

Acoustic assessment and distribution of the main pelagic fish species in ICES Subdivision 9a South during the *ECOCADIZ-RECLUTAS 2017-10* Spanish survey (October 2017).

By

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ABSTRACT

The present working document summarises the main results obtained during the *ECOCADIZ-RECLUTAS 2017-10* Spanish (pelagic ecosystem-) acoustic survey. The survey's main objective is the acoustic assessment of anchovy and sardine juveniles (age 0 fish) in the recruitment areas of the Gulf of Cadiz. The survey was planned to be conducted by IEO between 12nd and 31st October 2017 in the Portuguese and Spanish shelf waters (20-200 m isobaths) off the Gulf of Cadiz onboard the R/V *Ramón Margalef*. However, a serious breakdown of the vessel's propulsion system detected in the afternoon of the 22th October led to the early termination of the survey in that day. Only the seven (7) easternmost acoustic transects were sampled, which were accompanied by the conduction of eight (8) fishing hauls. The resulting estimates are therefore referred to this surveyed area, which corresponded to the eastern sector of the Spanish shelf waters, comprising the shelf between Doñana and Cape Trafalgar, and they are not comparable to the previous available estimates.

Anchovy abundance and biomass in that surveyed area were 1 492 million fish and 7 641 t. The abundance and biomass of age 0 anchovies in the surveyed area were estimated at 1 433 million fish and 7 290 t. This juvenile fraction accounted for 96% and 95% of the total estimated population abundance and biomass, respectively. The estimates for Gulf of Cadiz sardine in the surveyed area were of 591 million fish and 12 103 t. Estimates of age-0 sardine were of 483 million fish and 8 778 t, 82% and 72% of the total population, respectively. These estimates cannot be compared with the remaining data points in the series because the abovementioned problems with acoustic sampling coverage.

INTRODUCTION

During the 2007 and 2008 meetings of the ICES *Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES areas VIII and IX* (WGACEGG) was advanced the possibility of carrying out, since 2009 on, internationally coordinated yearly surveys aimed at the direct estimation of the anchovy and sardine recruitment in the Division 9a (ICES, 2007, 2008). The conduction of such surveys would require, at least in the Gulf of Cadiz, of an appropriate acoustic sampling of the shallowest waters of its central part, an area which the conventional surveys (either Spanish or Portuguese) do not sample but, however, used to form a great part of the recruitment areas of these species.

The general objective of these surveys should initially be focused in the acoustic assessment by vertical echo-integration and mapping of the abundance and biomass of recruits of small pelagic species (especially anchovy and secondarily sardine), as well as the mapping of both the oceanographic and biological

conditions featuring the recruitment areas of these species in the Division 9a. The long term objective of the surveys would be to be able to assess the strength of the incoming recruitment to the fishery the next year.

The first attempt by the IEO of acoustically assessing the abundance of anchovy and sardine juveniles in their main recruitment areas off the Gulf of Cadiz dates back to 2009 (*ECOCADIZ-RECLUTAS 1009* survey). However, that survey was unsuccessful as to the achievement of their objectives because of the succession of a series of unforeseen problems which led to drastically reduce the foreseen sampling area to only the 6 easternmost transects. The continuation of this survey series was not guaranteed for next years and in fact no survey of these characteristics was carried out in 2010 and 2011. In 2012, the *ECOCADIZ-RECLUTAS 1112* survey was financed by the Spanish Fisheries Secretariat and planned and conducted by the IEO with the aim of obtaining an autumn estimate of Gulf of Cadiz anchovy biomass and abundance. The survey was conducted with the R/V *Emma Bardán*. Although the survey was restricted to the Spanish waters only it has been considered as the first survey within its series (Ramos *et al.*, 2013). *ECOCADIZ-RECLUTAS 2014-10* re-started the series and it was conducted with the R/V *Ramón Margalef*.

The present survey, *ECOCADIZ-RECLUTAS 2017-10*, should be the fifth survey within its series. However, an unexpected a serious breakdown of the vessel's propulsion system led to an early termination of the survey, which restricted the surveyed area to the one comprised by the seven easternmost transects only. This Working Document will show the results that could be derived from the acoustic and biological sampling carried out in that surveyed area. However, such results cannot be used to infer trends of the whole population and the estimates which will be shown hereinafter in no way should be considered as a new data point within this survey series.

MATERIAL AND METHODS

The *ECOCADIZ-RECLUTAS 2017-10* survey was planned to be carried out between 12nd and 31st October 2017 onboard the Spanish R/V *Ramón Margalef* covering a survey area which comprised 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, 333 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 *Myriax Software Echoview™* software package (by *Myriax Software Pty. Ltd.*, ex *SonarData Pty. Ltd.*). Acoustic equipment was calibrated between 13rd and 16th October in the Bay of Algeciras following the new ICES standard procedures (Demer *et al.*, 2015; see also Foote *et al.*, 1987).

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 later by the *Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES areas VIII and IX* (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 *Gloria HOD 352* pelagic trawl gear (ca. 10 m-mean vertical opening net) at an average speed of 4-4.5 knots. Gear performance and geometry during the effective fishing was monitored with *Simrad™ Mesotech FS20/25* trawl sonar. Trawl sonar 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 (2 spp.) and horse-mackerel species (3 spp.), 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 (<i>Sardina pilchardus</i>)	-72.6
Round sardinella (<i>Sardinella aurita</i>)	-72.6
Anchovy (<i>Engraulis encrasicolus</i>)	-72.6
Chub mackerel (<i>Scomber japonicus</i>)	-68.7
Mackerel (<i>S. scombrus</i>)	-84.9
Horse mackerel (<i>Trachurus trachurus</i>)	-68.7
Mediterranean horse-mackerel (<i>T. mediterraneus</i>)	-68.7
Blue jack mackerel (<i>T. picturatus</i>)	-68.7
Bogue (<i>Boops boops</i>)	-67.0
Blue whiting (<i>Micromesistius poutassou</i>)	-67.5
Boarfish (<i>Capros aper</i>)	-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* software (J. Miquel, unpublished) has got implemented the needed procedures and routines for the acoustic assessment following the above approach and it has been the software package used for the acoustic estimation.

Egg sampling by CUFES was not carried out during the survey. 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 collect some hydrographical variables (sub-surface sea temperature, salinity, and *in vivo* fluorescence). Vertical profiles of hydrographical variables were also recorded by night from 57 CTDO₂ casts using a *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) profiler (see next section for causes for the reduced number of CTD casts, **Figure 2**). *VMADCP RDI 150 kHz* records were also continuously recorded by night between CTD stations. Census of top predators was not recorded during the survey.

RESULTS

Acoustic sampling

The acoustic sampling was restricted to the period comprised between 17th and 22nd October. The acoustic sampling stopped on 21st October in order to satisfy the R/V's refueling and provisioning needs. A serious breakdown of the vessel's propulsion system detected in the afternoon of the 22th October led to the early termination of the survey in that day. Consequently, the complete grid was not possible to be sampled. Only the seven (7) easternmost acoustic transects were sampled, restricting the surveyed area to

the one comprising the shelf waters between Doñana and Cape Trafalgar (**Table 1; Figure 1**). Transects R01 and R04 had to be repeated because the occurrence of some problems in the recording of the GPS positions in the raw files generated during the acoustic sampling of those transects.

In order to perform the acoustic sampling with daylight, this sampling started at 06:45-07:00 UTC, although this time might vary depending on the duration of the works related with the hydrographic sampling the previous night.

Groundtruthing hauls

A total of eight (8) fishing operations for echo-trace ground-truthing (all of them were valid according to a correct gear performance and resulting catches), could only be carried out during the survey (**Table 2, Figure 3**). One additional trial fishing haul was carried out just before the starting of the acoustic sampling in order to test different configurations of towing warp lengths, angles of attack of the doors (by adjusting the backstraps) and weights. 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 48 and 162 m.

During the survey were captured 1 Chondrichthyan, 24 Osteichthyes and 1 Cephalopod species. The percentage of occurrence of the more frequent species in the hauls is shown in the enclosed Text Table below (see also **Figure 4**). The pelagic ichthyofauna was both 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, sardine and anchovy were the most frequent species in the valid hauls (75% and 63% presence index), followed by chub mackerel and Mediterranean horse mackerel (50%), mackerel (38%), bogue and horse mackerel (with relative occurrences of 25%), and round sardinella (13%), (see text table below). Blue jack mackerel was absent in the hauls performed in the surveyed area.

For the purposes of the acoustic assessment, anchovy, sardine, mackerel species, horse & jack mackerel species, and bogue were initially considered as the survey target species. Cephalopods 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 2452 kg and 63 thousand fish (**Table 3**). Sixty five per cent (65.3%) of this "total" fished biomass corresponded to chub mackerel, 12.7% to sardine, 7.9% to Mediterranean horse mackerel, 5.0% to anchovy, 2.7% to mackerel and contributions lower than 1% for the remaining species. The most abundant species in ground-truthing trawl hauls were anchovy and chub mackerel (40% and 34% respectively), followed by sardine (23%), with each of the remaining species accounting for equal to or less than 1%.

Species	# of fishing stations	Occurrence (%)	Total weight (kg)	Total number
<i>Sardina pilchardus</i>	6	75	311,616	14612
<i>Merluccius merluccius</i>	6	75	3,068	25
<i>Engraulis encrasicolus</i>	5	63	121,694	25188
<i>Trachurus mediterraneus</i>	4	50	194,768	807
<i>Scomber colias</i>	4	50	1600,68	21447
<i>Pagellus bellottii bellottii</i>	3	38	1,076	6
<i>Pagellus erythrinus</i>	3	38	2,090	15
<i>Scomber scombrus</i>	3	38	65,461	633
<i>Boops boops</i>	2	25	0,410	2
<i>Pomatomus saltatrix</i>	2	25	10,602	38
<i>Trachurus trachurus</i>	2	25	0,203	2
<i>Mola mola</i>	2	25	8,740	6
<i>Loligo media</i>	2	25	0,015	6
<i>Alopias vulpinus</i>	2	25	115,000	2
<i>Liza ramada</i>	2	25	5,433	17
<i>Sarpa salpa</i>	2	25	3,502	9
<i>Sardinella aurita</i>	1	13	3,148	17
<i>Liza aurata</i>	1	13	1,060	2
<i>Trachinotus ovatus</i>	1	13	2,557	9
<i>Pagellus acarne</i>	1	13	0,529	2
<i>Diplodus annularis</i>	1	13	0,043	1
<i>Spondyliosoma cantharus</i>	1	13	0,149	1
<i>Mullus barbatus</i>	1	13	0,127	1
<i>Lepidopus caudatus</i>	1	13	0,004	1
<i>Cepola macrophthalma</i>	1	13	0,013	1
<i>Spicara flexuosa</i>	1	13	0,097	1

The species composition of these fishing hauls (as expressed in terms of percentages in number) is shown in **Figure 4**.

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

A total of 138 nmi (ESDU) from 7 transects has only been acoustically sampled by echo-integration for assessment purposes. These sampled ESDUs accounted approximately for 41% of the total sampled ESDUs during a complete survey. 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.	Anchovy	Sardine	Round sardinella	Mackerel	Chub mack.	Horse mack.	Medit. h-mack.	Blue jack-mack.	Bogue
Sampled Area	39183	12427	9827	43	3	12690	34	4137	0	22
%	100	31,7	25,1	0,1	0,01	32,4	0,1	10,6	0	0,1

For this “pelagic fish assemblage” has been estimated a total of 39 183 m² nmi⁻². The highest NASC value was recorded in the coastal waters in front of the Bay of Cadiz (transect R04, **Figure 7**). By species, chub mackerel and anchovy accounted each one for 32% of this total back-scattered energy, followed by sardine

(25%) and Mediterranean horse mackerel (11%), and the remaining species with relative contributions of acoustic energies lower than 1%.

According to the resulting values of integrated acoustic energy and the availability and representativeness of the length frequency distributions, the species acoustically assessed in the present survey finally were anchovy, sardine, round sardinella, mackerel, chub mackerel and Mediterranean horse mackerel.

Spatial distribution and abundance/biomass estimates

Anchovy

Parameters of the survey's length-weight relationship for anchovy are given in **Table 4**. Size composition and mean size in the fishing hauls are represented in the spatial context in **Figure 8**. The mapping of the backscattering energy (nautical area scattering coefficient, *NASC*, in $\text{m}^2 \text{nmi}^{-2}$) attributed to the species and the coherent strata considered for the acoustic estimation are shown in **Figure 9**. The estimated abundance and biomass by size and age class are given in **Tables 5 and 6** and **Figures 10 and 11**.

Anchovy showed the highest densities (within the reduced surveyed area) in the inner-shelf waters comprised between the Guadalquivir River mouth and the Bay of Cadiz (**Figure 9**). The size composition of anchovy catches indicates that smallest recruits occurred mainly in those coastal waters (**Figure 8**).

Anchovy abundance and biomass in the surveyed area were estimated in 1 492 million fish and 7 641 t, respectively (**Table 5, Figure 10**).

The size range recorded for the estimated population was comprised between 7.5 and 13.0 cm size classes, with a marked mode at 9 cm size class. A similar size composition is also recorded for the estimated biomass (**Table 5, Figure 10**). The mean size and weight of the estimated population were 9.4 cm and 5.1 g, respectively. The anchovy size composition by coherent post-strata in the surveyed area evidences that juveniles were widely distributed in the coastal-inner shelf waters between Matalascañas and Cape Trafalgar, with the Matalascañas-Bay of Cadiz area being the area where the highest densities of anchovy juveniles were recorded (**Table 5, Figure 10**).

The age-0 population fraction was estimated at 1 433 million fish and 7 290 t, 96% and 95% of the total population abundance and biomass respectively (**Table 6, Figure 11**).

Sardine

Parameters of the survey's size-weight relationship for sardine are shown in **Table 4**. Size composition and mean size in the fishing hauls are represented in the spatial context in **Figure 12**. The mapping of the backscattering energy (nautical area scattering coefficient, *NASC*, in $\text{m}^2 \text{nmi}^{-2}$) attributed to the species and the coherent strata considered for the acoustic estimation are shown in **Figure 13**. Estimated abundance and biomass by size and age class are given in **Tables 8 and 9**, and **Figures 14 and 15**.

Sardine was mainly concentrated in the coastal waters comprised between Matalascañas and Guadalquivir River mouth (**Figure 13**). The sardine size composition in the positive hauls indicates that juveniles were mainly distributed in those waters (**Figure 12**).

Sardine abundance and biomass in the surveyed area were of 591 million fish and 12 103 t (**Table 8, Figure 14**).

The size range recorded for the estimated population was comprised between 11.0 and 21.5 cm size classes, with a dominant mode at 13.5 cm size class. A similar size composition is also recorded for the

estimated biomass (**Table 8, Figure 14**). The mean size and weight of the estimated population were 13.6 cm and 20.5 g, respectively. The sardine size and age composition by coherent post-strata in the surveyed area evidence that juveniles were also widely distributed in the coastal-inner shelf waters between Matalascañas and Cape Trafalgar, with the area comprised between Matalascañas and the Guadalquivir River mouth being the area where the highest densities of sardine juveniles were recorded (**Tables 8 and 9, Figures 14 and 15**).

The age-0 population fraction in the surveyed area was estimated at 483 million fish and 8 778 t, 82% and 72% of the total estimated abundance and biomass, respectively (**Table 9, Figure 15**).

Round sardinella

Parameters of the survey's length-weight relationship are shown in **Table 4**. Size composition and mean size in the fishing hauls are represented in the spatial context in **Figure 16**. The mapping of the backscattering energy (nautical area scattering coefficient, *NASC*, in $\text{m}^2 \text{nmi}^{-2}$) attributed to the species and the coherent strata considered for the acoustic estimation are shown in **Figure 17**. Estimated abundance and biomass by size class are given in **Table 11** and **Figure 18**.

Round sardinella showed a scattered distribution in the surveyed area, mainly occurring in the inner shelf waters of the easternmost waters and those ones in front of Chipiona (**Figures 16 and 17**).

The abundance and biomass in the surveyed area were estimated at 0.5 million fish and 81 t (**Table 11, Figure 18**).

The size composition of the estimated population ranged between 25.5 and 29.5 cm size classes, with a dominant mode at 27.5 cm size class. A similar size composition is also recorded for the estimated biomass (**Table 11, Figure 18**).

Mackerel

Parameters of the survey's length-weight relationship are shown in **Table 4**. Size composition and mean size in the fishing hauls are represented in the spatial context in **Figure 19**. The mapping of the backscattering energy (nautical area scattering coefficient, *NASC*, in $\text{m}^2 \text{nmi}^{-2}$) attributed to the species and the coherent strata considered for the acoustic estimation are shown in **Figure 20**. Estimated abundance and biomass by size class are given in **Table 12** and **Figure 21**.

The species was confined to the outer shelf waters between Matalascañas and surroundings of the Guadalquivir River mouth (**Figure 20**). The mackerel size composition in the positive hauls indicates the occurrence of sub-adult fish in the surveyed population (**Figure 19**).

Mackerel abundance and biomass in the surveyed area were estimated at about 1 million fish and 87 t (**Table 12, Figure 21**).

The size range recorded for the estimated population was comprised between 20.0 and 27.5 cm size classes, with a dominant mode at 25.0 cm size class. A similar size composition is also recorded for the estimated biomass (**Table 12, Figure 21**).

Chub mackerel

Parameters of the survey's length-weight relationship are shown in **Table 4**. Size composition and mean size in the fishing hauls are represented in the spatial context in **Figure 22**. The mapping of the backscattering energy (nautical area scattering coefficient, *NASC*, in $\text{m}^2 \text{nmi}^{-2}$) attributed to the species and

the coherent strata considered for the acoustic estimation are shown in **Figure 23**. Estimated abundance and biomass by size class are given in **Table 13** and **Figure 24**.

Chub mackerel, although widely distributed, showed, however, wide voids, especially in the inner-middle shelf waters in front of both Doñana National Park and Bay of Cadiz. The highest integration values were recorded along the R05 transect, in front of Chipiona coasts (**Figure 23**). Size composition in the species' positive hauls indicates that juvenile/sub-adult fish mainly occurred in the outer-shelf waters of the surveyed area whereas larger fish were distributed in shallower waters (**Figure 22**).

Chub mackerel abundance and biomass in the surveyed area were of 86 million fish and 11 726 t (**Table 13, Figure 24**).

The size range recorded for the estimated population was comprised between 17.5 and 30.5 cm size classes, with a dominant mode at 26.5 cm size class, and a secondary mode at 20.0 cm size class. A similar size composition is also recorded for the estimated biomass (**Table 13, Figure 24**).

Mediterranean horse-mackerel

The survey's length-weight relationship for this species is shown in **Table 4**. Size composition and mean size in the fishing hauls are represented in the spatial context in **Figure 25**. The mapping of the backscattering energy (nautical area scattering coefficient, *NASC*, in $\text{m}^2 \text{nmi}^{-2}$) attributed to the species and the coherent strata considered for the acoustic estimation are shown in **Figure 26**. Estimated abundance and biomass by size class are given in **Table 14** and **Figure 27**.

The species was restricted to the shelf waters comprised between Chipiona and Cape Trafalgar (**Figure 26**). Size composition in the species' positive hauls shows that larger specimens are located in the outer shelf of easternmost waters of the surveyed area, whereas the rest of the surveyed area is frequented by juvenile fish (**Figure 25**).

Mediterranean horse mackerel abundance and biomass in the surveyed area were of 21 million fish and 4 260 t (**Table 14, Figure 27**).

The size range recorded for the estimated population was comprised between 23.0 and 40.5 cm size classes, with a main mode at 30.0 cm and a secondary one at 26.0 cm. The same modal classes were also recorded in the distribution of the estimated biomass by size class (**Table 14, Figure 27**).

(SHORT) DISCUSSION

Unfortunately, the early termination of the survey, entailing an incomplete coverage of the survey area, prevent to issue any judgment on the levels of sardine and anchovy recruitment during the survey and any comparison with the previous estimates within their respective series as well.

The relatively small surveyed area has yielded 1 433 and 483 millions of anchovy and sardine recruits, respectively. The available estimates from this survey series for both species are shown in **Tables 7** and **8** and **Figure 28**.

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Table 1. ECOCADIZ-RECLUTAS 2017-10 survey. 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	22/10/2017	36° 14,000' N	06° 07,030' W	06:43	24	36° 02,070' N	06° 28,696' W	08:48	200
R02	Sancti-Petri	22/10/2017	36° 08,740' N	06° 33,960' W	09:51	144	36° 19,400' N	06° 14,590' W	14:14	26
R03	Cádiz	18/10/2017	36° 17,593' N	06° 36,652' W	13:56	180	36° 27,172' N	06° 19,020' W	18:01	24
R04	Rota	18/10/2017	36° 35,162' N	06° 22,216' W	11:03	22	36° 24,652' N	06° 40,883' W	12:54	213
R05	Chipiona	19/10/2017	36° 31,205' N	06° 46,165' W	10:47	160	36° 40,509' N	06° 29,221' W	17:05	22
R06	Doñana	19/10/2017	36° 46,770' N	06° 35,410' W	06:49	21	36° 37,930' N	06° 51,580' W	09:55	231
R07	Matalascañas	20/10/2017	36° 44,150' N	06° 58,270' W	06:52	139	36° 54,508' N	06° 39,135' W	13:30	22
R08	Mazagón		Not sampled							
R09	Punta Umbría									
R10	El Rompido									
R11	Isla Cristina									
R12	V.R. Do Sto. Antonio									
R13	Tavira									
R14	Fuzeta									
R15	Cabo Sta. María									
R16	Cuarreira									
R17	Albufeira									
R18	Alfanzinha									
R19	Portimao									
R20	Burgau									
R21	Ponta de Sagres									

Table 2. ECOCADIZ-RECLUTAS 2017-10 survey. Descriptive characteristics of the fishing stations.

Fishing Station	Date	Start		End		UTC Time		Depth (m)		Duration (min)		Trawled Distance (nm)	Acoustic Transect	Zone (landmark)
		Latitude	Longitude	Latitude	Longitude	Start	End	Start	End	Effective Trawling	Total Manoeuvre			
01	19-10-2016	36° 30.9058 N	6° 29.7442 W	36° 32.3490 N	6° 26.7876 W	8:44	09:26	58,5	48,0	00:41	1:44	2,785	R04	Rota
02	19-10-2016	36° 22.5401 N	6° 27.3750 W	36° 20.6422 N	6° 30.7931 W	15:16	16:04	69,5	96,5	00:47	1:37	3,349	R03	Cádiz
03	20-10-2016	36° 41.8592 N	6° 44.4753 W	36° 42.3040 N	6° 43.5611 W	8:04	08:18	80,1	70,5	00:13	0:55	0,859	R06	Doñana
04	20-10-2016	36° 33.4058 N	6° 42.1413 W	36° 31.7140 N	6° 45.3655 W	11:41	12:29	111,5	161,5	00:47	1:50	3,099	R05	Chipiona
05	22-10-2016	36° 36.4927 N	6° 36.2841 W	36° 35.3294 N	6° 38.2186 W	14:57	15:26	65,8	79,5	00:28	1:19	1,943	R05	Chipiona
06	22-10-2016	36° 46.5296 N	6° 54.1384 W	36° 44.8424 N	6° 56.9286 W	7:40	08:22	110,0	133,5	00:41	1:38	2,805	R07	Matalascañas
07	23-10-2016	36° 51.4610 N	6° 46.5486 W	36° 49.0125 N	6° 44.9897 W	11:26	12:08	48,7	48,3	00:42	1:20	2,747	R07	Matalascañas
08	23-10-2016	36° 12.3945 N	6° 27.0701 W	36° 10.8279 N	6° 30.0369 W	11:02	11:43	95,5	118,5	00:40	1:40	2,866	R02	Sancti-Petri

Table 3. ECOCADIZ-RECLUTAS 2017-10 survey. Catches by species in number (upper panel) and weight (in kg, lower panel) from valid fishing stations.

CATCH IN NUMBER (n)										
Fishing station	<i>Anchovy</i>	<i>Sardine</i>	<i>Round Sardinella</i>	<i>Chub mack.</i>	<i>Mackerel</i>	<i>Horse-mack.</i>	<i>Medit. Horse-mack.</i>	<i>Bogue</i>	<i>Other spp.</i>	TOTAL
01	4357	71	0	0	0	1	9	0	53	4491
02	0	0	0	3	0	1	221	1	22	248
03	13396	77	0	0	0	0	0	0	2	13475
04	1422	1209	0	96	29	0	0	0	10	2766
05	4157	2178	17	2012	1	0	211	1	36	8613
06	0	3	0	19336	603	0	0	0	6	19948
07	1856	11074	0	0	0	0	0	0	6	12936
08	0	0	0	0	0	0	366	0	0	366
TOTAL	25188	14612	17	21447	633	2	807	2	135	62843

CATCH IN WEIGHT (kg)										
Fishing station	<i>Anchovy</i>	<i>Sardine</i>	<i>Round Sardinella</i>	<i>Chub mack.</i>	<i>Mackerel</i>	<i>Horse-mack.</i>	<i>Medit. Horse-mack.</i>	<i>Bogue</i>	<i>Other spp.</i>	TOTAL
01	22,050	0,943	0	0	0	0,156	1,068	0	15,455	39,672
02	0	0	0	0,836	0	0,047	49,200	0,162	2,771	53,016
03	59,100	1,542	0	0	0	0	0	0	80,058	140,700
04	11,176	47,700	0	5,994	3,096	0	0	0	1,331	69,297
05	17,768	71,800	3,148	318,500	0,365	0	41,800	0,248	11,410	465,039
06	0	0,131	0	1275,350	62,000	0	0	0	7,207	1344,688
07	11,600	189,500	0	0	0	0	0	0	35,718	236,818
08	0	0	0	0	0	0	102,700	0	0	102,700
TOTAL	121,694	311,616	3,148	1600,680	65,461	0,203	194,768	0,410	15,455	39,672

Table 4. ECOCADIZ-RECLUTAS 2017-10 survey. Parameters of the size-weight relationships for the survey's target species susceptible of being assessed. FAO codes for the species: PIL: *Sardina pilchardus*; ANE: *Engraulis encrasicolus*; SAA: *Sardinella aurita*; MAS: *Scomber colias*; MAC: *Scomber scombrus*; HMM: *Trachurus mediterraneus*.

Parameter	ANE	PIL	SAA	MAS	MAC	HMM
Size range (mm)	81-134	108-223	264-300	180-315	230-345	142-390
n	250	246	17	154	80	160
a	0,003706673	0,002371615	0,024203771	0,001892602	0,001968043	0,031780247
b	3,212202095	3,460656839	2,671685762	3,44134817	3,37196203	2,587944288
r ²	0,964380814	0,97034595	0,798176402	0,908633832	0,874570119	0,956166386

Table 5. ECOCADIZ-RECLUTAS 2017-10 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 9**.

ECOCADIZ-RECLUTAS 2017-10 . <i>Engraulis encrasicolus</i> . ABUNDANCE (in numbers and million fish)						
Size class	POL01	POL02	POL03	POL04	Surveyed area	
					<i>n</i>	Millions
6	0	0	0	0	0	0
6,5	0	0	0	0	0	0
7	0	0	0	0	0	0
7,5	0	6245622	0	0	6245622	6
8	46825	130718163	0	0	130764988	131
8,5	46825	318632392	0	0	318679217	319
9	1234479	435876530	151748	160974	437423731	437
9,5	2056046	294124327	1028512	1091043	298299928	298
10	1826177	177584004	3827413	4060110	187297704	187
10,5	774742	40470826	7654826	8120219	57020613	57
11	1187654	14450046	6626314	7029177	29293191	29
11,5	638524	8085233	2647153	2808094	14179004	14
12	89393	3140656	876764	930069	5036882	5
12,5	0	2529784	590130	626008	3745922	4
13	0	2529784	590130	626008	3745922	4
13,5	0	0	0	0	0	0
14	0	0	0	0	0	0
14,5	0	0	0	0	0	0
15	0	0	0	0	0	0
15,5	0	0	0	0	0	0
16	0	0	0	0	0	0
16,5	0	0	0	0	0	0
17	0	0	0	0	0	0
17,5	0	0	0	0	0	0
18	0	0	0	0	0	0
18,5	0	0	0	0	0	0
TOTAL <i>n</i>	7900665	1434387367	23992990	25451702	1491732724	1492
Millions	8	1434	24	25		

Table 5. ECOCADIZ-RECLUTAS 2017-10 survey. Anchovy (*E. encrasicolus*). Cont'd.

ECOCADIZ-RECLUTAS 2017-10 . <i>Engraulis encrasicolus</i> . BIOMASS (t)					
Size class	POL01	POL02	POL03	POL04	Surveyed area
					TOTAL
6	0	0	0	0	0
6,5	0	0	0	0	0
7	0	0	0	0	0
7,5	0	16,641	0	0	16,641
8	0,153	425,751	0	0	425,904
8,5	0,184	1253,702	0	0	1253,886
9	5,806	2050,172	0,714	0,757	2057,449
9,5	11,452	1638,317	5,729	6,077	1661,575
10	11,945	1161,549	25,034	26,557	1225,085
10,5	5,905	308,474	58,346	61,893	434,618
11	10,476	127,458	58,448	62,002	258,384
11,5	6,476	82,008	26,850	28,482	143,816
12	1,037	36,418	10,167	10,785	58,407
12,5	0	33,357	7,781	8,254	49,392
13	0	37,744	8,805	9,340	55,889
13,5	0	0	0	0	0
14	0	0	0	0	0
14,5	0	0	0	0	0
15	0	0	0	0	0
15,5	0	0	0	0	0
16	0	0	0	0	0
16,5	0	0	0	0	0
17	0	0	0	0	0
17,5	0	0	0	0	0
18	0	0	0	0	0
18,5	0	0	0	0	0
TOTAL	53,434	7171,591	201,874	214,147	7641,046

Table 6. ECOCADIZ-RECLUTAS 2017-07 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 9** and ordered from west to east.

Age class	POL01	POL02	POL03	POL04	SURVEYED AREA
	N	N	N	N	N
0	7707	1369026	22539	23910	1432977
I	94	12549	841	892	22864
II	100	46566	613	650	35892
III	0	0	0	0	0
TOTAL	7901	1428142	23993	25452	1491733

Age class	POL01	POL02	POL03	POL04	SURVEYED AREA
	B	B	B	B	B
0	52	6851	186	197	7290
I	0,7	101	11	12	177
II	0,7	204	5	5	175
III	0	0	0	0	0
TOTAL	53	7156	202	214	7642

Table 7. *ECOCADIZ-RECLUTAS* surveys series. Anchovy (*E. encrasicolus*). Acoustic estimates of biomass (t) and abundance (million fish) for the whole Gulf of Cadiz anchovy population and for the juvenile fraction (*i.e.* age 0 fish, between parentheses). The 2017 estimates correspond to an incomplete coverage of the standard surveyed area due to a research vessels' breakdown.

Estimate/Year	Total Population (Recruits at age 0)				
	2012	2014	2015	2016	2017
Biomass (t)	13680 (13354)	8113 (5131)	30827 (29219)	19861 (15969)	7642 (7290)
Abundance (millions)	2469 (2619)	986 (814)	5227 (5117)	3667 (3445)	1492 (1433)

Table 8. ECOCADIZ-RECLUTAS 2017-10 survey. Sardine (*Sardina 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 13**.

ECOCADIZ-RECLUTAS 2017-10. <i>Sardina pilchardus</i> . ABUNDANCE (in numbers and million fish)								
Size class	POL01	POL02	POL03	POL04	POL05	POL06	Surveyed area	
							<i>n</i>	Millions
6	0	0	0	0	0	0	0	0
6,5	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0
7,5	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0
8,5	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0
9,5	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0
10,5	0	0	0	0	0	0	0	0
11	2810525	0	5568040	519461	2773	0	8898026	9
11,5	7005946	0	25056180	977808	5220	0	33039934	33
12	21275721	0	38976280	397235	2121	0	60649236	61
12,5	68636743	0	22272160	1242631	6634	0	92151534	92
13	109267158	0	1392010	1242631	6634	0	111901799	112
13,5	135256975	0	2784020	1110220	5927	0	139151215	139
14	53239954	0	2784020	519461	2773	0	56543435	57
14,5	23057625	0	0	519461	2773	0	23577086	24
15	15912554	852131	0	916695	4894	10385	17681380	18
15,5	8787850	1131011	0	2943610	15715	13783	12862471	13
16	2929283	4121216	0	3799192	20283	50224	10849691	11
16,5	2929283	3826844	0	2882497	15389	46636	9638624	10
17	0	3547965	0	2159326	11528	43238	5707291	6
17,5	0	2416954	0	1110220	5927	29454	3527174	4
18	0	1564823	0	590759	3154	19070	2155582	2
18,5	0	418319	0	264823	1414	5098	683142	1
19	0	278879	0	264823	1414	3399	543702	1
19,5	0	139440	0	264823	1414	1699	404263	0,4
20	0	278879	0	132412	707	3399	411291	0,4
20,5	0	0	0	0	0	0	0	0
21	0	139440	0	61113	326	1699	200553	0,2
21,5	0	0	0	264823	1414	0	264823	0,3
22	0	0	0	0	0	0	0	0
22,5	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0
TOTAL <i>n</i>	451109617	18715901	98832710	22184024	118434	228084	590842252	
Millions	451	19	99	22	0,1	0,2		591

Table 8. ECOCADIZ-RECLUTAS 2017-10 survey. Sardine (*Sardina pilchardus*). Cont'd.

ECOCADIZ-RECLUTAS 2017-10. <i>Sardina pilchardus</i> . BIOMASS (t)							
Size class	POL01	POL02	POL03	POL04	POL05	POL06	Surveyed area
							TOTAL
6	0	0	0	0	0	0	0
6,5	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0
7,5	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0
8,5	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0
9,5	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0
10,5	0	0	0	0	0	0	0
11	28,941	0	57,336	5,349	0,029	0	91,626
11,5	83,858	0	299,911	11,704	0,062	0	395,473
12	294,167	0	538,902	5,492	0,029	0	838,561
12,5	1089,914	0	353,670	19,732	0,105	0	1463,316
13	1982,156	0	25,252	22,542	0,120	0	2029,950
13,5	2789,194	0	57,411	22,894	0,122	0	2869,499
14	1242,336	0	64,964	12,121	0,065	0	1319,421
14,5	606,243	0	0	13,658	0,073	0	619,901
15	469,542	25,144	0	27,050	0,144	0,306	521,736
15,5	289,937	37,315	0	97,118	0,518	0,455	424,370
16	107,685	151,502	0	139,664	0,746	1,846	398,851
16,5	119,592	156,236	0	117,682	0,628	1,904	393,510
17	0	160,371	0	97,603	0,521	1,954	257,974
17,5	0	120,603	0	55,399	0,296	1,470	176,002
18	0	85,962	0	32,453	0,173	1,048	118,415
18,5	0	25,233	0	15,974	0,085	0,308	41,207
19	0	18,426	0	17,497	0,093	0,225	35,923
19,5	0	10,068	0	19,121	0,102	0,123	29,189
20	0	21,956	0	10,425	0,056	0,268	32,381
20,5	0	0	0	0	0	0	0
21	0	12,971	0	5,685	0,030	0,158	18,656
21,5	0	0	0	26,699	0,143	0	26,699
22	0	0	0	0	0	0	0
22,5	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0
TOTAL	9103,565	825,787	1397,446	775,862	4,140	10,065	12102,660

Table 9. ECOCADIZ-RECLUTAS 2017-07 survey. Sardine (*Sardina pilchardus*). Estimated abundance (thousands of individuals) and biomass (tonnes) by age group. Polygons (i.e., coherent or homogeneous post-strata) numbered as in **Figure 13** and ordered from west to east.

Age class	POL01	POL02	POL03	POL04	POL05	POL06	TOTAL
	N	N	N	N	N	N	N
0	379415	839	95144	7340	39	10	482788
I	70603	14191	3689	12251	65	173	100972
II	1092	3128	0	1870	10	38	6138
III	0	418	0	397	2	5	823
IV	0	139	0	326	2	2	469
V	0	0	0	0	0	0	0
VI	0	0	0	0	0	0	0
VII	0	0	0	0	0	0	0
VIII	0	0	0	0	0	0	0
IX	0	0	0	0	0	0	0
X	0	0	0	0	0	0	0
TOTAL	451110	18716	98833	22184	118	228	591189

Age class	POL01	POL02	POL03	POL04	POL05	POL06	TOTAL
	B	B	B	B	B	B	B
0	7264	28	1338	147	1	0,3	8778
I	1803	600	59	481	3	7	2953
II	38	153	0	86	0,5	2	280
III	0	32	0	30	0,2	0,4	62
IV	0	13	0	32	0,2	0,2	46
V	0	0	0	0	0	0	0
VI	0	0	0	0	0	0	0
VII	0	0	0	0	0	0	0
VIII	0	0	0	0	0	0	0
IX	0	0	0	0	0	0	0
X	0	0	0	0	0	0	0
TOTAL	9105	826	1398	776	4	10	12119

Table 10. ECOCADIZ-RECLUTAS surveys series. Sardine (*Sardina pilchardus*). Acoustic estimates of biomass (t) and abundance (million fish) for the whole Gulf of Cadiz anchovy population and for the juvenile fraction (i.e. age 0 fish, between parentheses). Note that the 2012 survey only surveyed the Spanish waters. The 2017 estimates correspond to an incomplete coverage of the standard surveyed area due to a research vessels' breakdown.

Estimate/Year	Total Population (Recruits at age 0)				
	2012	2014	2015	2016	2017
Biomass (t)	22119 (9182)	36571 (705)	30992 (8645)	35173 (21899)	12119 (8778)
Abundance (millions)	603 (359)	507 (26)	861 (509)	2379 (1940)	591 (483)

Table 11. *ECOCADIZ-RECLUTAS 2017-10* survey. Round sardinella (*Sardinella aurita*). 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-RECLUTAS 2017-10. <i>Sardinella aurita</i> .				
ABUNDANCE (in million fish)				
Size class	POL01	POL02	Surveyed area	
			<i>n</i>	Millions
20	0	0	0	0
20,5	0	0	0	0
21	0	0	0	0
21,5	0	0	0	0
22	0	0	0	0
22,5	0	0	0	0
23	0	0	0	0
23,5	0	0	0	0
24	0	0	0	0
24,5	0	0	0	0
25	0	0	0	0
25,5	23506	4101	27607	0,03
26	23506	4101	27607	0,03
26,5	23506	4101	27607	0,03
27	94023	16406	110429	0,1
27,5	141034	24609	165643	0,2
28	47011	8203	55214	0,1
28,5	0	0	0	0
29	0	0	0	0
29,5	47011	8203	55214	0,1
30	0	0	0	0
30,5	0	0	0	0
31	0	0	0	0
31,5	0	0	0	0
32	0	0	0	0
TOTAL <i>n</i>	399597	69724	469321	0,5
Millions	0,4	0,1	0,5	

Table 11. ECOCADIZ-RECLUTAS 2017-10 survey. Round sardinella (*Sardinella aurita*). Cont'd.

ECOCADIZ-RECLUTAS 2017-10. <i>Sardinella aurita</i> .			
BIOMASS (t)			
Size class	POL01	POL02	Surveyed area
			TOTAL
20	0	0	0
20,5	0	0	0
21	0	0	0
21,5	0	0	0
22	0	0	0
22,5	0	0	0
23	0	0	0
23,5	0	0	0
24	0	0	0
24,5	0	0	0
25	0	0	0
25,5	3,344	0,583	3,927
26	3,520	0,614	4,134
26,5	3,702	0,646	4,348
27	15,558	2,715	18,273
27,5	24,499	4,275	28,774
28	8,565	1,495	10,060
28,5	0	0	0
29	0	0	0
29,5	9,835	1,716	11,551
30	0	0	0
30,5	0	0	0
31	0	0	0
31,5	0	0	0
32	0	0	0
TOTAL	69,023	12,044	81,067

Table 12. ECOCADIZ-RECLUTAS 2017-10 survey. Atlantic mackerel (*Scomber scombrus*). 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 20**.

ECOCADIZ-RECLUTAS 2017-10.			
<i>Scomber scombrus</i> . ABUNDANCE (in numbers and million fish)			
Size class	POL01	Surveyed area	
		<i>n</i>	Millions
15	0	0	0
15,5	0	0	0
16	0	0	0
16,5	0	0	0
17	0	0	0
17,5	0	0	0
18	0	0	0
18,5	0	0	0
19	0	0	0
19,5	0	0	0
20	5508	5508	0,01
20,5	0	0	0
21	0	0	0
21,5	0	0	0
22	0	0	0
22,5	5508	5508	0,01
23	5508	5508	0,01
23,5	28916	28916	0,03
24	165232	165232	0,2
24,5	147332	147332	0,1
25	229948	229948	0,2
25,5	100516	100516	0,1
26	88124	88124	0,1
26,5	23408	23408	0,02
27	12392	12392	0,01
27,5	17900	17900	0,02
28	0	0	0
28,5	0	0	0
29	0	0	0
29,5	0	0	0
30	0	0	0
TOTAL <i>n</i>	830292	830292	1
Millions	1		

Table 12. *ECOCADIZ-RECLUTAS 2017-10* survey. Atlantic mackerel (*Scomber scombrus*). Cont'd.

<i>ECOCADIZ-RECLUTAS 2017-10.</i>		
<i>Scomber scombrus</i> . BIOMASS (t)		
Size class	POL01	Surveyed area
		TOTAL
15	0	0
15,5	0	0
16	0	0
16,5	0	0
17	0	0
17,5	0	0
18	0	0
18,5	0	0
19	0	0
19,5	0	0
20	0,276	0,276
20,5	0	0
21	0	0
21,5	0	0
22	0	0
22,5	0,408	0,408
23	0,439	0,439
23,5	2,477	2,477
24	15,182	15,182
24,5	14,502	14,502
25	24,212	24,212
25,5	11,307	11,307
26	10,577	10,577
26,5	2,994	2,994
27	1,687	1,687
27,5	2,591	2,591
28	0	0
28,5	0	0
29	0	0
29,5	0	0
30	0	0
TOTAL	86,652	86,652

Table 13. ECOCADIZ-RECLUTAS 2017-10 survey. Chub mackerel (*Scomber colias*). 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 23**.

ECOCADIZ-RECLUTAS 2017-10.				
<i>Scomber colias</i> . ABUNDANCE (in numbers and million fish)				
Size class	POL01	POL02	Surveyed area	
			<i>n</i>	Millions
15	0	0	0	0
15,5	0	0	0	0
16	0	0	0	0
16,5	0	0	0	0
17	0	0	0	0
17,5	147331	0	147331	0,1
18	441993	0	441993	0,4
18,5	515659	0	515659	1
19	1482660	0	1482660	1
19,5	1890249	0	1890249	2
20	3435727	0	3435727	3
20,5	2529682	0	2529682	3
21	1719361	0	1719361	2
21,5	967001	0	967001	1
22	374683	0	374683	0,4
22,5	147331	0	147331	0,1
23	197440	1319619	1517059	2
23,5	73666	891634	965300	1
24	0	3530871	3530871	4
24,5	0	3530871	3530871	4
25	147331	5278474	5425805	5
25,5	0	8381361	8381361	8
26	0	11020599	11020599	11
26,5	0	12340217	12340217	12
27	0	9700980	9700980	10
27,5	0	8809346	8809346	9
28	0	4386840	4386840	4
28,5	0	2211253	2211253	2
29	0	0	0	0
29,5	73666	0	73666	0,1
30	0	0	0	0
30,5	0	427984	427984	0,4
31	0	0	0	0
TOTAL <i>n</i>	14143780	71830049	85973829	86
Millions	14	72		

Table 11. ECOCADIZ-RECLUTAS 2017-10 survey. Chub mackerel (*Scomber colias*). Cont'd.

ECOCADIZ-RECLUTAS 2017-10.			
<i>Scomber colias</i> . BIOMASS (t)			
Size class	POL01	POL02	Surveyed area
			TOTAL
15	0	0	0
15,5	0	0	0
16	0	0	0
16,5	0	0	0
17	0	0	0
17,5	5,550	0	5,550
18	18,320	0	18,320
18,5	23,456	0	23,456
19	73,837	0	73,837
19,5	102,820	0	102,820
20	203,677	0	203,677
20,5	163,096	0	163,096
21	120,318	0	120,318
21,5	73,308	0	73,308
22	30,715	0	30,715
22,5	13,038	0	13,038
23	18,829	125,848	144,677
23,5	7,559	91,492	99,051
24	0	389,239	389,239
24,5	0	417,560	417,560
25	18,665	668,709	687,374
25,5	0	1135,925	1135,925
26	0	1595,815	1595,815
26,5	0	1906,778	1906,778
27	0	1597,610	1597,610
27,5	0	1544,448	1544,448
28	0	817,845	817,845
28,5	0	437,904	437,904
29	0	0	0
29,5	16,410	0	16,410
30	0	0	0
30,5	0	106,827	106,827
31	0	0	0
TOTAL	889,598	10836,000	11725,598

Table 12. *ECOCADIZ-RECLUTAS 2017-10* survey. Mediterranean horse mackerel (*Trachurus mediterraneus*). 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 26**.

ECOCADIZ-RECLUTAS 2017-10.				
<i>Trachurus mediterraneus</i> . ABUNDANCE (in numbers and million fish)				
Size class	POL01	POL02	Surveyed area	
			<i>n</i>	Millions
20	0	0	0	0
20,5	0	0	0	0
21	0	0	0	0
21,5	0	0	0	0
22	0	0	0	0
22,5	0	0	0	0
23	47092	0	47092	0,05
23,5	0	0	0	0
24	199181	0	199181	0,2
24,5	99591	0	99591	0,1
25	597544	0	597544	1
25,5	298772	0	298772	0,3
26	689024	0	689024	1
26,5	589433	0	589433	1
27	489842	0	489842	0,5
27,5	487138	0	487138	0,5
28	1469526	0	1469526	1
28,5	2317174	0	2317174	2
29	2403246	651	2403897	2
29,5	2497429	837	2498266	2
30	2782682	2326	2785008	3
30,5	2065493	2326	2067819	2
31	1542079	2699	1544778	2
31,5	769687	2699	772386	1
32	536934	3536	540470	1
32,5	246273	1489	247762	0,2
33	390251	2140	392391	0,4
33,5	99591	837	100428	0,1
34	49795	1861	51656	0,1
34,5	0	1024	1024	0,001
35	0	1675	1675	0,002
35,5	0	2326	2326	0,002
36	0	2326	2326	0,002
36,5	0	1303	1303	0,001
37	96887	1024	97911	0,1
37,5	0	651	651	0,001
38	0	186	186	0,0002
38,5	0	0	0	0
39	0	651	651	0,001
39,5	0	1303	1303	0,001
40	0	186	186	0,0002
40,5	49795	0	49795	0,05
41	0	0	0	0
41,5	0	0	0	0
42	0	0	0	0
TOTAL <i>n</i>	20814459	34056	20848515	21
Millions	21	0,03		

Table 12. ECOCADIZ-RECLUTAS 2017-10 survey. Mediterranean horse mackerel (*Trachurus mediterraneus*). Cont'd.

ECOCADIZ-RECLUTAS 2017-10.			
<i>Trachurus mediterraneus</i> . BIOMASS (t)			
Size class	POL01	POL02	Surveyed area
			TOTAL
20	0	0	0
20,5	0	0	0
21	0	0	0
21,5	0	0	0
22	0	0	0
22,5	0	0	0
23	5,144	0	5,144
23,5	0	0	0
24	24,264	0	24,264
24,5	12,790	0	12,790
25	80,817	0	80,817
25,5	42,512	0	42,512
26	103,043	0	103,043
26,5	92,561	0	92,561
27	80,698	0	80,698
27,5	84,119	0	84,119
28	265,760	0	265,760
28,5	438,520	0	438,520
29	475,562	0,129	475,691
29,5	516,360	0,173	516,533
30	600,697	0,502	601,199
30,5	465,202	0,524	465,726
31	362,120	0,634	362,754
31,5	188,322	0,660	188,982
32	136,795	0,901	137,696
32,5	65,291	0,395	65,686
33	107,6	0,590	108,190
33,5	28,541	0,240	28,781
34	14,824	0,554	15,378
34,5	0	0,316	0,316
35	0	0,537	0,537
35,5	0	0,774	0,774
36	0	0,802	0,802
36,5	0	0,465	0,465
37	35,843	0,379	36,222
37,5	0	0,249	0,249
38	0	0,074	0,074
38,5	0	0	0
39	0	0,276	0,276
39,5	0	0,570	0,570
40	0	0,084	0,084
40,5	23,241	0	23,241
41	0	0	0
41,5	0	0	0
42	0	0	0
TOTAL	4250,626	9,828	4260,454

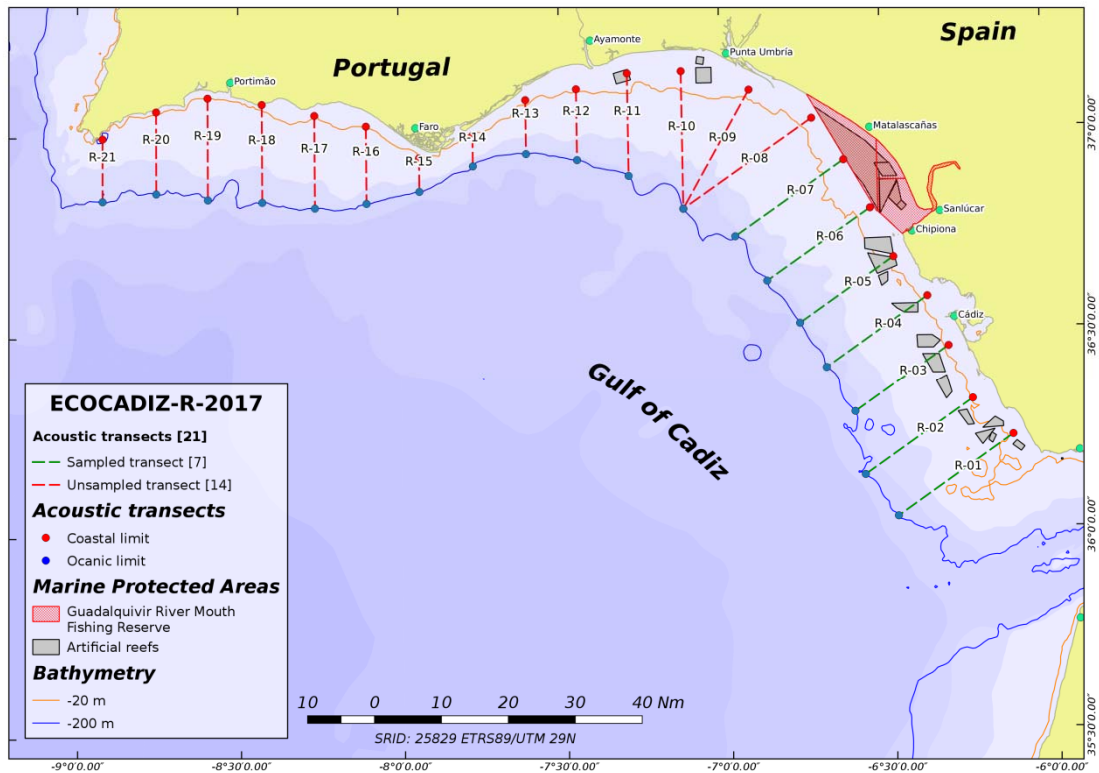


Figure 1. ECOCADIZ-RECLUTAS 2017-10 survey. Location of the acoustic transects sampled during the survey. The different protected areas inside the Guadalquivir river mouth Fishing Reserve and artificial reef polygons are also shown. Note that only the seven easternmost transects were sampled.

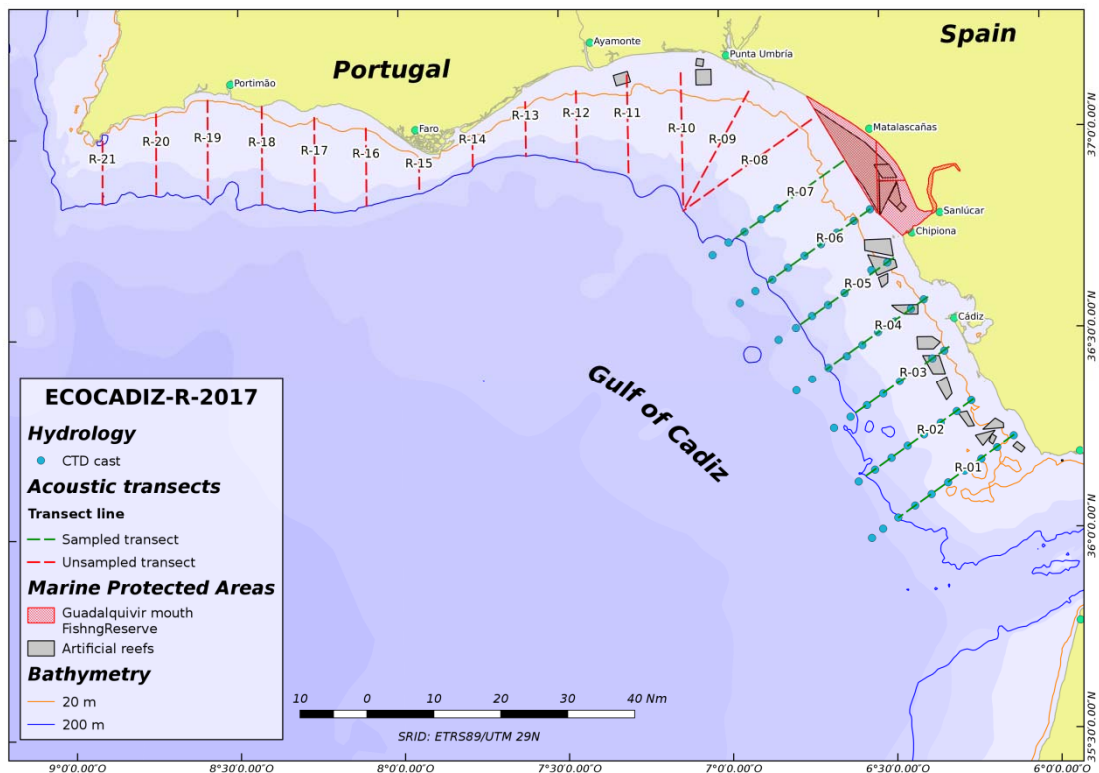


Figure 2. ECOCADIZ-RECLUTAS 2017-10 survey. Location of CTD stations. Note that only the seven easternmost transects were sampled.

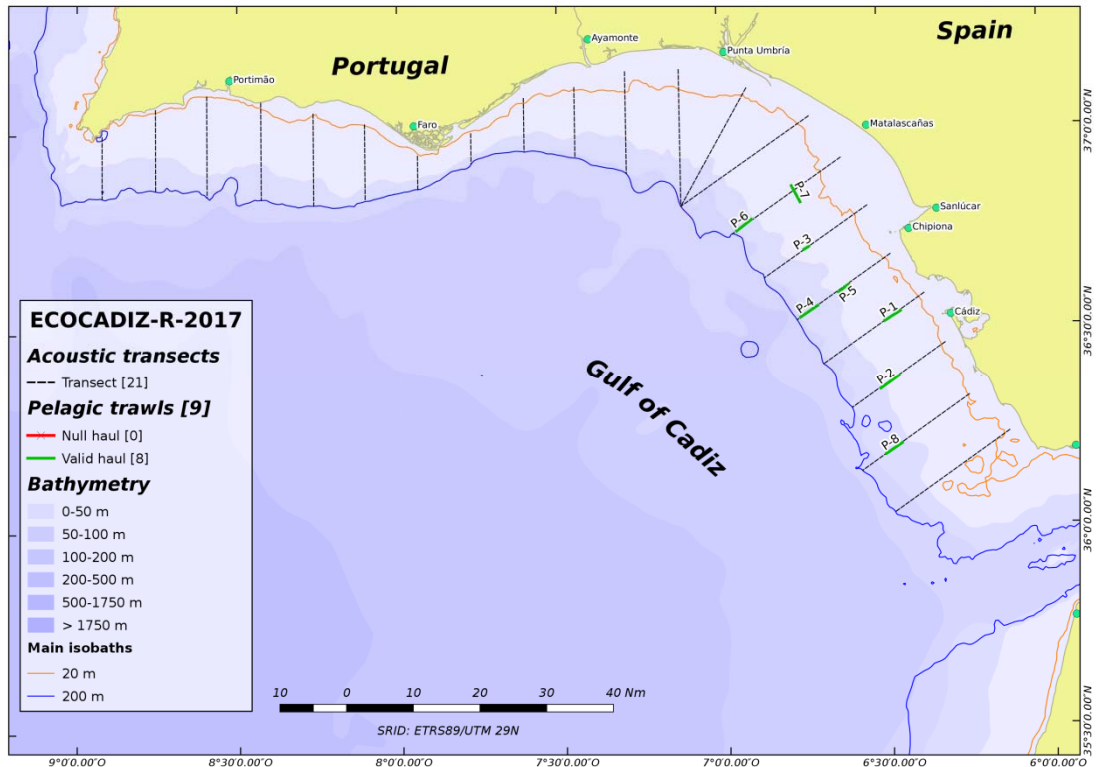


Figure 3. ECOCADIZ-RECLUTAS 2017-10 survey. Location of ground-truthing fishing hauls. Note that only the seven easternmost transects were sampled.

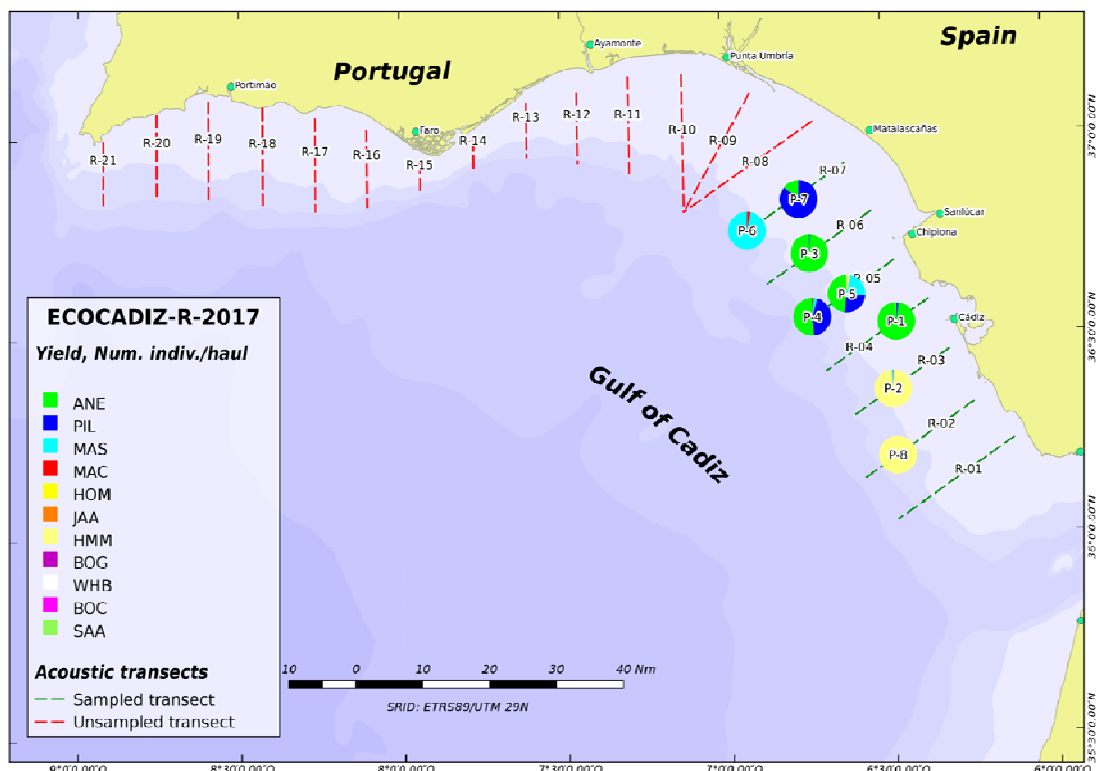


Figure 4. ECOCADIZ-RECLUTAS 2017-10 survey. Species composition (percentages in number) in valid fishing hauls. Note that only the seven easternmost transects were sampled.

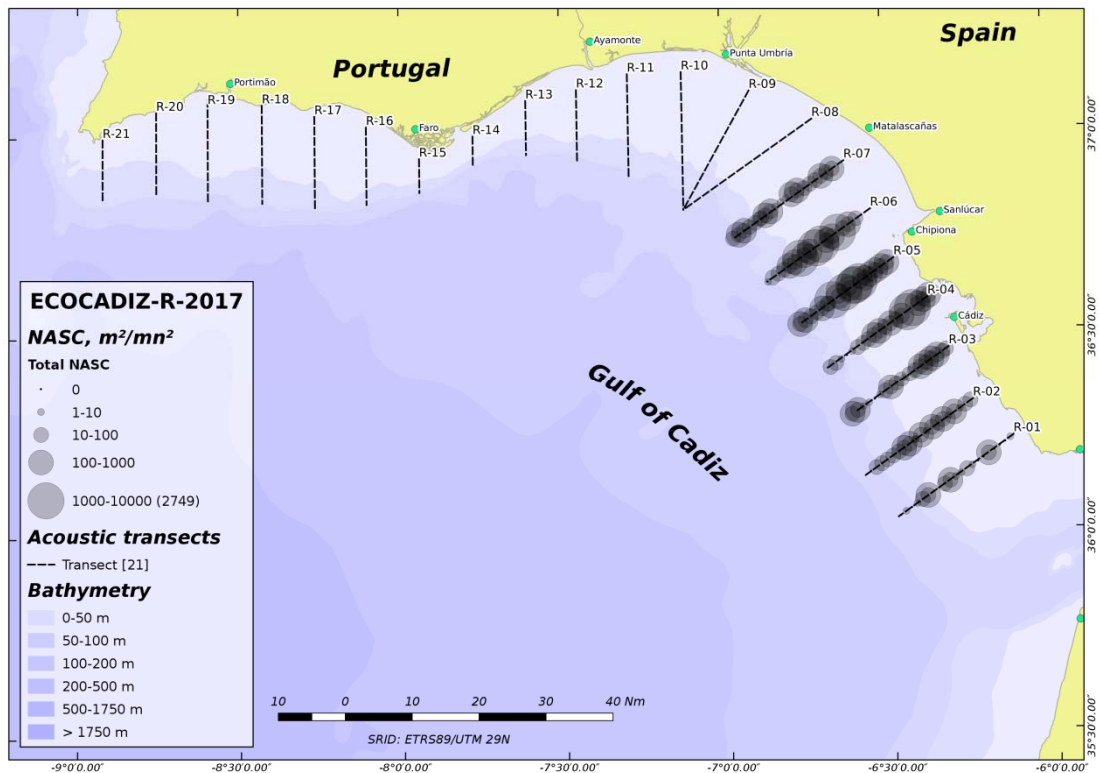


Figure 7. ECOCADIZ-RECLUTAS 2017-10 survey. Distribution of the total backscattering energy (Nautical area scattering coefficient, NASC, in $m^2 nmi^{-2}$) attributed to the pelagic fish species assemblage. Note that only the seven easternmost transects were sampled.

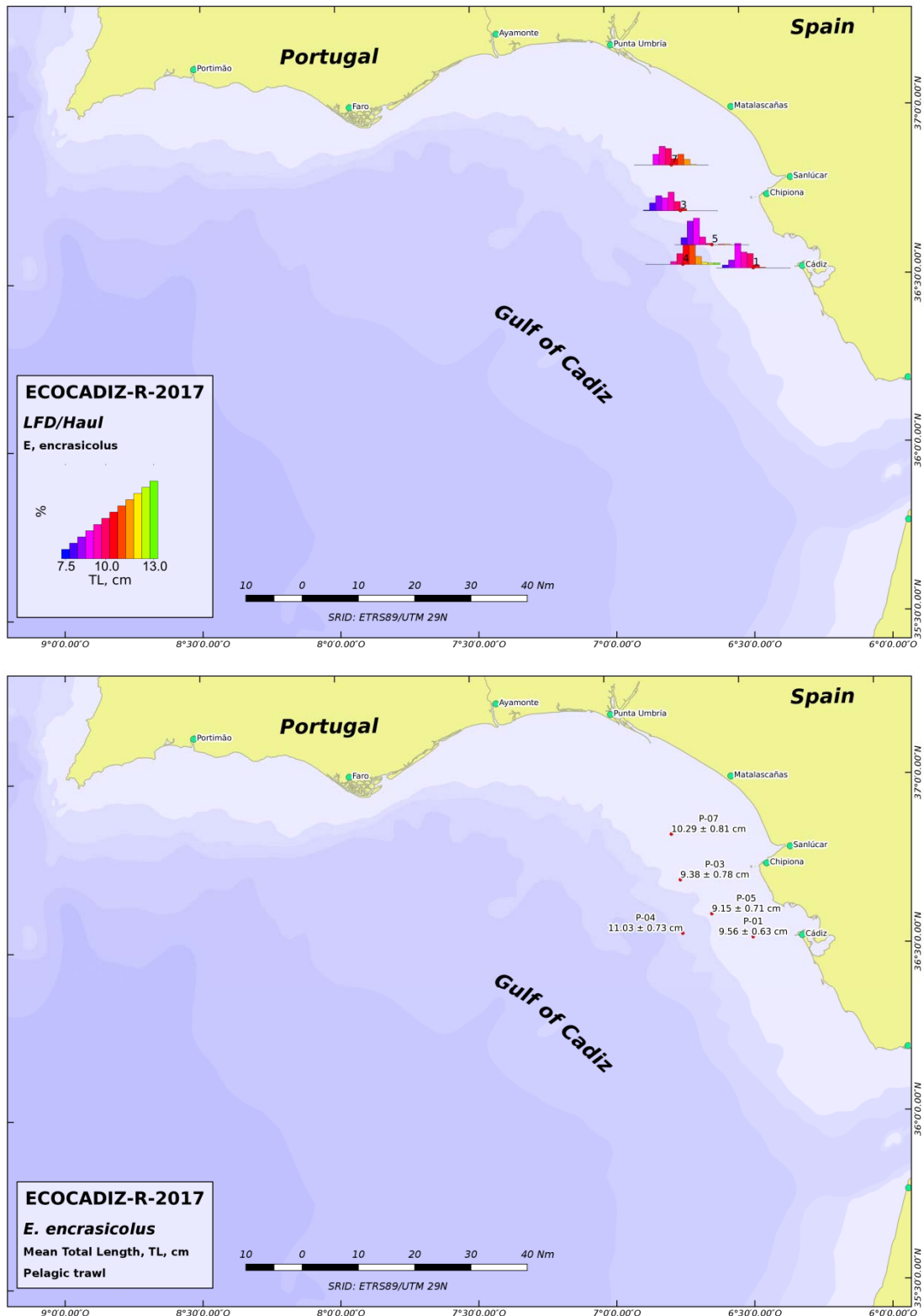


Figure 8. ECOCADIZ-RECLUTAS 2017-10 survey. Anchovy (*Engraulis encrasicolus*). Top: length frequency distributions in fishing hauls. Bottom: mean \pm sd length by haul. Note that only the seven easternmost transects were sampled.

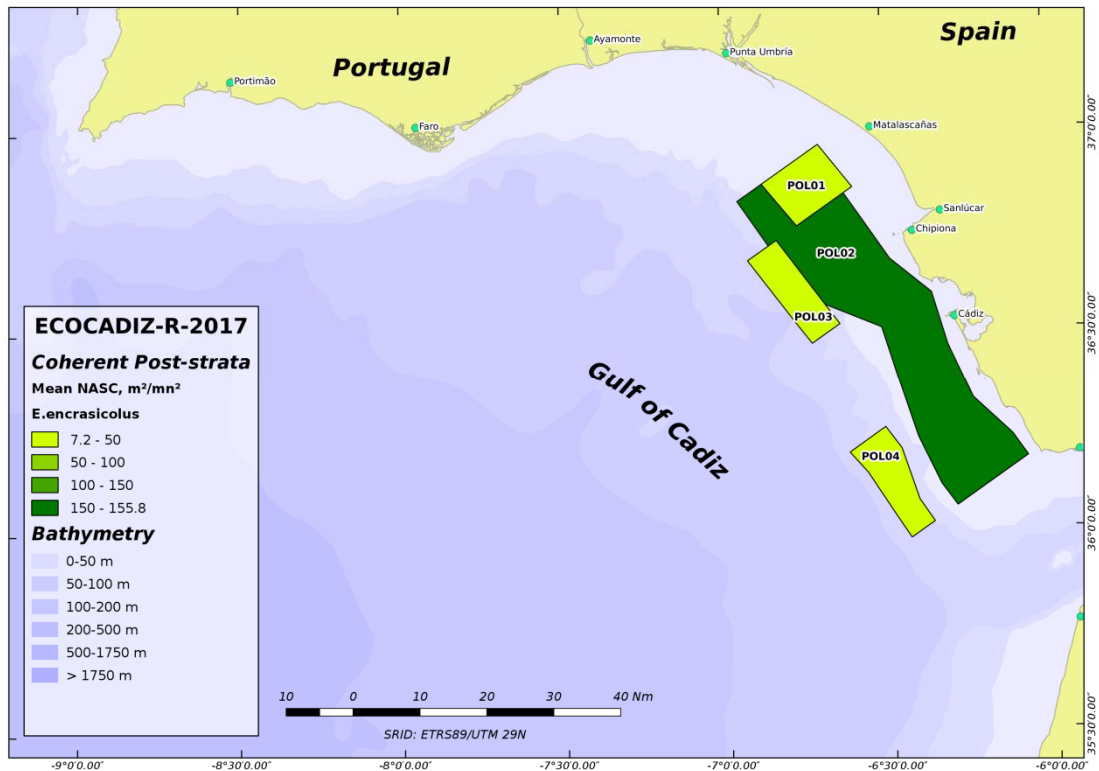
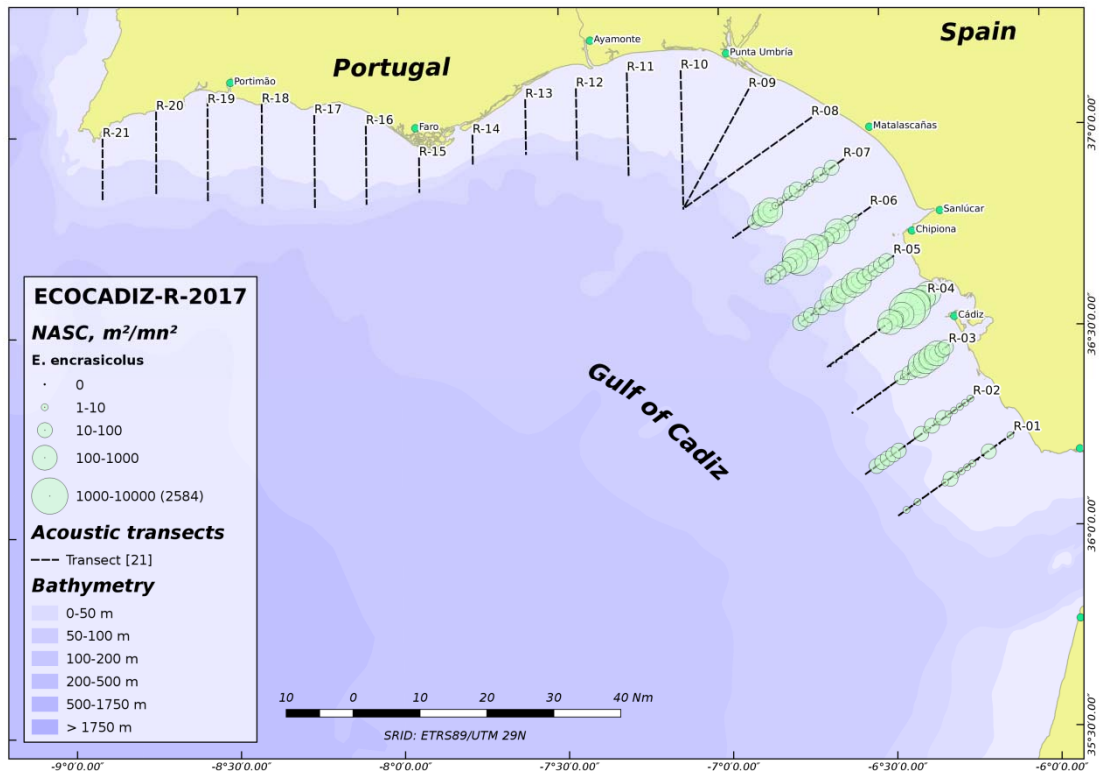


Figure 9. ECOCADIZ-RECLUTAS 2017-10 survey. Anchovy (*Engraulis encrasicolus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, NASC, in m² nmi⁻²) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum. Note that only the seven easternmost transects were sampled.

ECOCADIZ-RECLUTAS 2017-10: Anchovy (*E. encrasicolus*)

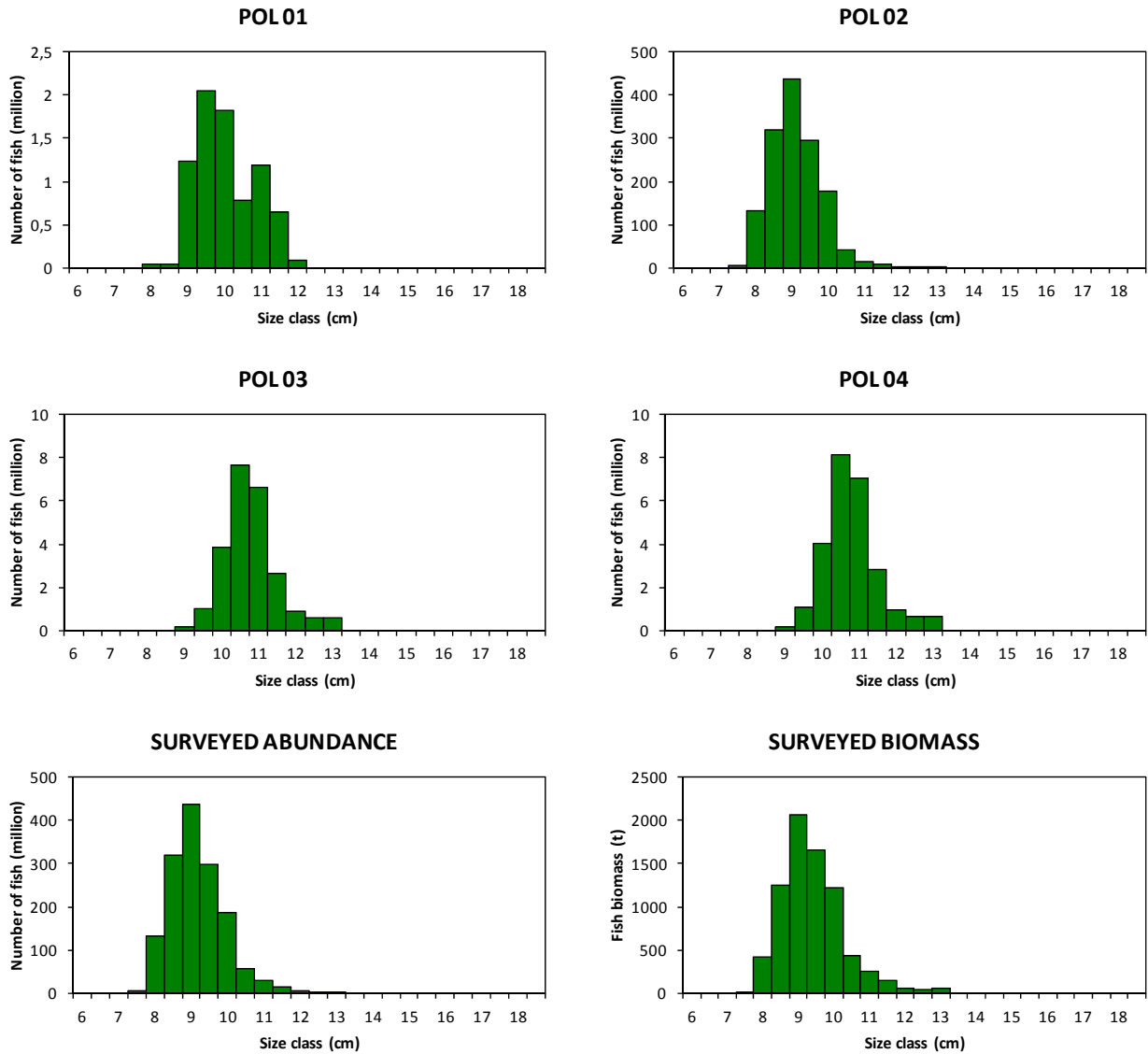


Figure 10. ECOCADIZ-RECLUTAS 2017-10 survey. Anchovy (*Engraulis encrasicolus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 9**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

ECOCADIZ-RECLUTAS 2017-10: Anchovy (*E. encrasicolus*)

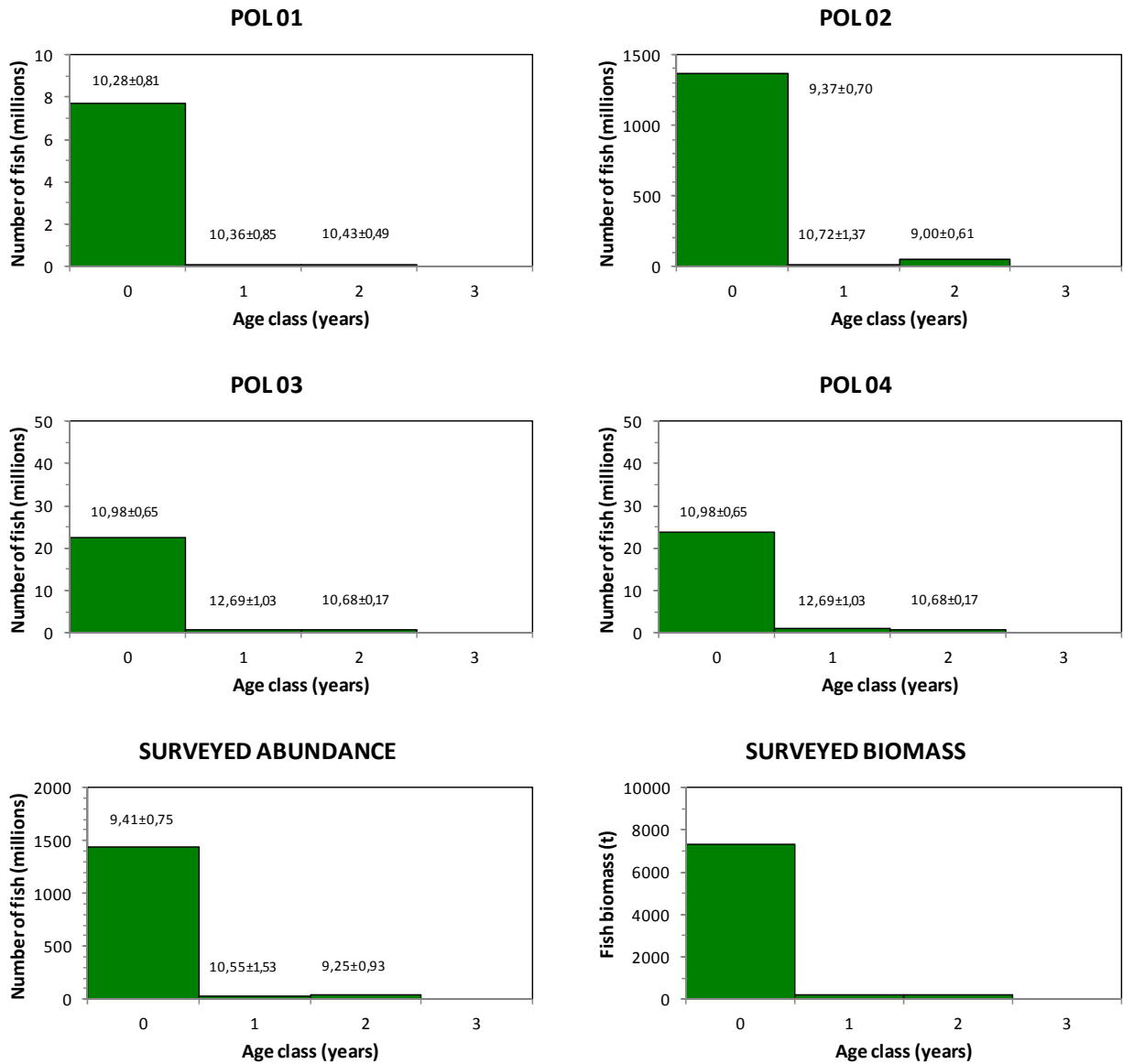


Figure 11. ECOCADIZ-RECLUTAS 2017-10 survey. Anchovy (*Engraulis encrasicolus*). Estimated abundances (number of fish in millions) by age class (years) by homogeneous stratum (POL01-POLn, numeration as in **Figure 9**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

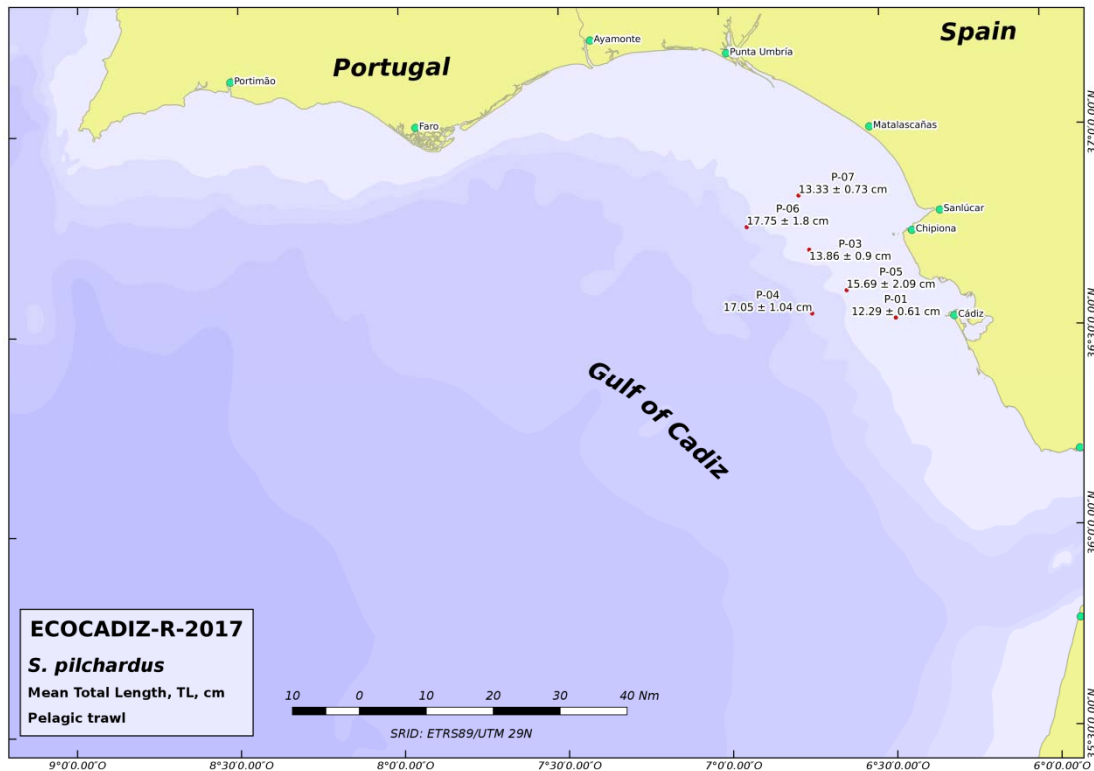
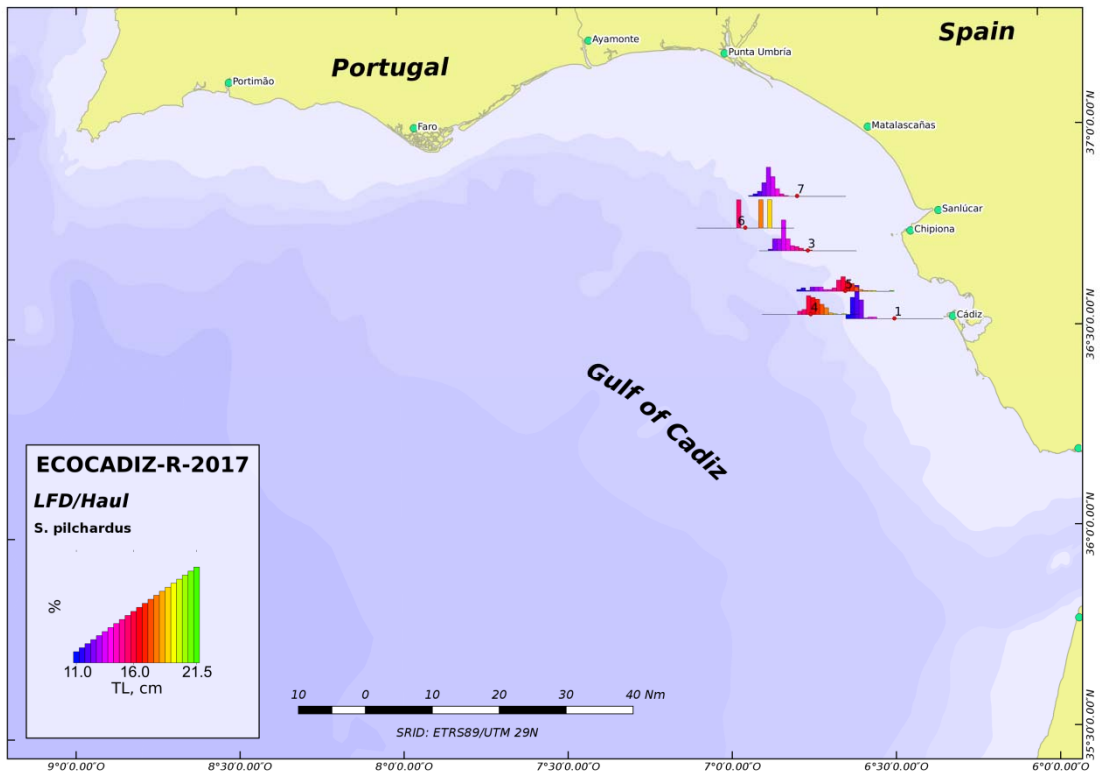


Figure 12. ECOCADIZ-RECLUTAS 2017-10 survey. Sardine (*Sardina pilchardus*). Top: length frequency distributions in fishing hauls. Bottom: mean \pm sd length by haul. Note that only the seven easternmost transects were sampled.

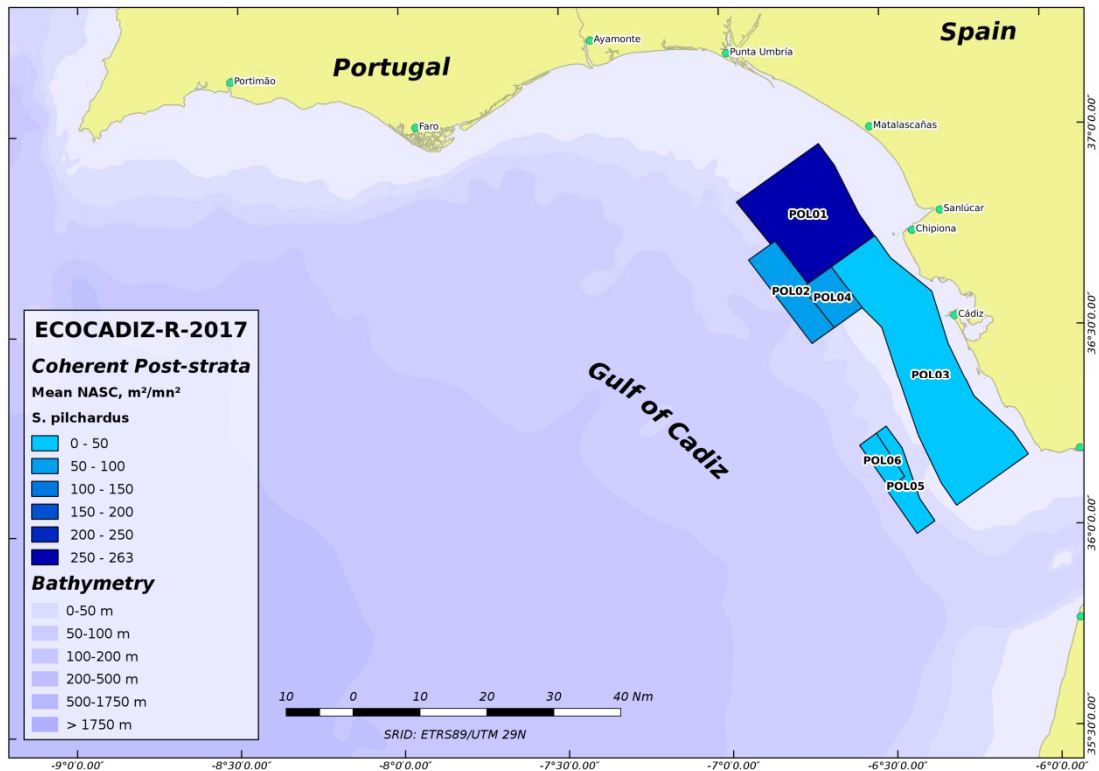
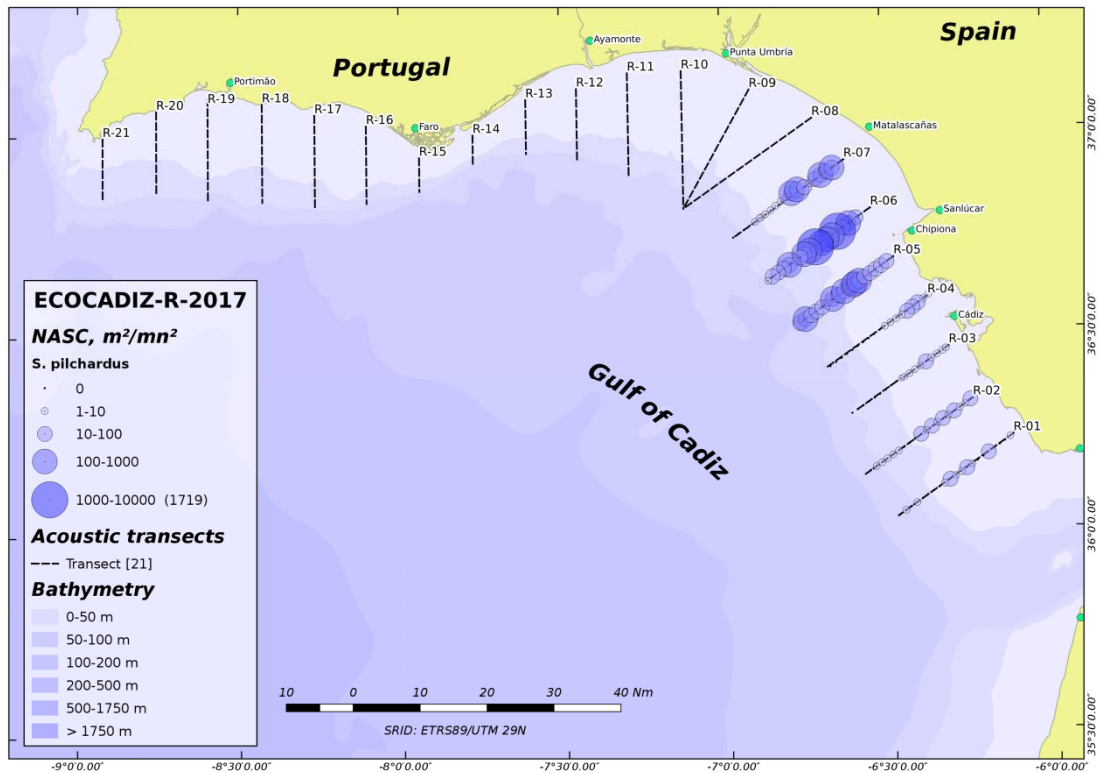


Figure 13. ECOCADIZ-RECLUTAS 2017-10 survey. Sardine (*Sardina pilchardus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, NASC, in $m^2 nmi^{-2}$) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum. Note that only the seven easternmost transects were sampled.

ECOCADIZ-RECLUTAS 2017-10: Sardine (*S. pilchardus*)

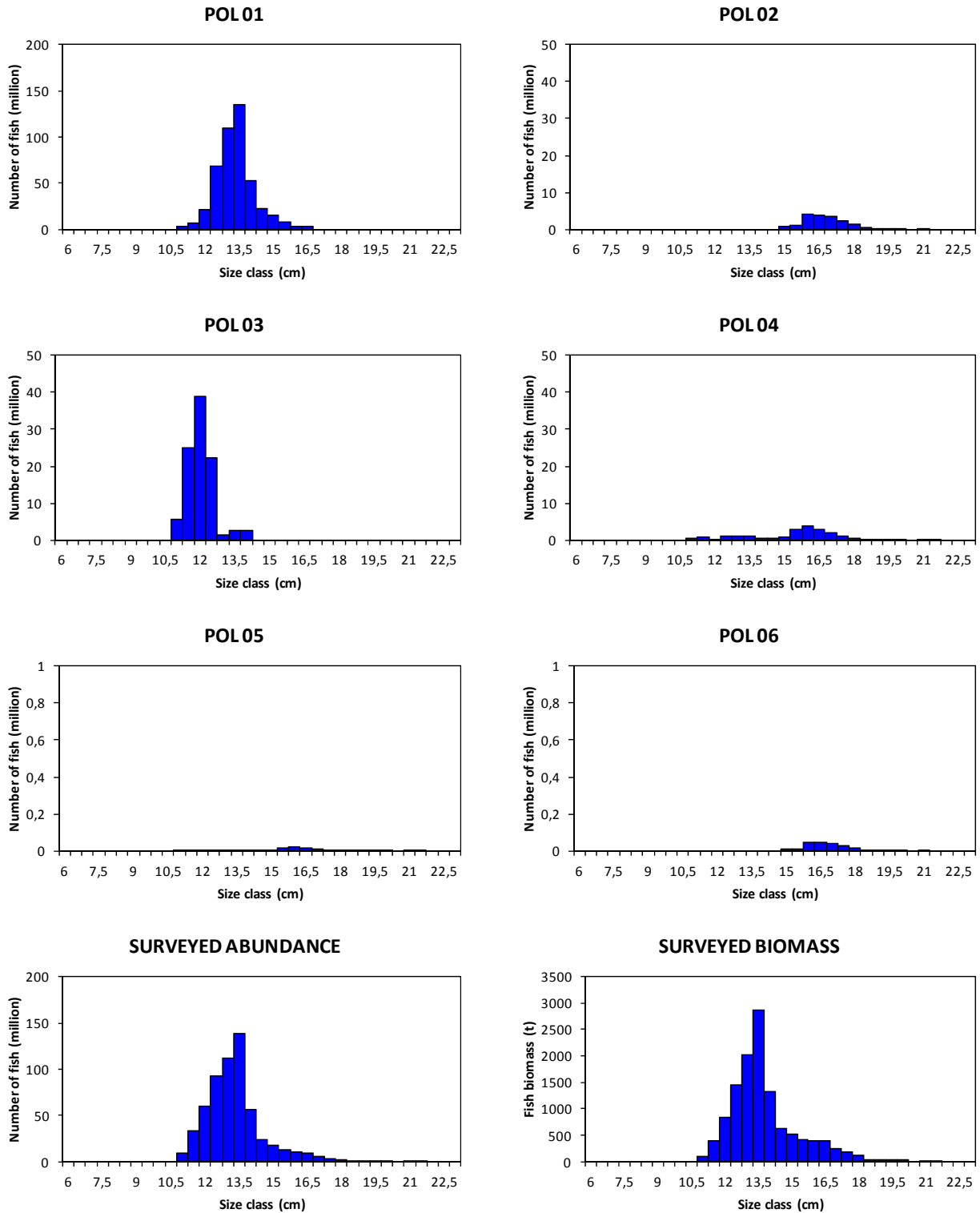


Figure 14. ECOCADIZ-RECLUTAS 2017-10 survey. Sardine (*Sardina pilchardus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 13**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

ECOCADIZ-RECLUTAS 2017-10: Sardine (*S. pilchardus*)

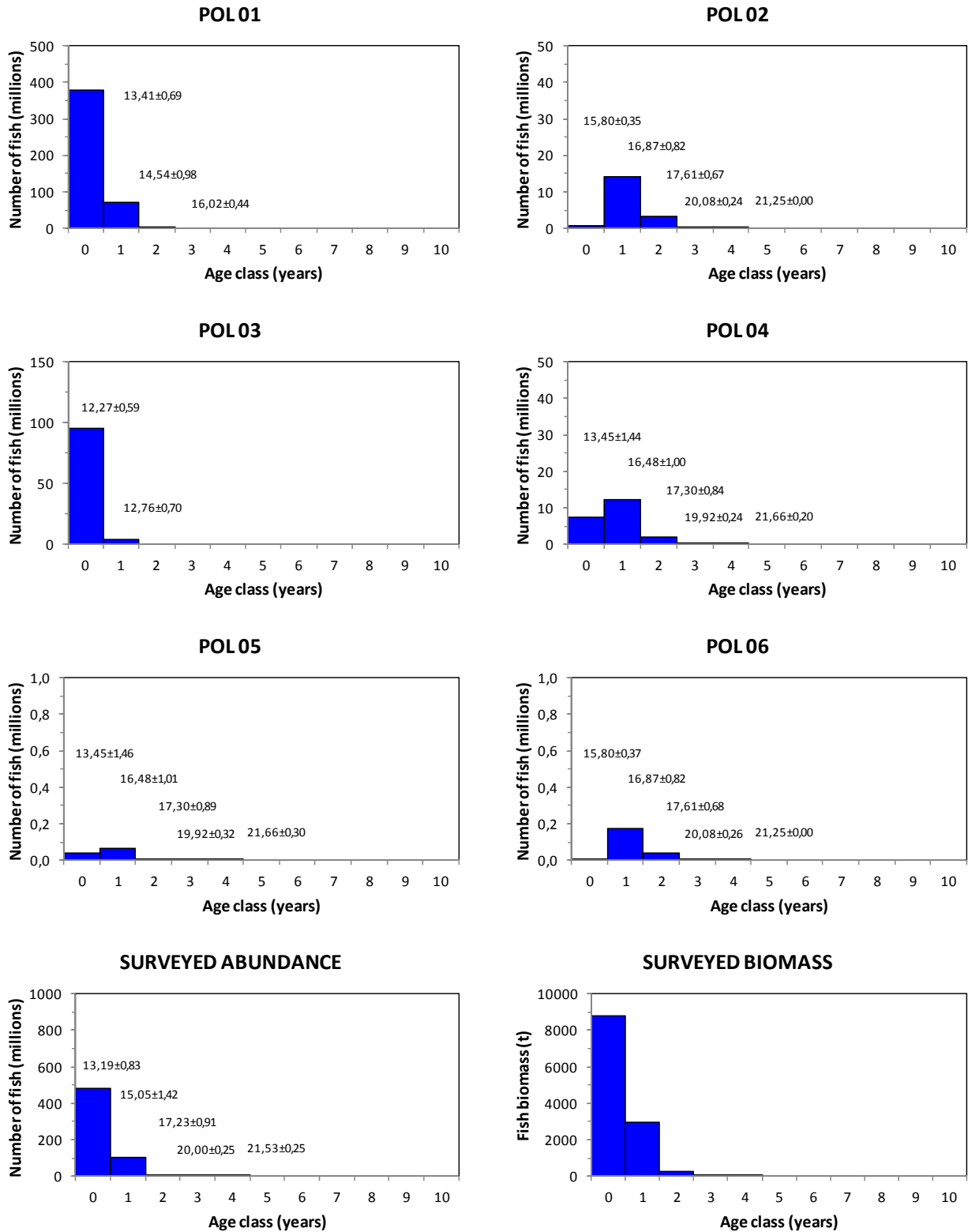


Figure 15. ECOCADIZ-RECLUTAS 2017-10 survey. Sardine (*Sardina pilchardus*). Estimated abundances (number of fish in millions) by age class (years) by homogeneous stratum (POL01-POLn, numeration as in **Figure 13**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

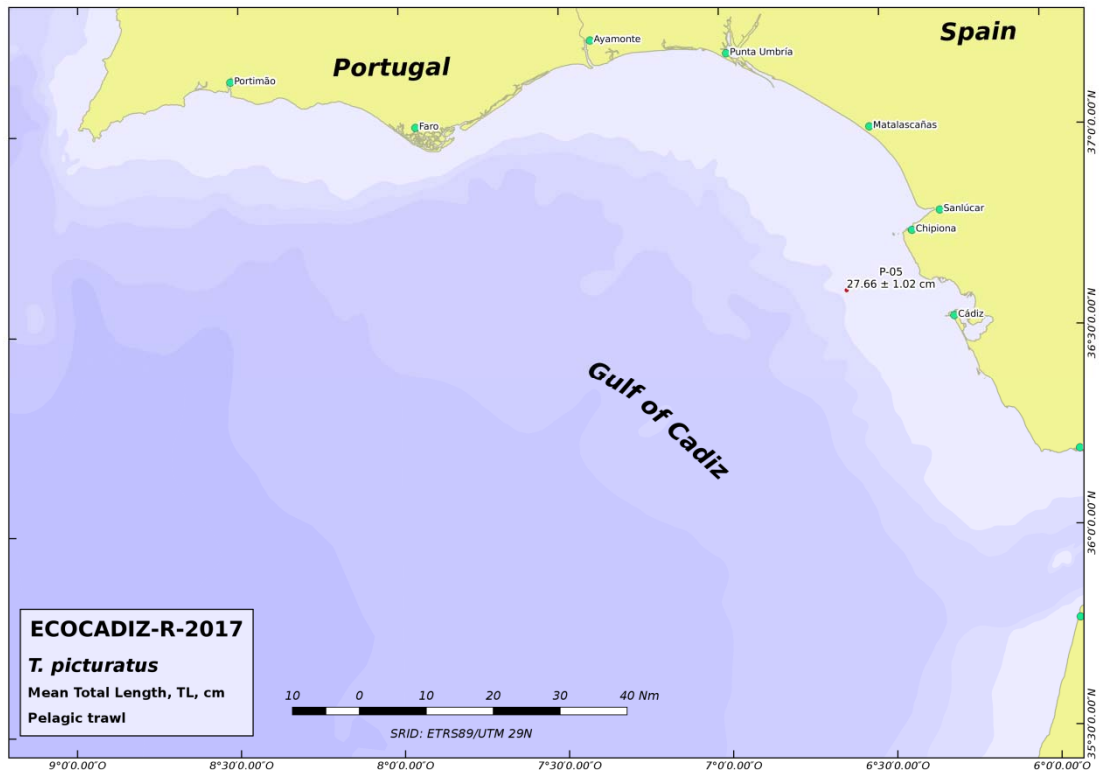
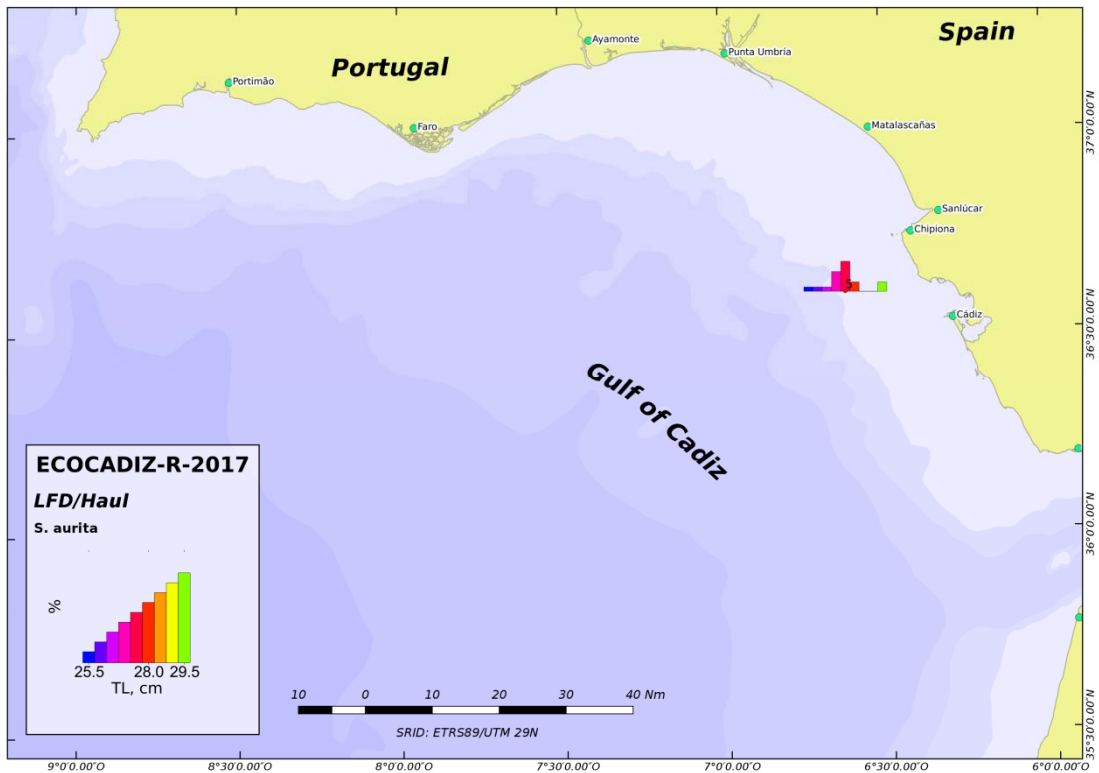


Figure 16. ECOCADIZ-RECLUTAS 2017-10 survey. Round sardinella (*Sardinella aurita*). Top: length frequency distributions in fishing hauls. Bottom: mean \pm sd length by haul. Note that only the seven easternmost transects were sampled.

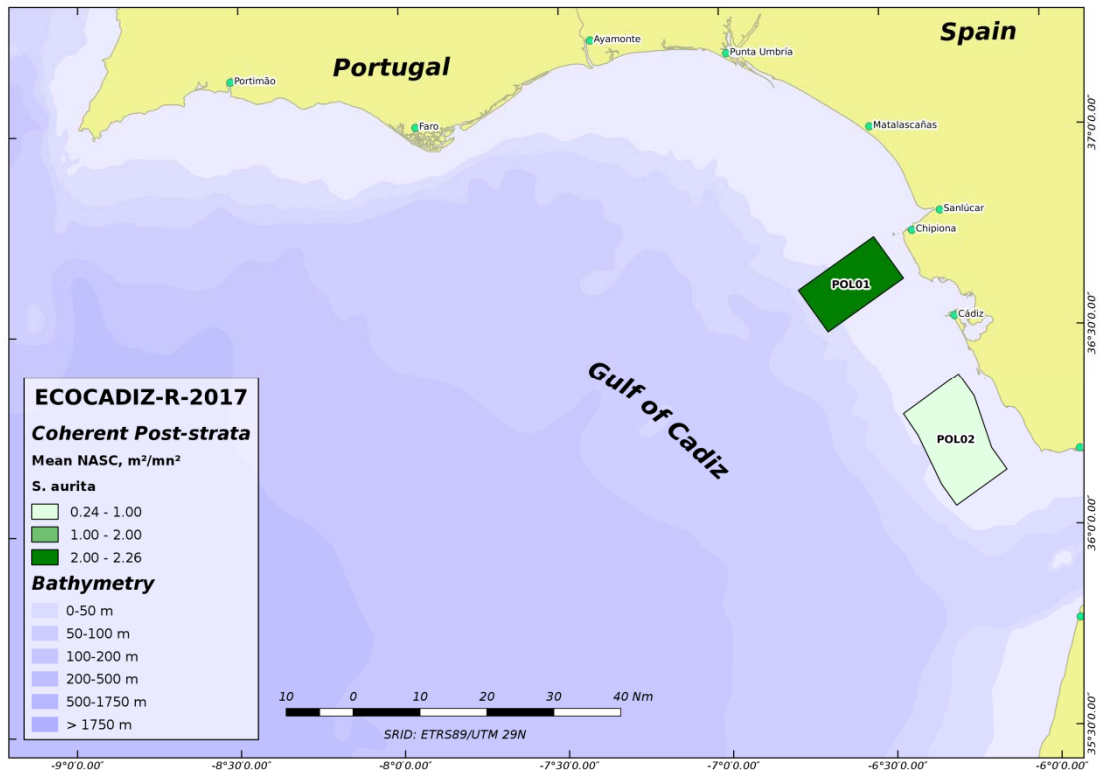
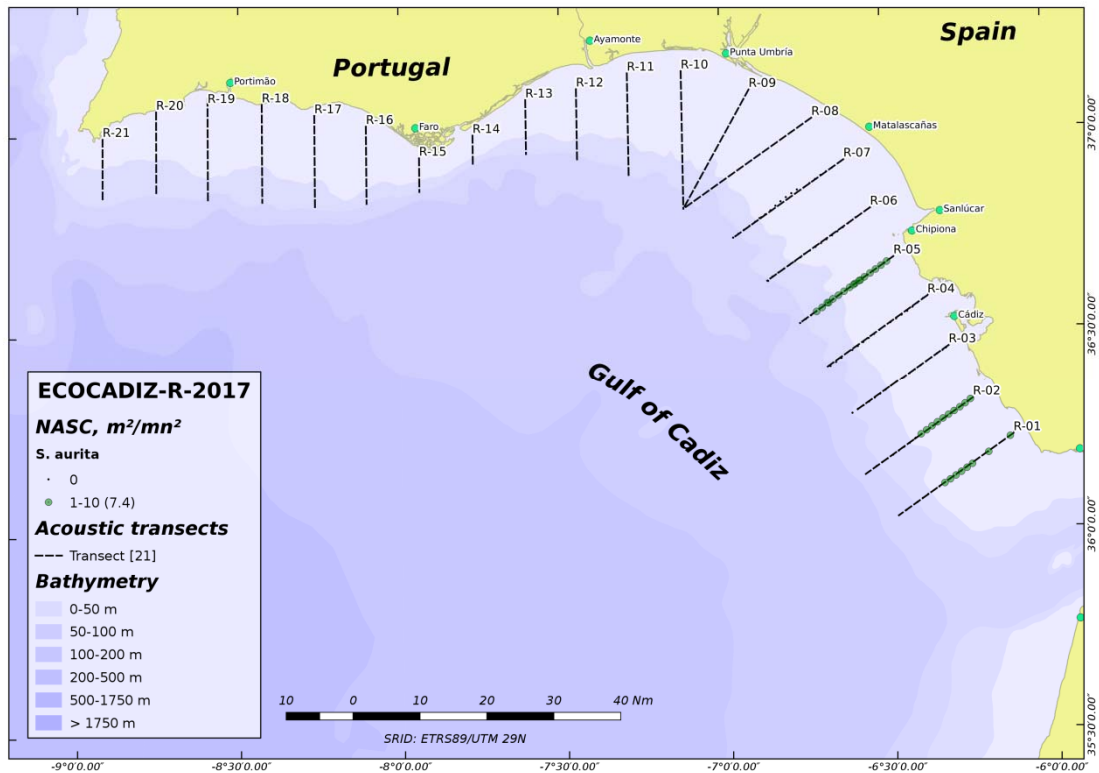


Figure 17. ECOCADIZ-RECLUTAS 2017-10 survey. Round sardinella (*Sardinella aurita*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in $\text{m}^2 \text{nm}^{-2}$) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum. Note that only the seven easternmost transects were sampled.

ECOCADIZ-RECLUTAS 2017-10: Round sardinella (*S. aurita*)

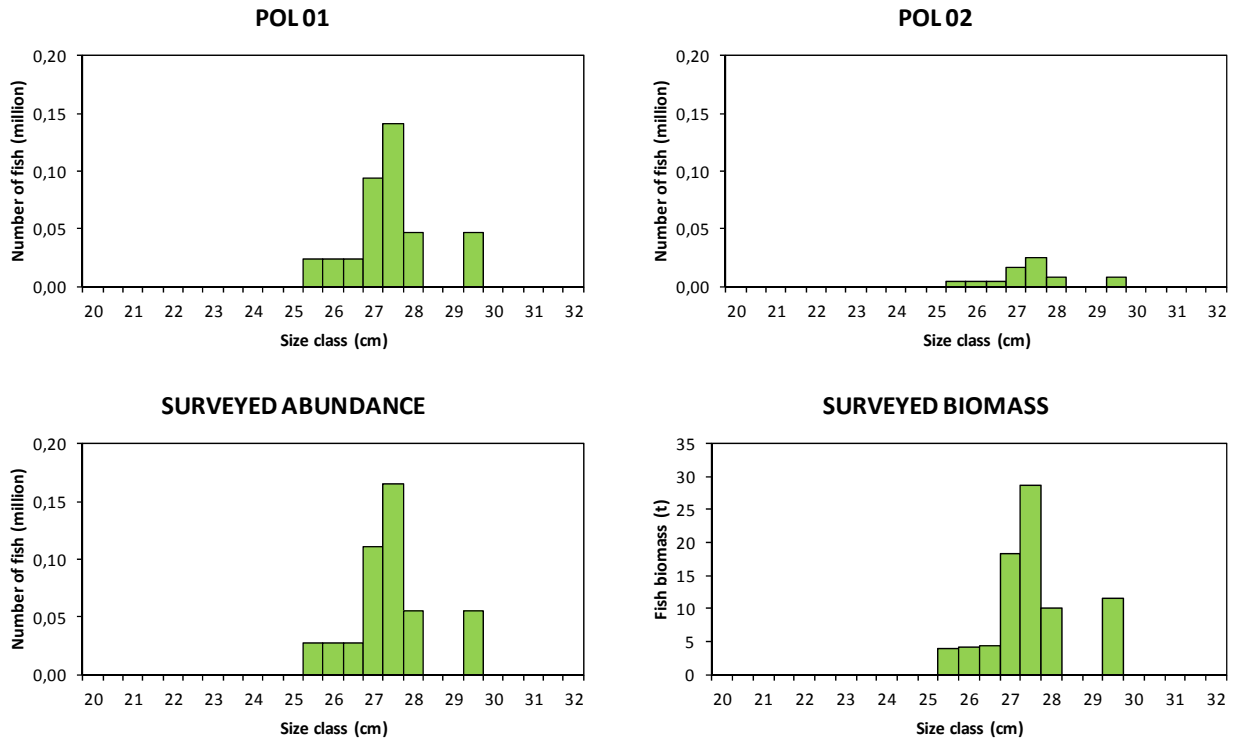


Figure 18. ECOCADIZ-RECLUTAS 2017-10 survey. Round sardinella (*Sardinella aurita*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 17**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

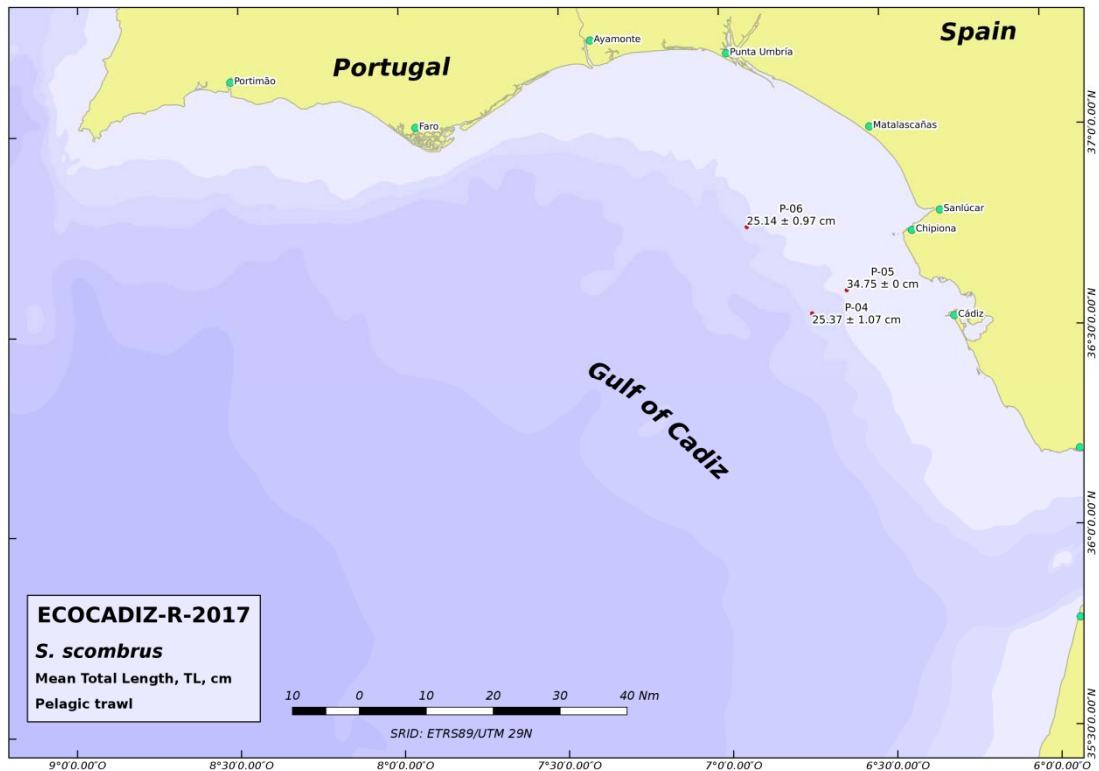
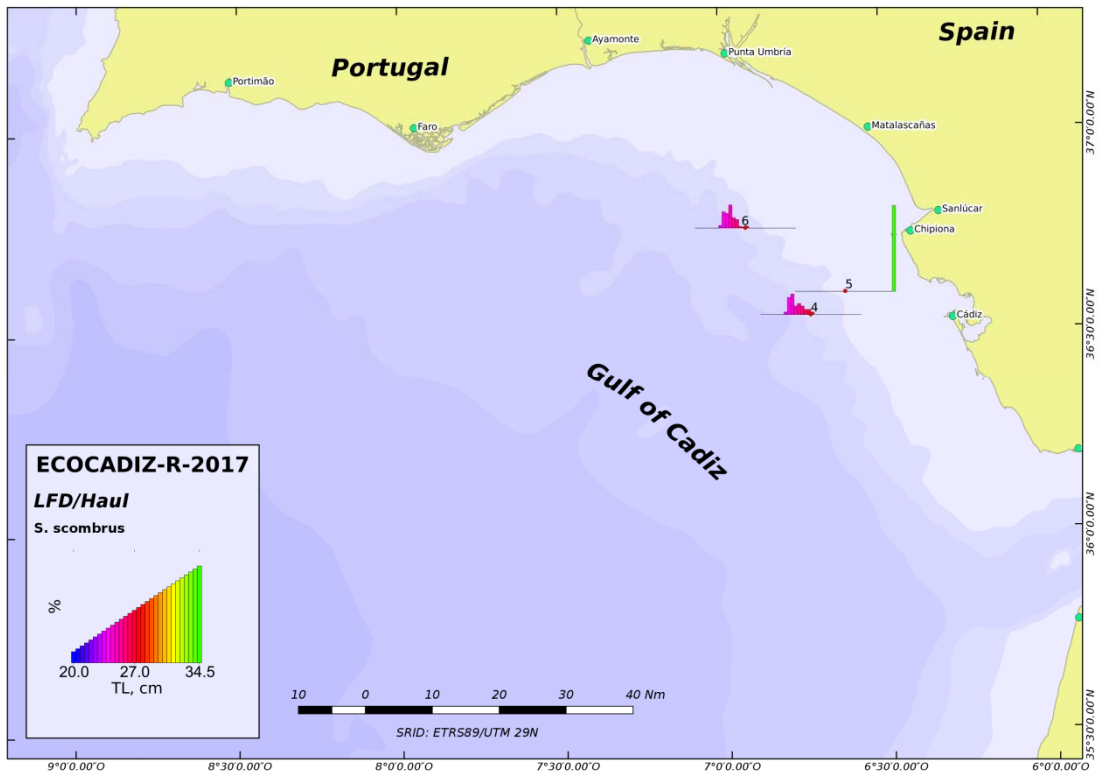


Figure 19. ECOCADIZ-RECLUTAS 2017-10 survey. Atlantic mackerel (*Scomber scombrus*). Top: length frequency distributions in fishing hauls. Bottom: mean \pm sd length by haul. Note that only the seven easternmost transects were sampled.

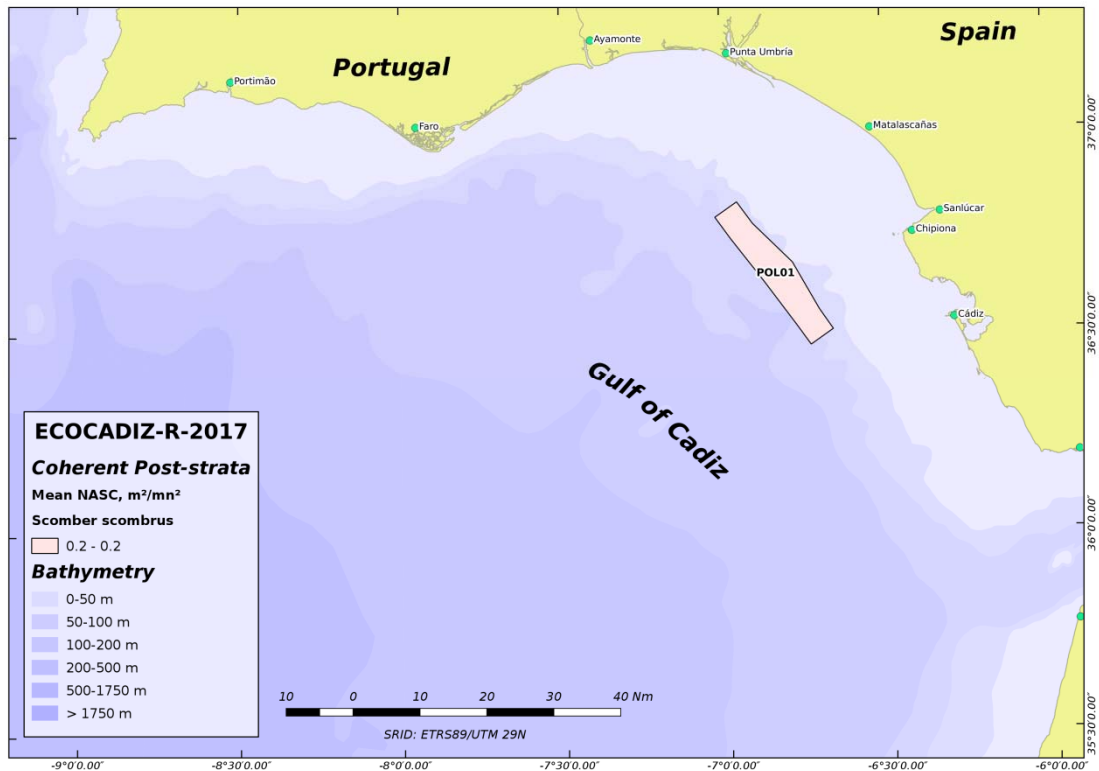
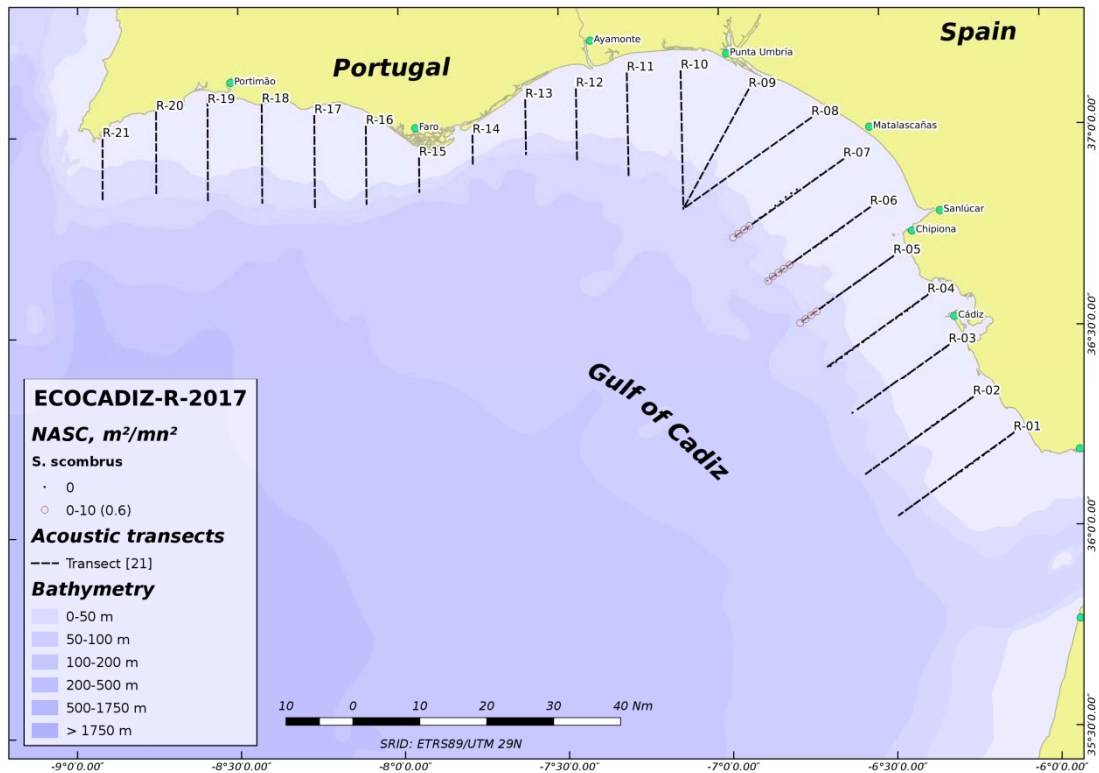


Figure 20. ECOCADIZ-RECLUTAS 2017-10 survey. Atlantic mackerel (*Scomber scombrus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, $NASC$, in $m^2 nmi^{-2}$) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum. Note that only the seven easternmost transects were sampled.

ECOCADIZ-RECLUTAS 2017-10: Atlantic mackerel (*S. scombrus*)

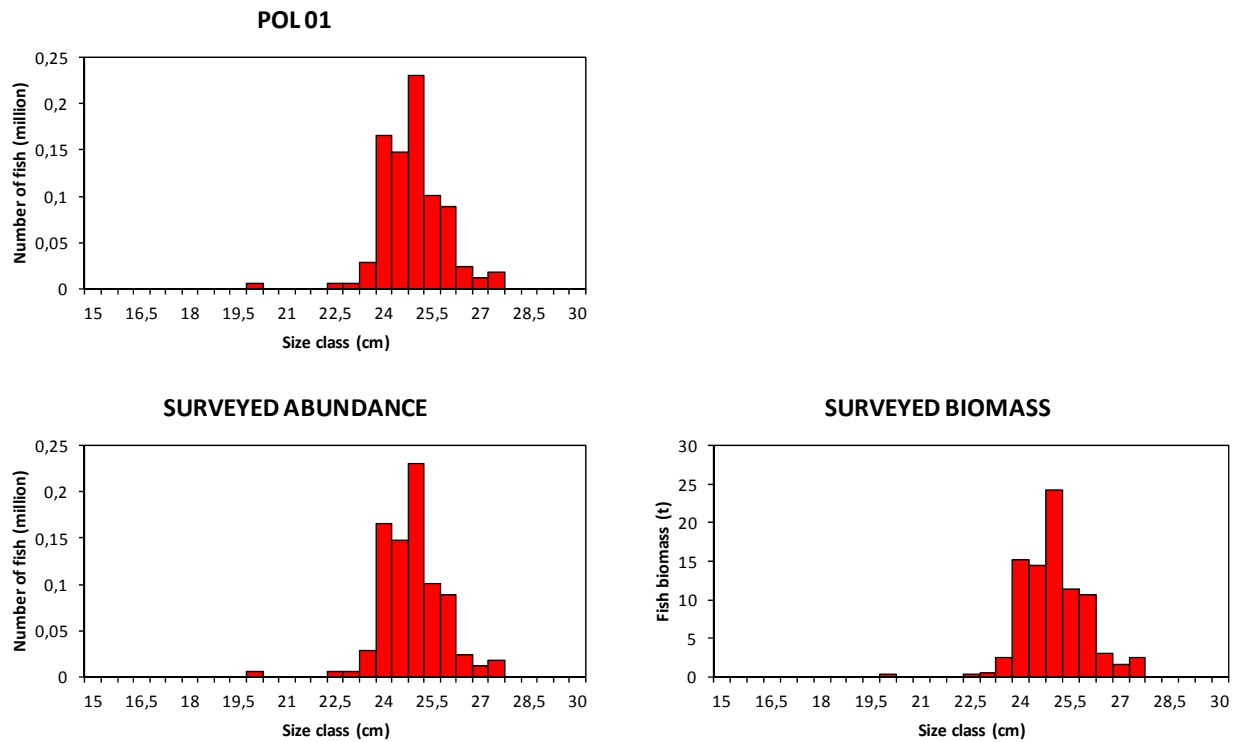


Figure 21. ECOCADIZ-RECLUTAS 2017-10 survey. Atlantic mackerel (*Scomber scombrus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 20**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

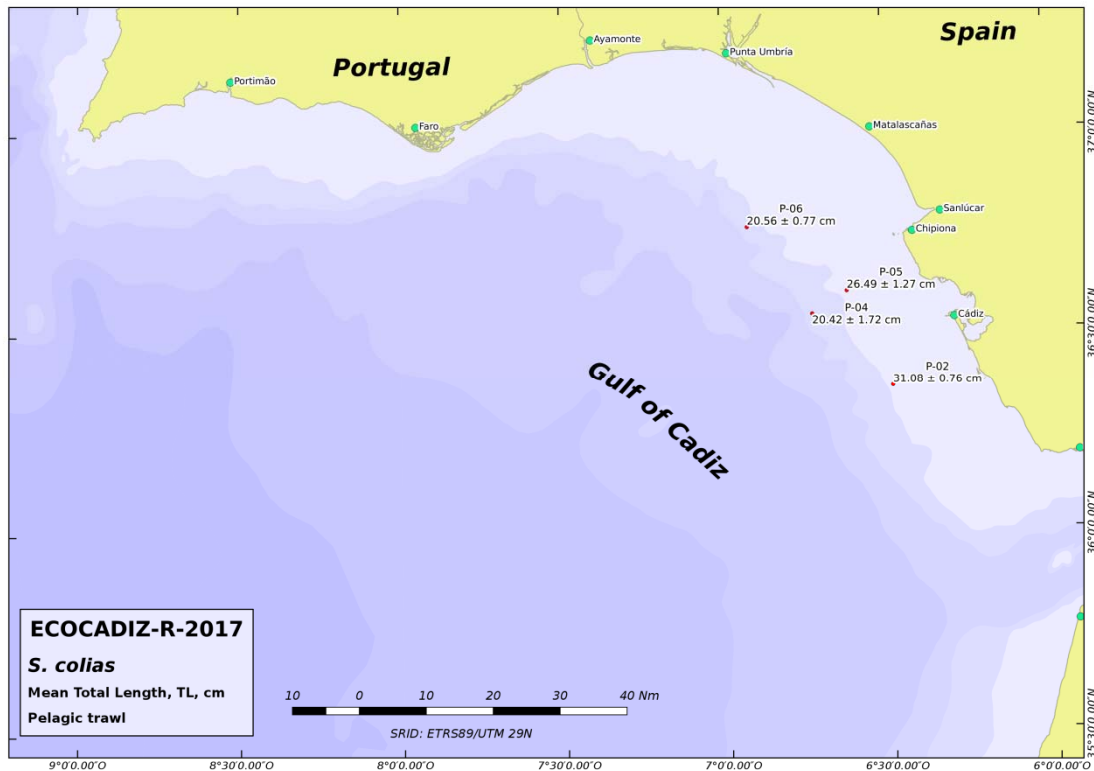
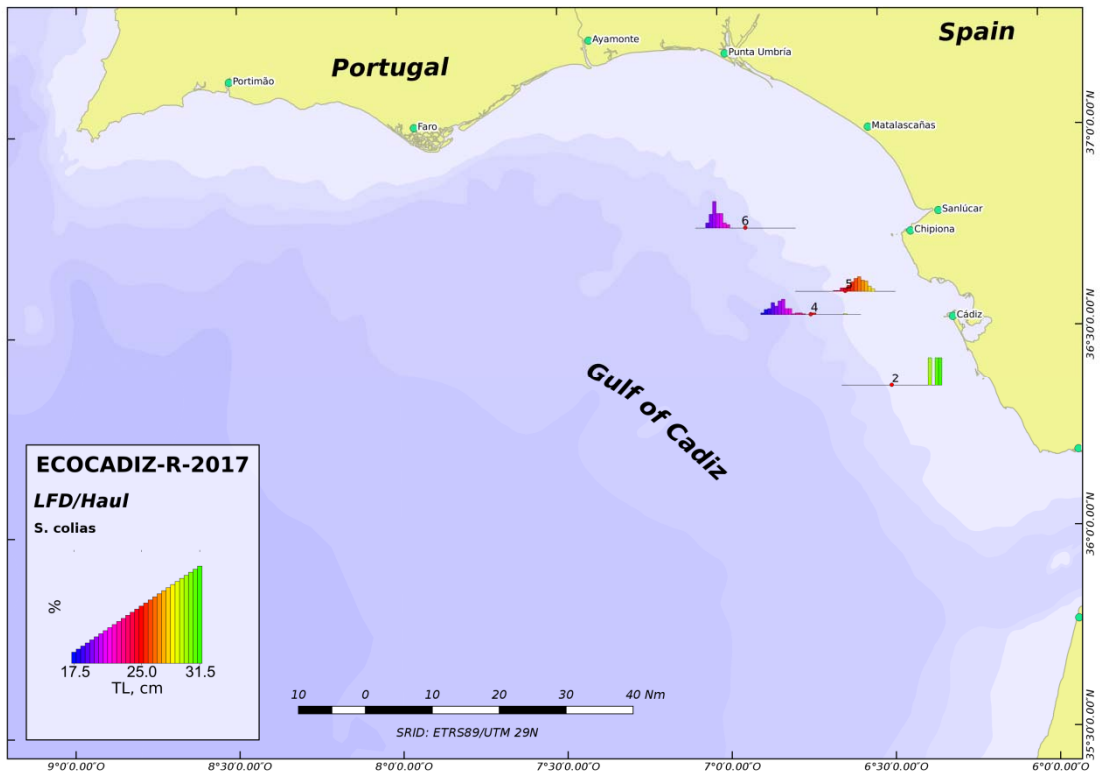


Figure 22. ECOCADIZ-RECLUTAS 2017-10 survey. Chub mackerel (*Scomber colias*). Top: length frequency distributions in fishing hauls. Bottom: mean \pm sd length by haul. Note that only the seven easternmost transects were sampled.

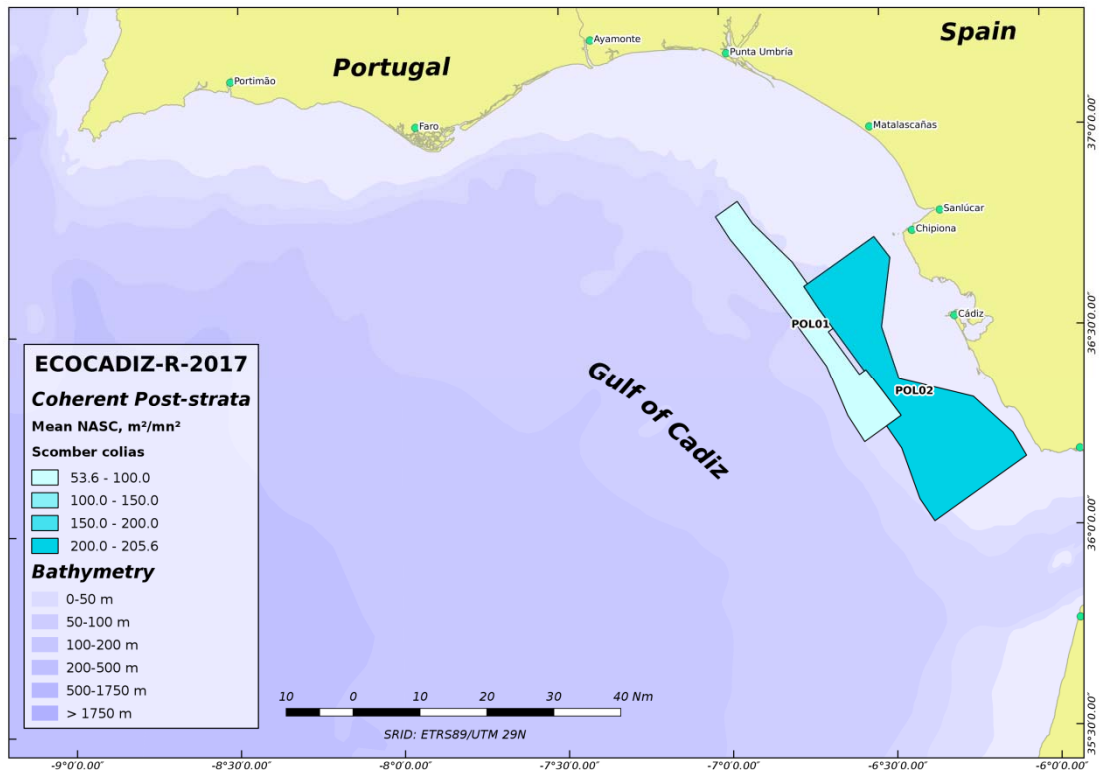
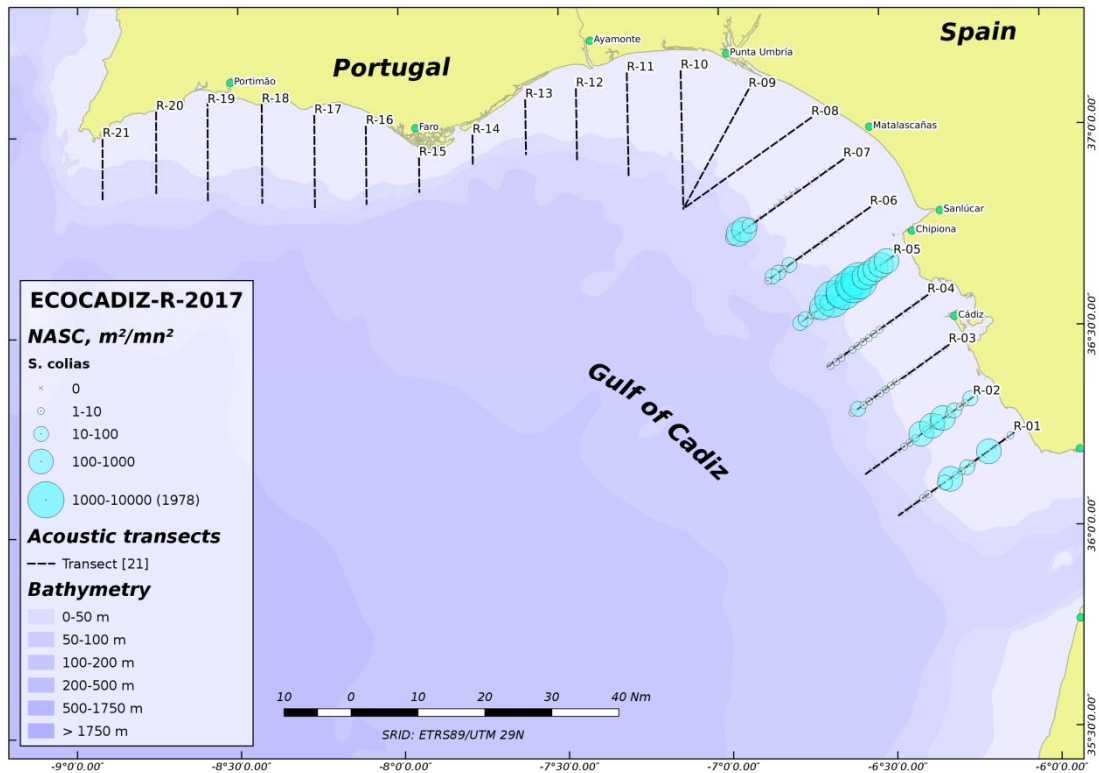


Figure 23. ECOCADIZ-RECLUTAS 2017-10 survey. Chub mackerel (*Scomber colias*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, $NASC$, in $m^2 nmi^{-2}$) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum. Note that only the seven easternmost transects were sampled.

ECOCADIZ-RECLUTAS 2017-10: Chub mackerel (*S. colias*)

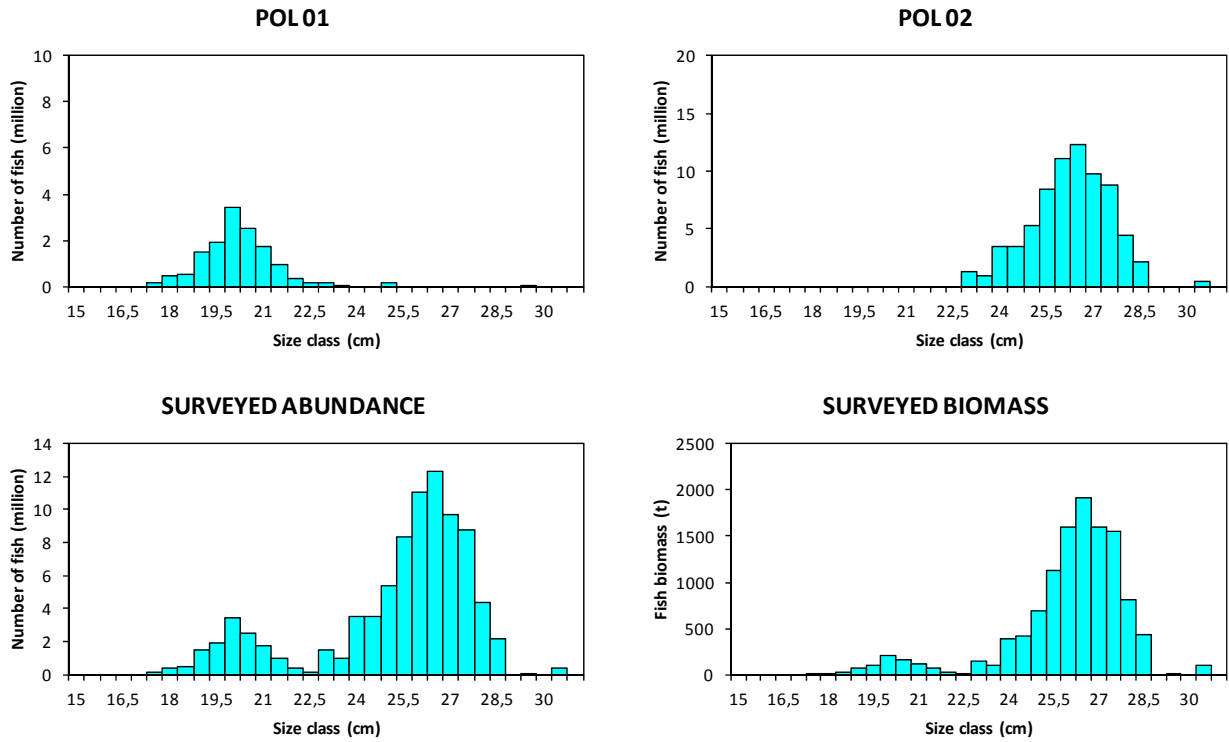


Figure 24. ECOCADIZ-RECLUTAS 2017-10 survey. Chub mackerel (*Scomber colias*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 23**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

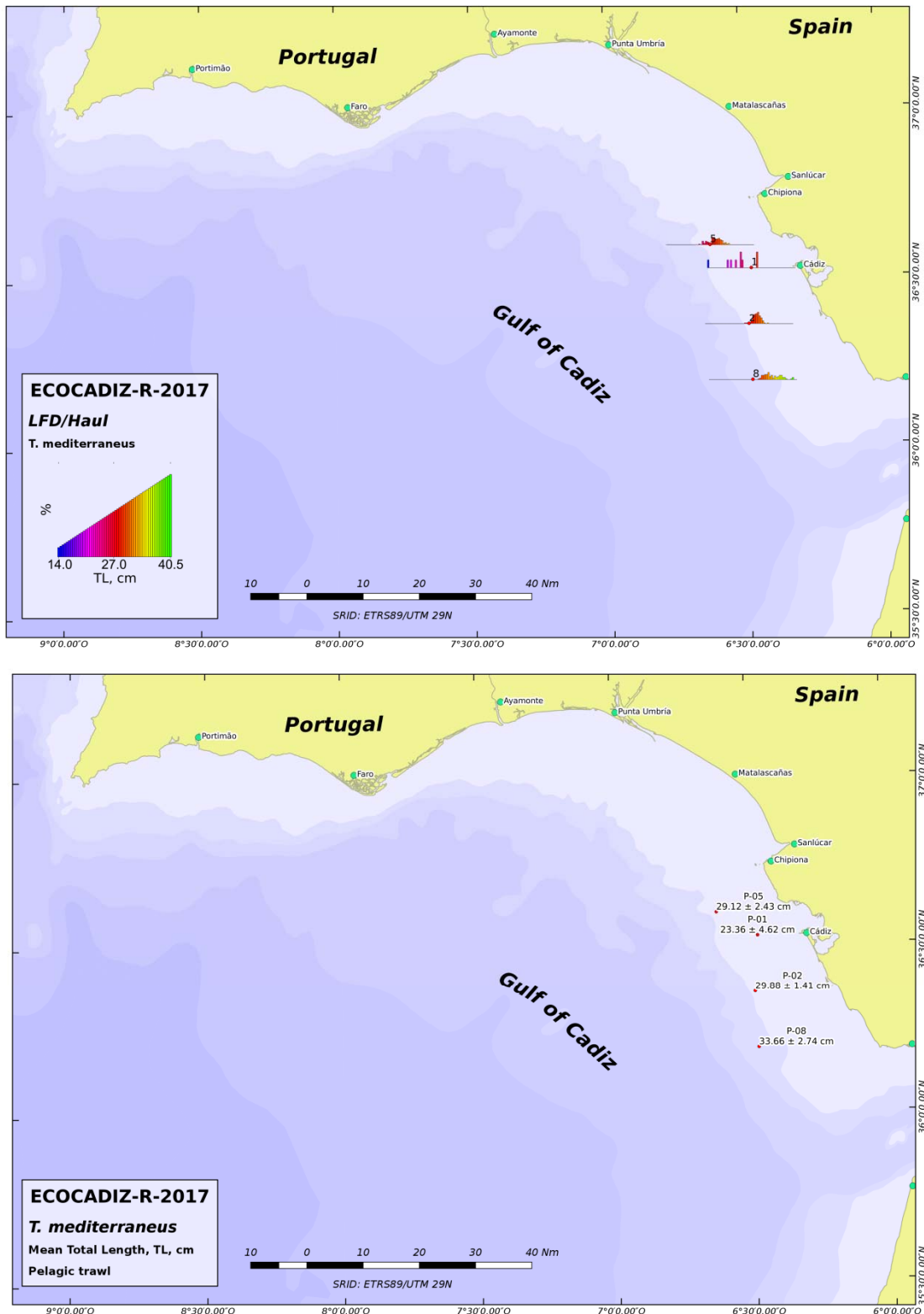


Figure 25. ECOCADIZ-RECLUTAS 2017-10 survey. Mediterranean horse mackerel (*Trachurus mediterraneus*). Top: length frequency distributions in fishing hauls. Bottom: mean \pm sd length by haul. Note that only the seven easternmost transects were sampled.

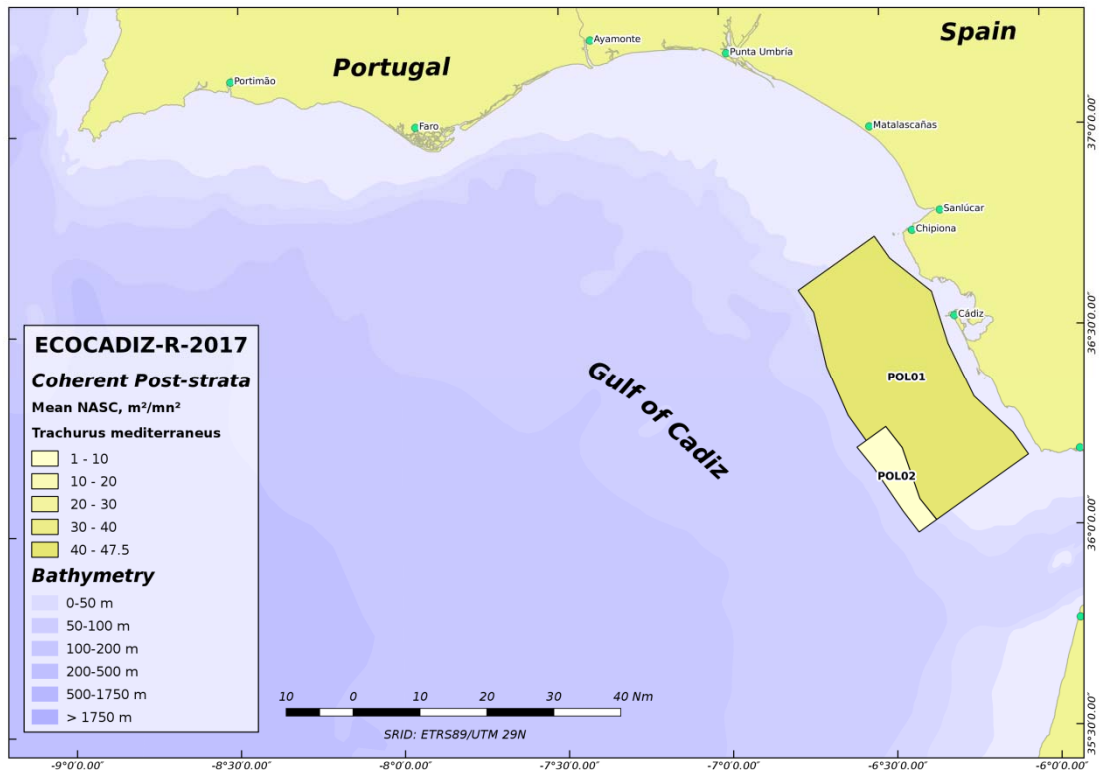
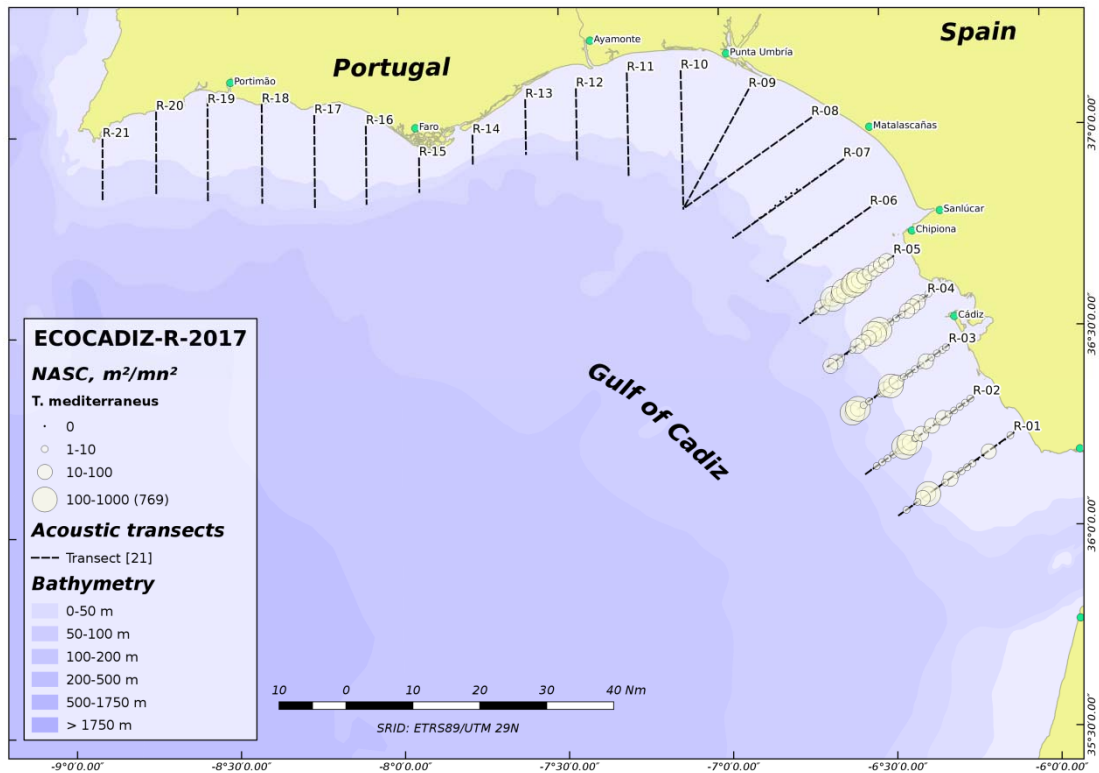


Figure 26. ECOCADIZ-RECLUTAS 2017-10 survey. Mediterranean horse mackerel (*Trachurus mediterraneus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, NASC, in $m^2 nmi^{-2}$) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum. Note that only the seven easternmost transects were sampled.

ECOCADIZ-RECLUTAS 2017-10: Mediterranean horse mackerel (*T. mediterraneus*)

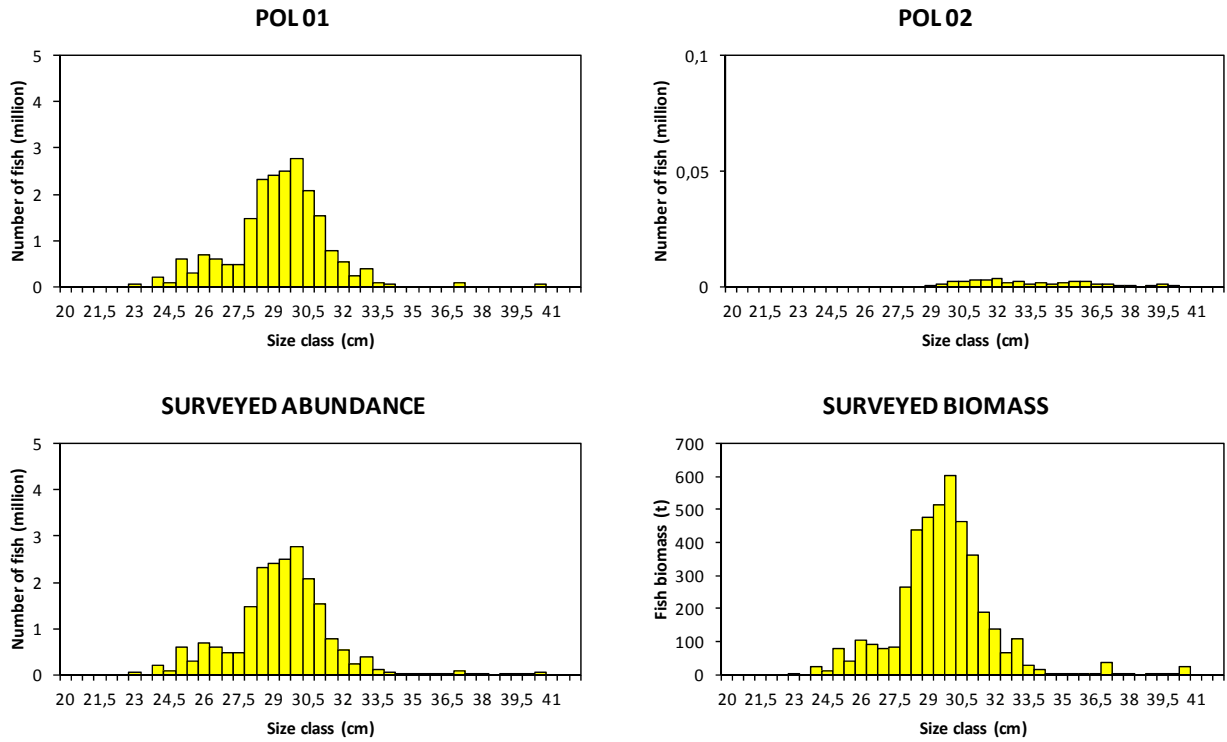


Figure 27. ECOCADIZ-RECLUTAS 2017-10 survey. Mediterranean horse mackerel (*Trachurus mediterraneus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 26**) and total sampled area. Post-strata ordered in the W-E direction. 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.

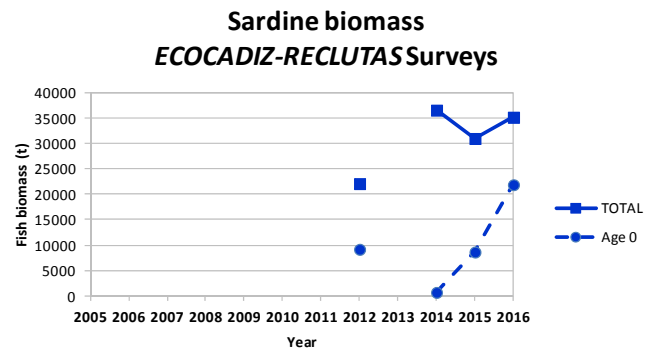
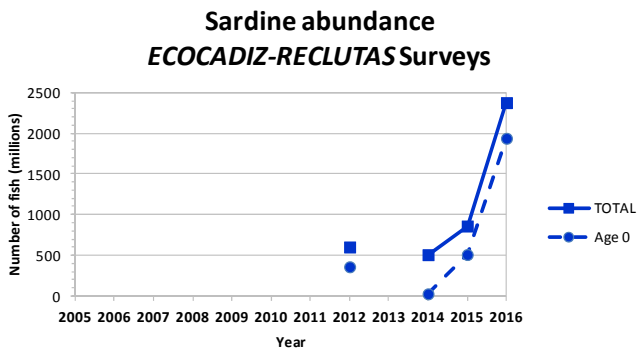
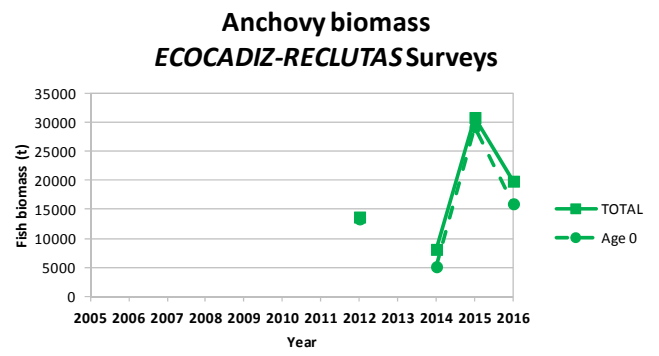
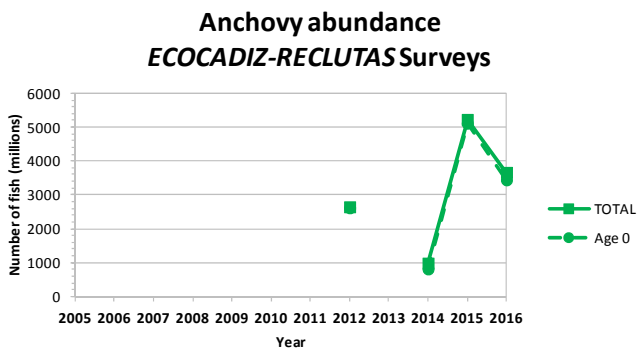


Figure 28. ECOCADIZ-RECLUTAS surveys series. Historical series of autumn acoustic estimates of anchovy and sardine abundance (million) and biomass (t) in Sub-division 9.a South. The estimates correspond to the total population and age 0 fish.

