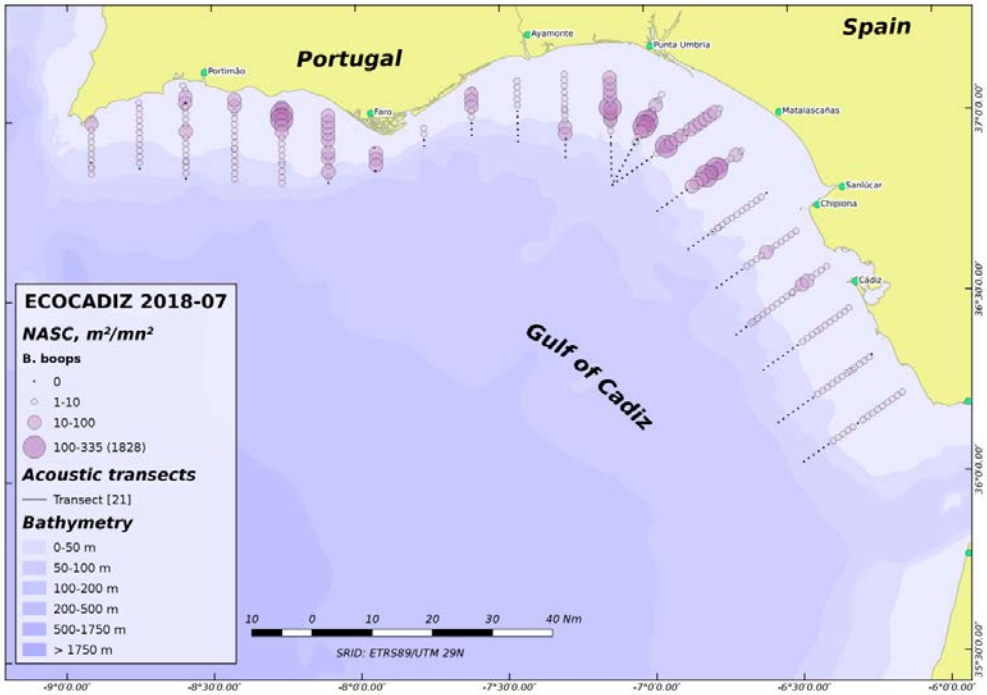


Figure 28. *ECOCADIZ 2018-07* survey. Bogue (*Boops boops*). Distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species.

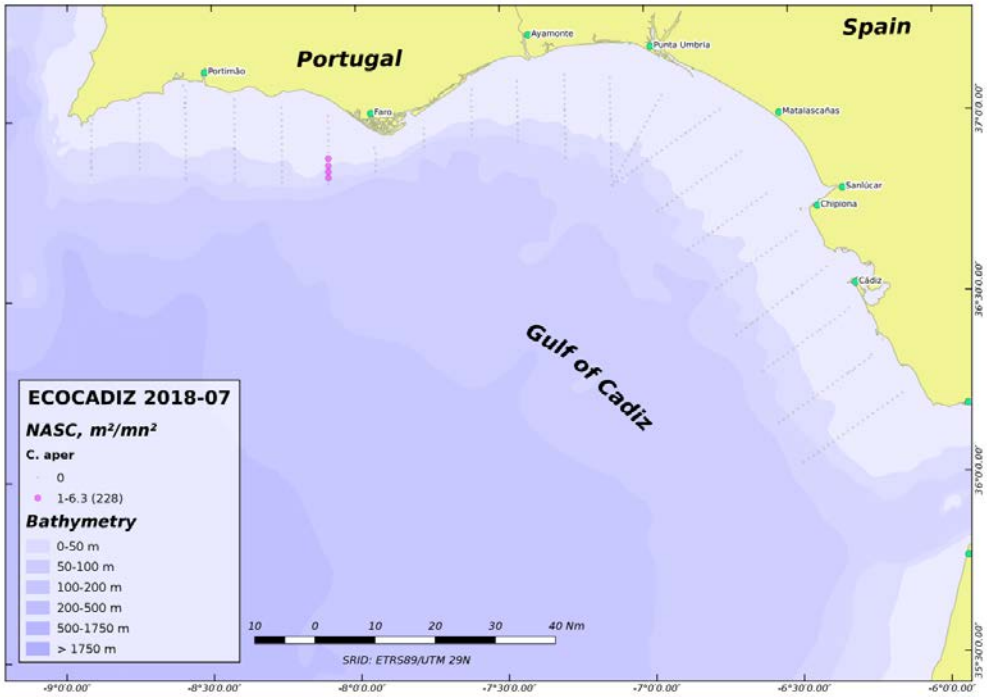


Figure 29. *ECOCADIZ 2018-07* survey. Boarfish (*Capros aper*). Distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species.

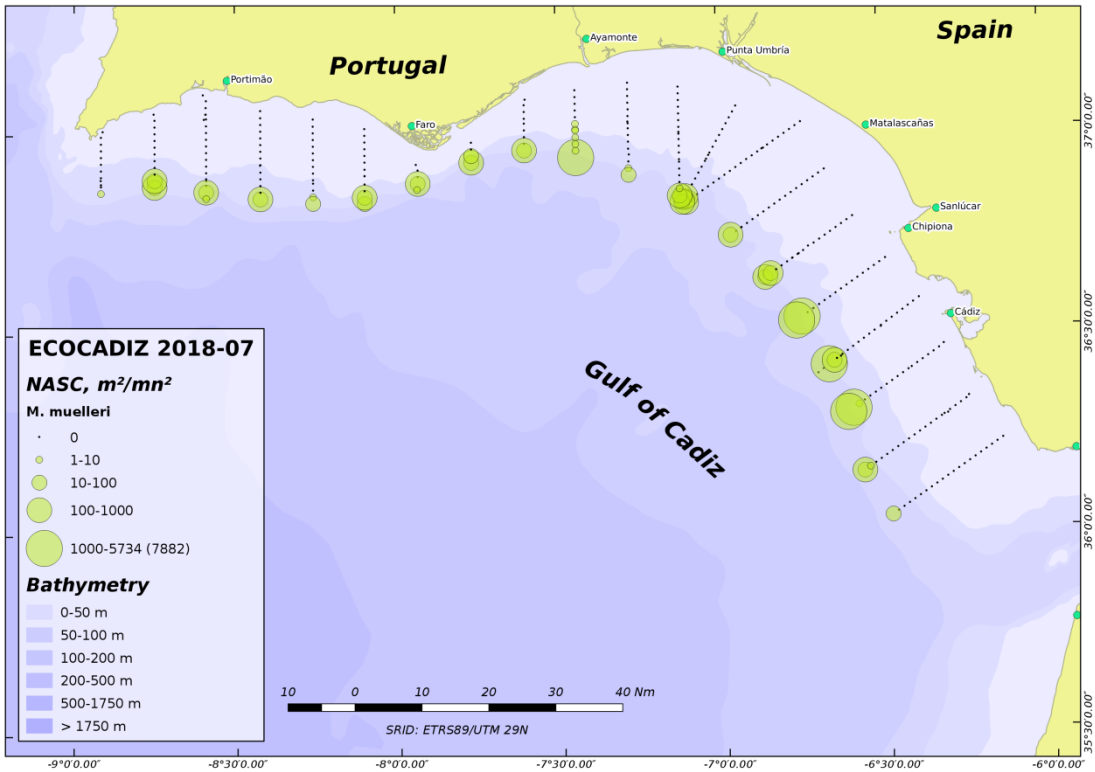


Figure 30. *ECOCADIZ 2018-07* survey. Silvery lightfish (*Maurolicus muelleri*). Distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species.

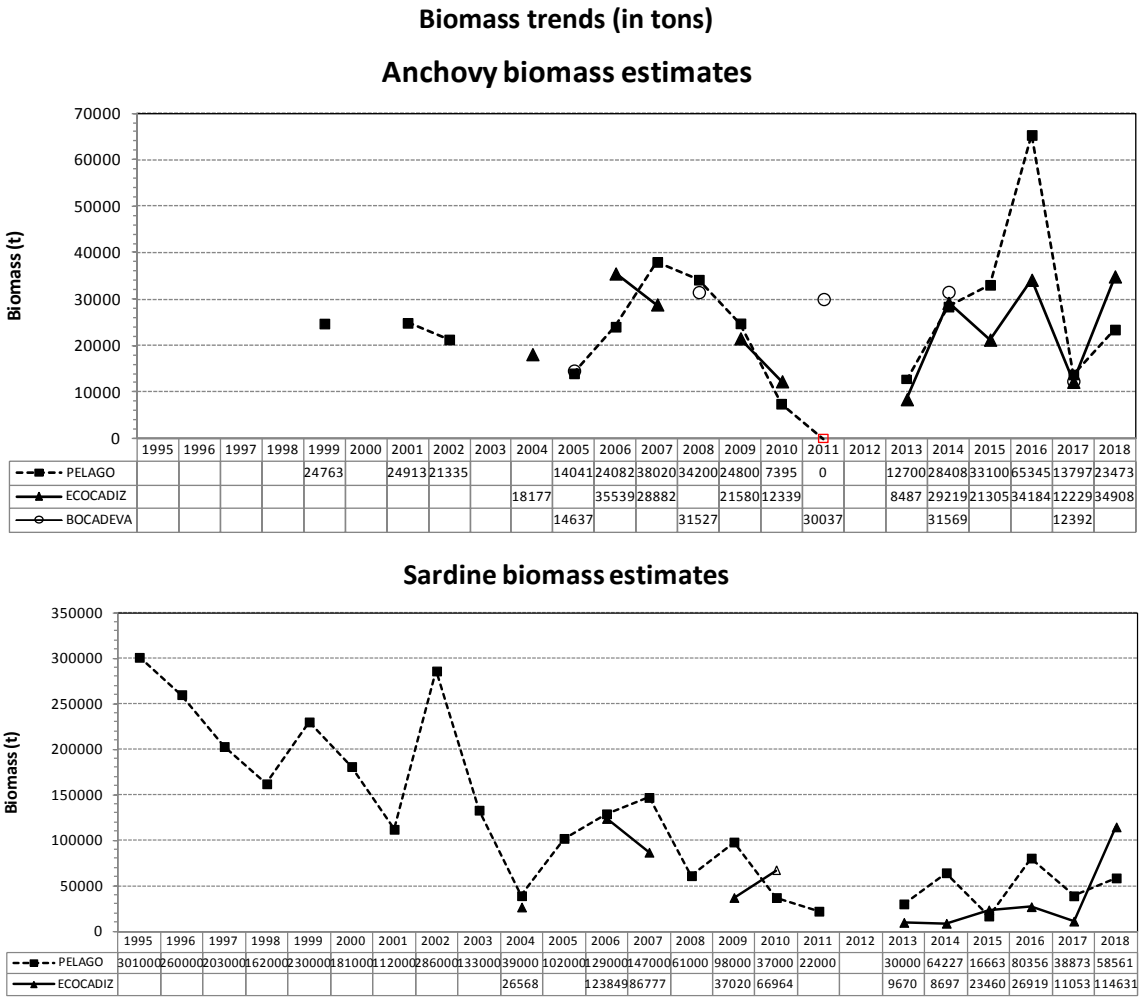


Figure 31. Trends in biomass estimates (in tons) for the main assessed species in Portuguese (*PELAGO*) and Spanish (*ECOCADIZ* and *BOCADEVA*) survey series. Note that the *ECOCADIZ* survey in 2010 partially covered the whole study area. The anchovy null estimate in 2011 from the *PELAGO* survey should be considered with caution.

ANNEX

(Figures of echograms showing dense sardine schools in shallow waters. EK60 echo-sounder. 38 kHz).

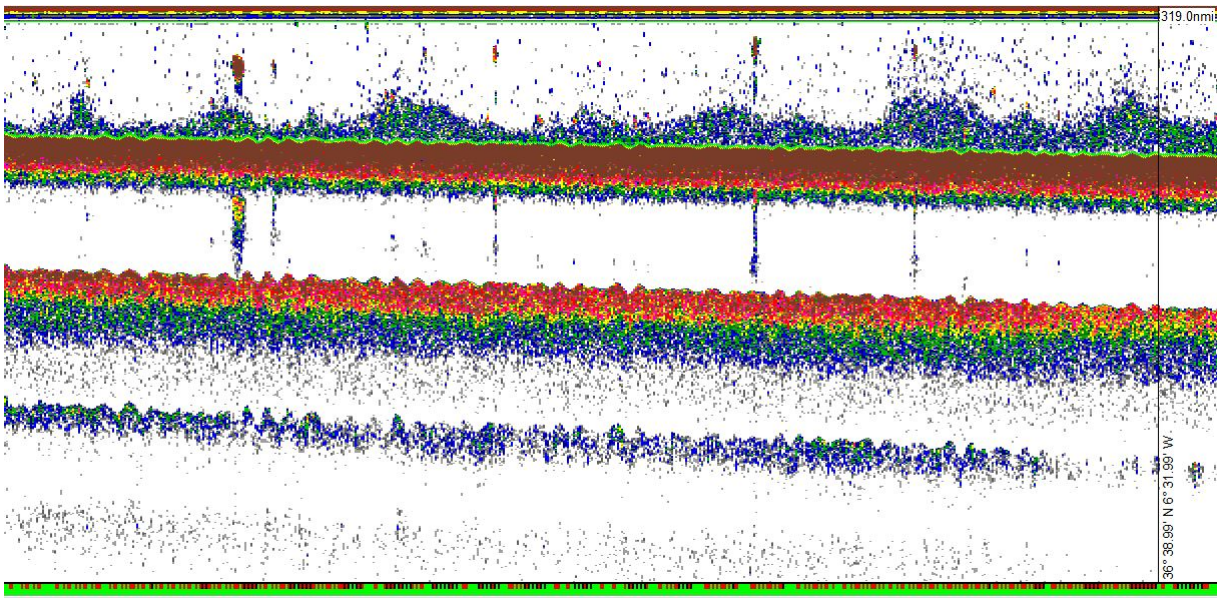


Figure A1. Transect RA05 (Chipiona), 23-25 m depth.

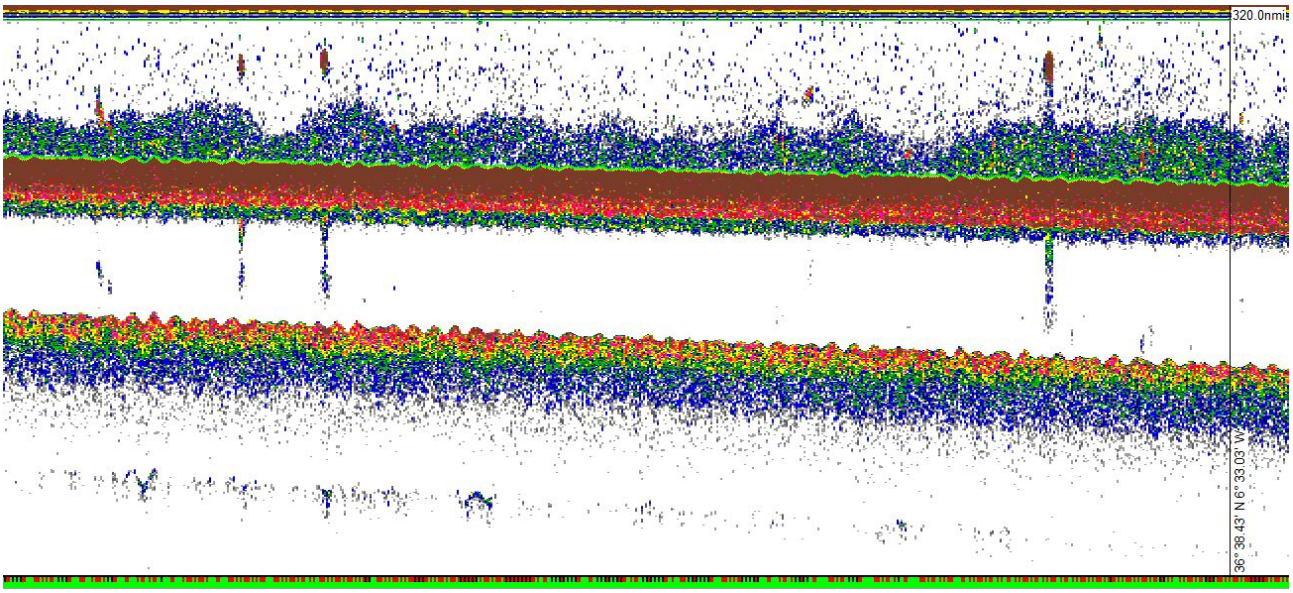


Figure A2. Transect RA05 (Chipiona), 27-29 m depth.

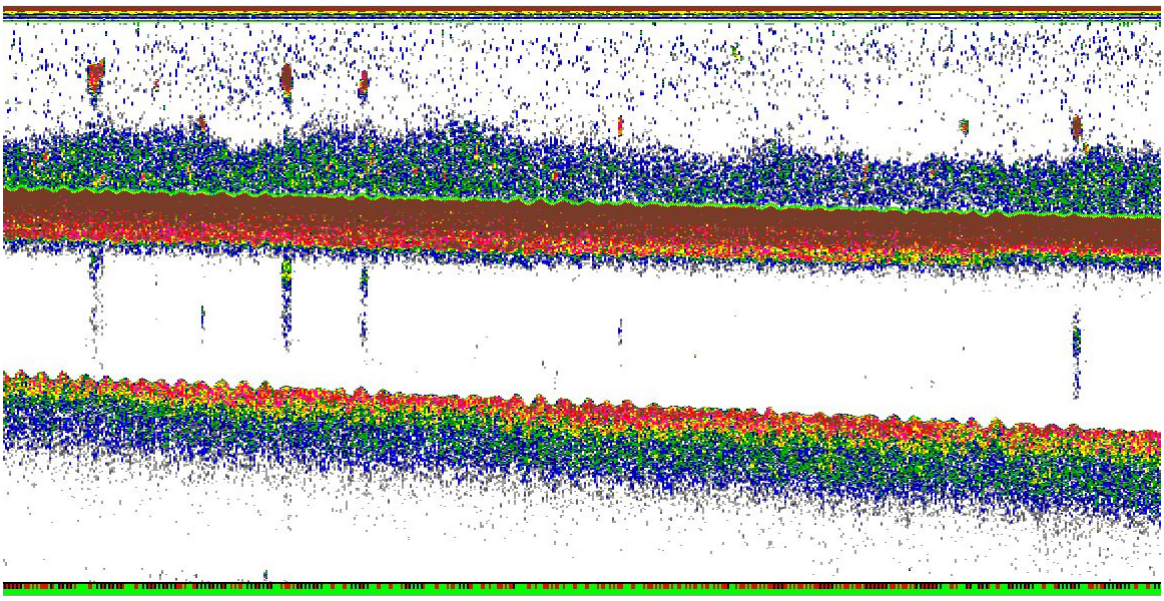


Figure A3. Transect RA05 (Chipiona), 31-37 m depth.

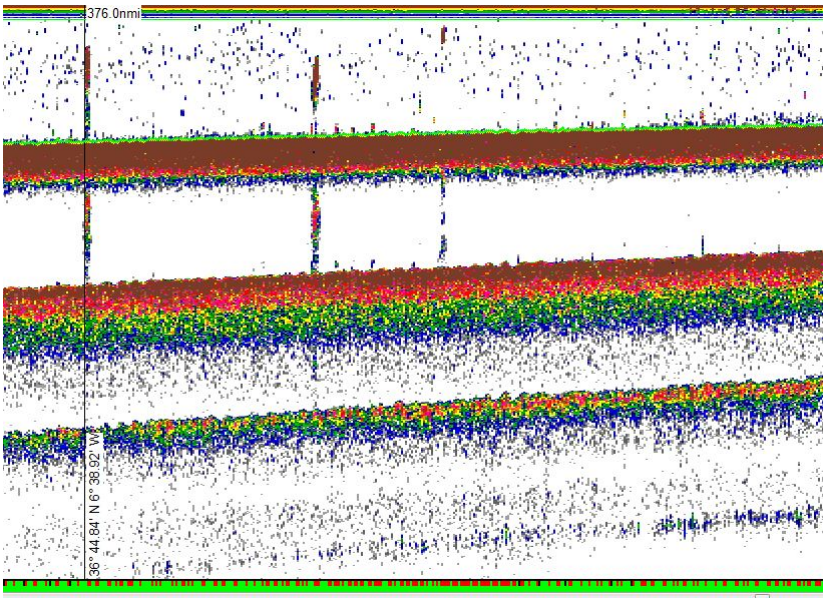


Figure A4. Transect RA06 (Doñana), 23-24 m depth.

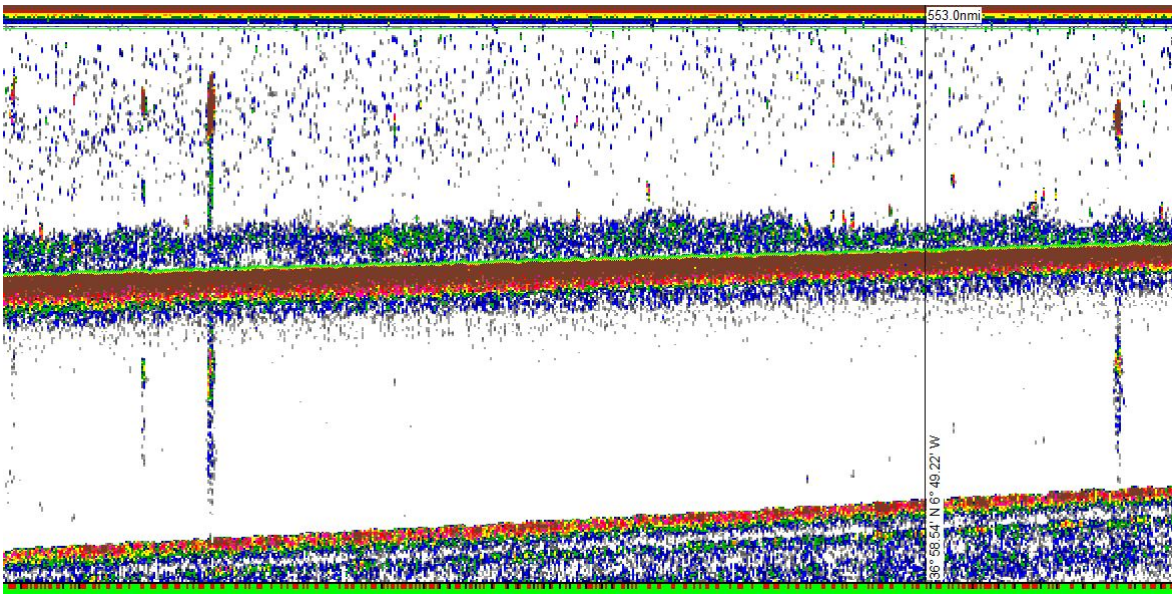


Figure A5. Transect RA08 (Mazagón), 23-24 m depth.

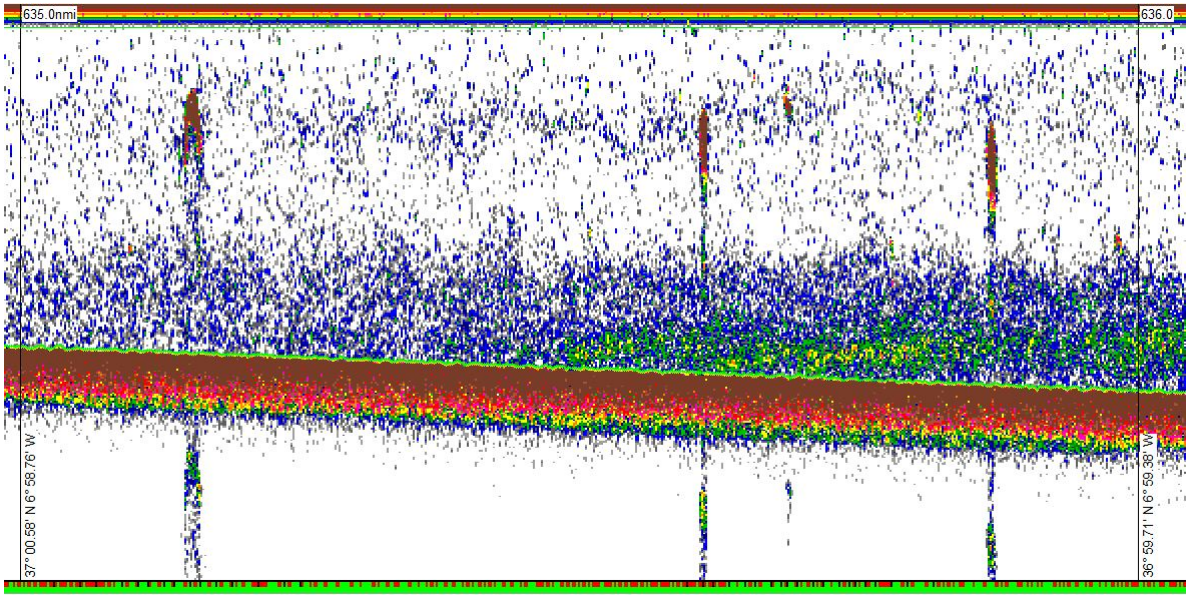


Figure A6. Transect RA10 (El Rompido), 40-44 m depth.