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24–29 June 2016

Lorient, France

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CIEM Conseil International pour l'Exploration de la Mer

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Executive Summary

The Working Group on Southern Horse Mackerel, Anchovy and Sardine (WGHANSA) met at IFREMER (Lorient, France), 24–29 June 2016, and was chaired by Lionel Pawlowski. There were 12 participants from France, Portugal and Spain. The main task was to assess the status and to provide short-term predictions for the stocks of anchovy in Division 9.a, for sardine in Divisions 8.c and 9.a, and in Divisions 8.a, b, d, and Subarea 7, and for horse mackerel (*T. trachurus*) in Division 9.a and blue jack mackerel (*T. picturatus*) in 10 (Azores). Assessments were updated according to the stock annexes.

As anchovy in Subarea 8 is scheduled for assessment and short term forecast in November 2016, no preliminary or exploratory assessment was carried out this year. Information from the new spring surveys are not conflicting with the previous assessment carried out in November 2015. Spring surveys from 2016 suggest similar levels of biomass as last year. Catches in 2015 were 28 258 t.

As in previous years, the WG collected the few available data on the fisheries of anchovy in northern areas (subareas 4, 5, and 6), although no assessment is so far required for the anchovy in those regions.

Anchovy in Division 9.a is a data poor stock category for which trend based assessment from surveys is provided. In 2016, the acoustic PELAGO+PELACUS surveys estimated a biomass of 103 852 t, well above the average 2007–2015 (31 562 t). In the western areas, catches are generally low (several hundred tonnes) but sometimes exceeds a thousand tonnes such as in 2015 (2716 t). PELAGO+PELACUS in northern and western areas (9.a North, 9.a Central-North and 9.a Central-South) estimated in 2016 a biomass of 38 507 t which is higher than the average for 2007–15 (2011 excluded), estimated on 8010 t following 2014 which was also higher than usual. The bulk of the population is usually concentrated in the Subdivision 9.a South, where the stock supports a fishery whose catches were 6880 t in 2015 (against 9597 t for the whole Division 9.a). The 2016 biomass index in the 9.a South from the acoustic PELAGO survey is estimated to be 65 345 t which is more than the double above the historical mean (29 285 t). However, neither the fishery nor the population indices (assessed by surveys) show any long-term trend for the anchovy in 9.a South. Exploratory evaluations of current harvest rates in the context of Yield-per-recruit analysis suggest that current exploitation levels in the 9.a South are sustainable. There is no information on recruitment that will form the bulk of the catches in the following year.

For the Iberian sardine, an updated analytic assessment of the population was carried out this year. Catches were 21 kt in 2015 which is the lowest historical value. The biomass of age 1 and older fish in 2015, 168 thousand tonnes, is 66% below the historical mean. The biomass 1+ increased 25% from 2014 to 2015 but is still around the historical low as observed in the past five years. .. Fishing mortality has decreased by 42% from 2013 to 2014 and by 41 from 2014 to 2015 is now 57% below the long-term average. Recruitment in 2015 is 58% lower than the historical geometric mean but this estimate is of the same magnitude of the recent low recruitments (2011–2015). As already stated for the last three years by the working group, the stock is expected to decline unless a new strong year class appears. Catch options were provided including one based on a multiannual management plan that has been evaluated by ICES in 2013. The advice for this stock for 2016 was updated as part of an EU request. The new assessment served as the basis for the advice for 2017.

The WG assessed the sardine in Divisions 8.a, b, d and Subarea 7, by analysing survey trends according to the benchmark carried out in February 2013 (WKPELA). Surveys, restricted to Subarea 8 (acoustic-Pelgas- and eggs-Bioman-surveys), show no neat trend in biomass indices since 2000, though marked fluctuations are recorded. The last big cycle peaked in 2009–2010. Biomass estimates during the following years were lower but around the range of biomass for the period 2000–2011. PELGAS survey pointed to the highest recruitment in 2013 in Subarea 8. Biomass is estimated by PELGAS to be 229 742 t in 2016 which is almost half of the estimated biomass last year. This is related to a relatively weak recruitment this year in comparison to last year historically high value. There is little information from Subarea 7: no survey index is available and catches are not monitored for biological sampling, so little can be done in terms of assessing the population and the fishery in this subarea, except assuming trends would be similar to Subarea 8. An attempt has been made to derive natural mortality from cohort analysis. There is no international TAC for this stock. Catches are mainly taken by France and Spain in 8 a, b, d and by France, the Netherlands and the United Kingdom in 7 with occurrences of other countries such as Germany and Denmark. Landings for the whole stock area accounted for 41 440 t in 2015 (40 254 t in 2014).

For the southern horse mackerel (Division 9.a) an updated analytical assessment was carried out following the stock annex. Catches were around 33 kt in 2015. The estimated SSB in 2015 from the assessment is 572 955 t. The SSB decreased gradually from 2007 to 2011, increasing in 2012 and 2013 to around the long-term average (372 kt) and has since then been well above it. Fishing mortality (0.044) has decreased since 2010 being at present around 60% below the long-term average. Recruitment is estimated to be well above long-term average in 2014. Catch options were provided under the assumption of historical geometric mean recruitment.

For the blue jack mackerel (*Trachurus picturatus*) in the waters of the Azores, the biennial advice was updated this year. The WG continued with the collation of data. The assessment is currently based on commercial abundance indices from the purse seiners and tuna bait boats, used as an indicator of stock trends. LPUEs show an increasing trend over the last 3 years.

In addition, the WG was asked to report on the advance of the preparation of the benchmarking for anchovy in Subarea 9.a; the WG recommended to delay the benchmarking to 2018, basically due to limited man power. Additional benchmarks are scheduled for 2017 for both sardine in 9.a and 8.c, sardine in 8.a, b, d, and 7 s and southern horse mackerel in 9.a. The working group members proposed to separate data compilation workshops between sardine and horse mackerel stocks and a single Bay of Biscay/Iberian Peninsula assessment benchmark for the three stocks because of regional similarities/links between those stocks and in order to get higher interest for regional stakeholders to participate.

1 Introduction

1.1 Terms of reference

The **Working Group on Southern Horse Mackerel, Anchovy and Sardine** (WGHANSA), chaired by Lionel Pawlowski, France, met in Lorient, France, 24–29 June 2016 and will met by correspondence 21–25 November 2016 (for Bay of Biscay anchovy) to:

a) address generic ToRs for Regional and Species Working Groups. The work on Bay of Biscay anchovy should be carried out by correspondence in November;

b) assess the progress on the benchmark preparation of anchovy in Division 9.a, horse mackerel in Division 9.a, sardine in divisions 8.a,b,d and Subarea 7, and sardine in divisions 8.c and 9.a.

c) Address the special request from the European Commission on a revised advice on fishing opportunities for 2016 for sar-soth by

   i) updating the catch advice for 2016 based on the results of an updated stock assessment and

   ii) use the updated catch advice as "intermediate year" assumption when calculating catch options for 2017

The assessments were carried out on the basis of the stock annexes during the meeting (not prior to it) and coordinated as indicated in the table below:

Fish Stock	Stock Name	Stock Coord.	Assess. Coord. 1	Assess. Coord. 2	Advice
ane-pore	Anchovy in Division 9.a	Spain	Spain	Spain	Update
ane-bisc	Anchovy in Subarea 8 (Bay of Biscay)	Spain	Spain	France	Update in november
hom-soth	Horse mackerel (*Trachurus trachurus*) in Division 9.a (Southern stock)	Spain	Portugal	Spain	Update
sar-soth	Sardine in divisions 8.c and 9.a	Portugal	Portugal	Spain	Update
sar-bisc	Sardine in divisions 8.a, b, d and Subarea 7	France	France	Spain	Second year of multiannual advice
jaa-10	Blue jack mackerel (*Trachurus picturatus*) in the waters off the Azores	Portugal	Portugal	Portugal	Update

WGHANSA reported by 6 July 2016 for all stocks except Bay of Biscay anchovy and will report by 23 November for Bay of Biscay anchovy stock for the attention of ACOM.

1.2 Report structure

Ad hoc and Generic ToR relative to the stocks for which assessment is required are dealt with stock by stock in respective sections of the report: Anchovy 8 (Section 3), Anchovy 9.a (Section 4), Sardine 8.a, b, d and 7 (Section 6), Sardine in 9.a (Section 7), Southern Horse Mackerel (Section 8) and Blue jack mackerel (*Trachurus picturatus*) in the waters off the Azores (Section 9).

Answer to generic ToRs are dealt with as follows:

Generic ToRs a) and b). The group had a look at ecosystem and fisheries overviews without emitting comments on it as some parts were clearly still to be developed. Due to limited time during the WG, no addition was made to those documents.

Generic ToR e) Frequency of the assessment. This question was considered not relevant for the Bay of Biscay anchovy stock due to the existence of an operational management plan. For sardine in the Iberian Peninsula and Southern horse mackerel, given the assessment protocol may change after the benchmark in 2017 and due to lack of time during the working group, the frequency of the assessment will be assessed during the benchmark. The sardine stock in the Bay of Biscay may also require this analysis depending on a possible change of stock category (eg. 3 to 1) after the benchmark.

Generic ToRs g) and h) No new stock was proposed for benchmark. The benchmark issue list was considered for each stock to be up to date. The progress on each stock was discussed during the meeting.

Generic ToR j) *Prepare the data calls for the next year update assessment and for the planned data evaluation workshops*. In regards to the sardine and horse mackerel benchmarks in 2017, some specific data call have been made after the working groups.

Generic ToR l) *Produce an overview of the sampling activities on a national basis based on the INTERCATCH database or, where relevant, the regional database*. This ToR is dealt with in the following introductory section 1.5.

c) An additional ToR was the following EU Request: Address the special request from the European Commission on a revised advice on fishing opportunities for 2016 for sar-soth by a) updating the catch advice for 2016 based on the results of an updated stock assessment and b) use the updated catch advice as "intermediate year" assumption when calculating catch options for 2017. This request was answered by the WG and is reflecting in the 2016 advice sheet.

Additionally some recommendations have been made regarding data and surveys (Section 10).

Finally, several annexes contain the remaining issues such as

- Relevant WDs (Annex 3);
- Comments to the WG structure, workload and timing of the meeting.

1.3 Comments to the WG structure, workload and timing of the meeting

Workload

The WG has noticed that there is a continuously increasing amount of demands to the WGs for reporting data issues, availability and transmission issues, data deficiencies, future needs, interactions with RACs etc. (see Generic ToRs etc.), indicators, recommendations etc. which certainly makes it difficult giving due responses to all these individual requests.

Since 2012 the WGHANSA benefits for a total of six working days (instead of five), as a result of the stocks added to the WG for assessment (the southern horse mackerel stock (Division 9.a) and Jack mackerel in Azores Islands stock). However, in 2015, the change in the management calendar for the Bay of Biscay anchovy and the inclusion of the latest JUVENA index have led the assessment and advice on this stock to be done late November after WGACEGG and just before the EU Council of the Ministers of Fisheries.

This work is now carried out by correspondence and this procedure has been in place since 2014. This change may seem to have somehow eased a little bit the workload in June and allows a closer look at the preliminary data on Bay of Biscay. A preliminary assessment has been carried out but it is harder for some participants more involved into the Bay of Biscay anchovy stock to justify their attendance at the June meeting. Therefore the attendance may decrease in the future.

The amount of days available for the meeting is currently seen as a minimum for this Working Group, with the perception that the group is becoming unable of providing satisfactory replies for all the increasing “extra” demands.

The group also points out that the workload during the WG is also dependant on the availability and quality of the data before the meeting. Data calls are expected to overcome this problem and data were fully available by the time of the WG but will not solve the fact that some of the spring surveys end only a few weeks before the meeting and in that case, any problem in the processing may be critical.

Another issue is the proper qualification of datasets. New data points labelled as "uncertain" or "unexplained" when provided to the working group tends to bring additional exploratory assessments or forecast assumptions to consider which requires extra times in an already tight schedule.

Timing of the meeting

Given the usual timing of the surveys for most of the stocks of this WG, there would be benefits in postponing the meeting to mid-November as this is now the case for the Bay of Biscay anchovy stock. The participants of the WG have discussed the opportunity and pros/cons of moving the WG date from end of June to early or mid-November. The following text is a summary of the key points:

- This working group heavily relies on spring, summer and fall surveys. Having the meeting by early summer as it is currently the case means the summer and fall surveys are only taken into account at the next WG which means a 10 months gap between the situation assessed by a summer survey and the stock assessment carried out by the WG. Autumn surveys provide indices of recruitment which are a requisite to provide advice for 9.a anchovy. Autumn surveys may also provide information to support recruitment assumptions for Iberian sardine.

The workload pressure would also decrease for the participants having spring surveys. Currently, the data processing between the end of surveys and the beginning of the WG is short and on some years, technical issues have led to some substantial delays. By moving the date of the WG to mid-November for all stocks, the survey indices would be used the same year. Data on egg abundance coming from spring surveys, which are often used as complementary information for stock assessment, would also be available by November.

- The assessment of Bay of Biscay anchovy at the end of the year is now done by correspondence. A physical meeting on such a complex assessment would be preferred but the attendance of participants is likely to be lower if two physical meetings would be set.

- The WG could closely interact with WGACEGG. Given how tight the new schedule is for the assessment of Bay of Biscay anchovy in regards of the end of the Juvena survey, processing of data at WGACEGG and EU Council, it is proposed that both meetings would occur on the same place and dates. Some work, such as the presentation of survey results (already presented in the two WGs) could eventually be merged in a common session for both WGs.

- The "live" collaboration with WGACEGG may be mutual for both working group as the methodologies developed in WGACEGG may be implemented in an easier way at WGHANSA and the expectation from WGHANSA in terms of data, methods, guidance over survey estimates would be beneficial to improve methodologies such as those developed during WGACEGG.

The participants are aware that having a meeting mid-November might pose some issues regarding the short gap between the delivery of the advice and the end of the year EU Council but there are practical benefits for the assessments.

1.4 Quality of the fishery input

In 2016 (2015 catch data), the differences between the WG estimates and official data were minimal, and as is the usual procedure, estimates of the working group were used to perform the assessment in all cases.

1.5 Overview of the sampling activities on a national basis for 2015

The Working Group again carried out a brief review of the sampling data and the level of sampling on the commercial fisheries. However this was not made on the basis of InterCatch as this has not been the usual procedure for collecting the national catch data inputting the assessments. The actual use of InterCatch is reflected below, and further down the level of sampling on national basis by stocks is reported.

Table of use and acceptance of InterCatch				
Stock code for each stock of the expert group	InterCatch used as the: 'Only tool' 'In parallel with another tool' 'Partly used' 'Not used'	If InterCatch have not been used what is the reason? Is there a reason why InterCatch cannot be used? Please specify it shortly. For a more detailed description please write it in the 'The use of InterCatch' section.	Discrepancy between output from InterCatch and the so far used tool: Non or insignificant Small and acceptable Significant and not acceptable Comparison not made	Acceptance test. InterCatch has been fully tested with at full data set, and the discrepancy between the output from InterCatch and the so far used system is acceptable. ThereforeInterCatch can be used in thefuture.
Example sai-3a46	*Only tool*	*InterCatch was used*	*Non or insignificant*	*Can be used*
ane-bisc	Used	*InterCatch was used*	Comparison not made	Test not performed yet.
ane-pore	Used.	*InterCatch was used*	Comparison not made.	No acceptance test has been done so far.
sar-soth	Used		Comparison not made.	No acceptance test has been done so far.
sar-north	Not used.	Shortage of manpower. Intention of being implemented interseasonally.	Comparison not made	Test not performed yet.
hom-south	Used		Comparison not made.	Test not performed yet.
jaa-10	Not used	Shortage of manpower. Intention of being implemented interseasonally.	Comparison not made.	Test not performed yet.

The sampling summary by stocks on national basis is the following:

a) Anchovy Other areas

Country	Official Catch 4	No. measured	Official Catch 6	No measured	Official Catch 7	No. measured
UK						
France						
Total						

b) Anchovy 8

Country	Official Catch	% of catch sampled	No. samples	No. measured	No. Aged
Spain	23 992	100%	251	35 947	3 610
France	4 261	100%	18	1 580	1 848
Total	28 253	99%	269	37 527	5 458

c) Anchovy 9.a

Country	Official Catch	% of catch sampled	No. samples	No. measured	No. Aged
Spain	6 874	100%	51	5 410	3 749
Portugal	2 546	100%	13	1 678	1 347
Total	9 420	100%	64	7 088	5 096

d) Sardine North

Country	Official Catch	% of catch sampled	No. samples	No. measured	No. Aged
France	15 517	100%	59	3 786	1 648
Spain	13 055	100%	216	24 333	150
Total	28 572	100%	275	28 119	1 798

e) Sardine 9.a and 8.c

Country	Official Catch	% of catch sampled	No. samples	No. measured	No. Aged
Spain	6 818	100%	141	10 968	3 081
Portugal	13 777	100%	93	9 325	1 934
Total	20 595	100%	234	20 293	5 015

f) Southern Horse Mackerel (Division 9.a)

Country	Official Catch	% of catch sampled	No. samples	No. measured	No. Aged
Spain	20 117	100%	115	16 104	2 159
Portugal	12 338	100%	244	12 420	1 537
Total	32 455	100%	359	28 524	3 696

g) Horse Mackerel (*T. picturatus*) in the waters of Azores (blue Jack Mackerel).

Country	Official Catch	% of catch sampled	No. samples	No. measured	No. Aged
Portugal	874	100%	246	11 800	147
Total	874	100%	246	11 800	147

1.6 Date and venue for WGHANSA in 2017

In section 1.3, the participants requested ICES to consider the possibility of having the meeting moved to mid/end-November at the same time as WGACEGG. The venue and calendar should be the same as for WGACEGG.

In the case that it is not possible, in order to allow more time for the data processing from the spring surveys, the Working Group proposes the meeting to be scheduled around the same date (24–29 June). The venue and precise dates are not yet decided at the time of the completion of this report but will be identified before the ICES annual conference.

2 Anchovy in northern areas

Both species, sardine and anchovy, exist outside the areas for which assessments are requested by ICES and made. In previous years, some work has been done on the sardine in other areas. Contributions on the occurrence of sardine and anchovy and historical records outside the core areas are useful to build up an understanding of the distribution dynamics of these species as well as potential effect from climate change on spatial expansion of fish stocks.

Anchovy is generally considered to be found in small amounts in other areas, typically associated with river outlets.

The WG reviewed available information on anchovy populations in ICES Division 4, 6 and 7. Division 7 is connected to the Bay of Biscay area where local stock is assessed by this working group. Anchovy populations in ICES Division 4 (North Sea), 6 (West of Scotland) and 7 (Celtic Sea and English Channel) are not assessed and not regulated, as those populations have not been considered so far to be locally substantial even if they sometimes represent enough biomass for a small or opportunistic fishery.

2.1 Connectivity between North Sea, Bay of Biscay and Western channel

In 2010, an ICES Workshop on Anchovy, Sardine and Climate Variability in the North Sea and Adjacent Areas (WKANSARNS) was held to investigate the phenomena of increased catches in anchovy and sardine since the mid-1990s in the North Sea and adjacent areas. The workshop attempted to increase our understanding by considering the phenomenon in terms of the processes controlling the life cycle of anchovy and sardine. It considered the historical context and synthesized across the scientific disciplines of oceanography, climatology, genetics, ecology, biophysical individual-based modeling and analysis of empirical time-series.

WKANSARNS concluded that the recent increase of anchovy in the North Sea is probably due to the development of local North Sea populations, rather than a northward movement of Bay of Biscay populations. There has always been anchovy, at a low abundance, in the North Sea (spawning along the Dutch coast, Wadden Sea and estuaries). The expansion of anchovy in the North Sea is thought to be driven by pulses of successful recruitment that are controlled by relatively high summer temperatures of sufficient duration followed (or preceded) by favourable winter conditions. There is probably a balance between high enough summer temperature allowing sufficient growth and winter conditions allowing sufficient survival at length. Variability in the length of these periods or in spatial extent where such conditions can be found may have a strong influence on the recruitment success. Whilst this workshop primarily considered driving processes related to temperature, other potential mechanisms, or mechanisms that co-vary with temperature, may be important in the dynamics of North Sea anchovy. The conclusion of the workshop, although preliminary, was that climate-driven changes in water temperature appear to mediate the productivity of anchovy in the North Sea.

On stock definition, the European anchovy shows large amounts of genetic differentiation between populations. An initial analysis has been carried out on the genetic structure of anchovy populations over the whole distributional range of the species by a research group of the genetics laboratory of the University of the Basque Country and Azti-Tecnalia. This study analyses 50 nuclear neutral SNP (Single Nucleotide polymorphism) markers on 790 individuals covering an extensive regions:

North Sea, English Channel, Bay of Biscay, Southeast Atlantic coast, Canary Islands, South Africa, Alboran, West Mediterranean and East Mediterranean (Adriatic and Aegean seas).

Nei standard (Ds) distance-based neighbour-joining tree, pair-wise FST comparisons and the Bayesian approach clustering method suggest that North Sea and English Channel samples are genetically homogenous, exhibiting significant genetic differences with the Bay of Biscay samples. Moreover, Bay of Biscay samples appeared to be genetically more similar to the West Mediterranean samples than to the North Sea-English Channel samples. These results support that the recent increase of anchovy in the North Sea is likely due to the development of local North Sea populations, rather than a northward movement of Bay of Biscay populations.

In looking for explanations for the recent expansion of anchovy in the North Sea, two main hypothesis arise: sympatry and allopatry. Allopatry could either be due to further adult migration to the north, or increase of larval and juvenile survival into the English Channel and southern North Sea for individuals originating from Biscay spawning. The second hypothesis was tested using a particle tracking model and showed that anchovy eggs spawned in the Bay of Biscay could be transported to the Channel, but no attempt was made to quantify the strength of that potential connectivity. It was also reported that, considering the seasonal shift in the circulation from northward to southward during the anchovy spawning season, and the northward progression of spawning during the season as the temperature increase, retention of eggs in the Bay of Biscay was much more likely compared to transport to the English Channel. The fraction of eggs arriving in the English Channel was low, from ~0% for spawning grounds 1 to 3, to 10% for spawning ground 5 in the north of the Bay (2.11% when averaged over the five spawning grounds). 87% of the particles lost from the Bay are entering the Channel, the rest remaining in the Celtic Sea. Results showed that the potential connectivity fraction of the Bay of Biscay to the north of 48°N is only 2%, essentially due to northern spawning in the Bay. Considering the observed spatio-temporal spawning pattern (shift to the north as the season progress), it was concluded that connectivity may be considered as negligible.

In the context of climate change, Bay of Biscay surface temperature has already been observed to increase, which will likely continue. This could advance the spawning season with earlier spawning in the north of the Bay. Under the hypothesis of no other change than temperature increase (e.g. circulation patterns), this would increase the potential for connectivity with the English Channel. From climate change scenarios (temperature increase, wind change) run over the Bay of Biscay, Lett *et al.* (2010) have suggested modification of the circulation with further impact on the dispersal kernel for Bay of Biscay anchovy, among them further distance dispersed under increased stratification.

2.2 Data Exploration from fishery statistics

Landings and effort data are scarcely available from France and United Kingdom. Length distributions were available in 7 from the French observer programme at sea (OBSMER).

2.2.1 Catch in Divisions 4 and 6

In Division 4, landings are very scarce (Table 2.2.1) with data available only past 1999 and ranging from 2 kgs to 4 tons (in 2002). Landings in 2010 were 280 kgs. In Division 6, 83 kgs were reported by the French fleets in 2000 and 1875 kgs in 2011. No landings were reported in those divisions since 2012. Nine tons were reported by the Netherlands in 2014, none in 2015. 3326 tons were reported by Denmark in 2015.

2.2.2 Catch in Division 7

In Division 7, landings from both French and British fleets have been scarce until 1996 with up to 25 t of landed fish (Table 2.2.2). The 1997–2013 period has shown a rise of landings up to 244 tons in 2003 followed by a decrease 5 tons over the period 2004–2006 and then strong landings especially in 2009 and 2010 where the strongest landings of the time-series were recorded (940 and 1450 tons respectively).

The proportion of France and UK landings in the total catch has been highly variable between years with the majority of the landings over the last decade made by French vessels. It is unknown if the increase of landings in 2009–2010 were a consequence of the expansion of stock of anchovy in the Bay of Biscay. In 2011, only France reported landings (77 tons) for that division. In 2012, landings were 788 t for France and 51 t for UK. In 2013, 10.3 t were reported by UK vessels only. In 2014, 767 t, 214 t and 53 t were respectively reported from UK, France and Denmark with landings mainly done in 7.e. In 2014, 38 t were reported by UK in 7.e and 7.f. France reported for 1716 t in 7.e and 7.h and 59 t in 7.k. Netherland, Germany and Ireland respectively reported 316 t, 447 t, 49 t according to ICES preliminary landing statistics but those number were not confirmed in the response to the ICES data call for WGHANSA therefore those information should be treated with caution.

Most of the French landings occur during the second semester (Q3–Q4) in statistical rectangles 25E4, 25E5 which are adjacent to the 8.a division (Figure 2.2.1). There have been evidences that the Bay of Biscay stock sometimes expand further north the 8.a division therefore an undefined portion of the catch of anchovy in 7 is likely to consist of individuals from the Bay of Biscay stock. A minor portion of the French catch is also made in 26E8 mainly during the summer (quarters 2–3). UK landings are located in the coastal rectangles of north-western part of the Channel (29E4–29E7) and are mainly made during the winter months (quarter 4 and 1).

The landings by the UK fleets are made by ringnets, purse seiners and midwater trawlers (Table 2.2.3). French catches in 2015 were almost made only by midwater trawler. No information were updated in 2015 regarding the details of landings.

Data from length distribution of catch anchovy are almost non-existent. No data were available in 2015. In previous years, the level of sampling in 7 was on some occasion enough to provide comparable length distributions to other areas. All distributions had different modes. Considering the low level of sampling (few stations), it was difficult to give any meaning to those results.

Table 2.2.1. UK and French landings (kg) of anchovy in Divisions 4 and 6.

	FR-6	UK-6	Landings in kg		FR-6	UK-6	Landings in kg
1983				1983			
1984				1984			
1985				1985			
1986				1986			
1987				1987			
1988				1988			
1989				1989			
1990				1990			
1991				1991			
1992				1992			
1993				1993			
1994				1994			
1995				1995			
1996				1996			
1997				1997			
1998				1998			
1999	1.6		1.6	1999			
2000	3.1		3.1	2000	82.6		82.6
2001				2001			
2002	4029	2	4031	2002			
2003	0		0	2003			
2004	12.1		12.1	2004			
2005				2005			
2006	10.8	0	10.8	2006			
2007	50	0	50	2007			
2008		2	2	2008			
2009	28	127	155	2009			
2010	280		280	2010			
2011				2011	1875		1875
2012				2012			
2013				2013			
2014				2014			
2015				2015			

Table 2.2.2. UK and French landings (tons) of anchovy in Division 7.

	Landings in tons			Portion of landings in	Portion of landings in
	FR-7	UK-7	Total	25E4-5 in FR landings	29E4-7 in UK landings
1983					
1984		25.0	25.0		?
1985					
1986	0.0		0.0	?	
1987		5.0	5.0		?
1988		3.9	3.9		?
1989	0.2	16.6	16.8	?	?
1990					
1991		12.0	12.0		?
1992			0.0		
1993	1.7		1.7	?	
1994	0.0		0.0	?	
1995					
1996	0.0			0.0%	
1997	56.0		56.0	84.7%	
1998	0.8	39.0	39.8	0.0%	?
1999	6.0		6.0	0.0%	
2000	51.1	0.0	51.1	71.6%	?
2001	141.0	0.9	141.9	92.3%	?
2002	109.8	0.3	110.1	39.8%	?
2003	220.2	23.8	244.0	50.0%	?
2004	18.2	67.6	85.8	90.9%	?
2005	7.5	7.7	15.2	99.3%	?
2006	5.2	0.2	5.4	61.7%	?
2007	0.3	763.2	763.4	0.0%	?
2008	0.7	175.8	176.5	0.0%	?
2009	585.1	353.5	938.6	85.0%	?
2010	1157.1	319.6	1449.2	84.2%	97.0%
2011	77.0		77.0	52.5%	
2012	788.3	50.9	839.2	91.2%	96.1%
2013	0	10.4	10.4	0.0%	39.5%
2014	241.2	767.2	1008.4	85%	86.6%
2015	1716.4	37.7	1754.0	100%	94.9%

Table 2.2.3. Landings (kg) of anchovy per fleets per year in ICES Division 7.

UK Fleets										
Gear	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
MIDWATER TRAWL	5814		619021	10126	98056	10840		34936	10307	355077
RINGNET			92560	132294	235788	244935		12220		230862
MIDWATER PAIR TRAWL	1665	200	28103	12600	4286	1100				181064
PURSE SEINE						47056				
DRIFTNET			5241	17838	1	15613				
UNSPECIFIED OTTER TRAWL			18216	1	270	22		3622		
TRIPLE *NEPHROPS* OTTER					15080					
OTHER OR MIXED POTS				2688						
BOTTOM PAIR TRAWL	245									
BEAM TRAWL				199						
UNSPECIFIED GILLNET			11	27		58				
GILLNET (NOT 52 OR 53)				8		7				
WHELK POTS			1							
Total	7724	200	763153	175781	353481	319631	0	50778	10307	613773
French Fleets										
Gear	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
PURSE SEINE					392150	517940	39692	445778		224816
MIDWATER PAIR TRAWL		1500			51460	437720	34582	208593		
MIDWATER OTTER TRAWL				0.5	78994	68294				50
SCOTISH SEINE					53400	33500	137			
BOAT DREDGES				1.7		37200		100		
NOT KNOWN					9000	26330		132283		
PURSE SEINE 1 BOAT	7415	1720					1050			
BOTTOM OTTER TRAWL	54.7	2002	270	19.7	80	4720	601	47		
OTTER TWIN TRAWL						2150	21			
GILLNETS				400		1730	936			
TRAMMELNETS				320				1470		
Total	7470	5222	270	741.9	585084	1129584	77019	788272		224866

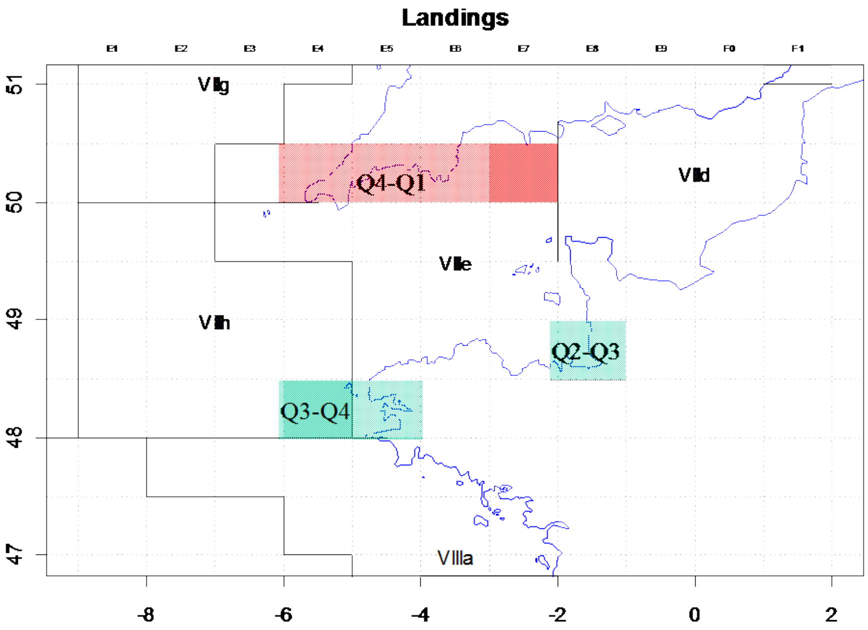


Figure 2.2.1. Map of the statistical rectangles where most of the catches of anchovy occur in ICES Division 7 for France (Green) and UK (Red).

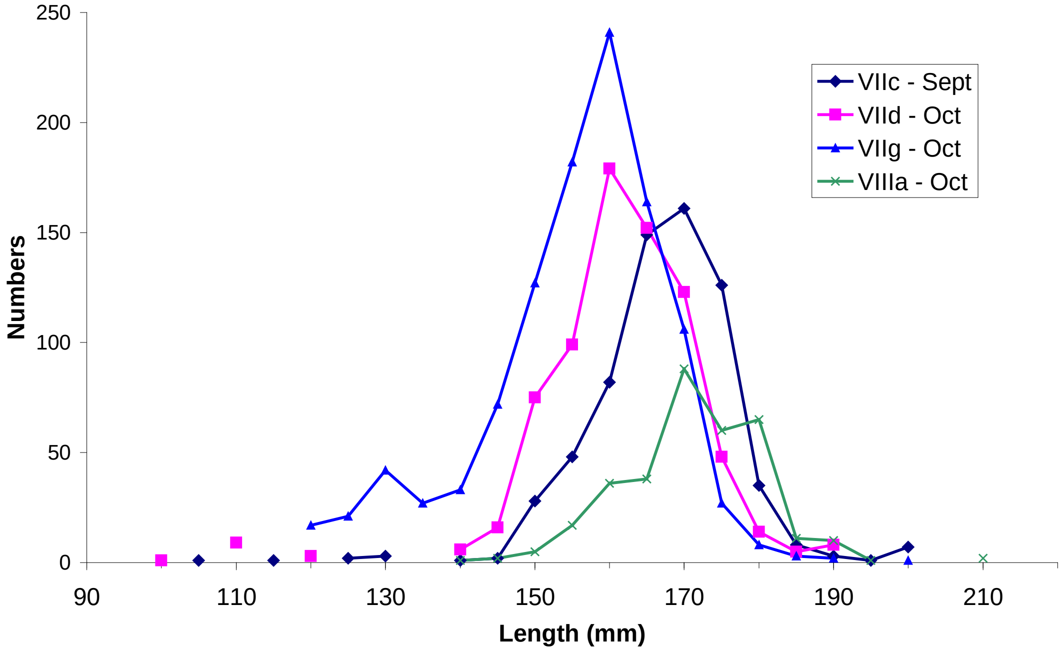


Figure 2.2.2. Length distributions of catch of anchovy in ICES Divisions 7.c, 7.d, 7.g and 8.a in 2010.

3 Anchovy in the Bay of Biscay (Subarea 8)

3.1 ACOM advice, STECF advice and political decisions

In June 2015 ICES conducted an exploratory assessment for the Bay of Biscay anchovy stock including the latest information from the 2015 spring surveys (PELGAS and BIOMAN) and the fishery in 2014. The final assessment of the stock was conducted by correspondence in November 2015, once the results from the JUVENA autumn acoustic survey were available. In December 2015 ICES advised that "when the management plan is applied, catches in 2016 should be no more than 25 000 tonnes". Furthermore, given that discards are considered negligible, ICES specifies that "All catches are assumed to be landed". The basis of the advice was the harvest control rule named G4 with a harvest rate of 0.45. This harvest control rule was selected by the European Commission, EU Member States and stakeholders among a set of harvest control rules evaluated by STECF in 2013 and 2014 (STECF, 2013; STECF 2014). ICES reviewed this harvest control rule in 2015 and concluded that it was precautionary (Annex 5 in ICES, 2015b).

In January 2016 the Council established the TAC in 2016 for the Bay of Biscay anchovy stock at 25 000 tonnes (Council Regulation No 72/2016), from which 90% corresponded to Spain and 10% to France. However, these percentages might be modified due to bilateral agreements between countries.

In May 2016 based on the good state of the stock the South Western Waters Advisory Council (SWWAC) asked for a change in the harvest control rule used for management to rule G3 with a rate of exploitation of 0.4 and an increase of the fishing opportunities for 2016 from 25 000 to 33 000 t (SWWAC Advice 101 released on 05/05/2016). In June the Council increased the 2016 TAC to 33 000 t (Council Regulation No 891/2016), on the basis that "The stock biomass and recruitment of anchovy in the Bay of Biscay are among the highest in the historical time-series, thus allowing a higher precautionary TAC in 2016 in accordance with the management strategy assessed by the Scientific, Technical and Economic Committee for Fisheries (STECF) in 2014".

Regarding the landing obligation regulation that aims at progressively eliminate discards in all Union fisheries, in October 2014 the European Commission established a discard plan for certain pelagic species in southwestern waters (No. 1394/2014). This includes an exemption from the landing obligation for anchovy caught in artisanal purse-seine fisheries based on evidence for high survivability and *de minimis* exemptions both in the pelagic trawl fishery and the purse-seine fishery from 2015 to 2017.

According to the European Commission Regulation No. 185/2013, the deductions from the anchovy fishing quota allocated to Spain on account of overfishing of mackerel quota in 2009 shall be applied from 2016 to 2023. This supposes a reduction of 3696 tonnes in the 2016 Spanish quota of Bay of Biscay anchovy.

3.2 The fishery in 2015 and 2016

3.2.1 Fishing fleets

Two fleets operate on anchovy in the Bay of Biscay: Spanish purse-seines (operating mainly during spring) and the French fleet constituted of purse-seiners (the Basque ones operating mainly in spring and the Breton ones in autumn) and pelagic trawlers (mainly during the second half of the year).

The total number of fishing licences for anchovy in Spain in 2016 was 156. Since the re-opening of the fishery in 2010 the number of fishing licences have been oscillating between 149 and 175.

For France, the number of purse-seiners able to catch anchovy in 2015 was around 29. The exact number of vessels is not fixed, due to important movements in this fleet. Most of them are based in Brittany. The number of Basque purse-seiners decreases progressively and some of them joined the North of the Bay of Biscay in the last five years. The real target specie of these vessels is sardine, and anchovy is more opportunistic in autumn. It must be noticed that the number of French purse-seiners is slowly increasing, year after year.

The number of French pelagic trawlers decreased drastically during last years because they were targeting mainly anchovy and tuna. Currently ten pairs of trawlers (20 vessels) are able to target anchovy. In 2014, as in 2013, a small shift occurred on the French anchovy fishery. Pair pelagic trawlers mainly target tuna between July and October, and single pelagic trawlers caught anchovy particularly in September and October.

A more complete description of the fisheries is made in the stock annex.

3.2.2 Catches

Historical catches are presented in Table 3.2.2.1 and Figure 3.2.2.1. Total catches in 2015 were 28 258 tonnes, from which 23 992 corresponded to Spain, 4261 to France and 4.85 to Netherlands. This is the first year that catches from other countries different from Spain and France are reported. The preliminary catches up the end of May 2016 were around 14 343 t, corresponding to the Spanish fleet.

The series of monthly catches are shown in Table 3.2.2.2.

The quarterly catches by division in 2015 are given in Table 3.2.2.3. Most of the catches took place in the second quarter (65%), followed by the second quarter (28%) and with few catches in the first and fourth quarter (4% and 2% respectively). The major fishing activity of the Spanish fleet occurred in the second quarter (73%), whereas the French fleet operated mainly in the second semester (81%). Regarding fishing areas, most of the Spanish catches in the first quarter corresponded to ICES Divisions 8.b and to ICES Division 8.c in the rest of the year. The French catches corresponded to ICES Divisions 8.a and 8.b. The other countries catches were taken mainly in the fourth quarter.

N.B.: non-negligible catches (around 1700 tons) originate from Divisions 7.h and 7.e, but these catches have been assigned to Division 8.a due to their very concentrated location at the boundary between 8.a, 7.h and 7.e in the same period. French anchovy landings declared in 25E5 and 25E4 have hence been reallocated to 8.a.

Discards are not measured and hence not included in the assessment, but nowadays they are considered not relevant for the two fleets exploiting this stock.

3.2.3 Catch numbers-at-age and length

Catch numbers-at-age by quarter in 2015 for Spain and France are given in Table 3.2.3.1. Age 1 individuals were predominant all along the year (ranging from 54% in the first quarter to 68% in the fourth quarter). Age 0 individuals appeared in the third and fourth quarters.

Table 3.2.3.2 records the age composition of the international catches since 1987, on a half-yearly basis. One year old anchovies have dominated in the catches during both halves of most of the years, except in some years with recruitment failure. In 2015, age 12 individuals predominated in the first and second halves.

Catch-at-length data (by 0.5 cm classes) by quarter in 2015 are given in Table 3.2.3.3. The length range was between 9.5 and 19 cm. The modal length was between 13.5 and 15 cm, except for the Spanish catches in the fourth quarter that was around 12 cm.

See the stock annex for methodological issues.

3.2.4 Weights and lengths-at-age in the catch

The series of mean weight-at-age in the fishery by half year, from 1987 to 2015, is shown in Table 3.2.4.1. See the stock annex for methodological issues.

Table 3.2.2.1. Bay of Biscay anchovy: Annual catches (in tonnes). The catches up to 2011 are estimated by the working group members and the catches from 2012 correspond to official records.

COUNTRY	FRANCE	SPAIN	SPAIN	UNALLOCATED	)THE COUNTRIES	INTERNATIONAL
YEAR	8ab	8bc, Landings	Live Bait Catches			Subarea 8
1960	1,085	57,000	n/a			58,085
1961	1,494	74,000	n/a			75,494
1962	1,123	58,000	n/a			59,123
1963	652	48,000	n/a			48,652
1964	1,973	75,000	n/a			76,973
1965	2,615	81,000	n/a			83,615
1966	839	47,519	n/a			48,358
1967	1,812	39,363	n/a			41,175
1968	1,190	38,429	n/a			39,619
1969	2,991	33,092	n/a			36,083
1970	3,665	19,820	n/a			23,485
1971	4,825	23,787	n/a			28,612
1972	6,150	26,917	n/a			33,067
1973	4,395	23,614	n/a			28,009
1974	3,835	27,282	n/a			31,117
1975	2,913	23,389	n/a			26,302
1976	1,095	36,166	n/a			37,261
1977	3,807	44,384	n/a			48,191
1978	3,683	41,536	n/a			45,219
1979	1,349	25,000	n/a			26,349
1980	1,564	20,538	n/a			22,102
1981	1,021	9,794	n/a			10,815
1982	381	4,610	n/a			4,991
1983	1,911	12,242	n/a			14,153
1984	1,711	33,468	n/a			35,179
1985	3,005	8,481	n/a			11,486
1986	2,311	5,612	n/a			7,923
1987	4,899	9,863	546			15,308
1988	6,822	8,266	493			15,581
1989	2,255	8,174	185			10,614
1990	10,598	23,258	416			34,272
1991	9,708	9,573	353			19,634
1992	15,217	22,468	200			37,885
1993	20,914	19,173	306			40,393
1994	16,934	17,554	143			34,631
1995	10,892	18,950	273			30,115
1996	15,238	18,937	198			34,373
1997	12,020	9,939	378			22,337
1998	22,987	8,455	176			31,617
1999	13,649	13,145	465			27,259
2000	17,765	19,230	n/a			36,994
2001	17,097	23,052	n/a			40,149
2002	10,988	6,519	n/a			17,507
2003	7,593	3,002	n/a			10,595
2004	8,781	7,580	n/a			16,361
2005	952	176	0			1,128
2006	913	840	0			1,753
2007	140 **	1.2 **	0			0
2008	0	0	0			0
2009	0	0	0			0
2010	4,573	5,744	n/a			10,317
2011	3,615	10,916	n/a			14,530
2012	5,975	7,896	n/a	531		14,402
2013	2,392	11,801	n/a			14,192
2014	4,012	16,114	n/a			20,126
2015	4,261	23,992	n/a		5	28,258
2016 (Up 31st May)	0	14,343	n/a			14,343
AVERAGE (1960-2004)	6,394	26,337	318			32,824

****: Experimental fishery.**

Table 3.2.2.2. Bay of Biscay anchovy: Monthly catches in Subarea 8 (without live bait catches).

YEAR\MONTH	J	F	M	A	M	J	J	A	S	O	N	D	TOTAL
1987	0	0	454	5246	5237	782	229	636	707	812	309	352	14763
1988	6	0	42	1657	4317	3979	584	1253	2423	445	136	246	15088
1989	706	73	36	588	4943	806	132	566	186	472	1619	301	10429
1990	80	6	2101	2658	11459	3083	1471	5132	5553	1570	652	92	33856
1991	1418	2175	626	2036	6913	1858	215	479	1621	822	238	882	19282
1992	2422	1864	1282	4241	13125	3448	719	1488	3291	3228	2489	89	37685
1993	1738	1864	3362	3260	7906	5927	2110	2979	4254	3342	3273	70	40086
1994	1972	1917	1591	5741	4761	7231	1796	2306	3382	3295	421	74	34487
1995	620	958	842	5967	12329	2764	439	1098	2155	1382	903	387	29843
1996	1132	647	752	1834	9763	6897	2449	2675	3617	2818	1575	17	34176
1997	2278	688	105	2782	2762	1985	1895	2400	3578	2381	921	185	21961
1998	1558	2363	1276	371	4839	2510	3943	5039	4298	2640	2500	104	31442
1999	2088	1360	626	4681	4282	2345	2052	948	4049	2130	2207	27	26794
2000	2219	948	925	1957	11922	4565	3148	3063	4043	2995	1210	0	36994
2001	960	565	479	2249	14428	4413	2514	3403	4435	3850	2852	1	40149
2002	1436	2561	1573	915	2506	2098	673	1034	2970	1152	578	0	17497
2003	39	2	0	1740	890	1403	294	2297	1602	1322	986	20	10595
2004	210	106	3	2377	3247	3241	902	2017	2886	557	813	2	16360
2005	363	17	35	4	183	525	0	0	0	0	0	0	1127
2006	1	0	33	124	630	870	95	0	0	0	0	0	1753
2007	0	0	0	39	57	45	0	0	0	0	0	0	141
2008	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0	0	0	0	0
2010	0	0	299	1324	2955	1532	75	632	2425	863	213	0	10317
2011	0	0	1586	4483	4492	351	2	176	815	1319	1258	47	14530
2012	0	0	68	1060	5663	1809	354	868	2352	1940	288	0	14402
2013	0	3	272	2226	5166	3269	312	316	1375	1069	185	1	14192
2014	0	0	0	3739	8604	1950	180	2081	2025	1188	357	0	20125

Table 3.2.2.3. Bay of Biscay anchovy: Catches by divisions and country in 2015 (without live bait catches).

COUNTRIES	DIVISIONS	QUARTERS				CATCH (t)	
		1	2	3	4	ANNUAL	%
SPAIN	8a	0	0	0	0	0	0.0%
	8b	718	5722	95	10	6545	27.3%
	8c	293	11891	5263	0	17447	72.7%
	8d	0	0	0	0	0	0.0%
	TOTAL	1011	17613	5358	10	23992	100.0%
	%	4.2%	73.4%	22.3%	0.0%	100.0%	
FRANCE	8ab	0	792	2783	686	4261	100.0%
	8c	0	0	0	0	0	0.0%
	8d	0	0	0	0	0	0.0%
	TOTAL	0	792	2783	686	4261	100.0%
	%	0.0%	18.6%	65.3%	16.1%	100.0%	
OTHER COUNTRIES	TOTAL	0.03	0.00	0.00	4.83	4.86	100.0%
INTERNATIONAL	TOTAL	1011	18404	8142	701	28258	100.0%

Table 3.2.3.1. Bay of Biscay anchovy: catch-at-age in thousands for 2015 by quarter (only for Spain and France) (without the catches from the live bait tuna fishing boats).

2015 units: thousands

TOTAL	QUARTERS	1	2	3	4	Annual total
TOTAL	AGE	8abc	8abc	8abc	8abc	8abc
	0	0	0	78	365	443
Sub-area 8	1	25,233	535,688	230,256	21,252	812,428
	2	20,773	336,271	119,124	9,455	485,623
	3	825	26,410	6,670	243	34,149
	4	0	173	0	0	173
	5	0	0	0	0	0
	TOTAL(n)	46,831	898,542	356,128	31,315	1,332,816
	W MED.	21.53	20.47	23.14	20.81	21.23
	CATCH. (t)	1011	18404	8142	696	28253
	SOP	1008	18391	8240	652	28291
	VAR. %	99.69%	99.93%	101.21%	93.60%	100.13%

Table 3.2.3.2. Bay of Biscay anchovy: Catches-at-age of anchovy of the fishery in the Bay of Biscay on half year basis (including live bait catches up to 1999). Only for Spain and France.

INTERNATIONAL

YEAR	1987		1988		1989		1990		1991		1992		1993		1994		1995	
Age	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
0	0	38,140	0	150,338	0	180,085	0	16,984	0	86,647	0	38,434	0	63,499	0	59,934	0	49,771
1	218,670	120,098	318,181	190,113	152,612	27,085	847,627	517,690	323,877	116,290	1,001,551	440,134	794,055	611,047	494,610	355,663	522,361	189,081
2	157,665	13,534	92,621	13,334	123,683	10,771	59,482	75,999	310,620	12,581	193,137	31,446	439,655	91,977	493,437	54,867	282,301	21,771
3	31,362	1,664	9,954	596	18,096	1,986	8,175	4,999	29,179	61	16,960	1	5,336	0	61,667	1,325	76,525	90
4	14,831	58	1,356	0	54	0	0	0	0	0	0	0	0	0	0	0	4,096	7
5	8,920	0	99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total #	431,448	173,494	398,971	529,130	294,445	219,927	915,283	615,671	663,677	215,579	1,211,647	510,015	1,239,046	766,523	1,049,714	471,789	885,283	260,719

YEAR	1996		1997		1998		1999		2000		2001		2002		2003		2004	
Age	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
0	0	109,173	0	133,232	0	4,075	0	54,357	0	5,298	0	749	0	267	0	7,530	0	11,184
1	683,009	456,164	471,370	439,888	443,818	598,139	220,067	243,306	559,934	396,961	460,346	507,678	103,210	129,392	50,327	133,083	254,504	252,887
2	233,095	53,156	138,183	40,014	128,854	123,225	380,012	142,904	268,354	64,712	374,424	98,117	217,218	77,128	44,546	87,142	85,679	20,072
3	31,092	499	5,580	195	5,596	3,398	17,761	525	84,437	18,613	19,698	5,095	37,886	3,045	34,133	11,459	12,444	1,153
4	2,213	42	0	0	155	0	108	0	0	0	4,948	0	76	0	887	1,152	4,598	16
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total #	949,408	619,034	615,133	613,329	578,423	728,837	617,948	441,092	912,725	485,584	859,417	611,639	358,390	209,832	129,893	240,366	357,225	285,312

YEAR	2005		2006		2007		2008		2009		2010		2011		2012		2013	
Age	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
0	0	0	0	0	0	0	0	0	0	0	0	16,287	0	4,656	0	3,761	0	10,343
1	7,818	0	48,718	3,894	0	0	0	0	0	0	125,198	135,570	164,061	159,675	56,013	167,935	84,863	81,392
2	32,911	0	17,172	991	0	0	0	0	0	0	77,342	13,864	214,454	11,080	254,863	69,396	223,958	45,177
3	6,935	0	6,465	320	0	0	0	0	0	0	10,897	815	7,161	503	5,055	1,115	87,493	5,559
4	586	0	49	2	0	0	0	0	0	0	1,711	189	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Total #	48,250	0	72,405	5,207	0	0	0	0	0	0	215,149	166,725	385,677	175,914	315,932	242,207	396,315	142,471

YEAR	2014		2015	
Age	1st half	2nd half	1st half	2nd half
0	0	37,068	0	443
1	228,729	187,159	560,920	251,508
2	336,224	12,181	357,044	128,579
3	53,703	3,035	27,236	6,914
4	4,271	0	173	0
5	0	0	0	0
Total #	622,927	239,443	945,373	387,443

Units: Thousands.

Table 3.2.3.3. Bay of Biscay anchovy: Catch numbers-at-length quarters in 2015. Only for Spain and France.

	QUARTER 1		QUARTER 2		QUARTER 3		QUARTER 4	
Length (half cm)	France 8ab	Spain 8bc	France 8ab	Spain 8bc	France 8ab	Spain 8bc	France 8ab	Spain 8bc
3.5								
4								
4.5								
5								
5.5								
6								
6.5								
7								
7.5								
8								
8.5								
9								
9.5				5				
10				620		203		13
10.5		87		1,935		291		13
11		335		5,156		2,581		104
11.5		704		13,926		5,675		285
12		1,620		33,642	35	9,424	407	337
12.5		2,035		66,273	355	12,373	1,301	181
13		4,733		93,558	1,941	15,860	3,170	26
13.5		4,697	635	121,113	10,103	24,888	4,657	
14		5,581	1,398	127,609	21,576	25,760	4,195	
14.5		6,509	4,955	112,809	25,734	31,181	4,193	
15		5,050	5,583	91,197	17,078	28,435	3,650	
15.5		5,647	5,178	82,662	16,810	29,353	2,838	
16		5,393	5,011	55,924	11,665	21,890	2,973	
16.5		2,520	3,502	34,593	8,113	12,749	1,351	
17		1,029	1,715	16,030	6,042	6,538	1,081	
17.5		647	1,215	8,835	3,134	2,737	135	
18		190	596	2,334	923	1,632	135	
18.5		119	119	437	148	820	270	
19				19		82		
19.5								
20								
20.5								
21								
21.5								
22								
22.5								
23								
23.5								
24								
24.5								
25								
25.5								
26								
Total ('000)		46,896	29,906	868,676	123,657	232,471	30,356	958
Catch (t)		1,011	792	17,613	2,783	5,358	686	10
Mean Length(cm)		14.51	15.56	14.21	15.01	14.49	14.54	11.82

Table 3.2.4.1. Bay of Biscay anchovy: Mean weight-at-age (grammes) in the international catches on half year basis. Only for Spain and France.

INTERNATIONAL

YEAR	1987		1988		1989		1990		1991		1992		1993		1994		1995	
Sources	Anon. (1989 & 1991)		Anon. (1989)		Anon. (1991)		Anon. (1991)		Anon. (1992)		Anon. (1993)		Anon. (1995)		Anon. (1996)		Anon. (1997)	
Periods	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
Age 0	na	11.7	na	5.1	na	12.7	na	7.4	na	14.4	na	12.6	na	12.3	na	14.7	na	15.1
1	21.0	21.9	20.8	23.6	19.5	24.9	20.6	23.8	18.5	25.1	19.6	23.0	15.5	20.9	16.8	25.3	22.5	26.9
2	32.0	34.2	30.3	30.4	28.5	35.2	28.5	27.7	25.2	29.0	30.9	28.8	27.0	29.4	26.8	28.1	32.3	31.3
3	37.7	39.2	34.5	44.5	29.7	42.7	44.8	40.8	28.2	39.0	37.7	27.4	30.5	na	30.7	30.0	36.4	36.4
4	41.0	40.0	37.6	na	27.1	na	na	na	na	na	na	na	na	na	na	na	37.3	29.1
5	42.0	0.0	48.5	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Total	27.3	20.8	24.6	10.7	23.9	15.6	21.3	24.0	22.1	21.1	21.7	22.5	19.6	21.2	22.3	24.3	26.9	25.0

YEAR	1996		1997		1998		1999		2000		2001		2002		2003		2004	
Sources:	Anon. (1998)		Anon. (1999)		Anon (2000)		WG data		WG data		WG data		WG data		WG data		WG data	
Periods	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
Age 0	na	12.0	na	11.6	na	10.2	na	15.7	na	19.3	na	14.3	na	9.5	na	15.4	na	15.5
1	19.1	23.2	14.4	20.3	21.8	23.7	17.1	27.0	21.7	28.2	22.7	27.5	25.0	28.8	21.0	25.4	21.7	24.9
2	29.3	27.7	26.9	30.1	24.3	27.7	29.8	33.5	29.1	33.0	31.8	31.1	31.6	33.4	36.2	29.5	35.7	33.5
3	35.0	35.7	32.0	29.7	31.9	28.7	34.7	38.9	32.8	36.9	36.3	38.6	42.8	36.5	40.3	36.4	39.3	40.7
4	46.1	39.7	na	na	31.9	na	55.9	na	na	na	40.7	na	45.6	na	36.9	37.9	44.0	42.8
5	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Total	22.2	21.6	17.3	19.1	22.5	24.3	25.4	27.7	24.9	29.0	27.1	28.2	30.9	30.6	31.4	27.1	26.0	25.2

YEAR	2005		2006		2007		2008		2009		2010		2011		2012		2013	
Sources:	WG data		WG data		WG data		WG data		WG data		WG data		WG data		WG data		WG data	
Periods	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
Age 0	na	na	na	na	na	na	na	na	na	na	na	14.4	na	8.9	na	12.6	na	12.0
1	19.3	na	20.3	17.8	na	na	na	na	na	na	25.0	25.9	22.5	20.5	16.7	22.3	20.8	21.9
2	24.5	na	27.7	19.7	na	na	na	na	na	na	32.1	27.4	32.4	27.3	28.9	25.9	28.8	28.7
3	27.6	na	31.3	19.7	na	na	na	na	na	na	43.7	43.2	36.4	34.8	38.7	26.5	31.5	31.6
4	24.5	na	37.3	34.3	na	na	na	na	na	na	43.0	44.4	na	na	na	na	na	na
5	na	na	na	na	na	na	na	na	na	na	55.7	na	na	na	na	na	na	na
Total	24.1	na	23.0	18.2	na	na	na	na	na	na	28.6	25.0	28.3	20.6	26.9	23.2	27.7	23.7

YEAR	2014		2015	
Sources:	WG data		WG data	
Periods	1st half	2nd half		
Age 0	na	16.1	0.0	9.4
1	18.3	26.3	17.0	19.9
2	25.1	33.3	25.5	28.1
3	28.9	45.8	28.7	38.5
4	26.0	na	25.5	na
5	na	na	na	na
Total	22.9	25.3	20.5	22.9

Units: grammes.

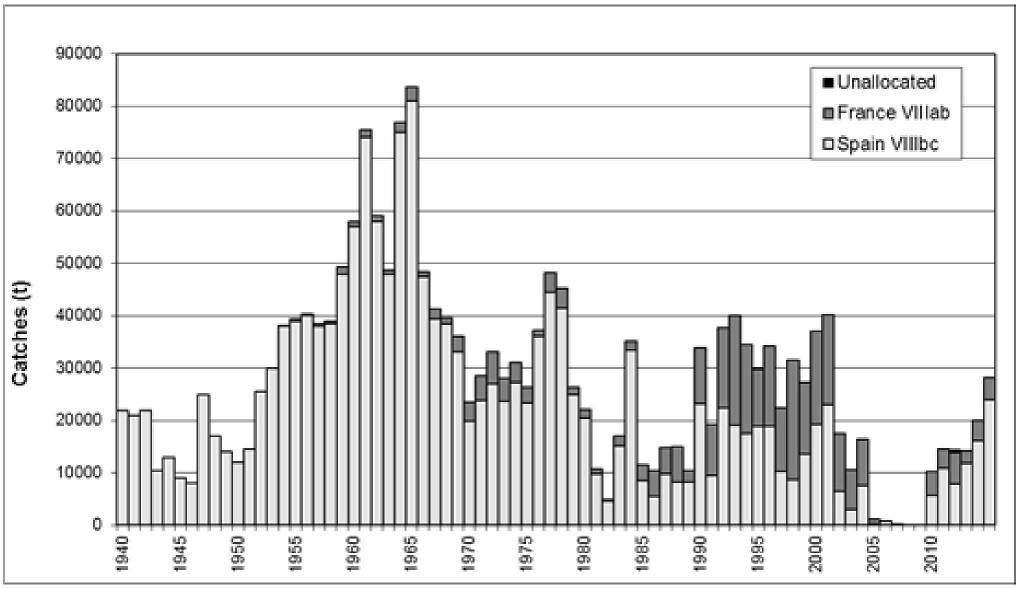


Figure 3.2.2.1. Bay of Biscay anchovy: Historical evolution of catches in Division 8 by countries. Catches until 2011 are working group estimates.

3.3 Fishery-independent data

3.3.1 BIOMAN DEPM survey 2016

All the methodology for the survey and the estimates performance are described in detail in the stock annex - Bay of Biscay Anchovy (Subarea 8). A detailed report of the survey and results 2016 is attached as **annex A3.2_ WD_DEPM_BIOMAN** (**Santos. M *et al.* – WD 2016).**

3.3.1.1 Survey description

The 2016 anchovy DEPM survey was carried out in the Bay of Biscay from 5th to the 25th of May, covering the whole spawning area of the species, following the procedures described in the stock annex- Bay of Biscay Anchovy (Subarea 8). Two vessels were used at the same time and place: the RV Ramón Margalef to collect the plankton samples and the pelagic trawler RV Emma Bardán to collect the adult samples. Sample specifications are given in Table 3.3.1.1.1.

Total number of PairoVET samples (vertical sampling) obtained was 680. From those, 466 had anchovy eggs (69%) with an average of 550 eggs m^{-2} per station in the positive stations, and a maximum of 7530 eggs m^{-2} in a station. A total of 25 564 anchovy eggs were encountered and classified in the PairoVET stations. The number of CUFES samples (horizontal sampling) obtained was 1648. From those 1051(64%) stations had anchovy eggs with an average of 20 eggs m^{-3} per station in the positive stations, and a maximum of 225 eggs m^{-3}. This year the west spawning limit in the Cantabrian coast was found at 5º38’W at the height of Gijón. In the French platform there were eggs all over the platform up to 200 m depth until 46ºN. From 46ºN to 47º23’N the egg were inside the 100 m depth isoline. The northern spawning limit was found at the height of Nantes (47º23’N) (Figure 3.3.1.1.1). The total area surveyed was 98 866 km^2 and the positive area was 55 092 km^2.

In relation with the adult samples, 44 pelagic trawls were performed, from which 36 provide anchovy and 32 were selected for the analysis. Moreover, two hauls from the purse-seines commercial fleet were added for the analysis. In total there were 34 adult anchovy samples for the estimation of the adult parameters. The spatial distribution of the samples and their species composition is shown in Figure 3.3.1.1.2. The most abundant species in the trawls were: anchovy, sardine, horse mackerel, mackerel, hake, sprat and sardine. Spatial distribution of mean weight and mean Length (males and females) for anchovy is shown in Figure 3.3.1.1.3. Less weight individuals were found all alone the coast and in the influence of the Gironde estuary while heavier anchovies were found in the French platform and the heaviest offshore and in the Cantabric coast. Figure 3.3.1.1.4 shows the age composition by haul.

The weather conditions during the survey were good in general with a mean Sea Surface Temperature of 14.8ºC. The average salinity was 34.57 and the influence of the Gironde River was well manifested with a salinity of around 30 in that area. Comparing with the last year this appears to be colder than last. Figure 3.3.1.1.5 shows the maps of surface salinity and temperature found during the survey with the anchovy egg distribution.

3.3.1.2 Total daily egg production estimate

The estimates of daily egg production, daily egg mortality rates and total egg production are given in Table 3.3.1.2.1 and the mortality curve model adjusted is shown in Figure 3.3.1.2.1. Total egg production in 2016 was estimated at 1.14 E+13 with a CV of 0.0817, higher than last year estimates (1.08 E+13).

3.3.1.3 Daily fecundity and preliminary index of biomass

To estimate the total Biomass following the DEPM a daily fecundity (DF) estimate is necessary. The anchovy adults from the survey to estimate DF are in process so it was obtained as a mean of the historical series. Two considerations were proposed: *a*) DF as the mean of the whole historical series (94.63 eggs/gramme) and *b*) DF as a mean of the last six years, just after the opening of the fishery in 2010 (69.60 eggs/gramme).

The preliminary total biomass estimate resulted in case *a*) in 120 934 t with a coefficient of variation of 24% and in case *b* in 164 411 t with a coefficient of variation of 15%. (Figure 3.3.1.3.1). Table 3.3.1.3.1 a and b.

The definitive anchovy total biomass will be estimated for November (WGHANSA-sub) based on the final DF estimate, to be used as input for the assessment model.

3.3.1.4 Population-at-age

In order to estimate the numbers-at-age, six strata were defined. The stratification was based on the egg abundance, the adult distribution and the size and age of adult anchovy: Southwest (SW), Southeast (SE), Centre (C), Garonne (G), North (N) and Northwest (NW) (Figure 3.3.1.4.1). 53% of the anchovy in numbers were estimated as individuals of age 1 (43% in mass), 44% of the individuals in numbers were of age 2 (52% in mass) and 3% of the individuals in numbers were of age 3 (5% in mass) (Table 3.3.1.4.1). The time-series of the age structure of the population, for instance in case *b* taken the DF as the mean of last six years is shown in Figure 3.3.1.4.2.

Table 3.3.1.1.1. Bay of Biscay anchovy: Details of the DEPM survey BIOMAN 2016.

Parameters	Anchovy DEPM survey
Surveyed area	(43º19' to 48º00′N & 5º 37′ to 1º14' W)
RV	Ramón Margalef & Emma Bardán
Date	5–25/05/2016
Eggs	RV RAMON MARGALEF
Total egg stations	680
% st with anchovy eggs	69%
Anchovy egg average by st	550 eggs/m2
Max. anchovy eggs in a St	7530 eggs/m^2
Total ane egg collected&staged	25 564 eggs
North spawning limit	47º′23′N
South spawning limit	5º 38′W
Total area surveyed	98 866 Km^2
Spawning area	55 092 Km^2
CUFES stations	1648
Adults	RV EMMA BARDAN
Pelagic trawls	44
With anchovy	36
Selected for analysis	32
Hauls from purse-seines	2
Total adult samples for analysis	34

Table 3.3.1.2.1. Bay of Biscay anchovy: Anchovy daily egg production (P_0), daily egg mortality rates (z) and total egg production (P_{tot}) estimates with their correspondent standard error (s.e.) and coefficient of variation (CV) for 2016.

Parameter	Value	S.e.	CV
P0	207.72	19.74	0.0950
z	0.32	0.046	0.1435
Ptot	1.14.E+13	1.1.E+12	0.0950

Table: 3.3.1.3.1. Bay of Biscay anchovy: Parameters to estimate preliminary index of anchovy total biomass (Tons) using the Daily Egg Production Method (DEPM) for 2016: P_{tot} (total egg production; eggs) and DF (daily fecundity; egg/gramme) and W_t (total mean weight (gramme) (female and male)) with correspondent variance. Case *a*: Considering DF as all years' historical mean and case *b*: Considering DF as last six years mean (after the open of the fishery).

a

Ptot (eggs)			DF (eggs/gramme)			Total biomass(Ton.)		
Model	Estimate	Var	Predic.Model	Estimate	Var.Pred.	Estimate	Var	Cv
GLM	1.14E+13	1.2E+24	all years mean	94.63	419.43	120,934	8.2.E+08	0.2364

b

Ptot (eggs)			DF (eggs/gramme)			Total biomass (Ton.)		
Model	Estimate	Var	Predic.Model	Estimate	Var.Pred.	Estimate	Var	Cv
GLM	1.14E+13	1.2E+24	6 years mean	69.60	66.19	164,411	6.1.E+08	0.1506

Table: 3.3.1.4.1. Bay of Biscay anchovy: Anchovy index of total biomass, percentage-at-age, numbers-at-age, mean weight-at-age, mean length-at-age, total biomass at-age in mass and percentage-at-age in mass with the correspondent standard error (s.e.) and coefficient of variation (CV) from BIOMAN 2016. Case *a*: Considering DF as all years' historical mean and case *b*: Considering DF as last six years' mean (after the open of the fishery).

a)

Parameter	Estimate	S.e.	CV
Biomass (Tons)	190,784	9,573	0.0502
Tot.mean W (g)	13.38	1.09	0.0816
Population (millions)	14,257	1365.6	0.0958
Percent age 1	0.53	0.0387	0.0734
Percent age 2	0.44	0.0337	0.0758
Percent age 3+	0.03	0.0065	0.2479
Numbers at age 1	7,526	908.1	0.1207
Numbers at age 2	6,332	773.6	0.1222
Numbers at age 3+	375	99.8	0.2658
Weight at age 1	10.9	0.98	0.0900
Weight at age 2	15.5	1.00	0.0643
Weight at age 3+	25.7	1.33	0.0498
Length at age 1	119.9	3.60	0.0300
Length at age 2	133.9	2.91	0.0217
Length at age 3+	160.7	2.17	0.0135
B at age 1 in mass	82,573		
B at age 2 in mass	98,534		
B at age 3+ in mass	9,677		
Percent age 1 in mass	0.43	0.04	0.0817
Percent age 2 in mass	0.52	0.03	0.0545
Percent age 3+ in mass	0.05	0.01	0.2178

b)

Parameter	Estimate	S.e.	CV
Total Biomass (Tons)	120,934	28,585	0.2364
Tot.mean W (g)	13.38	1.09	0.0816
Population (millions)	9,037	2259.8	0.2501
Percent age 1	0.53	0.0387	0.0734
Percent age 2	0.44	0.0337	0.0758
Percent age 3+	0.03	0.0065	0.2479
Numbers at age 1	4,770	1243.2	0.2606
Numbers at age 2	4,014	1048.8	0.2613
Numbers at age 3+	238	83.8	0.3521
Weight at age 1	10.9	0.98	0.0900
Weight at age 2	15.5	1.00	0.0643
Weight at age 3+	25.7	1.33	0.0498
Length at age 1	119.9	3.60	0.0300
Length at age 2	133.9	2.91	0.0217
Length at age 3+	160.7	2.17	0.0135
B at age 1 in mass	52,341		
B at age 2 in mass	62,459		
B at age 3+ in mass	6,134		
Percent age 1 in mass	0.43	0.035	0.0817
Percent age 2 in mass	0.52	0.028	0.0545
Percent age 3+ in mass	0.05	0.011	0.2178

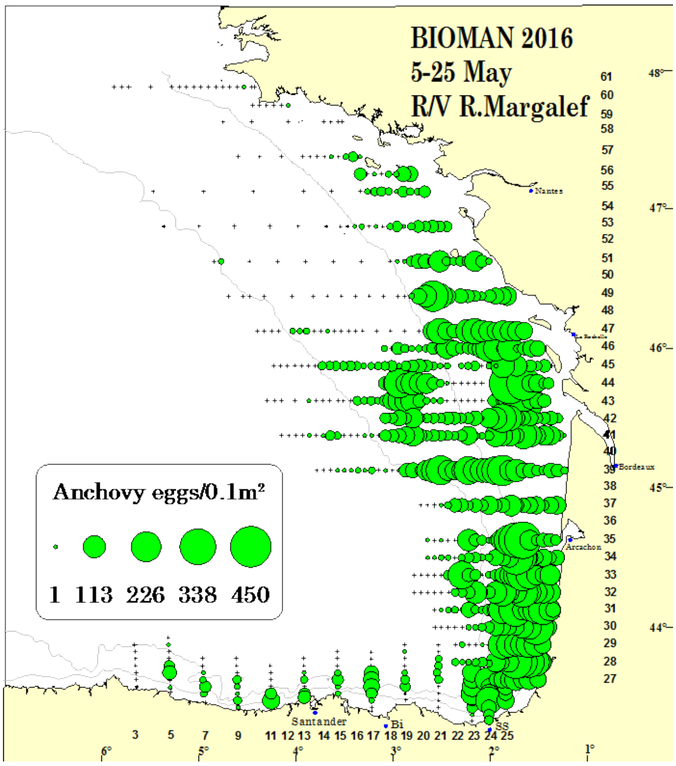


Figure 3.3.1.1.1. Bay of Biscay anchovy: Distribution of anchovy egg abundance (eggs per 0.1 m²) from the DEPM survey BIOMAN2016 obtained with PairoVET (vertical sampling).

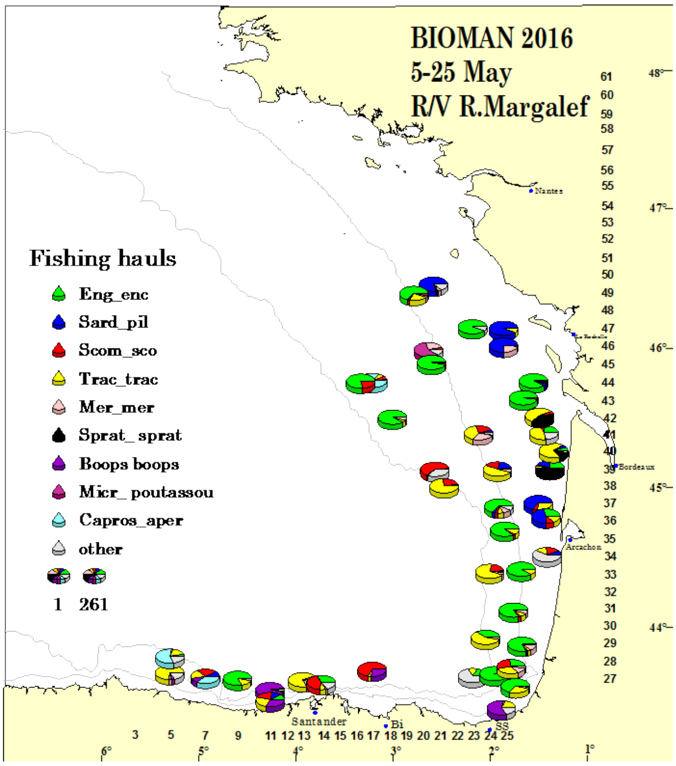
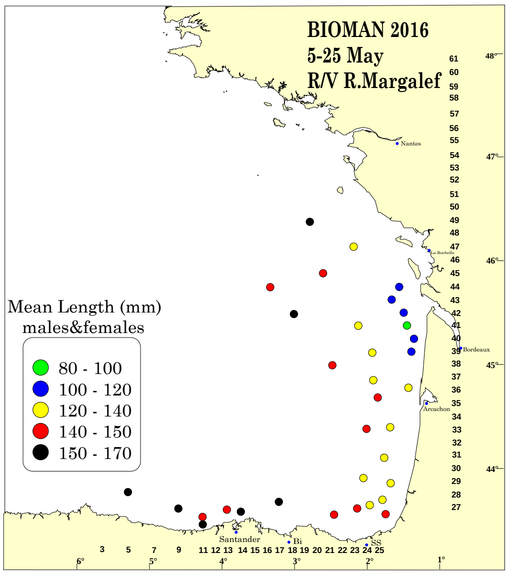


Figure 3.3.1.1.2. Bay of Biscay anchovy: Species composition of the 34 pelagic trawls from the RV Emma Bardán during BIOMAN2016.



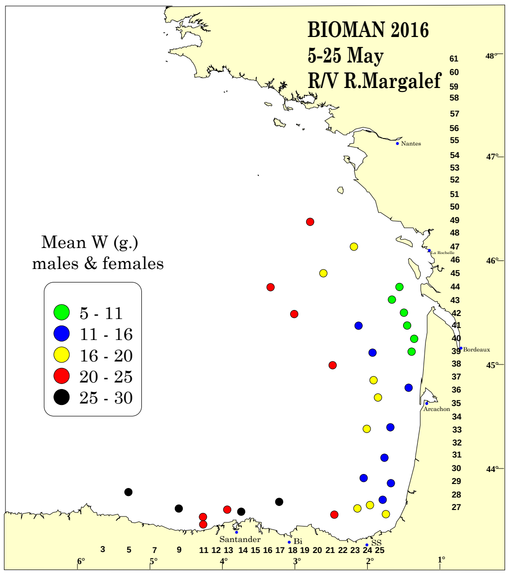


Figure 3.3.1.1.3. Bay of Biscay anchovy: Spatial distribution of anchovy mean size (left) and mean weight (right) (males and females) per haul in BIOMAN2016.

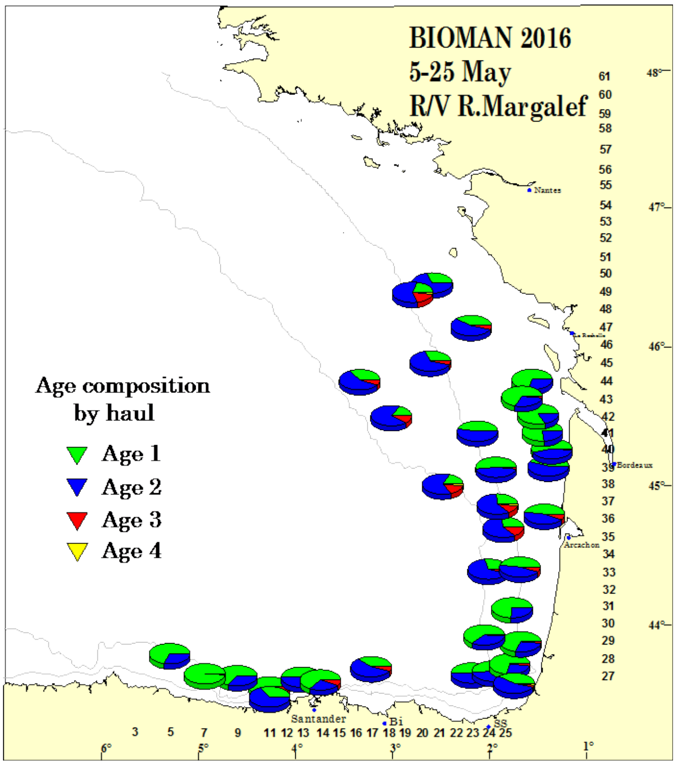


Figure 3.3.1.1.4. Bay of Biscay anchovy: Anchovy age composition per haul in BIOMAN2016.

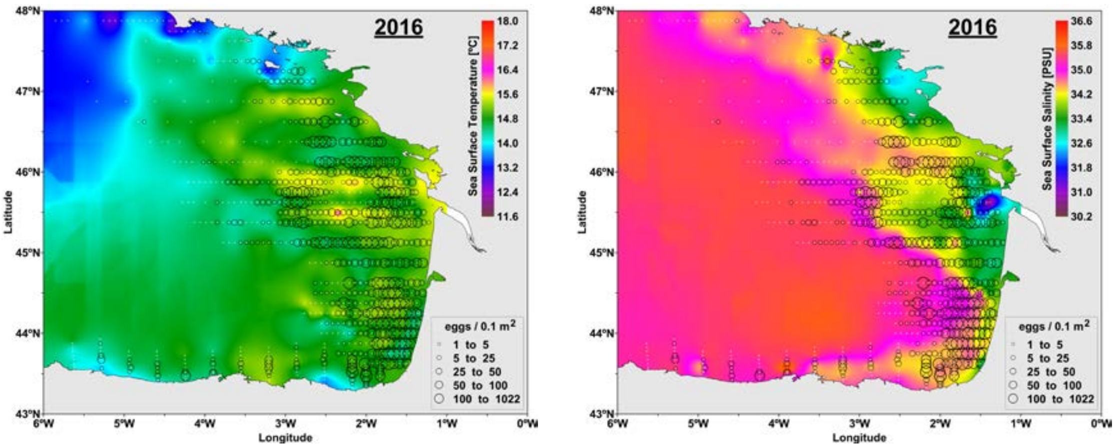


Figure 3.3.1.1.5. Bay of Biscay anchovy: From left to right spatial distribution of SST and SSS in BIOMAN 2016. The bubbles represent the anchovy egg abundance per 0.1 m².

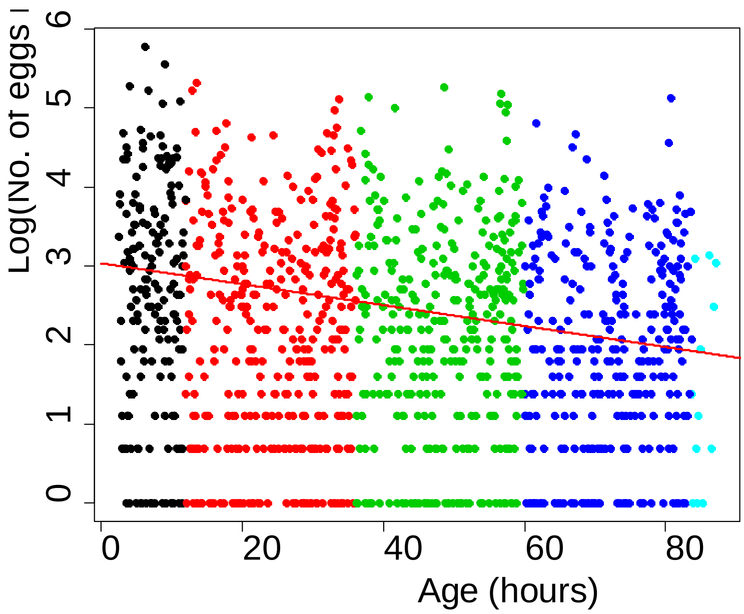


Figure 3.3.1.2.1. Bay of Biscay anchovy: Exponential mortality model adjusted applying a GLM to the data obtained in the Bayesian egg ageing (spawning peak assumed to be at 23:00 hours).The red line is the adjusted line. The coloured dots represent the different cohorts.

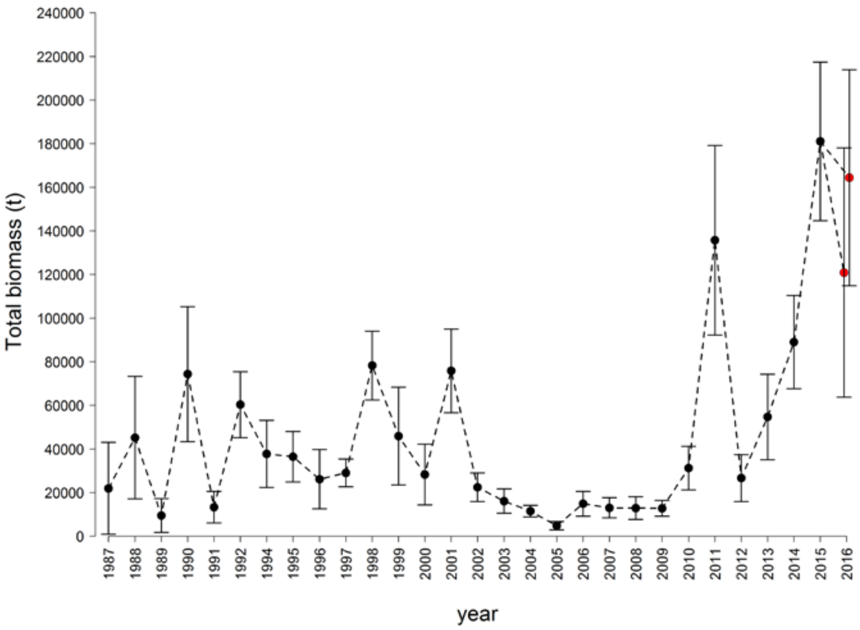


Figure 3.3.1.3.1. Bay of Biscay anchovy: Series of anchovy total biomass estimates (in tonnes) obtained from the DEPM. The two points (red) in 2016 are the total biomass estimate considering DF as all years historical mean (the lowest) and considering DF as the mean of the last six years (the highest).

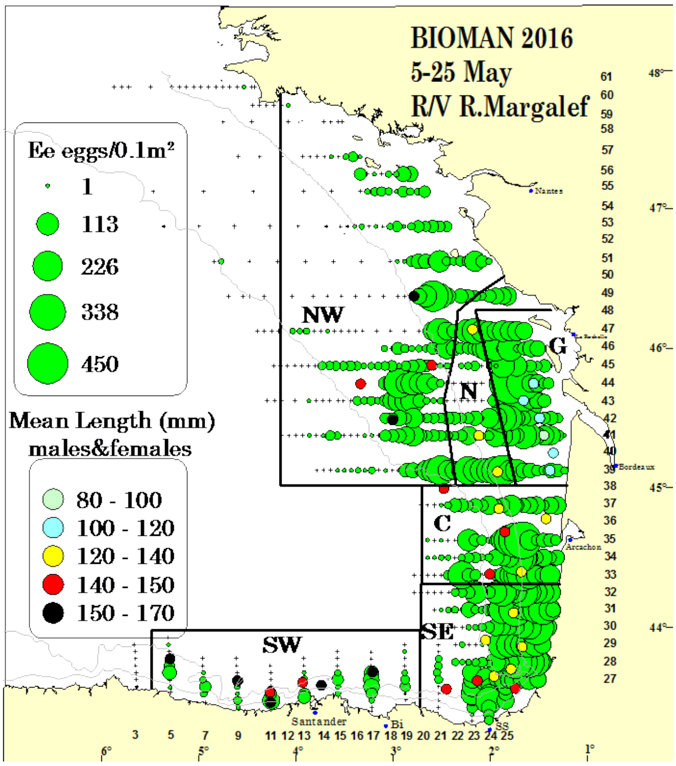


Figure 3.3.1.4.1. Bay of Biscay anchovy: Spatial 6 strata to weight the samples to estimate anchovy numbers-at-age in BIOMAN2016.

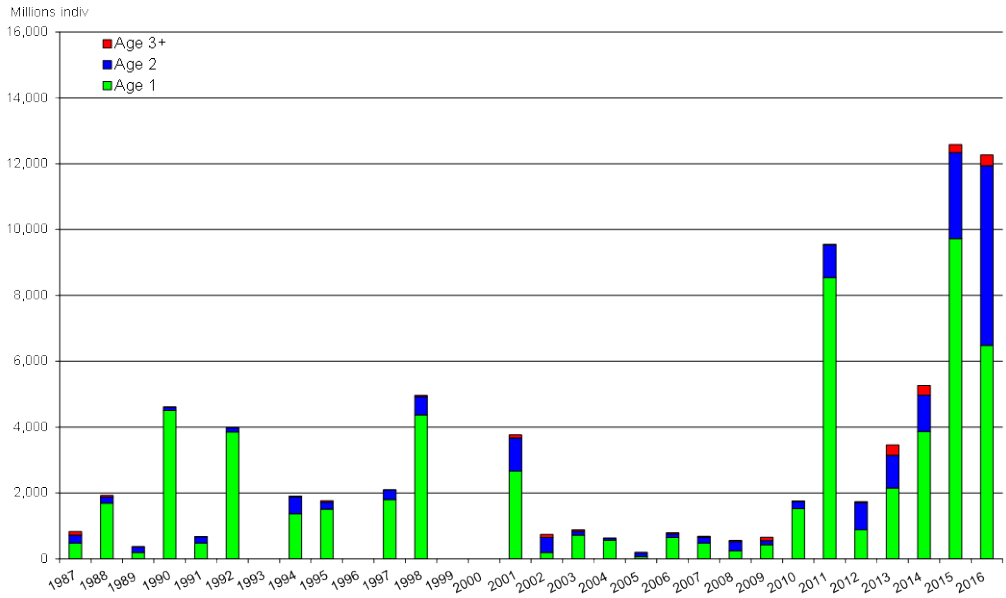


Figure 3.3.1.4.2. Bay of Biscay anchovy: Anchovy historical series of numbers-at-age from 1987 to 2016 from BIOMAN surveys. For instance considering DF as last six years mean (after the open of the fishery).

3.3.2 The PELGAS 16 spring acoustic survey

[for more details, see WD Duhamel *et al*. (2016) presented to this group.]

Acoustic surveys are carried out every year in the Bay of Biscay in spring on board the French research vessel Thalassa. The objective of PELGAS surveys is to study the abundance and distribution of pelagic fish in the Bay of Biscay. The main target species are anchovy and sardine, but they are considered in a multispecific context and within an ecosystemic approach as they are located in the centre of pelagic ecosystem.

The strategy this year was the identical to previous surveys (2000 to 2015). The protocol for acoustics has been described during WGACEGG in 2009 (Doray *et al*., 2009):

- acoustic data were collected along systematic parallel transects perpendicular to the French coast (Figure 3.3.2.1.). The length of the ESDU (Elementary Sampling Distance Unit) was one mile and the transects were uniformly spaced by 12 nautical miles and cover the continental shelf from 20 m depth to the shelf break (or sometimes more offshore, see figure below).
- coustic data were only collected during the day because of pelagic fishes behaviour in this area. These species are usually dispersed very close to the surface during the night and so "disappear" in the blind layer of the echosounder between the surface and 8 m depth.

Acoustic data were collected by RV Thalassa along a total amount of 5220 nautical miles from which 1876 nautical miles on one way transect were used for assessment. A total of 28 859 fish were measured (including 7433 anchovies and 4702 sardines) and 2857 otoliths were collected for age determination (1621 of anchovy and 1236 of sardine).

A consort survey is routinely organized since 2007 with French pair trawlers during 18 days. This approach, in the continuity of last year survey, and the commercial vessels hauls were used for echo identification and biological parameters at the same level than Thalassa ones. A total of 119 hauls were carried out during the assessment coverage including 54 hauls by Thalassa and 65 hauls by commercial vessels. (Figure 3.3.2.2.).

As for previous years (except in 2003, see WD-2003), the global area has been split into several strata where coherent communities were observed (species associations) in order to minimise the variability due to the variable mixing of species. Figure 3.3.2.3 shows the strata considered to evaluate biomass of each species. For each strata, energies where converted into biomass by applying catch ratio, length distributions and weighted by abundance of fish in the haul surrounded area.

Anchovy was present this year at a medium level, far away the huge abundance observed last year, with around 89 727 tonnes, with soft densities in the Gironde area. It must be noticed that we observed anchovy on the first transect along the Spanish coast in relatively high densities, mainly close to the surface. (Table 3.3.2.1 and Figure 3.3.2.4).

Sardine was also less present this year compared to 2015, almost exclusively in coastal waters from the south until the Loire River, and she was rather absent in surface along the shelf break.

About other species, another characteristic of this year is that horse mackerel shows a small increase of the biomass once again, and reach now a medium level, after ten years of low biomass at this period of the year in this area. (Table 3.3.2.2).

Mackerel appears very dispersed all over the area and seems to be relatively well present this year, particularly offshore, close to the bottom, and sometimes near the surface.

The one year old anchovies were mostly present around the Gironde plume (in terms of energy and, as well, biomass) but they were still well present on the platform, in the southern part of the Bay of Biscay. The most part of the age 1 of anchovy was there, in size class comparable with a "normal" year (all, except 2012 and particularly 2015 where the fish was much smaller).

Looking at the numbers-at-age since 2000 (Figure 3.3.2.5), the number of one year old anchovies this year seems to be equivalent as 2010 or 2013, far away from the very best recruitment observed last year. As it is described in chapter 3.7, the number of age 2 and 3 this year was probably underestimated, as they were present very closed to the surface offshore in the middle part of the Bay of Biscay, in the blind layer of vertical echosounders. The lateral one is not used for assessment purpose.

Globally observed length structure shows a unimodal distribution, with a mode around 12 centimetres; constituted by age 1 and age 2 fishes. It must be noticed that even some individuals are small (less than 10 centimetres), almost all fishes were mature and in their spawning period (compared to last year when a large part of the population were not spawning at the period of the survey). (Figure 3.3.2.6).

Taking advantage of the fact that the existence of an egg survey (CUFES) providing Ptot and an acoustic survey providing B, the daily fecundity (DF: # eggs g-1 d-1) may be estimated by the ratio Ptot/B. Note that here, DF is the egg production by gram of stock (i.e. both females and males). Because the two indices Ptot and B are linked through DF, the coherence between the egg (CUFES) and the acoustic survey indices of PELGAS can be investigated.

Briefly, the CUFES egg concentration is converted into egg abundance (vertically integrated) by using a one-dimensional distribution model which takes input account as parameters the egg buoyancy and dimension, the hydrological vertical profile, the tidal current and wind regime (Petitgas *et al.*, 2006; Petitgas *et al.*, 2009; Gatti, 2012). The complete series is shown in Figure 3.3.2.7.

The daily egg production Ptot depends on the spawning biomass (B) and the daily fecundity (DF). DF depends ultimately on environmental and trophic conditions, which determine individual fish fecundity (e.g. Motos *et al.*, 1996). Daily egg production (Ptot) and spawning biomass (B) were linearly related (Figure 3.3.2.8). The slope of the linear regression is a (direct) estimate of the average DF over the series. Its value is: 92.26 eggs g-1. Residuals are particularly important some years.

In Figure 3.3.2.9, globally the spatial distribution of eggs matches with the adult's one. But in the centre of the bay, a lot of eggs were counted despite a low abundance of adults. In this area particularly, anchovy was very close to the surface, in the blind layer of vertical echosounders. This led to a probable underestimation of adult biomass in this area.

Table 3.3.2.1. Acoustic biomass index for sardine and anchovy by strata during PELGAS16.

	classic	surface	total
anchovy	71 168	18 558	89 727
sardine	228 308	1 435	229 742
blue whiting	17 934	162	18 096
horse mackerel	115 840	3 390	119 230
sprat	36 593	0	36 593
chub mackerel	111 197	183 452	294 649
hake	16 780	0	16 780
boarfish	4 475	0	4 475

Table 3.3.2.2. Acoustic biomass index for the five main pelagic species since the beginning of PELGAS surveys (2000).

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
anchovy	**113 120**	**105 801**	**110 566**	**30 632**	**45 965**	**14 643**	**30 877**	**40 876**	**37 574**	**34 855**	**86 354**	**142 601**	**186 865**	**93 854**	**125 427**	**372 916**	**89 727**
CV anchovy	*0.064*	*0.141*	*0.113*	*0.132*	*0.167*	*0.171*	*0.136*	*0.100*	*0.162*	*0.112*	*0.147*	*0.0774*	*0.04665*	*0.1282*	*0.062928*	0.0735509	0.13
Sardine	**376 442**	**383 515**	**563 880**	**111 234**	**496 371**	**435 287**	**234 128**	**126 237**	**460 727**	**479 684**	**457 081**	**338 468**	**205 627**	**407 740**	**339 607**	**416 524**	**229 742**
CV sardine	*0.083*	*0.117*	*0.088*	*0.241*	*0.121*	*0.135*	*0.117*	*0.159*	*0.139*	*0.098*	*0.091*	*0.0699*	*0.07668*	*0.0738*	*0.065212*	0.1023153	0.08
Sprat	**30 034**	**137 908**	**77 812**	**23 994**	**15 807**	**72 684**	**30 009**	**17 312**	**50 092**	**112 497**	**67 046**	**34 726**	**6 417**	**44 651**	**33 894**	**91 248**	**36 593**
CV sprat	*0.098*	*0.155*	*0.120*	*0.198*	*0.178*	*0.228*	*0.162*	*0.132*	*0.268*	*0.108*	*0.108*			*0.1992*	*0.241009*	0.1953397	0.44
Horse mackere	**230 530**	**149 053**	**191 258**	**198 528**	**186 046**	**181 448**	**156 300**	**45 098**	**100 406**	**56 593**	**11 662**	**61 237**	**7 435**	**33 471**	**53 154**	**77 142**	**119 230**
CV HM	*0.079*	*0.204*	*0.156*	*0.137*	*0.287*	*0.160*	*0.316*	*0.065*	*0.455*	*0.09*	*0.188*			*0.3007*	*0.227089*	0.1549802	0.3
Blue Whiting	-	-	**35 518**	**1 953**	**12 267**	**26 099**	**1 766**	**3 545**	**576**	**4 333**	**48 141**	**11 823**	**68 533**	**25 715**	**25 015**	**8 684**	**11 852**
CV BW	-	-	*0.386*	*0.131*	*0.202*	*0.593*	*0.210*	*0.147*	*0.253*	*0.219*	*0.074*			*0.1542*	*0.337606*	*0.2234791*	*0.15*

3.3.3 Autumn juvenile acoustic survey 2015 (JUVENA 2015)

The methodology of the autumn juvenile acoustic survey JUVENA is described in detail in the stock annex. In particular the results of the last survey in autumn 2015 were reported and discussed in WGACEGG (ICES, 2014).

The main objective of the JUVENA survey is estimating the abundance of the anchovy juvenile population and their growth condition at the end of the summer in the Bay of Biscay. In 2015 the survey was coordinated between AZTI and IEO. AZTI led the assessment studies whereas IEO led the ecological studies.The survey JUVENA 2015 took place between the 1st and 30th of September with the RV Ramon Margalef (RM) and the RV Emma Bardán (EM), both equipped with echosounders.

The water column was sampled to depths of 200 m. Acoustic backscattered energy by surface unit was recorded for each geo-referenced ESDU (Echointegration Sampling Distance Unit) of 0.1 nautical mile. Fish identity and population size structure were obtained from fishing hauls and echotrace characteristic using a pelagic trawl. Acoustic data, thresholded to -60 dB, was processed using Movies+ software for biomass estimation and the processed data were represented in maps using ArcGIS. Hydrographic recording was made with CTD casts.

The survey sampled 2200 n.mi. that provided a coverage of about 33 000 n.mi.^{2} along the continental shelf and shelf break of the Bay of Biscay, from the 9º10′ W in the Cantabrian area up to 47º 30′ N at the French coast (Figure 3.3.3.1). Seventy nine hauls were done during the survey to identify the species detected by the acoustic equipment, 58 of which were positive of anchovy.

The survey was covered by both vessels in coordination, in the Spanish region both vessels followed alternate transects, while in the French part they concentrated the sampling effort of each vessel in the most appropriate areas according to their efficiency: this is, oceanic and slope waters for the RM and continental shelf for the smaller pelagic trawler EB.

The following strata were defined depending on the echotraces and the species composition:

- Pure juvenile stratum: In this stratum, anchovy was located in the uppermost part of the water column forming the typical superficial aggregations of pure juvenile anchovy, mixed in occasions with smaller proportions of juvenile horse mackerel, gelatinous species and krill. This stratum can be divided in the following two areas:
    - Cantabric substratum: in this area, anchovy juveniles were extended along a strip around the shelf break edge, from 9º10′ W to 1º30′ W. Mean size ranged between 4 and 7 cm in this area. The vertical distribution of juvenile anchovy extended from 5 to 50 m depth.
    - French substratum: this area was extended in front of the Southern French coast (to the south of 45ºN), from coastal areas to the slope waters. Sizes in this area varied between 7 and 11 cm. The superficial aggregations of anchovy were composed by a majority of juvenile anchovy, mixed with small quantities of horse mackerel and jellyfish.
- Mixed stratum: Anchovy size in this stratum was bigger, between 12 and 16 cm, a mix of adult and juvenile, and was detected in schools close to the bottom, mixed also with superior proportions of other species.

- Garonne: Around the plume of the Gironde River, a positive area was found extending from the coast to about 100 m isobath. Here, anchovy included both adults and juveniles, and was found mixed with sardine, sprat and horse mackerel plus other species, distributing along the whole water column. The sizes ranged from 9 to 13 cm.

Figure 3.3.3.2 shows the species composition of the hauls. The modal size of the anchovies found in each haul are given in Figure 3.3.3.3.

The biomass of juveniles estimated for year 2015 is around 462 300 tonnes (Table 3.3.3.1), which is the third largest of the historical series. The distribution area was also among the largest of the JUVENA series. The mean size of anchovy was slightly less than 7 cm long. Most of the biomass was located off-the-shelf or in the outer part of the shelf (Figure 3.3.3.4) in the first layers water of the water column.

Table 3.3.3.1. Bay of Biscay anchovy: Summary of the estimates obtained in the JUVENA autumn acoustic surveys from 2003 to 2015.

Year	Sampled area (mn2)	Area+ (mn2)	Size juveniles (cm)	Biomass juveniles (year y)
2003	16,829	3,476	7.9	98,601
2004	12,736	1,907	10.6	2,406
2005	25,176	7,790	6.7	134,131
2006	27,125	7,063	8.1	78,298
2007	23,116	5,677	5.4	13,121
2008	23,325	6,895	7.5	20,879
2009	34,585	12,984	9.1	178,028
2010	40,500	21,110	8.3	599,990
2011	37,500	21,063	6	207,625
2012	31,724	14,271	6.4	142,083
2013	33,250	18,189	7.4	105,271
2014	50,102	37,169	5.9	723,946
2015	32,763	21,867	6.8	462,340

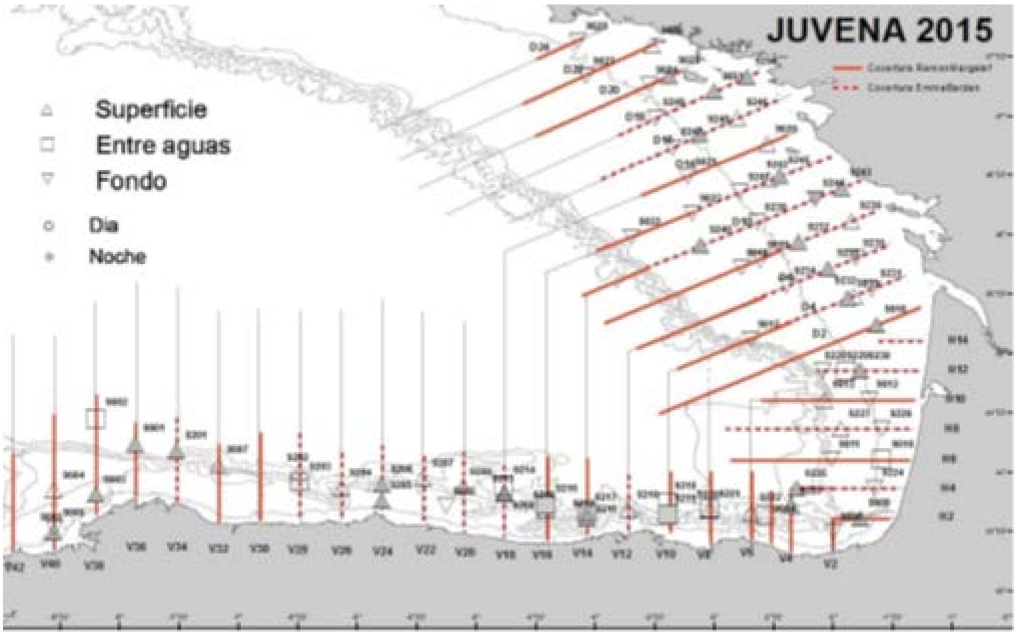


Figure 3.3.3.1. Bay of Biscay anchovy: Position of the fishing stations in JUVENA 2015.

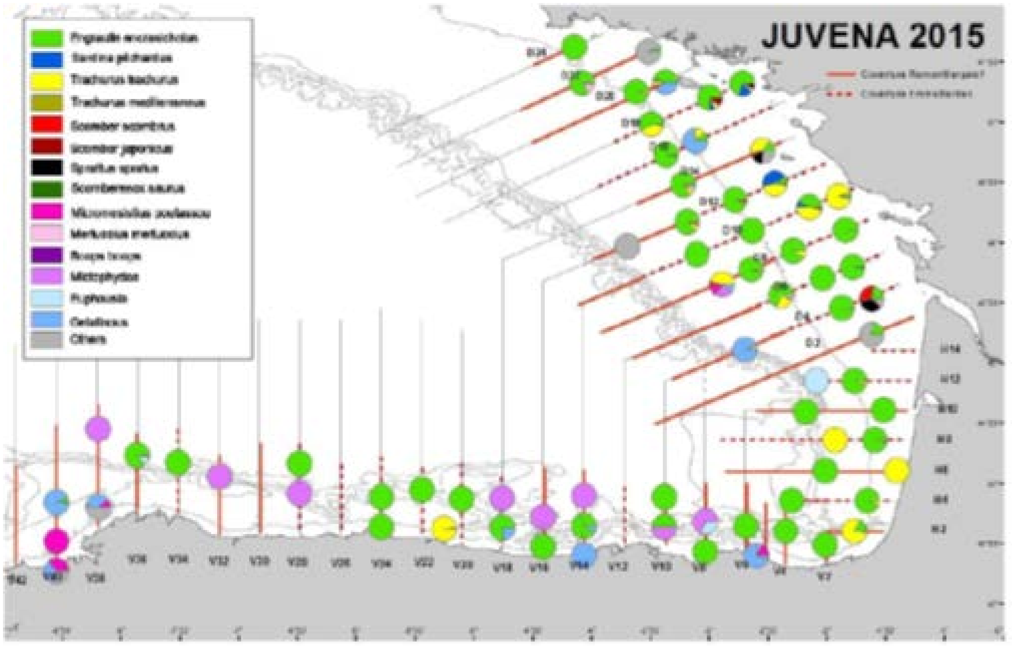


Figure 3.3.3.2. Bay of Biscay anchovy: Species composition of the hauls in JUVENA 2015.

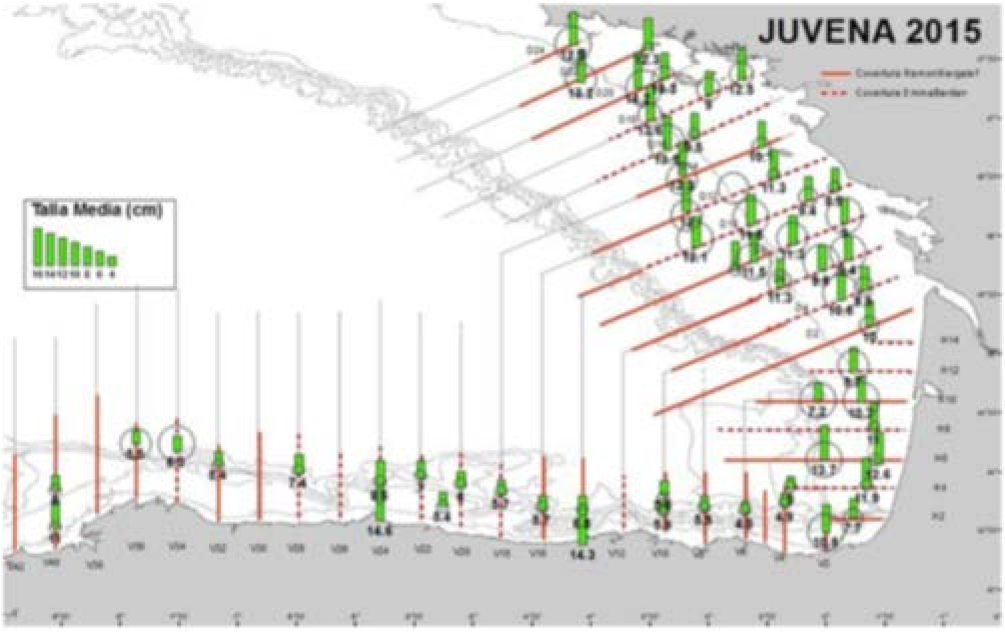


Figure 3.3.3.3. Bay of Biscay anchovy: Modal size of anchovy in the positive hauls in JUVENA 2015.

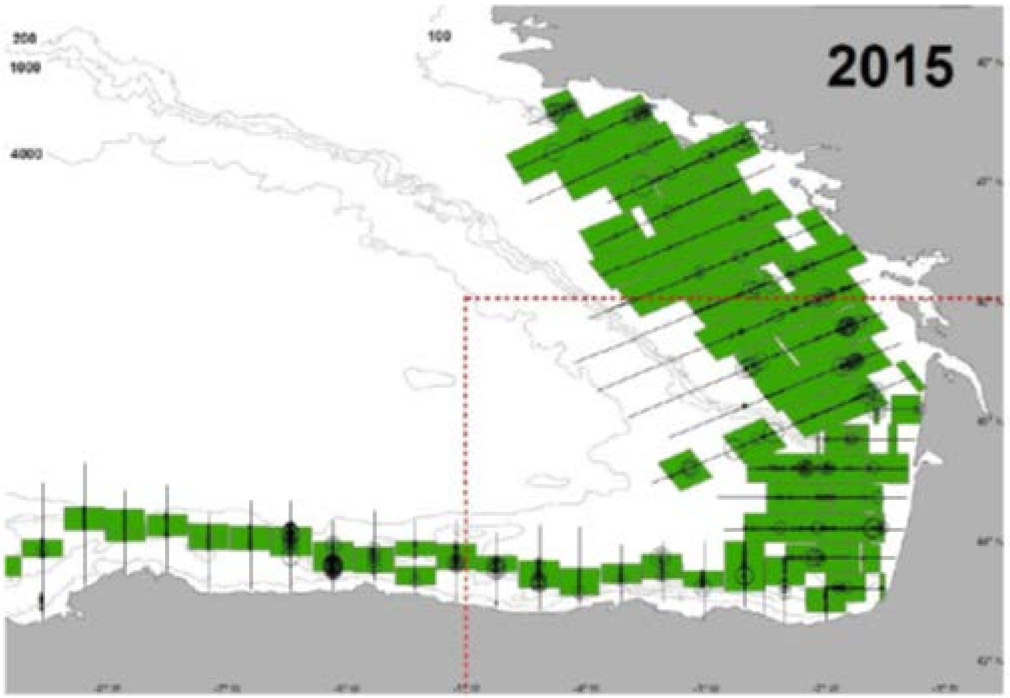


Figure 3.3.3.4. Bay of Biscay anchovy: Total acoustic energy (NASC) of all the identified species and the three subareas of the positive anchovy area in JUVENA 2015.

3.4 Biological data

3.4.1 Maturity-at-age

As reported in previous year reports, anchovies are fully mature as soon as they reach their first year of life, in the spring the year after the hatch. See stock annex - Bay of Biscay Anchovy (Subarea 8) for details.

3.4.2 Natural mortality and weight-at-age in the stock

Natural mortality is fixed at 0.8 for age 1 and 1.2 for older individuals (age 2+).

In the CBBM assessment model the parameters G_1 and G_{2+} representing the annual intrinsic growth of the population by age class are assumed constant along years and are estimated based on the weight-at-age data from the surveys.

See stock annex - Bay of Biscay Anchovy (Subarea 8) for further information.

3.5 State of the stock

According to the stock annex approved in October 2013 (Annex A.5), the assessment of this stock can be conducted in June or December. The management plan applied in the last two years is based on the December assessment. So, this year the final assessment of the stock will also be conducted in December 2016.

3.6 Short-term prediction

The short-term prediction of the population in order to explore catch options will be conducted in December, once the final assessment of the stock is conducted.

3.7 Reference points and management considerations

3.7.1 Reference points

The reference points and their definitions are found in the stock annex for this stock, which was approved in October 2013. B_{lim} is set at 21 000 t.

This year WGHANSA is requested to address the following ToR:

f) Estimate precautionary reference points for all the category 1 stocks with undefined PA reference points, following the Technical Guidelines document on reference points developed by ACOM and the WKMSYREF4 report.

Bay of Biscay anchovy is a short-lived species classified in category 1. According to the guidelines, the classification of status of stock for short-lived species should be based directly on the distribution of SSB at spawning time relative to B_{lim}. Given that the current assessment provides the probability distributions for SSB, the probability of SSB being below B_{lim} can be directly estimated and the definition of B_{pa} becomes irrelevant. Alternatively, F PA reference points don't need to be defined, since ICES does not use F reference points to determine exploitation status for short-lived species.

According to the recent advisory practice (ICES Advice 2016, Book1, Section 1.2 General context of ICES advice), the ICES MSY approach for short-lived stocks is aimed at achieving a target escapement (MSY $B_{escapement}$, the amount of biomass left to spawn), which is more robust against low SSB and recruitment failure than a fishing mortality approach. This applies to the Bay of Biscay anchovy. Hence, defining an F_{MSY} is irrelevant, and advice aiming at MSY is equivalent to the precautionary approach advice. MSY $B_{escapement}$ has not been defined for this stock.

3.7.2 Short-term advice

Providing a risk adverse advice according to the precautionary approach in the short-term perspective, translates into recommending a TAC which implies a low risk of leading below B_{lim}, for selected scenario(s) of recruitment.

The Bayesian assessment model provide estimates of the uncertainty which are expressed as posterior distributions of the interest parameters. The posterior distributions express the uncertainty of the results given the uncertainty of the data and the prior assumptions, and presumably represent more realistic estimates of the uncertainty than the assumptions underlying the distance between B_{lim} and B_{PA} in the common deterministic framework.

According to the current stock annex the assessment of this stock can be conducted at two points in time: in June when SSB is estimated based on the most recent spring surveys information and in December when the assessment can incorporate the most recent juvenile abundance index from JUVENA and any other updated data.

Similarly, the forecast can be given based either on the June or December assessment. In the former the assessment goes up to June, and given that there is no indication on the strength of the incoming year class, an undetermined scenario is assumed based on a mixture distribution of all the past recruitments. In the later the assessment covers the whole year up to December and the next year recruitment distribution is derived from the assessment which includes the latest juvenile abundance index.

3.7.3 Management plans

A draft management plan was proposed by the EC in 2009 in cooperation between science (STECF) and stakeholders (South Western Waters AC). This plan was not formally adopted by the EU but it was used from 2010 to 2014 for establishing the TAC for the period between 1st July and 30th June next year.

In February 2013 the Bay of Biscay anchovy stock was benchmarked in the Benchmark Workshop on Pelagic Stocks (WKPELA). The new stock annex for this stock was approved in October 2013 after further discussions held during WGHANSA 2013 and afterwards by correspondence.

Given that the 2009 long-term management plan proposal for the stock was based on the methods described in the previous stock annex (approved by WKSHORT 2009), STECF was requested to assess the harvest control rule and possible alternatives scoped with the stakeholders, and provide advice taking into account the long-term biological and economic objectives established in the plan. The STECF expert group met from 14 to 18 October 2013 and concluded that the change in the assessment methodology did not affect the usefulness of the LTMP proposal and that the HCR remained within the precautionary limits of risk.

In addition, the STECF expert group advised on a possible revision of the HCR (including changes regarding the HCR and the management calendar) and set the basis for conducting an impact assessment for the Bay of Biscay anchovy long-term management regulation (STECF, 2013).

The data analysis for support of the impact assessment for the management plan of Bay of Biscay anchovy was carried out by an STECF expert group that met from 10 to 14 March 2014 (STECF, 2014). A range of alternative HCR formulations were tested and they were considered to provide a sound base for developing options for fisheries management. In particular for all the HCRs tested, the STECF noted that changing the management period to January–December reduced the risks of the stock falling below B_{lim}, and leaded to a small increase in quantity and stability of catches in comparison to the management period July–June.

During the two expert group meetings, the STECF concluded that the HCR in the 2009 LTMP proposal remained appropriate as a basis for advising on TACs. Therefore, in July 2014 the TAC from July 2014 to June 2015was set according to this draft plan.

In the second semester of 2014 managers and stakeholders agreed on adopting the HCR named G4 in the STECF report with a harvest rate of 0.45. According to this rule, the TAC for the management period from January to December is set as:

$$TAC_{Jan_y-Dec_y} = \begin{cases} 0 & si\ \widehat{SSB}_y \leq 24000 \\ -3800 + 0.45 \cdot \widehat{SSB}_y & if\ 24000 < \widehat{SSB}_y \leq 64000 \\ 25000 & si\ \widehat{SSB}_y > 64000 \end{cases}$$

where is the expected spawning–stock biomass in year. See also Figure 3.7.3.1 for a graphical representation.

In this rule, the TAC from January to December is based on the spawning biomass that will occur during the management year, which at the same time depends on the catches taken during the first semester of the management year. So, both parameters (catches and *SSB*) are interdependent and vary together. This leads to seek the value of fishing mortality during the first semester solving the system for the median values of incoming recruitment, biomass at-age 2+ at the beginning of the year, the growth rates at-age 1 and 2+ and the selectivity at-age 1 in the first semester. The % of annual catches taken in the first semester is assumed to be 0.6 according to STECF (2013; 2014).

Subsequently the European Commission requested ICES to provide advice in December 2014 based on this new HCR, which was used to set a new TAC from January to December 2015. In 2015 ICES reviewed the selected harvest control rule and concluded that it was precautionary (Annex 5 in ICES, 2015a). Subsequently ICES advice for year 2016 was again provided in accordance with this HCR.

In May 2016 the SWWAC recommend to modify the management framework (SWW Opinion 101). Based on the good state of the stock, they asked to use the harvest control rule G3 with a rate of exploitation of 0.4 (Figure 3.7.3.2). This rule complies with the probability of risk of 5% as evaluated by STECF (2014). In particular, the SWWAC recommended an immediate application of this HCR and subsequent increase of the fishing opportunities for 2016 from 25 000 to 33 000 t. Furthermore, the SWWAC recommended that this exploitation rule should also be applied in 2017 and 2018.

3.7.4 Species interaction effects and ecosystem drivers

Anchovy is a prey species for other pelagic and demersal species, and also for cetaceans and birds. Recruitment depends strongly on environmental factors, and several recruitment predictions have been proposed in the past based on environmental variables. Approaches like the one presented in Fernandes *et al.* (2010) look promising, but its prediction capacity is still being tested.

3.7.5 Ecosystem effects of fisheries

These effects are not quantified.

3.7.6 Frequency of the assessment

WGHANSA is requested to address the following ToR:

e) With reference to the Frequency of Assessment criteria agreed by ACOM (see Section 5.1 of WGCHAIRS document 03): (1) Complete the calculation of the first set of criteria, by calculating Mohn's rho index for the final assessment year F; (2) Comment on the list of stocks initially identified as candidates for less frequent assessment from the first set of criteria (adding stocks to the list or removing them would require a sufficient rationale to be provided).

Anchovy is a short-lived species, living up to four years at most. Therefore, the assessment has to be conducted at least annually and the stock cannot be considered as a candidate for less frequent assessment. The rest criteria were not assessed.

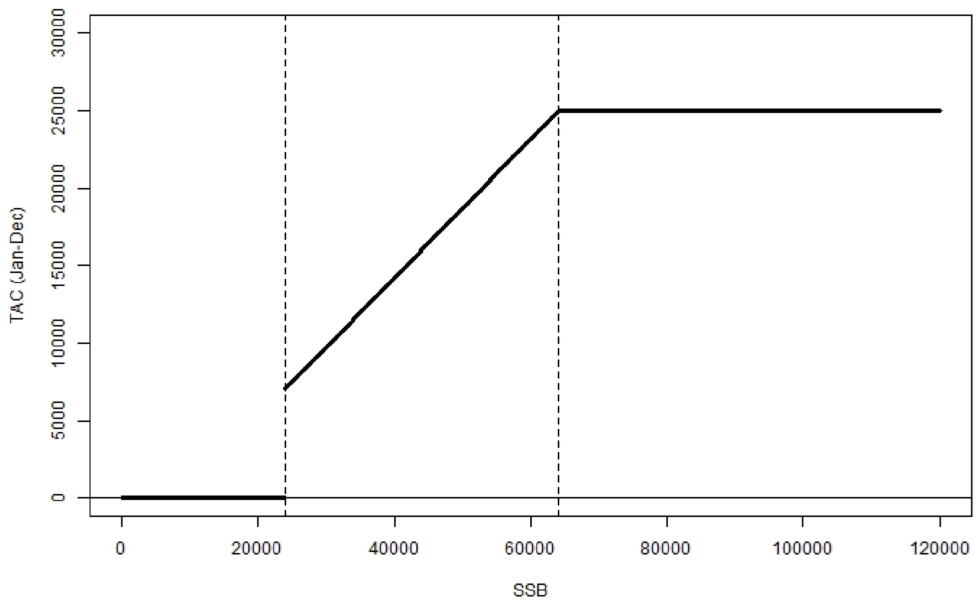


Figure 3.7.3.1. Bay of Biscay anchovy: Harvest control rule G4 with harvest rate of 0.45 according to which the TAC from January to December is set as a function of the expected spawning–stock biomass (on 15th May) in the management year.

4 Anchovy in Division 9.a

4.1 ACOM Advice Applicable to 2015 and 2016

The lack of available data on year classes that constitute the bulk of the biomass and catches (no survey indices for such year classes are available at the time of the formulation of the advice) prevents ICES from giving catch advice in the last years, including 2016. ICES notes, however, that the historical fisheries along the Division seem to have been sustainable.

The 2013 and 2014 annual TACs for this stock were initially agreed in 8778 t (Spanish quota= 4198 t; Portuguese quota= 4580 t). These fishing possibilities by country were those ones corresponding at the beginning of those years. However, fishing quotas swaps between both countries have occurred through the year in the last years. Thus, the Spanish quota in 2014 was finally increased up to 6530 t. Spanish official landings in 2014 were 6921 t, and the officially reported landings for the whole fishery in the Division were 7739 t. ICES catches estimates were 10 332 t. The TAC in 2015 was agreed in 9656 t (5038 t for Portugal and 4618 t for Spain). Again, the Spanish quota was expanded up to 6548 t, with the Spanish fishery officially yielding a total of 6874 t against total official landings in the Division of 9420 t. ICES catches were estimated at 9597 t. The 2016 annual TAC has been agreed in 10 622 t (PT: 5542 t; ES: 5080 t).

Given the high natural mortality experienced by this stock, its high dependence upon recruitment (the fishery depends largely on the incoming year class, the abundance of which cannot be properly estimated before it has entered the fishery), and the large interannual fluctuations observed in the spawning stock, ICES is aware that the state of this resource can change quickly. Therefore an in-year monitoring and management, or alternative management measures should be considered. However, such measures should take into account the data limitation on the stock and the need for a reliable index of recruitment strength.

4.2 The fishery in 2015

4.2.1 Fishing fleets

Anchovy harvesting throughout the Division 9.a was carried out in 2015 by the following fleets:

- Portuguese purse-seine fleet (PS_SPF_0_0_0).
- Portuguese multipurpose fleet (although fishing with artisanal purse-seines) (MIS_MIS_0_0_0_HC).
- Portuguese trawl fleet for demersal fish species (OTB_DEF_>=55_0_0).
- Spanish purse-seine fleet (PS_SPF_0_0_0).
- Spanish multipurpose fleet (artisanal fleets fishing with purse-seine temporally) (MIS_MIS_0_0_0_HC).

Technical characteristics of the Portuguese fleets fishing anchovy in 2015 in Division 9.a are described in the sardine section of this report.

The purse-seine fleet operated by Spain in the Subdivision 9.a North was composed in 2015 by a total of 189 vessels. From this total, 35 vessels captured anchovy in the Subdivision (**Table 4.2.1.1**).

Number and technical characteristics of the purse-seine vessels operated by Spain in their national waters off Gulf of Cadiz (Subdivision 9.a south), differentiated between total operative fleet and fleet targeting anchovy are also summarised in Table 4.2.1.1. In 2015, the Spanish fleet fishing in the Gulf of Cadiz with purse-seine was composed by 106 vessels. Gulf of Cadiz anchovy fishing was practised by the 87 purse-seiners. Details of the dynamics of this fleet in terms of number of operative vessels over time in recent years are given in the Stock Annex and in previous WG reports.

4.2.2 Catches by fleet and area

4.2.2.1 Catches in Division 9.a

Anchovy total catches in 2015 were 9597 t, which represented a 7% decrease in relation to the catches landed in the previous year (10 332 t), but still well above the historical average in the recent series (at about 6000 t; Table 4.2.2.1.1, Figure 4.2.2.1.1).

The contribution by each subdivision to the total catch was characterized in 2015 by a relatively important increase in landings in the Subdivision 9.a Central-North, and the location of the bulk of the fishery, as usual, in the Spanish waters of the Gulf of Cadiz (Subdivision 9.a South).

As usual, the anchovy fishery in 2015 was almost exclusively harvested by purse-seine fleets (99.4% of total catches; Table 4.2.2.1.2). However, unlike the Spanish fleet fishing in the Gulf of Cadiz, the remaining purse-seine fleets in the Division (targeting sardine and fishing anchovy as a commercial bycatch) only target anchovy when its abundance is high, as occurred in 2011 and in 2014–2015.

4.2.2.2 Catches by subdivision

The updated historical series of anchovy catches by subdivision are shown in Table 4.2.2.1.1 (see also Figure 4.2.2.1.1). Table 4.2.2.1.2 shows the contribution of each fleet in the total annual catches by subdivision. The seasonal distribution of 2015 catches by subdivision is shown in Table 4.2.2.2.1.

4.2.2.2.1 Subdivision 9.a North

Anchovy catches in 2015, 173 t, showed a noticeable decrease in relation to the 581 t recorded in 2014. Catches from this Subdivision only accounted for about 2% of total catches in the whole Division 9.a and occurred mainly during the first quarter of the year.

4.2.2.2.2 Subdivision 9.a Central-North

Anchovy catches in 2015 (2533 t) experienced a huge increase in relation to the previous year (678 t), comparable with the catches recorded during the northwestern anchovy outburst in 2011 (3239 t). Catches from this subdivision represented 26% of the total anchovy fishery in the division. The 2015 anchovy fishery in this subdivision was concentrated in the second and third quarters.

4.2.2.2.3 Subdivision 9.a Central-South

Anchovy catches in this subdivision in 2015 were only 10 t (0.1% of total landings in the division). The fishery in this subdivision was mainly concentrated in 2015 in the second quarter.

4.2.2.2.4 Subdivision 9.a South

Catches in 2015 (6880 t; 72% of the whole fishery) experienced a 24% decrease in relation to 2014 (9051 t). As usual, the Spanish waters of the subdivision yielded the bulk of the fishery in these southernmost areas (6877 t). Spanish catches herein presented are the result of the sum of official landings (6701 t), and estimates of discarded (176 t) catches (see Section 4.2.3). In this subdivision the fishery in 2015 mainly developed through the three first quarters in the year, outstanding, as usual, catches in the second and third quarters.

4.2.3 Discards

See the stock annex for previous available information on discards.

General guidelines on appropriate discard sampling strategies and methodologies were established during the ICES Workshop on Discard Sampling Methodology and Raising Procedures (ICES, 2003).

Data on anchovy discarding in the Spanish fisheries operating in the Gulf of Cadiz (Subdivision 9.a South) are being gathered on a quarterly basis since the fourth quarter in 2009 on, within the Spanish National Sampling Scheme framed into the EC Data Collection Regulation (DCR). However, the sampling intensity applied until 2013 to assess the anchovy discarding was very low because it was limited to the agreed minimum sampling scheme (two trips per quarter, eight trips per year). Such a sampling scheme resulted in unreliable and not representative quarterly discard estimates which were also affected by high CVs. This low sample size made their results not conclusive and hence they were not considered. Since 2014 on a more intense sampling scheme was developed which also extends to the Spanish fishery in Subdivision 9.a North.

Quarterly and annual estimates of discarded catches by size class and gear are shown in Tables 4.2.5.1.3 (bottom-trawl discards in 9.a North) and Tables 4.2.5.1.10 and 4.2.5.1.12 (purse-seine and bottom-trawl discards in 9.a South, respectively). The overall annual discard ratio for the Galician fishery in 9.a North has been estimated at 0.001 (i.e. less than 0.1%). In 9.a South, this discard ratio was 0.026 (2.6%). Therefore, discards for the Spanish fishery in 2015 may be considered as negligible.

Regarding the Portuguese anchovy fishery in the division, the official information provided to the WG states that there are no anchovy discards in the fishery.

4.2.4 Effort and landings per unit of effort

Annual standardised lpue series for the whole Spanish purse-seine fleet fishing Gulf of Cadiz anchovy (Subdivision 9.a-South) are routinely provided to this WG. An update of the available series (1988–2015) has been provided this year to this WG. Details of data availability and the standardisation process are commented in the Stock Annex. The recent dynamics of fishing effort and lpue for this fleet has been described in previous WG reports. Fishing effort experienced a relative decrease between 2008 and 2010 which was coupled to a relative stable trend in the lpue (at around 0.7 t/fishing day). A combination of fishing closures, both in the beginning and in the end of the year, bad weather at the start and/or the end of the fishing season, and the displacement of a part of the fleet to the Moroccan fishing grounds (under the EC-Morocco Fishery Agreement) at the same time of the reopening of the Gulf of Cadiz fishery (usually in February), may be the causes of the observed decrease in the fishing effort for the period 2008–2010. From 2011 to 2013 the EC-Morocco Fishery Agreement was not renewed and the whole fleet was again fishing in the Gulf of Cadiz probably causing the increase in the effort observed in 2011. The premature closure of the fishery in 2012 because of the consumption of the national quota may be the responsible for the lower total annual effort levels exerted in the fishery that year. In 2013 and 2014 the effort exhibited a slight increase with values (about 6300 fishing days) above the historical average (about 5500 fishing days) but such a trend was not continued in 2015, when was observed some decrease. Regarding lpue, it was suggested in previous WG reports a probable overestimation of the annual estimates computed so far because of a probable underestimation of the true exerted fishing effort on anchovy, since fishing trips targeting anchovy with zero anchovy catches are not considered in the effort measure. The available historical series of effort and lpue estimates are shown in Table 4.2.4.1 and Figure 4.2.4.1.

4.2.5 Catches by length and catches-at-age by subdivision

Length frequency distribution (LFD) of catches and catch-at-age data from the whole Division 9.a are routinely provided to this WG from the Spanish fishery operating in the Gulf of Cadiz (Subdivision 9.a South), since the anchovy fishery in the division is traditionally concentrated there. Data from the Spanish fishery in Subdivision 9.a North are usually not available since commercial landings used to be almost negligible. The same reason is also valid for the Portuguese subdivisions (included the Portuguese part of the 9.a South (Algarve)), although in this case anchovy is also a group 3 species in its national sampling program for DCF. Nevertheless, the local increases of anchovy abundance in Subdivisions 9.a North and Central North recorded in 2014 and 2015 led to a circumstantial exploitation of the species by the fleets operating in those areas. The respective national sampling programs accounted for this event those years but in an accidental way.

Quarterly LFDs in 2015 has been provided for the Spanish fishery in Subdivisions 9.a North and 9.a South. LFDs from the Portuguese fishery provided to this WG are those ones from the anchovy fishery in Subdivisions 9.a Central-North and Central-South.

Catch-at-age data in 2015 has been provided only for the Spanish fishery in the Subdivision 9.a North and South.

4.2.5.1 Length distributions

4.2.5.1.1 Subdivision 9.a North

Quarterly and annual size composition of anchovy catches by métier and for the whole fishery in the Subdivision 9.a North in 2015 are shown in Tables 4.2.5.1.1 to 4.2.5.1.4. Size range in catches from the whole fishery was comprised between 11.5 and 17.0 cm size classes (mode at 14.0 cm size class), with an annual mean size and weight in catches being estimated at 14.5 cm and 21.0 g, respectively.

4.2.5.1.2 Subdivision 9.a Central-North and 9.a Central-South

The size composition of 2015 anchovy catches from each of these western subdivisions are shown in Tables 4.2.5.1.5 to 4.2.5.1.9. Anchovy size composition in catches from the whole fishery in 9.a Central-North ranged between 10.5 and 18.5 size classes (mode at 14.5 cm size class) and a mean size of 14.6 cm. The scarce anchovy catches from 9.a Central-South measured between 11.5 and 17.5 cm size classes (mode at 15.5 cm size class) and a mean size of 15.1 cm.

4.2.5.1.3 Subdivision 9.a South

No LFDs are available from the Portuguese fishery in this subdivision because of the scarce quantity of anchovy catches.

Quarterly LFDs from the Spanish catches in 2015 are shown in Tables 4.2.5.1.10 to 4.2.5.1.13. Size range of the exploited stock in this fishery was comprised between 6.0 and 20.0 cm size classes, with the modal class at 11.0 cm size class. Anchovy mean length and weight in the Spanish 2015 annual catch (11.5 cm and 10.3 g) were still amongst the highest ever recorded in the historical series, as it is observed since 2008, although they used to be the smallest anchovies in the division.

4.2.5.2 Catch numbers-at-age

4.2.5.2.1 Subdivision 9.a North

Estimates from the fishery in this subdivision in 2015 have been provided to the WG (Table 4.2.5.2.1). These estimates are shown together with the age composition of catches in previous years with available data in Table 4.2.5.2.2 and Figure 4.2.5.2.1.

The estimated total catch in numbers in 2015 was of 8.4 million fish, composed by ages 1, 2 and 3 anchovies, with age 2 olds accounting for 79% of the total catch.

4.2.5.2.2 Subdivision 9.a Central-North

No estimate from this subdivision in 2015 has been provided to this WG.

4.2.5.2.3 Subdivision 9.a Central-South

No estimate from this subdivision in 2015 has been provided to this WG.

4.2.5.2.4 Subdivision 9.a South

Table 4.2.5.2.3 shows the quarterly and annual anchovy catches-at-age in the Spanish fishery in 2015. Total catches in the Spanish fishery in 2015 were estimated at 671 million fish, which accounted a 25% decrease in relation to the 888 million caught the previous year. Such a decrease was mainly caused by a 44% decrease of age 1 anchovies in catches, which was not compensated by the notable increases experienced especially by age 0 fish and in a lesser extent by age 2 anchovies. Age group 3 anchovies were absent in the fishery.

The recent historical series of annual landings-at-age in the Spanish fishery in 9.a South are shown in Table 4.2.5.2.4 and Figure 4.2.5.2.2. Description of annual trends of landings-at-age data from the Spanish fishery through the available dataseries is given in the stock annex and in previous WG reports.

No data are available from the Portuguese fishery in this subdivision.

4.2.6 Mean length and mean weight-at-age in the catch

4.2.6.1.1 Subdivision 9.a North

The available estimates for the fishery in 2015 are shown in Tables 4.2.6.1 and 4.2.6.2. The available series of estimates are shown in Figure 4.2.6.1 and indicate that anchovies by age class from this subdivision are usually larger and heavier than those harvested in the southernmost areas.

4.2.6.1.2 Subdivision 9.a Central-North

No estimate from this subdivision is available.

4.2.6.1.3 Subdivision 9.a Central-South

No estimate from this subdivision is available.

4.2.6.1.4 Subdivision 9.a South

The 2015 estimates of the mean length and weight-at-age of Gulf of Cadiz anchovy landings are shown in Tables 4.2.6.3 and 4.2.6.4. Figure 4.2.6.2 shows the recent history of the evolution of such estimates. Anchovy mean length and weight in the Spanish 2015 annual landings were estimated at 11.5 cm and 10.2 g respectively.

Age 0 and age 1 anchovies have showed a noticeable increasing trend in both estimates in the most recent years, with the 2008–2015 estimates of mean size in landings being between the highest ones in the historical series. Conversely, since 2002 on age 2 anchovies experienced a remarkable decreasing trend in mean size and weight of landed fish, excepting the punctual relative increase observed in 2011 and in the last year. Three year olds were firstly recorded in the sampled landings in 1992. New occurrences of these anchovies have been observed only from 2008 to 2010.

Seasonally, 0 age-group anchovies off the Gulf of Cadiz are larger (and usually also heavier) in the fourth quarter. This general pattern was apparent in 2006–2009 period, but it was not so in 2004 and 2005, when weights in the fourth quarter were rather similar to those estimated in the third quarter. The 1 and 2 year-old anchovies exhibit a clear and persistent pattern through the years, showing the larger mean length and heavier mean weight in the second half in the year, although the reversed pattern was, however, found in 2015 for age 2 olds. Three year olds occurred in a more or less constant way only through 2009. In that year, these eldest anchovies in the fishery showed larger sizes and weights between the second and fourth quarters, mainly in the second quarter.

4.3 Fishery-Independent Information

Table 4.3.1 shows the list of acoustic and DEPM surveys providing direct estimates for anchovy in Division 9.a. **The WG considers each of these survey series as an essential tool for the direct assessment of the population in their respective survey areas (subdivisions) and recommends their continuity in time, mainly in those series that are suffering of interruptions through its recent history**.

4.3.1 DEPM-based SSB estimates

***BOCADEVA* series**

Anchovy DEPM surveys in the division are only conducted by IEO for the SSB estimation of Gulf of Cadiz anchovy (Subdivision 9.a-South, *BOCADEVA* survey series). The methods adopted for both the conduction of these surveys and the estimation of parameters are described in the sStock annex and in ICES (2009 a,b).

The series started in 2005 and their surveys are conducted with a triennial periodicity. Since 2014 this series is financed by DCF. The last BOCADEVA survey was conducted in summer 2014. The next survey will be conducted in 2017. Figure 4.3.1.1 shows the available estimates within this survey series.

4.3.2 Spring/summer acoustic surveys

General

A description of the available acoustic surveys providing estimates for anchovy in Division 9.a is given in the stock annex (see also ICES, 2007 b). Survey's methodologies deployed by the respective national Institutes (IPMA and IEO) are also thoroughly described in ICES (2008 c, 2009 b).

A summary list of the available acoustic and DEPM surveys providing direct estimates for anchovy in Division 9.a is given in Table 4.3.1. Detailed information in the present section will be provided for those surveys carried out during the elapsed time between 2015 and 2016 WGHANSA meetings.

PELACUS series

This Spanish spring acoustic survey series is the only one that samples yearly the waters off the Subdivision 9.a-North and Subarea 8.c since 1984. This series is currently funded by DCF.

PELACUS 0316

PELACUS 0316 was conducted between 13rd March to 16th April 2016 on board the RV Miguel Oliver. Figure 4.3.2.1 shows the distribution and species composition of the 44 valid pelagic hauls carried out during the survey. Nine (9) fishing hauls were carried out in la Subdivision 9.a North. A detailed description of the survey is given by Riveiro and Carrera (WD 2016).

Anchovy in Subdivision 9.a North was recorded inside the rías (Figure 4.3.2.2), yielding very low acoustic estimates of abundance (8 million fish) and biomass (205 t). The estimated population showed two clear modal sizes, the smallest, at 11.0 cm, was mainly located in the southern part, whereas the second one, at 17.5 cm, was mainly found in the northern part. A third mode at 13.5 cm was also observed. Most of the population belonged to age groups 1 and 3, age 3 fish accounting for 53% in number and 77% in weight (Figure 4.3.2.3).

Table 4.3.2.1 and Figure 4.3.2.4 describe the available anchovy acoustic estimates from this survey series for the Subdivision 9.a North.

PELAGO series

The *PELAGO* survey series (spring Portuguese acoustic survey, until 2006 it was called *SAR*) is carried out every year surveying the waters of the Portuguese continental shelf and those of the Spanish Gulf of Cadiz (Subdivisions 9.a Central-North, Central-South, and South), between 20 and 200 m depth. This survey series is currently financed by DCF.

The 2012 WGHANSA concluded that the *PELAGO 11* anchovy null estimate in 9.a South resulted in a strong underestimation of the actual biomass levels in the region (as inferred by CUFES data during that survey and from the *BOCADEVA 0711* DEPM survey estimates). For this reason the estimates of *PELAGO 11* for anchovy in this area were disregarded for further analyses. There were no *PELAGO* survey in 2012 due to the RV Noruega was not operative for the survey season.

PELAGO 16

The *PELAGO 16* survey was conducted this year between 11th March and 1st May on board RV Noruega. Details of the survey are given by Marques *et al*. (WD 2016).

During this survey were performed 52 fishing hauls, with 19 of them being positive for anchovy (Figure 4.3.2.5).

In the Subdivision 9.a Central-North anchovy was found between Porto and Nazaré, being more abundant than in previous years (Figure 4.3.2.6). An estimation of 3198 million anchovies was obtained, corresponding to a biomass of 38 302 t (Table 4.3.2.2, Figure 4.3.2.7). Such estimates are the highest ever recorded in the historical series for this subdivision. The population in these waters showed a unimodal size composition (modal size class at 12.5–13.0 cm size classes) and dominated by age 1 and age 2 anchovies.

Anchovy was not found neither in the Subdivision 9.a Central-South nor in the Portuguese waters of the Subdivision 9.a South (Algarve).

In the Spanish waters of the Subdivision 9.a South, anchovy was mainly distributed from Huelva to Cadiz, usually inside a dense plankton layer. In this area, the biomass and abundance estimated (65 345 t and 9811 million anchovies, respectively) also were the highest ones of the whole series. However, these values should be later corroborated by the IEO's *ECOCADIZ* survey, because the anchovy acoustic energy in this area was masked by the referred dense plankton layer. The estimated population estimated in these southern waters showed a bimodal size composition, with modes at 9.0 and 11.5 cm size classes and dominated by age 1 anchovies (Table 4.3.2.2, Figure 4.3.2.7).

The acoustic estimates from the whole surveyed area were of 103 647 t and 13 009 millions, which accounted for 151% increase in relation to the previous year's estimates and were the highest estimates in the historical series (Table 4.3.2.2; Figure 4.3.2.8).

Table 4.3.2.2 and Figure 4.3.2.8 track the historical series of anchovy acoustic estimates from *PELAGO* surveys in the Division 9.a. Population levels in the Subdivision 9.a South have experienced a remarkable increase which place them well above the historical average levels. In relative terms, anchovy has also experienced an important increase in 9.a Central-North, with a current population level even higher than the previous historical peak recorded in the 2011 outburst. Conversely, anchovy in 9.a Central-South is still maintaining around the usually low or even null levels recorded in the last years.

Size composition and age structure of the population estimate in 9.a South through the series was described in previous reports. In Figure 4.3.2.9 we revisit the trends observed in the age structure of the population as estimated by the *PELAGO* and *ECOCADIZ* survey series. For *PELAGO* surveys the 2014 age-structured estimates were not available and those ones from 2013, although included in the figure, are pending of validation. As described in previous reports, Portuguese acoustic estimates for anchovy until 2013 were not provided age-structured to the WG. As an alternative, this age structure was estimated by applying the Spanish Gulf of Cadiz commercial age–length keys for the second quarter in the year. It should also be taken into consideration that such keys are based on commercial samples from purse-seine catches and therefore they may result in a biased picture of the population structure because of a different catchability.

Regarding the last years in the series, the size composition of the estimated population in 2010 it was characterised by a very low number of both small and larger anchovies than in 2009, with larger anchovies than 14 cm being absent, suggesting probably a weak population structure sustaining a very low biomass level in 2010. This perception is corroborated by the age structure as estimated by the Portuguese survey, which evidences a strong decrease in 1 year old anchovies in the population, but especially in 2 year old fish.

The population age structure in previous years suggests strong 2000, (exceptionally) 2001, and 2006 year classes, with the last one still being present in 2009 (as age 3 anchovies). The strength of the 2007, 2008 and 2009 year classes decreased in relation to that observed for the 2006 year class: population numbers of age 1 anchovies in 2008, 2009 and 2010 showed 49.7%, 43.3% and 68.9% decreases in relation those ones estimated in 2007. Notwithstanding the above, the extreme situation that the population reached in spring 2011, when no anchovy was detected in the *PELAGO* acoustic survey, seems uncertain because the observation of high egg densities during the survey is not consistent with the null detection of biomass with acoustics and with the estimates provided by the *BOCADEVA* DEPM survey (32.7 kt) some months later. Reasons that led to the WG to consider the 2011 acoustic estimate with caution have been commented above. The population age structure in 2013 resembles in a great extent to the one described for 2010 whereas in the last two–three years anchovy population seems to show again clear signs of recovery.

ECOCADIZ series

The *ECOCADIZ* survey series acoustically samples the shelf waters (20–200 m depth) off the Subdivision 9.a-South during mid-summer (currently between late July and early August).

No *ECOCADIZ* survey was conducted neither in 2011 (ship time invested in the *BOCADEVA 0711* DEPM survey) nor 2012 (no ship time available). The series continued in 2013. The more recent survey from this series was conducted in July 2015 (*ECOCADIZ 2015-07*), one month after the last year's WG meeting. This survey series is financed by DCF since 2014.

ECOCADIZ 2015–07

The *ECOCADIZ 2015-07* survey was carried out between 28th July and 10th August 2015 on board the Spanish RV Miguel Oliver. The survey design consisted in a systematic parallel grid with 21 transects equally spaced by 8 nm, normal to the shoreline. A total of 19 valid fishing hauls (between 38–172 m depth) for echo-trace ground-truthing purposes were carried out (Figure 4.3.2.8). CUFES sampling (117 stations) was carried during the survey in order to describe the extension of the anchovy spawning area. A census of top predator species was also carried out along the sampled acoustic transects. A total of 157 CTD (with coupled altimeter, oximeter, fluorimeter and transmissometer sensors) -LADCP casts, and subareasuperficial thermosalinograph-fluorimeter and VMADCP continuous sampling were carried out to oceanographically characterize the surveyed area. A detailed description of the ECOCADIZ 2014-07 survey methods and results are given in Ramos *et al.* (WD 2016a).

During the survey anchovy was absent in the easternmost waters of the Gulf. The bulk of the anchovy population was mainly distributed all over the shelf between the Guadiana river mouth and Bay of Cadiz, especially over the outer shelf waters of the central part of the Gulf, between the Guadiana river mouth and Matalascañas. A secondary nucleus of anchovy density was recorded in the western Portuguese Algarve, between

Cape San Vicente and Albufeira, with the species being quite scarce in the surroundings of the Cape of Santa Maria (Figure 4.3.2.8).

The size class range of the assessed population was comprised between the 6.5 and 17 cm size classes, with two modal classes at 8.0 and 10.5 cm (Figure 4.3.2.9). The size composition of anchovy by coherent post-strata confirmed the usual pattern exhibited by the species in the area during the spawning season, with the largest fish being distributed in the westernmost waters and the smallest ones concentrated in the surroundings of the Guadalquivir river mouth and adjacent shallow waters, including those ones in front of the Bay of Cadiz. In summer 2015 small anchovies were also recorded in the coastal area close to the Guadiana river mouth. As it has been happening in the last years, during the 2015 survey some recruitment has also been recorded, probably as a consequence of the delayed survey dates. However, this fact seems to have been much more evident last summer than in previous years because the markedly low mean length and weight estimated for the whole estimated population (106 mm; 8.0 g), the lowest record for both variables in the whole series. In fact, age 0 anchovies accounted for as much as 60% (1607 million fish) and 43% (9254 t) of the total estimated population abundance and biomass, respectively (Figure 4.3.2.10).

Precisely, these overall acoustic estimates in summer 2015 were of 2674 million fish and 21 305 tonnes. By geographical strata, the Spanish waters yielded 93.7% (2506 million) and 90% (19 168 t) of the total estimated population, confirming the importance of these waters in the species' distribution. The estimates for the Portuguese waters were 168 million and 2137 t.

The total biomass estimated for Gulf of Cadiz anchovy in summer 2015 was slightly below the historical average, but it is still in the range of population levels featuring to a recovered population (Figure 4.3.2.11). The comparison of these estimates with their spring counterparts from the PELAGO survey evidences almost identical values for the Portuguese waters, whereas the *ECOCADIZ* survey estimated in summer at about 1000 million and 11 800 t less anchovy in the Spanish waters (Tables 4.3.2.2 and 4.3.2.3; Figures 4.3.2.6 and 4.3.2.11). Such differences might be attributable to a possible overestimation of the acoustic energy attributed to anchovy in the Spanish waters of the Gulf by the PELAGO survey because of the difficulties in the discrimination of anchovy echoes in this area from a dense plankton layer where the species was embedded.

4.3.3 Recruitment surveys

SAR/JUVESAR autumn survey series

The last survey in the *SAR* series (aimed to cover the sardine early spawning and recruitment season in the Division 9.a, but also covering the anchovy recruitment season) which provided anchovy estimates was carried out in 2007 (see Table 4.3.1). Table 4.3.3.1 shows the historical series of anchovy acoustic estimates derived from this survey series in the Division 9.a available so far. In 2013 and 2014 were carried out the *JUVESAR* autumn surveys, acoustic surveys restricted to the Subdivision 9.a Central-North, the main sardine recruitment area for sardine in Portuguese waters. However, the scarce presence and abundance of anchovy in both surveys prevented from providing any acoustic estimate for the species. A new autumn survey, *JUVESAR 15*, was conducted last year but did neither provide any acoustic estimate for anchovy although the species was acoustically detected and fished (see below). The series of point estimates is at present scattered and scarce for these autumn survey series and they are not directly used in the qualitative trend-based assessment (but see Figure 4.3.3.6 for estimates in 9.a South).

JUVESAR 15

JUVESAR 15 was conducted by IPMA between 5th and 13st December 2015 in the Portuguese shelf waters of the Subdivision 9.a Central-North, between Viana do Castelo and Cape Espichel (30 parallel transects normal to the shoreline, between 12–60 m isobaths) on board the RV Noruega. The survey's main objective is the acoustic assessment of sardine recruitment in its main recruitment area of the Iberian Peninsula Atlantic façade. A total of 13 valid fishing hauls were carried out for echo-trace groundtruthing (Figure 4.3.3.1). Anchovy, mainly juveniles, was distributed from Viana do Castelo to Nazaré, with the species being always present in the fishing hauls, and showing the highest densities in the northernmost waters, between Viana do Castelo and Porto (Figure 4.3.3.2). In the Aveiro area anchovy was m9.ed with sardine juveniles. As commented above anchovy acoustic estimates are not yet available and therefore they have not been provided to the WG.

ECOCADIZ-RECLUTAS survey series

This series started in autumn 2009 as 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. However, the succession of a series of unforeseen problems during that survey drastically reduced the foreseen sampling area to the easternmost zone only. 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 survey was financed by the Spanish Fisheries Secretariat and planned and conducted by the IEO but only the Spanish waters of the Gulf of Cadiz were surveyed (Table 4.3.3.2). The most recent surveys have been conducted in October 2014 (reported in the last year's WG) and 2015. This survey series is financed by DCF since 2014.

ECOCADIZ-RECLUTAS 2015-10

ECOCADIZ-RECLUTAS 2015-10 was conducted by IEO between 10th and 29th October 2015 in the Portuguese and Spanish shelf waters (20–200 m isobaths) off the Gulf of Cadiz on board the RV Ramón Margalef. 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 is the second one within its series with a complete sampling coverage of the Subdivision 9.a South. Results from this survey have been reported to this WG by Ramos *et al*. (WD 2016b).

Anchovy avoid in autumn 2005, as it also did in summer, the easternmost waters of the Gulf, and showed a spatial pattern of distribution of the acoustic density very similar to the one described in summer, with the bulk of the population being mainly concentrated in an area comprising the shelf waters between the Guadiana river mouth and Bay of Cadiz. Anchovy acoustic densities in the westernmost waters were not relevant (Figure 4.3.3.3).

The size range recorded for the estimated population was comprised between 8 and 17.5 cm size classes, with a marked mode at 9 cm size class and a very residual secondary mode at 15 cm. A similar size composition is also recorded for the estimated biomass, although the main mode is located at 9.5 cm size class (Figure 4.3.3.4). The mean size and weight of the estimated population were 100 mm and 5.9 g respectively. The anchovy size composition by coherent post-strata in the autumn 2015 survey evidences that juveniles were mainly distributed in the coastal waters between the Guadiana river mouth and Bay of Cadiz, although this autumn the recruitment area showed a greater extension, even reaching the coastal waters of the eastern Algarve, as it was previously evidenced in the summer survey (Figure 4.3.3.4).

Gulf of Cadiz anchovy abundance and biomass in autumn 2015 were of 5227 million fish and 30 827 t, the highest values within its short series. Spanish waters concentrated 98% (5113 million) and 96% (29 491 t) of the total estimated abundance and biomass respectively. Portuguese waters yielded estimates which amounted to 115 million and 1335 t only (Table 4.3.3.2).

Although 0, 1 and 2 years old fish were recorded, the bulk of the population was composed by age 0 fish (recruits; Table 4.3.3.2; Figure 4.3.3.5), with a mean size and weight for the whole sampled area of 9.98 cm and 5.71 g respectively. The abundance and biomass of age 0 anchovies in the surveyed area were estimated at 29 219 t and 5117 million fish, respectively, i.e. 95% and 98% of the total estimated anchovy biomass and abundance. Spanish waters concentrated 99% of the juveniles in the Gulf, both in terms of number (5042 million) and biomass (28 789 t).

Given the shortness of the series it would be too much risky to advance that this 'historic' maximum might correspond to a good recruitment scenario. Notwithstanding the above, these estimates induce to optimistically perceive the present situation when they are compared with the estimates from previous years, at least when compared with the 2014 autumn estimate (Figure 4.3.3.7).

4.4 Biological data

4.4.1 Weight-at-age in the stock

Weights-at-age in the stock are shown in Table 4.4.1.1. See the Stock Annex for comments on computation and trends.

4.4.2 Maturity-at-age

Annual maturity ogives for Gulf of Cadiz anchovy are shown in Table 4.4.2.1. See the stock annex for comments on computation and trends in the maturity ogives of Gulf of Cádiz anchovy.

Maturity stage assignment criteria were agreed between national institutes involved in the biological study of the species during the Workshop on Small Pelagics (*Sardina pilchardus*, *Engraulis encrasicolus*) maturity stages (WKSPMAT; ICES, 2008 a).

4.4.3 Natural mortality

Natural mortality is unknown for this stock. By analogy with anchovy in Subarea 8, natural mortality is probably high (a half-year M=0.6 has been used in previous years for the data exploration, see stock annex).

Table 4.2.1.1. Anchovy in Division 9.a. Composition of the Spanish fleets operating in Southern Galician waters (Subdivision 9.a North) and in the Gulf of Cadiz (Subdivision 9.a-South) in 2015. Fleets are differentiated into vessels targeting anchovy and total fleet. The categories include both single purpose purse-seiners and trawl and artisanal vessels fishing with purse-seine in some periods through the year (multi-purpose vessels). Storage: catches are dry hold with ice (one fishing trip equals to one fishing day). Similar tables for yearly data since 1999 are shown for the Gulf of Cadiz Spanish fleet in the stock annex and previous WG reports.

Subdivision 9.a North

2015	Vessels targeting anchovy						2015	Total fleet					
	Engine (HP)							Engine (HP)					
Length (m)	0-50	51-100	101-200	201-500	>500	Total	Length (m)	0-50	51-100	101-200	201-500	>500	Total
≤10	6					6	≤10	36	3				39
11-15		7	5			12	11-15	17	28	22			67
16-20			3	4		7	16-20	1	1	16	19		37
>20			2	8		10	>20			5	39	2	46
Total	6	7	10	12		35	Total	54	32	43	58	2	189

Subdivision 9.a South (Spanish waters)

2015	Vessels targeting anchovy						2015	Total fleet					
	Engine (HP)							Engine (HP)					
Length (m)	0-50	51-100	101-200	201-500	>500	Total	Length (m)	0-50	51-100	101-200	201-500	>500	Total
≤10	1					1	≤10		1				1
11-15	3	12	8	1		24	11-15	2	13	7	1		23
16-20		5	31	11		47	16-20		5	37	17		59
>20			2	12	1	15	>20			6	16	1	23
Total	4	17	41	24	1	87	Total	2	19	50	34	1	106

Table 4.2.2.1.1. Anchovy in Division 9.a. Recent historical series of annual catches by Subdivision and total (t) since 1989 on (the period with available data for all the Subdivisions). Catches in Subdivision 9.a South are also differentiated between Portuguese (PT) and Spanish (ES) waters. (-) not available data; (0) less than 1 tonne (from Pestana, 1989 and 1996, and WGMHSA, WGANC, WGANSA and WGHANSA members). The rest of the historical series of catches is given in the stock annex. Discards are considered negligible in both the Portuguese (9.a C-N to 9.a S (PT)) and Spanish (9.a N, 9.a S (ES)) fisheries. Even so, since 2014 on estimates for the Spanish fishery include discarded (and unallocated) catches estimates.

Year	9.a N	9.a C-N	9.a C-S	9.a S (PT)	9.a S (ES)	9.a S (Total)	Total Division
1989	118	389	85	22	5330	5352	5944
1990	220	424	93	24	5726	5750	6487
1991	15	187	3	20	5697	5717	5922
1992	33	92	46	0	2995	2995	3166
1993	1	20	3	0	1960	1960	1984
1994	117	231	5	0	3035	3035	3388
1995	5329	6724	332	0	571	571	12956
1996	44	2707	13	51	1780	1831	4595
1997	63	610	8	13	4600	4613	5295
1998	371	894	153	566	8977	9543	10962
1999	413	957	96	355	5587	5942	7409
2000	10	71	61	178	2182	2360	2502
2001	27	397	19	439	8216	8655	9098
2002	21	433	90	393	7870	8262	8806
2003	23	211	67	200	4768	4968	5269
2004	4	83	139	434	5183	5617	5844
2005	4	82	6	38	4385	4423	4515
2006	15	79	15	14	4368	4381	4491
2007	4	833	7	34	5576	5610	6454
2008	5	211	87	37	3168	3204	3508
2009	19	35	5	32	2922	2954	3013
2010	179	100	2	28	2901	2929	3210
2011	541	3239	1	78	6216	6294	10076
2012	39	521	220	56	4754	4810	5589
2013	69	192	131	67	5172	5240	5632
2014	581	678	21	118	8933	9051	10332
2015	173	2533	10	2	6878	6880	9597

Table 4.2.2.1.2. Anchovy in Division 9.a. Catches (t) by gear and Subdivision in 1989–2015. Discards are considered negligible in both the Portuguese (9.a C-N to 9.a S (PT)) and Spanish (9.a N, 9.a S (ES)) fisheries. Even so, since 2014 on estimates for the Spanish fishery include discarded catches estimates by gear. Landings by gear in Subdivisions 9.a C-N to S (PT) are not available by Subdivision until 2009.

Subarea	Gear	1989	1990	1991	1992	1993	1994	1995*	1996	1997	1998	1999	2000
9.a N	Artisanal	0	0	0	0	0	0	0	0	0	0	0	0
	Purse-seine	118	220	15	33	1	117	5329	44	63	371	413	10
9.a C-N to 9.a S (PT)	Demersal Trawl	-	-	-	4	9	1	-	56	46	37	43	6
	P.-seine polyvalent	-	-	-	1	1	3	-	94	7	35	20	7
	Purse-seine	-	-	-	270	14	233	-	2621	579	1541	1346	297
	Not different. By gear	496	541	210	-	-	-	7056	-	-	-	-	-
9.a S (ES)	Demersal Trawl	0	0	0	0	330	152	75	224	190	1148	993	104
	Purse-seine	5336	5911	5696	2995	1630	2884	496	1556	4410	7830	4594	2078

Subarea	Gear	2001	2002	2003	2004	2005	2006	2007	2008	2009
9.a N	Artisanal	0	0	4	1	0	0	0	1	0,1
	Purse-seine	27	21	19	2	4	15	4	4	18
9.a C-N to 9.a S (PT)	Demersal Trawl	16	13	7	5	7	27	14	9	4
	P. seine polyvalent	32	13	184	197	57	24	376	141	38
	Purse-seine	806	888	287	455	62	57	484	185	30
	Not different. By gear	-	-	-	-	-	-	-	-	-
9.a S (ES)	Demersal Trawl	36	23	14	6	0,2	0,4	0,3	0,1	0,02
	Purse-seine	8180	7847	4754	5177	4385	4367	5575	3168	2922

Subarea	Gear	2010	2011	2012	2013	2014	2015
9.a N	Demersal trawl	-	-	-	-	-	0,2
	Artisanal	4	0	1	6	0	21
	Purse-seine	175	541	37	63	581	152
9.a C-N	Demersal Trawl	5	4	1	0.5	2	3
	P. seine polyvalent	45	1116	177	17	9	150
	Purse-seine	50	2119	342	175	668	2381
9.a C-S	Demersal Trawl	1	0,9	0.4	0.6	3	2
	P. seine polyvalent	0	0,1	17	4	1	0,4
	Purse-seine	0,7	0,4	202	127	18	8
9.a S (PT)	Demersal Trawl	8	13	16	2	5	1
	P. seine polyvalent	4	33	0.1	2	0.04	0,02
	Purse-seine	17	33	41	63	113	1
9.a S (ES)	Demersal Trawl	0	0	2	-	99	33
	Artisanal	-	-	-	-	-	0,1
	Purse-seine	2901	6216	4752	5172	8835	6845

Table 4.2.2.2.1. Anchovy in Division 9.a. Quarterly anchovy catches (t) by subdivision in 2015.

	QUARTER 1		QUARTER 2		QUARTER 3		QUARTER 4		ANNUAL (2015)	
SUBDIVISION	C(t)	%	C(t)	%	C(t)	%	C(t)	%	C (t)	%
9.a North	150	86,8	13	7,7	9	5,3	0,4	0,3	173	1,8
9.a Central North	322	12,7	860	33,9	1209	47,7	143	5,6	2533	26,4
9.a Central South	0,4	3,9	8	75,3	1	8,4	1	12,4	10	0,1
9.a South (PT)	0,001	0,1	0,3	13,8	2	75,4	0,3	10,7	2	0,02
9.a South (ES)	1467	21,3	2386	34,7	1850	26,9	1174	17,1	6878	71,7
9.a South	1467	21,3	2386	34,7	1852	26,9	1174	17,1	6880	71,7
TOTAL	1940	20,2	3267	34,0	3071	32,0	1319	13,7	9597	100,0

Table 4.2.4.1. Anchovy in Division 9.a. Subdivision 9.a South. Standardised effort (no. of standardised fishing trips fishing anchovy) and anchovy lpue (t/fishing trip) data for the Spanish purse-seine fleet operating in the Gulf of Cadiz (1988–2015). Increasing colour intensities denote increasing problems in sampling coverage of fishing effort.

Year	Landings	Effort	LPUE
1988	4263	4525	0,937
1989	5330	5681	0,928
1990	5726	6208	0,913
1991	5697	7670	0,734
1992	2995	5584	0,541
1993	1629	2981	0,480
1994	2883	3607	0,714
1995	495	1756	0,151
1996	1556	5571	0,224
1997	4376	4347	0,927
1998	7824	4963	1,472
1999	4594	5998	0,765
2000	2078	5968	0,348
2001	8180	6691	1,223
2002	7847	7526	1,043
2003	4754	6371	0,746
2004	5177	7102	0,728
2005	4386	5536	0,792
2006	4367	7089	0,616
2007	5575	6837	0,815
2008	3168	4556	0,695
2009	2922	4629	0,631
2010	2901	4343	0,668
2011	6196	6180	1,003
2012	4754	4656	1,021
2013	5172	6224	0,831
2014	6340	6363	0,996
2015	6701	5038	1,330

Table 4.2.5.1.1. Anchovy in Division 9.a. Subdivision 9.a North. Spanish purse-seine fishery (métier PS_SPF_0_0_0). Seasonal and annual length distributions ('000) of anchovy catches in 2015. Length–frequency distribution from Q2 was not available but it has been estimated by raising Q2 catches to the LFD from Q1. Discards are considered as negligible, hence landings correspond to catches.

2015	Q1	Q2	Q3	Q4	TOTAL
Length (cm)	9.a N	9.a N	9.a N	9.a N	9.a N
6	0	0	0	0	0
6.5	0	0	0	0	0
7	0	0	0	0	0
7.5	0	0	0	0	0
8	0	0	0	0	0
8.5	0	0	0	0	0
9	0	0	0	0	0
9.5	0	0	0	0	0
10	0	0	0	0	0
10.5	0	0	0	0	0
11	0	0	0	0	0
11.5	0	0	0,02	0	0,02
12	141	2	0,1	0	143
12.5	283	3	0,2	0	286
13	565	7	0,5	0	572
13.5	1130	14	0,5	0	1144
14	1413	17	0,8	0	1430
14.5	1130	14	0,8	0	1144
15	706	8	0,6	0	715
15.5	424	5	0,4	0	429
16	565	7	0,2	0	572
16.5	424	5	0,1	0	429
17	141	2	0,04	0	143
17.5	0	0	0	0	0
18	0	0	0	0	0
18.5	0	0	0	0	0
19	0	0	0	0	0
19.5	0	0	0	0	0
20	0	0	0	0	0
20.5	0	0	0	0	0
Total N	6922	83	4	0	7009
Catch (T)	150	2	0,1	0	152
L avg (cm)	14,6	13,3	14,5	-	14,6
W avg (g)	21,7	15,8	21,8	-	21,6

Table 4.2.5.1.2. Anchovy in Division 9.a. Subdivision 9.a North. Spanish artisanal fishery (métier MIS_MIS_0_0_0_HC). Seasonal and annual length distributions ('000) of anchovy catches in 2015. Length–frequency distributions are not available. They have been estimated by raising catches from this métier to the respective quarterly LFDs from the métier PS_SPF_0_0_0. LFD from Q4 has been estimated by raising Q4 catches to the purse-seine LFD from Q3. Discards are considered as negligible, hence landings correspond to catches.

2015	Q1	Q2	Q3	Q4	TOTAL
Length (cm)	9.a N	9.a N	9.a N	9.a N	9.a N
6	0	0	0	0	0
6.5	0	0	0	0	0
7	0	0	0	0	0
7.5	0	0	0	0	0
8	0	0	0	0	0
8.5	0	0	0	0	0
9	0	0	0	0	0
9.5	0	0	0	0	0
10	0	0	0	0	0
10.5	0	0	0	0	0
11	0	0	0	0	0
11.5	0	0	2	0,1	2
12	0,03	11	9	0,4	20
12.5	0,1	22	18	1	41
13	0,1	43	45	2	91
13.5	0,3	86	52	3	141
14	0,3	108	75	4	187
14.5	0,3	86	76	4	166
15	0,2	54	57	3	114
15.5	0,1	32	40	2	75
16	0,1	43	19	1	63
16.5	0,1	32	13	1	46
17	0,03	11	4	0,2	15
17.5	0	0	0	0	0
18	0	0	0	0	0
18.5	0	0	0	0	0
19	0	0	0	0	0
19.5	0	0	0	0	0
20	0	0	0	0	0
20.5	0	0	0	0	0
Total N	2	528	412	20	962
Catch (T)	0,03	11	9	0,4	21
L avg (cm)	14,6	13,3	14,5	14,5	13,7
W avg (g)	21,7	15,8	21,8	21,8	17,7

Table 4.2.5.1.3. Anchovy in Division 9.a. Subdivision 9.a North. Spanish bottom-trawl fishery (métier OTB_DEF_>=55_0_0). Seasonal and annual length distributions ('000) of anchovy discards in 2015.

2015	Q1	Q2	Q3	Q4	TOTAL
Length (cm)	9.a N	9.a N	9.a N	9.a N	9.a N
6	0	0	0	0	0
6.5	0	0	0	0	0
7	0	0	0	0	0
7.5	0	0	0	0	0
8	0	0	0	0	0
8.5	0	0	0	0	0
9	0	0	0	0	0
9.5	0	0	0	0	0
10	0	0	0	0	0
10.5	0	0	0	0	0
11	0	0	0	0	0
11.5	0	0	0	0	0
12	0	0	0	0	0
12.5	0	0	0	0	0
13	0	0	1	0	1
13.5	0	0	0	0	0
14	0	0	1	0	1
14.5	0	0	0	0	0
15	0	0	4	0	4
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
19	0	0	0	0	0
19.5	0	0	0	0	0
20	0	0	0	0	0
20.5	0	0	0	0	0
Total N	0	0	7	0	7
Catch (T)	0	0	0.2	0	0.2
L avg (cm)	-	-	14,7	-	14,7
W avg (g)	-	-	22,3	-	22,3

Table 4.2.5.1.4. Anchovy in Division 9.a. Subdivision 9.a North. Spanish fishery (all fleets). Seasonal and annual length distributions ('000) of anchovy catches in 2015.

2015	Q1	Q2	Q3	Q4	TOTAL
Length (cm)	9.a N	9.a N	9.a N	9.a N	9.a N
6	0	0	0	0	0
6.5	0	0	0	0	0
7	0	0	0	0	0
7.5	0	0	0	0	0
8	0	0	0	0	0
8.5	0	0	0	0	0
9	0	0	0	0	0
9.5	0	0	0	0	0
10	0	0	0	0	0
10.5	0	0	0	0	0
11	0	0	0	0	0
11.5	0	0	2	0,1	2
12	141	12	9	0,4	163
12.5	283	25	19	1	327
13	565	50	47	2	664
13.5	1130	100	53	3	1286
14	1413	125	77	4	1619
14.5	1130	100	76	4	1310
15	706	62	62	3	834
15.5	424	37	41	2	504
16	565	50	19	1	635
16.5	424	37	13	1	475
17	141	12	4	0,2	158
17.5	0	0	0	0	0
18	0	0	0	0	0
18.5	0	0	0	0	0
19	0	0	0	0	0
19.5	0	0	0	0	0
20	0	0	0	0	0
20.5	0	0	0	0	0
Total N	6923	611	423	20	7978
Catch (T)	150	13	9	0,4	173
L avg (cm)	14,6	13,3	14,5	14,5	14,5
W avg (g)	21,7	15,8	21,8	21,8	21,0

Table 4.2.5.1.5. Anchovy in Division 9.a. Subdivision 9.a Central-North. Portuguese purse-seine fishery (métier PS_SPF_0_0_0). Seasonal and annual length distributions ('000) of anchovy landings in 2015. Discards are considered as negligible, hence landings correspond to catches.

2015	Q1	Q2	Q3	Q4	TOTAL
Length (cm)	9.a CN	9.a CN	9.a CN	9.a CN	9.a CN
6	0	0	0	0	0
6.5	0	0	0	0	0
7	0	0	0	0	0
7.5	0	0	0	0	0
8	0	0	0	0	0
8.5	0	0	0	0	0
9	0	0	0	0	0
9.5	0	0	0	0	0
10	0	0	0	0	0
10.5	37	0	0	0	37
11	336	0	0	0	336
11.5	1007	610	0	0	1853
12	2312	610	0	0	3196
12.5	2387	1098	0	0	3936
13	3990	3415	94	0	8723
13.5	2573	2195	941	471	7216
14	3356	4879	4327	471	14828
14.5	2536	488	6867	1037	12315
15	2126	6708	10160	754	21111
15.5	1231	732	9690	754	13212
16	1081	7196	7056	660	16695
16.5	559	244	3575	283	5018
17	559	3537	2540	377	7383
17.5	373	122	941	377	2027
18	186	732	376	0	1416
18.5	37	0	0	0	37
19	0	0	0	0	0
19.5	0	0	0	0	0
20	0	0	0	0	0
Total N	24686	32564	46567	5184	122718
Catch (T)	319	732	1190	139	2381
L avg (cm)	14.1	15.1	15.6	15.5	14.7
W avg (g)	n.a.	n.a.	n.a.	n.a.	n.a.

Table 4.2.5.1.6. Anchovy in Division 9.a. Subdivision 9.a Central-North. Portuguese bottom-trawl fishery (métier OTB_DEF_>=55_0_0). Seasonal and annual length distributions ('000) of anchovy landings in 2015. Discards are considered as negligible, hence landings correspond to catches. LFDs of Q1, Q3 and Q4 (not provided to the WG) have been estimated by rising catches to the respective LFDs from the purse-seine fishery in the Subdivision 9.a Central North.

2015	Q1	Q2	Q3	Q4	TOTAL
Length (cm)	9.a CN	9.a CN	9.a CN	9.a CN	9.a CN
6	0	0	0	0	0
6.5	0	0	0	0	0
7	0	0	0	0	0
7.5	0	0	0	0	0
8	0	0	0	0	0
8.5	0	0	0	0	0
9	0	0	0	0	0
9.5	0	0	0	0	0
10	0	0	0	0	0
10.5	0	0	0	0	0
11	1	0	0	0	1
11.5	2	0	0	0	2
12	6	0	0	0	6
12.5	6	0	0	0	6
13	10	0	0	0	10
13.5	6	0	0	1	8
14	8	0	2	1	12
14.5	6	1	3	3	13
15	5	5	4	2	17
15.5	3	7	4	2	15
16	3	6	3	2	13
16.5	1	4	1	1	7
17	1	5	1	1	8
17.5	1	2	0	1	4
18	0	1	0	0	1
18.5	0	0	0	0	0
19	0	0	0	0	0
19.5	0	0	0	0	0
20	0	0	0	0	0
Total N	61	31	18	13	123
Catch (T)	0.8	0.9	0.5	0.3	3
L avg (cm)	14.1	16.2	15.6	15.5	15.0
W avg (g)	n.a.	n.a.	n.a.	n.a.	n.a.

Table 4.2.5.1.7. Anchovy in Division 9.a. Subdivisions 9.a Central-North. Portuguese polyvalent fishery (métier MIS_MIS_0_0_0_HC). Seasonal and annual length distributions ('000) of anchovy landings in 2015. Discards are considered as negligible, hence landings correspond to catches. LFDs of Q1, Q3 and Q4 (not provided to the WG) have been estimated by rising catches to the respective LFDs from the purse-seine fishery in the Subdivision 9.a Central North

2015	Q1	Q2	Q3	Q4	TOTAL
Length (cm)	9.a CN	9.a CN	9.a CN	9.a CN	9.a CN
6	0	0	0	0	0
6.5	0	0	0	0	0
7	0	0	0	0	0
7.5	0	0	0	0	0
8	0	0	0	0	0
8.5	0	0	0	0	0
9	0	0	0	0	0
9.5	0	0	0	0	0
10	0	0	0	0	0
10.5	0	0	0	0	0
11	2	0	0	0	2
11.5	7	127	0	0	134
12	16	1141	0	0	1157
12.5	16	1902	0	0	1919
13	28	1775	1	0	1804
13.5	18	1775	15	10	1817
14	23	888	67	10	987
14.5	18	380	106	21	525
15	15	127	157	16	314
15.5	9	380	150	16	554
16	7	0	109	14	130
16.5	4	0	55	6	65
17	4	0	39	8	51
17.5	3	0	15	8	25
18	1	0	6	0	7
18.5	0	0	0	0	0
19	0	0	0	0	0
19.5	0	0	0	0	0
20	0	0	0	0	0
Total N	171	8497	719	107	9494
Catch (T)	2	127	18	3	150
L avg (cm)	14.1	13.4	15.6	15.5	13.6
W avg (g)	n.a.	n.a.	n.a.	n.a.	n.a.

Table 4.2.5.1.8. Anchovy in Division 9.a. Subdivisions 9.a Central-North. Portuguese fishery (all fleets). Seasonal and annual length distributions ('000) of anchovy landings in 2015. Discards are considered as negligible, hence landings correspond to catches.

2015	Q1	Q2	Q3	Q4	TOTAL
Length (cm)	9.a CN	9.a CN	9.a CN	9.a CN	9.a CN
6	0	0	0	0	0
6.5	0	0	0	0	0
7	0	0	0	0	0
7.5	0	0	0	0	0
8	0	0	0	0	0
8.5	0	0	0	0	0
9	0	0	0	0	0
9.5	0	0	0	0	0
10	0	0	0	0	0
10.5	38	0	0	0	38
11	339	0	0	0	339
11.5	1016	737	0	0	1989
12	2334	1751	0	0	4359
12.5	2409	3000	0	0	5861
13	4028	5190	96	0	10537
13.5	2597	3971	956	482	9041
14	3388	5767	4396	482	15827
14.5	2560	870	6976	1061	12853
15	2145	6840	10321	771	21441
15.5	1242	1119	9843	771	13782
16	1092	7202	7167	675	16838
16.5	565	248	3631	289	5091
17	565	3542	2580	386	7442
17.5	376	124	956	386	2056
18	188	733	382	0	1424
18.5	38	0	0	0	38
19	0	0	0	0	0
19.5	0	0	0	0	0
20	0	0	0	0	0
Total N	24918	41092	47304	5304	132335
Catch (T)	322	860	1209	143	2533
L avg (cm)	14.1	14.8	15.6	15.5	14.6
W avg (g)	n.a.	n.a.	n.a.	n.a.	n.a.

Table 4.2.5.1.9. Anchovy in Division 9.a. Subdivisions 9.a Central-South. Portuguese bottom-trawl fishery (métier OTB_DEF_>=55_0_0). Seasonal and annual length distributions ('000) of anchovy landings in 2015. Discards are considered as negligible, hence landings correspond to catches. LFDs of Q1 to Q3 (not provided to the WG9 have been estimated by rising catches to the respective LFDs from the whole fishery in the Subdivision 9.a Central North.

2015	Q1	Q2	Q3	Q4	TOTAL
Length (cm)	9.a CS	9.a CS	9.a CS	9.a CS	9.a CS
6	0	0	0	0	0
6.5	0	0	0	0	0
7	0	0	0	0	0
7.5	0	0	0	0	0
8	0	0	0	0	0
8.5	0	0	0	0	0
9	0	0	0	0	0
9.5	0	0	0	0	0
10	0	0	0	0	0
10.5	0	0	0	0	0
11	0	0	0	0	0
11.5	1	0	0	0	1
12	3	0	0	0	3
12.5	3	0	0	0	3
13	5	0	0	0	5
13.5	3	0	0	0	4
14	4	0	1	2	7
14.5	3	0	1	4	8
15	3	0	2	16	21
15.5	2	0	2	21	24
16	1	0	1	5	8
16.5	1	0	1	7	8
17	1	0	0	1	2
17.5	0	0	0	0	1
18	0	0	0	0	0
18.5	0	0	0	0	0
19	0	0	0	0	0
19.5	0	0	0	0	0
20	0	0	0	0	0
Total N	31	2	8	54	95
Catch (T)	0.4	0.05	0.2	1	2
L avg (cm)	14.1	14.8	15.6	15.7	15.1
W avg (g)	n.a.	n.a.	n.a.	n.a.	n.a.

Table 4.2.5.1.10. Anchovy in Division 9.a. Subdivision 9.a South (ES). Spanish purse-seine fishery (métier PS_SPF_0_0_0). Seasonal and annual length distributions ('000) of anchovy landings and discards in 2015.

2015	Q1		Q2		Q3		Q4		TOTAL	
Length	9.a S		9.a S		9.a S		9.a S		9.a S	
(cm)	(ES)		(ES)		(ES)		(ES)		(ES)	
Fraction	Landings	Discards	Landings	Discards	Landings	Discards	Landings	Discards	Landings	Discards
6	0	0	0	0	0	0	0	0	0	0
6.5	0	0	0	0	0	0	0	0	0	0
7	0	0	0	1	0	0	0	0	0	1
7.5	252	451	0	0	0	0	0	0	252	451
8	802	765	0	12	0	6	0	0	802	783
8.5	1561	786	954	53	1769	70	0	7	4285	915
9	5811	1707	4218	279	8406	145	451	13	18886	2143
9.5	6827	1840	16686	800	22918	118	3526	23	49957	2782
10	10958	2597	34926	1465	25650	113	15047	28	86580	4203
10.5	7817	3182	37846	1340	23241	121	20242	8	89145	4650
11	14930	1387	33238	1080	26386	99	21041	3	95595	2569
11.5	10193	779	22839	536	28457	43	16932	1	78420	1359
12	13267	158	23185	254	18021	23	6824	0	61298	435
12.5	7740	5	12238	65	12520	44	9655	0	42152	115
13	6090	2	12813	4	10499	29	8898	0	38300	34
13.5	1563	0	9563	20	7643	22	7124	0	25894	42
14	8170	0	6251	38	3367	22	3803	0	21591	60
14.5	4519	0	3668	0	1230	0	1217	0	10635	0
15	5350	0	3070	0	243	0	1638	0	10301	0
15.5	430	0	2754	0	131	0	423	0	3738	0
16	3602	0	594	0	157	0	0	0	4353	0
16.5	0	0	259	0	9	0	134	0	401	0
17	645	0	70	0	0	0	0	0	715	0
17.5	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0
18.5	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0
19.5	0	0	0	0	0	0	0	0	0	0
20	0	0	58	0	0	0	0	0	58	0
20.5	0	0	0	0	0	0	0	0	0	0
Total N	110528	13658	225231	5947	190647	853	116954	84	643359	20542
Catch (T)	1373	90	2329	46	1843	7	1155	0.5	6701	143
L avg (cm)	12,0	10,1	11,6	10,7	11,3	10,6	11,8	10,0	11,6	10,3
W avg (g)	12,4	6,6	10,3	7,7	9,7	7,9	9,9	5,7	10,4	7,0

Table 4.2.5.1.11. Anchovy in Division 9.a. Subdivision 9.a South (ES). Spanish purse-seine fishery (métier PS_SPF_0_0_0). Seasonal and annual length distributions ('000) of anchovy catches in 2015.

2015	Q1	Q2	Q3	Q4	TOTAL
Length (cm)	9.a S (ES)	9.a S (ES)	9.a S (ES)	9.a S (ES)	9.a S (ES)
6	0	0	0	0	0
6.5	0	0	0	0	0
7	0	1	0	0	1
7.5	703	0	0	0	703
8	1567	12	6	0	1585
8.5	2347	1007	1839	7	5200
9	7517	4497	8551	464	21030
9.5	8668	17486	23036	3549	52739
10	13555	36390	25763	15075	90783
10.5	10998	39186	23362	20249	93796
11	16317	34319	26485	21043	98164
11.5	10972	23375	28500	16933	79780
12	13425	23439	18044	6825	61733
12.5	7745	12303	12564	9655	42267
13	6092	12816	10527	8898	38334
13.5	1563	9584	7665	7124	25936
14	8170	6289	3389	3803	21651
14.5	4519	3668	1230	1217	10635
15	5350	3070	243	1638	10301
15.5	430	2754	131	423	3738
16	3602	594	157	0	4353
16.5	0	259	9	134	401
17	645	70	0	0	715
17.5	0	0	0	0	0
18	0	0	0	0	0
18.5	0	0	0	0	0
19	0	0	0	0	0
19.5	0	0	0	0	0
20	0	58	0	0	58
20.5	0	0	0	0	0
Total N	124186	231178	191500	117038	663901
Catch (T)	1464	2375	1850	1156	6845
L avg (cm)	11,8	11,6	11,3	11,8	11,6
W avg (g)	10,3	10,3	9,7	9,9	10,3

Table 4.2.5.1.12. Anchovy in Division 9.a. Subdivision 9.a South (ES). Spanish bottom-trawl fishery (métier OTB_MCD_>=55_0_0). Seasonal and annual length distributions ('000) of anchovy discards in 2015.

2015	Q1	Q2	Q3	Q4	TOTAL
Length (cm)	9.a S (ES)	9.a S (ES)	9.a S (ES)	9.a S (ES)	9.a S (ES)
6	0	0	0	80	80
6.5	0	0	0	563	563
7	5	7	7	805	823
7.5	20	26	37	1368	1451
8	30	39	44	577	690
8.5	20	26	29	1569	1645
9	5	7	15	262	288
9.5	0	0	0	101	101
10	0	51	0	54	105
10.5	0	114	0	20	134
11	9	70	0	0	79
11.5	2	156	0	37	195
12	45	162	0	50	256
12.5	26	122	0	52	199
13	45	98	0	43	186
13.5	21	59	0	15	95
14	35	38	0	5	78
14.5	5	0	0	0	5
15	0	0	0	0	0
15.5	0	0	0	0	0
16	7	0	0	0	7
16.5	5	0	0	0	5
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
19	0	0	0	0	0
19.5	0	0	0	0	0
20	2	0	0	0	2
20.5	0	0	0	0	0
Total N	282	975	132	5600	6990
Catch (T)	4	11	0,4	18	33
L avg (cm)	11,8	11,7	8,3	8,2	8,8
W avg (g)	10,8	10,8	3,3	3,3	4,7

Table 4.2.5.1.13. Anchovy in Division 9.a. Subdivision 9.a South (ES). Spanish fishery (all fleets). Seasonal and annual length distributions ('000) of anchovy catches in 2015.

2015	Q1	Q2	Q3	Q4	TOTAL
Length (cm)	9.a S (ES)	9.a S (ES)	9.a S (ES)	9.a S (ES)	9.a S (ES)
6	0	0	0	80	80
6.5	0	0	0	563	564
7	5	7	7	805	824
7.5	723	27	37	1368	2154
8	1597	51	50	577	2275
8.5	2367	1033	1868	1576	6845
9	7522	4504	8565	726	21318
9.5	8668	17486	23036	3650	52840
10	13555	36442	25763	15129	90888
10.5	10998	39300	23362	20270	93930
11	16326	34389	26485	21043	98243
11.5	10975	23531	28500	16970	79975
12	13469	23601	18044	6874	61989
12.5	7771	12425	12564	9707	42466
13	6137	12915	10527	8942	38520
13.5	1584	9643	7665	7139	26031
14	8206	6327	3389	3808	21729
14.5	4524	3668	1230	1217	10639
15	5350	3070	243	1638	10301
15.5	430	2754	131	423	3738
16	3609	594	157	0	4360
16.5	5	259	9	134	406
17	645	70	0	0	715
17.5	0	0	0	0	0
18	0	0	0	0	0
18.5	0	0	0	0	0
19	0	0	0	0	0
19.5	0	0	0	0	0
20	2	58	0	0	60
20.5	0	0	0	0	0
Total N	124468	232154	191632	122638	670891
Catch (T)	1467	2386	1850	1174	6877
L avg (cm)	11,8	11,6	11,3	11,6	11,5
W avg (g)	11,8	10,3	9,7	9,6	10,3

Table 4.2.5.2.1. Anchovy in Division 9.a. Subdivision 9.a North. Spanish catches (all fleets) in numbers ('000) at-age of Galician anchovy in 2015 on a quarterly (Q), half-year (HY) and annual basis.

2015	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	0	0	0	0	0
	1	1213	184	258	12	1397	270	1667
	2	5655	839	165	8	6495	173	6667
	3	55	11	0	0	66	0	66
	Total (n)	6923	1034	423	20	7958	443	8401
	Catch (t)	150	13	9	0,4	163	10	173
	SOP	150	16	9	0,4	167	10	177
	VAR.%	100	81	100	102	98	100	98

Table 4.2.5.2.2. Anchovy in Division 9.a. Subdivision 9.a North. Spanish annual catches of anchovy in numbers ('000) at-age (only data for 2011–2012 and 2015).

Year	Age 0	Age 1	Age 2	Age 3
2011	2725	23903	380	0
2012	0	668	599	7
2013	n.a	n.a	n.a	n.a
2014	n.a	n.a	n.a	n.a
2015	0	1667	6667	66

Table 4.2.5.2.3. Anchovy in Division 9.a. Subdivision 9.a South. Spanish catches (all fleets) in numbers ('000) at-age of Gulf of Cadiz anchovy in 2015 on a quarterly (Q), half-year (HY) and annual basis.

2015	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	92260	104077	0	196337	196337
	1	116960	227966	97946	18015	344925	115961	460887
	2	7508	4188	1425	546	11696	1971	13667
	3	0	0	0	0	0	0	0
	Total (n)	124468	232154	191631	122638	356622	314269	670891
	Catch (t)	1467	2386	1850	1174	3853	3024	6877
	SOP	1468	2385	1848	1174	3853	3022	6875
	VAR.%	100	100	100	100	100	100	100

Table 4.2.5.2.4. Anchovy in Division 9.a. Subdivision 9.a South. Spanish annual catches (all fleets) in numbers ('000) at-age of Gulf of Cadiz anchovy (1995–2015).

Year	Age 0	Age 1	Age 2	Age 3
1995	34497	33961	189	0
1996	484540	162483	2053	0
1997	333758	279641	44823	0
1998	436307	1015535	13260	0
1999	124784	472348	32279	0
2000	118808	197497	3844	0
2001	158126	541331	23342	0
2002	74399	708070	17515	0
2003	71847	381407	13109	0
2004	105958	398862	2590	0
2005	37906	482256	3495	0
2006	11303	491307	5261	0
2007	61692	559217	7342	0
2008	57477	138295	30970	394
2009	9695	184941	20051	2673
2010	34462	210384	11118	257
2011	199191	406217	16117	0
2012	25265	335487	8348	0
2013	176169	300781	5950	0
2014	73210	808350	6155	0
2015	196337	460887	13667	0

Table 4.2.6.1. Anchovy in Division 9.a. Subdivision 9.a North. Mean length (TL, in cm) at-age in the Spanish catches of Galician anchovy (all fleets) in 2015 on a quarterly (Q), half-year (HY) and annual basis.

2015	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0							
	1	13,6	12,7	14,2	14,2	13,4	14,2	13,6
	2	14,8	13,3	15,1	15,1	14,7	15,1	14,7
	3	17,0	16,5			16,9		16,9
	Total	14,6	13,3	14,5	14,5	14,5	14,5	14,5

Table 4.2.6.2. Anchovy in Division 9.a. Subdivision 9.a North. Mean weight (in kg) at-age in the Spanish catches of Galician anchovy (all fleets) in 2015 on a quarterly (Q), half-year (HY) and annual basis.

2015	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0							
	1	0,017	0,014	0,020	0,020	0,016	0,020	0,017
	2	0,023	0,016	0,025	0,025	0,022	0,025	0,022
	3	0,034	0,031			0,034		0,034
	Total	0,022	0,016	0,022	0,022	0,021	0,022	0,021

Table 4.2.6.3. Anchovy in Division 9.a. Subdivision 9.a South. Mean length (TL, in cm) at-age in the Spanish catches of Gulf of Cadiz anchovy (all fleets) in 2015 on a quarterly (Q), half-year (HY) and annual basis.

2015	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			10,6	11,2		10,9	10,9
	1	11,6	11,5	12,0	13,6	11,5	12,2	11,7
	2	15,4	14,7	12,5	15,2	15,1	13,2	14,8
	3							
	Total	11,8	11,6	11,3	11,6	11,6	11,4	11,5

Table 4.2.6.4. Anchovy in Division 9.a. Subdivision 9.a South. Mean weight (in kg) at-age in the Spanish catches of Gulf of Cadiz anchovy (all fleets) in 2015 on a quarterly (Q), half-year (HY) and annual basis.

2015	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			0,008	0,009		0,008	0,008
	1	0,011	0,010	0,011	0,015	0,010	0,012	0,011
	2	0,026	0,023	0,014	0,022	0,025	0,016	0,023
	3							
	Total	0,012	0,010	0,010	0,010	0,011	0,010	0,010

Table 4.3.1. Acoustic and DEPM surveys providing direct estimates for anchovy in Division 9.a. (1): surveys used until 2008 as tuning series in the exploratory analytical assessment of anchovy in Subdivision 9.a South (Algarve and Gulf of Cádiz) (see Section 4.5.1); (2): surveys analysed since 2008 in the trends-based qualitative assessment; (3): *ECOCÁDIZ-COSTA 0709*, (pilot) Spanish survey surveying shallow waters <20 m depth and complementary to the standard survey; ((Month)): surveys that were carried out but did not provide any anchovy acoustic estimate because of its very low presence and/or for an incomplete geographical coverage (some areas were not covered: either the Spanish or the Portuguese part of the Gulf of Cadiz).

Method	Acoustics								DEPM	
Survey	PELACUS 04	PELAGO		SAR	JUVESAR	ECOCADIZ		ECOCADIZ-RECLUTAS	BOCADEVA	
Institute (Country)	IEO (Spain)	IPMA (Portugal)		IPMA (Portugal)	IPMA (Portugal)	IEO (Spain)		IEO (Spain)	IEO (Spain)	
Subareas	9.a N	9.a CN-9.a S		9.a CN-9.a S	9.a CN	9.a S		9.a S	9.a S	
Year/Quarter	Q2	Q1	Q2	Q4	Q4	Q2	Q3	Q4	Q2	Q3
1998				Nov						
1999		Mar (1,2)								
2000				Nov						
2001		Mar (1,2)		Nov						
2002		Mar (1,2)								
2003		Feb (1,2)		(Nov)						
2004			(Jun)			Jun(2)				
2005			Apr(1,2)	(Nov)					Jun(2)	
2006			Apr(1,2)	(Nov)		Jun(2)				
2007			Apr(1,2)	Nov			Jul (2)			
2008	Apr (2)		Apr(1,2)	(Nov)					Jun(2)	
2009	Apr (2)		Apr (2)			Jun(2)	(Jul)(3)	(Oct)		
2010	Apr (2)		Apr (2)				(Jul)(2)			
2011	Apr (2)		Apr (2)							Jul(2)
2012	Apr (2)							Nov		
2013	Mar (2)		Apr (2)		(Nov)		Aug(2)			
2014	Mar (2)		Apr (2)		(Nov)		Jul(2)	Oct		Jul(2)
2015	Mar (2)		Apr (2)		Dec		Jul(2)	Oct		
2016	Mar (2)		Apr (2)							

Table 4.3.2.1. Anchovy in Division 9.a. *PELACUS* survey series (spring Spanish acoustic survey in Subdivision 9.a North and Subarea 8.c). Historical series of acoustic estimates of anchovy abundance (N, millions) and biomass (B, tonnes) in Subdivision 9.a North.

Survey	Estimate	9.a North
Apr. 08	N	10
	B	306
Apr. 09	N	0.7
	B	26
Apr. 10	N	0.03
	B	90
Apr. 11	N	73
	B	1650
Apr. 12	N	1
	B	45
Mar 13	N	-
	B	-
Mar 14	N	-
	B	-
Mar 15	N	-
	B	-
Mar 16	N	8
	B	205

Table 4.3.2.2. Anchovy in Division 9.a. *PELAGO* survey series (spring Portuguese acoustic survey in Subdivisions 9.a Central-North to 9.a South). Historical series of overall and regional acoustic estimates of anchovy abundance (N, millions) and biomass (B, tonnes).

		Portugal				Spain		
Survey	Estimate	C-N	C-S	S(A)	Total	S(C)	S(Total)	TOTAL
Mar. 99	N	22	15	*	37	2079	2079	2116
	B	190	406	*	596	24763	24763	25359
Mar. 00	N	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-
Mar. 01	N	25	13	285	324	2415	2700	2738
	B	281	87	2561	2929	22352	24913	25281
Mar. 02	N	22	156	92	270	3731 **	3823 **	4001 **
	B	472	1070	1706	3248	19629 **	21335 **	22877 **
Feb. 03	N	0	14	*	14	2314	2314	2328
	B	0	112	*	112	24565	24565	24677
Mar. 04	N	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-
Apr. 05	N	-	59	-	59	1306	1306	1364
	B	-	1062	-	1062	14041	14041	15103
Apr. 06	N	-	-	319	319	1928	2246	2246
	B	-	-	4490	4490	19592	24082	24082
Apr. 07	N	0	103	284	387	2860	3144	3247
	B	0	1945	4607	6552	33413	38020	39965
Apr.08	N	69	252	213	534	1819	2032	2353
	B	3000	2505	4661	10166	29501	34162	39667
Apr.09	N	127	0****	159	286	1910	2069	2196
	B	2089	0****	3759	5848	20986	24745	26834
Apr. 10	N	0	62	0	62	963	963	1026
	B	0	1188	0	1188	7395	7395	8583
Apr. 11	N	1558	0	0	1558	0	0	1558
	B	27050	0	0	27050	0	0	27050
Apr. 12	N	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-
Apr. 13	N	251	0	263	514	634	897	1148
	B	3955	0	5044	8999	7656	12700	16655
Apr. 14	N	130	0	26	156	2216	2241	2371
	B	1947	0	509	2456	28408	28917	30864
Apr. 15	N	645	0	158	802	3531	3689	4334
	B	8237	0	2156	10393	30944	33100	41337
Apr. 16	N	3198	0	0	3198	9811	9811	13009
	B	38302	0	0	38302	65345	65345	103647

*** Due to the distribution observed during the survey, the last transect (near the border with Spain) that normally belongs to the Algarve subarea was included in Cadiz.** Corrected estimates after detection of errors in the sA values attributed to the Cadiz area (Marques and Morais, 2003). ****Possible underestimation: although no echotraces attributable to the species were detected in this area, however, the loss of pelagic gear samplers prevented from confirming this directly.**

Table 4.3.2.3. Anchovy in Division 9.a. *ECOCADIZ* survey series (summer Spanish acoustic survey in Subdivision 9.a South). Historical series of overall and regional acoustic estimates of anchovy abundance (N, millions) and biomass (B, tonnes).

		Portugal	Spain	TOTAL
Survey	Estimate	S(A)	S(C)	S(Total)
Jun. 04***	N	125	1109	1235
	B	2474	15703	18177
Jun. 05	N	-	-	-
	B	-	-	-
Jun. 06	N	363	2801	3163
	B	6477	30043	36521
Jul. 07	N	558	1232	1790
	B	11639	17243	28882
Jul. 08	N	-	-	-
	B	-	-	-
Jul. 09	N	35	1102	1137
	B	1075	20506	21580
Jul. 10	N	?	954+	954 +
	B	?	12339 +	12339 +
Jul. 11	N	-	-	-
	B	-	-	-
Jul. 12	N	-	-	-
	B	-	-	-
Aug. 13	N	50	558	609
	B	1315	7172	8487
Jul. 14	N	184	1778	1962
	B	4440	24779	29219
Jul. 15	N	168	2506	2674
	B	2137	19168	21305

*****Possible underestimation: shallow waters between 20 and 30 m depth were not acoustically sampled.**
+ Partial estimate due to an incomplete coverage of the subdivision (only the Spanish part).

Table 4.3.3.1. Anchovy in Division 9.a. *SAR/JUVESAR* autumn survey series (autumn Portuguese acoustic survey in Subdivisions 9.a Central-North to 9.a South - SAR - or Subdivision 9.a Central-North - *JUVESAR* -). Historical series of overall and regional acoustic estimates of anchovy abundance (N, millions) and biomass (B, tonnes).

		Portugal				Spain		
Survey	Estimate	C-N	C-S	S (PT)	Total	S (ES)	S (Total)	TOTAL
Nov. 98	N	30	122	50	203	2346	2396	2549
	B	313	1951	603	2867	30092	30695	32959
Nov. 99	N	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-
Nov. 00	N	4	20	*	23	4970	4970	4994
	B	98	241	*	339	33909	33909	34248
Nov. 01	N	35	94	-	129	3322	3322	3451
	B	1028	2276	-	3304	25578	25578	28882
Nov. 02	N	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-
Nov. 03	N	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-
Nov. 04	N	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-
Nov. 05	N	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-
Nov. 06	N	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-
Nov. 07	N	0	59	475	534	1386	1862	1921
	B	0	1120	7632	8752	16091	23723	24843
Nov. 13	N	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-
Nov. 14	N	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-
Dec. 15	N	n.a.	-	-	-	-	-	-
	B	n.a.	-	-	-	-	-	-

*** Due to the distribution observed during the survey, the last transect (near the border with Spain) that normally belongs to the Algarve subarea was included in Cadiz.**

Table 4.3.3.2. Anchovy in Division 9.a. *ECOCADIZ-RECLUTAS* survey series (autumn Spanish acoustic survey in Subdivision 9.a South). Historical series of overall and regional acoustic estimates of anchovy abundance (N, millions) and biomass (B, tonnes). Age 0 fish estimates between parentheses.

		Portugal	Spain	TOTAL
Survey	Estimate	S (PT)	S (ES)	S (Total)
Nov. 12*	N	-	2649 (2619)	-
	B	-	13680 (13354)	-
Oct. 14	N	111 (3)	875 (811)	986 (814)
	B	2168 (25)	5945 (5107)	8113 (5131)
Oct. 15	N	115 (75)	5113 (5042)	5227 (5117)
	B	1335 (430)	29491 (28789)	30827 (29219)

*** Partial estimate: only the Spanish waters were acoustically surveyed.**

Table 4.4.1.1. Anchovy in Division 9.a. Subdivision 9.a South. Mean weight-at-age in the stock (in g).

Year	Age 0	Age 1	Age 2	Age 3
1995	7.030	10.720	22.550	
1996	1.056	6.256	19.983	
1997	2.574	11.061	20.900	
1998	2.646	7.404	20.449	
1999	3.187	12.839	19.988	
2000	3.137	9.963	23.817	
2001	6.210	13.288	31.765	
2002	3.319	10.500	26.286	
2003	5.982	10.566	26.789	
2004	6.644	12.009	21.875	
2005	4.936	9.166	22.619	
2006	3.651	8.214	20.970	
2007	5.358	9.442	20.385	
2008	7.181	14.934	21.768	23.093
2009	4.120	12.194	20.261	24.207
2010	6.911	11.309	19.088	22.987
2011	8.230	10.323	22.731	
2012	8.300	14.326	22.530	
2013	6.414	11.865	21.767	
2014	6.600	10.874	19.046	
2015	7.667	10.459	20.746	

Table 4.4.2.1. Anchovy in Division 9.a. Subdivision 9.a South. Maturity ogives (ratio of mature fish at-age) for Gulf of Cadiz anchovy.

	Age		
Year	0	1	2+
1988	0	0.82	1
1989	0	0.53	1
1990	0	0.65	1
1991	0	0.76	1
1992	0	0.53	1
1993	0	0.77	1
1994	0	0.60	1
1995	0	0.76	1
1996	0	0.49	1
1997	0	0.63	1
1998	0	0.55	1
1999	0	0.74	1
2000	0	0.70	1
2001	0	0.76	1
2002	0	0.72	1
2003	0	0.69	1
2004	0	0.95	1
2005	0	0.95	1
2006	0	0.77	1
2007	0	0.91	1
2008	0	0.97	1
2009	0	0.99	1
2010	0	0.97	1
2011	0	0.97	1
2012	0	0.89	1
2013	0	0.94	1
2014	0	0.91	1
2015	0	0.92	1

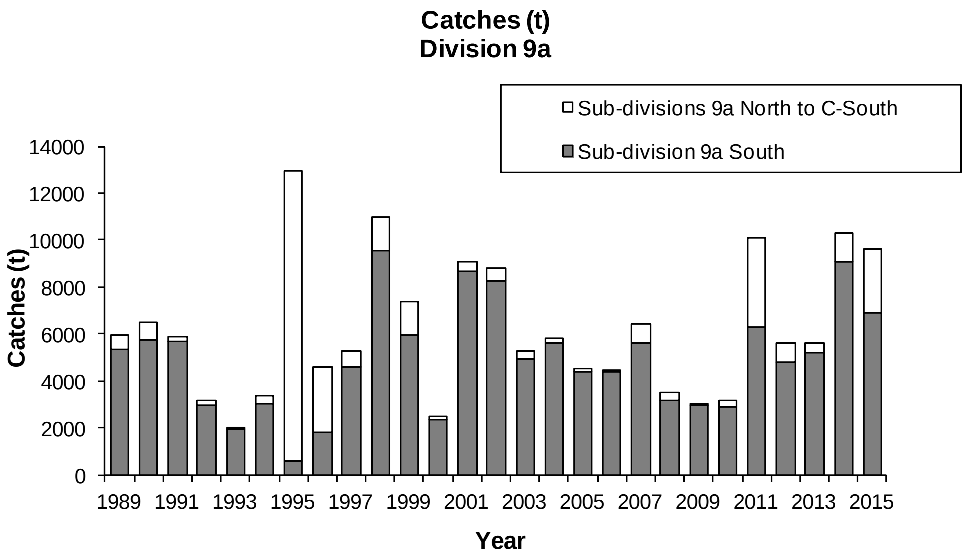


Figure 4.2.2.1.1. Anchovy in Division 9.a. Recent series of anchovy catches in Division 9.a (ICES estimates for 1989–2015, the period with data for all the subdivisions, all métiers are considered). Subarea areas are pooled in order to differentiate the anchovy fishery harvested throughout the Atlantic façade of the Iberian Peninsula (ICES Subdivisions 9.a North, Central-North and Central-South) from the fishery in the Gulf of Cadiz (Subdivision 9.a South), where both the stock and the fishery are mainly located. Discards are considered as negligible all over the division, but since 2014 on estimates include the available discarded catches (see Section 4.2.3).

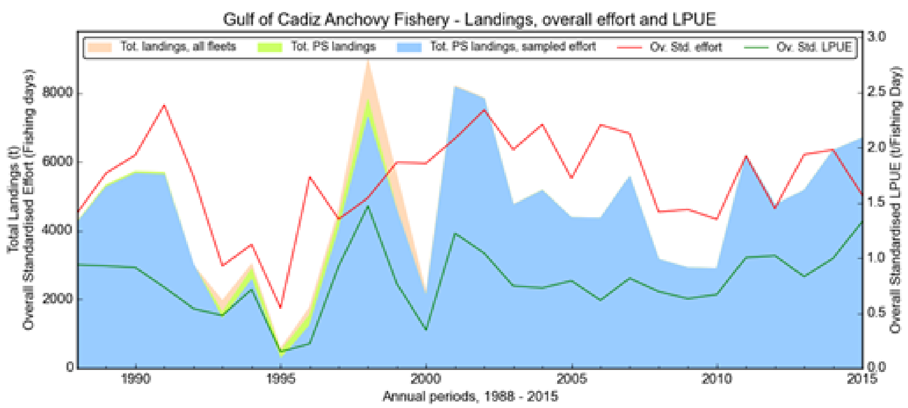


Figure 4.2.4.1. Anchovy in Division 9.a. Subdivision 9.a South. Spanish purse-seine fishery (métier PS_SPF_0_0_0). Trends in Gulf of Cadiz anchovy annual landings, and purse-seine fleets' standardised overall effort and lpue (1988–2015).

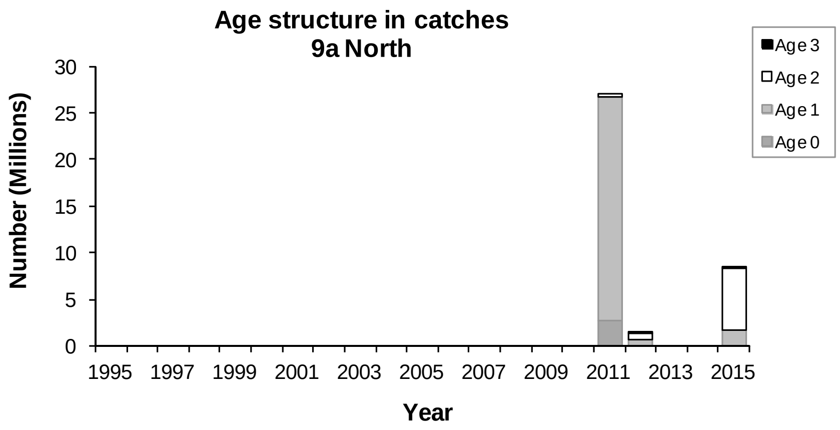


Figure 4.2.5.2.1. Anchovy in Division 9.a. Subdivision 9.a North. Spanish fishery (all métiers). Age composition in Spanish catches of SW Galician anchovy (available data provided to the WG). Although discards are still considered as negligible (hence landings are assumed as equal to catches), data for 2015 include discards estimates.

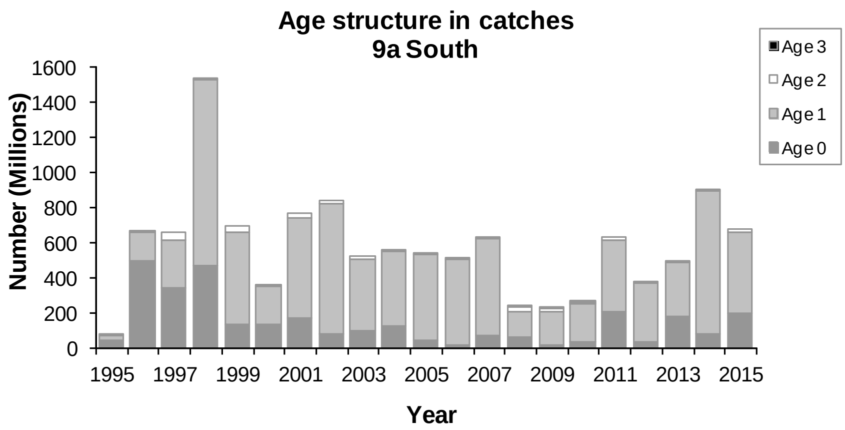
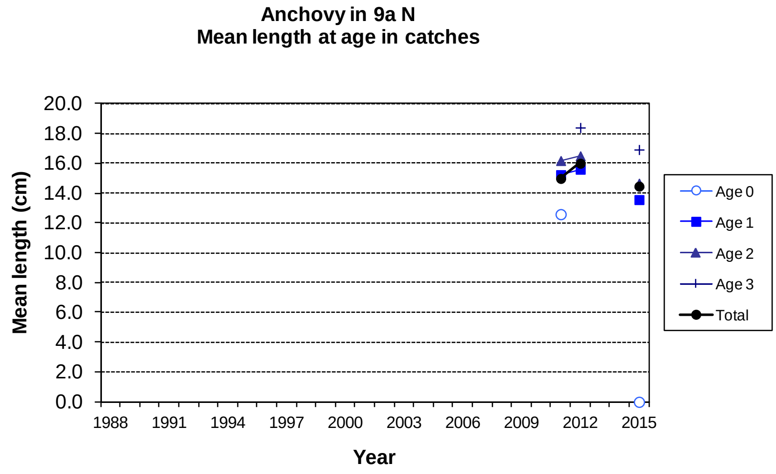


Figure 4.2.5.2.2. Anchovy in Division 9.a. Subdivision 9.a-South. Spanish fishery (all métiers). Age composition in Spanish catches of Gulf of Cadiz anchovy (1995–2015). Discards are considered as negligible in this fishery, but since 2014 on estimates include the available discarded catches (see Section 4.2.3).



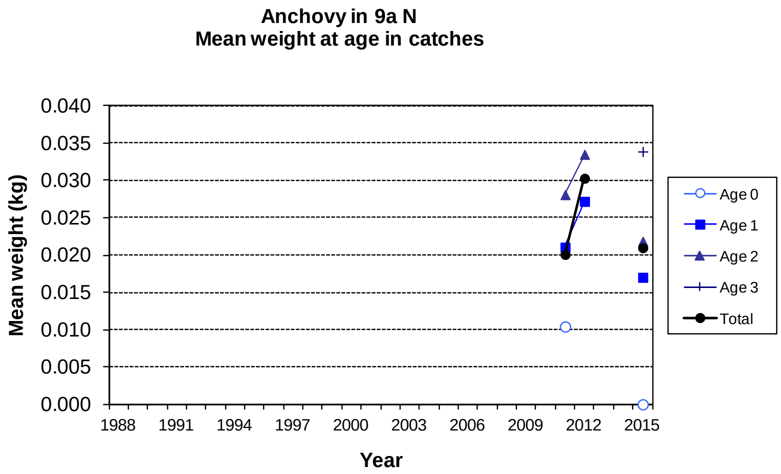
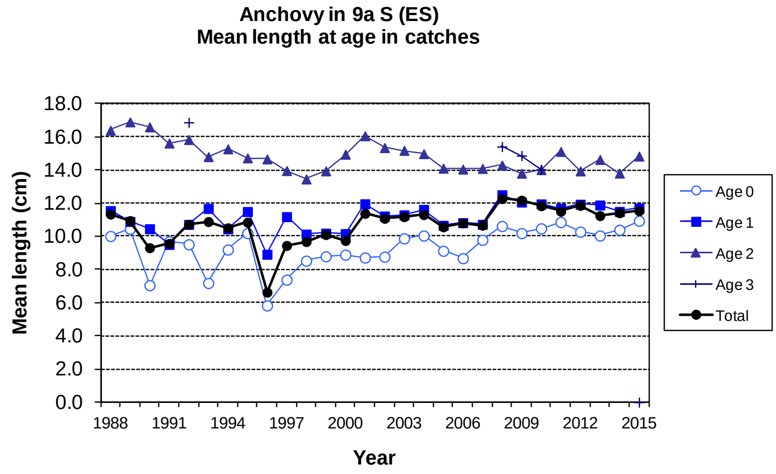


Figure 4.2.6.1. Anchovy in Division 9.a. Subdivision 9.a North. Spanish fishery (all métiers). Annual mean length (TL, in cm) and weight (kg) at-age in the Spanish catches of Western Galicia anchovy.



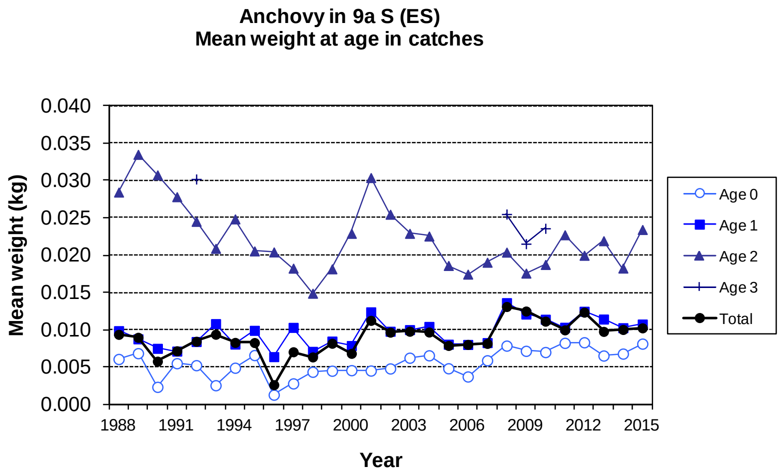


Figure 4.2.6.2. Anchovy in Division 9.a. Subdivision 9.a-South. Spanish fishery (all métiers). Annual mean length (TL, in cm) and weight (kg) at-age in the Spanish catches of Gulf of Cadiz anchovy (1988–2015).

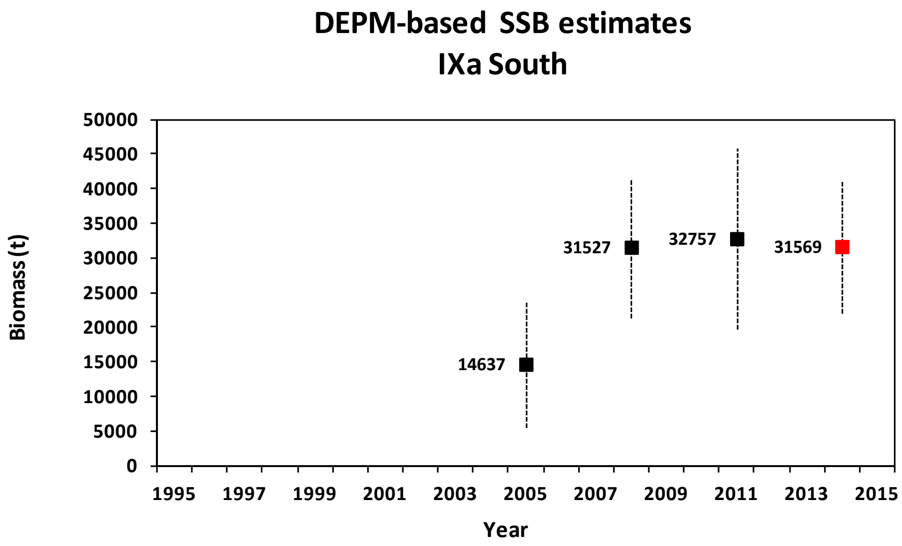


Figure 4.3.1.1. Anchovy in Division 9.a. Subdivision 9.a South. *BOCADEVA* survey series (summer Spanish DEPM survey in Subdivision 9.a South). Series of SSB estimates (±SD) obtained from the survey series. The 2014 SSB estimate (in red) is still provisional (computed with the 2011 Spawning Fraction estimate, *S*).

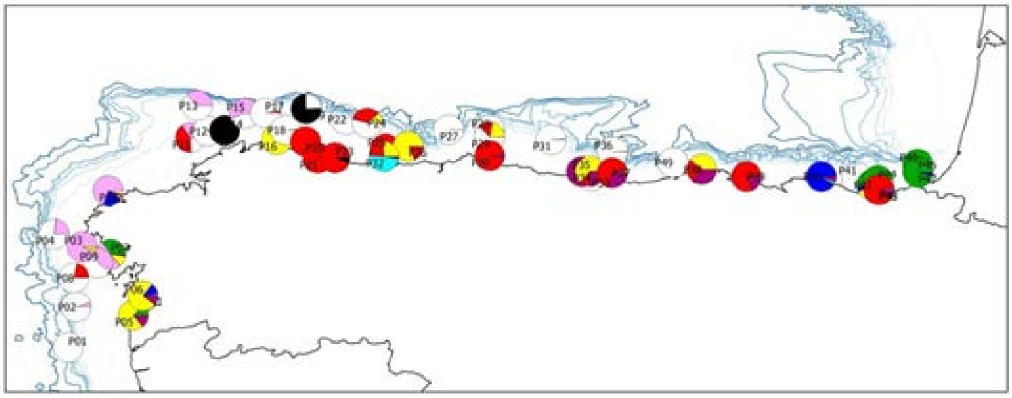


Figure 4.3.2.1. Anchovy in Division 9.a. Subdivision 9.a North. *PELACUS 0316* survey (spring Spanish acoustic survey in Subdivision 9.a North and Subarea 8.c in 2016). Distribution of pelagic hauls for echotraces identification with indication of the species composition. Subdivision 9.a North corresponds to the south westernmost geographical stratum.

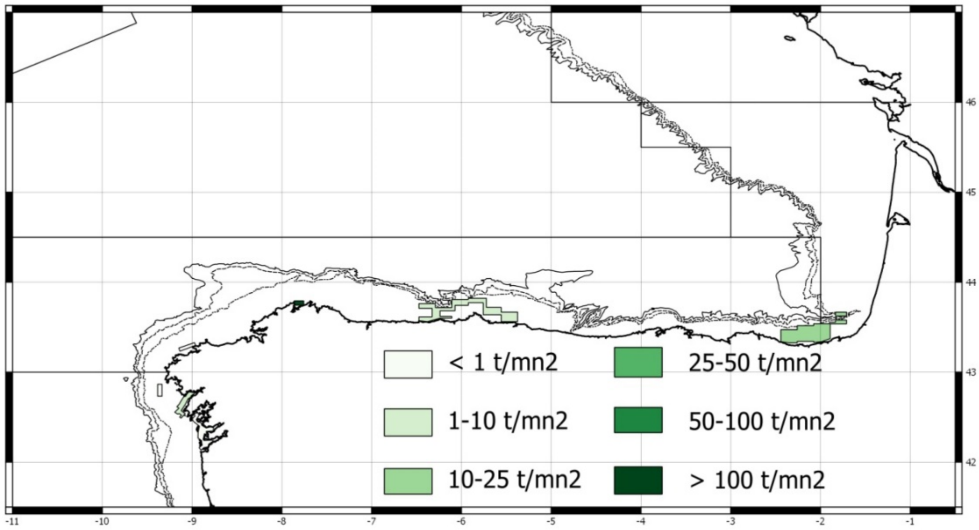


Figure 4.3.2.2. Anchovy in Division 9.a. Subdivision 9.a North. *PELACUS 0316* survey (spring Spanish acoustic survey in Subdivision 9.a North and Subarea 8.c in 2016). Spatial distribution of energy allocated to anchovy. Polygons are drawn to encompass the observed echoes, and polygon colour indicates density in mt/ nm[2] within each polygon.

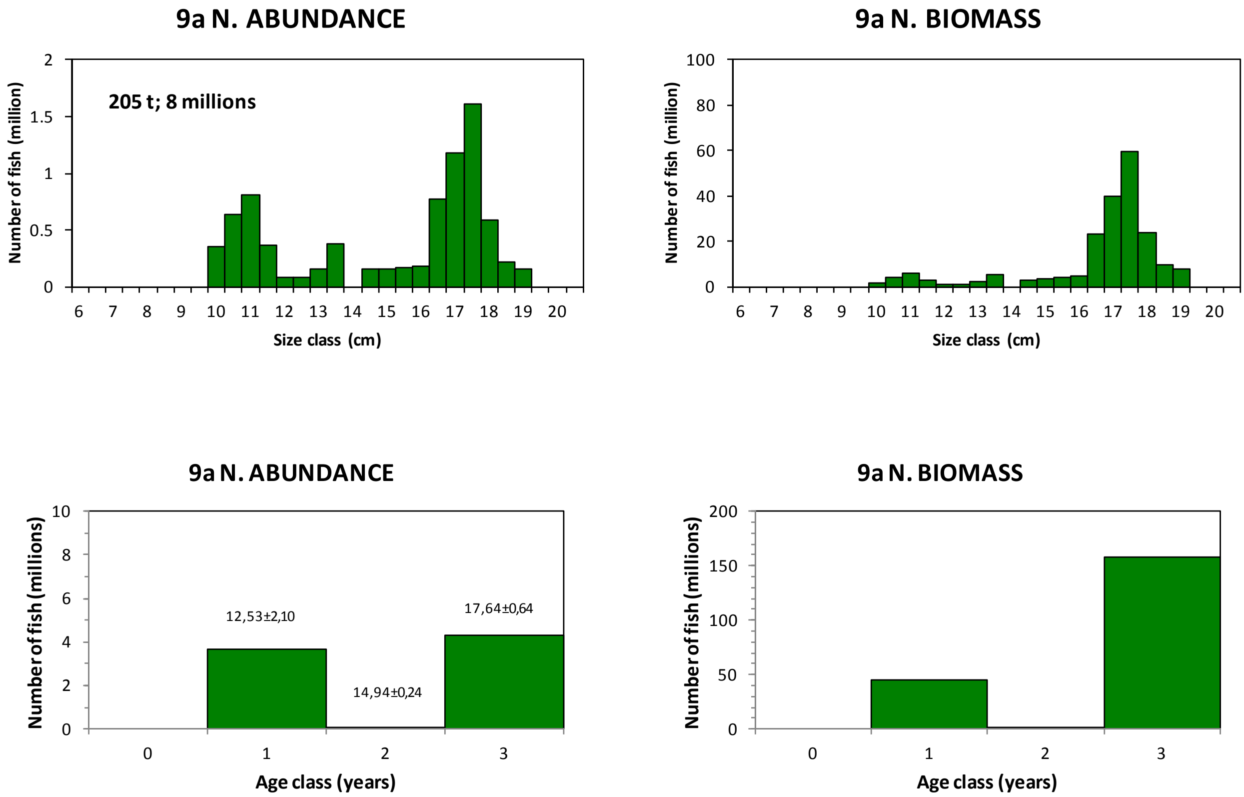


Figure 4.3.2.3. Anchovy in Division 9.a. Subdivision 9.a North. *PELACUS 0316* survey (spring Spanish acoustic survey in Subdivision 9.a North and Subarea 8.c in 2016). Estimated abundance (number of fish, in millions) by size class and age group in Subdivision 9a North.

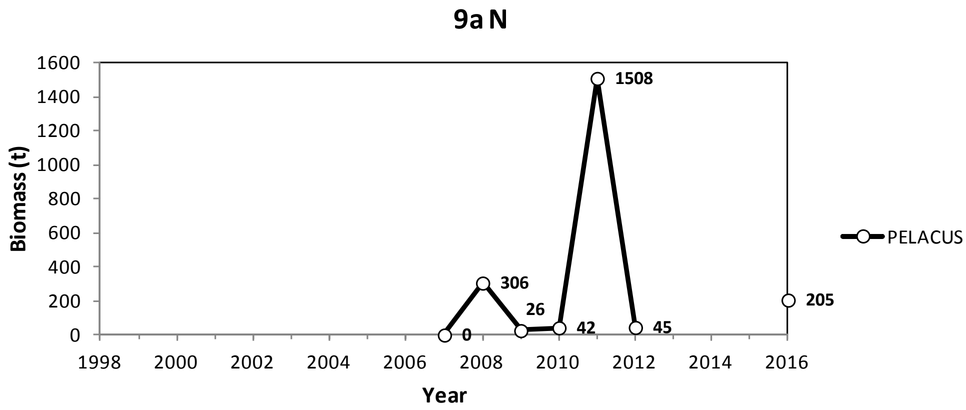


Figure 4.3.2.4. Anchovy in Division 9.a. Subdivision 9.a North. *PELACUS* survey series (spring Spanish acoustic survey in Subdivision 9.a North and Subarea 8.c). Historical series of acoustic estimates of anchovy biomass (t) for the Subdivision 9.a North.

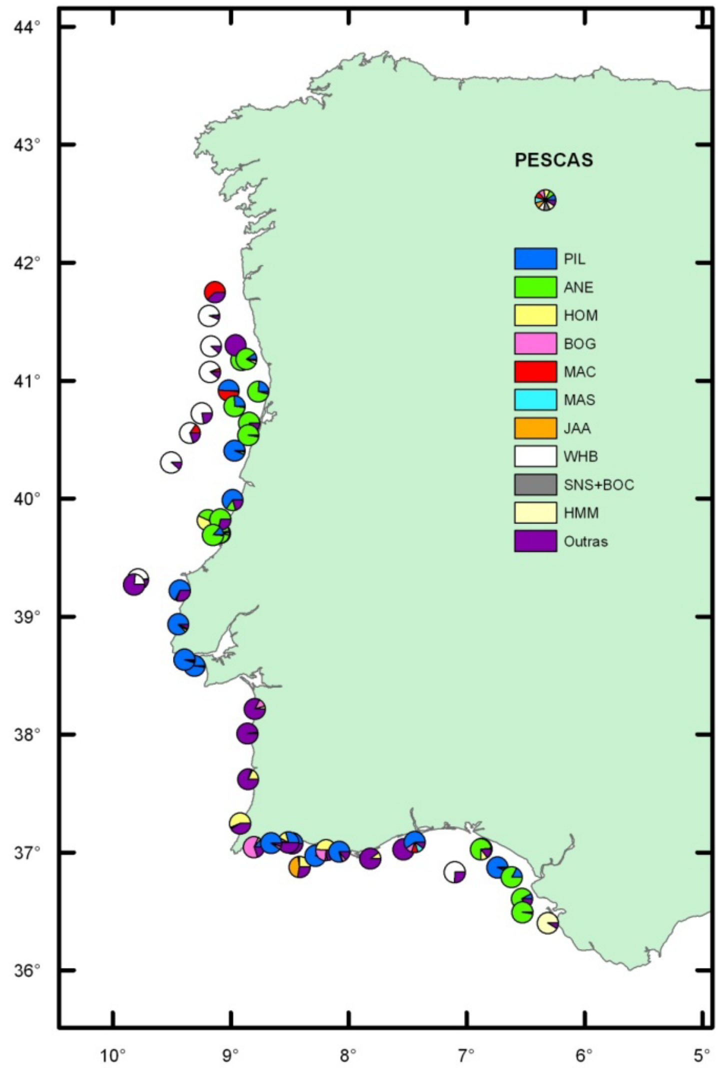


Figure 4.3.2.5. Anchovy in Division 9.a. Subdivisions 9.a Central-North to 9.a South. *PELAGO* survey series (spring Portuguese acoustic survey in Subdivisions 9.a Central-North to 9.a South). *PELAGO 16* survey. Fishing trawls location and hauls species composition (in number).

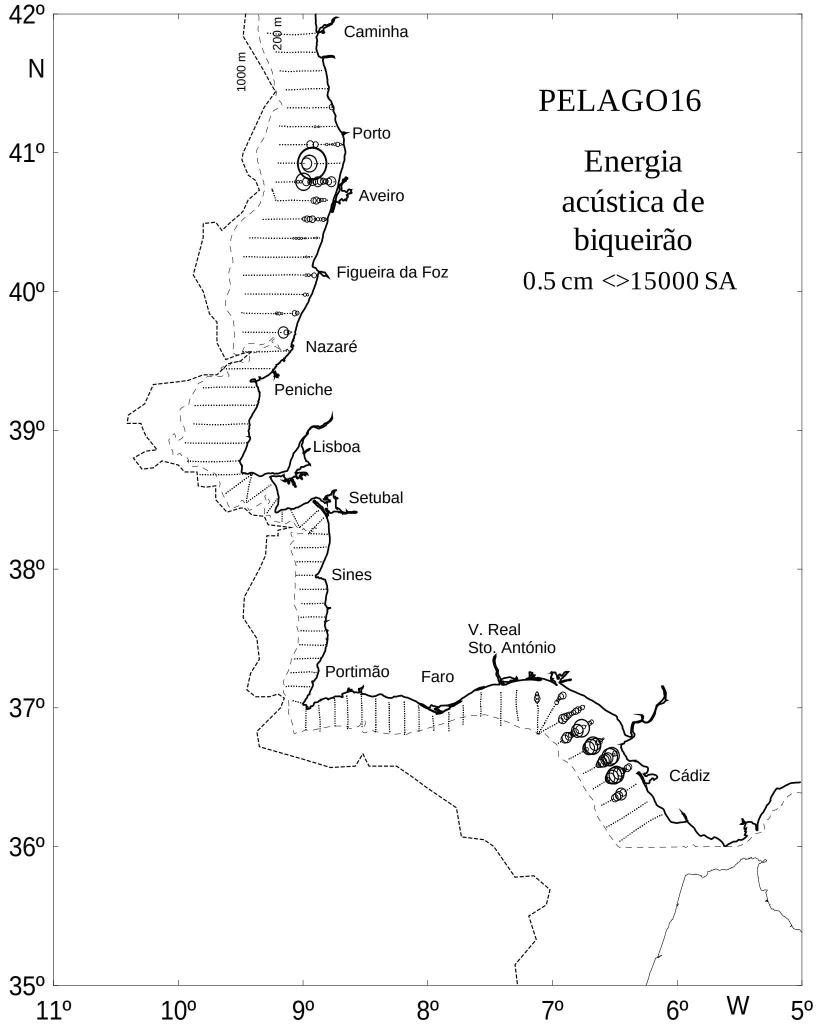


Figure 4.3.2.6. Anchovy in Division 9.a. Subdivisions 9.a Central-North to 9.a South. *PELAGO* survey series (spring Portuguese acoustic survey in Subdivisions 9.a Central-North to 9.a South). *PELAGO 16* survey. Distribution of the NASC coefficients (m^2/mn^2) attributed to anchovy.

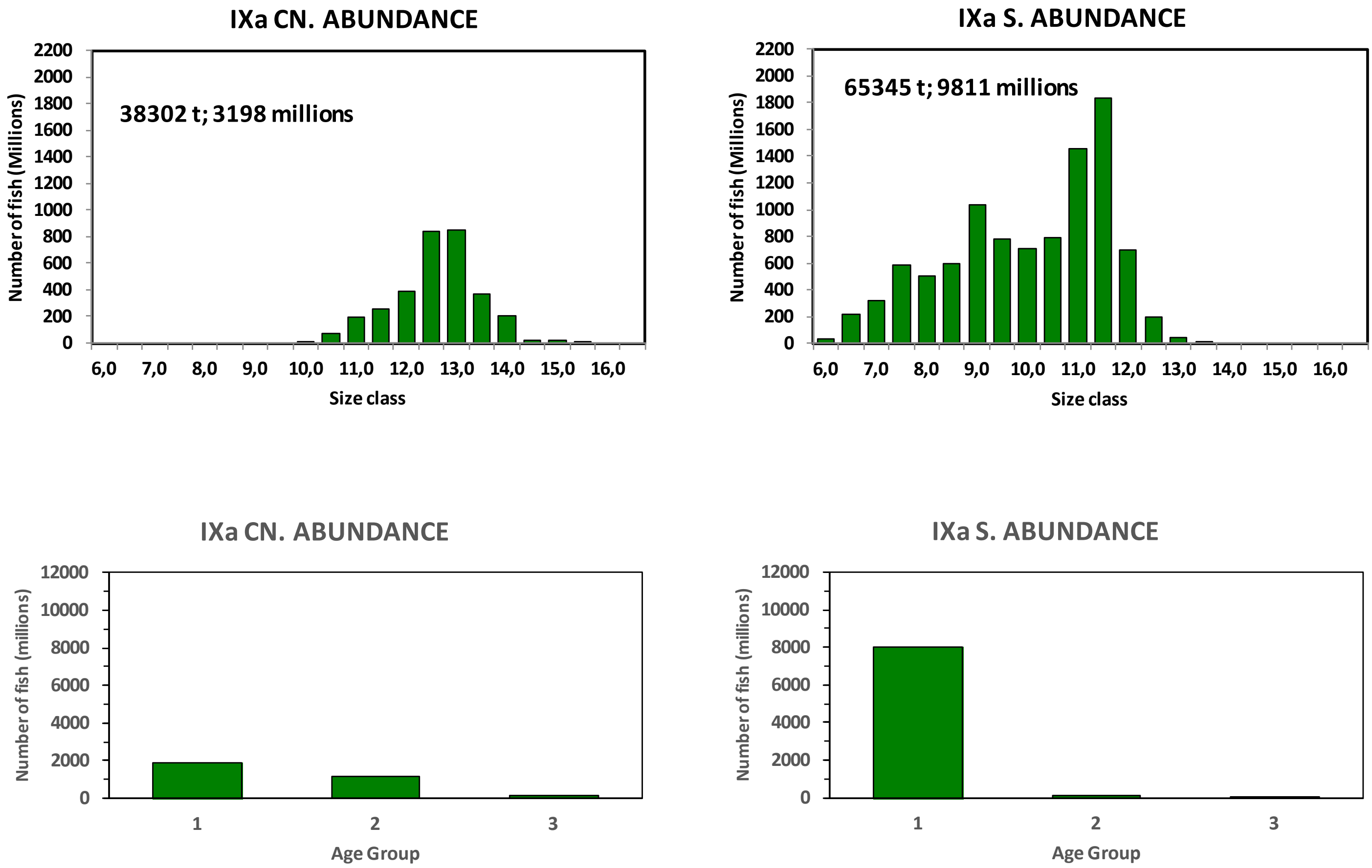


Figure 4.3.2.7. Anchovy in Division 9.a. Subdivisions 9.a Central-North to 9.a South. *PELAGO* survey series (spring Portuguese acoustic survey in Subdivisions 9.a Central-North to 9.a South). *PELAGO 16* survey. Estimated abundance (number of fish, in millions) by size class and age group from the Subdivision 9.a Central North and 9.a South.

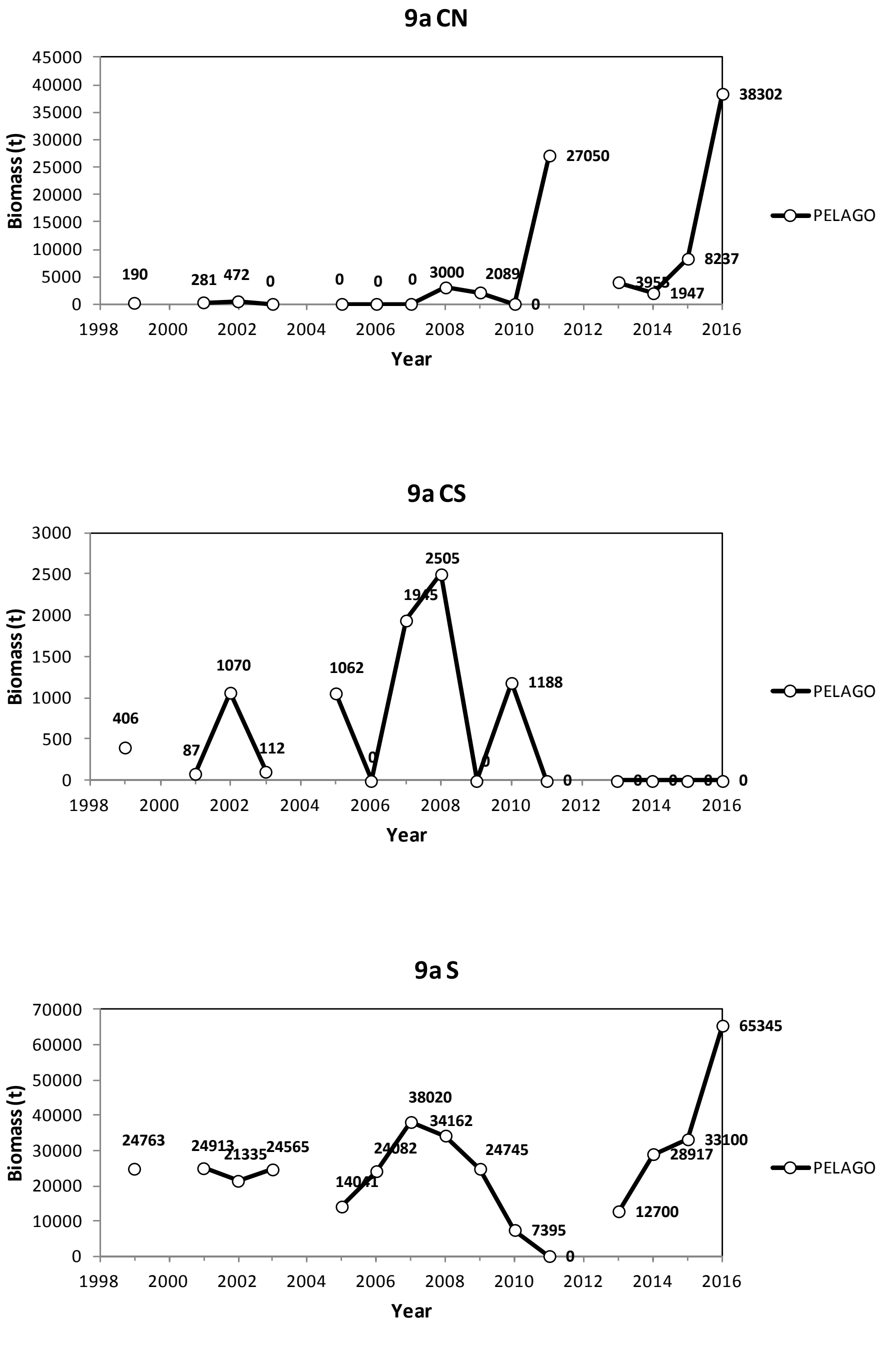
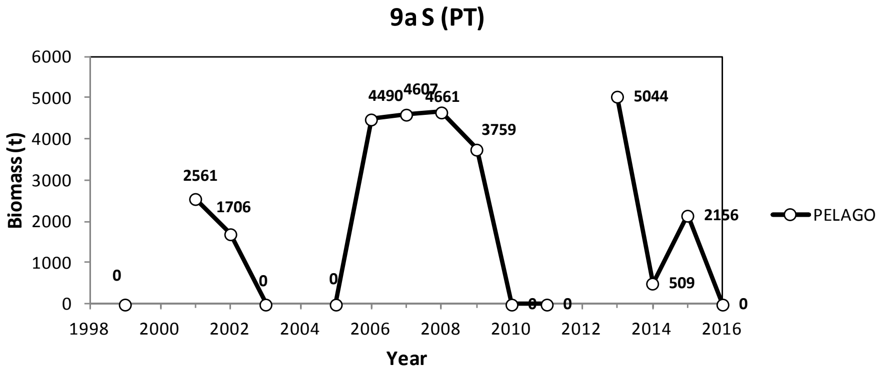


Figure 4.3.2.8. Anchovy in Division 9.a. Subdivisions 9.a Central-North to 9.a South. *PELAGO* survey series (spring Portuguese acoustic survey in Subdivisions 9a Central-North to 9.a South). Historical series of regional acoustic estimates of anchovy biomass (t). Note the different scale of the y-axis.



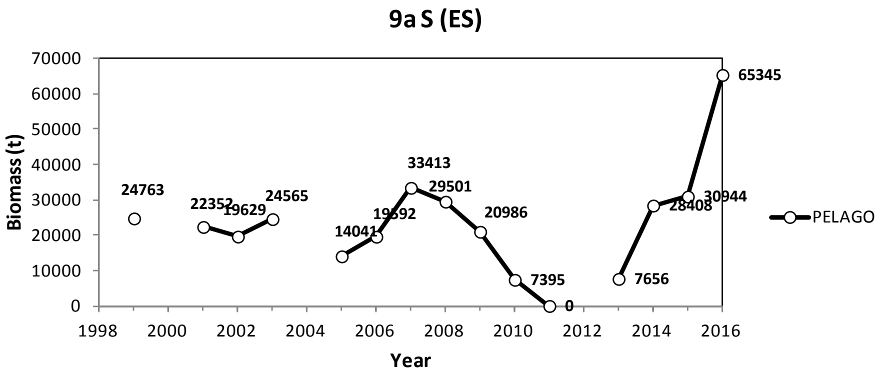
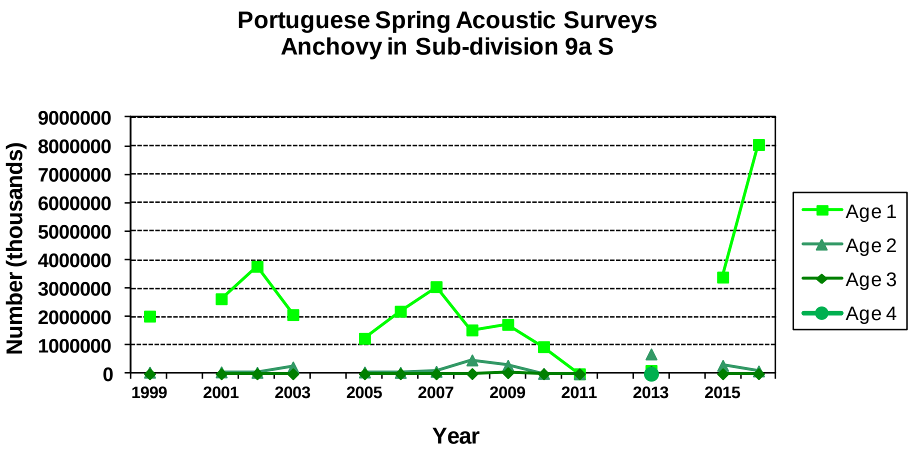


Figure 4.3.2.8. Continued. Acoustic estimates in the 9.a South differentiated by Portuguese (PT) and Spanish waters of the Gulf of Cádiz (ES). Note the different scale of the y-axis. Although estimates from Subdivision 9.a-South in 2010 and 2014 were not separately provided for Algarve and Cadiz to this WG, the total estimated for the Subdivision was assigned (by assuming some overestimation) to the Cadiz area according to the observed acoustic energy distribution in the area.



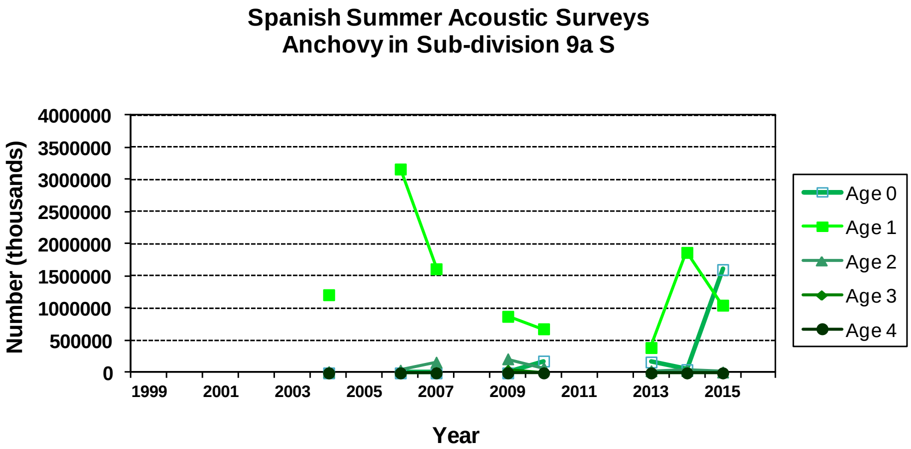


Figure 4.3.2.9. Anchovy in Division 9.a. Subdivision 9.a-South. Annual trends of the estimated population by age class from the Algarve + Gulf of Cádiz areas by the Portuguese Spring (upper plot) and Spanish summer (lower plot) acoustic surveys. Portuguese estimates until 2012 have been age structured using Spanish ALKs from the commercial fishery in the second quarter in the year. No Portuguese structured estimates available for 2014.

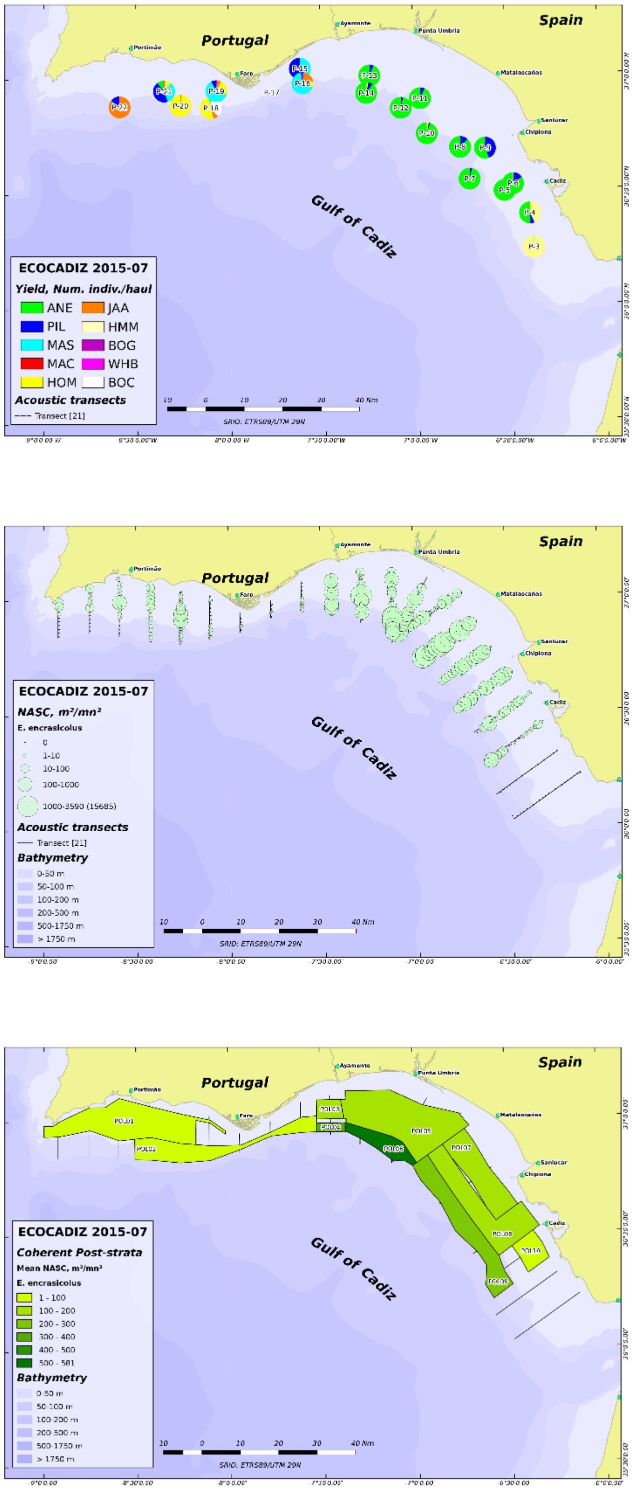


Figure 4.3.2.10. Anchovy in Division 9.a. Subdivision 9.a South. *ECOCADIZ 2015-07* survey (summer Spanish acoustic survey in Subdivision 9.a South). Top: Location of valid fishing stations with indication of their species composition (percentages in number).Middle: Distribution of the backscattering 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.

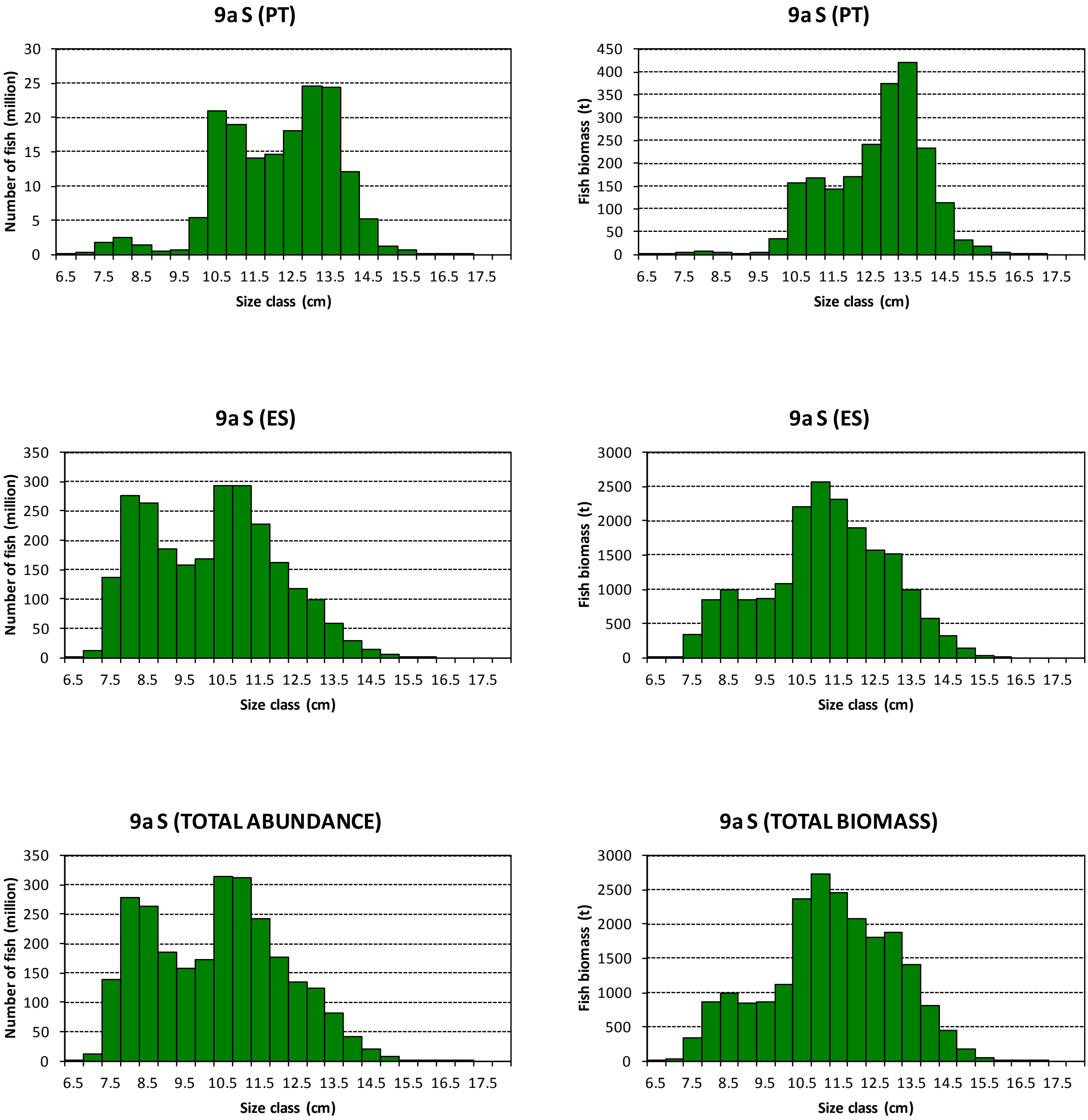


Figure 4.3.2.11. Anchovy in Division 9.a. Subdivision 9.a South. *ECOCADIZ 2015-07* survey (summer Spanish acoustic survey in Subdivision 9a South). Estimated abundances and biomasses (number of fish in millions and tonnes, respectively) for the surveyed area by length class (cm). Note the different scales in the y axis.

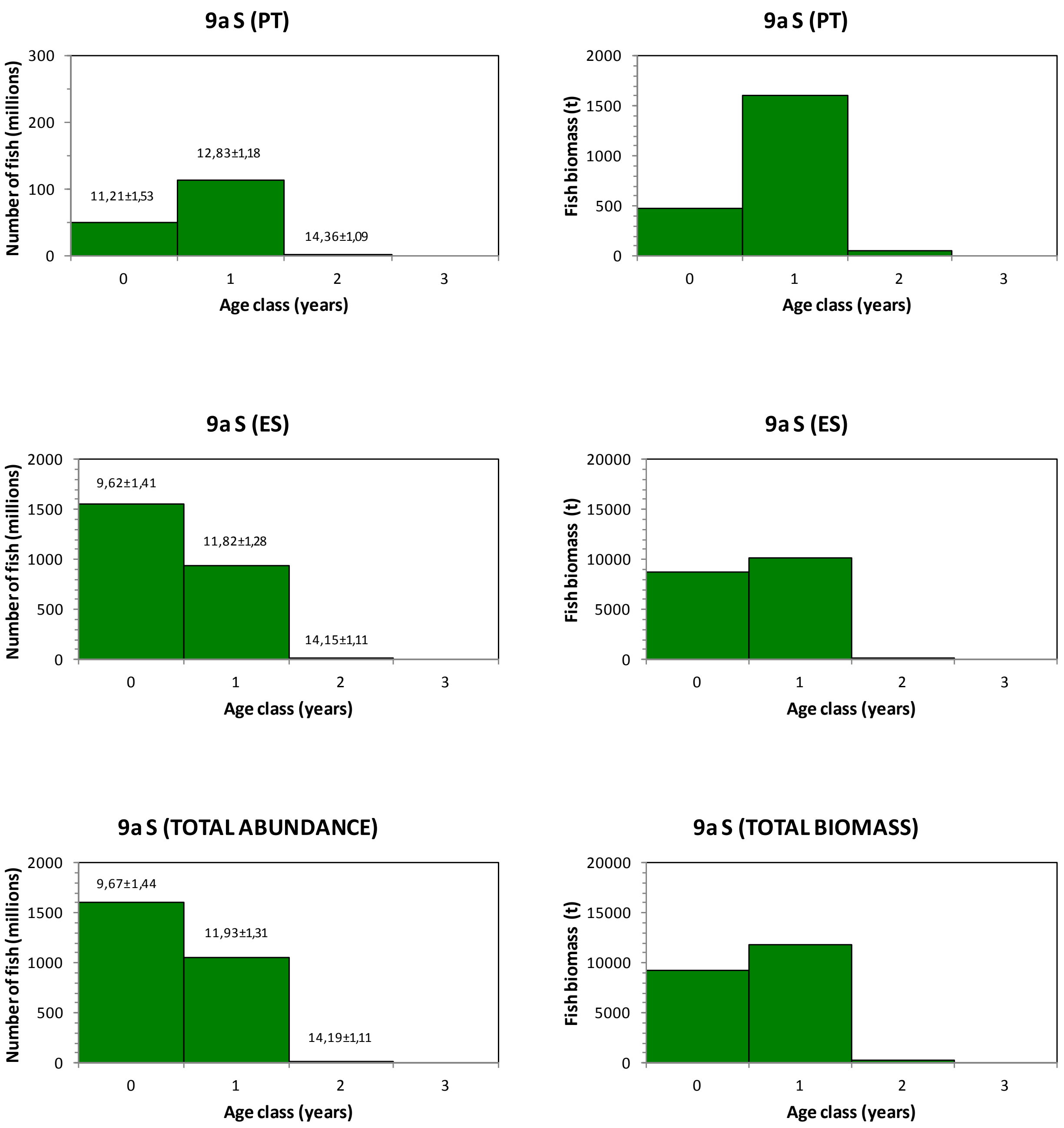


Figure 4.3.2.12. Anchovy in Division 9.a. Subdivision 9.a South. *ECOCADIZ 2015-07* survey (summer Spanish acoustic survey in Subdivision 9.a South). Estimated abundances and biomasses (number of fish in millions and tonnes, respectively) for the surveyed area by age group, with indication of the mean size by age. Note the different scales in the y axis.

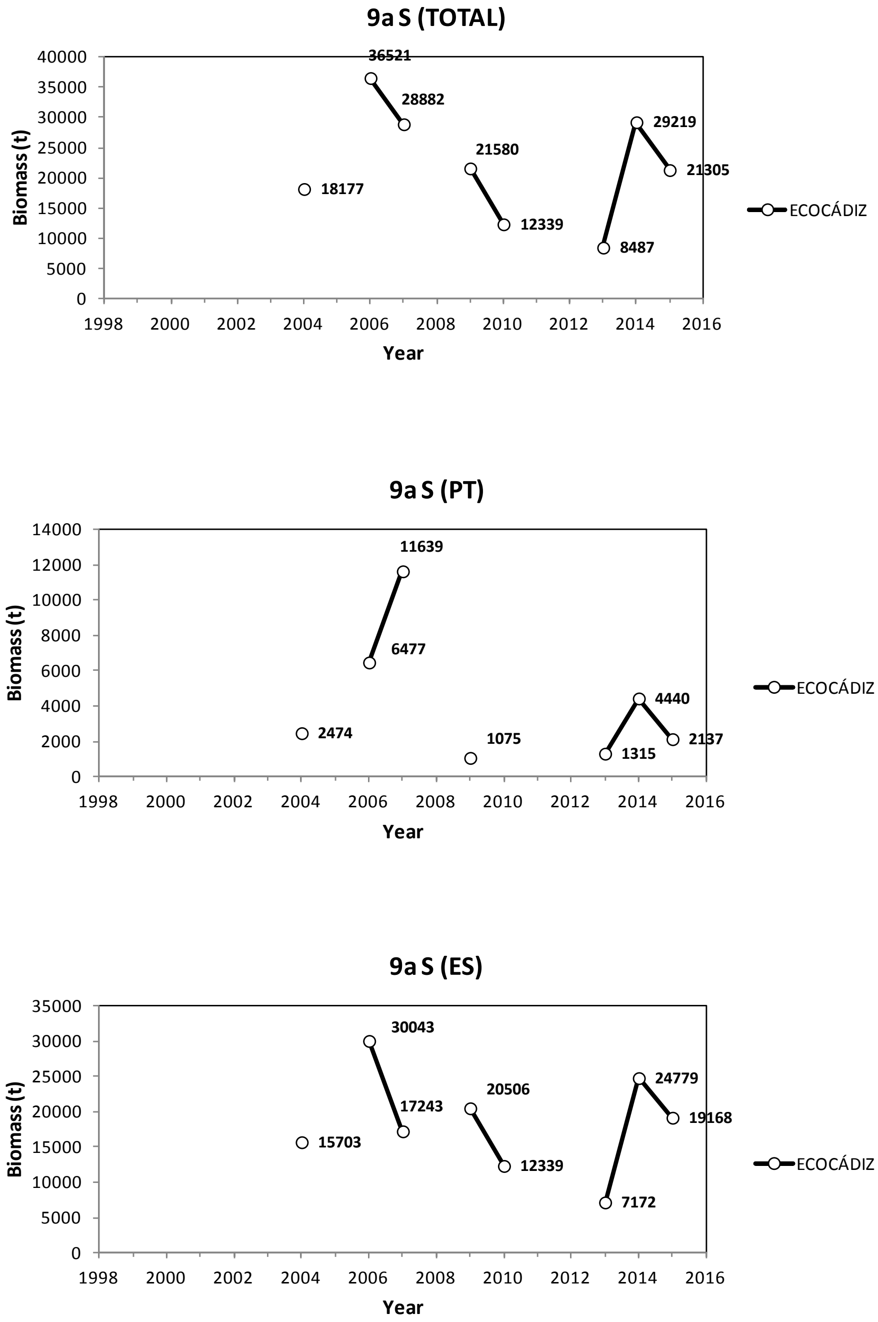


Figure 4.3.2.13. Anchovy in Division 9.a. Subdivision 9.a South. *ECOCADIZ* survey series (summer Spanish acoustic survey in Subdivision 9.a South). Historical series of overall and regional (Portuguese, PT, and Spanish waters of the Gulf of Cádiz, ES) acoustic estimates of anchovy biomass (t). Note the different scale of the y-axis.

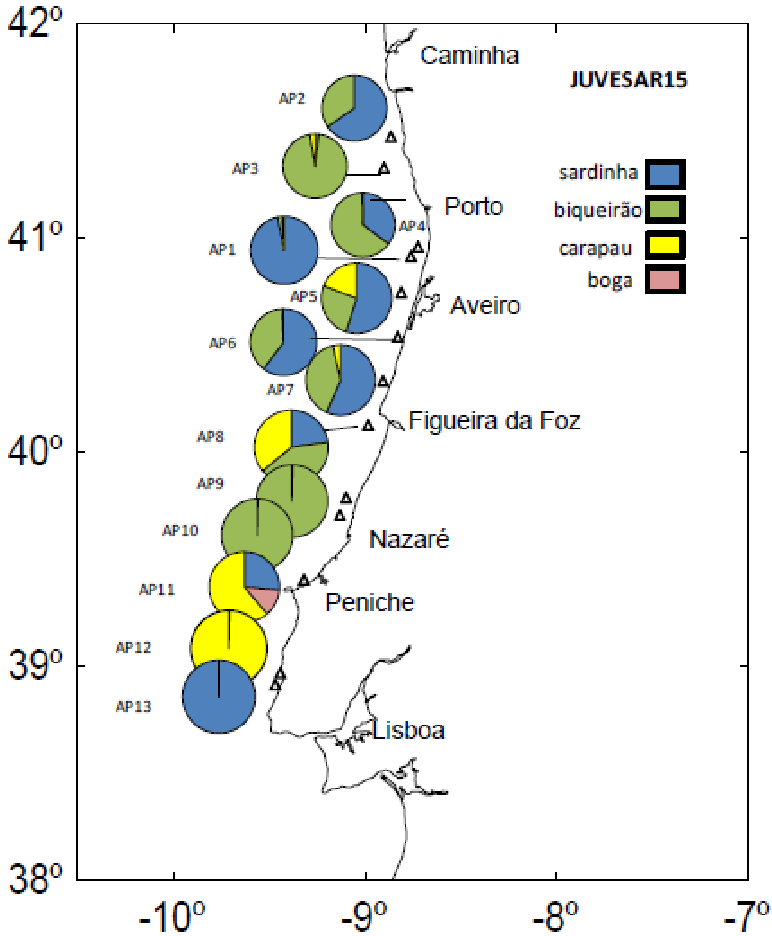


Figure 4.3.3.1. Anchovy in Division 9.a. Subdivision 9.a Central-North. *JUVESAR 15* survey (autumn Portuguese acoustic survey in Subdivision 9.a Central-North). Fishing trawls location and hauls species composition (in number).

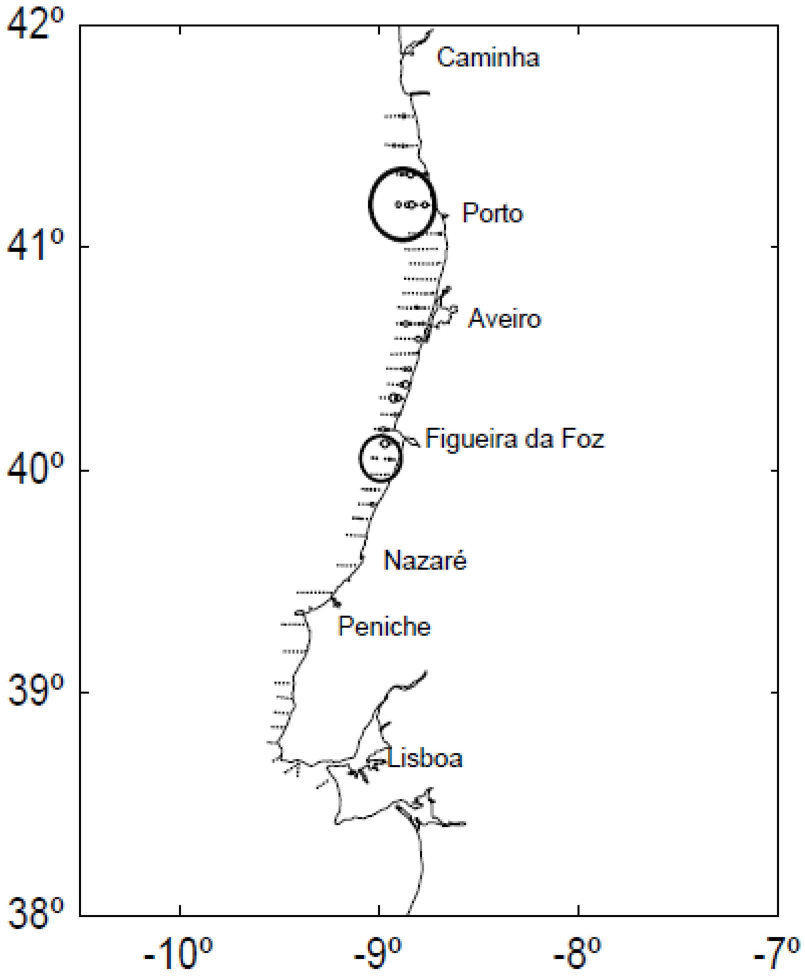


Figure 4.3.3.2. Anchovy in Division 9.a. Subdivision 9.a Central-North. *JUVESAR 15* survey (autumn Portuguese acoustic survey in Subdivision 9.a Central-North). Distribution of the NASC coefficients (m^2/mn^2) attributed to anchovy. The maximum diameter of circles corresponds to a NASC= 14 700 m^2/mn^2.

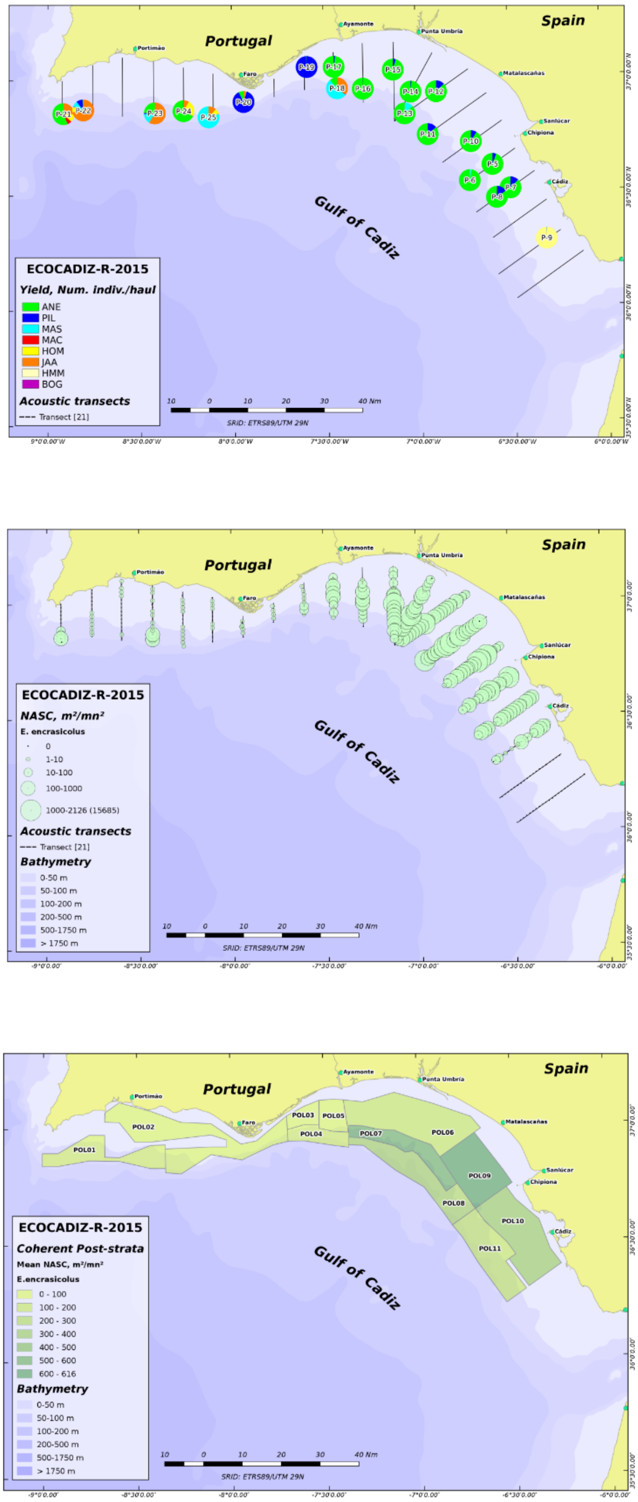


Figure 4.3.3.3. Anchovy in Division 9.a. Subdivision 9.a South. *ECOCADIZ-RECLUTAS 2015-10* survey (autumn Spanish acoustic survey in Subdivision 9.a South). Top: Location of valid fishing stations with indication of their species composition (percentages in number).Middle: Distribution of the backscattering 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.

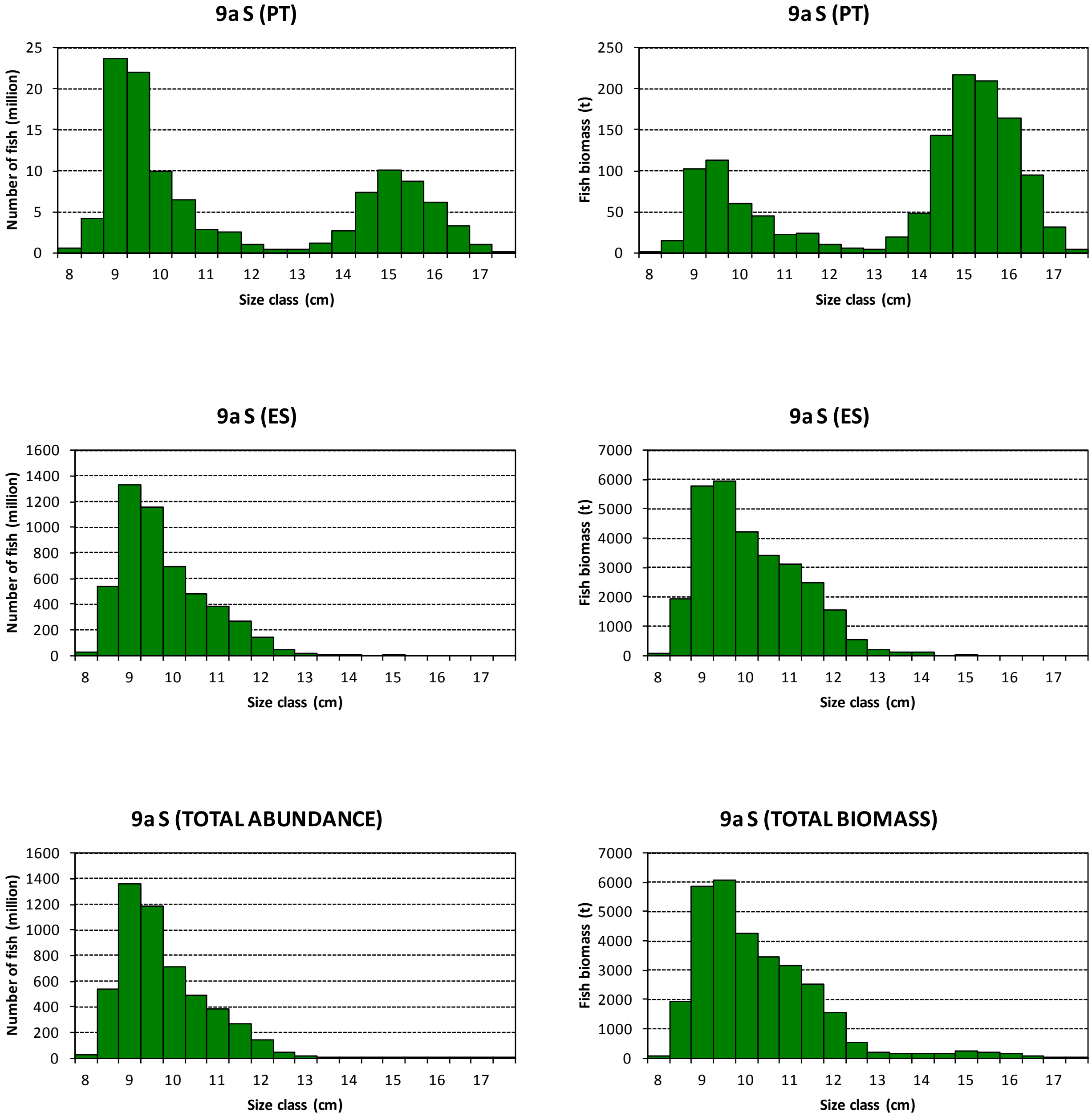


Figure 4.3.3.4. Anchovy in Division 9.a. Subdivision 9.a South. *ECOCADIZ-RECLUTAS 2015-10* survey (autumn Spanish acoustic survey in Subdivision 9.a South). Estimated abundances and biomasses (number of fish in millions and tonnes, respectively) for the surveyed area and country by length class (cm). Note the different scales in the y axis.

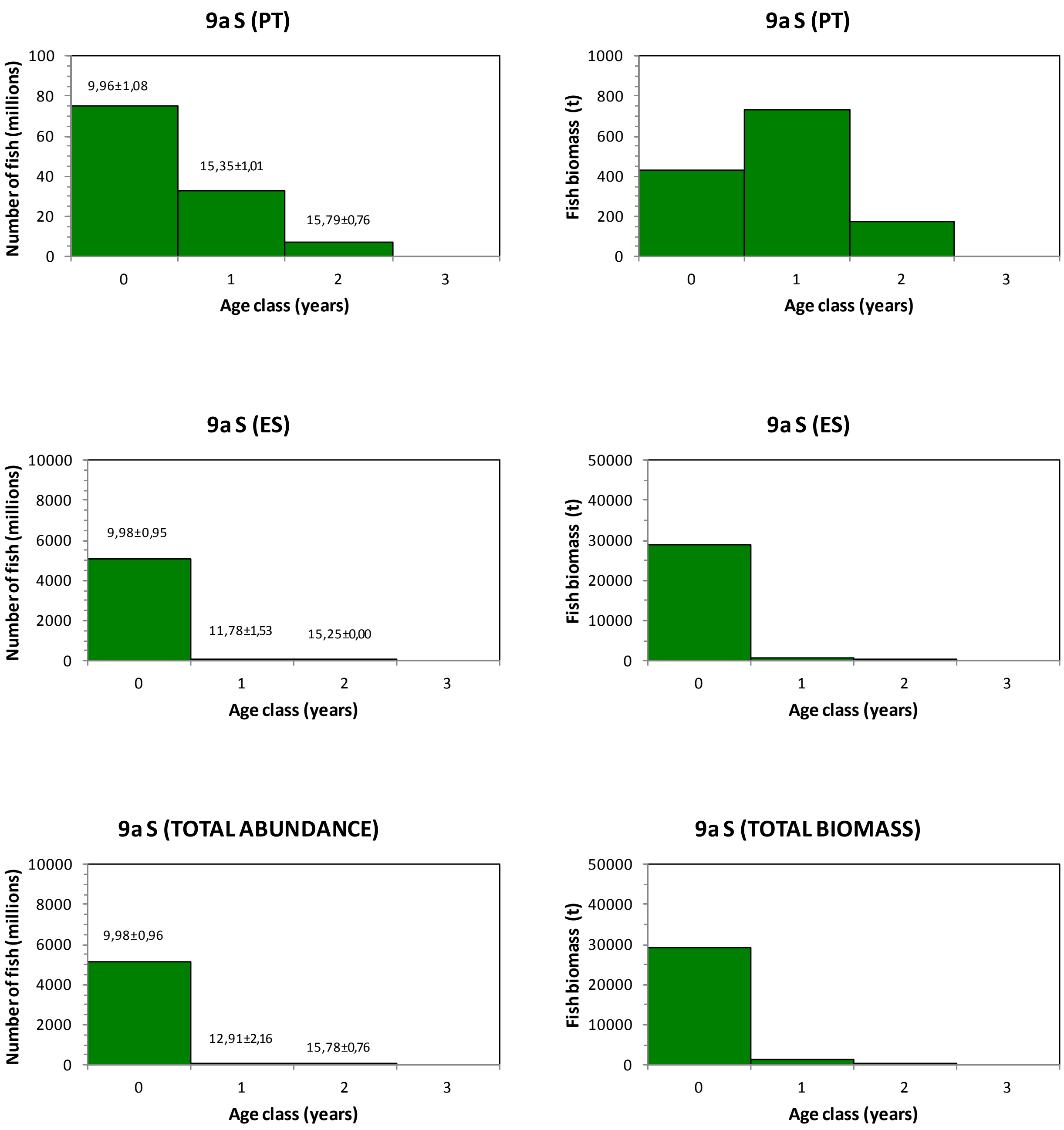


Figure 4.3.3.5. Anchovy in Division 9.a. Subdivision 9.a South. *ECOCADIZ-RECLUTAS 2015-10* survey (autumn Spanish acoustic survey in Subdivision 9.a South). Estimated abundances and biomasses (number of fish in millions and tonnes, respectively) for the surveyed area and by country by age group, with indication of the mean size by age. Note the different scales in the y axis.

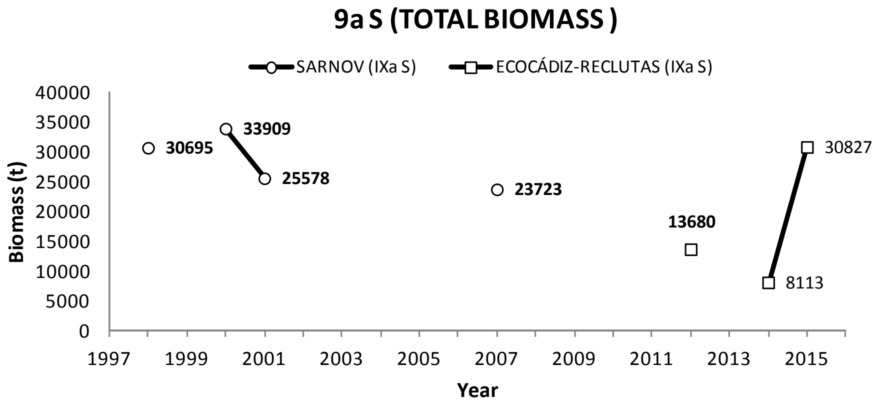


Figure 4.3.3.6. Anchovy in Division 9.a. Subdivision 9.a South. *ECOCADIZ-RECLUTAS* survey series (autumn Spanish acoustic survey in Subdivision 9.a South). Historical series of overall acoustic estimates of anchovy biomass (t), (squares). The estimates from the older Portuguese SARNOV survey series are also included for comparison of trends (circles).

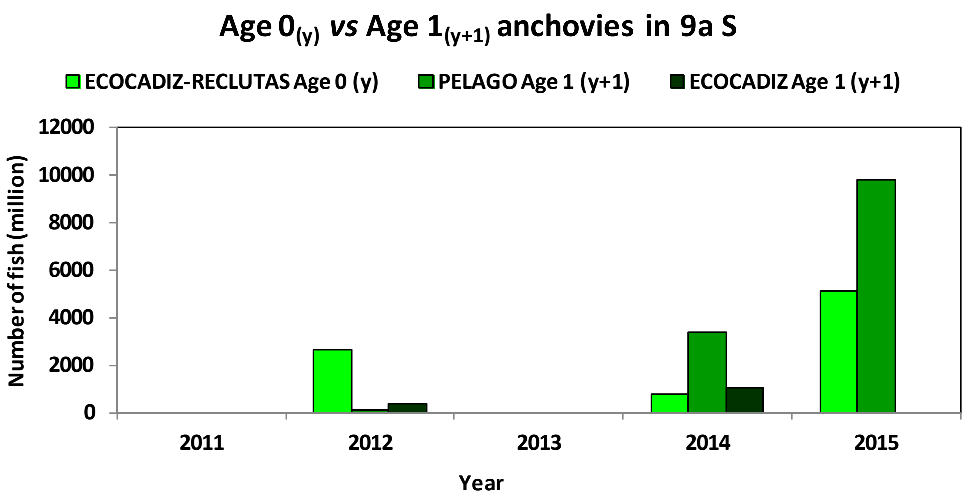


Figure 4.3.3.7. Anchovy in Division 9.a. Subdivision 9.a South. *ECOCADIZ-RECLUTAS* survey series (autumn Spanish acoustic survey in Subdivision 9.a South). Correspondence between acoustic estimates of abundance of Age 0 anchovies from *ECOCADIZ-RECLUTAS* surveys in the autumn of the year *y* against the abundance of Age 1 anchovies estimated in spring of the following year (*y+1*) by the *PELAGO* survey and in summer by the *ECOCADIZ* survey (no estimate for 2016 is still available for this last survey).

4.5 Assessment of the state of the stock

4.5.1 Previous data explorations

Data availability and some fishery (recent catch trajectories) and biological evidences were the basis for a previous data exploration of anchovy catch-at-age data in Subdivision 9.a South (Algarve and Gulf of Cadiz) until 2009 by applying an *ad hoc* seasonal (half-year) separable model implemented and run on a spreadsheet (Ramos *et al.*, 2001; ICES, 2002). Nevertheless, the exploratory assessments performed with this model were not recommended as a basis for predictions or advice due to they did not provide any reliable information about the true levels of the stock, F and Catch/SSB ratios since the assessment was not properly scaled. For the above reasons since 2009 it was preferred not to perform any exploratory assessment with this model. More details on the model settings and assumptions and its performance are described in the stock annex.

Upon request from the Workshop on the Development of Assessments based on life history traits and exploitation characteristics (WKLIFE), a first compilation and further exploration of available data on life-history traits (LHTs) of anchovy in Division 9.a was presented in the 2013 WG (ICES, 2013). Length-based reference points considered were: length (L_{mat}) at 50% maturity, von Bertalanffy growth parameters (Linf (L_{∞}), K, t_0), mean length at first capture (L_c, determined as the length at half of the maximum frequency in the ascending part of the curve), length where growth rate in weight is maximum (L_{opt}, where L_{opt}= 2/3 of *Linf* (L_{∞})), and the theoretical length resulting from fishing with F = M ($L_{(F=M)}$, where $L_{(F=M)}$= (3 * L_c+ *Linf*)/4). With weighted mean length in the catch (L_{mean}) as indicator (computed as the mean of fish larger than L_c), several of these population characteristics could be used as reference points to infer relative exploitation and relative stock status.

This exploratory analysis was focused in anchovy LHTs from the Subdivision 9.a South (Cadiz) because of the greater data availability. The resulting estimates seemed to suggest that the stock is supporting in its recent history a reasonable exploitation with L_{mean} above $L_{(F=M)}$ and very close to L_{opt} and L_c=L_{mat}. Nevertheless, WG members questioned the validity or appropriateness of these reference points for short-lived species like anchovy (with stocks and catches supported mainly by only age group and a fishery operating around spawning time). For the above reasons this exploratory analysis has not been updated since then.

4.5.2 Trends of biomass indices

Subdivision 9.a South

The provision of advice since 2009 has been traditionally restricted to Subdivision 9.a south as this is the only area showing a persistent population and fishery. It relies in an update of the qualitative assessment carried out in 2008 and accepted by the Review Groups of the 2008 and 2009 WGANC (2008 and 2009 RGANC). This qualitative assessment is based on the joint analysis of trends showed by the available data for the Subdivision 9.a South, both fishery-dependent and -independent information (i.e. landings, fishing effort, cpue, survey estimates). A summary of these trends for the Subdivision 9.a South is shown in Figures 4.5.2.1 and 4.5.2.2. They indicate a relatively stable stock status with little changes until 2009, without any evidence of serious problems: the drop of landings in 2008 and 2009 was caused by a parallel fall in the fishing effort. In fact, cpue is maintained relatively stable, and survey estimates, although variable did not show marked trends until 2009. The DEPM estimates, although uncertain, matched reasonable well with acoustic estimates. The relative levels of catches to biomass indexes (taken as absolute) suggested relatively acceptable levels of harvest rates until 2009 (of about ¼ the SSB index) (see an evaluation in Sections 4.5.2 and 4.7).

Since 2008 the acoustic estimates of biomass show a continuous declining trend which seems to reach an extreme situation in spring 2011, when no anchovy was detected in the *PELAGO* acoustic survey. However anchovy eggs sampled by CUFES during that survey were found at comparable or even higher levels than in the previous year 2010 during that acoustic survey, which was not consistent with the null detection of biomass with acoustics. The fishery maintained its normal activity throughout 2010 and

2011. Up to 2010 the cpue indices of the fleet did not show any declining trend. In addition, the *BOCADEVA* DEPM survey, conducted in July 2011, provided a new indication about the state of the anchovy biomass in 2011, pointing to an SSB estimate of 32 757 t. This confirmed that the reluctance of the WG to adopt the *PELAGO* estimate as a reliable indicator in that year was correct. *BOCADEVA* indicated a recovery of the biomass in 2011 up to levels above the average. Unfortunately, there was no indication about the state of the anchovy biomass in spring/summer 2012 since no survey index was available. The *ECOCADIZ-RECLUTAS 1112* autumn survey provided a partial estimate (since only the Spanish waters were surveyed) of 13 680 t in autumn 2012, which matches well with the estimates provided later by the *PELAGO* survey in spring 2013 (12 700 t) and by *ECOCADIZ* survey in summer that same year (8487 t). Both the 2014 spring and summer acoustic biomass estimates (at about 29 kt) indicate a recovery of the population levels to values slightly higher than the average ones in their respective historical series (23 kt and 21 kt respectively), a perception which is also confirmed by the *BOCADEVA* DEPM survey and which is still maintained in 2015, as evidenced by the *PELAGO* survey. Thus, landings suggest a rather stable situation for the fishery in this area, and the most recent population estimates suggest a stock in this area slightly above the average in 2014 and 2015 and, provisionally, well above the average in 2016. Results from the *ECOCADIZ* survey in late July this year will contribute to the perception about the state of the anchovy biomass in 2016. Table 4.5.2.1 and Figure 4.5.2.3 show the evolution of the stock size indicator computed for this subdivision and summarises the abovementioned trends. This indicator is estimated as the average of the annual estimates provided by each of the spring-summer surveys conducted in the subdivision. The rationale of this approach has been advanced before (see Section 4.3.2 and this section): uncertainties (i.e. a possible overestimation) in the anchovy acoustic assessment in the Spanish waters area and the strange situation found in 2011 by the *PELAGO* surveys and the gaps occurring in the *ECOCADIZ* series up to 2012, led to consider this averaging procedure under the assumption of equal catchabilities between surveys. Therefore, the data point in 2016 should be considered as provisional until it be conveniently averaged with the E*COCADIZ* counterpart.

Western Iberian shores (9.a North, Central-North and Central-South)

According to *PELAGO* survey the strongest outburst of anchovy biomass along the whole historical series has just happened in 2016 (38 kt; Table 4.5.2.1, Figures 4.5.2.4, 4.5.2.5). Previous outburst were recorded in 2008 (6 kt), 2011 (27 kt) and 2014 (8 kt). Anchovy population from 9.a Central-North was the main responsible for such outbursts. A former outburst of biomass might have happened in the mid-nineties, as a high record of catches appeared in 1995 (but acoustic surveys did only provide by then estimates of sardine and not of anchovy). The uncertainty about this phenomenon is its duration in time, as in the past these sudden outbursts have not been sustained in the following year.

Whole Division 9.a

Figure 4.5.2.6 shows a synoptic representation of the acoustic index from *PELAGO* and *PELACUS 04* over the total Division 9.a. The temporal evolution of the biomass stock size indicator is shown in Figure 4.5.2.7. Over the whole division there is a noticeably recovery of the anchovy throughout the 2014–2016 period. Anyway, a perception of a fluctuating resource without a neat trend will be inferred from the figure. However, we know that such perception is erroneous as the behaviour of the population is being quite different in the different subdivisions of the region. This puts in doubt the stock unit of the anchovy populations inhabiting this area and the suitability of the unified management applied to the fisheries on anchovy in the different subdivisions of Division 9.a (however, see management considerations about the definition of stocks in this area below).

4.5.3 Assessment of potential fishery Harvest Rates (HR) on anchovy in Subdivision 9.a South

A range of a likely potential Harvest Rates (HR) applied for the fishery on the anchovy in Subdivision 9.a South was directly tried in last years through the estimation of the quotient between total Catch (tons) and Survey Biomasses for a range of potential catchabilities of the surveys. This has been updated this year for the new surveys in 2015 and 2016. Given the rather consistent levels of biomass estimates provided by the acoustic and DEPM surveys applied in this area, the HR evaluation assumed equal catchability for all surveys. In addition, the range of catchabilities explored went from 0.6 to 1.6. The results of harvest rates for the different catchabilities are shown by years in Table 4.5.3.1. On average, for a catchability = 1, HR = 27.1% (CV of 0.41) and a maximum individual HR happens in 2013 with a HR of 49%. The sensitivity analysis for the range of selected catchabilities is at the bottom of Table 4.5.3.1. If catchabilities are higher than 1, the actual biomasses at sea would be lower and hence the HR will be higher than for catchabilities = 1, by a proportion equal to the catchability raising factor. As such for a catchability= 1.6 the average HR would be around 43.5% (CV of 0.41) and the maximum individual year value would rise up to 79.1%.

In the context of the Yield per Recruit analysis for Harvest Rates shown in Section 4.7, all the range of HR resulting from the former sensitivity analysis on the different q values, are at maximum, but generally well below the HR corresponding to the 50% SBR per recruit (= 0.78). As such, the Expected %SBR for the range of HR for this fishery resulting from sensitivity analysis above should generate Spawning Biomass per Recruit above 50% (see summary Table 4.5.3.2), thus the stock seems to be explored sustainable, for any potential catchability value below or equal to 1.6.

The exercise has not been repeated for the western subdivisions (9.a North to 9.a Central South), but notice that for the year of significant fishery, in 2011, a harvest ratio of about 13% can be derived from the merged acoustic estimates in these subdivisions (28 558 t) in relation to 3782 t of anchovy landings. This rate is even at a lower level than those ones estimated in the Subdivision 9.a South.

4.6 Prediction

There is no basis to predict the status of the anchovy population in 2017.

4.7 Yield per Recruit analysis and Reference Point on Harvest Rates

Although the current fishing pattern is uncertain, the matrix of catches-at-age allow to estimate the selectivities at-age (relative fishing mortalities at-age), which for an assumed natural mortality (M=1.2) would equal the relative catches at-age (in percentages). For a given selectivity at-age the Yield per Recruits can be computed straightforward. This section contains a sensitivity analysis of a Yield per Recruit analysis in terms of reference points for fishing mortality and Harvest Rates.

In 2012 we defined two vectors of relative catches at-age, generated from the catch statistics: a first vector corresponded to the average age composition in the period 1999–2011. A second vector corresponded with the catches in the earlier period and 2011 (years 1996, 1997, 1998 and 2011) when catches at-age 0 were more abundant. These two vectors are summarised in the text table below:

Mean catches at-age	Age 0	Age 1	Age 2	Age 3	Total
Mean 1999–2011	87.078	414.957	15.022	0.252	517.309
Percentage at-age	16.8	80.2	2.9	0.05	100

Mean catches at-age	Age 0	Age 1	Age 2	Age 3	Total
Mean 1996, 1997, 1998 & 2011	374.929	479.572	19.244	0.000	873.745
Percentage at-age	42.9	54.9	2.2	0.0	100

As the addition of the 2012–2015 catches would generate mean catches at-age for the period 1999–2015 almost equal to the period 1999–2011 (see table below), and it is somewhere in the middle between the one typical of the period 1999–2011 and that of the period 1996, 1997, 1998 and 2011.

Mean catches at-age	Age 0	Age 1	Age 2	Age 3	Total
Mean 1999–2015	94.563	430.209	13.502	0.193	538.467
Percentage at-age	17.6	79.9	2.5	0.0	100

Then the WG has decided not to remake the calculations associated to the sensitivity analysis which follows (as done in 2012). And as such the two catch-at-age vectors have remained constant and correspond with the two types of catches, one for the period 1999–2011 and the other for the period 1996, 1997, 1998 and 2011 (when ages 0 were more abundant in catches).

Mean weights-at-age in the catches for the same period were used for both the catches and the population. Maturity was assumed to be knife-edge like, full maturity and reproductive capacity at-age 1 (as estimated to happen here at least during the recent years and consistent with the biology of the anchovy in the Bay of Biscay as well).

As the selectivities required to reproduce the relative catches at-age can slightly change according to the actual level of fishing mortality (unknown) ,selectivities were fitted for a vector of potential F values at-age 1 (the age of reference) going from 0.2 to 1.4 in steps of 0.2. For each fitted selectivity at-age a Yield per Recruit analysis was made in terms of % of Spawning Biomass per Recruit (%SBR) for different levels of F multipliers and corresponding Harvest Rates (HR) (the quotient between catches in tonnes and Spawning Biomass). Spawning and surveying times were set to occur at the middle of the year. For the acoustic *ECOCADIZ* and DEPM *BOCADEVA* surveys this is correct, as they are made in June-July, though acoustic *PELAGO* survey is made in April.

Sensitivity to the vector of natural mortality was not made as it has been assumed to be constant across ages at an annual rate of 1.2, which given the extremely few ages 2 or older seems to be plausible value for this population.

The Y/R assessment was made with an Excel spreadsheet, which is laid down in the software folder of the Share point. The selectivities at different F at-age 1 levels were fitted with the Solver function. And the subsequent associated Y/R analysis is run with visual Basic macro in Excel.

Results for the first vector of relative catches at-age are shown in Table 4.7.1. Sensitivity of the selectivity at-age pattern to the concrete guessed level of F at-age 1 for which the selectivity was fitted is minor. As such, all reference points calculated, in terms of

Spawning Biomass per Recruit (at 50%, 40% and 35) as well as F_0.1, were rather similar across the potential alternative selectivities at-age (Table 4.7.1 a). Not surprisingly F_0.1 is rather similar to assumed M, but F_35%(SBR) and F_50%(SBR) fall to 0.53 and 0.34. The value of F_0.1 at 1.23 will certainly be not sustainable as it corresponds with a %SBR of about 11%. In terms of Harvest Rates, HR_35%(SBR) and HR_50%(SBR) are around 1.44 and 0.78. The potential for HR to exceed 1 comes from the fact that part of the catches are made on age 0 or age 1 prior to the spawning and first observations of the cohort at survey time. For the potential range of HR assessed for this fishery (with a mean and a maximum at 0.25 and 0.79, see Section 4.5.3), according to the selected range of potential survey catchabilities, it seems very likely that HR over the last 15 years are at or below HR_50%(SBR), so at sustainable levels.

For the second vector of catches at-age the sensitivity analysis did not differ much from the first analysis (Table 4.7.1 b). Results were again not much sensitive to the actual selectivity at-age of the fleet matching the 43% of age 0. A plot with the reference points for F and HR corresponding to the selectivity at-age fitted with a presumed F at-age 1 = 1 (as an example) are shown in Figure 4.7.1. Again F_0.1 is rather similar to assumed M, and F_(35%SPR) and F_50%(SPR) fall to 0.49 and 0.32. The value of F_0.1 was not sustainable, as it resulted in 10% of %SBR. Results in terms of Harvest Rates were rather coincident with the former analysis on the other vector of catches at age: HR_35%(SBR) and HR_50%(SBR) are around 1.5 and 0.79. As before, for the potential range of HR assessed for this fishery (with a mean and a maximum at 0.25 and 0.79, see Section 4.5.3), according to the selected range of potential survey catchabilities (from 0.6 to 1.6), it seems very likely that HR over the last 15 years are at or below HR_50%(SBR), so at sustainable levels.

4.8 Management considerations

4.8.1 Definition of stock units

A summarised description of the distribution of the main anchovy populations in NE Atlantic European waters is given in the stock annex. Traditionally, the distribution of anchovy in the Division 9.a has been concentrated in the Subdivision 9.a South (Figure 4.8.1.1.a), where about 99% of the population is usually encountered during the acoustic surveys, mainly in the Spanish waters of the Gulf of Cadiz. Outside the main nucleus of the Gulf of Cadiz, resilient anchovy populations were usually detected in all fishery-independent surveys (ICES, 2007 b, Figure 4.8.1.1.b). Occasionally large catches are produced in ICES Areas 9.a North and Central-North coincident with a sporadic raise up of the anchovy abundance in those areas, as for instance in 1995/1996 and in 2011. The Working Group has traditionally concentrated its exploratory analysis of the anchovy in Subdivision 9.a South, because it was the only persistent population in the area. The perception of the anchovy in other areas of 9.a is that they are marginal populations of independent dynamics from the anchovy population in 9.a South. As such the advice was based solely on the information coming from the anchovy in 9.a South (Algarve and Cadiz).

In 2014 the acoustic detection of anchovy biomass by *PELACUS* and *PELAGO* spring surveys in Subdivisions 9.a North to Central-North drop to 1947 t from 4284 t estimated in 2013. Contrary to this, the acoustic estimates in Subdivision 9.a South raised up to 28 917 t from 12 700 t estimated in the previous year (see Figures 4.5.2.2 and 4.5.2.3). Such data demonstrate the independent dynamics of the anchovy in the northern part of the 9.a from the dynamics of the population in 9.a south (with examples of a reversed situation in the period 1995/1996 and in 2011, see Figure 4.8.1.1.c).

This has a direct implication: there is no firm basis to consider the anchovy in Division 9.a as a single stock, given that the dynamics of the population (via their recruitment pulses) in the different areas are independent.

Ramos (2015) has recently reviewed the state of art of the studies on the stock identity of anchovy in 9.a. Thus, recent studies by Zarraonandía (2012) on the genetic structure of the European anchovy populations using single nucleotide polymorphisms (SNP) indicate that the Gulf of Cadiz anchovy (Subdivision 9.a South) is genetically different to the other samples in the Ibero-Atlantic coast, while is genetically similar to that of Alboran Sea (Spanish SW Mediterranean) (Figure 4.8.1.2). This genetic subdivision observed in Ibero-Atlantic coasts is in concordance with the morphological segregation pattern described by Caneco *et al.* (2004). That study suggests that the differences between areas could reflect slight adaptive reactions to small environmental differences.

In this context, the revision of this issue by Ramos (2015) was reviewed by the ICES Stock Identity Methods Working Group (SIMWG) just before the last year's WG meeting (ICES, 2015). SIMWG concluded that there is evidence to support a resident population in the Gulf of Cadiz (9.a South). However, SIMWG recognises there is still little information regarding the stock identity in the western and northern areas in the division and additional research to improve the understanding of the source of fish composing these local populations is needed. For these reasons, SIMWG recommends that the current stock structure stand for the time being, awaiting the results of the above requested studies, and also recommends the continued approach of employing spatially explicit management and monitoring of this stock through the division.

4.8.2 Current management situation

No EU management plan exists for the fisheries in Division 9.a.

The recent history of the regulatory measures in force for the anchovy fishery in the division (with a special reference to the Spanish fishery in the Gulf of Cadiz) is described in the stock annex. An updated information of such measures are given in the 2014 WG report (ICES, 2014). Since April 2013 Spain implemented a new management plan for fishing vessels operating in its national fishing grounds, so it affects the purse-seine fishing in Galician (9.a North) and Gulf of Cadiz waters (9.a South (CA)). One of the main measures in this new Plan is the introduction of an individual quota (IQ) system to allocate annual national quotas. In the case of the Gulf of Cadiz purse-seine fishery this measure involves to shift from a system of a fixed daily catch quota system for all the fleet to a new one based on the implementation of a IQ system managed quarterly by each fishery association after resolution of the National Fishery Administration on the annual allocation of the national quota by association.

By way of from Article 15(1) of Regulation (EU) No 1380/2013, which aims to progressively eliminate discards in all Union fisheries through the introduction of a landing obligation for catches of species subject to catch limits, the purse-seine fishery in ICES zones 8, 9. and 10 and in CECAF areas 34.1.1, 34.1.2 and 34.2.0 targeting anchovy has a final *de minimis* exemption to the quantities that may be discarded of up to a maximum of 2% in 2015 and 2016, and 1% in 2017, of the total annual catches of this species. STECF concluded that this exemption is supported by reasoned arguments which demonstrate the difficulties of improving the selectivity in this fishery. Therefore, the exemption concerned has been included in the Commission Delegated Regulation (EU) No 1394/2014 of 20 October 2014 establishing a discard plan for certain pelagic fisheries in southwestern waters.

Finally, the joint recommendation includes a minimum conservation reference size (MCRS) of 9 cm for anchovy caught in ICES Subarea 9 and CECAF area 34.1.2 with the aim of ensuring the protection of juveniles of that species. The STECF evaluated this measure and concluded that it would not impact negatively on juvenile anchovy, that it would increase the level of catches that could be sold for human consumption without increasing fishing mortality, and that it may have benefits for control and enforcement. Therefore, the MCRS for anchovy in the fisheries concerned should be fixed at 9 cm.

Results from the qualitative assessment described in Section 4.5 suggest that the anchovy population in the Subdivision 9.a South is a fluctuating population without any neat tendencies, even though it is assessed well above the average in 2016. Despite the likely drop of biomass in 2010 (according to the acoustic survey PELAGO), the DEPM estimates in 2011 and high levels of catches in this year suggest that biomass was about normal levels in 2011. The most recent population estimates from acoustic surveys in autumn and spring since 2014, although higher than average levels, don't contradict the abovementioned perception of fluctuating stock within the historical range. According to the Harvest rate analysis, exploitation seems to be sustainable. Therefore, it seems that catches can be allowed to remain at current mean levels.

In the absence of any recruitment index, neither for the anchovy in Subdivision 9.a South nor for the populations in the remaining Subdivisions of 9.a there is no sufficient information as to outline what the situation in 2017 will be.

4.8.3 Scientific advice and contributions

An in-depth evaluation of the possibilities of handling the above problems on the performance and suitability of the analytical model for the Subdivision 9.a South by other kinds of assessment models was out of reach for the WGHANSA. In that context, it may be productive to consider before any benchmark process a wide range of assessment approaches in an open-minded way. It is noted that most of the signals in the data are found in the catches at-age 1 in both semesters and at-age 0 in the second semester, in addition to the trends in the survey biomass measurements. It might be worth exploring the time signal in these data. Production models should also be explored, but large fluctuations of the catches over time raise some doubts about the stability of the carrying capacity.

The analyses of the data should also be viewed in the context of the management strategies that might be applied. The surveys have improved greatly in recent years, both through improvements of the acoustic surveys and the initiation of a DEPM survey. In addition, recent scientific efforts have improved the understanding of the biology of the stock. As stated in previous WG, these sources of information might become the core of a knowledge base for future management, which may not necessarily need to be dependent on analytic assessments. Alternative management regimes, like harvest rate rules based on survey information, could be examined by simulations.

In order to scale the assessment, additional DEPM estimates will also be required.

4.8.4 Species interaction effects and ecosystem drivers

Anchovy is a prey species for other pelagic and demersal species, and for cetaceans and seabirds.

The anchovy population in Subdivision 9.a-South appears to be well established and relatively independent of populations in other parts of the division. These other populations seem to be abundant only when suitable environmental conditions occur, while during unfavourable conditions they seem to be restricted to the river and "rías" estuaries (Ribeiro *et al*., 1996).

The recruitment depends strongly on environmental factors. Ruiz *et al*. (2006, 2007) evidenced the clear influence that meteorological and oceanographic factors have on the distribution of anchovy early life stages in shelf waters of the northeastern sector of the Gulf of Cadiz (9.a-South). The shallowness of the water column, the influence of the Guadalquivir River, and the local topography favour the existence of warm and chlorophyll-rich waters in the area, thus offering a favourable environment for the development of eggs and larvae. However, spring and early summer easterlies bursts may cause: a) a decrease of the water temperature by several degrees, b) generate oligotrophic conditions in the area, and c) force the offshore transport of waters over this portion of the shelf, advecting early life stages away from favourable conditions. These negative influences on the development conditions of anchovy eggs and larvae can impact on the recruitment of this species in the Gulf of Cadiz and subsequently in the anchovy fishery.

In this context, Ruiz *et al*. (2009) recently implemented the Bayesian approach for a state–space model of Gulf of Cadiz anchovy life stages. The model is used to infer 17 years (1988–2004) of stock size in the Gulf of Cadiz. Its population dynamics was modelled under the influence of the physical environment and connected to available observations of sea surface temperature, river discharge, wind, catches, catch per unit of effort, and acoustic records, as available. The model diagnosed values that are consistent with independent observations of anchovy early life stages in the Gulf of Cadiz. It was also able to explain the main crises historically recorded for this fishery in the region (e.g. in 1995–1996).

As previously described, the Gulf of Cadiz anchovy population has also experienced a noticeable decreasing trend during the period 2008–2010 as a probable consequence of successive failures in the recruitment strength in those years (ICES, 2011). A man-induced alteration of the nursery function of the Guadalquivir estuary, caused by episodes of highly persistent turbidity events (HPTE; González-Ortegón *et al*., 2010), during the anchovy recruitment seasons in 2008, 2009 and 2010 could be one plausible explanation. Thus, the control of the Guadalquivir River flow, from a dam 110 km upstream, has an immediate effect on the estuarine salinity gradient, displacing it either seaward (reduction) or upstream (enlargement of the estuarine area used as nursery). This also affects the input of nutrients to the estuary and adjacent coastal areas. The abovementioned HPTEs used to start with strong and sudden freshwater discharges after relatively long periods of very low freshwater inflow and caused significant decreases in abundances of anchovy recruits and the mysid *Mesopodopsis slabberi*, its main prey.

All of these evidences confirm that the Gulf of Cadiz anchovy population relies on recruits to persist and, therefore, is highly vulnerable to ocean processes and totally controlled by environment fluctuations.

4.8.5 Ecosystem effects of fisheries

The purse-seine fishery is highly mono-specific, with a low level of reported bycatch of non-commercial species. Information gathered from observers' at sea sampling programs and interview-based surveys indicate, at least for the western waters of the Iberian Peninsula façade, a low impact on the common dolphin population (Wise *et al*., 2007), but less data are available on seabird and turtle bycatch. Other species such as pelagic crabs are released alive and it is likely that the inflicted mortality is low.

4.9 Indicators and thresholds to trigger new advice

Anchovy, as a short-lived species, requires updated assessment every year since the population is basically sustained by the recruited year class (at-age 1), so no indicator to trigger advice is required for this species.

Criteria for reopening the advice in the autumn based on summer survey: The advice provided in June every year is informed by the Spring acoustic surveys *PELACUS–PELAGO*. Currently advice is provided split into two regions: one for Subdivision 9.a South (Cadiz and Algarve) and the other for the remainder northern areas of Division 9.a. For the Subdivision 9.a South, a survey is carried out after the June advice; this is the summer acoustic survey *ECOCADIZ*. Since 2013 on this survey is being conducted annually. This survey could trigger revision of the split advice for this Subdivision 9.a South in case of contradicting the tendencies observed by *PELAGO* in this area (as happened in 2011). A threshold level for the changes in the relative tendencies cannot be established easily at this stage as it would depend on the DLS method being applied (which is not clear) and whether we are in the second of the two consecutive years or not. *Ad hoc* approaches should be considered according to the series available in case of perceived contradictory information.

4.10 Benchmark preparation (ToR b)

The Benchmark for anchovy in 9.a, initially foreseen for 2014 and postponed in the last year's WG to 2017, is recommended to be delayed again until some progresses be achieved, basically due to limited man power and to allow for the new progresses will be achieved in the benchmark preparation during both this year and the next one to be examined in the next WGACEEG (issues related with surveys) and WGHANSA meetings (e.g. advances achieved in the exploration of the stock assessment method). In this context, the issue related to the stock identity of anchovy in 9.a was reviewed by the ICES Stock Identity Methods Working Group (SIMWG) just before the last year's WG meeting by using information previously compiled by the stock coordinator (Ramos, 2015), and their conclusions and recommendations have been described in Section 4.8.1. Data availability from the fishery, surveys and biological parameters is at present being re-examined through the Division in order to achieve a consistent data base (with a suitable geographical and time coverage) which satisfies the usual requirements of any assessment model (including those applicable to data-limited stocks) as well as those ones of the future specific compilation data workshop. The data compilation/exploration is including age–length data, maturity ogives, and other biological parameters considered in the assessment. This exercise is also being applied to the information coming from the surveys. A review of discarding/slipping practices, ratios and estimates in the anchovy fishery through the division is also planned to be carried out and reported as a working document for the benchmark workshop.

As surveys are concerned, the exploration of the results from inter-calibration exercises between *PELACUS* and *PELAGO* surveys for anchovy is still pending, but is expected that some review referred to anchovy in 9.a be presented in the next WGACEGG and/or WGHANSA.

Approaches (empirical, etc.) available to derive the estimate of natural mortality have not been explored yet.

The exploration of the assessment model is still in the very initial phase. Results from some trials with different models (generalised, DLS based, etc.) may be available for next year's WG. Somewhat more problematic could be the selection of the most suitable age-structured assessment model to this stock. Stock synthesis model is the model used at present for the Ibero-Atlantic sardine stock, and, originally, was firstly used with the northern anchovy (*Engraulis mordax*, Methot, 1986, 1989), although this anchovy species shows a rather more structured population than the European anchovy in Division 9.a and, specially, in the Gulf of Cadiz. In any case, SS3 it would be a possible candidate to be explored. Alternatively, a single-species GADGET model with the Gulf of Cadiz anchovy as a study case is being developed within the frame of the FP7 EU MAREFRAME research project. This model is making use of the information reported by the WG and the stock coordinator has initially been contacted by the project's researchers to provide advice on data characteristics, biological parameters, and fishery behaviour. In the interim between WGHANSA meetings it is expected a greater implication of the stock coordinator in the discussion on the suitability of the model inputs and preliminary outputs. Notwithstanding the above, these preliminary results may be available for the next WGHANSA meeting, but not before.

Table 4.5.2.1. Anchovy in Division 9.a. Series of annual estimates of each of the biomass stock size indicators derived for the western (Subdivisions 9.a N to 9.a CS) and southern (Subdivision 9.a South) stock components and the whole division, with indication of the surveys indices used in the computation of the indicator and the method of computation.

	Western component	Southern component	
	PELACUS+PELAGO	PELAGO+ECOCADIZ +BOCADEVA	
	9.a N to 9.a CS	9.a S	DIVISION IXa
Year	SUM OF ESTIMATES	MEAN ESTIMATE	SUM OF ESTIMATES
1999	596	24763	25359
2000			
2001	368	24913	25281
2002	1542	21335	22877
2003	112	24565	24677
2004		18177	18177
2005	1062	14339	15401
2006	0	30301	30301
2007	1945	33451	35396
2008	5811	32845	38655
2009	2115	23163	25278
2010	1230	9867	11097
2011	28558	16379	44937
2012			
2013	4284	10593	14878
2014	1947	29902	31849
2015	8237	27203 *	35440 *
2016	38507	65345**	103852**

*** Recalculated after averaging with ECOCADIZ 2015 estimate available in this WG. ** Provisional estimate. Needs to be averaged with ECOCADIZ estimate derived after WG in late July.**

Table 4.5.3.1. Anchovy in Division 9.a. Subdivision 9.a South. Assessment of yearly harvest rates on anchovy in the Gulf of Cadiz 9.a South) with the assumption of catchability equal 1 for all surveys (and averaging annual estimates).

BIOMASS																						
(tonnes)	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Mean	Desvest	CV	Max	Min
PELAGO (Acoustic)	24,763		24,913	21,335	24,565		14,041	24,082	38,020	34,162	24,745	7,395	failed		12,700	28,917	33,100	65,345	22,338	10583.6	47.4%	38,020	0
ECOCADIZ (Acoustic)						18,177		36,521	28,882		21,580	12,339			8,487	29,219	21,305		22,064	9269.8	42.0%	36,521	8,487
BOCADEVA (DEPM)							14,637			31,527			32,757			31,569			27,623	8675.7	31.4%	32,757	14,637
Mean Biomas (For q=1)	24,763		24,913	21,335	24,565	18,177	14,339	30,301	33,451	32,845	23,163	9,867	32,757		10,593	29,902	27,203		22,786	7580.9	33.3%	33,451	9,867
Catches	5,942	2,360	8,655	8,262	4,968	5,617	4,423	4,381	5,610	3,204	2,954	2,929	6,294	4,810	5,240	9,051	6,880		5,387	2003.0	37.2%	9,051	2,360
Harvest Rate (For Q=1)	24%		35%	39%	20%	31%	31%	14%	17%	10%	13%	30%	19%		49%	30%	25%		27%	11%	41%	49%	10%
Harvest Rate by Q levels																							
0.6	0.144		0.208	0.232	0.121	0.185	0.185	0.087	0.101	0.059	0.077	0.178	0.115		0.297	0.182	0.152		16.3%	6.6%	40.5%	29.7%	5.9%
0.8	0.192		0.278	0.310	0.162	0.247	0.247	0.116	0.134	0.078	0.102	0.237	0.154		0.396	0.242	0.202		21.8%	8.8%	40.5%	39.6%	7.8%
1	0.240		0.347	0.387	0.202	0.309	0.308	0.145	0.168	0.098	0.128	0.297	0.192		0.495	0.303	0.253		27.2%	11.0%	40.5%	49.5%	9.8%
1.2	0.288		0.417	0.465	0.243	0.371	0.370	0.174	0.201	0.117	0.153	0.356	0.231		0.594	0.363	0.303		32.7%	13.2%	40.5%	59.4%	11.7%
1.4	0.336		0.486	0.542	0.283	0.433	0.432	0.202	0.235	0.137	0.179	0.416	0.269		0.692	0.424	0.354		38.1%	15.4%	40.5%	69.2%	13.7%
1.6	0.384		0.556	0.620	0.324	0.494	0.493	0.231	0.268	0.156	0.204	0.475	0.307		0.791	0.484	0.405		43.5%	17.6%	40.5%	79.1%	15.6%

Table 4.5.3.2. Anchovy in Division 9.a. Subdivision 9.a South. Sensitivity assessment of the Status Quo exploitation of Anchovy in 9.a South to different levels of average catchability of surveys. For selectivity fixed at F age 1 of 1.

Sensitivity Assessment	0.6	0.8	1	1.2	1.4	1.6
Catchability of Surveys	q = 0.6	q = 0.8	q = 1	q = 1.2	q = 1.4	q = 1.6
Mean Harvest Rate (HR)	15.5%	20.7%	25.8%	31.0%	36.2%	41.3%
HR standard Deviation	6.7%	8.9%	11.1%	13.3%	15.6%	42.8%
CV	0.430	0.430	0.430	0.430	0.430	1.035
MIN (HR)	5.9%	7.8%	9.8%	11.7%	13.7%	15.6%
MAX (HR)	29.7%	39.6%	49.5%	59.4%	69.2%	79.1%
%SBR of Mean(HR)	83.2%	Not made	75.7%	Not made	68.5%	Not made
%SBR of Min(HR)	93.4%	Not made	89.0%	Not made	85.4%	Not made
%SBR of Max (HR)	72.8%	Not made	61.7%	Not made	53.4%	Not made

Table 4.7.1. Anchovy in Division 9.a. Subdivision 9.a South. Fishing mortality (F) and Harvest Rate (HR) reference points for a) the average age composition of the catches (1999–2011) and b) years with high presence of age 0 (1996, 1997, 1998 and 2011). Note: F reference points in terms of F_{bar} (ages 1–3).

a) First set of % of catches at-age (Average % of age 0 in catches = 17%)							F Reference Points				HR reference points			
ANALYSIS	Fitted selectivity	S_0	S_1	S_2	S_3	S_4+	F_SBR50%	F_SBR40%	F_SBR35%	F_0.1	HR_SBR50%	HR_SBR40%	HR_SBR35%	HR_0.1
Fitted at F (age 1)	0.02	0.0627	1.0000	0.1218	0.0074	0.0000	0.32	0.44	0.50	1.19	0.78	1.18	1.44	7.09
Fitted at F (age 1)	0.20	0.0580	1.0000	0.1372	0.0084	0.0000	0.33	0.44	0.51	1.20	0.77	1.17	1.44	6.94
Fitted at F (age 1)	0.40	0.0535	1.0000	0.1575	0.0099	0.0000	0.33	0.45	0.52	1.21	0.77	1.17	1.43	6.71
Fitted at F (age 1)	0.60	0.0494	1.0000	0.1822	0.0118	0.0000	0.34	0.46	0.53	1.23	0.78	1.17	1.44	6.51
Fitted at F (age 1)	0.80	0.0459	1.0000	0.2124	0.0143	0.0000	0.35	0.47	0.54	1.24	0.78	1.17	1.44	6.25
Fitted at F (age 1)	1.00	0.0428	1.0000	0.2502	0.0179	0.0000	0.36	0.48	0.56	1.26	0.78	1.16	1.46	6.02
Fitted at F (age 1)	1.20	0.0400	1.0000	0.2984	0.0225	0.0000	0.37	0.50	0.58	1.28	0.78	1.18	1.44	5.69
Fitted at F (age 1)	1.40	0.0374	1.0000	0.3618	0.0303	0.0000	0.39	0.52	0.60	1.30	0.79	1.18	1.45	5.36

b) Second set of Catches at age (Average % of age 0 in catches = 43%)							F Reference Points				HR reference points			
ANALYSIS	for a selectivity	S_0	S_1	S_2	S_3	S_4+	F_SBR50%	F_SBR40%	F_SBR35%	F_0.1	HR_SBR50%	HR_SBR40%	HR_SBR35%	HR_0.1
Fitted at F (age 1)	0.20	0.2121	1.0000	0.1522	0.0000	0.0000	0.27	0.37	0.42	1.10	0.79	1.21	1.49	9.97
Fitted at F (age 1)	0.60	0.1760	1.0000	0.2029	0.0000	0.0000	0.29	0.39	0.46	1.14	0.79	1.19	1.50	8.67
Fitted at F (age 1)	1.00	0.1493	1.0000	0.2805	0.0000	0.0000	0.32	0.43	0.49	1.19	0.79	1.21	1.48	7.65
Fitted at F (age 1)	1.40	0.1291	1.0000	0.4112	0.0000	0.0000	0.34	0.46	0.54	1.24	0.79	1.18	1.49	6.54

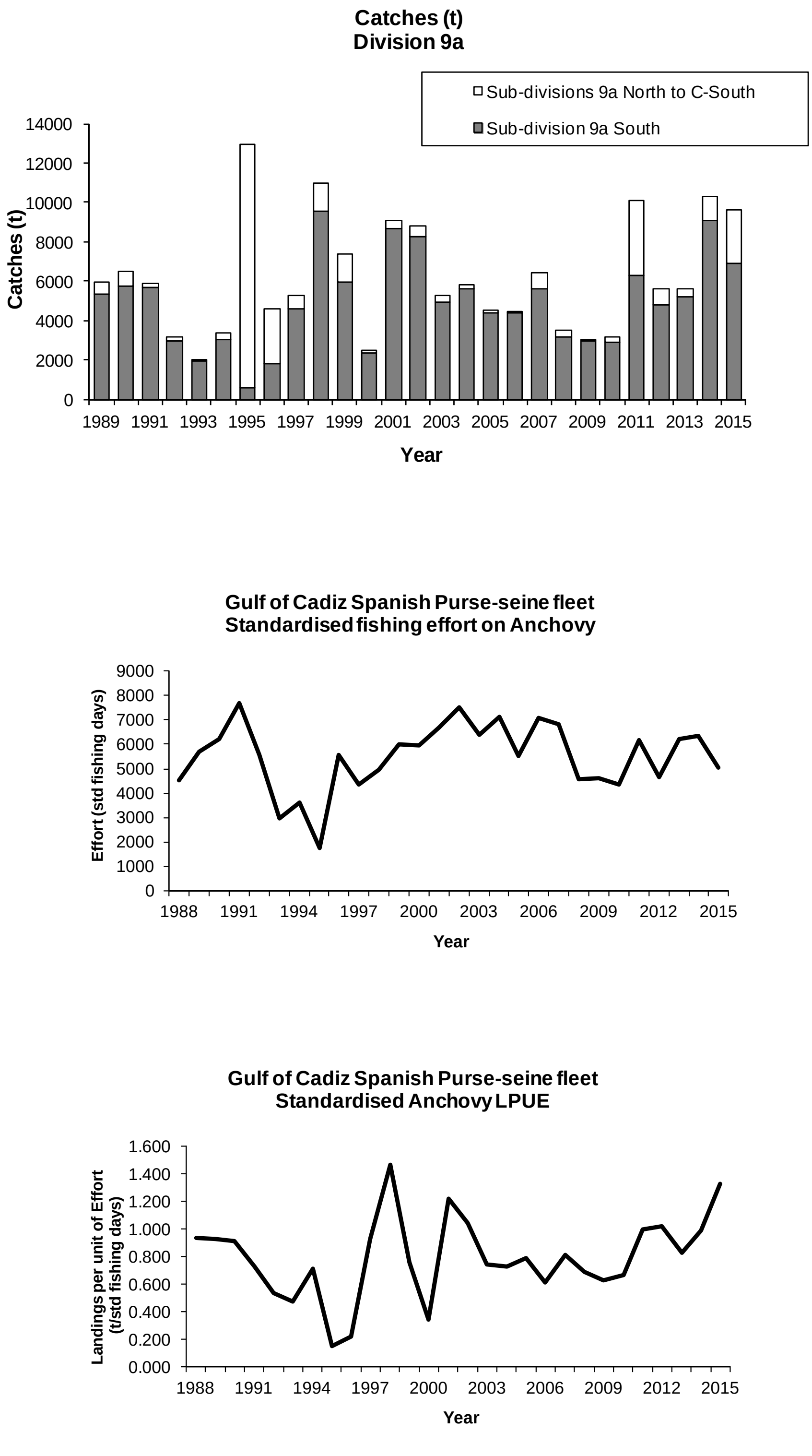
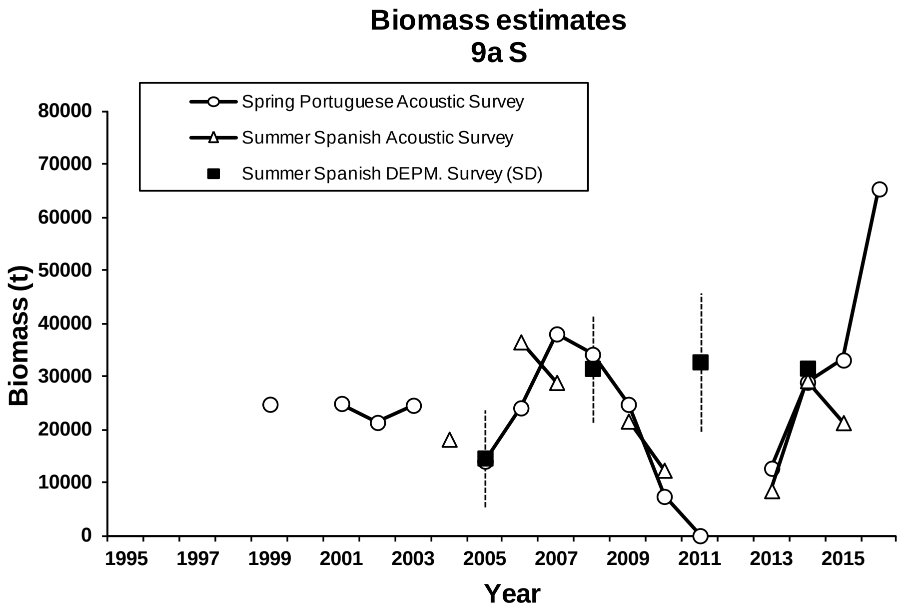


Figure 4.5.2.1. Anchovy in Division 9.a. Anchovy in Subdivision 9.a South. Information used in the Qualitative (Updated) Assessment. Top: total annual landings in Division 9.a differentiated between Subdivision 9.a South (PT + ES) and remaining Sub-divisions. Middle: standardised fishing effort (fishing days) exerted by the Spanish purse-seine fleet in the subdivision. Bottom: standardised anchovy lpue (tonnes/fishing day) of the same fleet.



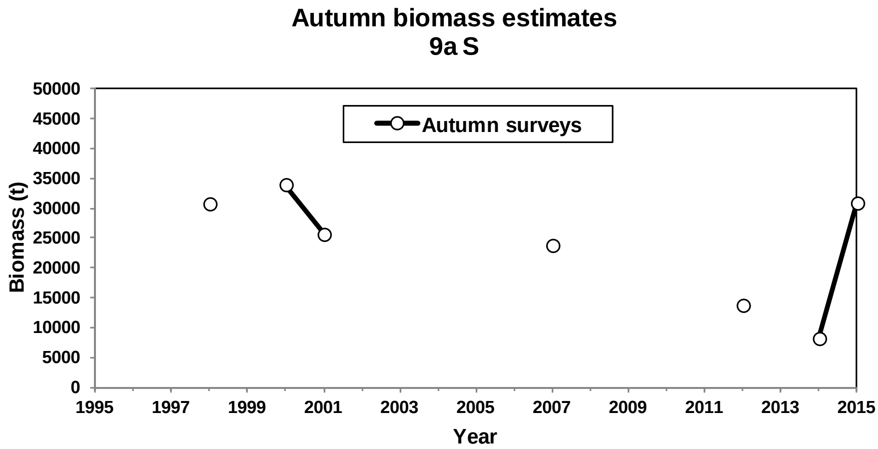


Figure 4.5.2.2. Anchovy in Division 9.a. Anchovy in Subdivision 9.a South. Information used in the Qualitative (Updated) Assessment (cont'd). Top: available biomass estimates from research surveys series sampling the subdivision in spring/summer used for comparative purposes. There are no available estimates in 2012. Bottom: available biomass estimates from research surveys series sampling the subdivision in autumn. *SARNOV* (1998, 2000, 2001, 2007) and *ECOCÁDIZ-RECLUTAS* (2012, 2014, 2015) surveys have been merged in one only series.

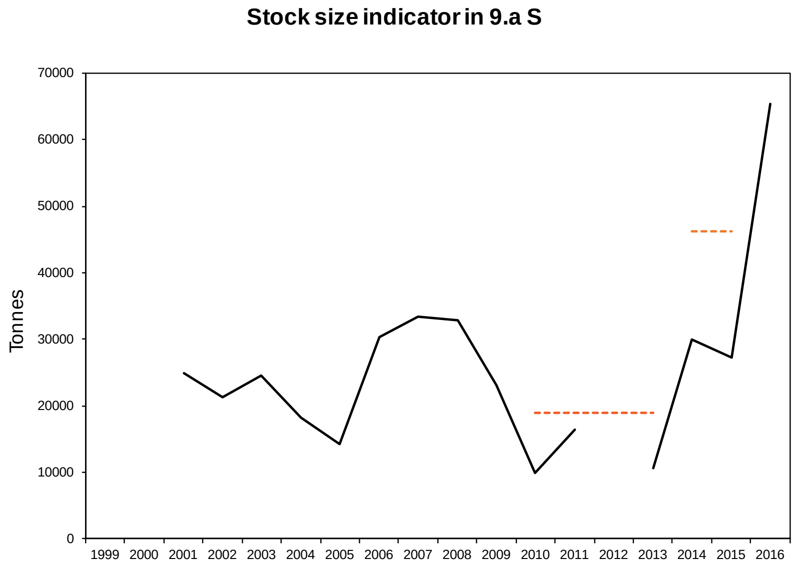


Figure 4.5.2.3. Anchovy in Division 9.a. Anchovy in Subdivision 9.a South. Information used in the Qualitative (Updated) Assessment: annual series of the Biomass Stock Size Indicator (in tonnes). This indicator is computed as the average of annual available survey estimates (the acoustic *PELAGO* and *ECOCADIZ* surveys and the DEPM *BOCADEVA* survey). Note that the 2015 datapoint has been re-computed after averaging with *ECOCADIZ* 2015 estimate and that 2016 datapoint is now a provisional estimate since it corresponds only to the *PELAGO* estimate and it has not been still averaged by the *ECOCADIZ* one (this survey will be conducted in late July–early August).

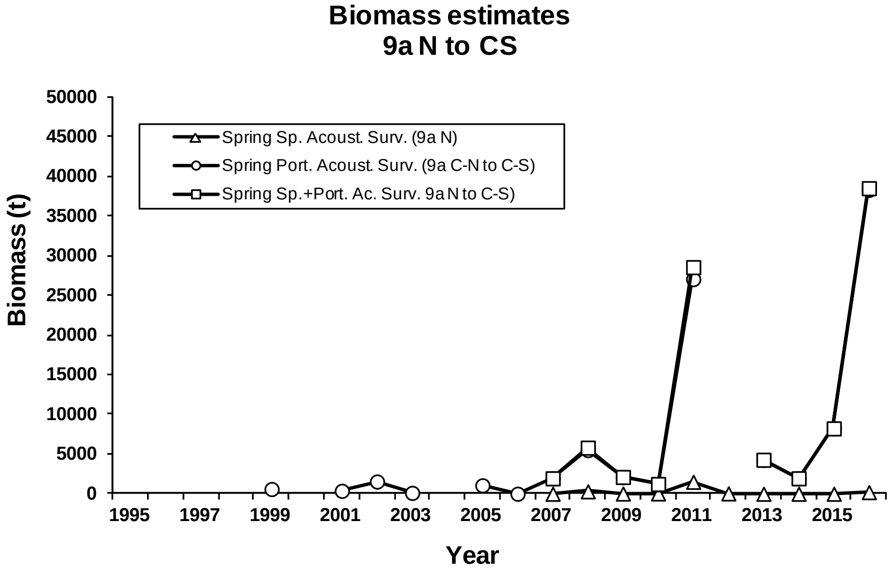


Figure 4.5.2.4. Anchovy in Division 9.a. Anchovy in Subdivisions 9.a North to Central-South (Western Iberian Atlantic façade). Information used in the Qualitative (Updated) Assessment: available biomass estimates from research surveys series sampling the subdivisions used for comparative purposes. For 2012 the only available estimates is the one from the *PELACUS 03* survey for 9.a North.

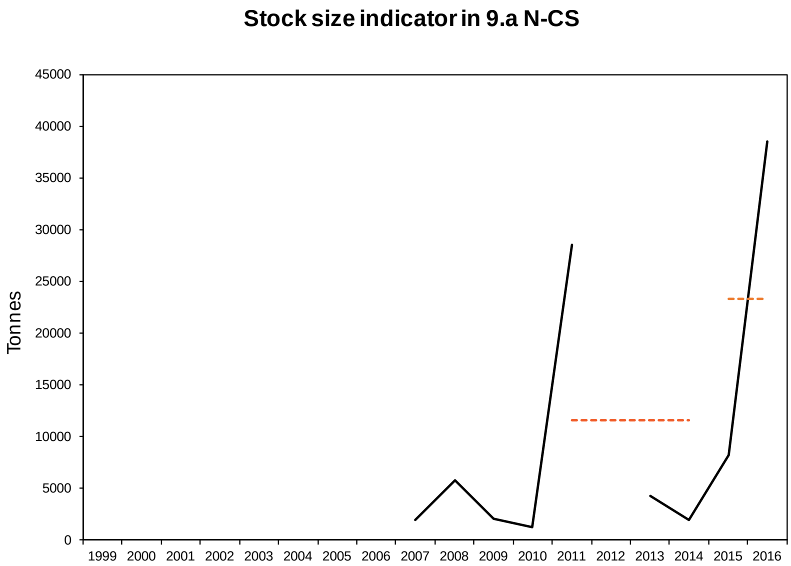


Figure 4.5.2.5. Anchovy in Division 9.a. Anchovy in Subdivision 9.a North to Central-South (Western Iberian Atlantic façade). Information used in the Qualitative (Updated) Assessment: annual series of the Biomass Stock Size Indicator (in tonnes). This indicator is computed as the sum of annual available survey estimates (the acoustic *PELACUS* and *PELAGO* surveys).

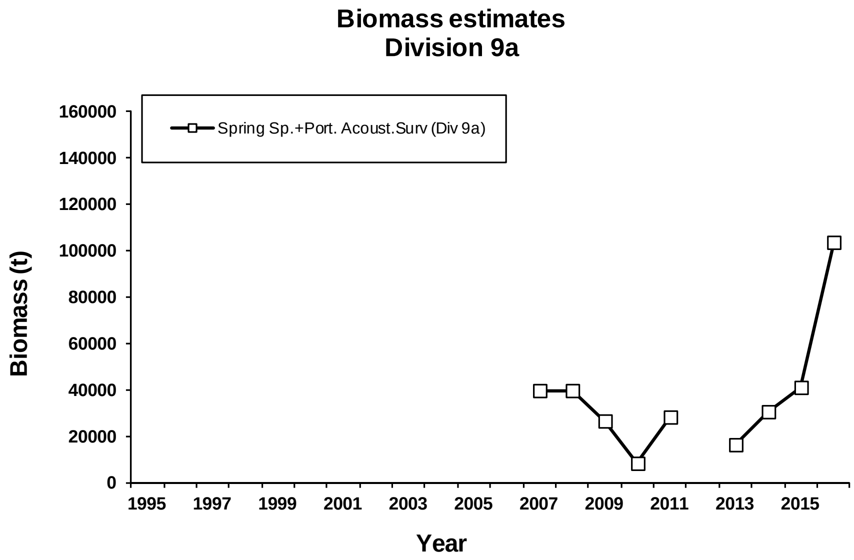


Figure 4.5.2.6. Anchovy in Division 9.a. Information used in the Qualitative (Updated) Assessment of the whole division: available biomass estimates from research surveys series sampling the division. For consistency, when merging estimates for the whole division, only spring surveys (both *PELACUS 04* and *PELAGO*) have been considered.

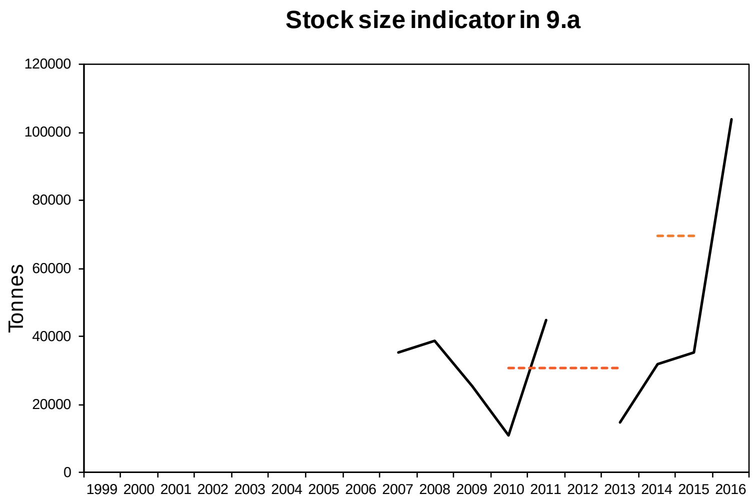
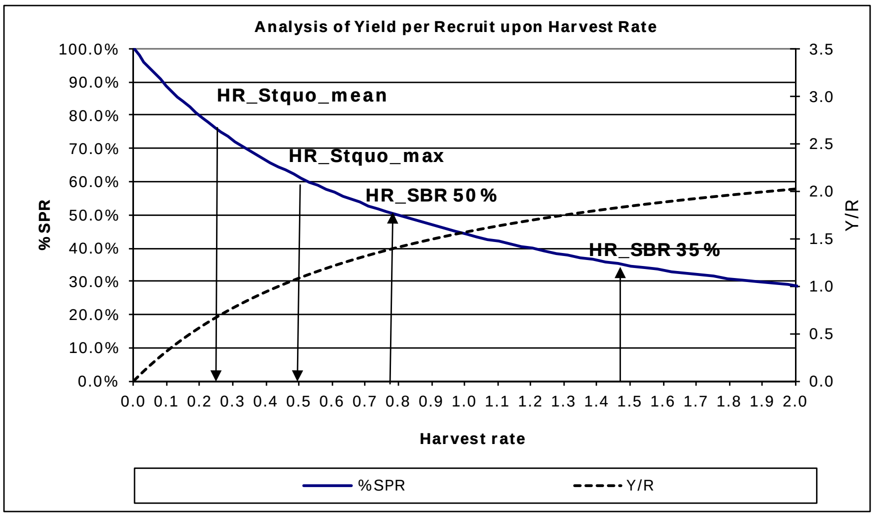


Figure 4.5.2.7. Anchovy in Division 9.a. Information used in the Qualitative (Updated) Assessment: annual series of the Biomass Stock Size Indicator (in tonnes). This indicator is computed as the sum of the regional indicators for western and southern stock components.



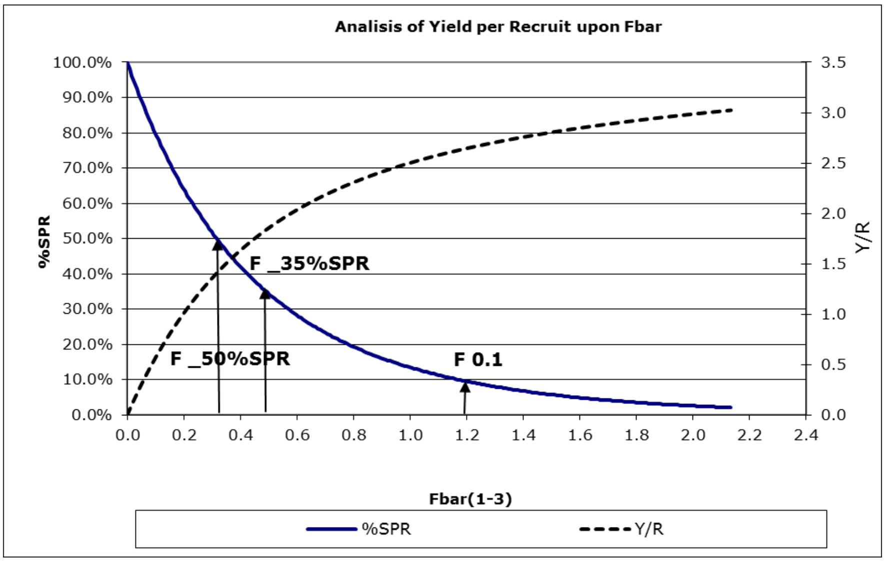


Figure 4.7.2. Anchovy in División 9a. Subdivision 9a South. Plots with some reference points for Harvest Rate (HR) and Fishing Mortality (F) corresponding to the selectivity-at-age of the period 1996, 1997, 1998 and 2011, fitted with a presumed F at-age 1 = 1.

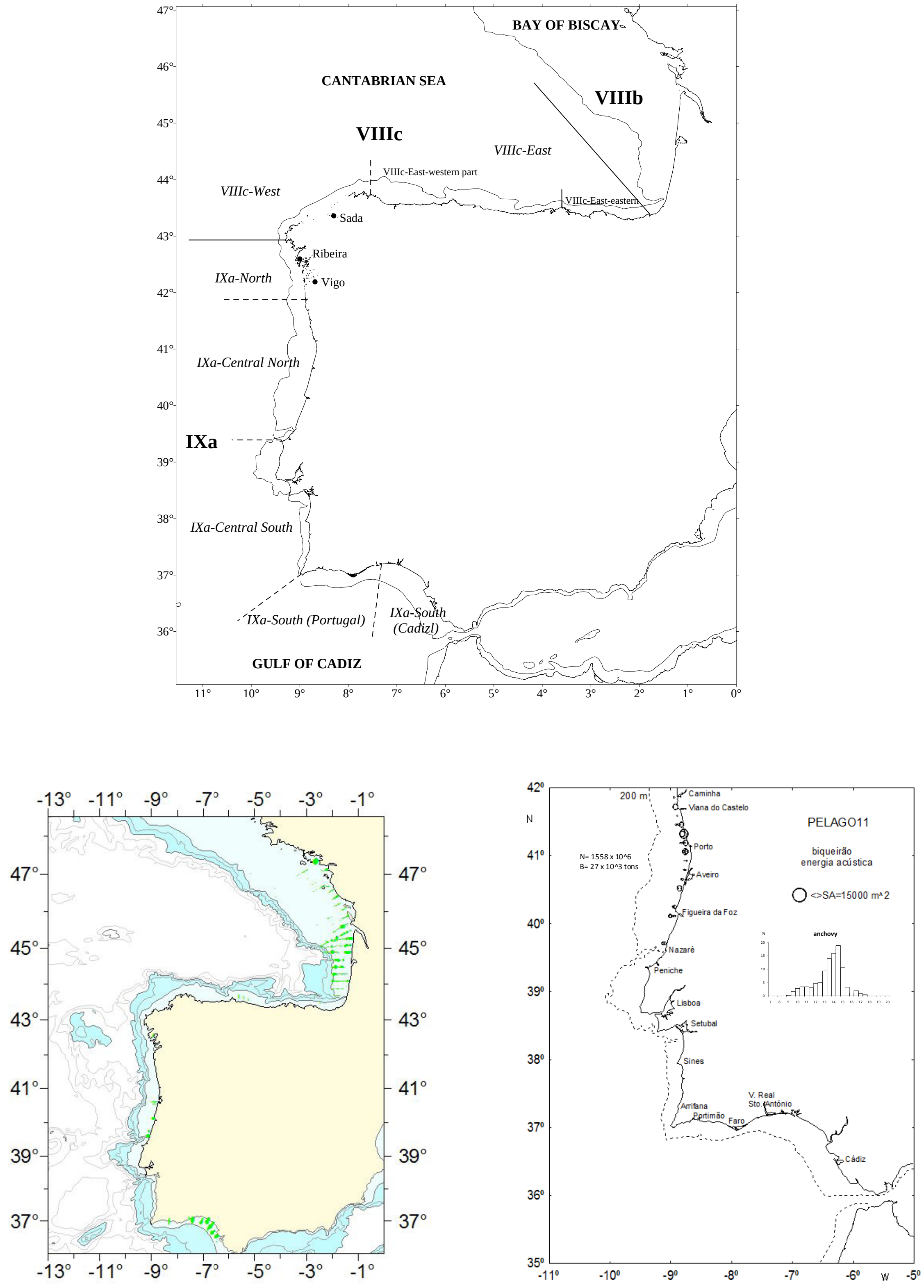


Figure 4.8.1.1. Anchovy in División 9a. A) Geographical distribution of subdivisions. B) Usual distribution of the anchovy populations throughout the division as derived from the combined 2007 acoustic surveys off Iberia and the Armorican shelf (from ICES, 2009b). C) Spatial pattern of the anchovy abundance in the division from the 2011 spring Portuguese acoustic survey.

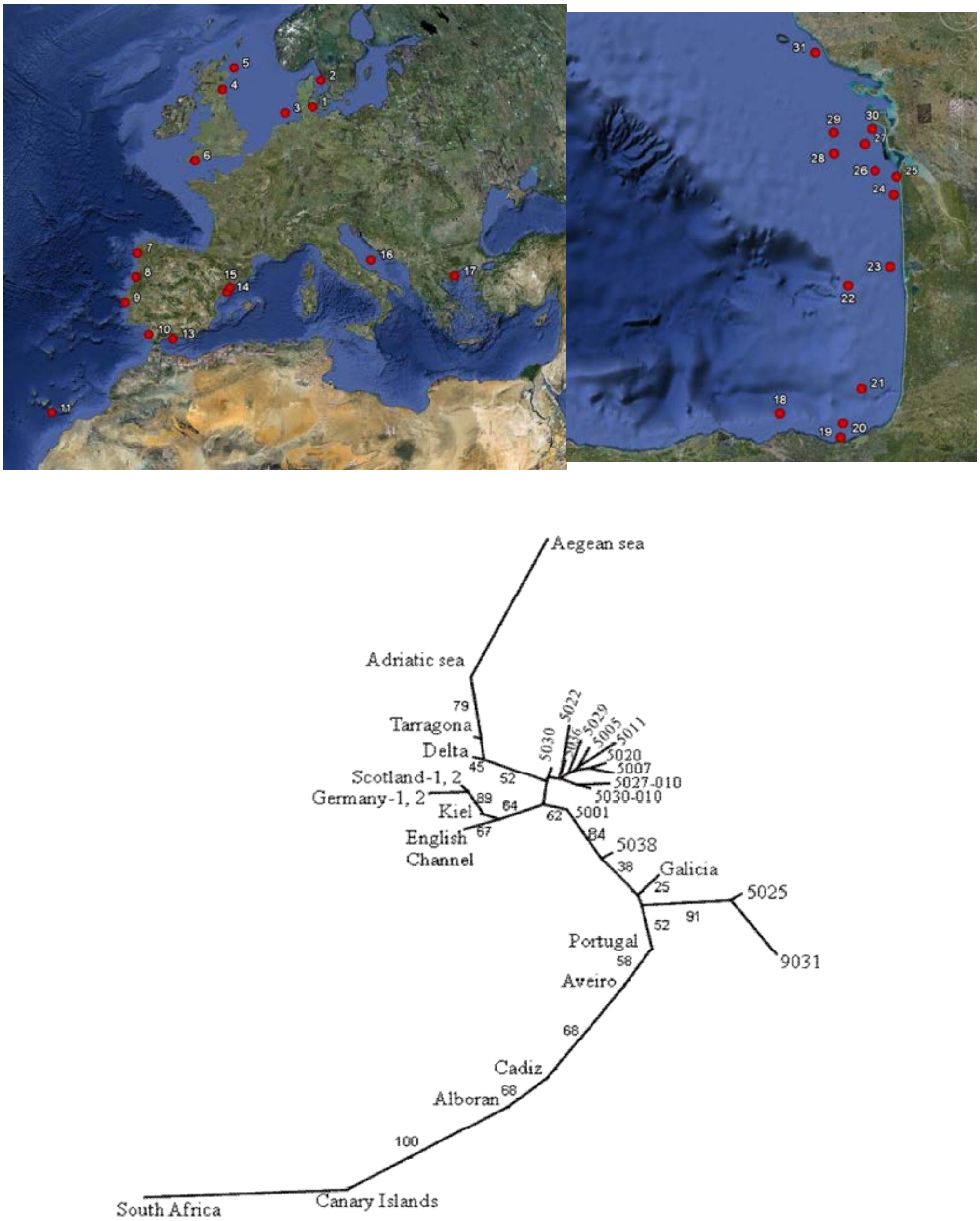


Figure 4.8.1.2. Anchovy in División 9a. Results from Zarraonandía's (2012) studies on genetic structure of European anchovy populations using single nucleotide polymorphisms (SNP). Upper row: geographical location of the analysed samples. Lower figure: Neighbour-Joining (NJ) dendrogram based on Reynolds distances among all the analysed localities. Topological confidence obtained by 1000 bootstrap replicates.

4.11 References

Caneco, B., Silva, A., Morais. A., 2004. Morphometric variation among anchovy (*Engraulis encrasicholus,* L.) populations from the Bay of Biscay and Iberian waters. *ICES CM 2004/EE:24*.

González-Ortegón, E., M. D. Subida, J. A. Cuesta, A. M. Arias, C. Fernández-Delgado, P. Drake. 2010. The impact of extreme turbidity events on the nursery function of a temperate European estuary with regulated freshwater inflow. *Estuarine, Coastal and Shelf Science* 87: 311–324.

ICES. 2002. Report of the Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine and Anchovy. ICES CM 2002/ACFM:06.

ICES. 2003. Report of the Workshop on Discard Sampling Methodology and Raising Procedures. Charlottenlund, Denmark, 2–4 September 2003.

ICES. 2007. Report of the Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VIII and IX (WGACEGG), 26-30 November 2007, Palma de Mallorca, Spain, ICES C.M. 2007/LRC:16. 167 pp.

ICES. 2008a. Report of the Workshop on Small Pelagics (*Sardina pilchardus*, *Engraulis encrasicolus*) maturity stages (WKSPMAT), 10–14 November 2008, Mazara del Vallo, Italy. ICES CM 2008/ACOM:40. 82 pp.

ICES. 2008b. Report of the Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VIII and IX (WGACEGG), 24–28 November 2008, Nantes, France. ICES CM 2008/LRC:17. 183 pp.

ICES. 2009a. Report of the Working Group on Anchovy and Sardine (WGANSA), 15–20 June 2009, ICES Headquarters, Copenhagen. ICES CM 2009/ACOM:13. 354 pp.

ICES. 2009b. Report of the Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VIII and IX (WGACEGG), 16–20 November 2009, Lisbon, Portugal. ICES CM 2009/LRC:20. 181 pp.

ICES. 2013. Report of the Working Group on Southern Horse Mackerel, Anchovy and Sardine (WGHANSA), 21–26 June 2013, Bilbao, Spain. ICES CM 2013/ACOM:16. 752 pp.

ICES. 2014. Report of the Working Group on Southern Horse Mackerel, Anchovy and Sardine (WGHANSA), 20–25 June 2014, Copenhagen, Denmark. ICES CM 2014/ACOM:16. 600 pp.

ICES. 2015. Interim Report of the Stock Identification Methods Working Group (SIMWG), 10–12 June 2015, Portland, Maine, USA. *ICES CM 2015/SSGEPI:13*. 67 pp.

Marques, V., Angélico, M.M., Moreno, A., Nunes, Cristina, Soares, E., García-Seoane, E., Silva, A., Amorim, P., Henriques, E., Silva, A. 2016. Spring 2016 Acoustics and DEPM surveys in ICES area IXa (PELAGO16 and PT-DEPM16-HOM). Sardine and Anchovy echo-acoustics estimations. Working document presented in the ICES Working Group on Southern Horse Mackerel, Sardine and Anchovy (WGHANSA). Lorient, France, 24–29 June 2016.

Methot, R.D. 1986. Synthetic estimates of historical abundance and mortality for northern anchovy, *Engraulis mordax*. *NMFS Southwest Fisheries Science Center Admin. Rep*. 12-86-29.

Methot, R.D. 1989. Synthetic estimates of historical and current biomass of northern anchovy, *Engraulis mordax*. *Am. Fish. Soc. Sympos*. 6, 66–82.

Ramos, F. 2015. On the population structure of the European anchovy (*Engraulis encrasicolus*) in ICES Division IXa: a short review of the state of art. Working document presented in the ICES Stock Identification Methods Working Group (SIMWG). 10–12 June 2015.

Ramos, F., Uriarte, A., Millán, M., Villamor, B. 2001. Trial analytical assessment for anchovy (*Engraulis encrasicolus*, L.) in ICES Subdivision IXa-South. Working Document presented to the ICES Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine and Anchovy. ICES, C.M. 2002/ACFM:06.

Ramos, F., Miquel, J., Tornero, J., Oñate, D., Jiménez, M.P. 2016a. Acoustic assessment and distribution of the main pelagic fish species in ICES Subdivision IXa South during the *ECOCADIZ 2015-07* Spanish survey (July–August 2015). Working document presented in the ICES Working Group on Southern Horse Mackerel, Sardine and Anchovy (WGHANSA). Lorient, France, 24–29 June 2016.

Ramos, F., Tornero, J., Oñate, D., Córdoba, P. 2016b. Acoustic assessment and distribution of the main pelagic fish species in ICES Subdivision IXa South during the *ECOCADIZ-RECLUTAS 2015-10* Spanish survey (October 2015). Working document presented in the ICES Working Group on Southern Horse Mackerel, Sardine and Anchovy (WGHANSA). Lorient, France, 24–29 June 2016.

Ribeiro, R., Reis, J., Santos, C, Gonçalves, F., Soares, A.M.V.M. 1996. Spawning of anchovy *Engraulis encrasicolus* in the Mondego estuary, Portugal. *Estuarine, Coastal and Shelf Science* 42(4): 467–482.

Riveiro, I., Carrera, P. 2016. Preliminary results of the PELACUS0316 survey: estimates of sardine, anchovy and horse mackerel abundance and biomass in Galicia and Cantabrian waters. Working document presented in the ICES Working Group on Southern Horse Mackerel, Sardine and Anchovy (WGHANSA). Lorient, France, 24–29 June 2016.

Ruíz, J., García-Isarch, E., Huertas, I.E. *et al*. 2006. Meteorological forcing and ocean dynamics controlling *Engraulis encrasicolus* early life stages and catches in the Gulf of Cadiz. *Deep-Sea Res. II* 53:1363–1376.

Ruíz, J., González-Quirós, R., Prieto, L. and García-Lafuente, J. 2007. Anchovy in the Gulf of Cadiz: a case of BOTTOP control. *GLOBEC International Newsletter* 13:10–12.

Ruíz, J., González-Quirós, R., Prieto, L., Navarro, G. 2009. A Bayesian model for anchovy (*Engraulis encrasicolus*): the combined forcing of man and environment. *Fish. Oceanogr*. 18:1, 62–76.

Wise, L., Silva, A., Ferreira, M., Silva, M.A., Siqueira, M. 2007. Interactions between small cetaceans and the purse-seine fishery in western Portuguese waters. *Scientia Marina* 71(2): 405–412.

Zarraonaindia, I., Iriondo, M., Albaina, A., Pardo, M.A., Manzano, C., Grant, W.S., Irigoien, X., Estonba, A. 2012. Multiple SNP markers reveal fine-scale population and deep phylogeographic structure in European anchovy (*Engraulis encrasicolus* L.). *PloS One*, 7: e42201. doi:10.1371/journal.pone.0042201.

5 Sardine general

5.1 The fisheries for sardine in the ICES area

5.1.1 Catches for sardine in the ICES area

Commercial catch data for 2015 were provided by Portugal, Spain, France, Netherlands, Ireland and UK (England and Wales) (**Table 5.1.1.1**). Total reported catch was 62 001 tonnes, divided as follows: 22% of the catches by Portugal, 39% by Spain and 25% by France. The remaining 14% of catches are reported by Netherlands, England and Wales, Denmark, Germany and Belgium. Catches in 8.c and 9.a amount to 39% of the total sardine catches. It should be noted that fishing activities are limited in both Spain and Portugal, while there are no catch regulations in place in the other countries. In 2015, there was a 9% decrease with respect to the total 2014 sardine catches reported in European waters. This decrease is mainly due to the decreasing catches in the southern parts of the European waters: Portugal and Spain showed a 14% decrease and for France, the decrease was 19% of the amount of catches with respect to 2014. Overall there is, over the period 2014–2015, a near *status quo* in catches in Northern areas (8.a and 7) while Southern areas had decreasing catches for the last four years (-14%).

Table 5.1.1.1. Sardine general: 2015 commercial catch data from the ICES area, available to the Working Group.

Divisions	UK (E&W)	Germany	Ireland	Denmark	France	Spain	Portugal	Netherlands	Belgium	Total
4.a										0
4.b								0		0
4.c	0				248			7	1	256
6.a										0
7.a										0
7.b										0
7.c										0
7.d	84	1	27	151	1037			37	0	1337
7.e	2618	1550	345	860	4			1031		6408
7.f	1599							5		1604
7.g			5							5
7.h								65		65
7.i										0
7.j										0
8.a	3		25		14229					14 256
8.b	4					13 951				13 955
8.c						5285				5285
8.d										0
8.e										0
9.aN						2097				2097
9.aCN							7117			7117
9.aCS							4848			4848
9.aS-Alg							1812			1812
9.aS-Cad						2957				2957
Total	4308	1551	402	1011	15518	24 289	13 777	1145	1	62 001

6 Sardine in divisions 8.a, b, d, and Subarea 7

6.1 Population structure and stock identity

Sardine in Celtic Seas (7.a, b, c, f, g, j, k), English Channel (7.d, 7.e, 7.h) and in Bay of Biscay (8.a, b, d) are considered to belong to the same stock from a genetic point of view. Therefore, the sardine stock in 8.a, b, d and 7 can be considered as a single-stock unit with substantial mixing between areas.

There is evidence from landings that some fish coming from 8.a are caught in 7.h and 7.e and vice versa. Dutch vessels which operate in the English Channel and North Sea sometimes declare catches in 8.a. Major landings occur in both 8.a, b, d and near and in the English Channel (7.d, 7.e, 7.f, 7.h) area. Fewer landings occur in other 7 areas although they reach one or two thousand tons.

Information is almost inexistent regarding biological sampling of sardine in the English Channel and inexistent in the Celtic Sea. From the little information available, it appears that the sardines caught in the Channel tend to be bigger than in 8.a, b, d.

From the modelling point of view, the lack of commercial sampling, survey and biological information in area 7, in contrast to the richness of the datasets available in 8.a, b, d does not allow the use of a single assessment method for the whole area.

This stock was benchmarked at WKPELA in 2013 by ICES and although it was considered to be a single-stock unit, it was decided to approach this stock by subareas: 8.a, b, d and 7 to account for the regional differences in terms of environment, fisheries and data availability. No analytical assessment is currently usable for these regions therefore the assessment and advice are based on the trends of several indicators defined in the stock annex.

6.2 Input data in 8.a, b, d and 7

French sardine landings have been corrected for notorious misallocations between 7.e, h and 8.a, from 2005 to present. A substantial part of the French catches originates from divisions 7.h and 7.e, but these catches have been assigned to division 8.a due to their very concentrated location at the boundary between 8.a, 7.h and 7.e. French sardine landings declared in 25E5 and 25E4 have hence been reallocated to 8.a.

Official landings per country for the whole area are available in Table 6.2.1.1.

6.2.1 Catch data

Divisions 8.a, b, d

An update of the French and Spanish catch data series in divisions 8.ab (from 1983 and 1996 on for France and Spain, respectively) including 2015 catches was presented to this year´s WG (Table 6.2.1.2).

The Spanish fishery takes place mainly during March and April and in the fourth quarter of the year. Spanish vessels are purse-seines from the Basque Country which operate mostly in division 8.b (Figure 6.2.1.2.1). Spanish landings averaged around 4000 tonnes in the late 1990s early 2000s with peaks in 1998 and 1999 at almost 8000 tonnes. Catches have then decreased until 2010 to below 1000 tonnes. Since 2011, catches have raised again, reaching 16 237 tonnes in 2014. Landings in 2015 were 13 055 tonnes.

French catches consistently increased from 1983 to 2008, with values ranging from 4367 tonnes in 1983 to 21 104 tonnes in 2008. Since 2009, French landings displayed a decreasing trend which stopped in 2013 with 20 066 tonnes landed, which is close to the time-series maximum. In 2015, landings were 15 854 tonnes. About 90% of French catches are taken by purse-seiners while the remaining 10% is reported by pelagic trawlers (mainly pair trawlers). Both purse-seiners and pelagic trawlers target sardine in French waters. Average vessel length is about 18 m. Purse-seiners operate mainly in coastal areas (< 10 nautical miles) while trawlers are allowed to fish within 3 nautical miles from the coast. Both pair trawlers and purse-seiners operate close to their base harbour when targeting sardine. The highest catches are taken in summer. Almost all the catches are taken in southwest Brittany.

Catches were sampled and numbers by length-class for divisions 8.a, b by quarter are shown in tables 6.2.1.3 and 6.2.1.4, for France and Spain (only 8.b), respectively. Sardine caught in area 8.a, b ranges from 9 to 25 cm. In 2015, a peak is observed in the catch-at-size distributions at 15 to 16 cm length.

Subarea 7

Most of the catches are concentrated close to or in the English Channel (7.d, e, f). Historically, highest landings were made by France and the Netherlands, but the participation of the UK increased to become the majority in the last two years. Some landings are occasionally declared by Ireland. No information was available from other countries operating in that subarea. Catches have substantially oscillated with time and between countries (Table 6.2.1.5) from 12 000 to 3800 tonnes. In 2015, the catches were 9314 tonnes, the highest value since 2010.

No additional information was available such numbers by length-class due to lack of monitoring of the fisheries operating in that subarea.

6.2.2 Surveys in divisions 8.a, b, d

6.2.2.1 DEPM surveys in divisions 8.a, b, d

The DEPM survey BIOMAN takes place annually in spring in the Bay of Biscay with the main objective of estimating the total biomass and distribution of anchovy in the Bay of Biscay and the egg abundance of sardine. Triennially the SSB of sardine is as well estimated since 2011. In 2016, BIOMAN took place from 5–25 May. All the methodology for the survey is described in detail in the stock annex for Bay of Biscay Anchovy (Subarea 8). A detailed report of the survey can be found in Annex 3 (WD4).

Total egg abundance for sardine was estimated as the sum of the eggs/m^2 in each station multiplied by the area each station represents. This year sardine egg abundance estimate was 8.87 E+12 eggs, taken into account the whole area surveyed. Removing the area of the cantabrian coast and part of the North as done in 2014 the total egg abundance was 8.56 E+12 eggs 1.5 times higher than the time series average (Figure 6.2.2.1.1, Table 6.2.2.1.1). A small amount of sardine eggs were encountered in the cantabrian between 4º20′ and 5º30′W. In the French platform sardine eggs were encountered all along the coast between coast and 100 m depth until 48ºN (Figure 6.2.2.1.2). Nevertheless, this survey did not cover the potential presence of sardine to the North. In the sampling with the PairoVET net (vertical sampling) from 680 stations a total of 266 (39%) had sardine eggs with an average of 290 eggs/m^2/station in the positive stations and a maximum of 6690 eggs m^2. In the sampling with CUFES (horizontal sampling) a total of 1517 stations from 1649 (31%) had sardine eggs.

The updated BIOMAN egg abundance estimates series (considering only eggs found in 8.a, b) are given in Table 6.2.2.1.1. Discrepancies between updated (8.a, b) and previous (8.a, b, c) estimates are small (Figure 6.2.2.1.3).

In addition, the Daily Egg Production Method (DEPM) survey of Atlanto-Iberian sardine stock (SAREVA survey) conducted by IEO has been extended for sardine in Division 8.b up to a maximum of 45°N in April of 1997, 1999, 2002, 2008, 2011 and 2014. From 1999, surveys have been planned and executed under the auspices of ICES on a triennial basis. Results of the time series of SSB estimated during SAREVA survey for 8.b subdivision were presented at this WG (Diaz *et al*., 2015, WD WGHANSA 2015).

Moreover, since 2011 triennially a biomass applying the DEPM is estimated in 8.a, b, planned jointly by IEO and AZTI within the framework of WGACEGG. The area until 45ºN is covered by IEO (from SAREVA survey) and from there to 48ºN is covered by AZTI (from BIOMAN survey). This information was presented at WGACEGG 2014 (Diaz P. *et al*, 2014 WD WGHACEGG 2014). Furthermore, since 2011 triennially, a SSB for 8.a, b a sardine spawning stock biomass is estimated using the data from BIOMAN survey (AZTI) presented to WGACEGG 2014 (Santos. M *et al*., 2014 WD WGACEGG 2014).

6.2.2.2 PELGAS acoustic survey in divisions 8.a, b, d

The French acoustic survey PELGAS takes place every spring in the Bay of Biscay on board the RV Thalassa with the main objective of studying the abundance and distribution of pelagic fish in the Bay of Biscay and to monitor the pelagic ecosystem. In 2016, PELGAS took place from 29 April–2 June and detailed objectives, methodology and sampling strategy are described in the WD- *Duhamel et al., (2016)* presented in this group.

Target species were anchovy and sardine but both species were considered in a multispecies context.

The biomass estimate of sardine observed during PELGAS15 is 229 742 tonnes (Table 2.3.), which is at a low average level of the PELGAS series, and constituting a real decrease of the biomass compared to the last four years. It must be enhance that this survey does not cover the total area of potential presence of sardine, and it is possible that some years, this specie could be present up to the North, in the Celtic sea, SW of Cornouailles or Western Channel where some fishery occurs, more or less regularly. It is also possible that sometimes, a small fraction of the population could be present in very coastal waters, when the R/V Thalassa is unable to operate in those waters. It seems to be the case along the coast of Brittany this year where eggs were counted along the coast but without real energy attributed to sardine.

The estimate is representative of the sardine present in the survey area at the time of the survey and can be therefore considered as an estimate of the Bay of Biscay (8.a, b) sardine population.

Sardine was distributed (Figure 6.2.2.2.1) all along the French coast of the bay of Biscay often mixed with anchovy and sometimes with sprat, from the Gironde to the South coast of Brittany. Sardine appeared rather absent offshore, close to the surface, along the shelf break, contrary to previous years when sardine was well present along the shelf break.

This year, sardine shows a trimodal length distribution (Figure 6.2.2.2.2), the first one (about 7 cm), corresponding to the age 0, and present for the first time this year at this period front of the Gironde and in the Extrem south of the bay of Biscay. The second, about 14cm, corresponds to age 1 and the third, about 18cm, is mainly constituted by the 2 and 3 years old, still present a bit more offshore than the 1 year class, mainly between depths 60 and 80 m. The older individuals (age 5 and more) seems to be rather absent of the bay of Biscay this year.

PELGAS2016 sardine length-weight and age-length keys are presented in Figure 6.2.2.2.3 and Table 6.2.2.2.1, respectively.

PELGAS2016 sardine proportions at age are presented in Figure 6.2.2.2.4. The age distribution is dominated by a large age 1 group, denoting a good recruitment.

PELGAS series of sardine abundances at age (2000–2016) is shown in Figure 6.2.2.2.5. Cohorts can be visually tracked on the graph. The respectively very low and very high 2005 and 2008 cohorts denote atypical years in terms of environmental conditions, and therefore fish (and particularly sardine) distributions.

The PELGAS sardine mean weights at age series (Table 6.2.2.2.2) shows a clear decreasing trend, whose biological determinant is still poorly understood.

6.2.3 Biological data

6.2.3.1 Catch numbers at length and age

Tables 6.2.3.1.1 and Table 6.2.3.1.2 shows the catch-at-age in numbers for each quarter of 2014 for French and Spanish landings respectively in 8.a, b. For France, fish of age 1 dominated the fishery while for Spain, age 2 dominated the fishery in 2015. This difference is due to the absence of catch from Spain in quarter 3 as the Spanish vessels are targeting tuna while the French fleets are still fishing sardine.

No data were available for Subarea 7.

6.2.3.2 Mean length and mean weight at age

Mean length and mean weight at age by quarter in 2015 are shown in tables 6.2.3.2.1-6.2.3.2.4 for both French and Spanish landings in 8.a, b, d.

No data were available for Subarea 7.

6.2.4 Exploratory assessments

6.2.4.1 Trends of indicators in 8.a, b, d

Bay of Biscay has the most available data in the stock unit. However, with most of them starting in 2000–2002, the benchmark WKPELA concluded that for the time being time-series were still too short to be used by an assessment model. It was rather recommended to use indicators in order to assess the state of the stock.

a) comparison between PELGAS (acoustic) and BIOMAN (egg abundances from DEPM survey)

Time-series of biomass estimates from the PELGAS acoustic survey were compared at WGHANSA 2015 against the time-series of egg abundance from BIOMAN (DEPM) survey (Figure 6.2.4.1.1). This exercise was not carried out this year. Both indices show very similar long-term trends except for 2001 (correlation between indices is $r^2 = 0.7$ if 2001 is removed, 0.64 if included). A linear model was fitted on PELGAS and BIOMAN sardine indices. It also showed good long term agreement between the sardine survey indices ($R^2 = 0.89$), except for 2001 (Figure 6.2.4.1.2).The biomass oscillates over the period covered by the time-series. The last big cycle peaked in 2009–2010. Following years were lower and the trend in the last three years seems to be to a new increase. Larger discrepancies between the survey indices series however appear when looking at the series within the time window used to assess the stock percentage of change for advice (5 last years) (Figure 6.2.4.1.3). The correlation coefficient drops to 0.02 when considering the 2011–2015 subset. The PELGAS indices confidence intervals overlap for all years, except 2012, where the sardine biomass index was significantly lower. This suggests that the PELGAS sardine biomass indices increased between the 2011–2013 and 2014–2015 periods, even when taking into account the sampling uncertainty. The absence of confidence intervals for BIOMAN indices prevents from drawing definitive conclusions on the egg index trend over the assessment period.

Discrepancies between PELGAS and BIOMAN sardine indices can stem from:

i) differences in spatial coverage: the PELGAS survey samples 8.ab, whereas the BIOMAN survey covered 8.c.1, b and part of a (Figure 6.2.2.1.1). The BIOMAN surveys samples most of 8.a, b every 3 years, the last complete coverage was performed in 2014;

ii) the fact that the BIOMAN index is egg abundance, and not biomass. In fact, the same amount of eggs could be either produced by a larger number of small fish spawning few eggs, or a smaller number of larger fish spawning lots of eggs. These two scenarios would have different implications in terms of stock biomass. These changes in stock biomass would be captured by the acoustic index and not by the egg abundance index, yielding possible discrepancies between the two indices. Every three years the full application of the DEPM (including the estimation of the daily fecundity) would allow obtaining spawning stock biomass estimates, which would allow direct comparison between both surveys.

In 2016, the value provided by the acoustic survey of 230 thousand tonnes is an increase of 45% in comparison to 2015. This is the lowest value since 2012. The DEPM estimate, on the other hand, suggests an increase of 55% of the abundance of eggs and of the same order of magnitude than in 2014. In 2015, the magnitude of landings compared to PELGAS biomass estimates of the same year are very low, around 10%, which suggests low harvest rates.

b) Stock structure

Structure at age is available from both catches from Spanish and French fleets and estimates from the PELGAS survey for 8.a, b, d (Figures 6.2.4.1.4 and 6.2.4.1.5). Similar information is not available from Subarea 7.

Time-series of weight at age and number-at-age for both commercial fleets and surveys are provided in Table 6.2.4.1.2 and Table 6.2.4.1.3.

The composition of catches-at-age for the commercial fleets (Figure 6.2.4.1.4) is variable through time. Large proportions of age 1 are observed in 2012, 2013 and 2014, 2015, as well as a large proportion of age 2 in 2013, 2014 and 2016, consequences of the good recruitments of 2011, 2012 and 2013. The composition of catches-at-age from the PELGAS survey (Figure 6.2.4.1.5) shows similarly the dominance of ages 1 and 2 in 2016.

Recruitment in 2015 was estimated at 1.2 million individuals based on PELGAS data, which is the second lowest value since 2007.

c) Catch curve analysis on survey and commercial fleets

The catch curve analysis carried out last year, was updated during the working group using 2015 and 2016 numbers for commercial and survey data respectively.

Neither time-series revealed very efficient at tracking cohorts (figures 6.2.4.1.4 and 6.2.4.1.5). Estimates of total mortality per year were nonetheless computed for age classes 3 to 6, mostly to try to detect possible changes in the dynamics of the population since the first evaluation. The average total mortality according to commercial landings is 0.49 (std.dev. 0.32) while Pelgas gives an estimate of 0.77 (std.dev. 1.28) over the same period (2002–2014). The values of Z estimated this year are 1.34 for commercial data (corresponding to 2015) and 1.64 for PELGAS survey (corresponding to 2016). They are thus in the range of previous estimates (Figure 6.2.4.1.6 and Figure 6.2.4.1.7).

6.2.4.2 Trends on landings in Subarea 7 based on the WKLIFE framework

As only catch and few efforts information are available for Subarea 7, it is impossible to use any assessment model for the time being. This substock is considered as a category 4 stock (catch only).

Overall landings in Subarea 7 have decreased since 2004, especially since 2010 (Figure 6.2.4.2.1). This is mainly due to a decrease in French landings only partly compensated by an increase in landings from the UK. It is worth noting that since 2004 this subarea almost evolve in opposite to the neighbouring landings in the Bay of Biscay. The opportunistic nature of the fisheries and the mixing between 7 and 8 makes the interpretation of this decrease difficult. Observations suggest that the stock moves northward therefore the decrease in catch might not be related to a lesser abundance of fish but possibly a lower effort on sardine.

6.2.5 Short-term predictions

Due to the exploratory nature of the assessment, no predictions have been carried out.

6.2.6 Reference points and harvest control rules for management purposes

No reference points, TACs and no harvest control rules are currently implemented for this stock.

6.2.7 Management considerations

There are no management objectives for these fisheries and there is no international TAC. Catches are mainly taken by France and Spain in areas 8a, b, d and by France, the Netherlands and the United Kingdom in Subarea 7. The absence of a sampling program in Subarea 7 makes any attempt to analytically assess this stock useless. If a sampling program were started, several years of data collection would be necessary before the time-series of data would be long enough. It is therefore recommended that a proper sampling program should be implemented to monitor the sardine fishery in Subarea 7 and that data collection in 8.a, b continues.

Table 6.2.1.1 Official landings reported to ICES (1989–2015)

	7								8.a, b, d								
Year	France	United Kingdom	Netherlands	Ireland	Germany	Denmark	Lithuania	Spain	France	Spain	Netherlands	Ireland	United Kingdom	Denmark	Germany	Lithuania	Total
1989	1219	1660	11	0	0	4667	0	0	8811	0	0	0	0	0	0	0	16368
1990	1128	2078	6	0	107	6113	0	0	8543	0	0	0	0	0	0	0	17975
1991	1963	2952	0	0	8	4462	0	0	12482	35	0	0	0	0	0	0	21902
1992	1777	4493	41	0	4	17843	0	0	8847	43	0	0	0	0	0	0	33048
1993	1135	4917	109	0	0	13395	0	0	8805	45	0	0	0	308	0	0	28714
1994	1285	2081	20	0	2	20804	0	0	8604	0	0	0	0	0	0	0	32796
1995	1282	7133	107	0	66	9603	0	0	9877	0	24	0	0	0	0	0	28092
1996	1563	7304	48	0	0	1396	0	0	8604	0	0	0	0	0	0	0	18915
1997	3346	7280	411	0	13	1124	0	0	10706	0	26	0	0	0	0	0	22906
1998	1974	6873	1647	192	100	14316	0	0	9778	873	0	0	0	0	68	0	35821
1999	0	4815	5166	2375	146	3490	0	8	0	2384	0	0	0	124	11	0	18519
2000	1667	4353	6586	354	436	1682	0	0	10444	1989	34	0	0	0	38	0	27583
2001	9625	10375	6609	1060	454	0	0	0	10121	0	333	0	0	0	135	0	38712
2002	8642	7858	1905	2652	224	0	0	10	12316	2881	23	19	276	0	4	0	36810
2003	12546	4358	6897	2580	25	0	0	0	10631	2408	68	1750	68	0	0	0	41331
2004	8882	2681	2187	6195	109	742	0	0	9971	1853	6	1401	0	0	0	0	34027
2005	10814	3631	2231	2083	274	0	0	5	15462	1203	1	974	0	0	54	0	36732
2006	12390	1925	2287	698	481	0	17	2	16000	839	2	49	0	12	78	5	34786
2007	7826	2654	1106	14	0	4	0	0	16060	706	0	0	0	48	0	0	28418

7									8.a, b, d								
Year	France	United Kingdom	Netherlands	Ireland	Germany	Denmark	Lithuania	Spain	France	Spain	Netherlands	Ireland	United Kingdom	Denmark	Germany	Lithuania	Total
2008	8673	3470	2073	875	42	54	0	0	21104	1989	0	0	1	39	0	0	38320
2009	3413	2541	3406	33	0	0	0	0	20627	602	0	0	0	0	0	0	30622
2010	168	2521	6645	25	106	13	0	0	19484	2948	0	0	0	0	0	0	31910
2011	412	3604	513	983	22	3	0	0	17927	5283	5	0	0	0	0	0	28751
2012	444	4423	1439	8	0	0	0	0	15952	14948	0	0	0	0	0	0	37214
2013	1768	3722	1804	236	214	40	0	0	20066	12423	445	0	252	0	0	0	40971
2014	1202	3889	249	0	18	953	0	0	17706	16237	0	0	0	0	0	0	40254
2015	4258	4293	1137	274	1551	1011	0	0	15854	13055	0	0	7	0	0	0	41440

Table 6.2.1.2 Sardine landings by France (1983–2014) and Spain (1996–2015) in ICES divisions 8.a, b, and d as estimated by the WG.

Year	Catch (tonnes)	
	France	Spain*
1983	4367	n/a
1984	4844	n/a
1985	6059	n/a
1986	7411	n/a
1987	5972	n/a
1988	6994	n/a
1989	6219	n/a
1990	9764	n/a
1991	13 965	n/a
1992	10 231	n/a
1993	9837	n/a
1994	9724	n/a
1995	11 258	n/a
1996	9554	2053
1997	12 088	1608
1998	10 772	7749
1999	14 361	7864
2000	11 939	3158
2001	11 285	3720
2002	13 849	4428
2003	15 494	1113
2004	13 855	342
2005	15 462	898
2006	15 916	825
2007	16 060	1263
2008	21 104	717
2009	20 627	228
2010	19 485	642
2011	17 925	5283
2012	15 952	14 948
2013	20 066	12 423
2014	17706	16237
2015	14229	13055

*** all landings from division 8.b**

n/a = not available

Table 6.2.1.3 French Sardine catch at length composition (thousands) in ICES divisions 8.a and b in 2015.

Length (cm)	Quarter 1	Quarter 2	Quarter 3	Quarter 4	All year
3.5					
4					
4.5					
5					
5.5					
6					
6.5					
7					
7.5					
8					
8.5	16				16
9					
9.5					
10	16				16
10.5					
11					
11.5					
12		32			32
12.5	31	32			63
13	31	238		128	397
13.5	15	730	215	538	1 498
14	108	1 728	6 150	397	8 383
14.5	108	3 225	20 379	256	23 967
15	278	9 166	45 820	921	56 184
15.5	123	12 604	24 265	2 985	39 977
16	247	10 493	17 517	3 926	32 183
16.5	262	8 261	6 023	2 528	17 074
17	386	9 395	6 069	1 595	17 444
17.5	405	8 393	8 371	2 577	19 746
18	488	6 265	11 404	6 123	24 279
18.5	516	3 109	9 923	8 713	22 261
19	941	3 434	9 679	6 495	20 548
19.5	937	2 516	7 734	5 408	16 595
20	719	1 887	6 556	5 046	14 208
20.5	671	2 012	4 173	4 280	11 136
21	585	1 161	2 626	2 023	6 394
21.5	616	521	1 008	1 363	3 508
22	569	352	840	735	2 495
22.5	617	323		405	1 345
23	604	54	168	713	1 540
23.5	261	54	168		483
24	161	54			215

Length (cm)	Quarter 1	Quarter 2	Quarter 3	Quarter 4	All year
24.5	33				33
25					
25.5					
26					
26.5					
27					
27.5					
28					
28.5					
29					
29.5					
30					
30.5					
31					
TOTAL numbers	9 743	86 037	189 088	57 151	342 020

Table 6.2.1.4 Spanish sardine catch-at-length composition (thousands) in ICES divisions 8.b in 2015.

Length (cm)	Quarter 1	Quarter 2	Quarter 3	Quarter 4	All year
3.5					
4					
4.5					
5					
5.5					
6					
6.5					
7					
7.5					
8					
8.5					
9					
9.5					
10					
10.5	30				30
11					
11.5					
12					
12.5	30				30
13	13			28	41
13.5				5	5
14	23			19	42
14.5	32			28	60
15	171	28		788	987
15.5	588	147		4 200	4 935
16	1 261	190		12 234	13 685
16.5	2 218	207		16 947	19 372
17	2 361	344		20 040	22 746
17.5	2 738	512		22 518	25 767
18	2 490	320		29 290	32 100
18.5	2 131	266		27 945	30 342
19	1 433	155		26 379	27 968
19.5	1 385	60		18 110	19 556
20	1 002	99		13 827	14 928
20.5	1 208	42		9 328	10 579
21	1 190	57		6 799	8 047
21.5	1 151			4 033	5 184
22	906			3 315	4 222
22.5	619			1 918	2 537
23	259			1 078	1 337
23.5	164			626	791
24	17			267	284

Length (cm)	Quarter 1	Quarter 2	Quarter 3	Quarter 4	All year
24.5	8			6	14
25					
25.5					
26					
26.5					
27					
27.5					
28					
28.5					
29					
29.5					
30					
30.5					
31					
TOTAL numbers	23 428	2 428		219 731	245 588

Table 6.2.1.5. Sardine landings (tons) in ICES Subarea 7 in 2015.

Year	France	Netherlands	UK	Ireland	Germany	Denmark	Total
1996	1563	48	7304	0	0	1396	10311
1997	3346	411	7280	0	13	1124	12174
1998	1974	1647	6873	192	100	14316	25102
1999	119	5166	4815	3195	146	3490	16931
2000	1594	6586	4353	2577	436	1682	17228
2001	2313	6608	10375	2427	454	0	22177
2002	2232	1905	7858	5728	224	0	17947
2003	5318	6897	4358	2015	25	0	18613
2004	3266	2187	2681	1567	109	742	10552
2005	4315	2231	3631	461	274	0	10912
2006	5156	2287	1925	1211	481	0	11060
2007	4418	1106	2654	14	0	4	8196
2008	5195	2073	3470	236	42	54	11070
2009	6674	3406	2541	33	0	0	12654
2010	2787	6645	2521	25	106	13	12097
2011	2515	513	3603	983	22	3	7639
2012	444	1439	4423	8	0	0	6314
2013	1768	1439	3722	9	214	40	7192
2014	1202	249	3889	0	18	953	6311
2015	1040	1137	4301	274	1551	1011	9314

Table 6.2.2.1.1a Time series for sardine, Total egg abundances (Σ(eggm^{-2}_St*area_st)) positive area (Km^2), total area surveyed (Km^2) and % of positive area.

Year	TotAb	posarea all
1999	1.057E+12	26 679
2000	5.034E+12	46 286
2001	2.202E+12	30 232
2002	7.819E+12	41 309
2003	3.264E+12	29 273
2004	7.834E+12	38 113
2005	1.087E+13	44 569
2006	3.837E+12	26 916
2007	2.330E+12	18 885
2008	9.367E+12	30 759
2009	6.051E+12	34 746
2010	1.035E+13	36 361
2011	4.290E+12	22 851
2012	5.600E+12	20 054
2013	5.474E+12	25 423
2014	8.209E+12	55 563
2015	5.520E+12	39 110
2016	8.558E+12	31 653

Table 6.2.2.1.1b Time series for sardine, Total egg abundances (Σ(eggm⁻²_St*area_st(m²))) without the cantabric coast and without a part of the North. (see 2014 report to check the area North removed).

Year	TotAb_whithoutN&Cant
1999	1.06E+12
2000	5.03E+12
2001	2.20E+12
2002	7.82E+12
2003	3.26E+12
2004	7.83E+12
2005	1.09E+13
2006	3.84E+12
2007	2.33E+12
2008	9.37E+12
2009	6.05E+12
2010	1.03E+13
2011	4.29E+12
2012	5.60E+12
2013	5.474E+12
2014	8.209E+12
2015	5.52E+12
2016	8.56E+12

Table 6.2.2.2.1 Sardine age/length key from PELGAS16 samples (based on 1225 otoliths).

Nombre de Age	Age											
Taille	0	1	2	3	4	5	6	7	8	9	10	Total
6.5	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
7	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
7.5	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
8	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
9.5	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
10	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
10.5	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
11	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
11.5	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
12	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
12.5	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
13	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
13.5	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
14	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
14.5	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
15	0.00%	94.74%	5.26%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
15.5	0.00%	95.24%	4.76%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
16	0.00%	44.44%	55.56%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
16.5	0.00%	23.64%	76.36%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
17	0.00%	8.51%	89.36%	2.13%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
17.5	0.00%	6.48%	87.04%	4.63%	1.85%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
18	0.00%	0.00%	83.04%	16.07%	0.89%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
18.5	0.00%	0.00%	58.77%	34.21%	7.02%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
19	0.00%	0.00%	41.46%	42.28%	16.26%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
19.5	0.00%	0.00%	20.59%	55.88%	23.53%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
20	0.00%	0.00%	6.33%	46.84%	37.97%	6.33%	2.53%	0.00%	0.00%	0.00%	0.00%	100.00%
20.5	0.00%	0.00%	2.00%	28.00%	62.00%	6.00%	0.00%	2.00%	0.00%	0.00%	0.00%	100.00%
21	0.00%	0.00%	0.00%	31.25%	34.38%	28.13%	0.00%	6.25%	0.00%	0.00%	0.00%	100.00%
21.5	0.00%	0.00%	0.00%	15.79%	57.89%	15.79%	0.00%	10.53%	0.00%	0.00%	0.00%	100.00%
22	0.00%	0.00%	0.00%	4.55%	54.55%	13.64%	4.55%	18.18%	4.55%	0.00%	0.00%	100.00%
22.5	0.00%	0.00%	0.00%	5.56%	27.78%	33.33%	16.67%	11.11%	0.00%	5.56%	0.00%	100.00%
23	0.00%	0.00%	0.00%	0.00%	6.67%	13.33%	40.00%	33.33%	6.67%	0.00%	0.00%	100.00%
23.5	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	41.67%	25.00%	25.00%	0.00%	8.33%	100.00%
24	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	50.00%	33.33%	16.67%	0.00%	100.00%
24.5	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	100.00%
25	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%
Total	0.82%	21.39%	38.78%	19.51%	12.73%	2.53%	1.39%	1.96%	0.57%	0.16%	0.16%	100.00%

Table 6.2.2.2.2a Mean weight at age (g) of sardine for each PELGAS survey.

	age										
survey	0	1	2	3	4	5	6	7	8	9	10
PEL 2000	-	35.05	54.74	69.15	76.46	84.82	89.93	98.83	110.18	105.04	112.87
PEL 2001	-	41.28	58.85	76.83	83.84	93.68	96.92	103.41	105.35	112.71	120.97
PEL 2002	-	40.48	60.2	74.94	81.7	92.31	99.42	106.68	118.05		
PEL 2003	-	53.35	68.04	73.15	78.11	86.04	93.33	88.74	96.09		
PEL 2004	-	35.94	64.73	76.54	84.39	95.87	98.83	104.34	109.19	106.15	
PEL 2005	-	34.44	63.45	73.29	79.62	84.88	88.96	90.04	105.42	109.45	98.35
PEL 2006	-	39.17	58.37	70.78	81.18	86.37	82.48	91.25	97.22	107.02	112.02
PEL 2007	-	37.55	65.96	71.77	79.05	84.02	94.45	100.37	96.93	101.27	114.86
PEL 2008	-	33.44	60.33	71.1	75.18	83.82	92.84	90.45	95.67	99.48	101.41
PEL 2009	-	29.51	57.13	73.62	81.28	83.26	88.35	95.67	91.44	96.50	106.67
PEL 2010	-	30.33	50.55	64.04	73.05	78.43	87.58	93.16	105.88	106.96	116.01
PEL 2011	-	27.37	50.13	58.69	69.84	78.35	83.00	84.28	108.17	105.38	108.33
PEL 2012	-	22.88	44.66	57.40	65.45	78.42	87.83	95.26	92.27	99.83	
PEL 2013	-	21.16	44.33	55.82	68.30	77.42	84.27	89.28	99.10	113.27	89.17
PEL 2014	-	23.02	44.53	55.93	62.07	69.35	76.11	78.46		86.50	
PEL 2015	-	18.75	44.73	56.98	67.22	78.86	87.07	94.81	95.23	90.01	
PEL 2016	3.01	22.94	43.64	56.03	63.76	75.71	88.48	95.36	102.21	102.39	105.47

Table 6.2.2.2.2b Proportion of sardine abundance (left) and biomass (right) at age from the PELGAS2015 survey.

	pel16 - % - N
age 0	14.70%
age 1	21.85%
age 2	38.68%
age 3	14.22%
age 4	7.89%
age 5	1.13%
age 6	0.50%
age 7	0.80%
age 8	0.16%
age 9	0.05%
age 10	0.02%

	PEL16 - W - %
age 0	1.18%
age 1	13.31%
age 2	44.86%
age 3	21.17%
age 4	13.37%
age 5	2.28%
age 6	1.17%
age 7	2.03%
age 8	0.45%
age 9	0.13%
age 10	0.05%

Table 6.2.2.2.3 Mean weight at age (g) of sardine over PELGAS survey series.

	age											
survey	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**13**
PEL00	35.05	54.74	69.15	76.46	84.82	89.93	98.83	110.18	105.04	112.87		117.35
PEL01	41.28	58.85	76.83	83.84	93.68	96.92	103.41	105.35	112.71	120.97	119.92	
PEL02	40.48	60.2	74.94	81.7	92.31	99.42	106.68	118.05				
PEL03	53.35	68.04	73.15	78.11	86.04	93.33	88.74	96.09				
PEL04	35.94	64.73	76.54	84.39	95.87	98.83	104.34	109.19	106.15			
PEL05	34.44	63.45	73.29	79.62	84.88	88.96	90.04	105.42	109.45	98.35		
PEL06	39.17	58.37	70.78	81.18	86.37	82.48	91.25	97.22	107.02	112.02	110.9	
PEL07	37.55	65.96	71.77	79.05	84.02	94.45	100.37	96.93	101.27	114.86		
PEL08	33.44	60.33	71.1	75.18	83.82	92.84	90.45	95.67	99.48	101.41	109.39	
PEL09	29.51	57.13	73.62	81.28	83.26	88.35	95.67	91.44	96.50	106.67	82.00	
PEL10	30.33	50.55	64.04	73.05	78.43	87.58	93.16	105.88	106.96	116.01		
PEL11	27.37	50.13	58.69	69.84	78.35	83.00	84.28	108.17	105.38	108.33		
PEL12	22.88	44.66	57.40	65.45	78.42	87.83	95.26	92.27	99.83			
PEL13	21.16	44.33	55.82	68.30	77.42	84.27	89.28	99.10	113.27	89.17		
PEL14	23.02	44.53	55.93	62.07	69.35	76.11	78.46		86.50			
PEL15	18.75	44.73	56.98	67.22	78.86	87.07	94.81	95.23	90.01			
PEL16	15.05	42.77	61.82	74.16	83.68	99.25	107.48	107.30	107.74	126.41		

Table 6.2.3.1.1 French 2015 landings in ICES Division 8.b: Catch in numbers (thousands) at age.

Age	First Quarter	Second Quarter	Third quarter	Fourth Quarter	Whole Year
0	215	666	880		
1	1287	46333	144882	22165	214667
2	1805	24010	26156	18700	70670
3	2899	11610	12609	10265	37383
4	1219	2308	4051	3706	11283
5	719	790	84	178	1771
6	892	550	924	1115	3481
7	724	341	168	357	1590
8	154	68	222		
9	45	28	72		
10	0				
11	0				
12	0				
13	0				
14	0				
15	0				
Total	9744	86038	189089	57152	342019
Official Catch (t)	638.7	3361.868	7147.144	3081.098	14228.81

Table 6.2.3.1.2 Spanish 2015 landings in ICES Division 8.b: Catch in numbers (thousands) at age.

Age	First Quarter	Second Quarter	Third quarter	Fourth Quarter	Whole Year
0	0	0	0	33	33
1	4472	634	0	84670	89776
2	8082	1129	0	90816	100027
3	6189	558	0	32693	39439
4	1926	75	0	7573	9573
5	947	23	0	1152	2122
6	941	5	0	2210	3156
7	668	5	0	584	1257
8	156	0	0	0	156
9	48	0	0	0	48
10	0	0	0	0	0
11	0	0	0	0	0
12	0	0	0	0	0
13	0	0	0	0	0
14	0	0	0	0	0
15	0	0	0	0	0
Total	23429	2429	0	219731	245587
Official Catch (t)	1285.6595	112.0775	0	11656.9761	13054.7131

Table 6.2.3.2.1 French 2015 landings in divisions 8.a, b: Mean length (cm) at age.

Age	First Quarter	Second Quarter	Third quarter	Fourth Quarter	Whole Year
0	13.5	13.4	13.43		
1	15.31	15.57	15.65	17	15.77
2	18.19	17.48	18.9	19.02	18.43
3	19.64	18.97	19.59	19.7	19.43
4	20.9	20.18	20.42	20.65	20.5
5	21.9	20.95	23.25	23	21.65
6	22.39	21.68	22.11	22.25	22.16
7	22.69	21.81	23.25	23	22.63
8	22.7	22.49	22.64		
9	22.62	22.11	22.43		

Table 6.2.3.2.2 French 2015 landings in divisions 8.a, b: Mean weight (kg) at age.

Age	First Quarter	Second Quarter	Third quarter	Fourth Quarter	Whole Year
0				0.01819691	0.01829887
1	0.02780294	0.02607159	0.02607159	0.03878574	0.02991089
2	0.0481138	0.03802103	0.03802103	0.05548928	0.04894169
3	0.06142418	0.0496358	0.0496358	0.06202652	0.05775393
4	0.07483039	0.06068333	0.06068333	0.07210059	0.06913334
5	0.08694307	0.06860957	0.06860957	0.10155871	0.08110239
6	0.09321936	0.07673323	0.07673323	0.09139171	0.08907052
7	0.09721745	0.07820692	0.07820692	0.10155871	0.09494667
8	0.09740585	0.08644953	0.08644953		0.09402596
9	0.09636372	0.08174496	0.08174496		0.09079319

Table 6.2.3.2.3 Spanish 2015 landings in ICES division 8.b: mean length (cm) at age.

Age	First Quarter	Second Quarter	Third quarter	Fourth Quarter	Whole Year
0				13.33	13.33
1	16.49	16.49		17.37	17.32
2	17.96	17.87		19.01	18.92
3	19.55	19.02		19.96	19.88
4	20.98	20.13		21.24	21.18
5	21.72	20.8		22.85	22.32
6	22.21	20.74		22.55	22.45
7	22.41	20.86		23.5	22.91
8	22.77				22.77
9	21.86				21.86

Table 6.2.3.2.4 Sardine general: Spanish 2014 landings in ICES division 8.b: mean weight (kg) at age.

Age	First Quarter	Second Quarter	Third quarter	Fourth Quarter	Whole Year
0	0	0	0	0.01732549	0.01732549
1	0.03473934	0.03459581	0	0.04108	0.04071839
2	0.04557962	0.04477067	0	0.05490998	0.05404165
3	0.06013793	0.05486198	0	0.06420273	0.06343277
4	0.07525274	0.06565696	0	0.07829373	0.07758361
5	0.08398015	0.07280088	0	0.09838752	0.09168159
6	0.08994635	0.0719692	0	0.09435225	0.09300608
7	0.09267322	0.07330154	0	0.10753199	0.09949641
8	0.09723759	0	0	0	0.09723759
9	0.08527852	0	0	0	0.08527852

Table 6.2.4.1.1 Survey indices from Pelgas (acoustic) and Bioman (DEPM) surveys in 8.a, b, d. Landings in 8.a, b, d and 7.

Year	Survey			Landings
	PELGAS	PELGAS	BIOMAN	8.a, b, d, and 7
	age 1 individuals	Biomass	egg count (billions)	(tonnes)
1999			1.10E+12	41591.553
2000	1276312	376442	5.00E+12	33280.593
2001	1280080	383515	2.20E+12	37446.176
2002	3458311	563880	7.80E+12	36520.459
2003	160136	111234	3.30E+12	37055.0992
2004	2997203	496371	7.80E+12	26886.5151
2005	2613794	435287	1.10E+13	28306.1877
2006	605847	234128	3.80E+12	27951.403
2007	631471	126237	2.30E+12	25570.65
2008	3432039	460727	1.10E+13	32889.708
2009	6111475	479684	6.10E+12	33508.798
2010	1511640	457081	1.00E+13	32206.194
2011	1435411	338468	4.30E+12	30851.424
2012	3257929	205627	5.60E+12	37214.272
2013	8334258	407740	5.50E+12	40971
2014	3987596	339607	8.10E+12	45312
2015	7417101	416524	5.80E+12	41440
2016	1222367	229742	8.55E+12	

Table 6.2.4.1.2a Weight at age (in kg) from French and Spanish commercial fleets in 8.a, b, d.

AGE	0	1	2	3	4	5	6	7	8	9
2002	0.018	0.044	0.069	0.08	0.088	0.1	0.112	0.115	0.13	0.133
2003	0.019	0.054	0.08	0.091	0.101	0.111	0.117	0.129	0.132	0.124
2004	0.02	0.04	0.08	0.09	0.095	0.101	0.111	0.12	0.13	0.125
2005	0.018	0.047	0.081	0.089	0.094	0.097	0.105	0.11	0.119	0.133
2006	0.024	0.039	0.074	0.088	0.094	0.101	0.11	0.115	0.118	0.133
2007	0.032	0.053	0.081	0.087	0.099	0.104	0.109	0.12	0.123	0.131
2008	0.018	0.044	0.063	0.076	0.078	0.091	0.1	0.095	0.103	0.11
2009	0.032	0.038	0.062	0.073	0.086	0.087	0.096	0.098	0.1	0.115
2010	0.023	0.038	0.061	0.074	0.081	0.09	0.092	0.102	0.103	0.111
2011	0.028	0.043	0.066	0.074	0.082	0.09	0.096	0.1	0.113	0.115
2012	0.043	0.045	0.056	0.068	0.077	0.082	0.086	0.1	0.102	0.121
2013	0.021	0.037	0.055	0.07	0.076	0.082	0.09	0.096	0.097	0.105
2014	0.029	0.039	0.049	0.071	0.076	0.083	0.099	0.107	0.12	0.084
2015	0.018	0.033	0.052	0.061	0.073	0.087	0.091	0.097	0.095	0.089

Table 6.2.4.1.2b Weight at age (in g) from the Pelgas acoustic survey in 8.a, b, d.

Survey	AGE											
	1	2	3	4	5	6	7	8	9	10	11	13
PEL00	35.05	54.74	69.15	76.46	84.82	89.93	98.83	110.18	105.04	112.87		117.35
PEL01	41.28	58.85	76.83	83.84	93.68	96.92	103.41	105.35	112.71	120.97	119.92	
PEL02	40.48	60.2	74.94	81.7	92.31	99.42	106.68	118.05				
PEL03	53.35	68.04	73.15	78.11	86.04	93.33	88.74	96.09				
PEL04	35.94	64.73	76.54	84.39	95.87	98.83	104.34	109.19	106.15			
PEL05	34.44	63.45	73.29	79.62	84.88	88.96	90.04	105.42	109.45	98.35		
PEL06	39.17	58.37	70.78	81.18	86.37	82.48	91.25	97.22	107.02	112.02	110.9	
PEL07	37.55	65.96	71.77	79.05	84.02	94.45	100.37	96.93	101.27	114.86		
PEL08	33.44	60.33	71.1	75.18	83.82	92.84	90.45	95.67	99.48	101.41	109.39	
PEL09	29.51	57.13	73.62	81.28	83.26	88.35	95.67	91.44	96.50	106.67	82.00	
PEL10	30.33	50.55	64.04	73.05	78.43	87.58	93.16	105.88	106.96	116.01		
PEL11	27.37	50.13	58.69	69.84	78.35	83.00	84.28	108.17	105.38	108.33		
PEL12	22.88	44.66	57.40	65.45	78.42	87.83	95.26	92.27	99.83			
PEL13	21.16	44.33	55.82	68.30	77.42	84.27	89.28	99.10	113.27	89.17		
PEL14	23.02	44.53	55.93	62.07	69.35	76.11	78.46		86.50			
PEL15	18.75	44.73	56.98	67.22	78.86	87.07	94.81	95.23	90.01			
PEL16	15.05	42.77	61.82	74.16	83.68	99.25	107.48	107.30	107.74	126.41		

Table 6.2.4.1.3a Catch-at-age (in numbers) from French and Spanish commercial fleets in8.a, b, d. (Thousands)

Age	0	1	2	3	4	5	6	7	8	9
2002	3703	162938	67783	25016	15760	11127	7444	2157	1170	824
2003	4382	89475	62145	27447	16545	9657	6207	3334	1647	737
2004	22283	88306	50184	36191	15110	9388	2796	1328	632	306
2005	4114	91371	41479	29105	22998	17983	9190	5115	3167	1805
2006	8896	35588	84755	30337	21008	15204	9519	6946	3558	2807
2007	24017	66813	25930	59416	13095	14186	12178	7468	3582	2907
2008	3845	162408	71484	26645	42044	13223	11590	10818	5354	5062
2009	8535	117821	139899	50134	25636	24240	12465	9282	5517	1916
2010	1907	37905	107444	59131	18719	14837	22904	7452	8527	4811
2011	3938	42575	62666	118526	56833	8562	15571	5400	5518	3082
2012	3120	146755	46509	46419	71903	27064	6378	2880	1850	1195
2013	9821	256384	136539	52648	69869	44753	13705	3312	2808	752
2014	20494	243108	309392	56630	30728	27472	15020	3479	504	179
2015	913	304443	170697	76822	20856	3893	6637	2847	378	120

Table 6.2.4.1.3b Population at age estimates (in numbers) from the Pelgas acoustic survey in 8.a, b, d.

PELGAS	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
2000	1 276 312	1 559 347	1 083 847	721 738	551 465	218 657	152 984	132 676
2001	1 280 080	1 367 856	819 203	751 576	353 970	466 190	175 124	277 453
2002	3 458 311	3 585 189	1 115 098	566 798	162 725	85 013	38 003	9 120
2003	160 136	528 081	463 812	165 696	55 940	2 234	5 426	1 090
2004	2 997 203	2 029 661	1 606 397	706 117	467 766	283 692	95 817	61 324
2005	2 613 794	1 807 043	824 020	822 188	610 585	383 260	230 492	174 773
2006	605 847	2 819 592	274 996	90 287	42 056	38 918	13 436	16 260
2007	631 471	296 092	761 271	131 707	57 856	64 658	27 165	35 554
2008	3 432 039	1 549 493	383 747	1 478 305	301 616	223 603	241 521	373 181
2009	6 111 475	3 286 964	707 700	301 305	737 098	215 647	148 810	157 875
2010	1 511 640	5 227 578	1 558 567	267 859	125 992	122 739	27 877	41 082
2011	1 435 411	1 504 792	2 516 162	794 842	106 115	64 749	23 433	33 899
2012	3 257 929	1 129 668	833 824	1 158 709	340 656	77 427	54 120	43 030
2013	8 334 258	1 934 208	558 270	313 743	563 894	211 086	49 522	47 293
2014	3 987 596	3 240 908	863 755	269 980	183 557	132 252	39 784	4 771
2015	7 417 101	1 610 331	1 698 312	482 737	193 540	159 560	141 105	33 719
2015	1 222 367	2 164 400	795 680	441 492	63 454	27 872	44 752	12 868

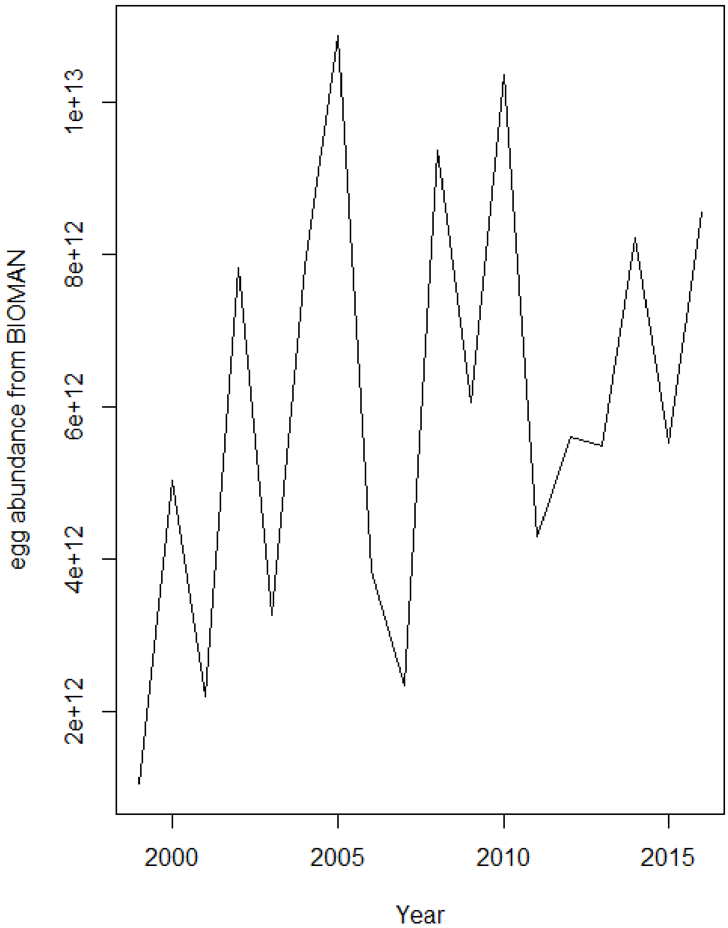


Figure 6.2.2.1.1 Historical series for sardine egg abundances from BIOMAN 2016.

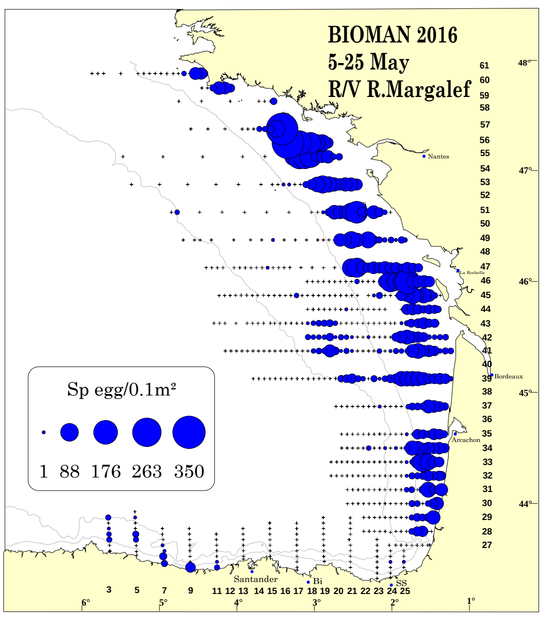


Figure 6.2.2.1.2 Distribution of sardine egg abundances (eggs per 0.1m²) from the DEPM survey BIOMAN2016 obtained with PairoVET.

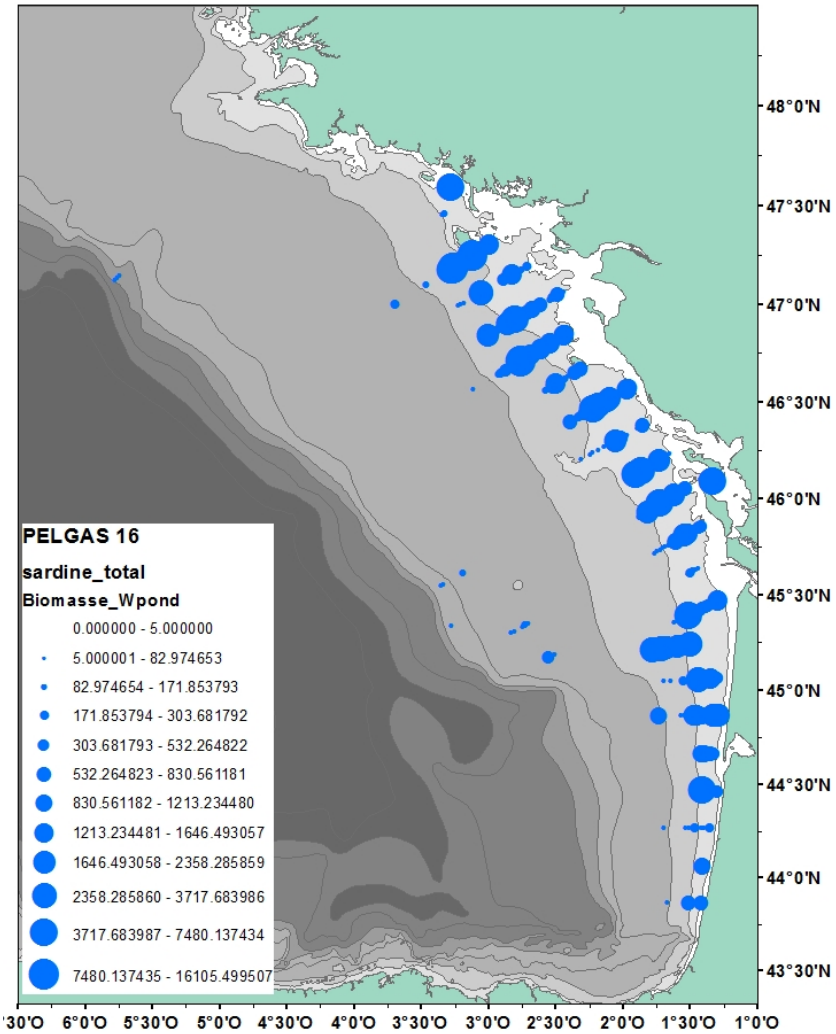


Figure 6.2.2.2.1 Sardine distribution during PELGAS survey.

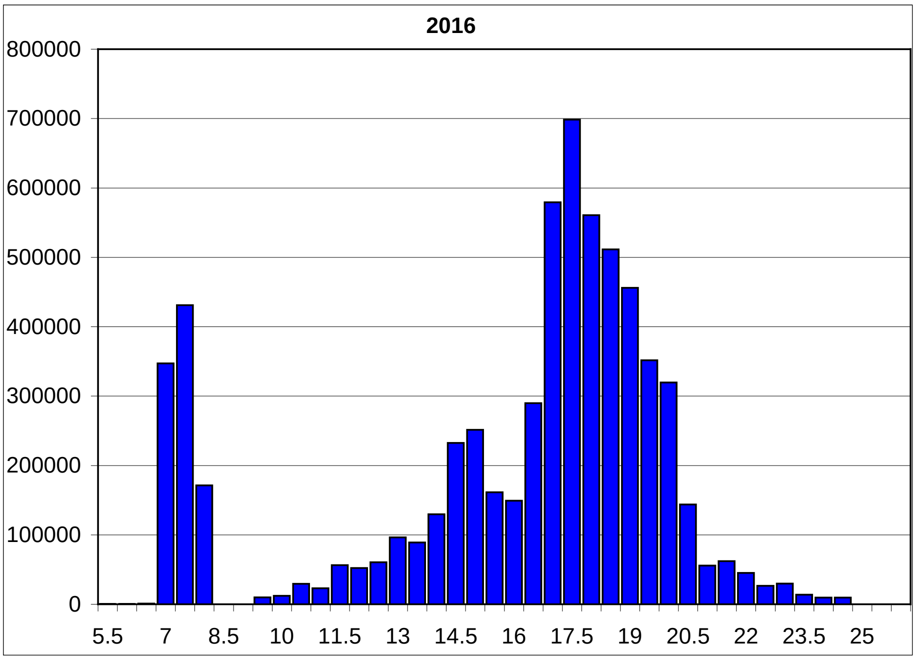


Figure 6.2.2.2.2 Length distribution of sardine as observed during PELGAS16.

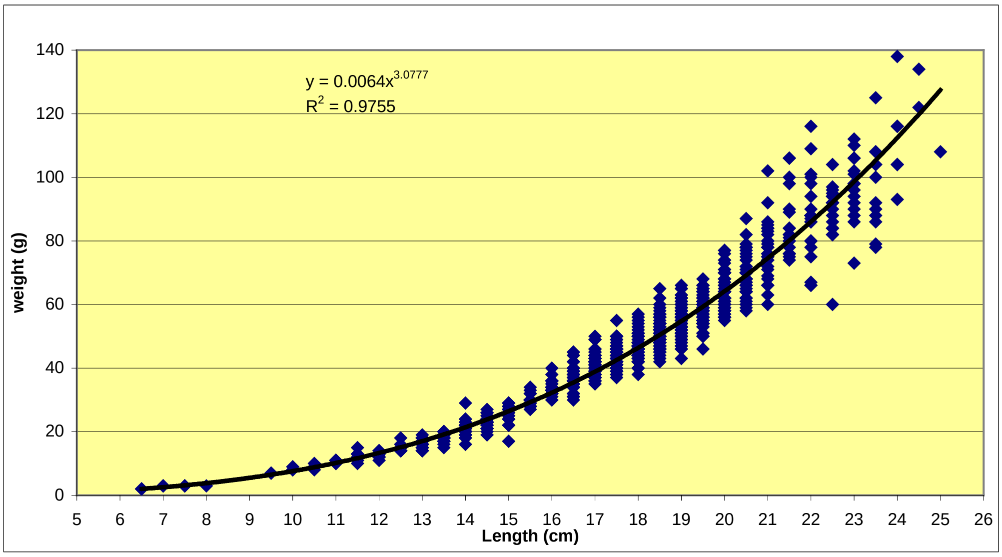


Figure 6.2.2.3 Weight/length key of sardine established during PELGAS16.

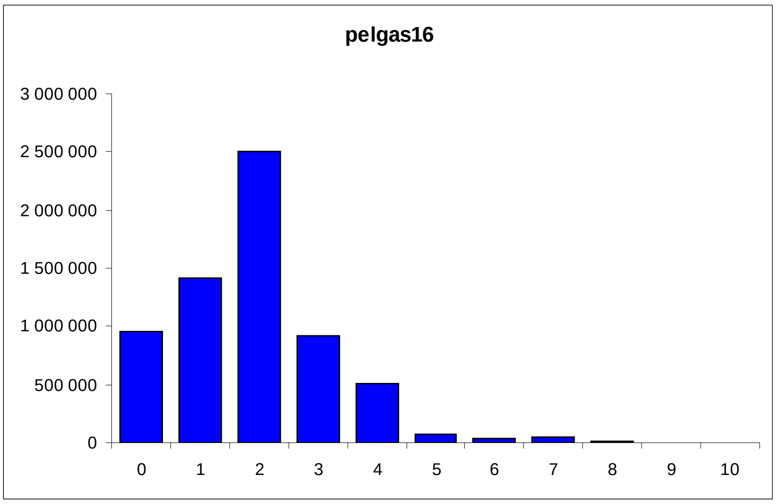


Figure 6.2.2.2.4 Global age composition (nb) of sardine as observed during PELGAS 16.

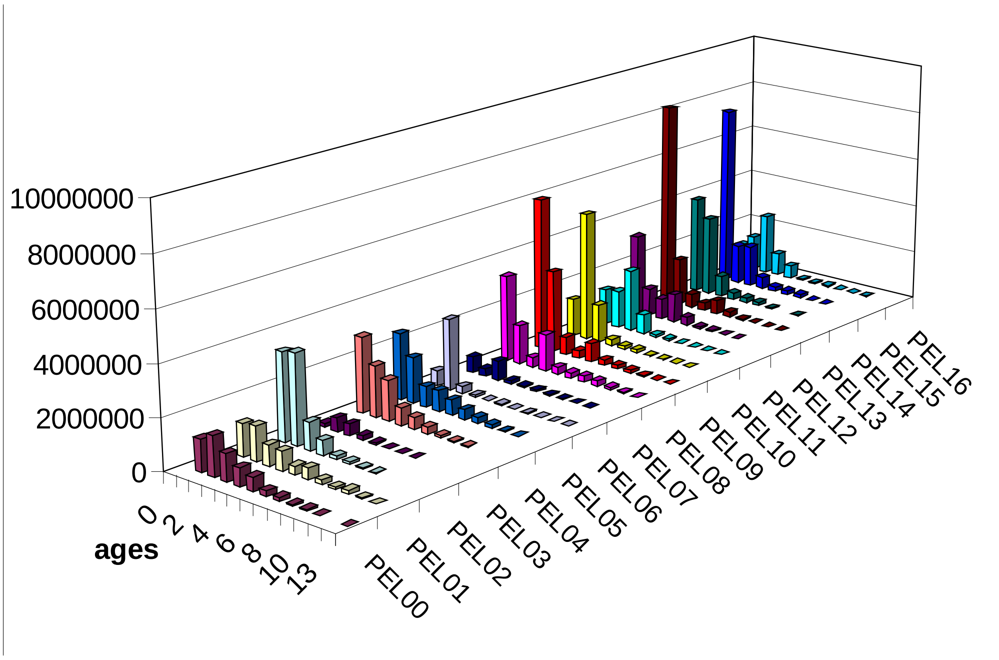


Figure 6.2.2.2.5 Age composition of sardine as estimated by acoustics since 2000.

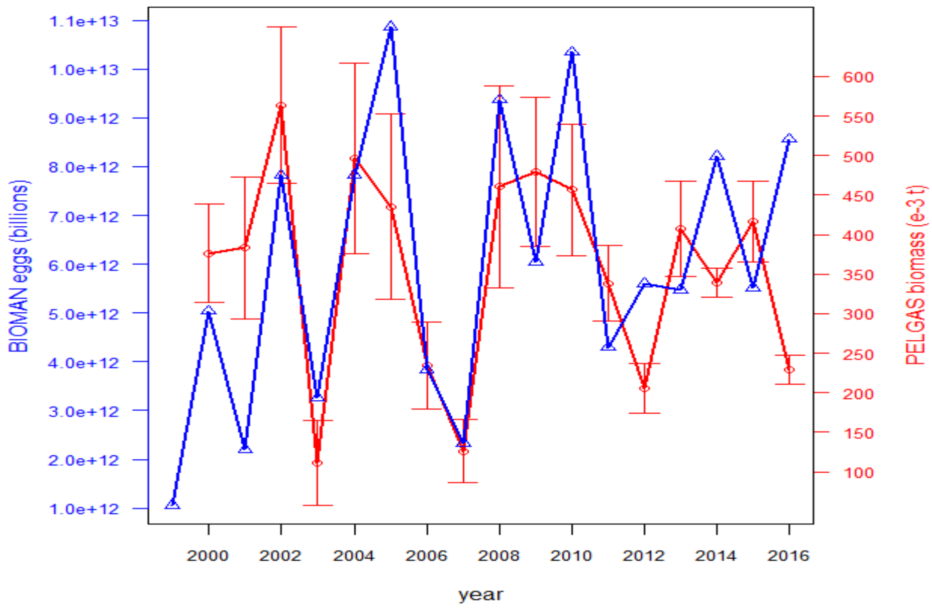


Figure 6.2.4.1.1 Survey indices from Pelgas (acoustic) and Bioman (DEPM) surveys in 8.a, b, d.

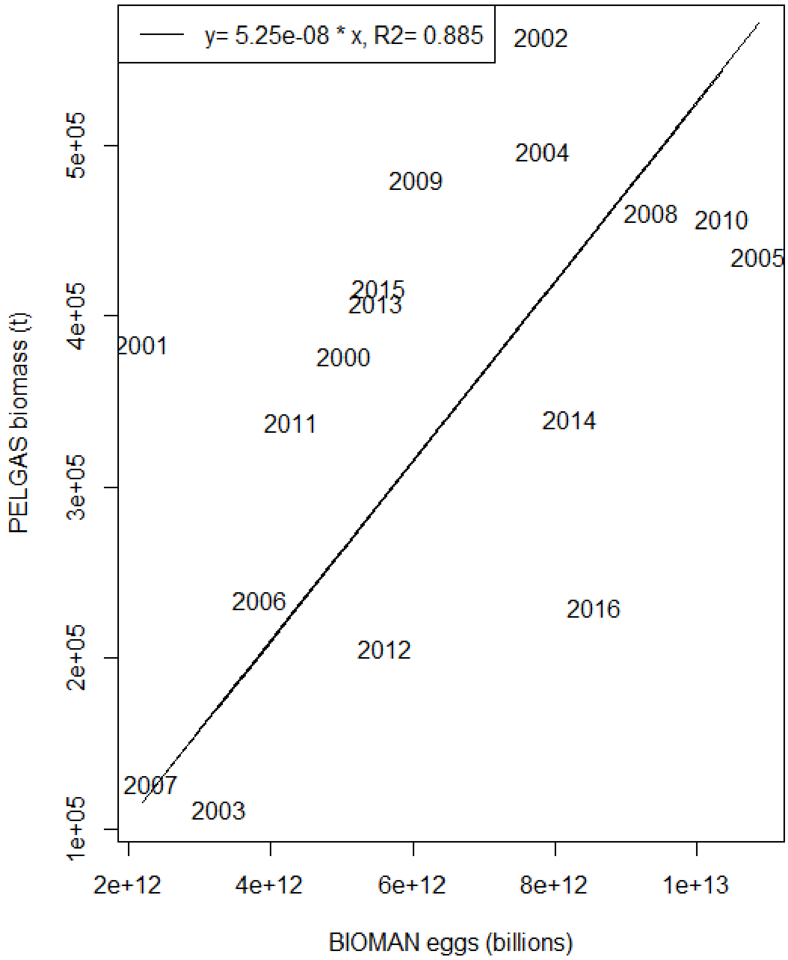


Figure 6.2.4.1.2 Linear model fit of Pelgas (acoustic) with Bioman (DEPM) surveys sardine indices in 8.a, b, d.

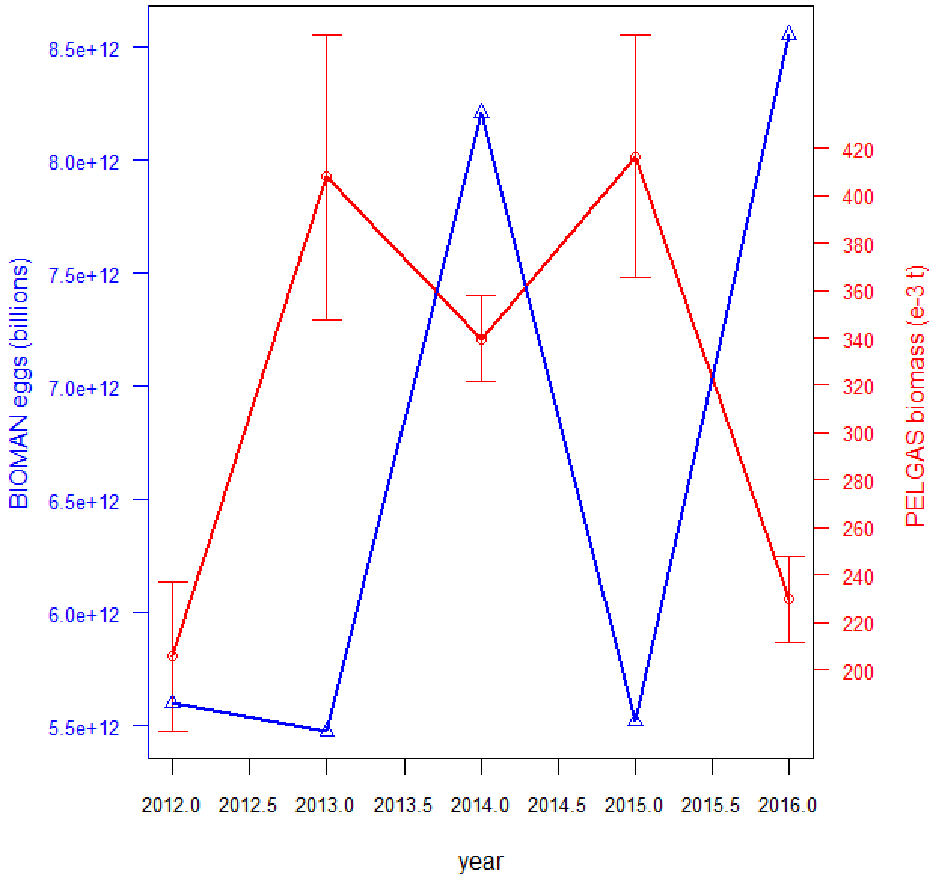


Figure 6.2.4.1.3 Survey indices from Pelgas (acoustic) and Bioman (DEPM) surveys in 8.a, b, d, 2012–2016.

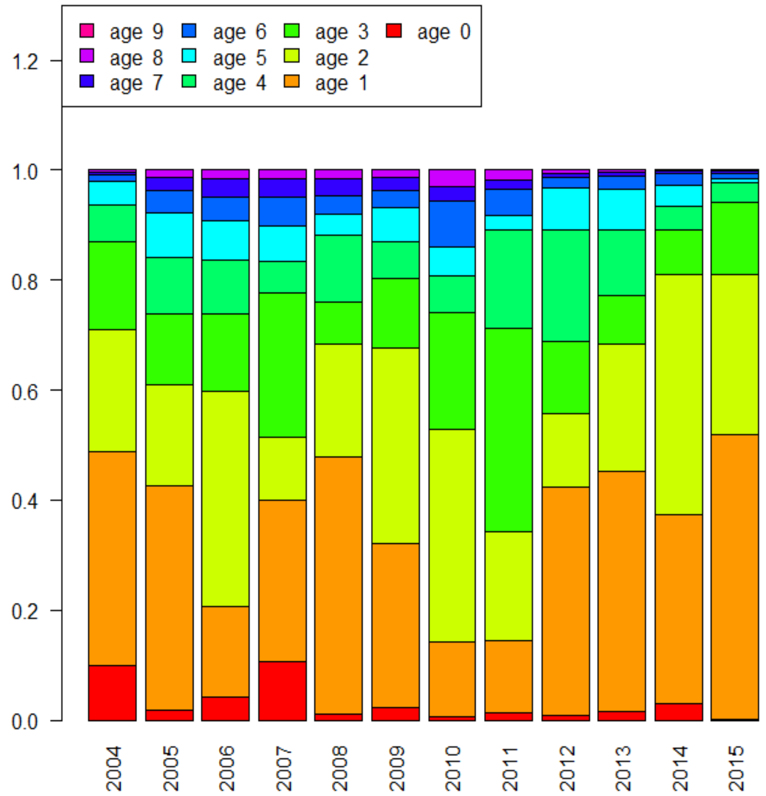


Figure 6.2.4.1.4 Relative composition of catches-at-age for the commercial fleets in 8.a, b, d.

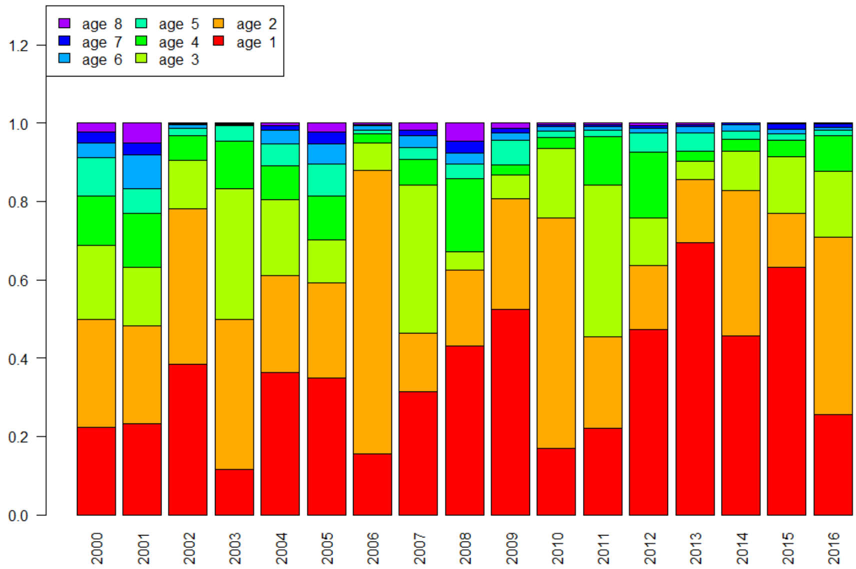


Figure 6.2.4.1.5 Relative composition of the catches-at-age for PELGAS survey in 8.a, b, d.

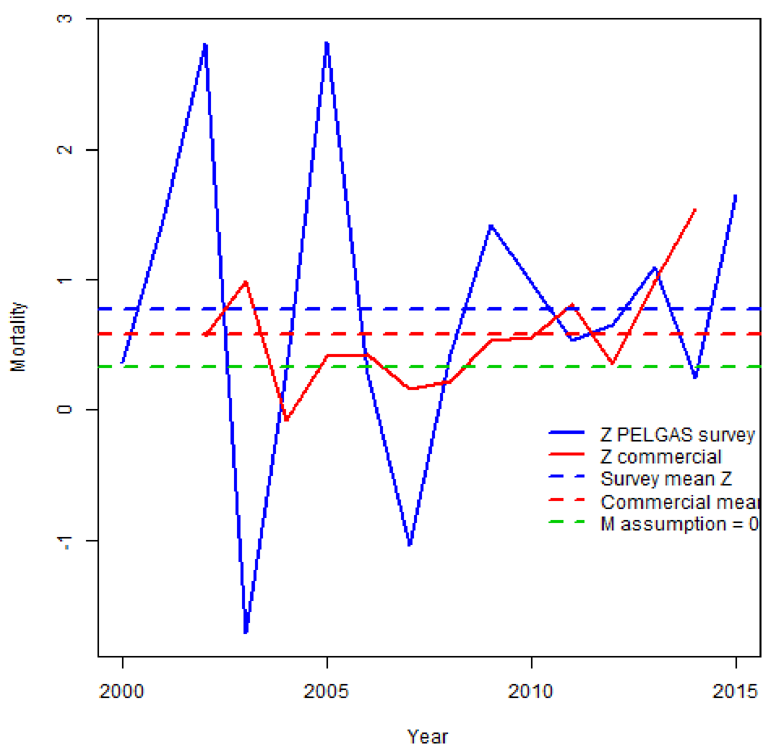


Figure 6.2.4.1.6.Sardine Z total mortalities estimated from PELGAS survey and commercial catch curve analysis (solid lines), and M natural mortality assumption (dotted green line). Overall Z average values for surveys and landings are shown as blue and red dotted lines, respectively.

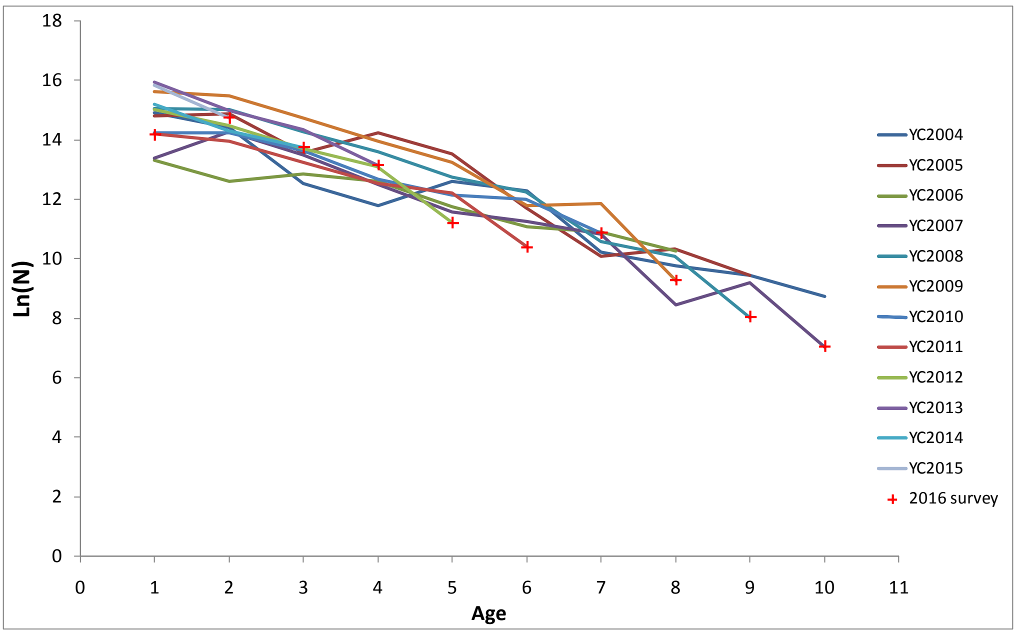


Figure 6.2.4.1.7.Cohort tracking using Pelgas survey catch-at-age data.

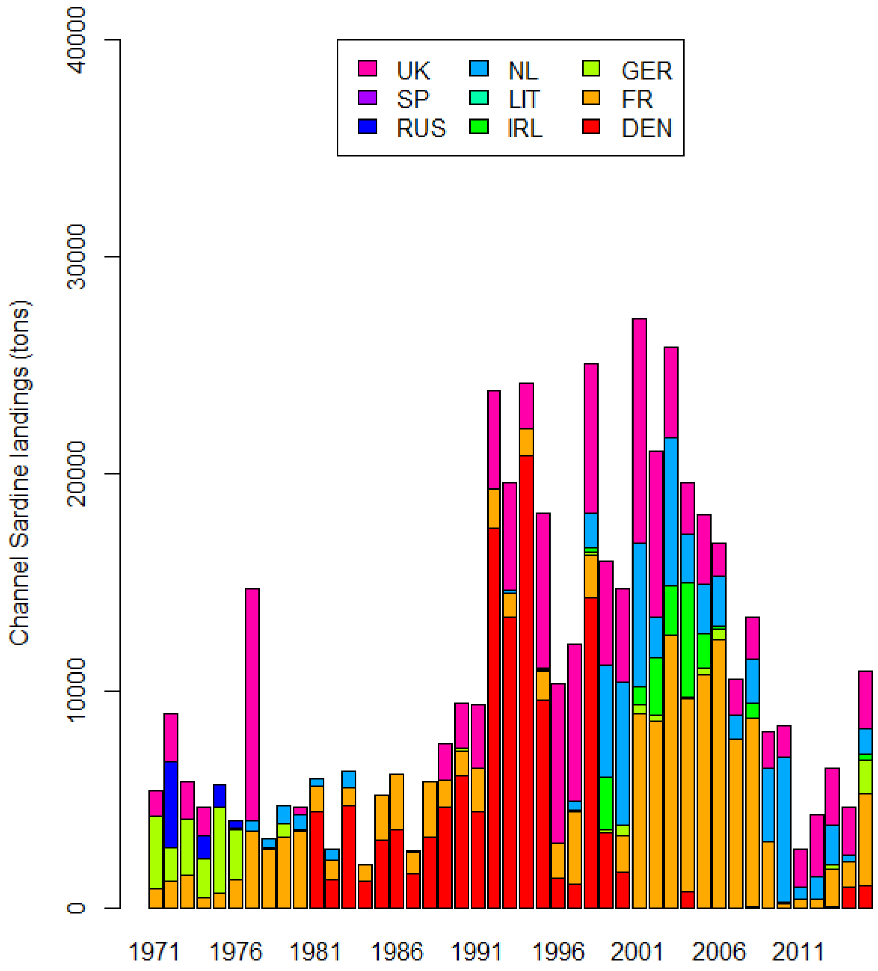


Figure 6.2.4.2.1.Sardine landings per country in area 7.e, d, h.

7 Sardine in 8.c and 9.a

7.1 ACOM Advice Applicable to 2016, STECF advice and Political decisions

ICES advises on the basis of the Management Plan that catches in 2016 should be no more than 1587 tonnes.

7.2 The fishery in 2015

7.2.1 Fishing fleets in 2015

Details about the vessels operated by both Spain and Portugal targeting sardine are given in Table 7.2.1.1.

Sardine is taken in purse seine throughout the stock area and the fleet has remained constant in recent years.

In Spain (Gulf of Cadiz and northern waters), data from 2015 indicates that the number of purse seiners taking sardine were 325, with mean power of 208 Kw. In Portuguese waters, fleet data indicate that, in 2015, 147 vessels were licensed for purse seining, with mean vessel length of 38 GT tonnage and 2015 Fishing Fleets engine power category of 198 Kw.

7.2.2 Catches by fleet and area

The WG estimates of landings and catches are shown in tables 7.2.2.1 and 7.2.2.2.

Total sardine landings in 2015 have suffered a decline in comparison with those of 2014 (tables 7.2.2.1 and 7.2.2.2, Figure 7.2.2.1). Total 2015 landings in divisions 8.c and 9.a were 20 595 t, i.e. a decrease of 26% with respect to the 2014 values (27 937). This sharp decrease can be partly explained by the Management Plan catch limit application for 2015, 19 095 tonnes. The bulk of the landings (99%) were made by purse-seiners.

In Spain, landings of sardine, 6 818 tonnes, have shown a 43% decrease in relation to values from 2014 (11 903 tonnes). All ICES subdivisions showed a substantial decrease in catches (by 56% in 8.c and 48% in 9.aS), except the 9.aN, where catches remained stable (+1% increase).

In Portugal, landings in 2015 (13 777 tonnes) were 14% lower than the landings in 2014 (16 035 tonnes). This decrease in landings was originated in 9.aCS (28%) and 9.aS-Algarve subdivisions, while the northern subdivision, 9.aCN, showed a slight increase of 3%.

Table 7.2.2.1 summarises the quarterly landings and their relative distribution by ICES Subdivision. 59% of the catches were landed in the second semester and 35% of the landings took place off the northern Portuguese coast (9.aCN), representing a relative contribution similar to that of recent years (i.e. last year the contribution of 9.aCN was 33% of the total catches).

In the recent years (2013–2015) the percentage of catches in the northern areas (9.aN and 8.c) has decreased, and catches in both years represented about one fifth of those in 2012. The figure 7.2.2.2 shows the historical relative contribution of the different subareas to the total catches.

Data from on board observers in Portugal (Fernandes and Feijó, 2016WD) and Spanish regular DCF monitoring in 2015, show that discards are negligible and do not constitute a major issue for this fishery.

7.2.3 Effort and catch per unit of effort

No new information on fishing effort has been presented to the WG.

7.2.4 Catches by length and catches-at-age

Tables 7.2.4.1a, b, c, and d show the quarterly length distributions of landings from each subdivision. Annual length distributions (Table 7.2.4.1.) were unimodal in Spain in subdivisions 8.cEast and 8.cWest, with modes at 14.5 and 18.5 cm and 13.5 and 21 cm, respectively. Sardine in 9.aS-Cádiz subdivision showed a trimodal distribution (modes at 12.5, 17 and 20 cm) and 9.aNorth subdivision didn't show any clear mode.

For Portugal, sardine showed unimodal length distributions in 9.aS-Algarve (mode at 19 cm) and bimodal distribution in 9.aCN y 9.aCS subdivisions, with modes at 13 and 18 cm and 16.5 and 21.5 cm, respectively

Table 7.2.4.2 shows the catch-at-age in numbers for each quarter and subdivision and table 7.2.4.3 shows the historical catch-at-age data. In Table 7.2.4.4, the relative contribution of each age group in each Subdivision is shown as well as their relative contribution to the catches. In 2014 the dominant year class in catches was age-1. Age-0 class had a higher contribution to total catches than the previous year, when the fishery was closed at the beginning of the second semester (when age-0 appears). Age 0 fish was prevailing in 8.cW, while in 9S-CAdiz almost half of the catches belong to age 1 (43%). Older ages are dominant in 8.cE, 9.aCN (both with age 2) and 9.aS-Algarve (with a 34% of catches of age 3)

7.2.5 Mean length and mean weight-at-age in the catch

Mean length and mean weight at age by quarter and Subdivision are shown in tables 7.2.5.1 and 7.2.5.2.

7.3 Fishery-independent information

Figures 7.3.1 and 7.3.2 show the time-series of fishery-independent information for the sardine stock.

7.3.1 Iberian DEPM survey (PT-DEPM-PIL+SAREVA)

As part of the Iberian DEPM survey, surveys are carried out every three years by Portugal (IPIMAR) and Spain (IEO). The DEPM survey is planned and discussed within WGACEG (e.g. WGACEGG, 2015), where final results were presented and fully discussed.

In 2014, the Portuguese survey took place in February-March covering the western and southern distribution area of the stock, and the Spanish survey took place in March-April covering the northern area.

Main conclusions of the surveys are (figures 7.3.1.1 and 7.3.1.2):

- Spawning area was reduced compared to 2011 (the smallest of the time series), especially in the north.
- Total egg production was much lower than in 2011, in particular in the northern and southern regions
- Mortality values was on the lowest of the series, but with a higher CV.
- Mean female weight and batch fecundity were lower than values ever reported in this stock
- Batch fecundity doubled in the west area and increased slightly in the south

- Spawning fraction were very similar between strata and identical of the 2008 values
- SSB estimate (126 584 tonnes) is the lowest of the whole time series and represents a substantial decrease regarding 2011 values (by 74%).

As described in the Stock Annex, the total spawning biomass from the two surveys is used in the assessment.

7.3.2 Iberian acoustic survey (PELACUS04+PELAGO)

As part of the Iberian acoustic survey, surveys are carried out each year by Portugal and Spain to estimate small pelagic fish abundance in 9.a and 8.c. The Iberian acoustic survey is planned and discussed within WGACEGG (e.g WGACEGG, 2015). As described in the Stock Annex, the total numbers-at-age from the two surveys are used as input to the assessment.

There are two annual surveys carried out to estimate small pelagic fish abundance in 9.a and 8.c using acoustic methods. The March-April 2015 Portuguese survey (PELAGOS15) took place on board the RV "Noruega" while the Spanish survey (PELACUS0315) took place in March-April on board the RV "Miguel Oliver".

Both surveys were conducted following the methodology applied in previous years and agreed and revised at the WGACEGG.

7.3.2.1 Portuguese spring acoustic survey

In 2016, the acoustic survey PELAGO16 and the horse-mackerel DEPM (Daily Egg Production Method) survey were carried out simultaneously on board RV "Noruega", from the 11th of March (beginning of data collection) to the 1st of May, covering the Portuguese and Gulf of Cádiz waters ranging from 20 to 200 m depth. Acoustic survey was carried out during the day while, plankton samples and CTDF casts were obtained for the DEPM (horse-mackerel and sardine) during the night. Fishing hauls were performed taking into account the objectives of the joint surveys. Detailed objectives, methodology and sampling strategy are described in the WD-Marques *et al*. (2016) presented in this group.

The survey started at the Portugal-Galicia border and proceeded from there to south, but due to adverse weather and some logistics constraints it was not synoptic.

Globally, the surface water temperatures were below the values observed for other years during similar period (~12–18°C). This was more evident during the first leg of the survey on the northern shelf, where quite an extended area was occupied by surface waters with temperatures between 12–13°C.

During the survey, 52 sampling trawl hauls were performed. Sardine was sampled in 22 of these hauls and anchovy in 19 of them. Sardine was usually captured together with other pelagic species, being the most abundant: bogue (*Boops boops*), chub mackerel (*Scomber colias*) and horse mackerel (*Trachurus trachurus*). Off the south coast, Mediterranean horse mackerel (*Trachurus mediterraneus*) was also found. Anchovy was mainly found off Cadiz Bay, but it was also caught in the west coast, from Matosinhos to Nazaré. Offshore, near the shelf edge, blue whiting was the more abundant species.

The estimated sardine biomass was 172 thousand tonnes, representing an important increase in relation to the 2015 survey and reflecting mainly the abundance in a restricted area of the OCS (ICES 9.aCS) and in Algarve (ICES 9.aS) (figures 7.3.2.1.1 and 7.3.2.1.2).

In the Occidental North zone (9.a CN subdivision- Caminha to Nazaré), sardine was mainly distributed from Porto to South of Figueira da Foz and presented a trimodal length structure with modes at 11.5 cm, 15.0 cm and 19.5 cm (mainly composed of 1 year-old individuals). In this area 1315 million sardines were estimated, corresponding to 30 thousand tonnes.

In the Occidental South Zone (9.aCS subdivision) sardine was concentrated near Ericeira and Cascais. Sardine in this zone presented an estimated biomass of 50 thousand tonnes, consisting in 1322 million individuals and dominated by age group 1 (and three modes: 13.5 cm, 17.0 cm and 20.5 cm).

In the Algarve area (9.aS subdivision), sardine was mainly found between Lagos and Faro, with a length distribution with a mode around 20.0 cm and age groups 3 and 5. The abundance result for this area was 1249 million sardines (76.7 thousand tonnes).

In the Gulf of Cadiz, sardine was found between Huelva and Cadiz and it was constituted by very young individuals (with modal length at 6.5 cm). In this area, there was a marked increase of sardine abundance, mainly of juveniles (99.8%). It was estimated 5558 million individuals, which corresponds to 15.3 thousand tonnes.

Despite the birth criteria agreed on January 1st and the assumption that no age 0 individuals occur in the first semester, ICES (2011), most of the individuals found in the Gulf of Cadiz had a size too small to be considered 1 year old (figures 7.3.2.1.2).

Some of the otoliths from those small individuals were re-examined in order to clarify structure and determine the possibility of being considered age-1 again next year (Figure 7.3.2.1.3). Conclusions of this analysis are (Moreno *et al.*, 2016WD):

- Growth pattern of otolith from sardine individuals bigger than 9 cm shows that they were born in 2015, with a clear translucent ring, and some of them starting to create the opaque one. These individuals will be assigned to age-2 in the next 2017 spring survey.
- Otolith structure of sardine individuals below 9 cm has a different morphology, without hyaline ring and will probably be classifyed as age-1 individuals in the 2017 spring survey.

Based on these arguments, and taking also into account gap between the modal groups observed in the length composition, the WG decided that sardine under 10 cm should not be included in age 1 (2015 cohort) of PELAGO16 survey. This issue can only be fully clarified when additional data becomes available for the 2015 and 2016 year-classes (next surveys).

The occurrence of very small sardines and possible mixing of cohorts has been observed in past PELAGO surveys especially in the Gulf of Cadiz (e.g. 2000, 2001, 2008, 2010, see example in Moreno *et al.*, 2016WD). However, the proportion of those individuals in the total abundance was relatively small (< 14%, except in 2010 where it was 26%) and possible mixing of cohorts was not a matter of concern. Nevertheless, the issue should be addressed in the next benchmark.

The acoustic survey does not provide an estimate of recruitment at age 0 because it is carried out in spring. Recruitment takes place mostly in the second half of the year. Therefore, in consistency with past practice, the abundance of individuals < 10 cm observed in the 2016 PELAGO survey, likely to be age 0 fish, were not included in the acoustic index used in the assessment.

Preliminary results on egg abundance, from one of the paired CalVET nets, showed sardine eggs distribution overlapping quite well with the main sardine schools identified by acoustics (Figure 7.3.2.1.4). However, egg abundance was very low, being in fact the lowest of the DEPM historic series, even considering the 2014 survey which was also delayed. In addition, the spawning area defined for both the western and the southern shores were the smallest of the whole data series. Consequently, these initial results indicate very low egg production estimations for the survey period. These observations may be partially explained by the size structure of the population, which included a very large proportion of young sardines, likely first year spawners or even still immature individuals (mainly from the Gulf of Cadiz).

7.3.2.2 Spanish spring acoustic survey

The Spanish survey PELACUS 0316 took place on board the RV "Miguel Oliver" from the 13th March to 16th April, covering the north Spanish continental self between the Miño river (Spanish/Portuguese border) and the Bidasoa one (Spanish/French border). Unexpectedly, weather and oceanographic conditions found were those of the winter time rather than the incipient spring ones. Consecutive deep W/NW storm fronts have affected the survey plan; five days were lost due to the bad weather conditions and even during part of the survey either strong south wind (up to 45 knots) or a persistent swell of about 2–4 m height have also made problems to achieve clean echograms (i.e. without bubbles) and good performance at the fishing station. These conditions might have been also affected the availability of the fish. This seems clearer in the southern part (9.aN), where a stronger winter poleward current led the continental self almost empty of plankton and with a very scarce concentration of fish.

A total of 3650 nautical miles were steamed, 1248 corresponding to the survey track.

In the area surveyed, a total of 49 fishing stations were performed, 3 of them considered null (Figure 7.3.2.2.1). Abundance of the main pelagic fish species was lower than that of the previous year.

For sardine the abundance was very low, practically below an acceptable threshold for an acoustic assessment (Figure 7.3.2.2.2). Only was detected the presence of a very thick school with acoustic and morphological characteristics being compatible to those of sardine, thus being possible sardine but not ground truthed (and accounted for the 59% of the total backscattering energy allocated to sardine). In total the assessed biomass was very low, and excluding this school only 3 thousand tonnes were estimated (corresponding to 70.3 million fish), the lowest record in the time series (13 thousand tonnes (308 10^6 individuals) including this school but still at a very low level). Sardine ranged in length from 14 to 24 cm, with a mode at 18.5 cm which corresponds to quite large fish. Most fish in the entire surveyed area were assigned as belonging to the age 2 (45% of the abundance and 43% of the biomass), age 3 (25% of the abundance and 28% of the biomass) and age 1 (21% of the abundance and 17% of the biomass) year-classes , thus with a weak signal of recruitment.

By subarea, 8.cEast-West subdivision represents 83.2%, 8.cEast- East 8.2%, 9.a North 7.2% and 8.c West 1.4 of the total abundance. Age group 1 was dominant in 9.aN, while it was absent in 8.cW, were age group 4 was dominant. In 8.cE, age group 2 was the most abundant (Table 7.3.2.2.1, Figure 7.3.2.2.3).

The distribution of sardine eggs (obtained from the analysis of 215 CUFES stations) indicates a coastal distribution, agreeing with that observed in previous years (Figure 7.3.2.2.4). Total number of sardine eggs detected in Spanish waters was 1696, which represents an important decrease from the 2015 value (7588 in 355 CUFES stations), although the number of stations was lower. For this reason, we compared mean egg abundance in 2015 with that obtained this year. While inside the Rias Baixas (coastal waters of 9.aN) mean egg abundance, expressed as number of egg/m^3, remained quite similar (2.32 in 2015 and 2.5 this year), the highest differences were found in the 8.c division where the mean egg abundance decreased from 4.74 to only 1.35 eggs/m^3, which is in agreement with the lower fish abundance estimated by echo-integration. Besides, the number of positive stations is still very low (37% in 2016, 45% in 2015, 33% in 2014, and 28% in 2013).

7.3.3 Other regional indices

Despite it not is included as an input of the sardine assessment, ECOCADIZ survey (fully described in the section 4), provides sardine abundance and biomass estimates in the Gulf of Cadiz and Algarve (9.aS subdivision) in summer, which can be compared with the results obtained by the spring Portuguese acoustic survey in the same area. For both surveys, trends are broadly similar, although they have interannual differences (figures 7.3.3.1 and 7.3.3.2). Although at this moment the time series is too short, another survey ECOCADIZ-RECLUTAS has been carried out in autumn since 2012 in the Gulf of Cadiz and Figure 7.3.3.3 shows the relationship between age 0 in this survey and age 1 in PELAGO spring survey for sardine.

In the past (from 1997) some sardine juvenile surveys were carried out in the northwestern Portuguese coast in autumn. In the recent period (2013–2015) three acoustic surveys (JUVESAR) were carried out from Lisbon to the Portuguese-Spanish border, a major recruitment area of the stock, to assess the abundance of recruits in that particular area. Figure 7.3.3.4 shows the estimation of age 0 in the autumn surveys and age 1 in the next spring survey, with similar trends.

7.3.4 Mean weight-at-age in the stock and in the catch

Mean weight-at-age in the catch in 2015 and in the stock in 2016 was calculated according to the Stock Annex.

The historical stock weight at age and catch weight at age series are shown in tables 7.4.1a and 7.4.1b, respectively.

Mean weights at age in the stock are obtained from samples collected in the acoustic surveys (Table 7.4.1b). The mean weight-at-age 1 in 2016, 24 g, was calculated excluding small individuals observed in Cadiz (< 10 cm, see Section 7.3.2.1). If those individuals were included, the mean weight-at-age 1 in 2016 would be 9 g.

Catch weights in 2015 and stock weights in 2016 are within the range of historical values.

7.3.5 Maturity-at-age

Following the Stock Annex, maturity at age in 2015 was 0 for age 0, 0.8 for age 1 and 1 for ages 2+.

7.3.6 Natural mortality

Following the Stock Annex, natural mortality is:

	M, YEAR-1
Age 0	0.8
Age 1	0.5
Age 2	0.4
Age 3	0.3
Age 4	0.3
Age 5	0.3
Age 6	0.3
Mean (2–5)	0.3

7.3.7 Catch-at-age and abundance-at-age in the spring acoustic survey

The historical series of catches-at-age and abundance-at-age in the spring acoustic survey are presented in figures 7.4.4.1 and 7.4.4.2.

7.4 Assessment Data of the state of the stock

7.4.1 Stock assessment

The assessment follows the Stock Annex and is a SPALY.

The table below presents an overview of the model settings. Additional details can be found in the Stock Annex. This years assessment was transitioned from Stock Synthesis version 3.21d to version 3.24f. Trial runs with the two versions showed the results were similar.

Model structure and assumptions:	
M	M-at-age 0=0.8, M-at-age 1=0.5, M-at-age 2=0.4, M-at-age 3+=0.3, all years
Recruitment	No SR model; annual recruitments are parameters, defined as lognormal deviations from a constant mean value penalized by a sigma of 0.55 (the standard deviation of log(recruits) estimated in WGANSA 2011)
Catch biomass	Assumed to be accurate and precise. The F values are tuned to match this catch. Total catch biomas by year is assumed to be a median unbiased index of abundance.
Fishing mortality	Fishing mortality is applied as the hybrid method. This method does a Pope's approximation to provide initial values for iterative adjustment of the continuous F values to closely approximate the observed catch.
Initial population	N-at-age in the first year are parameters, derived from an input initial equilibrium catch, the geometric mean recruitment and the selectivity in the first year.
Fishery selectivity-at-age	S-at age are parameters, each estimated as a random walk from the previous age; S-at-age 0 not estimated, used as the reference; S-at-ages 4 and 5 assumed to be equal to S-at-age 3.
Fishery selectivity over time	Two periods: 1978-1990 with selectivity-at-age varying as a random walk and 1991-last year in assessment for which selectivity-at-age is fixed over time
Survey selectivity-at-age	S-at age are parameters, each estimated as a random walk from the previous age; S-at-age 1 not estimated, used as the reference; S-at-ages 3 to 5 assumed to be equal to S-at-age 2; fixed over time
Fishery catchability	Scaling factor, median unbiased
Acoustic survey catchability	Scaling factor, mean unbiased
DEPM catchability	Scaling factor, mean unbiased
Precision of acoustic data	A standard error of 0.25 assumed for all years for the acoustic index (total number of fish). A sample size=50 is assumed for all years of the acoustic age composition.
Precision of DEPM data	A standard error of 0.25 assumed for all years for the DEPM index (spawning biomass).
Precision of catch-at-age data	Ageing imprecision is 0.1 at Age0, 0.2 at Age1, 0.3 at Ages 2-5, 0.4 at age 6+ .The sample size for annual age compositions is 50 in 1978-1990 and 75 in 1991-2last year in the assessment
Objective function	Log likelihood function, user-weighted composite of components from the different data sources. Variance estimates for all estimated parameters are calculated from the Hessian matrix.

Table 7.5.1.1 shows the parameters estimated by the assessment model. Changes in parameters from last years assessment ranged from – 6.9% to + 7%. Major changes were in 2011 R deviation, age 6+ selectivity in 1978 and DEPM catchability. Figures 7.5.1.1 and 7.5.1.2 show the fit of the model to the acoustic and DEPM survey indices (total number of fish and spawning biomass by year, respectively). Catchability coefficient (q) for the DEPM series is estimated to be 1.0 (residual mean standard error = 0.57) and the scaling factor for the acoustic survey 1.9 (residual mean standard error = 0.29). As noted in past assessments, the model fit to the acoustic survey index is reasonable (near mean estimates and within error bounds). The fit to the DEPM survey index is poor. Since 2011, the model estimates are above the acoustic index.

Figure 7.5.1.3 shows the model residuals from the fit to the catch-at-age composition and the acoustic survey age composition. The residuals from the present assessment are comparable to those from last years' assessment. Catch residuals show some clustering being generally larger at age 0. Positive catch residuals at age 0 are noted between 2007 and 2014. In the past three years, acoustic surveys are largely dominated by age 1 individuals (Figure 7.4.4.2) and there are no clear year-classes signals. Survey residuals are positive at age 1, negative at intermediate ages (2–4 years) and positive again at older ages (5–6 years) reflecting a compromise to fit lower than expected abundance of year-classes at intermediate ages given their abundance at age 1 and older ages. The model fits well to age 1 in the 2016 survey but positive residuals increase at older ages in comparison with previous surveys. A year effect is apparent in the age composition of the 2016 survey (Figure 7.4.4.2).

Both the survey and the fishery selectivity patterns are comparable to those from last years' assessment (Figure 7.5.1.4). Standard deviations of selectivity parameters for the fixed selectivity period (CVs below 30%) and comparable to those from last years assessment. As in last years assessment, standard deviations of random walk fishery selectivity parameters are exceptionally large (CVs above 100%, Table 7.5.1.1). As a consequence fishing mortality confidence intervals show an abrupt and unrealistic increase from 1991 towards the beggining of the assessment period (1978, Table 7.5.1.4).

Estimates of fishing mortality at age and numbers at age are presented in tables 7.5.1.2 and 7.5.1.3. The assessment estimates of B1+, recruitment and fishing mortality are presented in Table 7.5.1.4 and Figure 7.5.1.5). The estimate of B1+ in 2016 assumes stock weights are equal to those in the 2016 acoustic survey instead of assuming stock weights in 2016 equal to stock weights in 2015 (see Section 7.4.1). The procedure is not written in the Stock Annex. Although this is a deviation from past practice it improves the consistency between estimates of Biomass 1+ in successive assessments; stock weights in the last year of the assessment are taken from the acoustic survey. The model estimates standard errors of SSB, recruitment and ApicalF (maximum F over age within years). We assume the CVs of SSB and ApicalF apply to B1+ and F(2–5).

B1+ in 2015 = 168 thousand t (CV = 16%) is 66% below the historical mean 1978–2014. B1+ shows an increase of 25% from 2014 to 2015. Nevertheless it is still around the historical low as observed in the past 5 years. F in 2015 is estimated to be 0.14 year (CV = 17%), 57% below the historical mean. F has decreased continuously since 2011 and F2015 is 76% below F2011. The decrease from 2014 to 2015 was 41%. The large reduction of catches has contributed to the decrease in F; from 2014 to 2015, both the catch decrease and the B1+ increase contributed to the decrease in F. B1+ in 2016 is estimated to be 199 thousand tonnes.

The series of historical recruitments 1978–2014 shows a marked downward trend until 2006 and since then, fluctuates around historically low values. The R2015 estimate, 4026 million (CV = 21%), is 58% lower than the historical geometric mean. This estimate is 16% above the geometric mean of the recent low recruitments 2011–2015 (RGM(11–15) = 4005 millions. The estimate of the recruitment in the last year of the assessment (2015 in the present assessment) is supported by the 2016 Iberian acoustic survey index.

7.4.2 Reliability of the assessment

Compared to last year's assessment, B1+ in 2014 is revised upwards 9.6%, F2014 is revised downwards 10% and R2014 is estimated to be similar (–0.4%). The consistency between historical assessment results has increased and there is currently no obvious retrospective pattern in the assessment (Figure 7.5.2).

The 2015 biomass was revised upwards 20% in comparison with last years' assessment. The upward revision of the 2015 biomass is, in turn, mainly caused by the higher estimates of stock numbers for ages 4 to 6+ in 2015 and the upward revision of 2015 stock weights in this years' assessment compared to last years' assessment. This effect is driven by the 2016 acoustic survey, and shows an impact back in time. The scaling effect decreases to 6–7% upwards in the case of biomass and to similar percentages downwards in the case of fishing mortality, back in the early 2000s.

The very small individuals (5–9 cm total length) observed in the 2016 acoustic survey in the Gulf of Cadiz are likely to belong to the 2016 yearclass (age 0 fish in 2016, Section 7.3.2.1). The assignment to age group 0 (2016 yearclass) or 1 (2015 yearclass) is difficult for individuals of this size observed in spring. Based on biological arguments presented to the WG, the decision was to allocate them at age 0 even though this deviates from past practices. In the past, the magnitude of this issue was not a matter of concern because of the low numbers of individuals of that size range. The acoustic survey does not provide an estimate of recruitment at age 0 because it is carried out in spring. Recruitment takes place mostly in the second half of the year. Therefore, in consistency with past practice, possibly age 0 fish observed in the 2016 survey were not included in the 2016 acoustic index and in this years' assessment. This issue affects the estimate of 2015 recruitment in this years' assessment and can only be fully clarified when additional data becomes available for the 2015 and 2016 yearclasses (next surveys).

It is noted that the current low abundance of sardine is likely to affect the accuracy and precision of acoustic estimates and increase the noise in the index in comparison with past periods of higher abundance (Section 7.3.2).

Uncertainties in the assessment related to possible difference in catchability of Portuguese and Spanish acoustic surveys, to fishery and survey selection patterns –at-age and over time, to divergent signals in the trends from DEPM and acoustic surveys and to the extent of sardine movement across the northern stock boundary still apply. These issues are included in the list to be addressed in the next sardine benchmark process (benchmark workshop scheduled for early 2017).

7.5 Short-term predictions (Divisions 8.c and 9.a)

Catch predictions are carried out following the Stock Annex, apart from the assumptions about recruitment, about fishing mortality in the interim year and about stock weights in the interim year.

Recruitment (Age 0) estimated in the final year of the assessment, 2015, was accepted for the projection since it is supported by the acoustic survey in the interim year.

Input values for 2016 and 2017 recruitments (Age 0) were set equal to the geometric mean of the period 2011–2015, RGM(11–15) = 4005 million individuals, instead of using a geometric mean of the recruitments of the last 15 years, as indicated in the Stock Annex. This year's assumption is equal to that adopted in last year's assessment. As argued last year, the assessment indicates recruitment to be at a historically low level since 2006. The WG considers the possibility that low recruitments continue in the near future should be taken into account in the short term predictions. Therefore, a low recruitment, corresponding to the geometric mean of the last five years, 2011–2015, is assumed for 2016–2017. The 2015 recruitment was included in the geometric mean since it is supported by the acoustic survey in 2016.

Input values for weights-at-age in the stock in the interim year (2016) are the mean weight-at-age in the 2016 acoustic survey, instead of the mean values of the last three years (2013–2015) indicated in the Stock Annex. This practice results in equal B1+ 2016 values in the assessment and in the short term forecast. Weights-at-age in the stock in 2017 and 2018 are mean values of the last three years (2013–2015) as indicated in the Stock Annex.

Weights-at-age in the catch are mean values of the last three years (2013–2015) as indicated in the Stock Annex. Historical weights at age show an increase over time reflecting an improvement of sardine condition. In this situation, an average of the most recent weights at age (2013–2015) was considered to be representative of weights at age in the short term.

The assessment assumes the exploitation pattern is fixed over time since 1991 and that it is equal for ages 3–5 years. The exploitation pattern estimated by the assessment since 1991 was considered to apply in the short term. Natural mortality-at-age is assumed to be equal to that used in the assessment.

Fishing mortality assumed in the interim year was scaled to F = F2002–2007 × (B1+2016/ B1+2002–2007) = 0.08, corresponding to the revised catch advice for 2016 (13 000 tonnes) according to Precautionary considerations (see also ToR c-ii). The WG considers 13 000 tonnes to be the more realistic prediction of 2016 catches which can be made at this time. The basis for this assumption is that Spanish (Boletín Oficial del estado, nº 50, 27/02/2016, sec. III, pág. 16086; Boletín Oficial del estado, nº 44, 20/02/2016, sec. III, pág. 13215) and Portuguese (Despacho n.º 3112-B/2016, *DR-2.ª série, N.º 41, 29 de fevereiro de 2016*) catch regulations for 2016 seem to be based on ICES advice for 2016 based on Precautionary considerations and not on the Management Plan.

For 2017, predictions were carried out with an $F_{multiplier}$ assuming an F_{sq} equal 2015 F (F_{sq} = 0.14). This deviates from the stock annex because there it is said that F_{sq} should be equal to the average estimate of the last three years in the assessment (i.e. F mean 2013–2015). The WG adopted this deviation because F shows a marked downward trend since 2011

Input values are shown in Table 7.6.1 and results are shown in Table 7.6.2.

7.6 Reference points

The Sardine Fishery Management Plan -2012–2015, agreed by Spanish and Portuguese governments and evaluated by ICES to be provisionally precautionary, considers:

- B0 = 135 000 tonnes; the level below which the fishery is closed; biomass values to ensure a recovery of the stock in the short term
- Btrigger = 368 400 t; equal to 1.2 Bloss (2012 assessment) = 3 060 000 tonnes
- Harvest Rate = 0.23; above Btrigger constant catch = 86 000 tonnes, between Btrigger and B0 HR is applied to decline catch, below B0, HR = 0.

The stock is undergoing a benchmark process which will have the main workshop in early 2017. Since the data and assessment might be reviewed in the benchmark, the WG considers the estimation of reference points within the framework of the MSY approach or the Precautionary approach should be postponed at least until the benchmark.

7.7 Management considerations

There is no international TAC.

In order to ensure recovery of the sardine stock, Portugal and Spain developed a multiannual management plan (WKSardineMP, 2013). ICES concluded that the plan is provisionally precautionary (ICES, 2013).

This management plan consists in a rule where the TAC is set at a fixed level, but reduced if the biomass (B1+) is below a trigger B1+ (at 368.4 kt), and the fishery is stopped at B1+ below another B1+ reference point, called lower trigger level or simplyB0 (set at 135 kt).

Following the sardine Management Plan implies that the catch for 2017 is set by the formula 0.36 × (B1+ (2016) – lower trigger level) = (0.36 × (199–135))) because the biomass is currently between the two trigger points in the harvest rule, resulting in catches of no more than 23 000 tonnes in 2017.

The stock biomass has shown a downward trend due to the lack of strong recruitments since 2006 and high fishing mortality in 2008–2013. The stock biomass shows an increase of 25% from 2014 to 2015 and is predicted to increase 18% from 2015 to 2016. However, those recent and expected changes are rather uncertain given the uncertainties in the inputs and assessment itself (see next paragraph). Hence the major conclusion is that the stock biomass is still around the lowest historical level; therefore, the development of the stock and the fishery is currently mainly dependent on the strength of the incoming recruitment.

In addition to the low biomass and uneven spatial distribution, and despite the increase in acoustic abundance in 2016, the egg distribution and abundance were the lowest of the time series. The stock spawning area has shrunk when compared to 2011 (ICES, 2015a).The stock and the catches are largely dominated by young individuals with low reproductive potential. The survival of incoming yearclasses until older ages may be important to improve the stock's reproductive potential. This reinforces the need to maintain a low fishing mortality level.

National quotas and effort limitations have contributed to a reduction in fishing mortality by 76% since 2011; F2015 is 57% below the historical average.

7.8 Indicators and thresholds to trigger new advice

There is at present no coordinated survey to assess sardine recruitment (a Portuguese autumn survey was discontinued in 2008) although in recent years, both Portugal and Spain have carried out surveys to assess recruitment. Given the low level of the stock, the dynamics of the stock and therefore the short term catch options for the fishery are almost exclusively determined by the strength of the incoming recruitment. In case there is data from an autumn recruitment survey, these data could be evaluated within an ICES sub-group (e.g. working by correspondence) to decide if the advice should be re-opened.

7.9 Answer to EU Special request

Catch options for 2016 were revised based on the results of this years' stock assessment. The basis for the revised catch options for 2016 are presented in Table 7.6.3.

Catch options for 2016 were carried out with an $F_{multiplier}$ assuming an F_{sq} equal to the 2015 F (F_{sq} = 0.14). The WG adopted the scaling procedure to F2015 (even though this deviated from the stock annex) because F shows a marked downward trend since 2011. Input value for 2016 recruitment (Age 0) was set equal to the geometric mean of the period 2011–2015, RGM(11–15) = 4005 million individuals. The assessment indicates recruitment to be at a historically low level since 2006 and the WG considers the possibility that low recruitments continue in the near future should be taken into account in short term predictions. Therefore, a low recruitment, corresponding to the geometric mean of the last five years, 2011–2015, is assumed for 2016. The 2015 recruitment was included in the geometric mean since it is supported by the acoustic survey in 2016. Input values for weights-at-age in the stock in 2016 are the mean weights-at-age observed in the 2016 acoustic survey. Weights-at-age in the catch for 2016 are mean values of the last three years (2013–2015). Historical weights at age show an increase over time reflecting an improvement of sardine condition. In this situation, an average of the most recent weights at age (2013–2015) was considered to be representative of weights at age in the short term. Natural mortality-at-age is assumed to be equal to that used in the assessment.

Input values for the catch options are shown in Table 7.6.4 and results are shown in Table 7.6.5.

The basis for catch advice according to the Management Plan depends only on the revision of the 2015 Biomass 1+ whereas the basis for catch advice according to Precautionary considerations adjust the current level of fishing mortality by the ratio of the current (2015 in the present case) and reference (average of period 2002–2007) biomasses.

The catch for 2016 according to the Management Plan is revised upwards from 1587 thousand tonnes to 12 thousand tonnes, as a consequence of the 20% upward revision of the 2015 Biomass 1+ in this years' assessment (by the formula 0.36 × (B1+ (2015) – lower trigger level) = (0.36 × (168–135))).

The catch for 2016 according to the Precautionary considerations had a minor downward revision, from 14 thousand tonnes to 13 thousand tonnes. The upward scaling of historical biomasses and downward scaling of fishing mortality in the 2016 assessment affect B1+ and F estimates in the reference period 2002–2007 in similar percentages. Therefore, the revised F basis for precautionary considerations (0.08) is similar to the value obtained last year. However, the F basis obtained last year corresponds to a 70% reduction of F in relation to the corresponding former F_{sq} (0.27) whereas the revised F basis implies a 45% reduction in F in relation to the corresponding F_{sq} (0.14). In summary, the upward scaling of historical biomass in this years' assessment indicates a higher precautionary biomass and lower precautionary F than assumed in last years' assessment resulting in a similar precautionary catch.

Table 7.2.1.1. Sardine in 8.c and 9.a: Spanish fleet that operates in the purse-seine fishery in 2015 and Portuguese composition of the fleet licensed to catch sardine in 2015. Dimensions average (units), Engine power average in HP.

Country	Engine power (Kw)	Gear	Storage	Discard estimates	No vessels
Spain	208	Purse-seine	Dry hold with ice	No	325
Portugal	198	Purse-seine	Dry hold with ice	No	147

Table 7.2.2.1. Sardine in 8.c and 9.a: Quarterly distribution of sardine landings (t) in 2015 by ICES subdivision. Above absolute values; below, relative numbers.

Sub-Div	1st	2nd	3rd	4th	Total
VIIIc-E	142	103	83	428	**756**
VIIIc-W	48	281	737	94	**1160**
IXa-N	111	394	1181	260	**1946**
IXa-CN	8	3094	3527	489	**7117**
IXa-CS	248	2094	1800	706	**4848**
IXa-S (A)	194	696	913	9	**1812**
IXa-S (C)	550	519	781	1106	**2956**
Total	**1302**	**7181**	**9022**	**3091**	**20596**

Sub-Div	1st	2nd	3rd	4th	Total
VIIIc-E	0.69	0.50	0.40	2.08	**3.67**
VIIIc-W	0.24	1.36	3.58	0.46	**5.63**
IXa-N	0.54	1.91	5.73	1.26	**9.45**
IXa-CN	0.04	15.02	17.12	2.37	**34.56**
IXa-CS	1.21	10.17	8.74	3.43	**23.54**
IXa-S (A)	0.94	3.38	4.43	0.04	**8.80**
IXa-S (C)	2.67	2.52	3.79	5.37	**14.35**
Total	**6.32**	**34.87**	**43.80**	**15.01**	

Table 7.2.2.2. Sardine in 8.c and 9.a: Iberian Sardine Landings (tonnes) by subarea and total for the period 1940–2015.

				Subarea				
Year	8.c	9.a North	9.a Central North	9.a Central South	9.a South Algarve	9.a South Cadiz	All subareas	Division 9.a
1940	66816		42132	33275	23724		165947	99131
1941	27801		26599	34423	9391		98214	70413
1942	47208		40969	31957	8739		128873	81665
1943	46348		85692	31362	15871		179273	132925
1944	76147		88643	31135	8450		204375	128228
1945	67998		64313	37289	7426		177026	109028
1946	32280		68787	26430	12237		139734	107454
1947	43459	21855	55407	25003	15667		161391	117932
1948	10945	17320	50288	17060	10674		106287	95342
1949	11519	19504	37868	12077	8952		89920	78401
1950	13201	27121	47388	17025	17963		122698	109497
1951	12713	27959	43906	15056	19269		118903	106190
1952	7765	30485	40938	22687	25331		127206	119441
1953	4969	27569	68145	16969	12051		129703	124734
1954	8836	28816	62467	25736	24084		149939	141103
1955	6851	30804	55618	15191	21150		129614	122763
1956	12074	29614	58128	24069	14475		138360	126286
1957	15624	37170	75896	20231	15010		163931	148307
1958	29743	41143	92790	33937	12554		210167	180424
1959	42005	36055	87845	23754	11680		201339	159334
1960	38244	60713	83331	24384	24062		230734	192490
1961	51212	59570	96105	22872	16528		246287	195075
1962	28891	46381	77701	29643	23528		206144	177253
1963	33796	51979	86859	17595	12397		202626	168830
1964	36390	40897	108065	27636	22035		235023	198633
1965	31732	47036	82354	35003	18797		214922	183190
1966	32196	44154	66929	34153	20855		198287	166091
1967	23480	45595	64210	31576	16635		181496	158016
1968	24690	51828	46215	16671	14993		154397	129707
1969	38254	40732	37782	13852	9350		139970	101716
1970	28934	32306	37608	12989	14257		126094	97160
1971	41691	48637	36728	16917	16534		160507	118816
1972	33800	45275	34889	18007	19200		151171	117371
1973	44768	18523	46984	27688	19570		157533	112765
1974	34536	13894	36339	18717	14244		117730	83194
1975	50260	12236	54819	19295	16714		153324	103064
1976	51901	10140	43435	16548	12538		134562	82661
1977	36149	9782	37064	17496	20745		121236	85087
1978	43522	12915	34246	25974	23333	5619	145609	102087
1979	18271	43876	39651	27532	24111	3800	157241	138970
1980	35787	49593	59290	29433	17579	3120	194802	159015

				Subarea				
Year	8.c	9.a North	9.a Central North	9.a Central South	9.a South Algarve	9.a South Cadiz	All subareas	Division 9.a
1981	35550	65330	61150	37054	15048	2384	216517	180967
1982	31756	71889	45865	38082	16912	2442	206946	175190
1983	32374	62843	33163	31163	21607	2688	183837	151463
1984	27970	79606	42798	35032	17280	3319	206005	178035
1985	25907	66491	61755	31535	18418	4333	208439	182532
1986	39195	37960	57360	31737	14354	6757	187363	148168
1987	36377	42234	44806	27795	17613	8870	177696	141319
1988	40944	24005	52779	27420	13393	2990	161531	120587
1989	29856	16179	52585	26783	11723	3835	140961	111105
1990	27500	19253	52212	24723	19238	6503	149429	121929
1991	20735	14383	44379	26150	22106	4834	132587	111852
1992	26160	16579	41681	29968	11666	4196	130250	104090
1993	24486	23905	47284	29995	13160	3664	142495	118009
1994	22181	16151	49136	30390	14942	3782	136582	114401
1995	19538	13928	41444	27270	19104	3996	125280	105742

Table 7.2.2.2. Continued. Sardine in 8.c and 9.a: Iberian Sardine Landings (tonnes) by subarea and total for the period 1940–2015.

				Subarea				
Year	8.c	9.a North	9.a Central North	9.a Central South	9.a South Algarve	9.a South Cadiz	All subareas	Division 9.a
1996	14423	11251	34761	31117	19880	5304	116736	102313
1997	15587	12291	34156	25863	21137	6780	115814	100227
1998	16177	3263	32584	29564	20743	6594	108924	92747
1999	11862	2563	31574	21747	18499	7846	94091	82229
2000	11697	2866	23311	23701	19129	5081	85786	74089
2001	16798	8398	32726	25619	13350	5066	101957	85159
2002	15885	4562	33585	22969	10982	11689	99673	83787
2003	16436	6383	33293	24635	8600	8484	97831	81395
2004	18306	8573	29488	24370	8107	9176	98020	79714
2005	19800	11663	25696	24619	7175	8391	97345	77545
2006	15377	10856	30152	19061	5798	5779	87023	71646
2007	13380	12402	41090	19142	4266	6188	96469	83088
2008	13636	9409	45210	20858	4928	7423	101464	87828
2009	11963	7226	36212	20838	4785	6716	87740	75777
2010	13772	7409	40923	17623	5181	4662	89571	75798
2011	8536	5621	37152	13685	6387	9023	80403	71867
2012	13090	4154	19647	9045	2891	6031	54857	41768
2013	5272	2128	15065	9084	4112	10157	45818	40546
2014	4344	1924	6889	6747	2398	5635	27937	23593
2015	1916	1946	7111	4848	1812	2956	20595	18679

Table 7.2.4.1. Sardine in 8.c and 9.a: Sardine length composition (thousands) by ICES subdivision in 2015.

Length	8c E	8c W	9a N	9a CN	9a CS	9a S	9a S-C	Total
6.5								
7								
7.5								
8				5				5
8.5								
9								
9.5							65	65
10							460	460
10.5				15			2 783	2 798
11	14			117			4 096	4 227
11.5	45	209		333			4 268	4 855
12	84			325			4 940	5 349
12.5	170	335		404			9 761	10 670
13	358	1 312		350			7 782	9 802
13.5	638	3 792		751	40		7 801	13 021
14	752	3 269		2 005	2		5 842	11 871
14.5	811	1 586	124	4 182	126	5	2 732	9 567
15	667	1 175	755	4 318	318	10	1 675	8 918
15.5	465	395	2 139	2 553	891	22	2 889	9 354
16	525	134	2 926	1 251	1 100	29	3 116	9 081
16.5	915	59	1 867	953	1 104	94	4 207	9 200
17	968	87	1 314	2 776	874	277	4 335	10 630
17.5	1 350	146	711	3 523	818	925	3 482	10 955
18	1 485	219	982	5 234	441	2 050	1 909	12 321
18.5	1 503	312	1 478	8 663	1 252	5 269	4 122	22 599
19	1 343	482	1 327	11 685	2 298	6 453	4 311	27 898
19.5	1 169	613	1 576	12 663	3 501	6 376	3 259	29 158
20	772	955	1 599	12 059	6 064	3 476	3 678	28 603
20.5	499	1 084	1 800	11 095	6 186	1 887	1 888	24 439
21	469	1 138	1 379	9 007	7 104	1 288	2 252	22 638
21.5	220	1 125	940	3 644	9 173	435	215	15 752
22	228	1 078	866	2 948	7 194	64	413	12 790
22.5	130	748	922	949	5 286	21	112	8 167
23	66	481	1 652	620	2 324		24	5 168
23.5	24	309	1 191	52	681	2		2 259
24	2	216	543		288			1 050
24.5		65	228		20			313
25		22	249		46			316
25.5		3	154					156
26			65					65
26.5			16					16
27			8					8
27.5								
28								
28.5								
29								
Total	15 673	21 349	26 811	102 482	57 130	28 683	92 419	344 546
Mean L	17.7	17.2	19.4	19.1	20.9	19.5	15.3	18.2
sd	2.40	3.69	2.82	2.25	1.81	0.93	3.07	3.21
Catch	**756**	**1160**	**1946**	**7117**	**4848**	**1812**	**2956**	**20596**

Table 7.2.4.1a. Sardine in 8.c and 9.a: Sardine length composition (thousands) by ICES subdivision in the first quarter 2015.

Length	8c E	8c W	9a N	9a CN	9a CS	9a S	9a S-C	Total
6.5								
7								
7.5								
8								
8.5								
9								
9.5								
10								
10.5								
11								
11.5								
12							11	11
12.5							32	32
13							90	90
13.5	57						97	154
14	261						300	561
14.5	400	8				5	130	543
15	376	12				10	300	698
15.5	246	4	45			22	304	621
16	212	13	176			29	622	1 053
16.5	324	20	517			22	1 541	2 424
17	246	28	725			75	1 140	2 214
17.5	308	19	244			71	1 013	1 655
18	248	28	69			182	178	705
18.5	260	33	54			651	1 035	2 033
19	135	45	31			770	1 819	2 800
19.5	163	63	35			855	413	1 530
20	52	41	55		87	322	1 574	2 130
20.5	79	42	65		115	169		471
21	40	71	94		375	182	527	1 290
21.5	46	55	105		692	79		977
22	14	50	79		664	20	264	1 089
22.5	19	68	31		548	21	88	775
23	5	57	6		317			385
23.5	8	27	5		58	2		101
24	1	10			87			97
24.5		3						3
25								
25.5								
26								
26.5								
27								
27.5								
28								
28.5								
29								
Total	3 500	696	2 336		2 943	3 487	11 477	24 439
Mean L	17.0	20.5	18.0		22.2	19.4	18.2	18.7
sd	2.04	2.26	1.84		0.84	1.10	1.96	2.31
Catch	**142**	**48**	**111**	**8**	**248**	**194**	**550**	**1 302**

Table 7.2.4.1b. Sardine in 8.c and 9.a: Sardine length composition (thousands) by ICES subdivision in the second quarter 2015.

Length	8c E	8c W	9a N	9a CN	9a CS	9a S	9a S-C	Total
7								
7.5								
8								
8.5								
9								
9.5							63	63
10							189	189
10.5							1 197	1 197
11							1 073	1 073
11.5							821	821
12							130	130
12.5							340	340
13							470	470
13.5					40		2 586	2 625
14							1 766	1 766
14.5					126		846	972
15	2				316		481	800
15.5	7	7	14		828		327	1 182
16	25	39	26	70	1 011		484	1 656
16.5	64	26	106	802	1 011	32	470	2 512
17	72	58	151	2 603	849	78	657	4 467
17.5	189	119	190	3 257	742	423	621	5 542
18	295	152	184	4 009	421	703	731	6 494
18.5	324	208	344	6 527	871	2 409	1 213	11 896
19	224	264	336	7 304	958	1 542	979	11 607
19.5	224	309	424	6 940	1 027	2 431	581	11 936
20	126	353	475	4 934	1 817	1 591	507	9 802
20.5	68	387	670	4 463	2 944	1 180	401	10 112
21	57	279	665	3 270	3 455	854	86	8 667
21.5	18	347	320	1 203	4 949	309	129	7 276
22	24	338	166	833	3 386		8	4 756
22.5	16	308	73	199	2 504		24	3 125
23	17	184	47	100	770		24	1 142
23.5	7	118	84		198			407
24		73	66		66			204
24.5		12	137					149
25			223					223
25.5			154					154
26			65					65
26.5			16					16
27			8					8
27.5								
28								
28.5								
29								
Total	1 759	3 580	4 943	46 515	28 290	11 552	17 205	113 843
Mean L	19.	20.8	20.8	19.4	20.5	19.6	15.3	19.2
sd	1.36	1.80	2.31	1.28	2.14	0.99	3.09	2.57
Catch	**103**	**281**	**394**	**3 094**	**2 094**	**696**	**519**	**7 181**

Table 7.2.4.1c. Sardine in 8.c and 9.a: Sardine length composition (thousands) by ICES subdivision in the third quarter 2015.

Length	8c E	8c W	9a N	9a CN	9a CS	9a S	9a S-C	Total
6.5								
7								
7.5								
8				5				5
8.5								
9								
9.5							2	2
10							14	14
10.5				15			42	58
11	14			117			686	817
11.5	45	209		333			1 966	2 553
12	84			325			4 500	4 910
12.5	170	335		381			9 105	9 991
13	357	1 312		327			6 733	8 729
13.5	581	3 792		681			4 454	9 508
14	488	3 269		1 637	2		3 090	8 486
14.5	407	1 578	31	3 390			1 369	6 775
15	279	1 163	103	3 709	2		419	5 676
15.5	152	384	123	2 204	63		468	3 395
16	98	82	21	1 051	88		533	1 874
16.5	13	14	33	151	93	40	547	890
17	33		65	152	25	123	777	1 176
17.5	4	8	183	266	76	431	879	1 845
18	3	40	730	1 226	20	1 166	479	3 662
18.5	5	71	1 080	2 136	381	2 210	299	6 181
19	4	163	960	4 239	1 320	4 141	184	11 010
19.5	8	190	1 117	5 285	2 324	3 090	129	12 143
20	15	428	1 070	6 288	3 718	1 563	188	13 269
20.5	9	398	1 065	5 478	2 138	539	41	9 667
21	9	580	620	4 812	1 768	252	13	8 053
21.5	7	595	516	2 132	2 399	47	12	5 708
22	4	613	621	1 863	1 850	44	6	5 002
22.5	2	334	818	631	1 706			3 492
23	1	212	1 599	445	919			3 177
23.5	1	144	1 101	36	358			1 640
24		116	478		56			650
24.5		44	91					135
25		19	25		26			70
25.5		3						3
26								
26.5								
27								
27.5								
28								
28.5								
29								
Total	2 792	16 094	12 449	49 318	19 333	13 645	36 937	150 568
Mean L	14.3	16.0	21.0	18.7	21.0	19.4	13.6	17.6
sd	1.47	3.34	2.11	2.75	1.38	0.79	1.72	3.55
Catch	**83**	**737**	**1 181**	**3 527**	**1 800**	**913**	**781**	**9 022**

Table 7.2.4.1d. Sardine in 8.c and 9.a: Sardine length composition (thousands) by ICES subdivision in the fourth quarter 2015.

Length	8c E	8c W	9a N	9a CN	9a CS	9a S	9a S-C	Total
7								
7.5								
8								
8.5								
9								
9.5								
10							257	257
10.5							1 544	1 544
11							2 338	2 338
11.5							1 481	1 481
12							299	299
12.5				23			284	307
13	2			23			488	513
13.5				69			664	733
14	3			368			687	1 058
14.5	5		93	792			388	1 277
15	9		652	609			474	1 745
15.5	60		1 957	349			1 790	4 156
16	190		2 702	130			1 476	4 499
16.5	514		1 211				1 648	3 374
17	617		373	21			1 761	2 772
17.5	850		93				970	1 912
18	939						521	1 460
18.5	914						1 575	2 489
19	979	10		141	20		1 330	2 481
19.5	774	51		439	150		2 135	3 549
20	579	134		837	443		1 409	3 402
20.5	343	258		1 154	989		1 446	4 189
21	363	208		924	1 506		1 626	4 627
21.5	149	129		308	1 133		73	1 792
22	185	78		251	1 294		135	1 943
22.5	93	37		119	527			776
23	43	29		75	318			464
23.5	9	20		16	66			111
24	2	17			80			
24.5		6			20			
25		3			20			
25.5								
26								
26.5								
27								
27.5								
28								
28.5								
29								
Total	7 623	978	7 082	6 649	6 565		26 800	55 549
Mean L	18.9	21.3	16.2	18.8	21.7		16.4	17.7
sd	1.56	1.04	.55	2.94	.94		3.45	3.26
Catch	**428**	**94**	**260**	**489**	**706**	**9**	**1 106**	**3 091**

Table 7.2.4.2. Sardine in 8.c and 9.a: Catch in numbers (thousands) at age by quarter and by subdivision in 2015.

							First Quarter	
Age	**8c-E**	**8c-W**	**9a-N**	**9a-CN**	**9a-CS**	**9a-S**	**9a-C**	**Total**
0								
1	1 928	172	1 711			346	3 595	7 751
2	644	172	339		261	225	3 879	5 520
3	750	211	151		267	1 035	2 616	5 030
4	87	51	73		603	180	753	1 747
5	38	29	26		1 812	1 110	145	3 160
6	31	32	10			304	232	609
7	16	20	9			185	257	487
8	4	8	9			64		85
9	2		9			8		18
10		1				31		32
11								
12								
Total	3 500	696	2 336		2 943	3 487	11 477	24 439
Catch (Tons)	142	48	111	8	248	194	550	1 302

							Second Quarter	
Age	**8c-E**	**8c-W**	**9a-N**	**9a-CN**	**9a-CS**	**9a-S**	**9a-C**	**Total**
0								
1	137	703	976	15 960	6 126	1 204	11 403	36 508
2	504	1 011	1 913	21 358	6 827	1 801	3 208	36 622
3	906	1 192	836	5 490	5 814	4 145	1 736	20 119
4	111	249	306	1 886	3 766	2 061	586	8 966
5	44	144	105	1 159	2 848	1 210	118	5 627
6	34	149	38	276	993	334	84	1 907
7	17	89	34	252	1 145	693	71	2 301
8	5	39	323	79	421			867
9	1		412	44	193	103		753
10		5		11	156			172
11								
12								
Total	1 759	3 580	4 943	46 515	28 290	11 552	17 205	113 843
Catch (Tons)	103	281	394	3 094	2 094	696	519	7 181

							Third Quarter	
Age	**8c-E**	**8c-W**	**9a-N**	**9a-CN**	**9a-CS**	**9a-S**	**9a-C**	**Total**
0	2 424	11 658	1 062	14 375	265		23 031	52 816
1	294	1 222	3 692	13 750	4 878	1 501	12 894	38 231
2	39	2 094	4 207	12 383	6 147	5 273	658	30 802
3	21	418	2 044	4 645	3 233	4 534	242	15 138
4	7	330	498	2 222	2 640	1 184	91	6 971
5	3	201	606	1 178	1 074	511	13	3 585
6	2	170	340	433	628	455	8	2 036
7	1			182	257	187		627
8				151	210			361
9								
10								
11								
12								
Total	2 792	16 094	12 449	49 318	19 333	13 645	36 937	150 568
Catch (Tons)	83	737	1 181	3 527	1 800	913	781	9 022

							Fourth Quarter	
Age	**8c-E**	**8c-W**	**9a-N**	**9a-CN**	**9a-CS**	**9a-S**	**9a-C**	**Total**
0	19	208	6 098	2 371	662		6 860	16 217
1	1 779	587	984	1 052	1 931		11 380	17 714
2	4 210	76		1 729	1 617		3 422	11 054
3	1 128	52		792	1 248		3 193	6 412
4	243	31		368	530		1 386	2 559
5	133	24		211	265		385	1 019
6	93			72	124		175	464
7	17			27	187			231
8				26				26
9								
10								
11								
12								
Total	7 623	978	7 082	6 649	6 565		26 800	55 696
Catch (Tons)	428	94	260	489	706	9	1 106	3 091

							Whole Year	
Age	**8c-E**	**8c-W**	**9a-N**	**9a-CN**	**9a-CS**	**9a-S**	**9a-C**	**Total**
0	2 443	11 866	7 160	16 746	265		29 891	68 371
1	4 138	2 684	7 364	30 762	11 667	3 050	39 270	98 936
2	5 398	3 354	6 459	35 471	15 166	7 299	11 167	84 313
3	2 806	1 873	3 031	10 926	10 932	9 714	7 787	47 069
4	448	661	877	4 476	8 256	3 425	2 816	20 960
5	218	398	737	2 547	6 265	2 831	661	13 656
6	160	351	388	781	1 886	1 092	499	5 157
7	51	109	42	461	1 527	1 065		3 255
8	9	47	332	257	817	64		1 526
9			421	44	193	111		769
10		6		11		31		48
11								
12								
Total	15 671	21 349	26 811	102 482	56 974	28 683	92 091	344 060
Catch (Tons)	756	1 160	1 946	7 117	4 848	1 812	2 956	20 596

Table 7.2.4.3. Sardine 8.c and 9.a: Historical catch-at-age data.

Year	Age0	Age1	Age2	Age3	Age4	Age5	Age6+
1978	869	2297	947	295	137	42	16
1979	674	1536	956	431	189	93	36
1980	857	2037	1562	379	157	47	30
1981	1026	1935	1734	679	195	105	76
1982	62	795	1869	709	353	131	129
1983	1070	577	857	803	324	141	139
1984	118	3312	487	502	301	179	117
1985	268	564	2371	469	294	201	103
1986	304	755	1027	919	333	196	167
1987	1437	543	667	569	535	154	171
1988	521	990	535	439	304	292	189
1989	248	566	909	389	221	200	245
1990	258	602	517	707	295	151	248
1991	1581	477	436	407	266	75	105
1992	498	1002	451	340	186	111	81
1993	88	566	1082	521	257	114	120
1994	121	60	542	1094	272	113	72
1995	31	189	281	830	473	70	64
1996	277	101	348	515	653	197	47
1997	209	549	453	391	337	225	70
1998	449	366	502	352	234	179	106
1999	246	475	362	340	177	106	73
2000	490	355	314	256	194	98	64
2001	220	1172	256	196	126	75	50
2002	107	587	754	181	112	56	40
2003	198	319	446	518	114	61	51
2004	590	181	264	387	378	78	55
2005	169	1006	266	207	191	117	46
2006	18	250	777	129	108	121	81
2007	199	82	313	536	80	83	121
2008	298	219	183	370	412	65	109
2009	378	354	196	125	252	197	84
2010	278	517	263	136	83	129	183
2011	342	452	383	122	88	41	111
2012	220	194	168	123	94	49	53
2013	281	233	156	88	48	27	28
2014	64	189	110	55	35	19	22
2015	68	99	84	47	21	14	11

Table 7.2.4.4. Sardine 8.c and 9.a: Relative distribution of sardine catches. Upper panel relative contribution of each group within each subdivision. Lower panel, relative contribution of each subdivision within each age group.

Age	8c-E	8c-W	9a-N	9a-CN	9a-CS	9a-S	9a-S-C	Total
0	16%	56%	27%	16%	0%	0%	32%	20%
1	26%	13%	27%	30%	20%	11%	43%	29%
2	34%	16%	24%	35%	27%	25%	12%	25%
3	18%	9%	11%	11%	19%	34%	8%	14%
4	3%	3%	3%	4%	14%	12%	3%	6%
5	1%	2%	3%	2%	11%	10%	1%	4%
6+	1%	2%	4%	2%	8%	8%	1%	3%
	100%	100%	100%	100%	100%	100%	100%	100%

Age	8c-E	8c-W	9a-N	9a-CN	9a-CS	9a-S	9a-S-C	Total
0	4%	17%	10%	24%	0%	0%	44%	100%
1	4%	3%	7%	31%	12%	3%	40%	100%
2	6%	4%	8%	42%	18%	9%	13%	100%
3	6%	4%	6%	23%	23%	21%	17%	100%
4	2%	3%	4%	21%	39%	16%	13%	100%
5	2%	3%	5%	19%	46%	21%	5%	100%
6+	2%	5%	11%	14%	41%	22%	5%	100%

Table 7.2.5.1. Sardine 8.c and 9.a: Sardine Mean length (cm) at age by quarter and by subdivision in 2015.

						First Quarter	
Age	**8c-E**	**8c-W**	**9a-N**	**9a-CN**	**9a-CS**	**9a-S**	**9a-S-C**
0							
1	15.5	17.9	17.1		21.0	17.5	16.4
2	18.0	20.1	19.3		21.2	18.8	18.1
3	19.0	21.5	21.5		21.6	19.5	19.5
4	20.2	22.6	22.1		22.7	20.1	20.2
5	21.3	22.7	22.0			19.3	20.7
6	21.7	23.3	22.4			20.1	21.5
7	22.7	23.1	22.4			21.0	22.3
8	23.0	23.3	22.4			21.5	
9	21.9		22.4			21.8	
10		23.8				22.6	
11							
12							

						Second Quarter	
Age	**8c-E**	**8c-W**	**9a-N**	**9a-CN**	**9a-CS**	**9a-S**	**9a-S-C**
0							
1	17.0	18.6	18.3	18.3	17.1	18.3	13.6
2	18.4	20.3	20.1	19.6	20.5	19.0	17.9
3	19.2	21.4	21.2	20.7	21.5	19.4	19.4
4	20.1	22.5	21.9	21.2	21.9	19.9	20.1
5	21.0	22.6	22.0	21.4	22.1	20.6	21.0
6	21.6	23.4	22.8	21.6	22.4	20.9	21.1
7	22.9	23.1	22.8	22.0	22.4	21.1	22.6
8	22.9	23.3	24.9	21.9	22.7		
9	21.8		25.2	22.0	22.1	21.8	
10		23.8		22.8	23.0		
11							
12							

						Third Quarter	
Age	**8c-E**	**8c-W**	**9a-N**	**9a-CN**	**9a-CS**	**9a-S**	**9a-S-C**
0	13.9	14.1	17.6	14.8	16.4		12.7
1	16.1	18.6	19.5	19.6	19.8	18.6	14.9
2	19.5	21.3	21.6	20.4	20.6	19.1	18.5
3	20.8	22.1	22.4	21.2	21.7	19.5	19.9
4	21.5	22.7	23.5	22.0	22.4	19.9	19.8
5	22.1	23.4	23.7	21.6	22.2	20.0	20.8
6	22.7	23.7	24.2	22.1	22.6	20.4	21.7
7	23.4			22.2	22.4	19.9	
8				21.7	23.1		
9							
10							
11							
12							

						Fourth Quarter	
Age	**8c-E**	**8c-W**	**9a-N**	**9a-CN**	**9a-CS**	**9a-S**	**9a-S-C**
0	14.8	20.8	16.1	15.0			11.5
1	17.4	21.1	16.4	20.2	20.6		16.7
2	19.0	21.8		20.7	21.2		19.5
3	20.2	22.5		21.3	21.8		20.3
4	21.4	23.2		21.9	22.2		20.5
5	21.1	23.6		21.6	22.0		21.0
6	22.6			22.2	22.3		21.5
7	23.3			22.3	22.3		
8				21.7	23.6		
9							
10							
11							
12							

						Whole Year	
Age	**8c-E**	**8c-W**	**9a-N**	**9a-CN**	**9a-CS**	**9a-S**	**9a-S-C**
0	13.9	14.2	16.3	14.8	16.4		12.4
1	16.4	19.1	18.4	18.9	18.4	18.3	15.2
2	18.8	20.9	21.0	20.0	20.6	19.1	18.5
3	19.6	21.6	22.0	21.0	21.6	19.5	19.8
4	20.9	22.7	22.8	21.6	22.1	19.9	20.3
5	21.1	23.1	23.4	21.5	22.3	20.0	20.9
6	22.2	23.5	24.0	21.9	22.4	20.5	21.4
7	22.9	23.1	22.7	22.1	22.4	20.9	22.3
8	22.9	23.3	24.8	21.7	23.0	21.5	
9	21.9		25.2	22.0	22.1	21.8	
10		23.8			23.0	22.6	
11							
12							

Table 7.2.5.2. Sardine 8.c and 9.a: Sardine Mean weight (kg) at age by quarter and by subdivision in 2015.

						First Quarter	
Age	**8c-E**	**8c-W**	**9a-N**	**9a-CN**	**9a-CS**	**9a-S**	**9a-S-C**
0							
1	0.030	0.046	0.040			0.040	0.033
2	0.046	0.064	0.058		0.070	0.050	0.046
3	0.055	0.078	0.077		0.072	0.056	0.059
4	0.067	0.089	0.083		0.077	0.061	0.065
5	0.078	0.090	0.083		0.091	0.054	0.071
6	0.082	0.097	0.087			0.060	0.081
7	0.094	0.095	0.086			0.069	0.090
8	0.099	0.097	0.086			0.074	
9	0.084		0.086			0.077	
10		0.102				0.086	
11							
12							

						Second Quarter	
Age	**8c-E**	**8c-W**	**9a-N**	**9a-CN**	**9a-CS**	**9a-S**	**9a-S-C**
0							
1	0.041	0.057	0.054	0.056	0.043	0.051	0.020
2	0.053	0.072	0.070	0.068	0.073	0.056	0.043
3	0.060	0.084	0.081	0.079	0.082	0.059	0.055
4	0.069	0.096	0.089	0.084	0.088	0.062	0.061
5	0.078	0.097	0.091	0.087	0.089	0.068	0.069
6	0.085	0.106	0.099	0.089	0.093	0.070	0.070
7	0.099	0.103	0.099	0.093	0.093	0.072	0.087
8	0.099	0.105	0.127	0.092	0.097		
9	0.085		0.131	0.093	0.089	0.077	
10		0.111		0.103	0.100		
11							
12							

						Third Quarter	
Age	**8c-E**	**8c-W**	**9a-N**	**9a-CN**	**9a-CS**	**9a-S**	**9a-S-C**
0	0.027	0.027	0.055	0.032	0.048		0.016
1	0.041	0.067	0.074	0.077	0.080	0.062	0.027
2	0.069	0.097	0.101	0.088	0.088	0.066	0.053
3	0.086	0.108	0.113	0.100	0.101	0.068	0.067
4	0.096	0.117	0.128	0.111	0.109	0.070	0.066
5	0.104	0.128	0.132	0.106	0.108	0.071	0.077
6	0.112	0.133	0.140	0.113	0.112	0.074	0.088
7	0.122			0.115	0.109	0.071	
8				0.107	0.119		
9							
10							
11							
12							

						Fourth Quarter	
Age	**8c-E**	**8c-W**	**9a-N**	**9a-CN**	**9a-CS**	**9a-S**	**9a-S-C**
0	0.027	0.088	0.036	0.034	0.091		0.014
1	0.042	0.093	0.039	0.086	0.100		0.040
2	0.056	0.104		0.093	0.109		0.060
3	0.068	0.116		0.101	0.116		0.067
4	0.081	0.129		0.112	0.113		0.068
5	0.078	0.138		0.106	0.118		0.073
6	0.095			0.115	0.117		0.078
7	0.104			0.117	0.141		
8				0.107			
9							
10							
11							
12							

						Whole Year	
Age	**8c-E**	**8c-W**	**9a-N**	**9a-CN**	**9a-CS**	**9a-S**	**9a-S-C**
0	0.027	0.029	0.039	0.032	0.048		0.016
1	0.036	0.069	0.059	0.066	0.061	0.055	0.029
2	0.054	0.088	0.090	0.076	0.082	0.063	0.050
3	0.062	0.089	0.102	0.089	0.092	0.063	0.061
4	0.075	0.107	0.111	0.100	0.098	0.065	0.066
5	0.079	0.114	0.124	0.097	0.095	0.063	0.072
6	0.091	0.118	0.135	0.105	0.103	0.069	0.078
7	0.099	0.102	0.097	0.103	0.097	0.071	0.089
8	0.099	0.104	0.125	0.102	0.113	0.074	
9	0.085		0.130	0.093	0.089	0.077	
10		0.109		0.103	0.100	0.086	
11							
12							

Table 7.3.2.1.1. Sardine in 8.c and 9.a: Sardine assessment from 2016 Portuguese spring acoustic survey (PELAGO16). Number (N) in thousand fish and biomass (B) in tonnes. MW (mean weight) in grams and ML (mean length) in cm.

AREA		1	2	3	4	5	6	7	8	9	10	TOTAL
9aCN	Biomass	20863	4940	3314	279	211	224					29831
	%	69.9	16.6	11.1	0.9	0.7	0.8					100
	No fish	1143806	100918	55537	6886	2717	4669					1314533
	%	87.0	7.7	4.2	0.5	0.2	0.4					100
	Mean weight, g	18.2	48.9	59.7	40.5	77.7	48.0					22.7
	Mean length, cm	14.0	19.6	20.8	18.5	22.7	19.5					14.8
9aCS	Biomass	24915	14462	5118	1710	3724	164		164			50257
	%	49.6	28.8	10.2	3.4	7.4	0.3					100
	No fish	862713	287910	82034	25089	59251	2281		2281			1321559
	%	65.3	21.8	6.2	1.9	4.5	0.2		0.2			100
	Mean weight, g	28.9	50.2	62.4	68.2	62.8	72.0		72.0			38.0
	Mean length, cm	15.5	18.9	20.4	21.1	20.5	21.5		21.5		22.8	16.9
9aS	Biomass	6008	4790	16521	13740	14382	12374	4644	1932	1496	797	76685
Algarve	%	7.8	6.2	21.5	17.9	18.8	16.1	6.1	2.5	2.0	1.0	100
	No fish	152335	83490	289578	214504	218435	176537	60835	23963	18078	10867	1248622
	%	12.2	6.7	23.2	17.2	17.5	14.1	4.9	1.9	1.4	0.9	100
	Mean weight, g	39.4	57.4	57.1	64.1	65.8	70.1	76.3	80.6	82.8	73.4	61.4
	Mean length, cm	16.9	19.5	19.4	20.3	20.5	21.0	21.6	22.1	22.3	21.3	19.9
9aS	Biomass	2997	217	457								3671
Cadiz	%	81.6	5.9	12.4								100
	No fish	212772	3803	7606								224181
	%	94.9	1.7	3.4								100
	Mean weight, g	5.4	57.1	60.1								8.1
	Mean length, cm	11.9	18.5	18.8								12.2
Portugal	Biomass	51786	24192	24954	15729	18316	12763	4644	2096	1496	797	156773
	%	33.0	15.4	15.9	10.0	11.7	8.1	3.0	1.3	1.0	0.5	100.0
	No fish	2158854	472318	427149	246479	280403	183487	60835	26244	18078	10867	3884714
	%	55.6	12.2	11.0	6.3	7.2	4.7	1.6	0.7	0.5	0.3	100.0
	Mean weight, g	24.0	51.2	58.4	63.8	65.3	69.6	76.3	79.9	82.8	73.4	40.4
	Mean length, cm	14.8	19.2	19.8	20.3	20.5	20.9	21.6	22.0	22.3	21.3	17.1
TOTAL	Biomass	54783	24409	25411	15729	18316	12763	4644	2096	1496	797	160444
	%	34.1	15.2	15.8	9.8	11.4	8.0	2.9	1.3	0.9	0.5	100.0
	No fish	2371626	476121	434755	246479	280403	183487	60835	26244	18078	10867	4108895
	%	57.7	11.6	10.6	6.0	6.8	4.5	1.5	0.6	0.4	0.3	100.0
	Mean weight, g	22.3	51.3	58.4	63.8	65.3	69.6	76.3	79.9	82.8	73.4	38.6
	Mean length, cm	14.5	19.1	19.8	20.3	20.5	20.9	21.6	22.0	22.3	21.3	16.9

Table 7.3.2.2.1. Sardine in 8.c and 9.a: sardine abundance in number (thousands of fish) and biomass (tonnes) by age groups and ICES Subdivision in PELACUS0316. MW (mean weight) in grams and ML (mean length) in cm.

AREA 8cE									
AGE	1	2	3	4	5	6	7	8	TOTAL
Biomass (Tonnes)	1979	5601	3708	1127	88	6	25	25	12558
% Biomass	15.8	44.6	29.5	9.0	0.7	0.0	0.2	0.2	100
Abundance (N in '000)	53793	127649	73402	20200	1599	68	299	299	277309
% Abundance	19.4	46.0	26.5	7.3	0.6	0.0	0.1	0.1	100
Medium Weight (gr)	36.78	43.88	50.52	55.80	55.07	86.01	82.08	82.08	45.29
Medium Length (cm)	17.12	18.25	19.19	19.88	19.76	23.25	22.86	22.86	18.42

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

AREA 9aN									
AGE	1	2	3	4	5	6	7	8	TOTAL
Biomass (Tonnes)	408	375	132	78	18	2	11	8	1032
% Biomass	39.5	36.3	12.8	7.5	1.8	0.2	1.0	0.8	100
Abundance (N in '000)	12249	9179	2419	1204	240	29	120	100	25540
% Abundance	48.0	35.9	9.5	4.7	0.9	0.1	0.5	0.4	100
Medium Weight (gr)	33.30	40.85	54.59	64.40	76.94	76.05	89.21	84.47	40.42
Medium Length (cm)	16.5	17.8	19.7	20.9	22.3	22.3	23.6	23.1	17.6

TOTAL SPAIN									
AGE	1	2	3	4	5	6	7	8	TOTAL
Biomass (Tonnes)	2387	6014	3924	1331	146	23	67	61	13952
% Biomass	17.10	43.10	28.12	9.54	1.05	0.17	0.48	0.44	100
Abundance (N in '000)	66042	137403	77015	23079	2335	280	771	724	307648
% Abundance	21.47	44.66	25.03	7.50	0.76	0.09	0.25	0.24	100
Medium Weight (gr)	36.14	43.77	50.95	57.69	62.47	83.24	86.30	83.90	45.35
Medium Length (cm)	17.01	18.23	19.24	20.09	20.61	22.97	23.27	23.03	18.41

Table 7.4.1a. Sardine in 8.c and 9.a: Mean weights-at-age (kg) in the catch. Weights-at-age 1978–1987 are fixed and equal to those in 1988. Age 6+ weight is fixed over time at 0.100 Kg.

YEAR	AGE0	AGE1	AGE2	AGE3	AGE4	AGE5	AGE6+
1988	0.017	0.034	0.052	0.060	0.068	0.072	0.100
1989	0.013	0.035	0.052	0.059	0.066	0.071	0.100
1990	0.024	0.032	0.047	0.057	0.061	0.067	0.100
1991	0.020	0.031	0.058	0.063	0.073	0.074	0.100
1992	0.018	0.045	0.055	0.066	0.070	0.079	0.100
1993	0.017	0.037	0.051	0.058	0.066	0.071	0.100
1994	0.020	0.036	0.058	0.062	0.070	0.076	0.100
1995	0.025	0.047	0.059	0.066	0.071	0.082	0.100
1996	0.019	0.038	0.051	0.058	0.061	0.071	0.100
1997	0.022	0.033	0.052	0.062	0.069	0.073	0.100
1998	0.024	0.040	0.055	0.061	0.064	0.067	0.100
1999	0.025	0.042	0.056	0.065	0.070	0.073	0.100
2000	0.025	0.037	0.056	0.066	0.071	0.074	0.100
2001	0.023	0.042	0.059	0.067	0.075	0.079	0.100
2002	0.028	0.045	0.057	0.069	0.075	0.079	0.100
2003	0.024	0.044	0.059	0.067	0.079	0.084	0.100
2004	0.020	0.040	0.056	0.066	0.072	0.082	0.100
2005	0.023	0.037	0.055	0.068	0.074	0.075	0.100
2006	0.031	0.042	0.056	0.068	0.073	0.078	0.100
2007	0.028	0.054	0.071	0.074	0.085	0.086	0.100
2008	0.025	0.043	0.066	0.074	0.075	0.083	0.100
2009	0.020	0.041	0.065	0.075	0.079	0.083	0.100
2010	0.026	0.046	0.061	0.075	0.082	0.084	0.100
2011	0.024	0.045	0.064	0.073	0.077	0.077	0.100
2012	0.031	0.056	0.065	0.078	0.083	0.086	0.100
2013	0.025	0.052	0.069	0.077	0.085	0.090	0.100
2014	0.030	0.046	0.061	0.076	0.080	0.089	0.100
2015	0.025	0.049	0.073	0.079	0.089	0.090	0.100

*** Weight-at-age for 2016 are average of weight-at-age 2012–2015.**

Table 7.4.1b. Sardine in 8.c and 9.a: Mean weights-at-age (kg) in the stock. Weights-at-age 1978–1989 are fixed and equal to those in 1990.

YEAR	AGE1	AGE2	AGE3	AGE4	AGE5	AGE6+
1990	0.015	0.038	0.050	0.064	0.067	0.100
1991	0.019	0.042	0.050	0.064	0.071	0.100
1992	0.027	0.036	0.050	0.062	0.069	0.100
1993	0.022	0.045	0.057	0.064	0.073	0.100
1994	0.031	0.040	0.049	0.060	0.067	0.100
1995	0.029	0.050	0.062	0.072	0.079	0.100
1996	0.021	0.042	0.050	0.057	0.065	0.077
1997	0.024	0.032	0.052	0.059	0.064	0.072
1998	0.029	0.037	0.048	0.054	0.059	0.066
1999	0.024	0.040	0.052	0.059	0.067	0.073
2000	0.017	0.043	0.056	0.061	0.067	0.067
2001	0.021	0.041	0.060	0.071	0.072	0.074
2002	0.024	0.040	0.055	0.068	0.074	0.074
2003	0.019	0.043	0.053	0.065	0.070	0.076
2004	0.020	0.045	0.061	0.069	0.076	0.100
2005	0.019	0.045	0.059	0.068	0.073	0.079
2006	0.030	0.042	0.060	0.068	0.068	0.075
2007	0.039	0.054	0.062	0.070	0.076	0.077
2008	0.017	0.052	0.065	0.070	0.080	0.087
2009	0.020	0.053	0.060	0.065	0.069	0.076
2010	0.018	0.042	0.058	0.064	0.064	0.071
2011	0.026	0.048	0.058	0.065	0.066	0.067
2012	0.026	0.048	0.058	0.065	0.066	0.067
2013	0.036	0.052	0.057	0.075	0.075	0.079
2014	0.023	0.046	0.057	0.058	0.069	0.072
2015	0.024	0.055	0.064	0.072	0.074	0.080
2016	0.024	0.064	0.067	0.069	0.066	0.073

Table 7.5.1.1. Sardine in 8.c and 9.a: Parameters and asymptotic standard deviations estimated in the final assessment model.

Parameter	Value	Phase	Initial value	Std Dev	% change in parameters 2015-2016
SR_LN(R0)	9.279	1	8.9	0.0420	0.16
Main_RecrDev_1978	0.781	_	_	0.1374	-0.18
Main_RecrDev_1979	0.906	_	_	0.1372	-0.18
Main_RecrDev_1980	1.036	_	_	0.1319	-0.14
Main_RecrDev_1981	0.569	_	_	0.1647	-0.07
Main_RecrDev_1982	-0.003	_	_	0.2238	0.06
Main_RecrDev_1983	1.512	_	_	0.1067	0.28
Main_RecrDev_1984	0.372	_	_	0.1808	0.52
Main_RecrDev_1985	0.333	_	_	0.1749	0.93
Main_RecrDev_1986	0.153	_	_	0.1834	1.44
Main_RecrDev_1987	0.883	_	_	0.1251	2.14
Main_RecrDev_1988	0.302	_	_	0.1600	2.74
Main_RecrDev_1989	0.267	_	_	0.1587	3.10
Main_RecrDev_1990	0.292	_	_	0.1543	2.85
Main_RecrDev_1991	1.299	_	_	0.0899	2.79
Main_RecrDev_1992	0.962	_	_	0.0972	2.84
Main_RecrDev_1993	0.145	_	_	0.1313	2.70
Main_RecrDev_1994	-0.005	_	_	0.1234	2.98
Main_RecrDev_1995	-0.348	_	_	0.1252	2.68
Main_RecrDev_1996	0.104	_	_	0.0982	2.98
Main_RecrDev_1997	-0.422	_	_	0.1221	2.87
Main_RecrDev_1998	-0.148	_	_	0.1074	3.02
Main_RecrDev_1999	-0.354	_	_	0.1226	3.04
Main_RecrDev_2000	0.785	_	_	0.0800	3.29
Main_RecrDev_2001	0.258	_	_	0.0993	3.02
Main_RecrDev_2002	-0.362	_	_	0.1284	2.44
Main_RecrDev_2003	-0.624	_	_	0.1547	2.70
Main_RecrDev_2004	0.845	_	_	0.0672	3.11
Main_RecrDev_2005	-0.190	_	_	0.1005	2.90
Main_RecrDev_2006	-1.306	_	_	0.1561	2.51
Main_RecrDev_2007	-0.835	_	_	0.1159	2.78
Main_RecrDev_2008	-0.630	_	_	0.1005	2.99
Main_RecrDev_2009	-0.475	_	_	0.0874	3.42
Main_RecrDev_2010	-1.179	_	_	0.1164	4.72
Main_RecrDev_2011	-1.223	_	_	0.1239	6.76
Main_RecrDev_2012	-1.073	_	_	0.1161	3.48
Main_RecrDev_2013	-0.807	_	_	0.1290	0.39
Main_RecrDev_2014	-0.983	_	_	0.1595	-0.56
Main_RecrDev_2015	-0.833	_	_	0.1942	
InitF_1purse_seine	0.566	1	0.3	0.4333	1.40
Q_base_3_DEPM_survey	-0.004	1	0	0.1378	-6.89

Table 7.5.1.1. (cont.) Parameters and asymptotic standard deviations estimated in the final assessment model.

Parameter	Value	Phase	Initial value	Std Dev	% change in parameters 2015-2016
AgeSel_1P_2_purse_seine	1.062	2	0.9	0.0798	0.04
AgeSel_1P_3_purse_seine	0.590	2	0.4	0.0784	-2.41
AgeSel_1P_4_purse_seine	0.308	2	0.1	0.0838	-2.39
AgeSel_1P_7_purse_seine	-1.260	2	-0.5	0.2081	-5.31
AgeSel_2P_3_Acoustic_survey	-0.392	2	-0.3	0.0807	-3.59
AgeSel_2P_7_Acoustic_survey	-0.771	2	-0.8	0.2324	-0.17
AgeSel_1P_2_purse_seine_BLK1delta_1978	0.682	2	0.9	0.2314	0.02
AgeSel_1P_3_purse_seine_BLK1delta_1978	0.157	2	0.4	0.2231	2.47
AgeSel_1P_4_purse_seine_BLK1delta_1978	-0.390	2	0.1	0.2570	2.66
AgeSel_1P_7_purse_seine_BLK1delta_1978	1.621	2	-0.5	0.6551	6.98
AgeSel_1P_2_purse_seine_DEVrwalk_1978	0.000	_	_	0.1000	0.00
AgeSel_1P_2_purse_seine_DEVrwalk_1979	-0.028	_	_	0.0973	0.01
AgeSel_1P_2_purse_seine_DEVrwalk_1980	-0.043	_	_	0.0960	0.01
AgeSel_1P_2_purse_seine_DEVrwalk_1981	-0.049	_	_	0.0955	0.02
AgeSel_1P_2_purse_seine_DEVrwalk_1982	-0.012	_	_	0.0954	0.02
AgeSel_1P_2_purse_seine_DEVrwalk_1983	-0.035	_	_	0.0953	0.02
AgeSel_1P_2_purse_seine_DEVrwalk_1984	-0.038	_	_	0.0953	0.02
AgeSel_1P_2_purse_seine_DEVrwalk_1985	-0.067	_	_	0.0955	0.02
AgeSel_1P_2_purse_seine_DEVrwalk_1986	-0.075	_	_	0.0957	0.01
AgeSel_1P_2_purse_seine_DEVrwalk_1987	-0.077	_	_	0.0958	0.00
AgeSel_1P_2_purse_seine_DEVrwalk_1988	-0.003	_	_	0.0965	-0.04
AgeSel_1P_2_purse_seine_DEVrwalk_1989	0.019	_	_	0.0973	-0.06
AgeSel_1P_2_purse_seine_DEVrwalk_1990	0.011	_	_	0.0983	-0.06
AgeSel_1P_3_purse_seine_DEVrwalk_1978	0.000	_	_	0.1000	0.00
AgeSel_1P_3_purse_seine_DEVrwalk_1979	0.043	_	_	0.0963	-0.01
AgeSel_1P_3_purse_seine_DEVrwalk_1980	0.010	_	_	0.0952	0.00
AgeSel_1P_3_purse_seine_DEVrwalk_1981	0.016	_	_	0.0942	0.01
AgeSel_1P_3_purse_seine_DEVrwalk_1982	0.029	_	_	0.0938	0.02
AgeSel_1P_3_purse_seine_DEVrwalk_1983	-0.022	_	_	0.0937	0.02
AgeSel_1P_3_purse_seine_DEVrwalk_1984	-0.028	_	_	0.0934	0.02
AgeSel_1P_3_purse_seine_DEVrwalk_1985	0.005	_	_	0.0938	0.02
AgeSel_1P_3_purse_seine_DEVrwalk_1986	-0.034	_	_	0.0939	0.02
AgeSel_1P_3_purse_seine_DEVrwalk_1987	-0.037	_	_	0.0943	0.01
AgeSel_1P_3_purse_seine_DEVrwalk_1988	0.015	_	_	0.0946	-0.03
AgeSel_1P_3_purse_seine_DEVrwalk_1989	0.018	_	_	0.0959	-0.09

Table 7.5.1.1. (cont.) Parameters and asymptotic standard deviations estimated in the final assessment model.

Parameter	Value	Phase	Initial value	Std Dev	% change in parameters 2015-2016
AgeSel_1P_3_purse_seine_DEVrwalk_1990	0.009	_	_	0.0971	-0.09
AgeSel_1P_4_purse_seine_DEVrwalk_1978	0.000	_	_	0.1000	0.00
AgeSel_1P_4_purse_seine_DEVrwalk_1979	0.024	_	_	0.0980	-0.02
AgeSel_1P_4_purse_seine_DEVrwalk_1980	0.012	_	_	0.0973	-0.02
AgeSel_1P_4_purse_seine_DEVrwalk_1981	0.025	_	_	0.0967	-0.01
AgeSel_1P_4_purse_seine_DEVrwalk_1982	0.038	_	_	0.0958	0.00
AgeSel_1P_4_purse_seine_DEVrwalk_1983	0.016	_	_	0.0952	0.01
AgeSel_1P_4_purse_seine_DEVrwalk_1984	-0.005	_	_	0.0948	0.01
AgeSel_1P_4_purse_seine_DEVrwalk_1985	0.010	_	_	0.0946	0.01
AgeSel_1P_4_purse_seine_DEVrwalk_1986	0.004	_	_	0.0949	0.00
AgeSel_1P_4_purse_seine_DEVrwalk_1987	0.014	_	_	0.0947	0.01
AgeSel_1P_4_purse_seine_DEVrwalk_1988	0.043	_	_	0.0953	-0.02
AgeSel_1P_4_purse_seine_DEVrwalk_1989	0.038	_	_	0.0963	-0.07
AgeSel_1P_4_purse_seine_DEVrwalk_1990	0.026	_	_	0.0970	-0.09
AgeSel_1P_7_purse_seine_DEVrwalk_1978	0.000	_	_	0.1000	0.00
AgeSel_1P_7_purse_seine_DEVrwalk_1979	0.004	_	_	0.1000	-0.01
AgeSel_1P_7_purse_seine_DEVrwalk_1980	0.006	_	_	0.1001	-0.02
AgeSel_1P_7_purse_seine_DEVrwalk_1981	0.009	_	_	0.1002	-0.03
AgeSel_1P_7_purse_seine_DEVrwalk_1982	0.012	_	_	0.1002	-0.03
AgeSel_1P_7_purse_seine_DEVrwalk_1983	0.006	_	_	0.1000	-0.02
AgeSel_1P_7_purse_seine_DEVrwalk_1984	-0.001	_	_	0.0999	-0.02
AgeSel_1P_7_purse_seine_DEVrwalk_1985	-0.003	_	_	0.0998	-0.02
AgeSel_1P_7_purse_seine_DEVrwalk_1986	-0.001	_	_	0.0996	-0.02
AgeSel_1P_7_purse_seine_DEVrwalk_1987	0.000	_	_	0.0993	-0.01
AgeSel_1P_7_purse_seine_DEVrwalk_1988	0.003	_	_	0.0993	-0.01
AgeSel_1P_7_purse_seine_DEVrwalk_1989	-0.003	_	_	0.0993	-0.02
AgeSel_1P_7_purse_seine_DEVrwalk_1990	0.000	_	_	0.0991	-0.01

Table 7.5.1.2. Sardine in 8.c and 9.a: Fishing mortality-at-age estimated in the assessment. F(2–5) is the reference fishing mortality, corresponding to the average F of ages 2 to 5 years.

YEAR	AGE0	AGE1	AGE2	AGE3	AGE4	AGE5	AGE6+
1978	0.051	0.294	0.621	0.572	0.572	0.572	0.821
1979	0.046	0.257	0.567	0.534	0.534	0.534	0.770
1980	0.043	0.229	0.510	0.487	0.487	0.487	0.705
1981	0.041	0.206	0.466	0.456	0.456	0.456	0.667
1982	0.036	0.182	0.424	0.430	0.430	0.430	0.637
1983	0.036	0.173	0.395	0.408	0.408	0.408	0.607
1984	0.036	0.170	0.376	0.386	0.386	0.386	0.575
1985	0.032	0.139	0.308	0.320	0.320	0.320	0.474
1986	0.037	0.148	0.318	0.331	0.331	0.331	0.491
1987	0.043	0.162	0.335	0.354	0.354	0.354	0.524
1988	0.040	0.149	0.314	0.346	0.346	0.346	0.514
1989	0.030	0.114	0.244	0.280	0.280	0.280	0.414
1990	0.035	0.133	0.288	0.339	0.339	0.339	0.502
1991	0.042	0.123	0.222	0.302	0.302	0.302	0.086
1992	0.031	0.089	0.160	0.218	0.218	0.218	0.062
1993	0.032	0.093	0.168	0.229	0.229	0.229	0.065
1994	0.028	0.082	0.147	0.201	0.201	0.201	0.057
1995	0.028	0.080	0.144	0.196	0.196	0.196	0.055
1996	0.036	0.104	0.188	0.256	0.256	0.256	0.073
1997	0.046	0.133	0.241	0.328	0.328	0.328	0.093
1998	0.053	0.154	0.277	0.377	0.377	0.377	0.107
1999	0.050	0.145	0.261	0.355	0.355	0.355	0.101
2000	0.044	0.126	0.228	0.310	0.310	0.310	0.088
2001	0.042	0.121	0.219	0.298	0.298	0.298	0.085
2002	0.036	0.103	0.186	0.254	0.254	0.254	0.072
2003	0.035	0.102	0.183	0.250	0.250	0.250	0.071
2004	0.039	0.112	0.202	0.275	0.275	0.275	0.078
2005	0.038	0.109	0.197	0.268	0.268	0.268	0.076
2006	0.033	0.095	0.172	0.234	0.234	0.234	0.066
2007	0.036	0.103	0.186	0.253	0.253	0.253	0.072
2008	0.053	0.154	0.278	0.379	0.379	0.379	0.107
2009	0.060	0.174	0.314	0.427	0.427	0.427	0.121
2010	0.081	0.236	0.425	0.578	0.578	0.578	0.164
2011	0.092	0.266	0.480	0.654	0.654	0.654	0.185
2012	0.070	0.202	0.365	0.497	0.497	0.497	0.141
2013	0.063	0.182	0.329	0.448	0.448	0.448	0.127
2014	0.037	0.107	0.192	0.262	0.262	0.262	0.074
2015	0.022	0.063	0.114	0.155	0.155	0.155	0.044

Table 7.5.1.3. Sardine in 8.c and 9.a: Numbers-at-age, in millions at the beginning of the year, estimated in the assessment. Estimates of survivors in 2016 are also shown. Age 0 in 2016 is the geometric mean recruitment of the historical period.

YEAR	AGE0	AGE1	AGE2	AGE3	AGE4	AGE5	AGE6+
1978	23398	4646	2301	1005	502	251	216
1979	26512	9986	2100	829	420	210	175
1980	30181	11375	4685	799	360	182	151
1981	18916	12990	5486	1885	364	164	138
1982	10676	8161	6410	2307	885	171	129
1983	48575	4626	4126	2813	1111	426	133
1984	15537	21058	2359	1864	1386	548	264
1985	14951	6731	10777	1086	938	698	386
1986	12487	6508	3555	5309	584	505	554
1987	25900	5409	3404	1734	2824	311	520
1988	14490	11145	2791	1632	901	1468	389
1989	13985	6256	5822	1367	855	472	942
1990	14339	6098	3385	3057	766	479	726
1991	39271	6223	3237	1701	1614	404	578
1992	28032	16912	3338	1738	932	884	615
1993	12380	12214	9385	1906	1035	555	955
1994	10657	5386	6748	5316	1123	610	990
1995	7567	4655	3011	3903	3222	681	1062
1996	11888	3308	2608	1748	2378	1963	1159
1997	7022	5153	1808	1448	1003	1364	1925
1998	9241	3013	2735	953	773	535	2027
1999	7520	3937	1567	1389	484	393	1621
2000	23484	3214	2067	809	721	251	1290
2001	13869	10102	1718	1103	440	392	1012
2002	7459	5976	5427	925	607	242	904
2003	5738	3234	3269	3019	532	349	762
2004	24927	2489	1772	1824	1742	307	727
2005	8855	10775	1350	970	1026	980	671
2006	2901	3832	5860	743	550	581	1016
2007	4646	1261	2112	3306	435	322	1045
2008	5706	2014	690	1176	1901	250	906
2009	6661	2431	1047	350	596	964	730
2010	3296	2818	1239	513	169	288	945
2011	3152	1365	1351	543	213	70	714
2012	3665	1292	635	560	209	82	467
2013	4782	1535	640	295	252	94	337
2014	4009	2017	776	309	140	120	265
2015	4655	1736	1100	429	176	80	250
2016	**10713**	2047	989	658	272	112	228

Table 7.5.1.4. Sardine in 8.c and 9.a: Summary table of the final WGHANSA 2016 assessment. CVs, in %, are presented for SSB, recruitment and Apical F (maximum F-at-age by year); biomass and landings in thousand t, recruits in millions of individuals, F in year^{-1}. Biomass 1+ and SSB in 2016 are calculated with weight at age 2016 presented in Table 7.4.1b. Age 0 in 2016 is the geometric mean recruitment of the historical period.

Year	Biomass 1+	SSB	CV SSB	Recruits	CV R	F (2–5)	Apical F	CV apicalF	Landings
1978	278	264	0.13	23398	0.13	0.58	0.82	0.76	146
1979	329	314	0.11	26512	0.13	0.54	0.77	0.05	157
1980	439	416	0.11	30181	0.13	0.49	0.71	0.07	195
1981	546	517	0.10	18916	0.17	0.46	0.67	0.10	217
1982	562	547	0.11	10676	0.23	0.43	0.64	0.12	207
1983	480	474	0.13	48575	0.11	0.40	0.61	0.13	184
1984	650	593	0.12	15537	0.18	0.38	0.57	0.76	206
1985	710	692	0.12	14951	0.18	0.32	0.47	0.75	208
1986	625	603	0.12	12487	0.19	0.33	0.49	0.74	187
1987	551	528	0.13	25900	0.13	0.35	0.52	0.73	178
1988	550	501	0.12	14490	0.17	0.34	0.51	0.72	162
1989	564	519	0.12	13985	0.17	0.27	0.41	0.72	141
1990	527	475	0.13	14339	0.16	0.33	0.50	0.71	149
1991	529	462	0.13	39271	0.10	0.28	0.30	0.69	133
1992	844	696	0.11	28032	0.11	0.20	0.22	0.65	130
1993	1002	871	0.10	12380	0.14	0.21	0.23	0.65	142
1994	905	792	0.10	10657	0.13	0.19	0.20	0.64	137
1995	920	804	0.11	7567	0.13	0.18	0.20	0.57	125
1996	619	542	0.11	11888	0.11	0.24	0.26	0.58	117
1997	542	459	0.11	7022	0.13	0.31	0.33	0.14	116
1998	441	376	0.12	9241	0.12	0.35	0.38	0.14	109
1999	403	337	0.12	7520	0.13	0.33	0.36	0.13	94
2000	336	287	0.12	23484	0.09	0.29	0.31	0.12	86
2001	483	395	0.11	13869	0.11	0.28	0.30	0.12	102
2002	537	446	0.10	7459	0.14	0.24	0.25	0.12	100
2003	479	419	0.10	5738	0.16	0.23	0.25	0.12	98
2004	457	398	0.11	24927	0.07	0.26	0.28	0.12	98
2005	517	366	0.10	8855	0.10	0.25	0.27	0.12	97
2006	559	488	0.08	2901	0.16	0.22	0.23	0.12	87
2007	504	449	0.09	4646	0.12	0.24	0.25	0.13	96
2008	378	334	0.10	5706	0.10	0.35	0.38	0.13	101
2009	286	247	0.10	6661	0.09	0.40	0.43	0.12	87
2010	229	195	0.10	3296	0.12	0.54	0.58	0.11	90
2011	198	178	0.10	3152	0.13	0.61	0.65	0.11	80
2012	147	125	0.13	3665	0.13	0.46	0.50	0.11	55
2013	158	138	0.14	4782	0.15	0.42	0.45	0.09	46
2014	135	139	0.16	4009	0.18	0.24	0.26	0.10	28
2015	168	140	0.16	4655	0.21	0.14	0.16	0.11	21
2016	199	141	0.16	10713					

Table 7.6.1. Sardine in 8.c and 9.a: Input data for short term catch predictions. N-at-age for 2016. Input values of natural mortality (M), Maturity (Mat), proportion of F (PF), proportion of M (PM).

2016								
Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	4005	0.8	0	0	0	0.000	0.012	0.027
1	2047	0.5	1	0	0	0.024	0.035	0.049
2	989	0.4	1	0	0	0.064	0.063	0.068
3	658	0.3	1	0	0	0.067	0.086	0.077
4	272	0.3	1	0	0	0.069	0.086	0.085
5	112	0.3	1	0	0	0.066	0.086	0.090
6	228	0.3	1	0	0	0.073	0.024	0.100
2017								
Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	4005	0.8	0	0	0	0.000	0.022	0.027
1	.	0.5	1	0	0	0.028	0.063	0.049
2	.	0.4	1	0	0	0.051	0.114	0.068
3	.	0.3	1	0	0	0.059	0.155	0.077
4	.	0.3	1	0	0	0.068	0.155	0.085
5	.	0.3	1	0	0	0.073	0.155	0.090
6	.	0.3	1	0	0	0.077	0.044	0.100
2018								
Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	4005	0.8	0	0	0	0.000	0.022	0.027
1	.	0.5	1	0	0	0.028	0.063	0.049
2	.	0.4	1	0	0	0.051	0.114	0.068
3	.	0.3	1	0	0	0.059	0.155	0.077
4	.	0.3	1	0	0	0.068	0.155	0.085
5	.	0.3	1	0	0	0.073	0.155	0.090
6	.	0.3	1	0	0	0.077	0.044	0.100

Input units are millions and kg.

Table 7.6.2. Sardine in 8.c and 9.a: Output data for short term catch predictions.

2016						
Biomass	SSB	FMult	FBar	Landings		
199	199	1	0.08	13		

2017					**2018**	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
210	210	0	0	0	232	232
.	210	0.1	0.0145	3	230	230
.	210	0.2	0.029	6	228	228
.	210	0.3	0.0434	8	226	226
.	210	0.4	0.06	11	224	224
.	210	0.5	0.0724	14	222	222
.	210	0.6	0.0869	16	220	220
.	210	0.7	0.1013	19	218	218
.	210	0.8	0.1158	22	216	216
.	210	0.9	0.1303	24	215	215
.	210	1	0.14	27	213	213
.	210	1.1	0.1592	29	211	211
.	210	1.2	0.1737	32	209	209
.	210	1.3	0.1882	34	207	207
.	210	1.4	0.20	37	205	205
.	210	1.5	0.2171	39	204	204
.	210	1.6	0.2316	41	202	202
.	210	1.7	0.2461	44	200	200
.	210	1.8	0.2606	46	199	199
.	210	1.9	0.275	48	197	197
.	210	2	0.2895	51	195	195

Input units are millions and kg - output in kilo tonnes.

Table 7.6.3 Sardine in 8.c and 9.a: Basis for the revised catch options for 2016.

Variable	Value	Source	Notes
F ages 2-5 (2015)	0.14	ICES, 2016a	Estimated in the 2016 assessment
B1+ (2016)	199000 t	ICES, 2016a	Estimated in the 2016 assessment
R_{age0} (2015)	4655 mill	ICES, 2016a	Estimated in the 2016 assessment
R_{age0} (2016)	4005 mill	ICES, 2016a	Geometric mean (2011–2015)
Total catch (2015)	20595 t	ICES, 2016a	2015 catch
Discards (2015)	Negligible	ICES, 2015a	

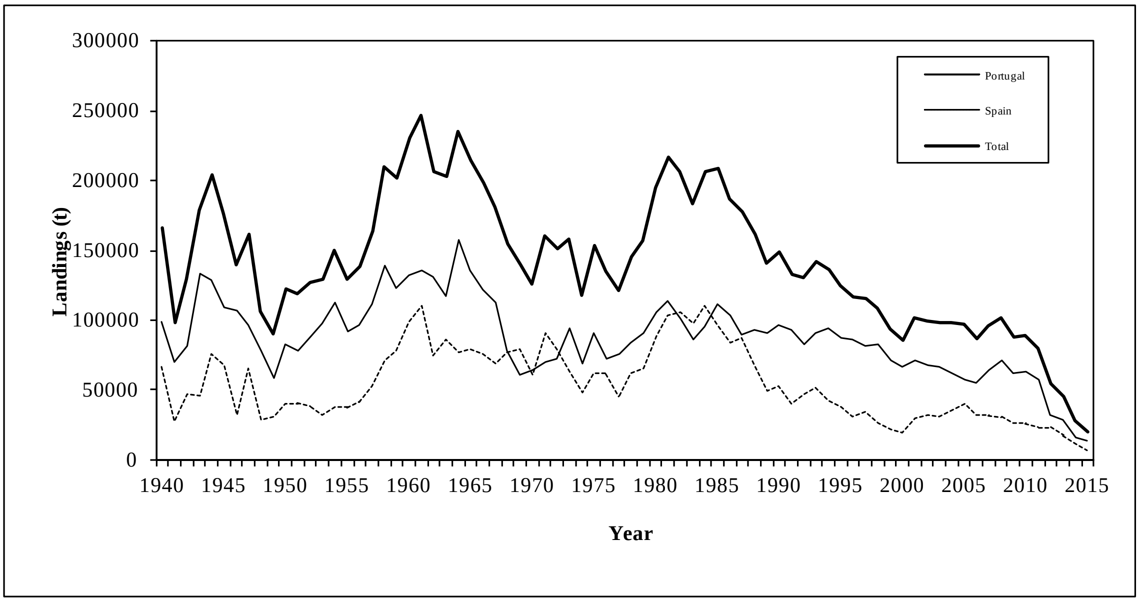
Table 7.6.4 Sardine in 8.c and 9.a: Input data for the revised catch options for 2016.

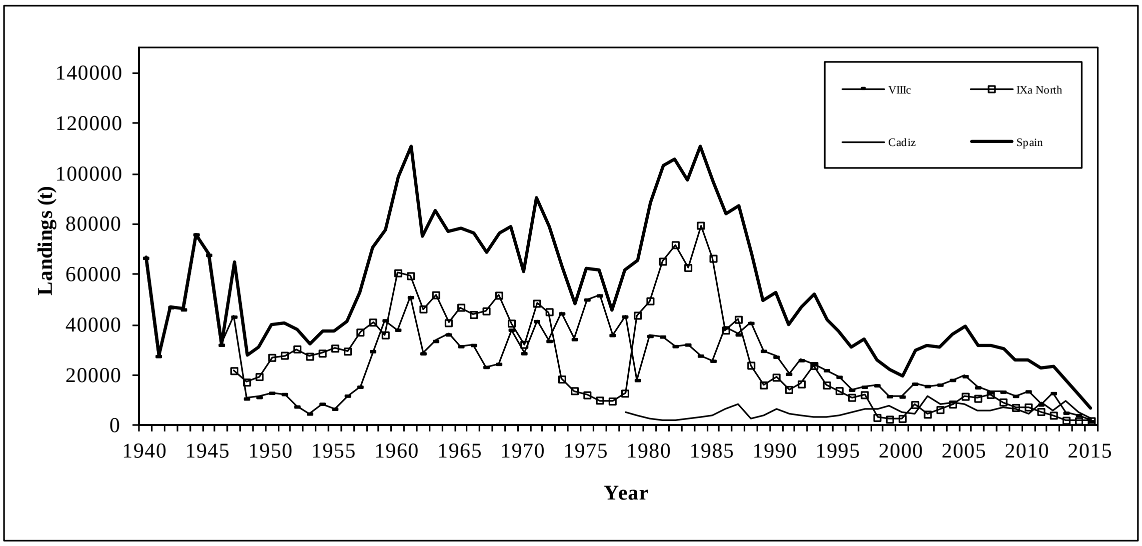
2016								
Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	4005	0.8	0	0	0	0	0.022	0.027
1	2046	0.5	1	0	0	0.024	0.063	0.049
2	989	0.4	1	0	0	0.064	0.114	0.067
3	658	0.3	1	0	0	0.067	0.155	0.077
4	272	0.3	1	0	0	0.069	0.155	0.085
5	112	0.3	1	0	0	0.066	0.155	0.089
6	228	0.3	1	0	0	0.073	0.044	0.1

Table 7.6.5 Sardine in 8.c and 9.a: Output data for the revised catch options for 2016.

2016				2017
Biomass 1+	FMult	FBar	Landings	Biomass 1+
199	0.500	0.072	12	211
199	0.525	0.076	13	211
199	0.550	0.080	13	210
199	0.575	0.083	14	210
199	0.600	0.087	14	209
199	0.625	0.091	15	209
199	0.650	0.094	16	208
199	0.675	0.098	16	208
199	0.700	0.101	17	208
199	0.725	0.105	17	207
199	0.750	0.109	18	207
199	0.775	0.112	19	206
199	0.800	0.116	19	206
199	0.825	0.119	20	205
199	0.850	0.123	20	205
199	0.875	0.127	21	205
199	0.900	0.130	21	204
199	0.925	0.134	22	204
199	0.950	0.138	23	203
199	0.975	0.141	23	203
199	1	0.145	24	202
199	1.025	0.148	24	202
199	1.050	0.152	25	202
199	1.075	0.156	25	201
199	1.100	0.159	26	201
199	1.125	0.163	26	200
199	1.150	0.167	27	200
199	1.175	0.170	28	200
199	1.200	0.174	28	199
199	1.225	0.177	29	199
199	1.250	0.181	29	198
199	1.275	0.185	30	198
199	1.300	0.188	30	198
199	1.325	0.192	31	197
199	1.350	0.195	31	197
199	1.375	0.199	32	196
199	1.400	0.203	32	196
199	1.425	0.206	33	196
199	1.450	0.210	33	195
199	1.475	0.214	34	195
199	1.500	0.217	35	194

Input units are millions and kg - output in kilo tonnes





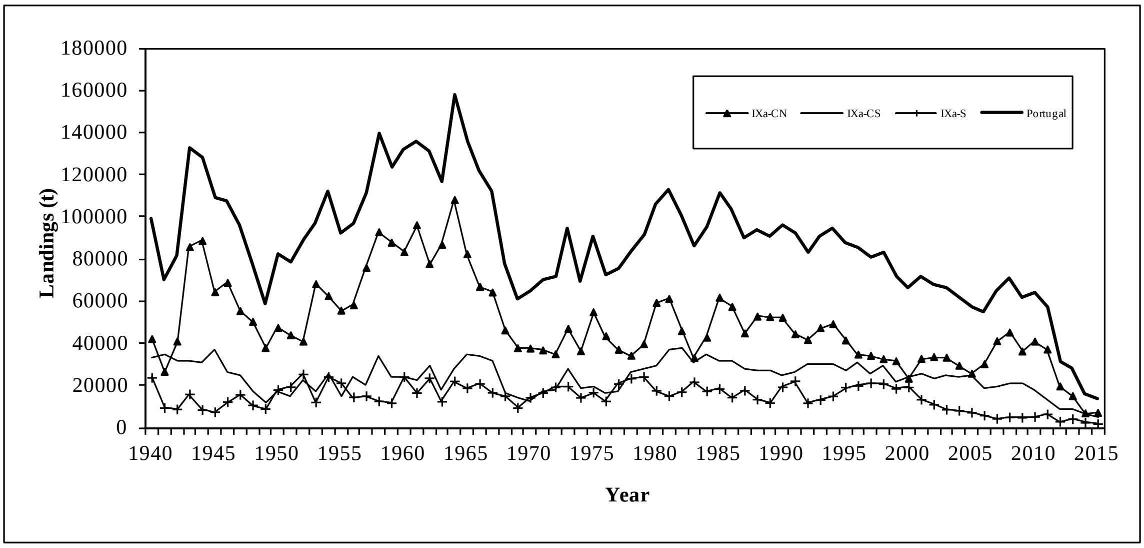


Figure 7.2.2.1. Sardine in 8.c and 9.a: WG estimates of annual landings of sardine, by country (upper panel) and by ICES Subdivision and country.

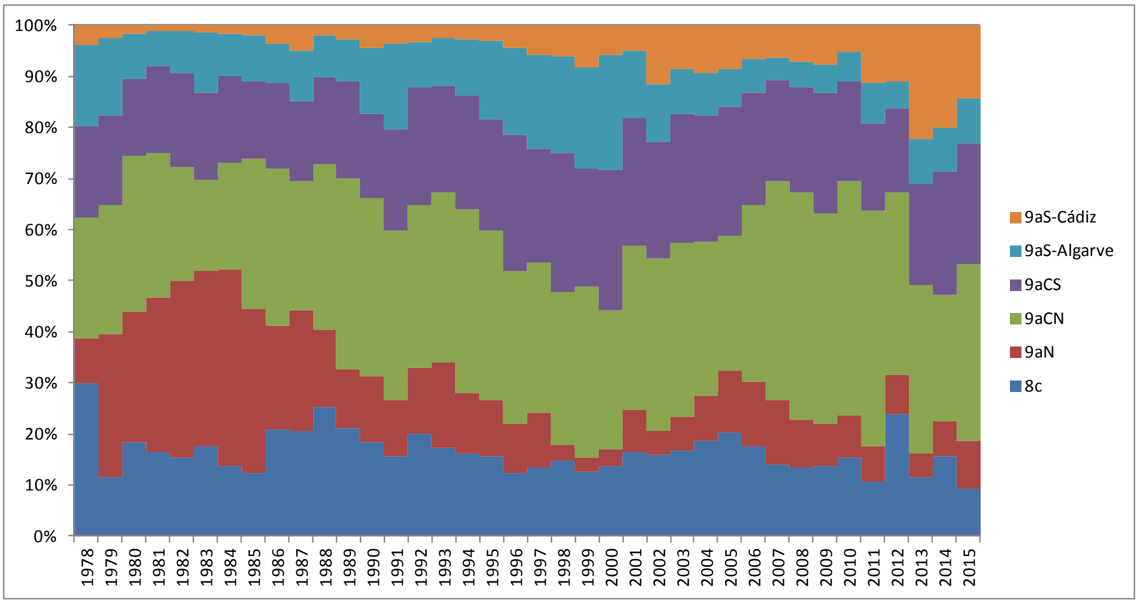


Figure 7.2.2.2. Sardine in 8.c and 9.a: Historical relative contribution of the different subareas to the total catches (1978–2015).

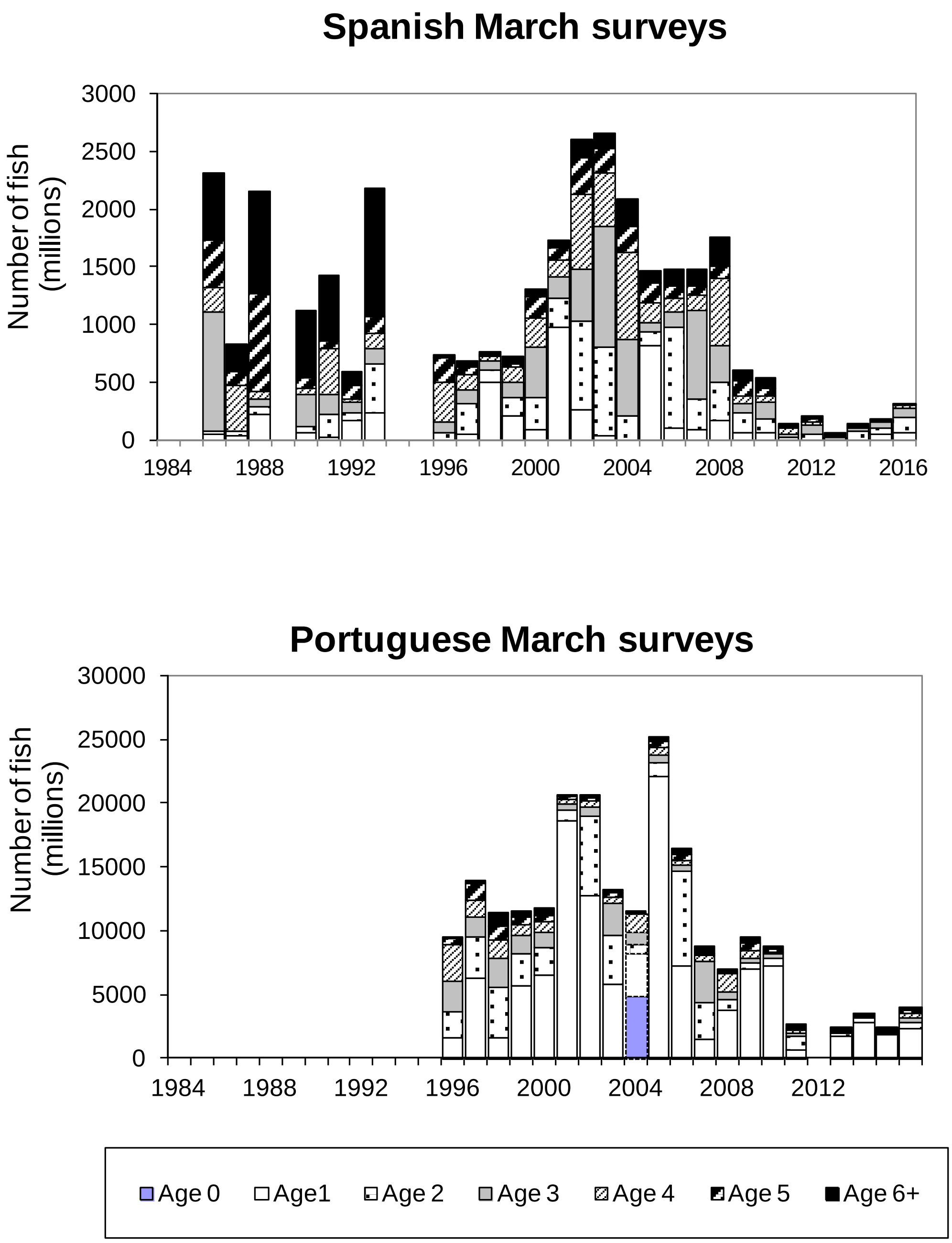


Figure 7.3.1. Sardine in 8.c and 9.a: Total abundance and age structure (numbers) of sardine estimated in the acoustic surveys. The Spanish March survey series covers area 8.c and 9.a-N (Galicia) and the Portuguese March surveys covers the Portuguese area and the Gulf of Cadiz (Subdivisions 9.CN, 9.aCS, 9.aS Algarve and 9.aS Cadiz). Portuguese acoustic survey in June 2004 was considered as indications of the population abundance and is not included in assessment. Estimates from Portuguese acoustic surveys are not available for 2012.

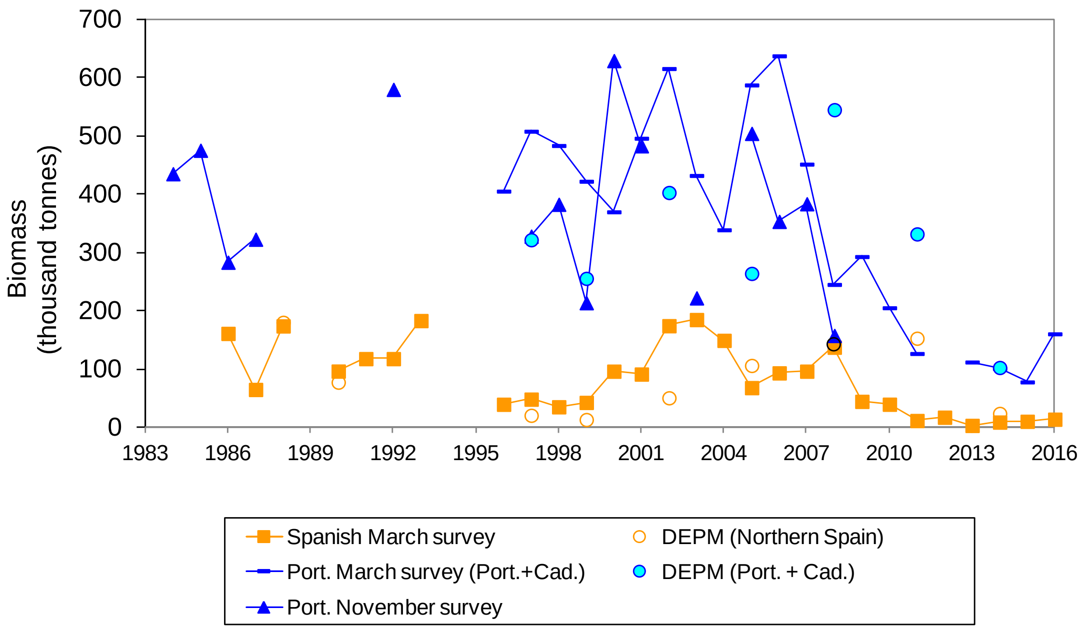


Figure 7.3.2. Sardine in 8.c and 9.a: Total sardine biomass (thousand tonnes) estimated in the different series of acoustic surveys and SSB estimates from the DEPM series covering the northern area and the west and southern area of the stock.

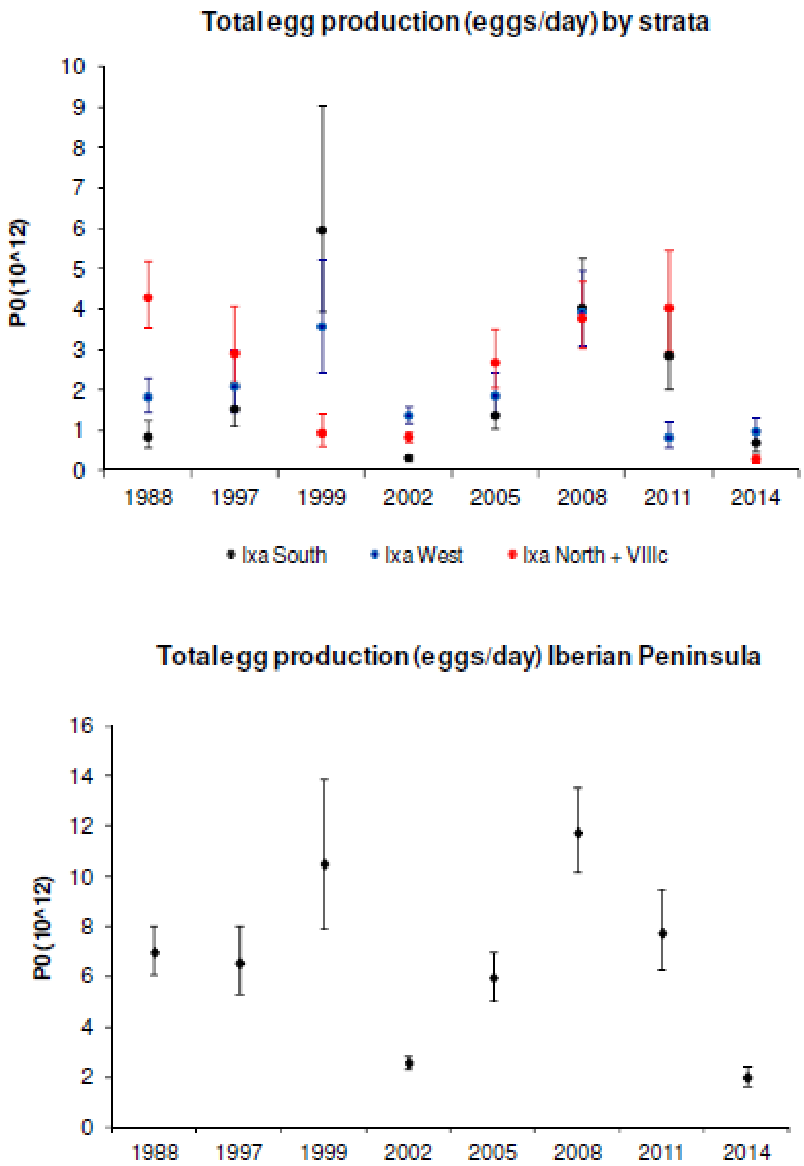


Figure 7.3.1.1. Sardine in 8.c and 9.a: Total egg production (eggs/day*10[12]) by spatial strata (top panel); black – 9.a South, blue – 9.a West stratum, red – 9.a North + 8.c and for the total stock area off the Iberian Peninsula (bottom panel). Dots and lines indicate the estimates of egg production and their confidence intervals.

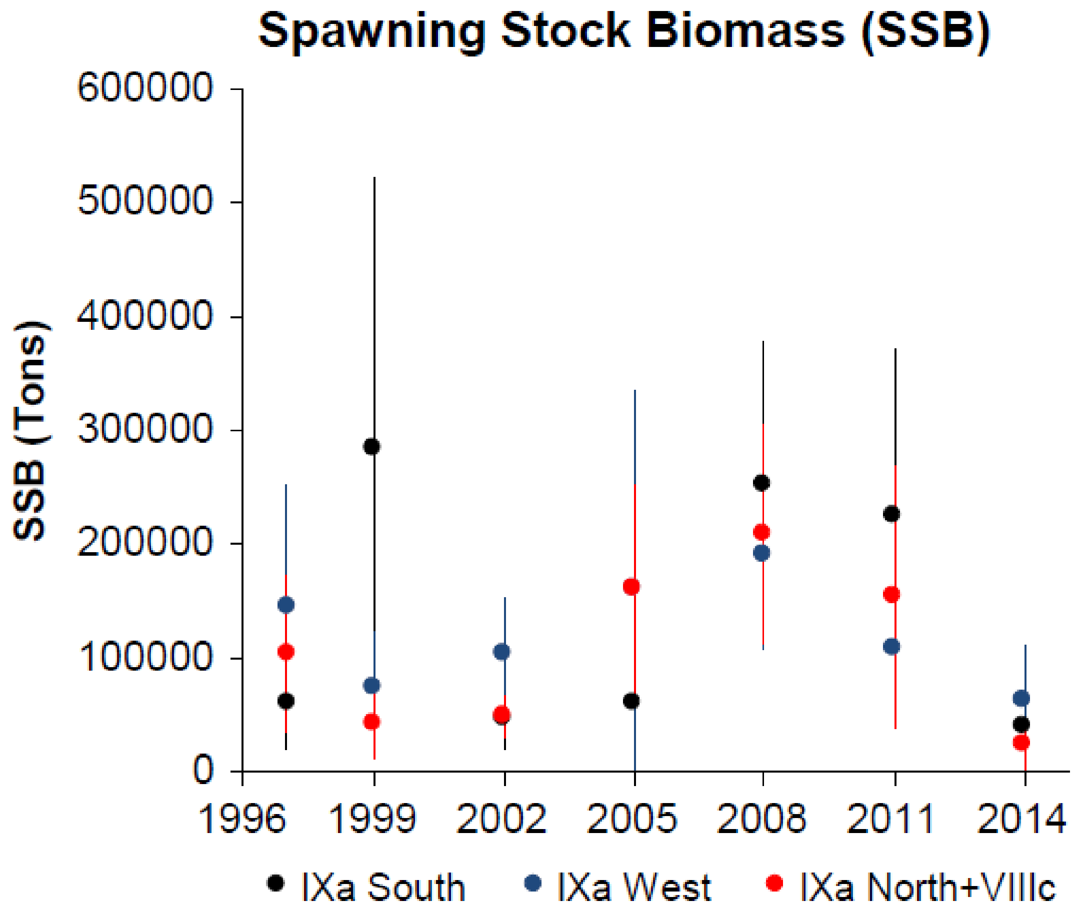


Figure 7.3.1.2. Sardine in 8.c and 9.a: Spawning–Stock Biomass (Tonnes) by spatial strata; black – 9.a South, blue – 9.a West, red – 9.a North + 8.c. Dots and lines indicate the estimates of SSB and their confidence intervals.

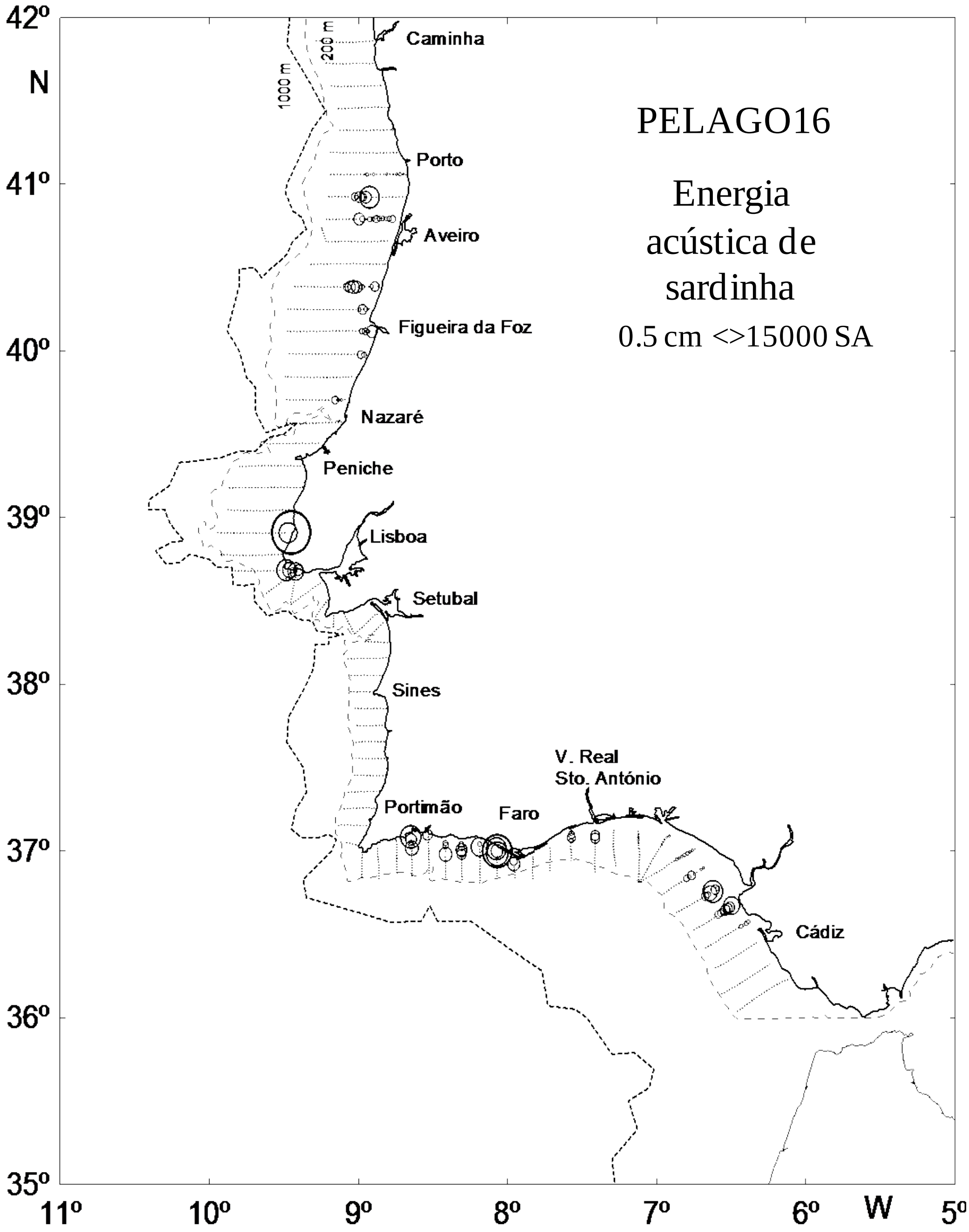


Figure 7.3.2.1.1. Sardine in 8.c and 9.a: Portuguese spring acoustic survey in 2016. Acoustic energy by nautical mile and abundance (in millions), biomass (in thousand tonnes) and length structure by area. Circle area is proportional to the acoustic energy (S_A m²/nm²).

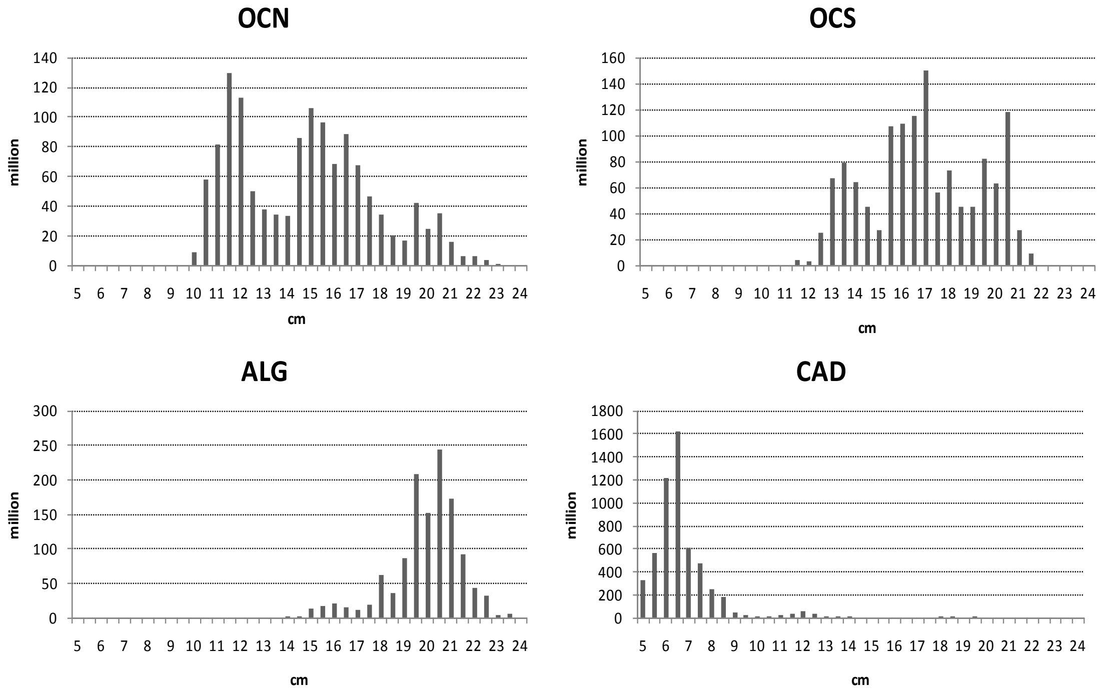


Figure 7.3.2.1.2. Sardine in 8.c and 9.a: Portuguese spring acoustic survey in 2016. Length distribution by area.

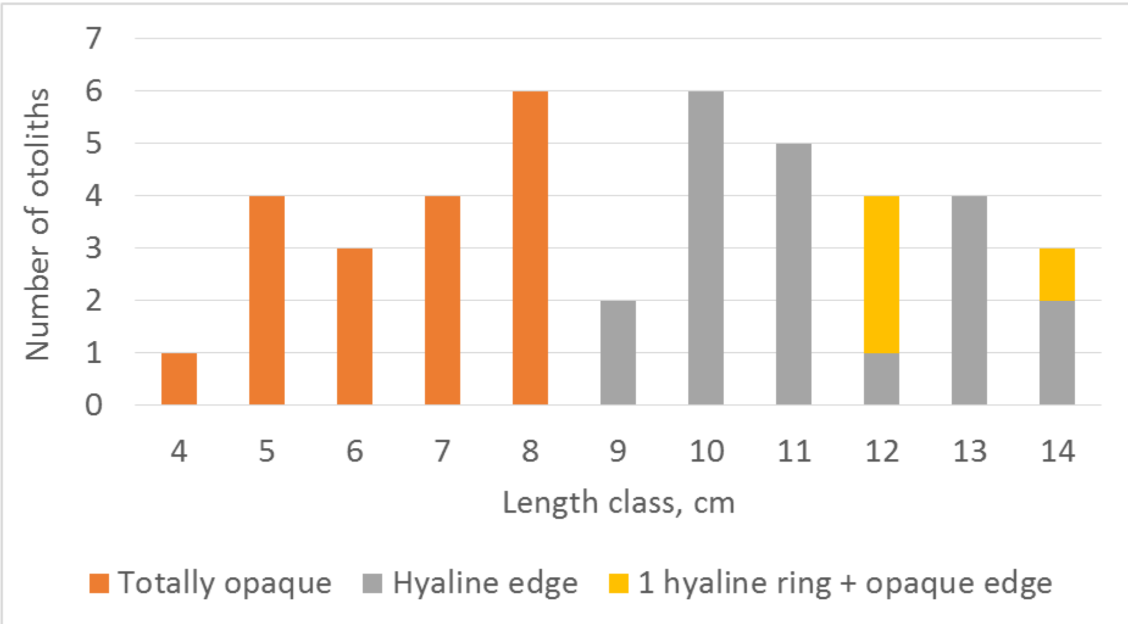


Figure 7.3.2.1.3. Sardine in 8.c and 9.a: Portuguese spring acoustic survey in 2016. Otolith appearance.

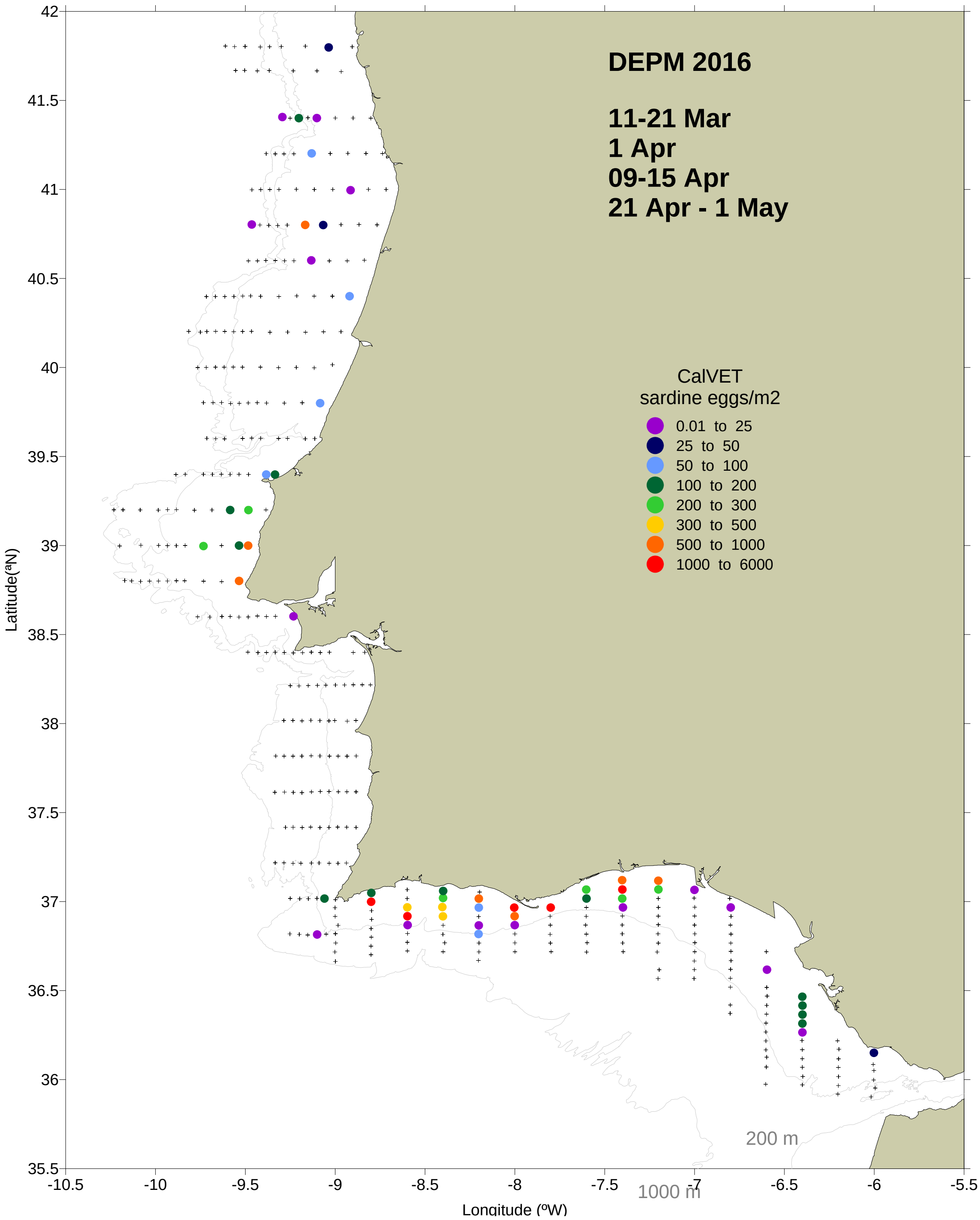


Figure 7.3.2.1.4. Sardine in 8.c and 9.a: Portuguese spring acoustic survey in 2016. Preliminary data on egg abundance.

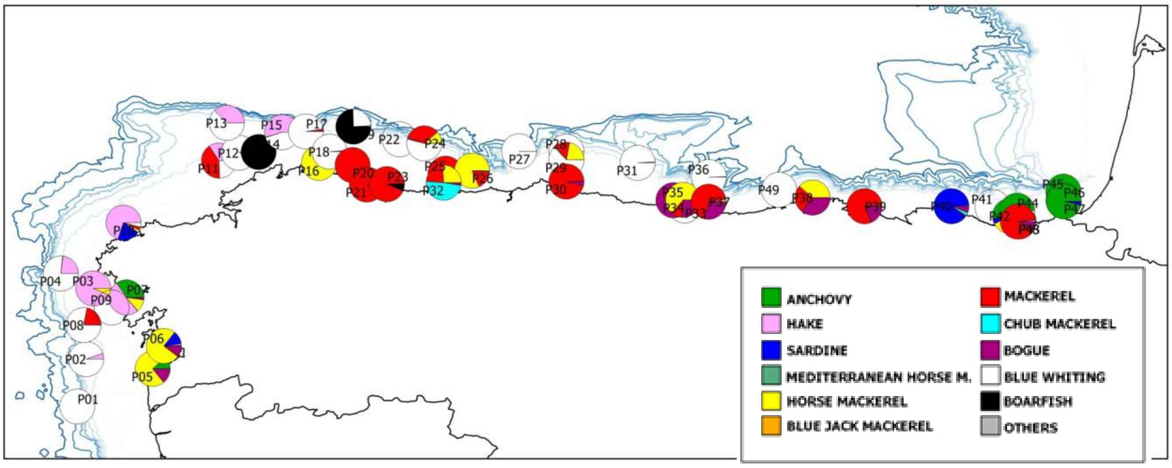


Figure 7.3.2.2.1 Sardine in 8.c and 9.a: Spanish spring acoustic survey PELACUS0316. Fishing hauls.

Figure 7.3.2.2.2. Sardine in 8.c and 9.a: Spanish spring acoustic survey PELACUS0316. Spatial distribution of energy allocated to sardine during the PELACUS0315 survey. Polygons are drawn to encompass the observed echoes, and polygon colour indicates integrated energy in m^2 within each polygon.

Figure 7.3.2.2.3. Sardine in 8.c and 9.a: Spanish spring acoustic survey PELACUS0316. Sardine length distribution (cm) in numbers and biomass (tonnes). In the small chart, the estimates when excluding the school accounted as probably sardine.

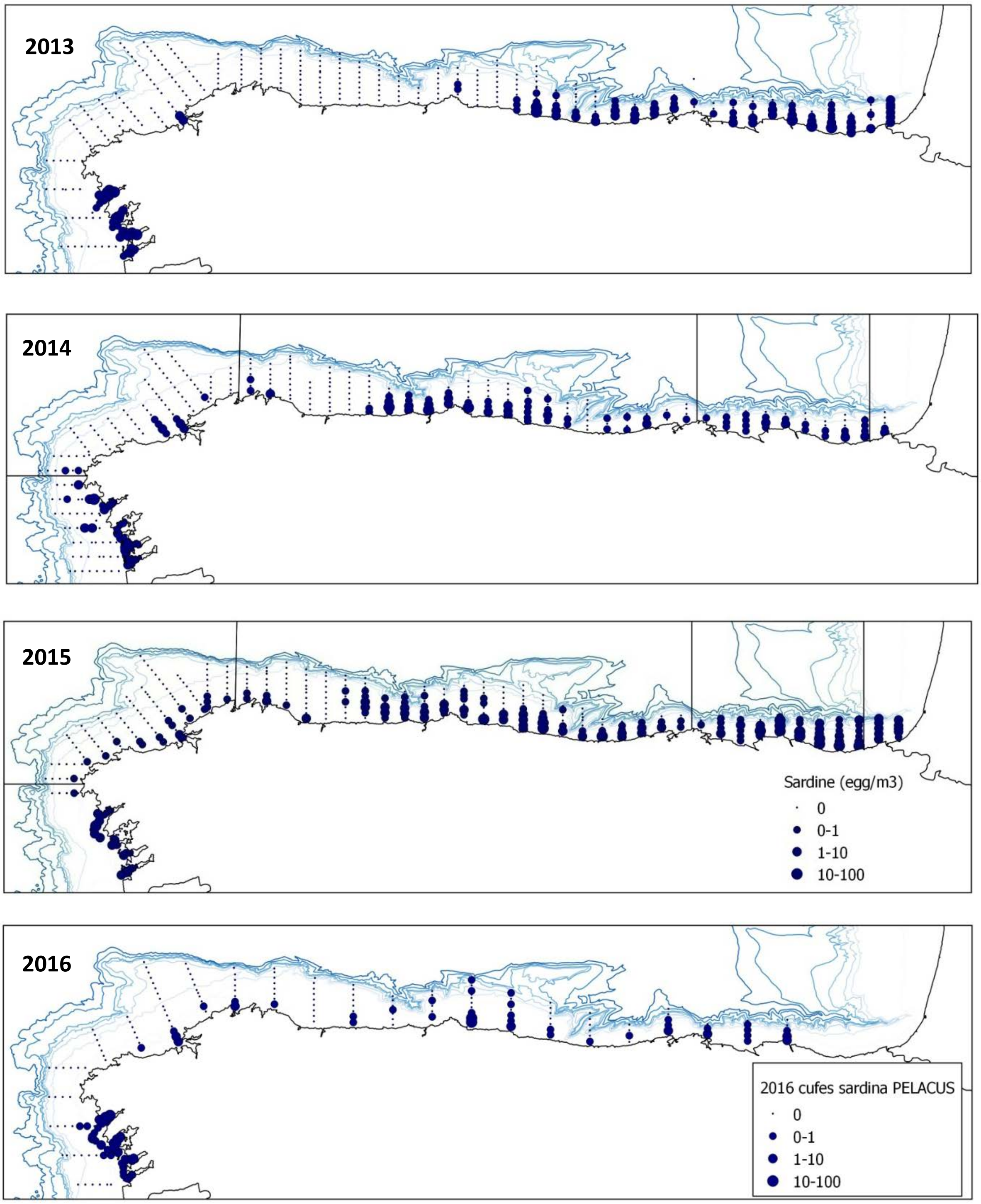


Figure 7.3.2.2.4. Sardine in 8.c and 9.a: Spanish spring acoustic survey in 2016 PELACUS0316. Total number of sardine eggs obtained during the PELACUS (2013–2016) surveys. Diameter of circles is proportional to egg density.

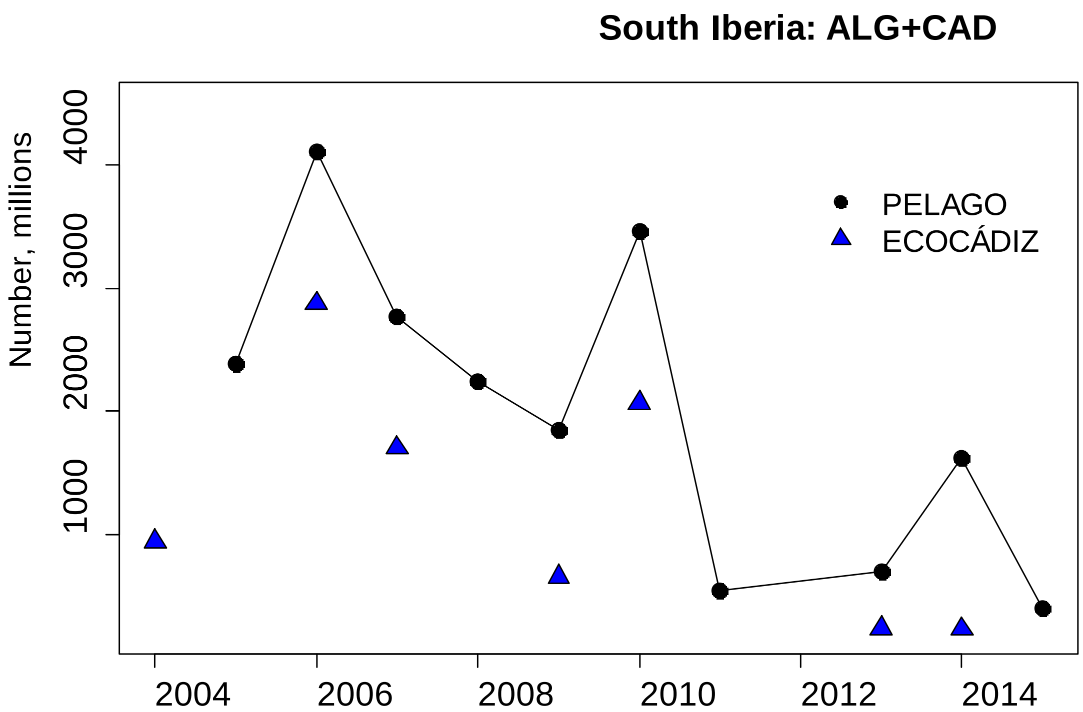


Figure 7.3.3.1. Sardine in 8.c and 9.a: sardine abundance estimate in PELAGO spring acoustic survey (black) and ECOCADIZ summer acoustic (blue) surveys along the time-series, for the 9.a South subdivision. In 2010 the area from Sagres to Cape. St Maria was not covered by ECOCADIZ.

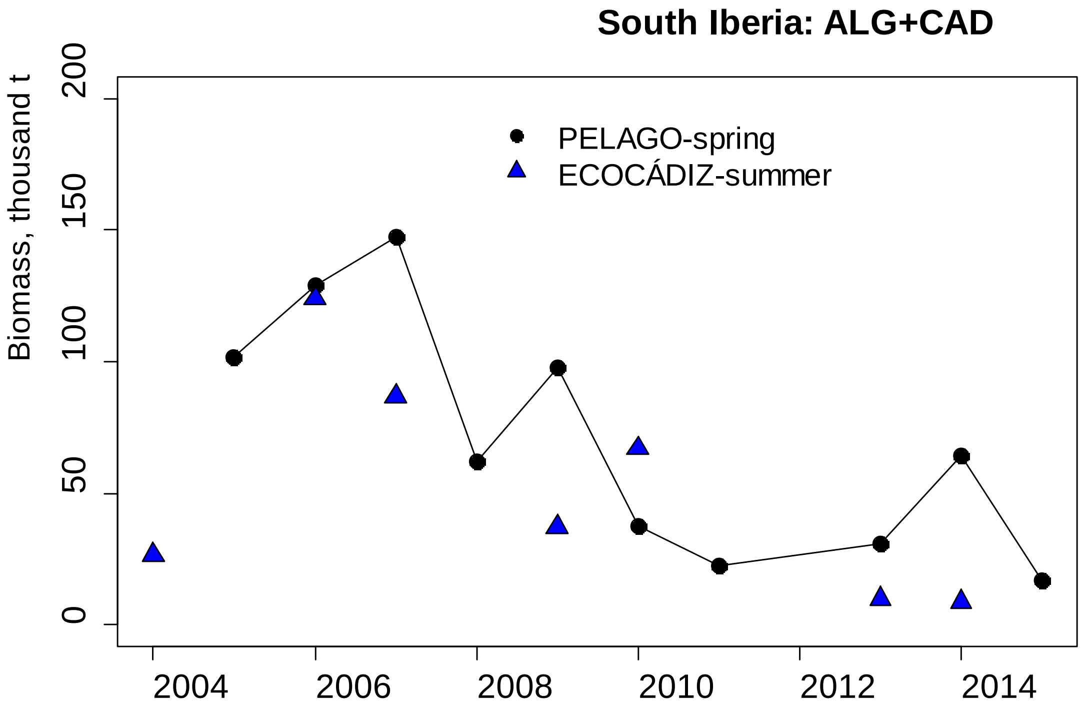


Figure 7.3.3.2. Sardine in 8.c and 9.a: sardine biomass estimate in PELAGO spring acoustic survey (black) and ECOCADIZ summer acoustic (blue) surveys along the time series, for the 9.a South subdivision. In 2010 the area from Sagres to Cape. St Maria was not covered by ECOCADIZ.

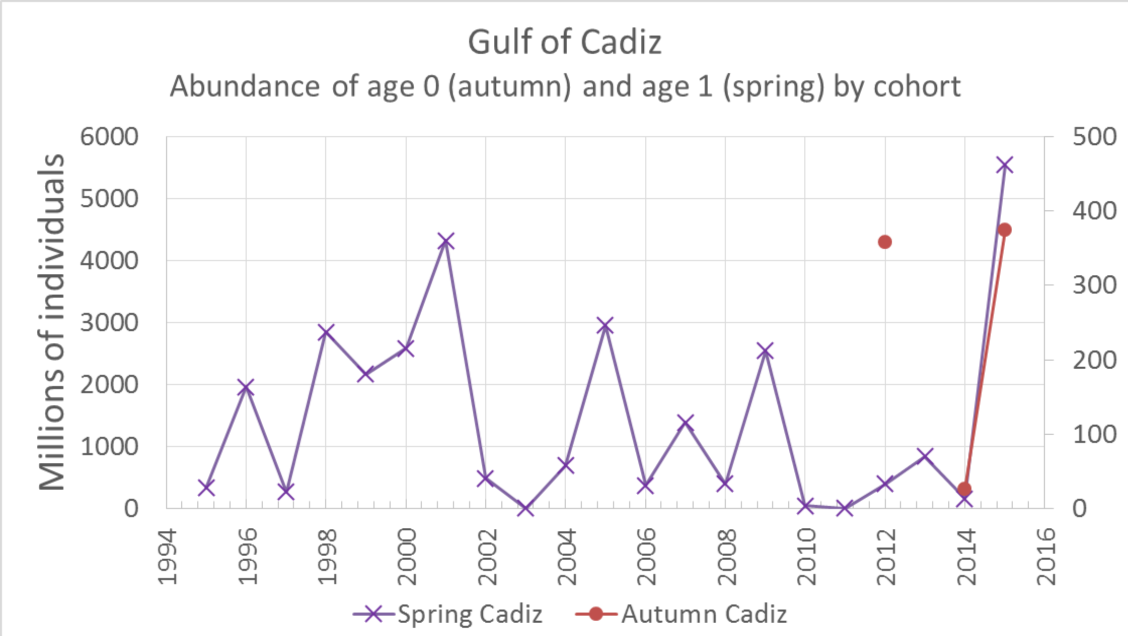


Figure 7.3.3.3. Sardine in 8.c and 9.a: sardine biomass estimate at-age 0 in autumn ECOCADIZ-RECLUTAS (red) and at-age 1 PELAGO spring acoustic survey (black).

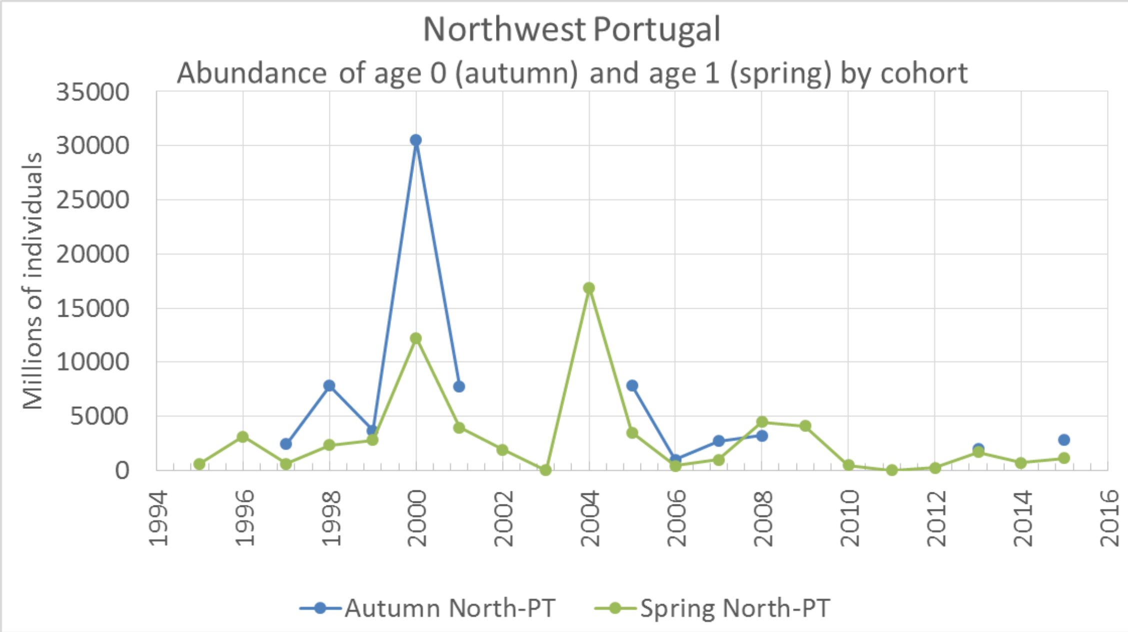


Figure 7.3.3.4. Sardine in 8.c and 9.a: sardine biomass estimate at-age 0 in autumn surveys in north-western coast of Portugal (red) and at-age 1 PELAGO spring acoustic survey (black).

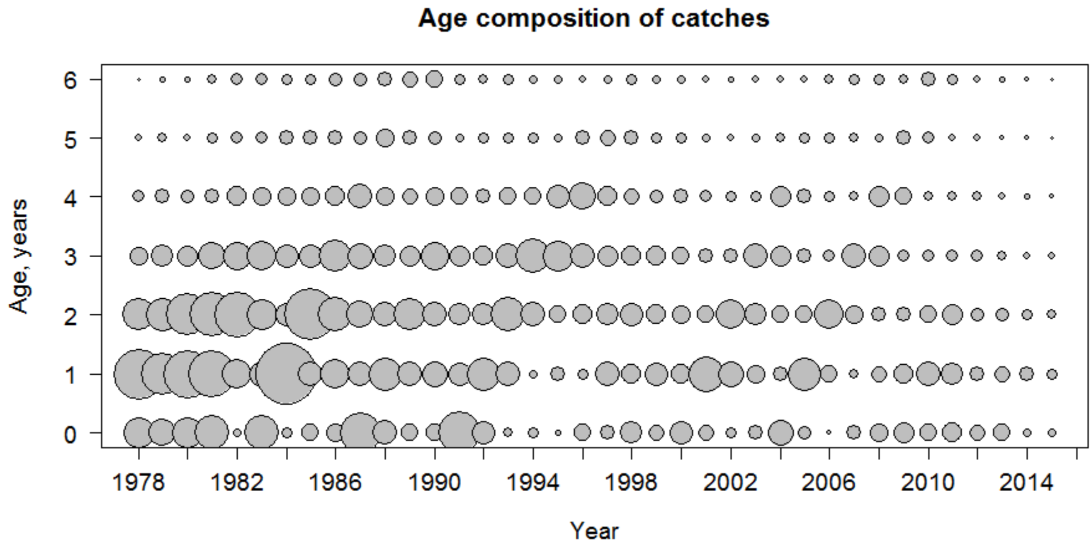


Figure 7.4.4.1. Sardine in 8.c and 9.a: Catches-at-age for 1978–2015.

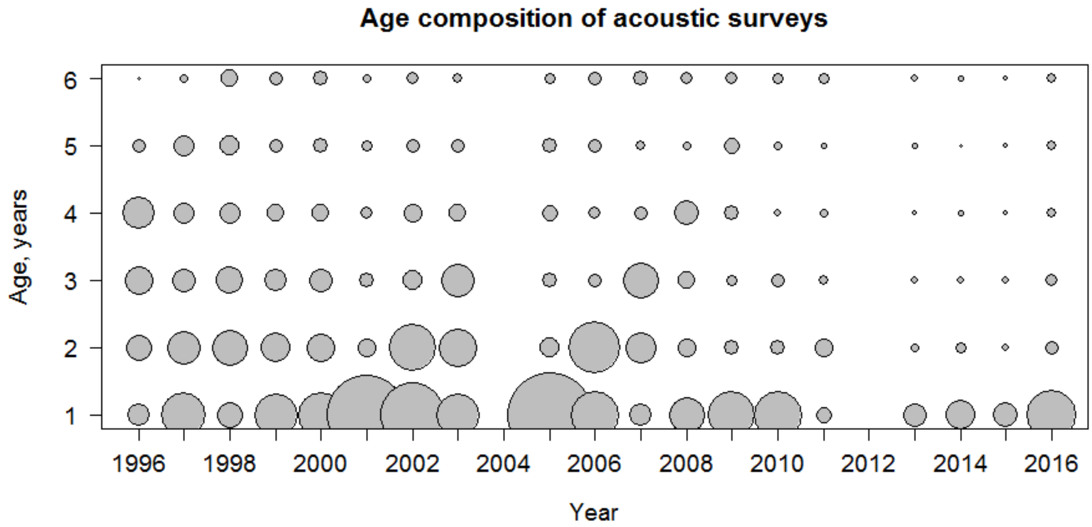


Figure 7.4.4.2. Sardine in 8.c and 9.a: Abundance-at-age in the joint Spanish-Portuguese spring acoustic survey 1996–2016.

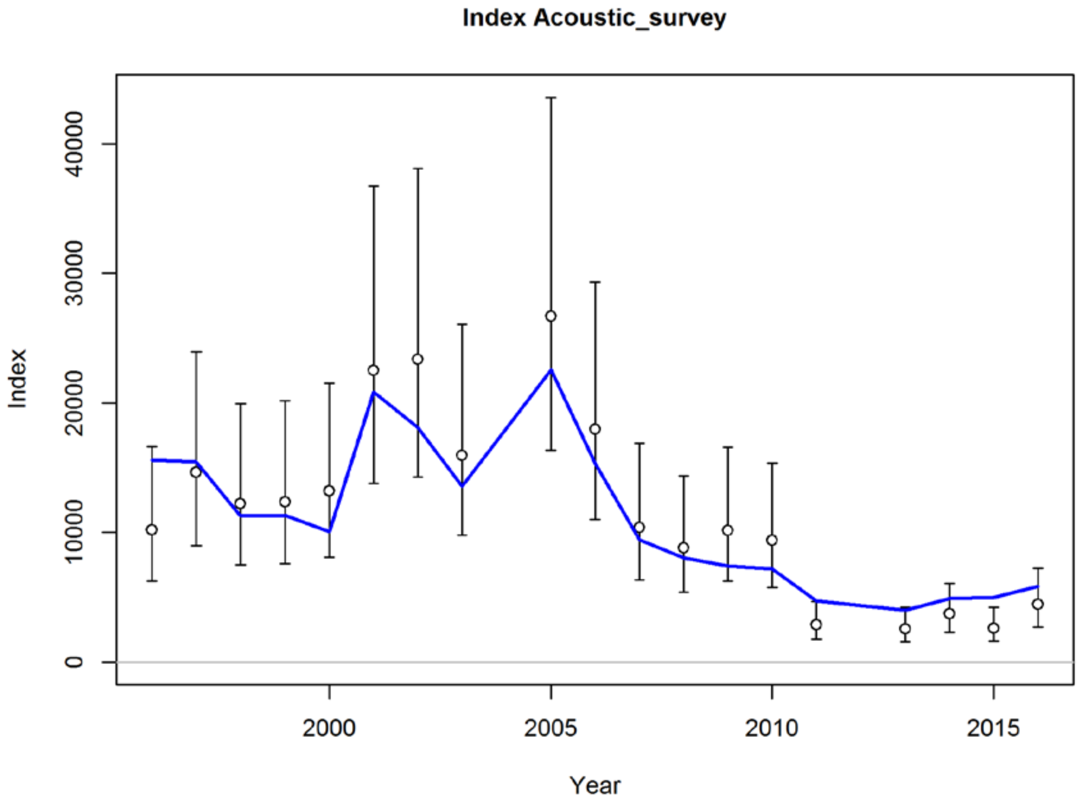


Figure 7.5.1.1. Sardine in 8.c and 9.a: Model fit to the acoustic survey series. The index is total abundance (in thousands of individuals). Bars are standard errors retransformed from the log scale.

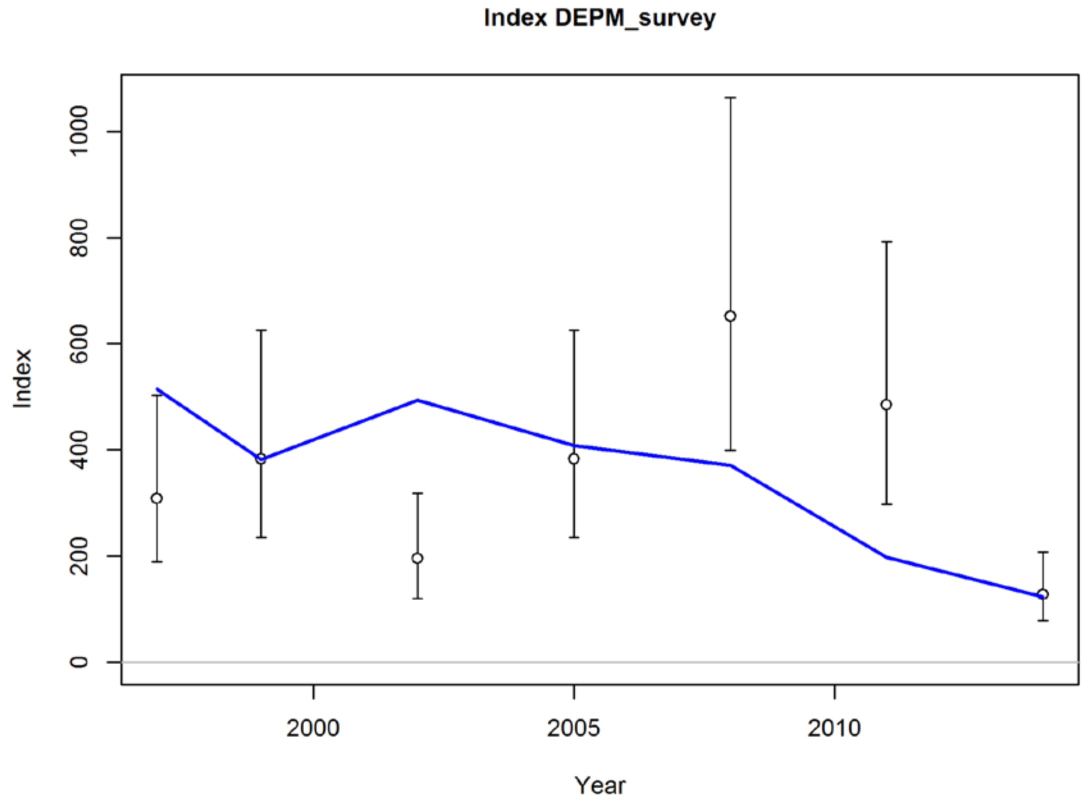


Figure 7.5.1.2. Sardine in 8.c and 9.a: Model fit to the DEPM survey series. The index is SSB (in thousand tonnes). Bars are standard errors retransformed from the log scale.

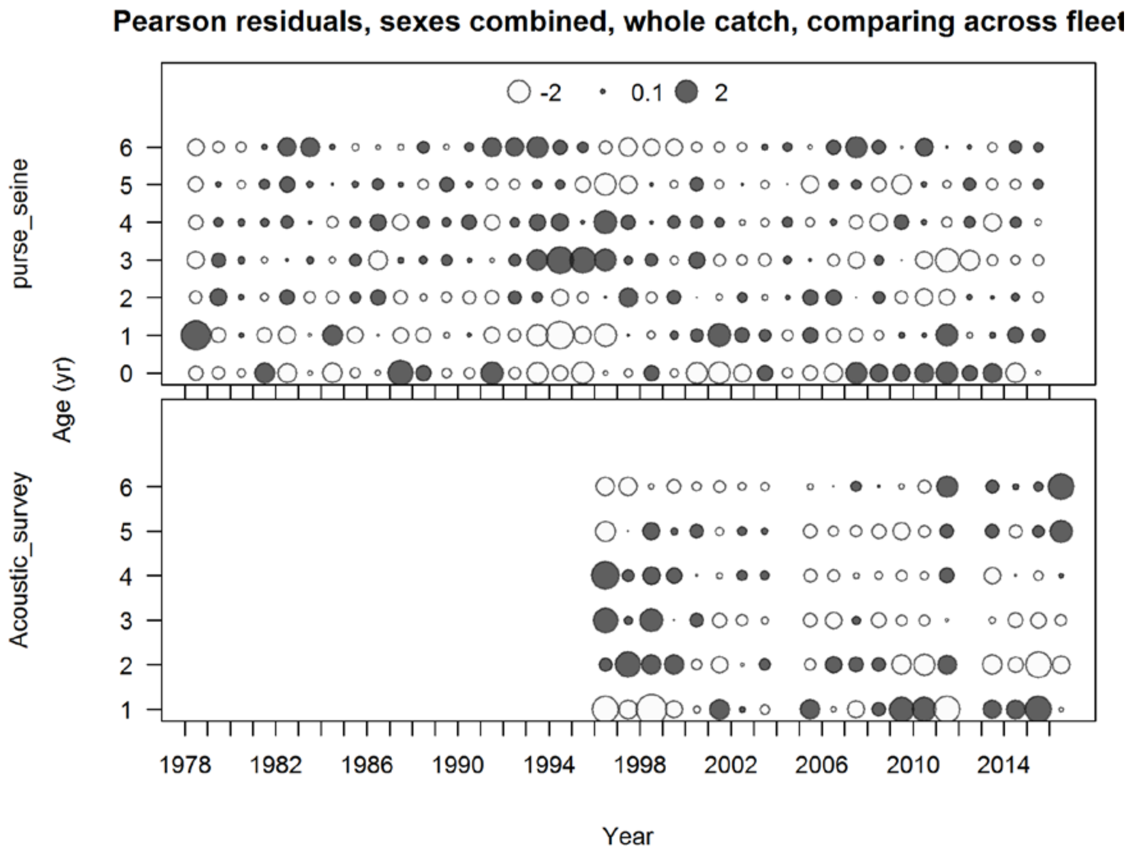


Figure 7.5.1.3. Sardine in 8.c and 9.a: Model residuals from the fit to the catch-at-age composition (top) and the acoustic survey age composition (bottom).

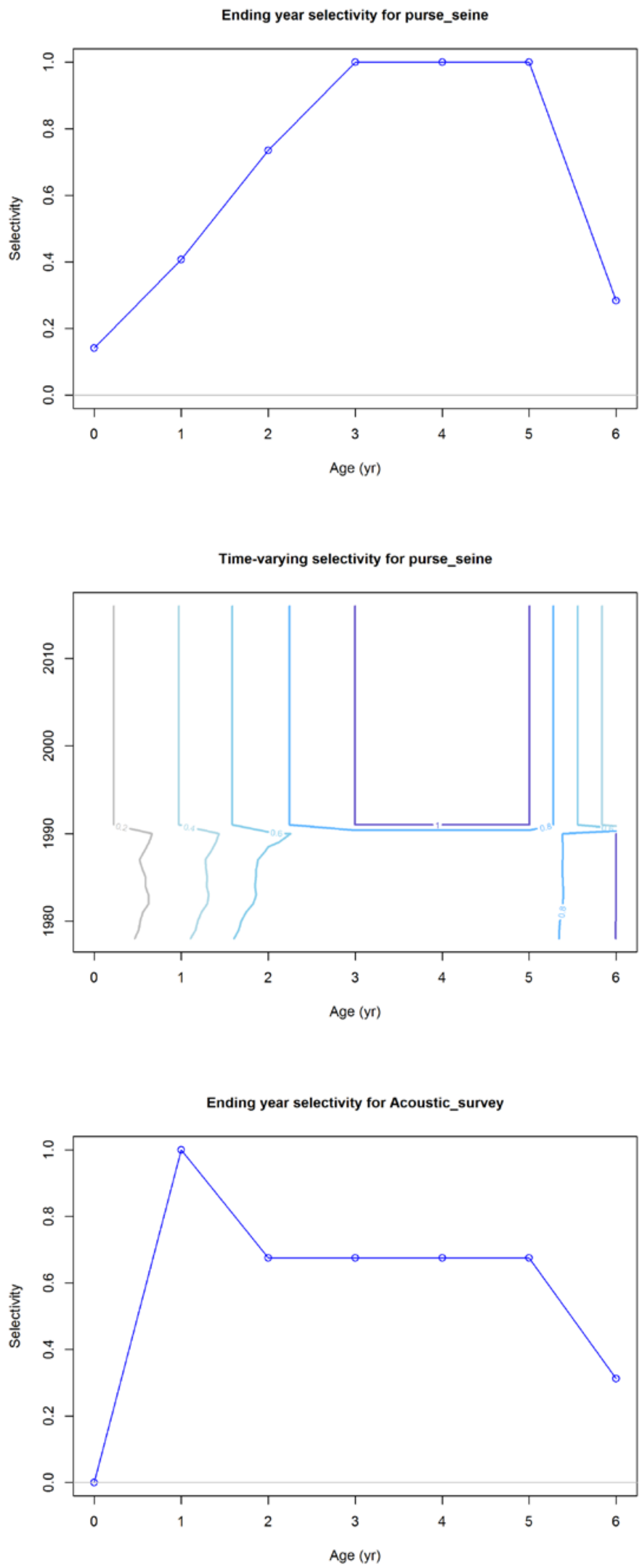


Figure 7.5.1.4. Sardine in 8.c and 9.a: Selectivity-at-age in the fishery (top) and in the acoustic survey (bottom).

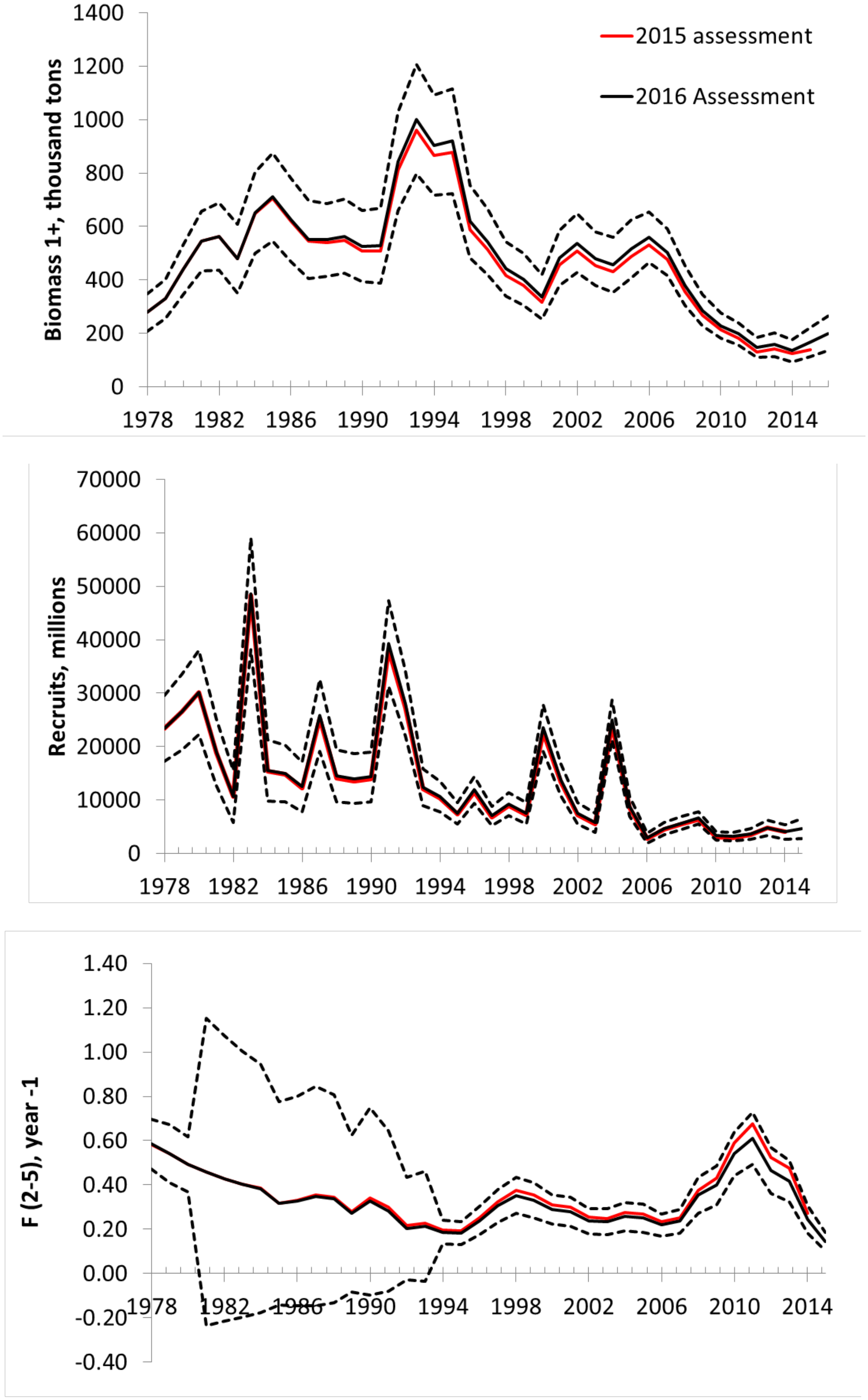


Figure 7.5.1.5. Sardine in 8.c and 9.a: Historical B1+ (top), F (middle) and recruitment (bottom) trajectories in the period 1978–2015. The WG2015 assessment is shown for comparison (red line).

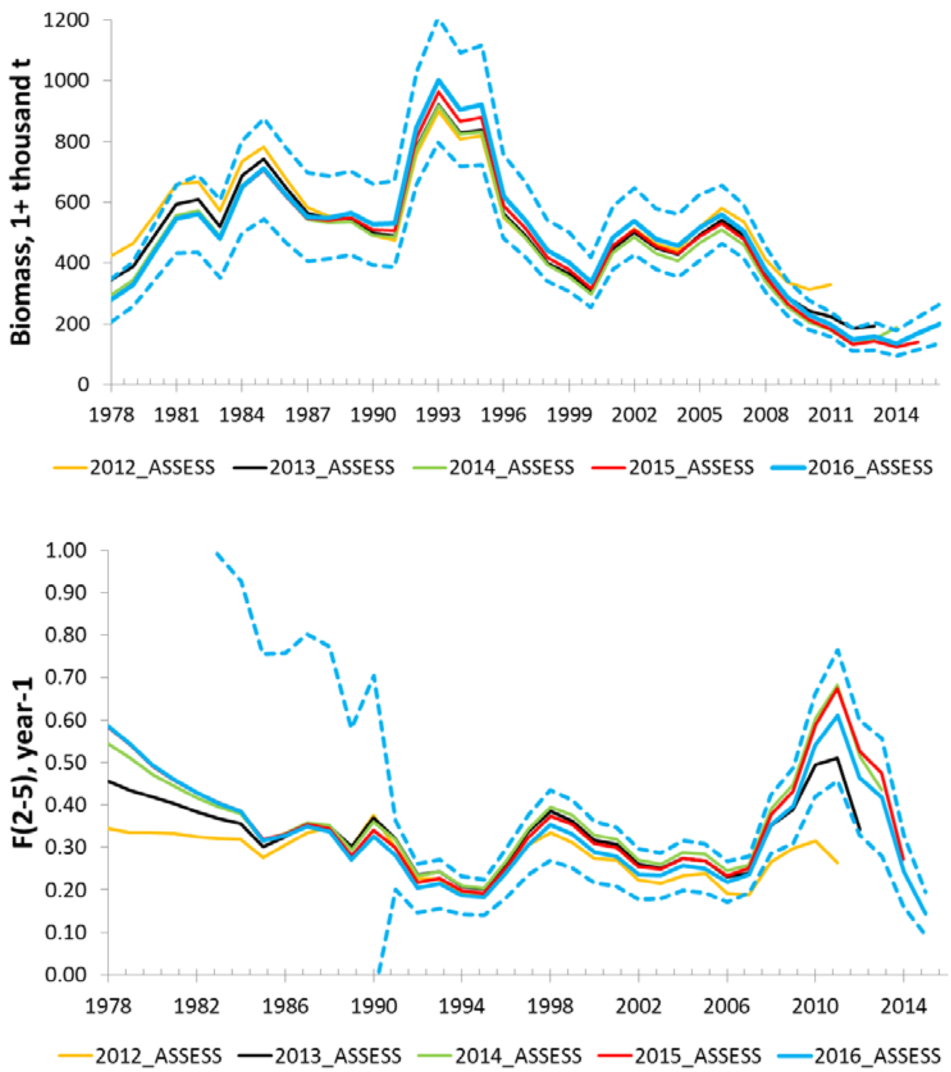


Figure 7.5.2. Sardine in 8.c and 9.a: Historical assessment results for the Biomass 1+ (above) and F(2–5) (below) in the assessment. Dotted lines show approximate 95% confidence intervals for the 2016 assessment results. The plots are equivalent to retrospective error plots, apart from the Assess 2012, where the model structure was different from other years due to the lack of a survey in the interim year.

8 Southern Horse Mackerel (Division 9.a)

8.1 ACOM Advice Applicable to 2015, STECF advice and Political decisions

The fishing mortality (F) has been below F_{MSY} (proxy) over the whole time-series (1992–2014) and the spawning–stock biomass (SSB) has been relatively stable, showing an increase in recent years resulting from the strong recruitments in 2011 and 2012. The ICES advice was based on the MSY approach. ICES therefore recommended that catches in 2016 should not exceed 68 583 t. ICES also recommended that the TAC for this stock should only apply to *Trachurus trachurus*.

STECF agreed with the ICES assessment of the state of the stock and the advice for 2015. A TAC of 68 583 t in 2016 has been set for *Trachurus* spp.

8.2 The fishery in 2015

8.2.1 Fishing fleets in 2015

Six fleets used to target on southern horse mackerel in Division 9.a. These fleets are considered defined by the gear type (bottom trawl, purse-seine and artisanal) and country (Portugal and Spain). Portuguese bottom-trawl fleet, Portuguese purse-seine fleet and Spanish purse-seine fleet show a similar exploitation pattern with a great presence of juveniles and lower abundance of adults. Moreover the Portuguese artisanal fleet, and the Spanish bottom-trawl and artisanal fleets show the opposite: a significant presence of adults and low presence of juveniles. The catch of Spanish artisanal fishery is negligible (<5%). Description of the Portuguese and Spanish fleets is available in Stock Annex.

8.2.2 Catches by fleet and area

Catch allocation between subdivisions for this stock is described in the Stock Annex. The definition of the ICES subdivisions was set in 1992 and some of the previous catch statistics came from an area that comprises more than one subdivision. This is the case of the Galician coast where the Subdivisions 8.c West and Subdivision 9.a North are located. Further work is necessary to collect the catches by port and to distribute them by subdivision. At the moment it has been collected the required information for the period 1992–2012, and it is expected to go back in time during the next years.

The catch time-series during the assessment period does not show a clear trend, with a peak reached in 1998 and a minimum in 2003 (Table 8.2.2.1). The relative contribution of each gear to the total catch is given in Table 8.2.2.2. Since 2012 the relative contribution of each gear has changed with a significant increase in landings for Spanish and Portuguese purse-seine and a significant decrease for Spanish bottom-trawl fleet landings. The different fleets targeting Southern horse mackerel are described in the Stock Annex.

Table 8.2.2.1. Time-series of southern horse mackerel historical catches (in tonnes).

YEAR	TOTAL CATCH
1991	34,992
1992	27,858
1993	31,521
1994	28,4411
1995	25,147
1996	20,4001
1997	29,491
1998	41,564
1999	27,733
2000	26,160
2001	24,910
2002	22,506 // (23,663)*
2003	18,887 // (19,566)*
2004	23,252 // (23,577)*
2005	22,695 // (23,111)*
2006	23,902 // (24,558)*
2007	22,790 // (23,424)*
2008	22,993 // (23,593)*
2009	25,737 // (26,497)*
2010	26,556// (27,216)*
2011	21,875// (22575)*
2012	24,868//(25316)*
2013	28,993//(29,382)*
2014	29,017//(29,205)*
2015	32,723///(33,178)*

(*) In parenthesis: the Spanish catches from Subdivision 9.a South are also included. These catches are only available since 2002 and they will not be considered in the assessment data until the rest of the time-series be completed.

(1) These figures have been revised in 2008.

Table 8.2.2.2. Southern horse mackerel. Landings by gear with an indication (in parenthesis) of the percentage that represent those landings.

Year	Bottom trawl	Purse-seine	Artisanal
1992	14,651	9,763	3,445
	52.6%	35.0%	12.4%
1993	20,660	7,004	3,841
	65.6%	22.2%	12.2%
1994	13,121	12,093	3,202
	46.2%	42.6%	11.3%
1995	15,611	7,387	2,137
	62.1%	29.4%	8.5%
1996	13,379	5,727	1,228
	65.8%	28.2%	6.0%
1997	14,576	13,161	1,800
	49.3%	44.6%	6.1%
1998	16,943	22,359	2,287
	40.7%	53.8%	5.5%
1999	10,106	15,781	1,855
	36.4%	56.9%	6.7%
2000	12,697	11,237	2,227
	48.5%	43.0%	8.5%
2001	12,226	11,048	1,637
	49.1%	44.3%	6.6%
2002	12,307	8,230	1,969
	54.7%	36.6%	8.7%
2003	10,116	6,523	2,248
	53.6%	34.5%	11.9%
2004	16,126	5,700	2,658
	65.9%	23.3%	10.9%
2005	14,029	6,040	2,621
	61.8%	26.6%	11.6%
2006	15,019	5,430	3,445
	62.9%	22.7%	14.4%
2007	13,705	6,775	2,308
	60.1%	29.7%	10.1%
2008	12,380	7,670	2,949
	53.8%	33.3%	12.8%
2009	15,075	6,669	3,984
	58.6%	25.9%	15.5%
2010	16,062	6,847	4,308
	59.0%	25.2%	15.8%
2011	11,038	7,301	3,530
	50.40%	33.30%	16.40%
2012	7,839	12,897	4,579
	30.97%	50.95%	18.09%

Year	Bottom trawl	Purse-seine	Artisanal
2013	9,9221	16,774	2,687
	33.77%	57.09%	9.14%
2014	12,573	14,114	2,330
	43.33%	48.64%	8.03%
2015	13,310	16,937	2,932
	40.12%	51.05%	8.84%

In general discards of southern horse mackerel are considered negligible. The horse mackerel Spanish discards mainly come from the bottom-trawl fleet. Spanish discards for 2015 were low and were estimated in 76 t at Subdivision 9.a North and 157 t at Subdivision 9.a South (Table 8.2.2.3).

The Portuguese discards of horse mackerel are also usually very low and not frequent. For other years (except 2005), estimates were not obtained because the frequency of occurrence of discards for this species was too low, and therefore estimates could be highly biased (Prista *et al.*, 2014 ICES WD). In 2015, discards of the bottom-trawl fleet targeting crustaceans were estimated to be 33 t (Table 8.2.2.3) and discards from other fleets are either inexistent or very low.

Table 8.2.2.3. Discard estimation by quarter for southern horse mackerel of Portuguese and Spanish fleet for 2015.

Gear	Fishing Area	Q1	Q2	Q3	Q4
Spanish trawl	9.a N	36	28	15	8
Spanish trawl	9.a S	21	46	29	42
Spanish purse seine	9.a S	13	5	2	0
Portuguese trawl	9.a	7	10	8	8

8.2.3 Effort and catch per unit of effort

No series of catch per unit of effort is currently available to be used for stock assessment.

8.2.4 Catches by length and catches-at-age

The procedure to estimate numbers-at-age in the catch is described in the Stock Annex. Catch in numbers-at-age have been obtained by applying a quarterly ALK to each of the catch length distribution estimated from the samples of each subdivision.

In general, catches are dominated by juveniles and young adults (Table 8.2.4.1, Figure 8.2.4.1).

Table 8.2.4.1. Southern horse mackerel. Time-series of catch-at-age data in number (thousands).

	AGES											
YEAR	0	1	2	3	4	5	6	7	8	9	10	11+
1992	11684	95186	145732	40736	12171	9102	5018	6864	5155	4761	13973	14354
1993	6480	66211	137089	100515	35418	13367	12938	10495	6597	5552	4497	14442
1994	12713	63230	86718	96253	28761	7628	4398	3433	5209	4834	6047	12264
1995	7230	55380	31265	52030	28199	11010	4003	3139	2720	3352	2530	31343
1996	69651	13798	14021	28125	33937	9861	6611	4501	4164	5504	3306	14243
1997	5056	295329	112210	26236	17168	12886	7780	7169	3938	3867	2425	8847
1998	22917	95950	320721	68438	18770	11317	9712	20627	12760	6686	6212	11323
1999	51659	29795	26231	66704	42960	15700	13840	7555	4175	4790	2475	7417
2000	12246	72936	23547	41618	35968	18643	17254	12118	7915	5227	3124	3557
2001	105759	77364	31261	24104	23721	16794	15391	14964	9795	3310	2023	3989
2002	18444	94402	84379	26482	13161	11396	10263	12501	10156	7525	3607	4433
2003	40033	6830	36754	28559	21931	12790	14751	13582	10631	6492	3531	2333
2004	7101	126797	58054	18243	8328	13586	11836	14878	10542	3876	5258	5318
2005	21015	108070	49197	24289	17877	11334	11179	7927	9124	7445	5502	11420
2006	3329	92563	92896	22665	6738	13176	11892	6029	7303	8070	8947	15322
2007	2885	16419	27667	44357	20534	8187	4459	3563	5975	4748	4943	30001
2008	48380	54167	31951	28058	16616	7194	4782	3660	4579	3975	4537	24990
2009	22618	85415	32416	8482	9774	7162	3289	2860	2791	3579	4236	39096
2010	81048	102016	33906	17496	11979	7569	3847	3942	2452	2671	2977	32284
2011	85973	23285	20987	19082	15047	7199	4272	3511	2885	5250	4639	22097
2012	201691	119136	30060	13964	14547	7693	5322	4373	2731	3218	4373	14562
2013	35849	123495	109557	30511	17468	9670	4085	3600	3123	2763	2488	17864
2014	22723	51727	89258	37772	18645	5573	2493	2899	1886	2137	2533	17588
2015	66497	92922	49067	50211	45753	16675	10529	5163	4253	4730	5149	13182

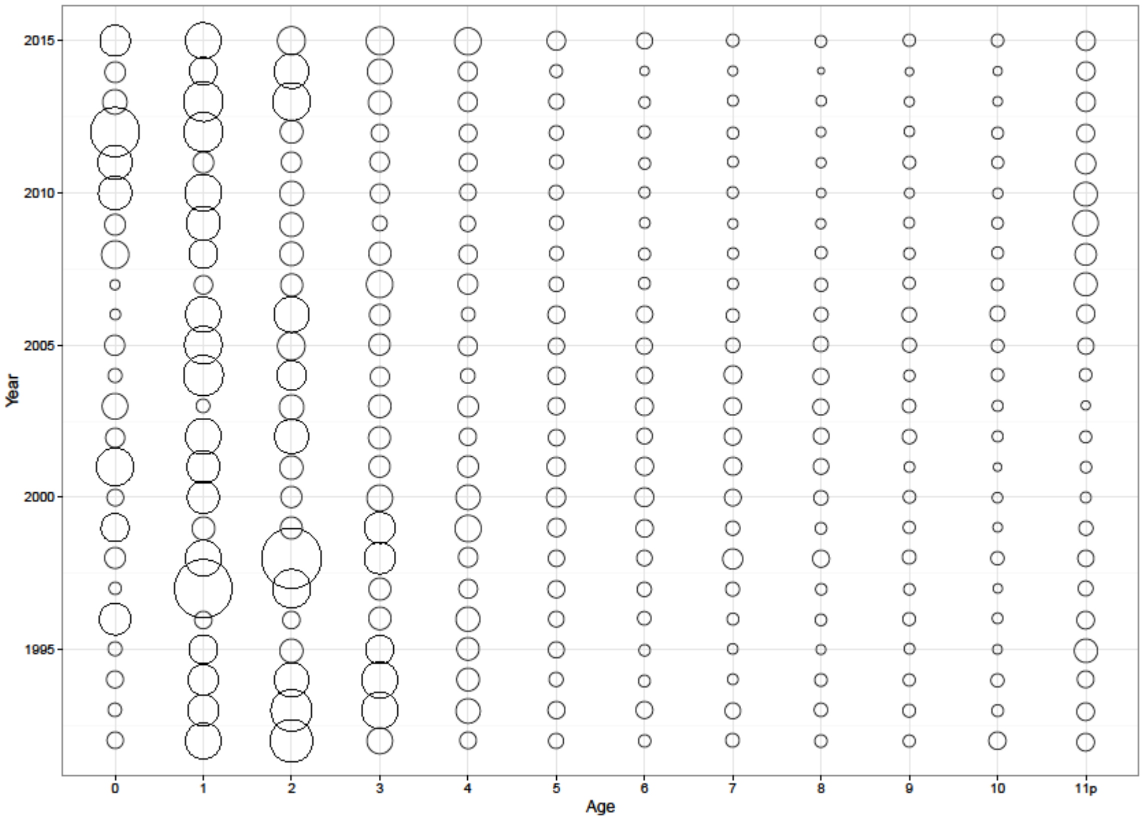


Figure 8.2.4.1. Southern horse mackerel. Bubble plot of proportions of the catch in numbers at-age by year.

To know more in depth the exploitation history of the southern horse mackerel a series of catch in numbers at-age by fishing fleet is provided (Table 8.2.4.2, Figure 8.2.4.2). Three fishing fleets are considered defined by the gear type (bottom trawl, purse-seine and artisanal) and country (Portugal and Spain). The time-series starts in 1992 although it is expected to be extended back in time in the future.

Table 8.2.4.2. Southern horse mackerel. Catch in number by gear.

Bottom trawl												
	AGES											
YEAR	0	1	2	3	4	5	6	7	8	9	10	11+
1992	98	8739	40094	78016	28660	10904	10401	8174	5166	3923	3319	9412
1993	3413	16252	37679	55079	16322	3926	2138	1559	2530	2200	2207	5223
1994	3917	12983	18292	22807	11447	5375	2541	2280	2299	2739	2138	25610
1995	30763	10340	10123	19245	23331	6326	4524	3063	2772	3245	2211	8611
1996	2828	180543	68330	15055	7846	4536	2087	1216	811	801	608	4360
1997	4444	36544	205609	32994	7151	3427	2487	3562	3100	2418	2724	7225
1998	28176	11492	16059	23745	8653	2914	3643	2570	1650	1932	1614	5525
1999	1106	35946	13685	18085	10763	7890	9180	7657	5546	4146	2544	2516
2000	39871	25245	10861	9401	8291	6329	8686	10261	7644	2630	1556	2606
2001	3572	59041	49402	12288	4796	4461	5100	7280	6068	5197	2671	3156
2002	14581	2077	18079	12556	13025	7525	7410	6940	6045	3966	2255	1526
2003	1352	77529	44171	12649	4758	9114	7787	9616	6875	2366	3823	3958
2004	2956	50643	30389	15100	12246	6636	6997	6190	7047	5546	3710	6705
2005	1666	59477	61175	14915	3798	9822	9492	3762	3871	4302	4908	9981
2006	19	2444	14853	31470	10967	2932	1983	1461	2681	2644	3135	21375
2007	5512	12787	21078	21828	10408	2984	1695	1166	1918	1678	2373	16881
2008	4552	19630	14558	5033	4758	4463	1581	1070	1183	1830	2579	27993
2009	10832	46074	15193	11434	6888	3661	1723	1728	1417	1531	1897	25218
2010	5984	3440	9440	9357	6696	2999	1871	1655	1426	3414	2876	16256
2011	7674	20041	14102	4899	4089	1915	2101	1356	987	1094	1799	7586
2012	6928	23225	29279	11222	3625	1573	903	1283	1357	1233	1170	11420
2013	7734	14850	18232	8434	5210	2040	987	1207	888	1072	1726	13972
2014	7845	18476	19923	11544	12206	5060	3228	2033	2411	3671	4417	13825
2015	4707	43326	72194	19569	7265	6349	3562	4339	3125	2623	7008	6134

Table 8.2.4.2. (cont.) Southern horse mackerel. Catch in number by gear.

PURSE-SEINE												
	AGES											
YEAR	0	1	2	3	4	5	6	7	8	9	10	11+
1992	6977	51859	73537	21162	4860	2677	1362	1973	1299	1204	2572	2402
1993	6293	51337	83236	16597	4355	795	512	819	544	862	667	1842
1994	7634	45429	45987	39236	11267	2838	1379	1036	1640	1691	2550	3530
1995	3311	42111	12457	27030	14822	4224	854	445	163	362	217	2247
1996	38888	3446	3801	8189	8955	2917	1621	1107	1022	2003	891	4301
1997	2211	114184	42908	9797	6407	5775	4380	5300	2707	2831	1539	3672
1998	18294	59225	112386	34393	9893	6028	5838	15381	8920	3621	2760	2041
1999	23481	18237	9440	41032	31471	10684	7777	3835	2092	2465	764	1328
2000	11068	35861	8832	22508	23779	9645	5890	2291	876	338	172	231
2001	65468	51105	20260	14164	14394	9020	5035	3008	1170	290	227	644
2002	13660	32185	34516	13604	7895	6041	3804	3510	2435	1141	359	116
2003	22915	4609	17093	15338	7464	3944	5188	3784	2554	1447	675	260
2004	5258	42114	12332	5137	2673	3042	2600	2603	958	489	980	929
2005	17856	56690	18512	8881	5272	3365	2539	799	904	848	600	1026
2006	1637	27295	29845	7133	2103	2210	1506	1225	1638	1804	2037	1514
2007	2863	13802	12416	11231	8019	3800	1912	1712	2799	1667	1323	4186
2008	42868	41050	9766	4672	3729	2223	2138	1918	2063	1877	1707	3544
2009	18016	65130	17157	2736	3551	2078	1139	1206	1041	1168	1136	3200
2010	70206	41433	11571	2766	2058	1531	1038	904	446	377	561	1598
2011	76225	18619	10553	7915	5197	1941	1480	719	315	707	723	1881
2012	193478	96833	12558	5530	7261	3945	1375	1991	1106	1282	1279	1268
2013	28908	98794	77552	17612	12427	7287	2665	1692	1196	1033	730	2644
2014	14794	35667	68564	27850	12383	3078	1272	1316	712	699	384	540
2015	56896	73247	28072	34914	28163	10304	6699	2790	1444	860	524	1110

Table 8.2.4.2. (cont.) Southern horse mackerel. Catch in number by gear.

ARTISANAL												
	AGES											
YEAR	0	1	2	3	4	5	6	7	8	9	10	11+
1992	0	0	1	5	45	76	93	553	731	935	4393	5818
1993	89	6135	13760	5902	2402	1668	2025	1501	886	766	511	3187
1994	1666	1549	3052	1939	1171	863	882	839	1039	943	1290	3511
1995	2	286	516	2193	1929	1410	608	415	258	252	175	3485
1996	0	11	97	692	1651	618	465	331	370	255	205	1330
1997	17	602	972	1384	2915	2575	1313	653	420	235	278	814
1998	180	181	2726	1051	1726	1861	1387	1684	740	647	728	2056
1999	2	67	731	1927	2836	2102	2420	1151	433	394	98	564
2000	73	1129	1030	1024	1425	1108	2184	2171	1494	743	408	810
2001	420	1014	140	539	1036	1445	1671	1695	981	390	240	739
2002	1212	3176	461	591	471	895	1358	1711	1653	1187	578	1161
2003	2537	144	1581	665	1442	1320	2152	2858	2032	1079	601	547
2004	491	7154	1552	457	897	1429	1449	2659	2709	1021	455	431
2005	203	738	295	308	359	1332	1643	938	1174	1051	1193	3689
2006	26	5790	1875	617	837	1144	894	1041	1793	1964	2002	3826
2007	3	173	398	1656	1548	1456	563	390	496	438	486	4440
2008	0	330	1108	1557	2479	1987	948	576	599	420	456	4564
2009	49	654	701	713	1465	621	569	585	567	581	521	7903
2010	10	14509	7141	3295	3033	2378	1087	1309	589	763	519	5469
2011	3764	1226	992	1810	3153	2258	920	1137	1144	1126	1039	3156
2012	539	2263	3401	3535	3197	1833	1846	1026	637	843	1295	5708
2013	14	1477	2726	1677	1416	810	516	625	570	497	588	3800
2014	0	73	178	221	350	275	155	195	164	208	242	1399
2015	103	2468	2215	3186	4380	1564	773	404	449	378	424	3072

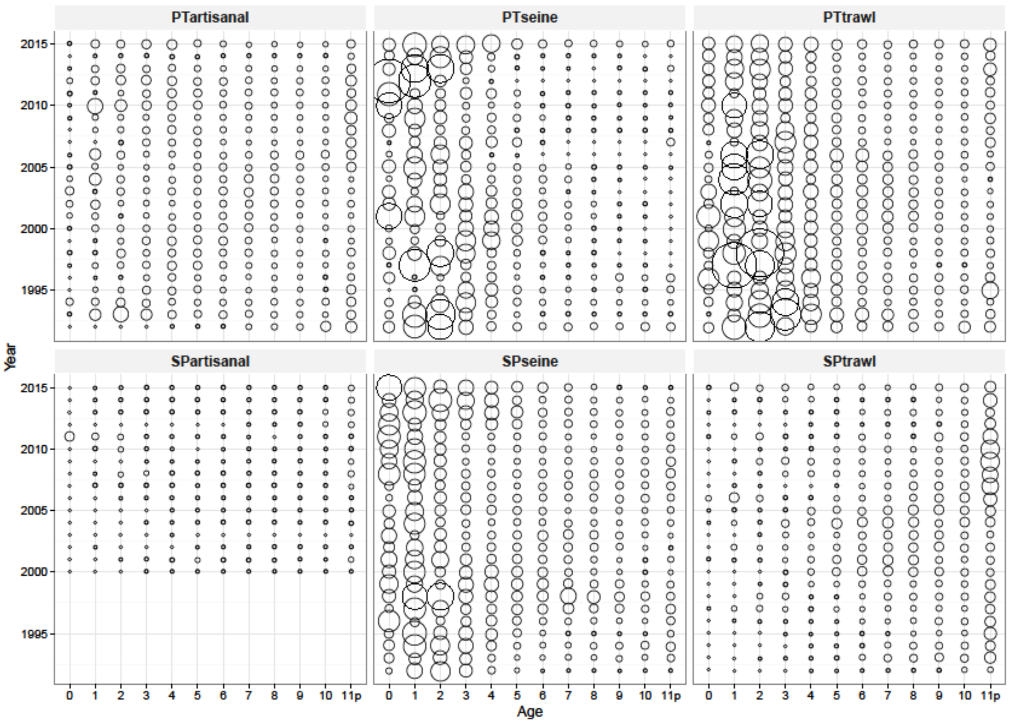


Figure 8.2.4.2. Southern horse mackerel. Bubble plot of proportions of the catch in numbers at-age by year, gear and country.

The following fleets: Portuguese bottom-trawl fleet, Portuguese purse-seine fleet and Spanish purse-seine fleet show a similar exploitation pattern with a great presence of juveniles and lower abundance of adults. On the other hand the Portuguese artisanal fleet and the Spanish bottom-trawl fleet show the opposite: a significant presence of adults and low presence of juveniles. The catch of Spanish artisanal fishery is negligible.

8.2.5 Mean weight-at-age in the catch

Detailed information on the way to calculate mean weight and mean length-at-age values is included in the Stock Annex.

Tables 8.2.5.1 and 8.2.5.2 show the mean weight-at-age in the catch, and the mean length-at-age in catch respectively from 1992 to 2015. Weight-at-age for 2014 was estimated as the arithmetic mean of the three previous years (Table 8.2.5.3).

Table 8.2.5.1. Southern horse mackerel. Mean weight (kg) at-age in the catch.

	AGES											
YEAR	0	1	2	3	4	5	6	7	8	9	10	11+
1992	0.03	0.03	0.04	0.07	0.1	0.13	0.15	0.17	0.19	0.2	0.23	0.3
1993	0.02	0.03	0.04	0.07	0.09	0.13	0.17	0.21	0.24	0.24	0.25	0.3
1994	0.04	0.04	0.06	0.07	0.09	0.13	0.16	0.19	0.23	0.25	0.27	0.34
1995	0.04	0.03	0.06	0.08	0.1	0.12	0.16	0.17	0.2	0.22	0.23	0.31
1996	0.02	0.05	0.07	0.09	0.11	0.14	0.17	0.19	0.22	0.24	0.26	0.31
1997	0.03	0.03	0.05	0.07	0.11	0.14	0.17	0.2	0.24	0.26	0.26	0.36
1998	0.03	0.03	0.04	0.07	0.1	0.13	0.17	0.21	0.17	0.24	0.25	0.35
1999	0.02	0.04	0.06	0.08	0.11	0.14	0.16	0.19	0.22	0.25	0.27	0.36
2000	0.02	0.03	0.05	0.09	0.11	0.13	0.16	0.19	0.22	0.24	0.25	0.31
2001	0.02	0.03	0.07	0.08	0.09	0.13	0.16	0.18	0.2	0.23	0.24	0.31
2002	0.03	0.03	0.04	0.07	0.1	0.12	0.15	0.17	0.2	0.23	0.25	0.31
2003	0.02	0.03	0.05	0.06	0.09	0.12	0.15	0.18	0.2	0.23	0.25	0.31
2004	0.04	0.03	0.05	0.08	0.12	0.16	0.18	0.21	0.23	0.25	0.27	0.33
2005	0.02	0.03	0.04	0.07	0.12	0.15	0.17	0.18	0.22	0.24	0.25	0.3
2006	0.03	0.03	0.05	0.06	0.09	0.13	0.14	0.17	0.19	0.23	0.25	0.33
2007	0.03	0.05	0.06	0.07	0.09	0.11	0.16	0.19	0.23	0.22	0.24	0.3
2008	0.02	0.05	0.06	0.08	0.1	0.13	0.15	0.17	0.2	0.21	0.23	0.32
2009	0.02	0.03	0.06	0.09	0.11	0.13	0.15	0.17	0.18	0.21	0.24	0.36
2010	0.02	0.04	0.06	0.08	0.11	0.14	0.16	0.18	0.19	0.2	0.24	0.38
2011	0.03	0.06	0.07	0.08	0.11	0.13	0.17	0.18	0.19	0.22	0.26	0.35
2012	0.02	0.03	0.07	0.10	0.13	0.16	0.18	0.19	0.21	0.24	0.28	0.37
2013	0.05	0.04	0.05	0.09	0.13	0.16	0.18	0.20	0.21	0.23	0.26	0.33
2014	0.03	0.05	0.06	0.09	0.12	0.15	0.18	0.19	0.21	0.23	0.27	0.36
2015	0.03	0.04	0.06	0.09	0.11	0.14	0.17	0.19	0.21	0.24	0.26	0.35

Table 8.2.5.2. Southern horse mackerel. Mean length (cm) at-age in the catch.

YEAR\AGE	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1992	14.9	15.6	17.5	19.8	23.2	25.8	27.4	28.6	29.6	31.2	31.5	32.6	33.3	33.9	34.7	36.8
1993	14.0	15.5	17.4	18.9	21.3	28.2	29.6	31.1	31.7	31.7	32.1	32.5	34.1	34.7	35.8	37.2
1994	13.4	14.6	18.1	21.1	22.7	24.8	27.0	29.5	31.2	31.7	32.4	32.2	33.3	34.2	34.4	36.5
1995	16.0	15.4	19.9	21.8	23.1	24.5	28.6	26.5	30.1	30.9	31.6	32.6	33.9	34.0	35.2	36.9
1996	13.3	19.0	19.7	21.8	24.7	26.3	28.0	28.6	30.3	30.7	31.5	32.0	33.4	32.5	36.2	37.0
1997	13.4	15.8	18.9	20.7	24.3	26.3	27.6	29.5	31.2	32.4	31.9	33.1	34.6	34.8	35.4	38.5
1998	14.5	13.9	15.9	20.4	23.5	25.5	28.3	30.3	26.9	31.7	32.0	32.7	33.4	34.5	36.4	39.1
1999	13.4	16.4	19.0	22.3	24.5	26.2	27.5	29.0	30.3	31.7	32.7	33.3	33.9	34.7	37.3	39.6
2000	13.6	16.4	18.4	21.7	24.8	26.0	27.2	28.6	30.2	30.8	31.5	32.3	32.7	34.2	34.5	35.0
2001	14.1	15.6	20.2	21.9	22.5	25.4	27.4	28.7	29.6	30.9	31.2	33.0	32.8	34.0	34.7	38.2
2002	15.0	15.7	17.5	20.3	23.1	25.4	26.6	28.0	29.6	30.9	31.8	32.6	34.2	34.7	35.4	36.9
2003	13.0	15.7	18.8	20.7	23.1	26.1	26.7	29.2	30.0	31.2	32.0	32.9	33.6	33.9	38.9	35.3
2004	16.2	14.4	17.2	21.2	24.0	26.7	28.1	29.4	30.5	31.6	32.3	32.2	33.0	32.2	36.4	35.9
2005	12.5	13.9	16.6	20.1	23.5	25.9	27.1	28.1	30.0	31.1	31.6	32.8	32.6	33.5	32.6	37.2
2006	14.6	14.7	17.0	19.2	22.2	24.6	25.6	27.2	28.7	30.3	31.5	33.2	34.0	35.9	36.7	37.0
2007	14.6	17.5	18.5	20.0	22.1	23.6	26.9	28.7	30.6	30.3	30.9	31.8	33.4	32.2	34.5	35.7
2008	13.0	17.3	20.5	22.3	24.0	25.4	26.5	27.7	28.8	29.6	30.5	31.3	32.2	33.5	35.6	37.2
2009	13.0	17.3	20.5	22.3	24.0	25.4	26.5	27.7	28.8	29.6	30.5	31.3	32.2	33.5	35.6	37.2
2010	13.1	15.8	18.4	20.8	23.4	25.4	26.9	27.8	28.6	29.2	31.2	31.7	33.5	34.7	36.7	38.0
2011	15.1	18.4	19.5	21.3	23.3	25.2	27.4	28.1	28.6	30.2	32.0	33.3	34.2	35.0	36.5	39.0
2012	15.7	15.8	18.4	22.8	24.9	26.5	27.8	28.8	29.9	31.1	33.2	34.4	35.5	36.7	39.4	39.8
2013	16.8	16.8	17.9	21.4	24.6	26.2	27.5	28.3	29.1	29.7	31.0	32.5	34.7	35.7	37.9	36.3
2014	13.9	18.7	20.4	21.4	23.0	25.2	26.5	27.5	28.5	28.9	31.2	32.9	34.5	35.4	36.6	38.0
2015	15.6	15.9	18.3	21.6	23.0	25.4	27.4	27.8	28.7	30.3	31.4	31.6	33.9	34.3	36.2	38.4

The mean weight-at-age are of a similar magnitude to previous years in all ages (Figure 8.2.5.1) and the variations of mean length-at-age are of a similar scale along temporal series (Table 8.2.5.2).

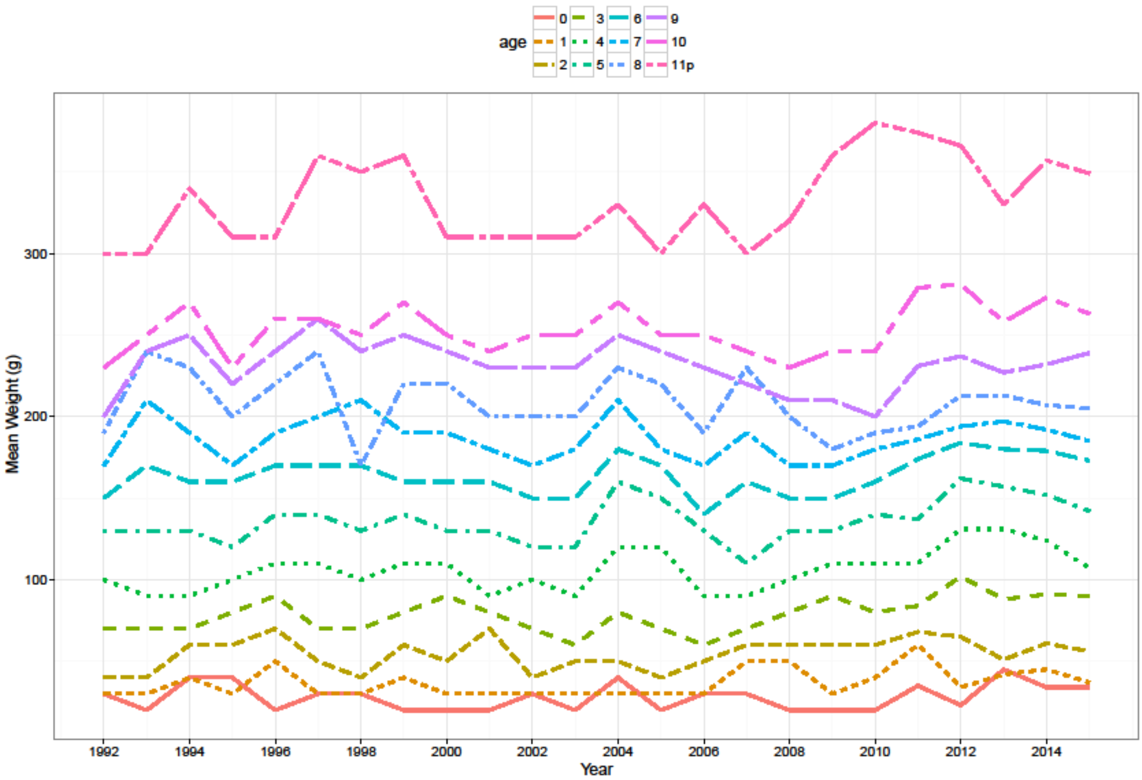


Figure 8.2.5.1. Southern horse mackerel. Time-series of mean weight-at-age in the catch (from age 1 to 11 plus).

8.3 Fishery-independent information

The stock assessment of southern horse mackerel is performed with a combined survey index of abundance-at-age (Section 8.3.1). Regarding the DEPM, work is in progress to improve the precision and accuracy of the egg production estimates and of SSB with focus on issues related with egg misidentification, egg distribution area, definition of the reproductive season and peak spawning period and the estimation of the spawning fraction.

8.3.1 Bottom-trawl surveys

The Spanish survey from Subdivision 9.a North and the Portuguese survey are treated as a single survey, although they are carried out with different vessels and slightly different bottom-trawl gears. Both survey indices are shown in Table 8.3.1.1. Thus, the raw data (number per hour and age in each haul, including zeros) of the two datasets were merged and treated as a single dataset in order to estimate a combined survey index. There was no Portuguese survey in 2012 and the combined survey index for 2012 is not estimated.

Table 8.3.1.1. Southern horse mackerel. Cpue-at-age from bottom-trawl surveys.

Portuguese October Survey

	AGES															
YEAR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1992	442.6	481.6	154.5	54.1	24.6	9.8	6.7	6.9	3.6	3.0	4.0	0.7	0.8	0.3	0.1	0.1
1993	1843.0	248.0	249.0	153.2	36.3	4.8	2.8	1.7	1.0	1.1	0.7	1.7	0.5	0.3	0.1	0.1
1994	3.5	8.8	61.0	55.8	23.2	5.7	2.6	1.8	0.9	0.5	0.3	0.1	0.0	0.0	0.0	0.0
1995	20.6	81.2	116.4	70.5	31.4	6.0	1.2	1.4	0.4	0.2	0.2	0.3	0.3	0.5	0.1	0.2
1996*	1451.9	10.2	16.6	26.8	27.0	5.1	2.1	0.8	0.3	0.2	0.1	0.1	0.1	0.1	0.0	0.0
1997	1148.9	81.0	133.8	39.9	64.9	37.6	7.6	6.0	2.4	2.7	1.0	0.1	0.0	0.1	0.1	0.1
1998	94.0	39.7	111.7	16.2	6.0	3.3	1.8	1.8	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0
1999*	132.3	28.1	52.9	62.3	5.2	1.8	0.9	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
2000	3.0	19.2	25.8	29.0	14.1	7.9	4.1	1.2	0.6	0.1	0.0	0.1	0.0	0.0	0.0	0.0
2001	726.8	1.2	4.7	3.7	5.1	7.3	8.8	14.0	7.6	2.5	1.4	0.4	0.2	0.2	0.0	0.0
2002[1]	41.6	2.6	8.9	14.6	11.6	6.0	1.9	1.3	0.9	0.5	1.0	0.3	0.2	0.1	0.1	0.0
2003*	75.2	9.5	9.6	18.5	16.5	4.7	2.6	1.6	1.0	0.6	0.2	0.0	0.0	0.0	0.0	0.0
2004	63.1	39.3	140.7	55.2	11.6	5.0	2.4	5.9	7.7	1.2	0.2	0.0	0.0	0.0	0.0	0.0
2005	379.1	1458.4	234.5	80.1	39.4	17.0	20.0	20.4	15.6	8.1	4.9	5.9	5.4	1.0	1.3	0.4
2006	92.0	94.1	250.5	62.4	3.7	12.0	8.6	7.1	2.9	1.6	0.7	0.2	0.0	0.0	0.0	0.0
2007	40.8	0.9	28.2	45.7	34.3	8.6	2.9	1.7	0.2	0.6	1.6	1.5	0.7	0.3	0.3	0.6
2008	51.7	26.7	41.1	23.7	30.4	21.1	2.9	1.0	1.4	2.0	1.4	1.0	0.5	0.9	0.6	2.0
2009	1725.2	81.5	121.2	44.4	36.0	10.0	2.7	1.5	1.2	0.7	0.6	0.5	0.9	1.9	0.5	0.9
2010	77.0	30.7	55.5	45.6	51.8	20.1	9.3	6.5	5.4	4.1	3.7	2.5	2.4	2.9	0.8	1.0
2011	89.1	35.7	34.5	56.8	53.7	13.2	5.8	8.2	4.0	5.1	5.7	2.1	1.8	1.8	1.0	0.9
2012	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2013	20.8	371.8	797.5	142.9	34.9	3.9	2.5	2.6	2.0	2.2	1.6	1.2	2.9	1.0	0.9	0.5
2014	81.3	64.7	36.5	105.1	37.7	6.7	1.9	1.6	1.0	1.2	2.2	2.8	3.3	2.7	1.0	0.6
2015	1126.9	214.7	151.6	77.8	66.0	6.4	2.9	1.2	1.0	1.0	0.8	0.5	0.4	0.4	0.3	0.4

Table 8.3.1.1. (cont.) Southern horse mackerel. Cpue-at-age from bottom-trawl surveys.

Spanish October Survey (only Subdivision 9.a North)

	AGES															
YEAR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1991	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	1.9	0.8	0.8	2.7	1.4	1.7	1.8
1992	6.6	0.0	0.0	0.0	0.1	0.0	0.0	0.2	0.2	0.3	3.4	1.6	1.9	1.1	0.3	2.2
1993	92.1	1.7	5.2	3.9	0.4	0.0	1.2	5.2	5.7	8.7	5.2	10.8	2.2	1.6	0.4	1.0
1994	0.1	0.0	0.5	0.0	0.0	0.0	0.0	0.2	0.6	1.4	2.6	0.2	16.1	12.8	1.3	6.4
1995	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.2	0.8	2.5	4.0	8.8	2.4	2.2
1996	33.6	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.9	2.7	0.6	0.4	1.8	2.6	1.0	4.4
1997**	2.0	0.0	0.0	0.0	0.0	0.1	0.2	1.0	1.2	1.7	0.8	0.2	0.3	0.8	1.1	2.6
1998	1.0	0.0	0.0	0.0	0.0	0.0	0.1	0.9	0.5	0.3	0.1	0.0	0.1	0.1	0.0	0.2
1999	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.3	0.6	2.2	3.2	2.6	4.7	1.9	1.6	0.3
2000	0.5	0.0	0.0	0.0	0.0	0.0	0.4	2.8	3.7	3.2	0.7	0.6	0.4	0.5	0.3	0.7
2001	12.7	2.9	0.0	0.0	0.0	0.2	0.4	2.5	4.4	4.1	3.2	1.8	1.0	0.9	0.1	0.3
2002	0.1	0.0	0.0	0.0	0.0	0.0	0.6	1.2	7.3	7.1	8.9	10.4	3.5	4.5	1.3	2.3
2003	8.8	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.1	0.8	0.9	0.3	0.2	0.1	0.1	0.9
2004	90.0	1.2	2.5	16.2	5.4	4.6	1.7	1.3	0.7	0.3	0.8	0.1	0.3	0.0	0.1	0.1
2005	3520.4	0.0	0.0	0.0	0.3	0.4	0.3	0.3	0.5	0.5	0.1	0.6	0.3	0.2	0.1	0.0
2006	28.4	0.1	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.1	0.2	0.2	0.3	0.2	0.0	0.2
2007	1.4	0.0	0.0	0.0	0.1	0.2	1.0	1.3	1.6	0.8	0.6	0.6	0.2	0.2	0.2	0.2
2008	18.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.4	0.4	0.3	0.1	0.0	0.1	0.4
2009	84.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.2	0.1	0.8	0.7	0.3
2010	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.6	0.5	0.8	1.3	1.1
2011	1.5	0.0	0.0	0.1	0.1	0.3	0.4	0.6	0.5	1.1	1.2	0.1	0.1	0.0	0.2	0.6
2012	12.9	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.2
2013	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
2014	39.4	7.9	55.5	52.3	17.3	2.9	1.5	1.7	1.4	1.2	0.8	6.52	-	-	-	-
2015	61.8	0.0	0.8	17.3	26.0	10.3	1.0	2.6	0.5	0.9	2.3	0.5	0.8	0.0	1.1	2.0

*** The surveys were carried out with a different vessel.**

**** Since 1997 another stratification design was applied in the Spanish surveys.**

[1] In 2002 started a new series in which the duration of the trawling per haul has changed from one hour to thirty minutes.

[2] 11 plus age.

Table 8.3.1.2. Time-series of cpue-at-age from Portuguese and Spanish combined bottom trawl.

	AGES											
YEAR	0	1	2	3	4	5	6	7	8	9	10	11+
1992	329.79	355.18	113.94	39.86	18.21	7.25	4.93	5.20	2.74	2.34	4.70	5.06
1993	1451.66	190.40	192.85	119.01	27.93	3.66	2.63	3.64	3.35	4.84	2.92	9.37
1994	2.92	7.18	49.83	45.48	18.92	4.68	2.11	1.47	0.88	0.91	1.18	13.04
1995	16.63	65.59	93.98	56.92	25.36	4.81	0.99	1.15	0.47	0.21	0.44	8.78
1996	1144.22	7.93	12.93	20.89	20.99	3.97	1.73	0.81	0.59	1.29	0.29	4.72
1997	844.43	59.50	98.27	29.34	47.67	27.65	5.73	4.98	2.40	2.92	1.17	3.49
1998	77.56	32.60	91.65	13.25	4.92	2.74	1.53	1.77	0.40	0.13	0.07	0.20
1999	104.55	22.21	41.75	49.25	4.13	1.42	0.82	0.32	0.34	0.99	1.15	3.66
2000	2.53	15.43	20.76	23.35	11.36	6.34	3.40	2.01	1.86	1.28	0.30	1.04
2001	545.08	1.90	3.51	2.73	3.79	5.49	6.71	11.50	7.63	3.66	2.41	2.61
2002	32.48	2.04	6.89	11.33	9.00	4.62	1.76	1.59	3.96	3.51	4.56	9.90
2003	62.51	7.54	7.57	14.64	13.03	3.73	2.06	1.30	0.85	0.74	0.48	0.66
2004	82.36	31.80	113.13	49.81	11.13	5.62	2.48	5.19	6.39	1.08	0.47	0.23
2005	1438.11	1189.30	189.50	64.68	31.95	13.92	16.24	16.54	12.74	6.70	4.02	11.63
2006	84.24	76.65	206.84	52.26	3.88	12.03	8.51	7.29	2.58	1.42	0.66	0.49
2007	34.22	0.72	23.33	37.78	28.41	7.16	2.69	1.78	0.64	0.71	1.55	3.26
2008	48.48	21.65	33.42	19.24	24.72	17.09	2.40	0.80	1.24	1.74	1.24	4.36
2009	1436.41	66.51	98.82	36.24	29.39	8.12	2.20	1.26	0.93	0.58	0.55	4.57
2010	64.94	31.91	33.91	34.16	47.54	14.94	4.81	6.39	4.12	3.95	1.57	11.06
2011	120.96	33.85	22.38	16.19	6.85	1.65	0.52	0.69	0.45	0.85	1.01	1.53
2012	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2013	16.99	300.70	644.92	115.58	28.20	3.16	2.04	2.07	1.64	1.78	1.27	5.31
2014	72.33	52.59	40.57	93.85	33.31	5.91	1.83	1.62	1.05	1.23	1.89	9.55
2015	910.12	171.02	120.89	65.48	57.88	7.20	2.56	1.46	0.88	0.96	1.06	2.43

The abundance data by age and year do not follow a Normal distribution, having a big proportion of zeros and a few extreme values. This is explained by the patchiness in the distribution of horse mackerel and by its characteristic of forming large shoals. Therefore, it is questionable whether a simple average of the number-per-hour, by age and year, is an adequate abundance index for tuning the stock assessment. Methods and approaches to derive a combined survey index will be further explored during the next benchmark of this stock.

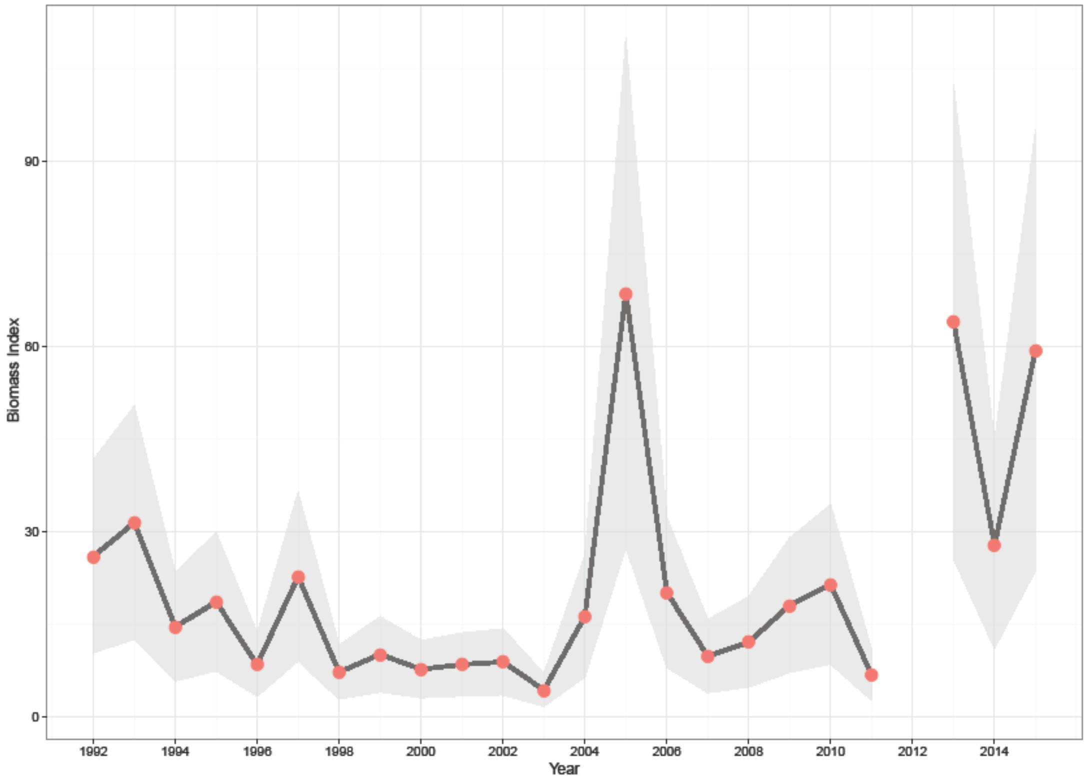


Figure 8.3.1.1. Southern horse mackerel. Historical series of biomass index estimates from the combined bottom-trawl survey (combined Spanish and Portuguese surveys).

Table 8.3.1.2 and Figure 8.3.1.1 show the combined survey index (mean number per hour, by age and year) used in the assessment. There are two very clear features in this dataset: a strong variability of age 0 and strong year effects (some years with higher abundance of all ages than others). The first feature may be explained by the greater aggregation tendency of these small fish in dense shoals and by their typically pelagic behaviour which makes them less available to the bottom trawl. The apparent year effects in the data are more difficult to explain, and are likely due to natural variations in the availability of the fish in that time of the year and small variations in sampling effort (e.g. due to bad weather). At present, age 0 is not used in the assessment.

8.3.2 Mean length and mean weight-at-age in the stock

Taking in consideration that the spawning season is very long, spawning is almost from September to June, and that the whole length range of the species has commercial interest in the Iberian Peninsula, with scarce discards, there is no special reason to consider that the mean weight-at-age in the catch is significantly different from the mean weight-at-age in the stock.

8.3.3 Maturity-at-age

Maturity ogive estimation procedures are detailed in Stock Annex. In WGANSA 2011, a working document was presented (Murta, Costa, and Gonçalves, 2011) showing the possible variation in SSB caused by poor coverage of the ages range when sampling for the maturity ogive. The group discussed this problem, and it has been decided to use a single maturity ogive for the whole assessment period, which is an average of all maturity ogives estimated in the past, with the values for each age weighted by the corresponding number of samples that were used to estimate it. The resulting maturity ogive is described below. It was also decided to only make drastic changes to the maturity ogive in the case that strong evidence arises, based on an appropriate number of samples, showing that the proportion of fish mature at-age has changed.

Age	0	1	2	3	4	5	6	7	8	9	10
Maturity	0	0	0.36	0.82	0.95	0.97	0.99	1.0	1.0	1.0	1.0

8.3.4 Natural mortality.

The procedure in estimation of natural mortality rate is detailed in Stock Annex. The natural mortality used in the assessment is:

Age	0	1	2	3	4	5	6	7	8	9	10
Nat Mort	0.9	0.6	0.4	0.3	0.2	0.15	0.15	0.15	0.15	0.15	0.15

8.3.5 Stock assessment

The stock assessment has been performed as agreed during the latest benchmark (ICES, 2011), with the settings and method as described in the Stock Annex. For further details see the Stock Annex and 2011 report (WGANSA 2011).

The assessment was tuned with the combined series from the Portuguese and Spanish bottom-trawl surveys. The stock assessment was performed with the survey series updated to 2015, though without tuning index for 2012 (in 2012 Portuguese survey was not carried out then the combined survey index for 2012 could not be estimated).

The survey data are especially noisy in the younger ages. This variability is partially due to natural causes and partly due to the low availability of very young fish to the fishing gear of the survey, because of a more pelagic behaviour (being the gear a bottom trawl) and a distribution closer to the shore, where it is frequently difficult to trawl. For this reason, the age 0 is excluded from the tuning data used in the assessment.

Strong year effects in the survey data are present as large fluctuations in overall abundance from year to year (e.g. Figure 8.5.1.1) but also in differences in the proportions-at-age from year to year (Figure 8.5.2.3). To account for these characteristics of the dataset, four selectivity vectors of parameters were estimated (Figure 8.5.1.2). For the catch proportions-at-age, two selectivity parameter vectors were estimated (Figure 8.5.1.2). In all selectivity vectors of parameters, ages above 8 were kept constant and with the same value estimated to age 8 (which was the reference age).

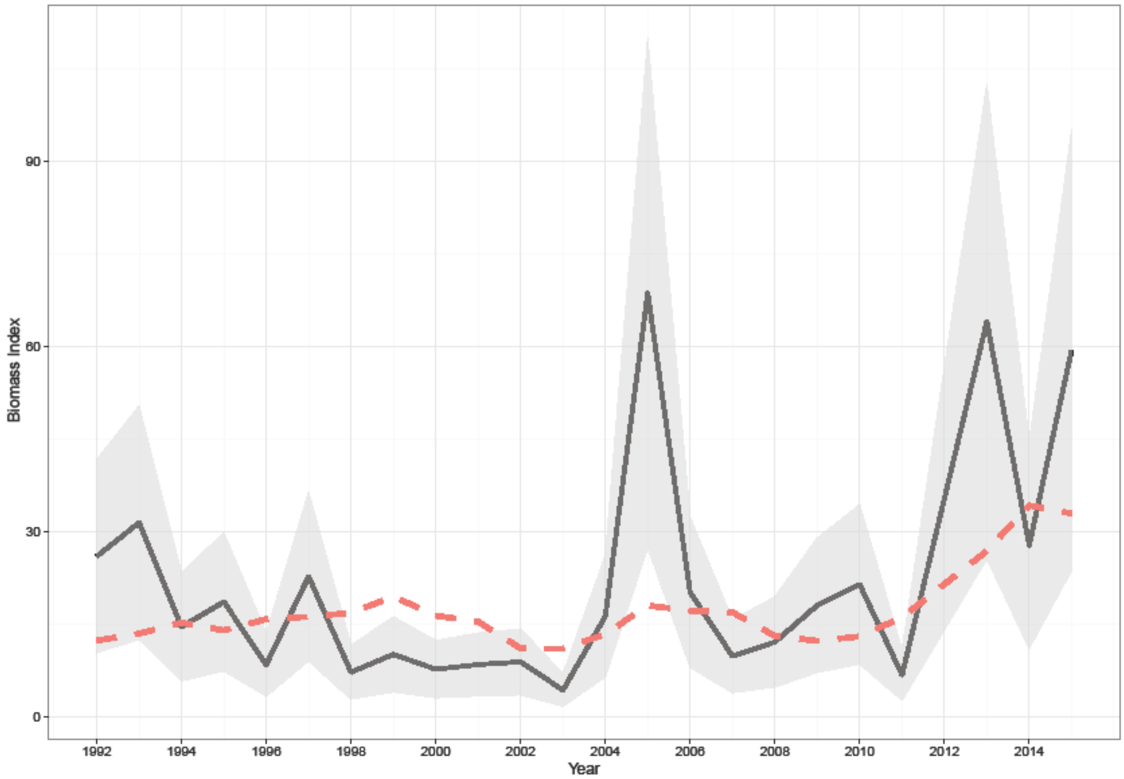


Figure 8.5.1.1. Southern horse mackerel. Historical series of biomass index estimates from the combined bottom-trawl survey (solid black line) and by the assessment model (dashed red line).

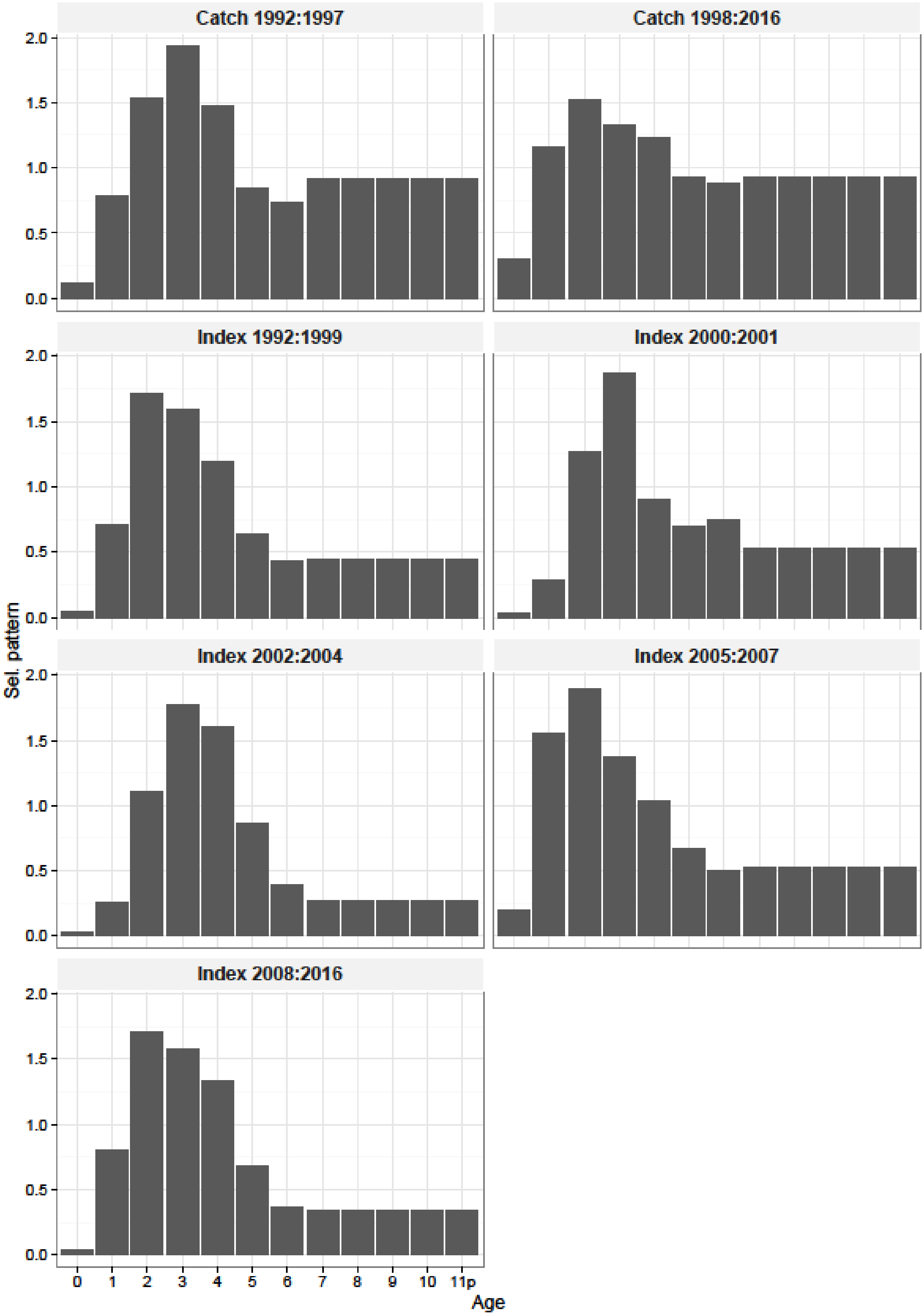


Figure 8.5.1.2. Southern horse mackerel. Selectivity patterns of catch data (1992–1997; 1998–2016) and selectivity patterns of survey index (1992–1999; 2000–2001; 2002–2004; 2005–2007; 2008–2016). Proportions of catches-at-age by selectivity period.

The summarised results of the stock assessment are shown in Figure 8.5.1.4 and Table 8.5.1.1. The estimated SSB shows a significant increase since 2012 to above the long-term average, though with wide confidence intervals (in the range 25–36%). The fishing mortality shows a significant decrease in 2011 but in recent years fishing mortality has been stable at low levels. The stock shows relatively stable recruitment with sporadic events of strong recruitments (1996, 2011 and 2012). Recruitment estimation in 2015 (8852 million) is above the long-term average but with wide confidence intervals (coefficient of variance of 40%). Figure 8.5.1.5 shows the scatterplot of the estimated spawning–stock biomass (SSB) and recruitment series.

Table 8.5.1.1. Southern horse mackerel. Final assessment. Stock summary table.

Year	Recruits (10*6)	SD Rec	SSB(ton)	SD SSB	mean F(2-10)	SD mean F (2-10)	Landings
1992	4242	847	274236	66782	0.0925024	0.0193780	27858
1993	3046	642	293962	74022	0.0983024	0.0217180	31521
1994	3033	649	313515	82593	0.0801241	0.0183700	28441
1995	4096	860	300437	82213	0.0762947	0.0178170	25147
1996	10850	2081	321255	90776	0.0551706	0.0129100	20400
1997	3662	766	338410	95871	0.0762639	0.0178960	29491
1998	2322	519	343720	96134	0.1018493	0.0259140	41564
1999	3563	767	393136	113056	0.0627776	0.0164010	27733
2000	3280	728	382014	112806	0.0636052	0.0168070	26160
2001	3984	885	367265	111103	0.0624419	0.0166830	24910
2002	2237	540	356018	109569	0.0604920	0.0163380	22506
2003	4442	1005	358238	111976	0.0502495	0.0133750	18887
2004	4796	1089	410088	129281	0.0543409	0.0145490	23252
2005	2954	709	377794	120262	0.0555434	0.0151120	22695
2006	1498	399	366936	117052	0.0615284	0.0171540	23902
2007	2271	586	372443	120850	0.0585998	0.0165580	22790
2008	3679	944	367049	121979	0.0603340	0.0174280	22993
2009	3279	892	366739	125131	0.0684372	0.0204350	25737
2010	4230	1191	368264	128931	0.0681947	0.0208980	26556
2011	11211	3087	371066	132928	0.0429916	0.0132590	21875
2012	13683	3880	394300	141126	0.0433092	0.0133850	24868
2013	5741	1829	404559	141477	0.0420456	0.0130960	28993
2014	6691	2297	520590	176697	0.0381822	0.0120610	29017
2015*	4060		572955	193925	0.0438036	0.0140770	32723

(*)Recruitment :Geometric mean 1992–2014.

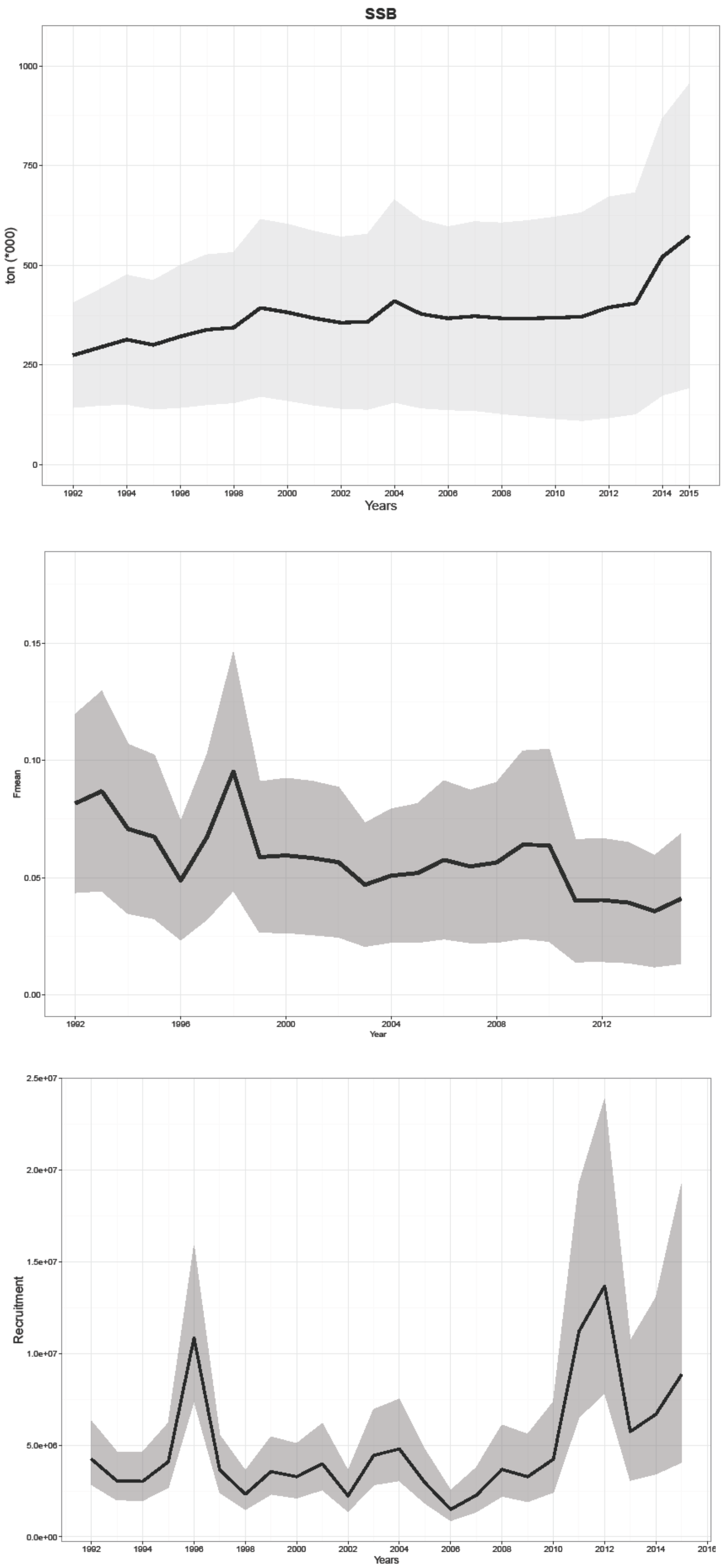


Figure 8.5.1.4. Southern horse mackerel. Final assessment. Stock summary. Plots of SSB, Recruitment and Fishing mortality (F mean 2–10) with 95% confidence intervals included for R, F, and SSB (grey). SSB are in thousand tonnes and recruitment in billions (10^9). (CVs of SSB in the range 25–36%).

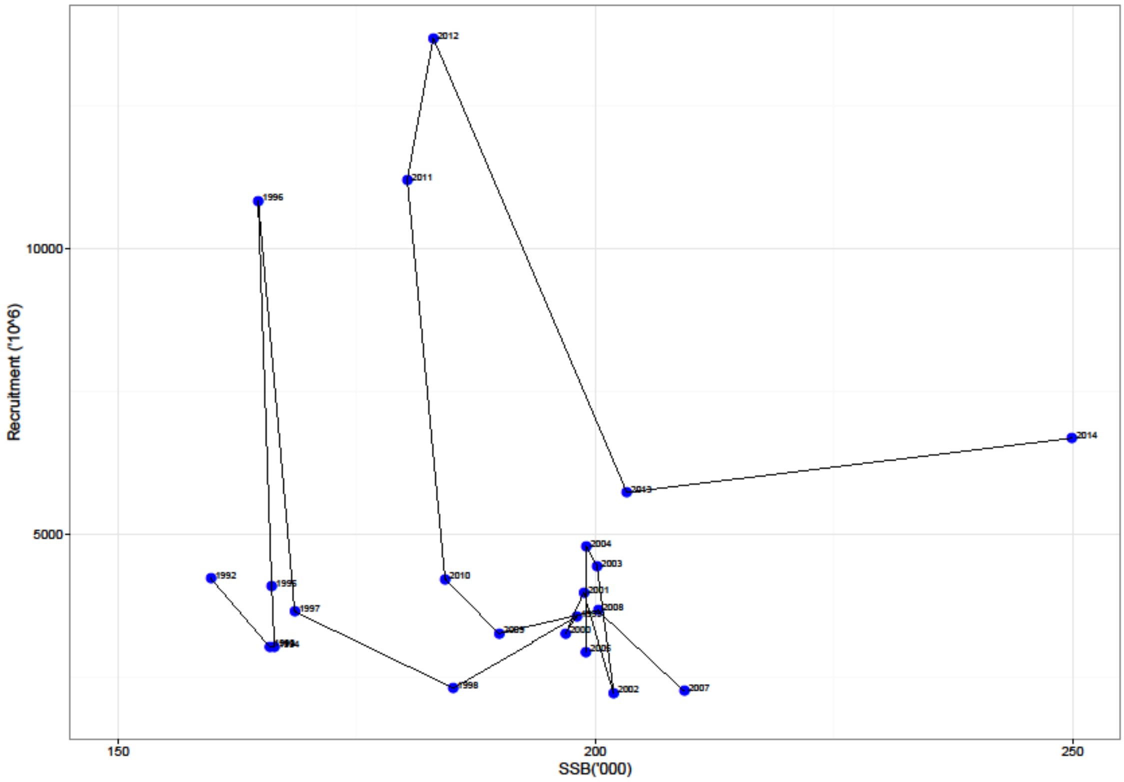


Figure 8.5.1.5. Stock–recruitment relationship for southern horse mackerel.

8.3.6 Reliability of the assessment

The landings of this stock are believed to be fairly accurate, given the good sampling coverage, few discards (according to on-board observers) and the existence of well-defined ageing criteria. Therefore, a higher weight was given to the dataseries of landings in weight, which was very well fitted by the model (Figure 8.5.2.1).

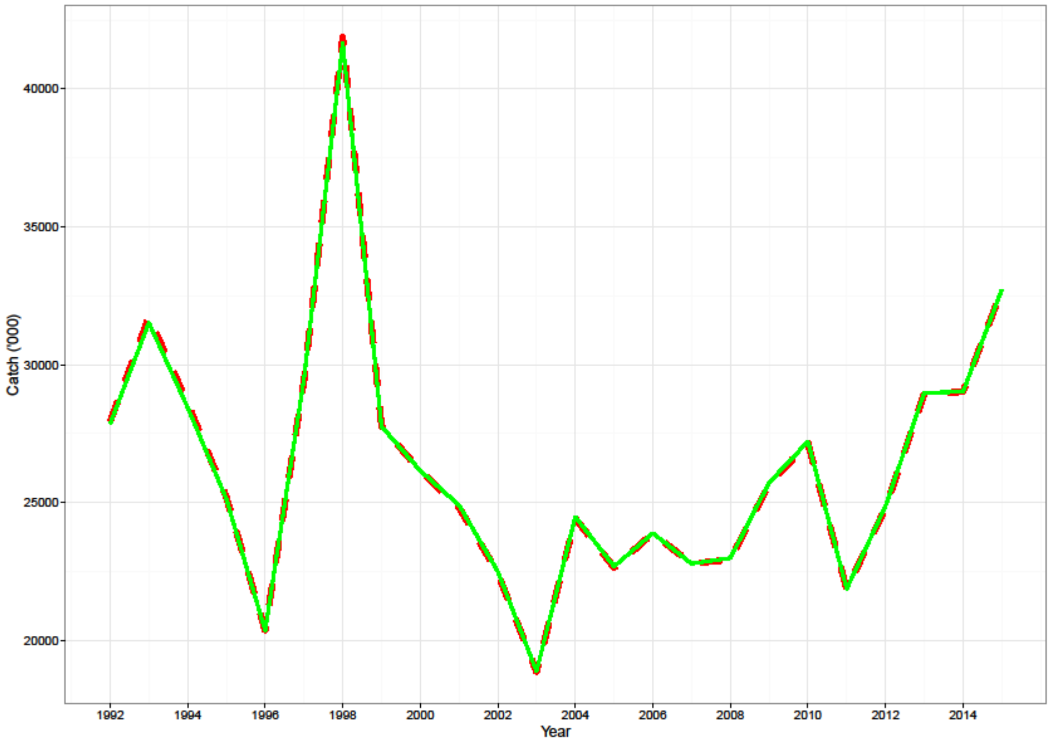


Figure 8.5.2.1. Southern horse mackerel. Fitting of historical series of stock landings (solid green line) and estimated landings by the assessment model (dashed red line).

A good fit was also obtained for the proportions-at-age of the catch in numbers (Figure 8.5.2.2) as well as for the abundance indices in number/hour from the bottom-trawl surveys (Figure 8.5.2.3). The bubble plots of the residuals corresponding to the fitting of those data are shown in Figures 8.5.2.4 and 8.5.2.5, respectively.

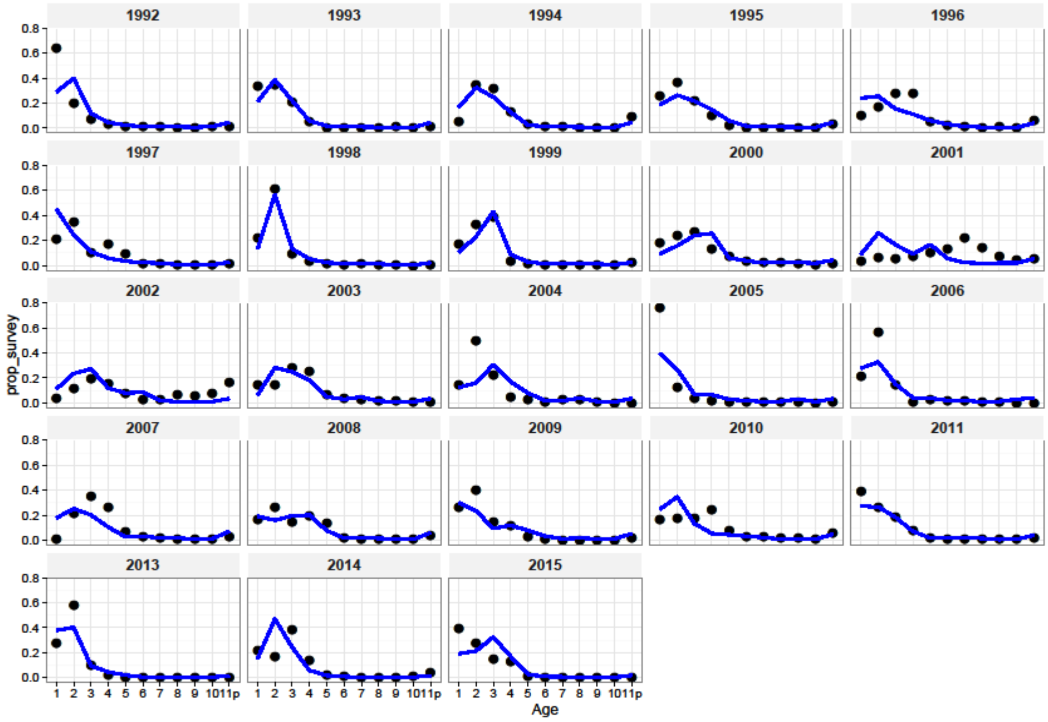


Figure 8.5.2.2. Southern horse mackerel. Comparison of proportions at-age of the abundance indices observed in catch data and those fitted by the AMISH model. Observed values =dots; fitted values = solid lines.

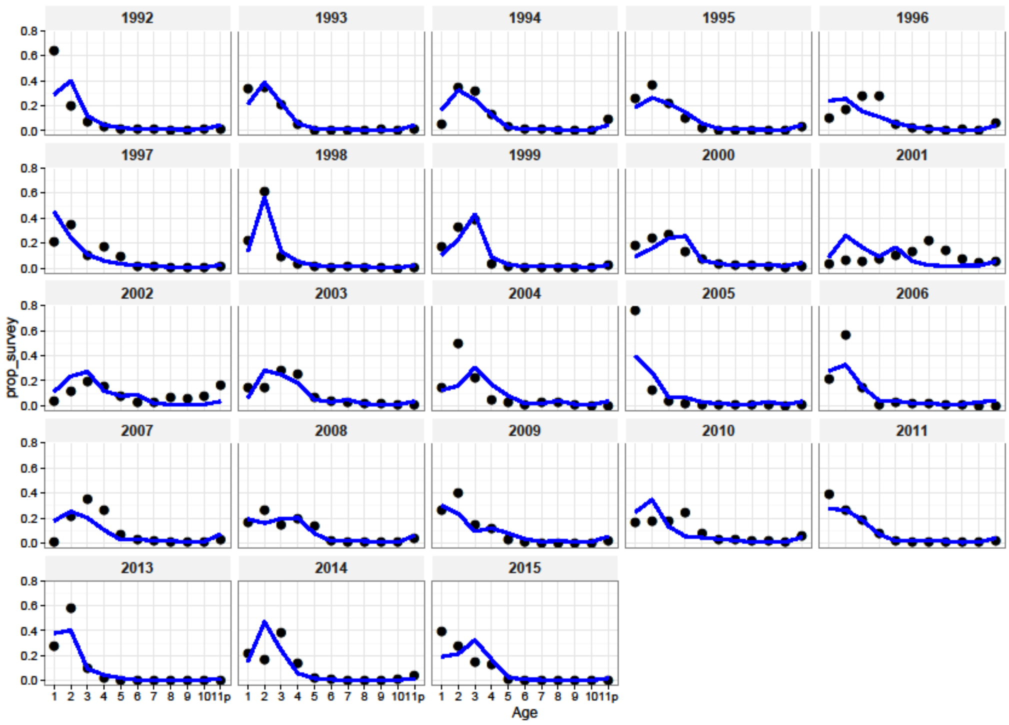


Figure 8.5.2.3. Southern horse mackerel. Comparison of proportions at-age of the abundance indices observed in survey data and those fitted by the AMISH model. Observed values =dots; fitted values = solid lines.

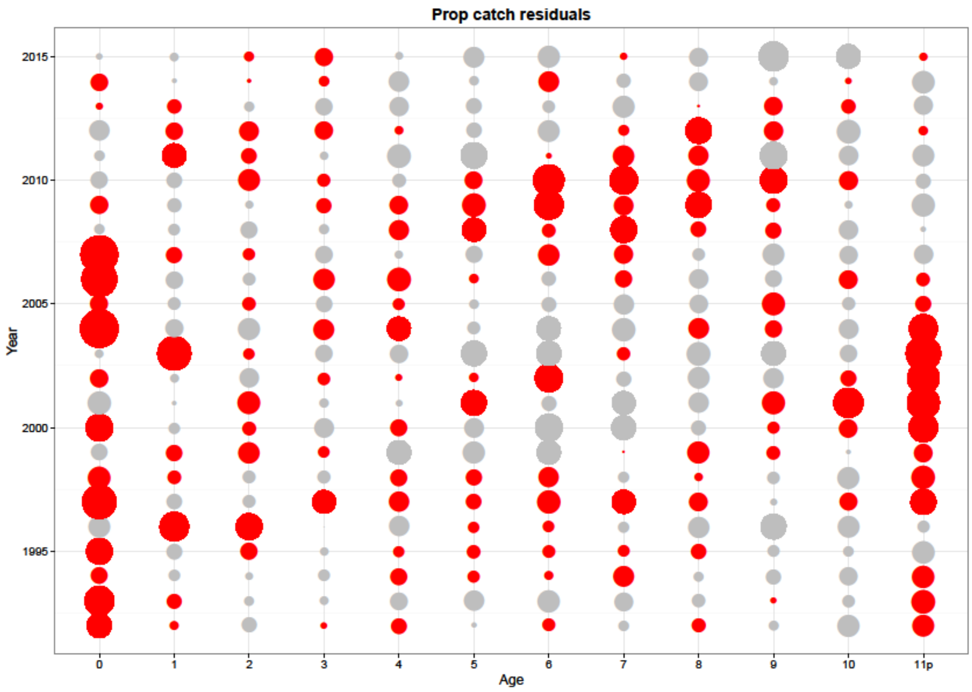


Figure 8.5.2.4. Southern horse mackerel. Bubble plot of catch data residuals from the AMISH assessment. (negative residuals – red bubbles).

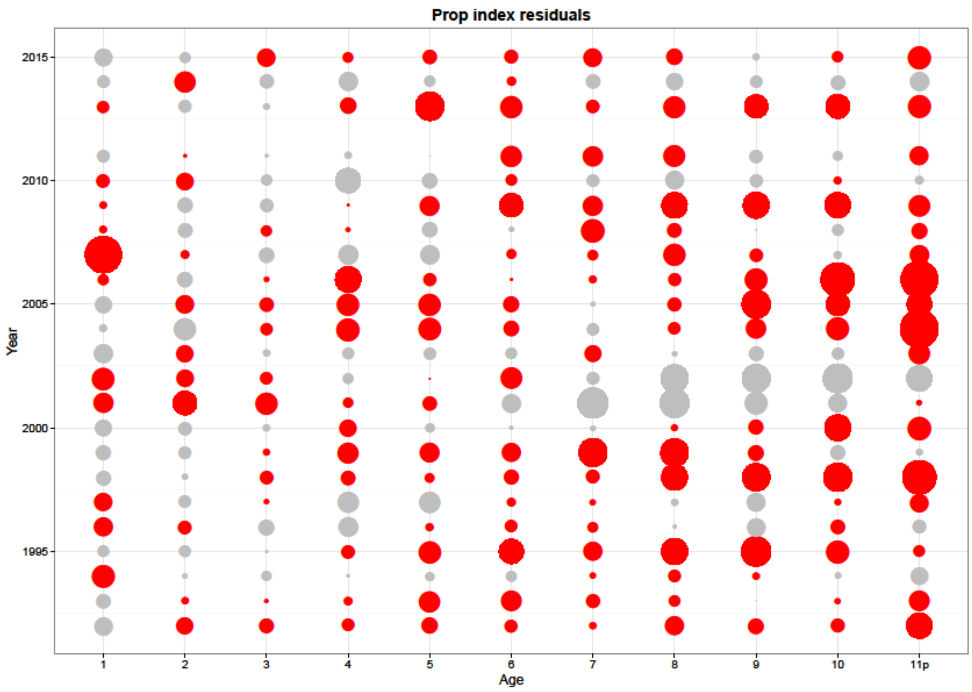


Figure 8.5.2.5. Southern horse mackerel. Bubble plot of bottom-trawl survey residuals from the AMISH assessment. (survey index not available for 2012; negative residuals – red bubbles).

The model downweighted the large total biomasses observed in the survey in 2005 and 2013 (Figure 8.5.1.1). The high survey biomass in 2005 is mainly due to a few sampling stations with very high catch rates, most likely due to fluctuations in availability rather than to natural causes.

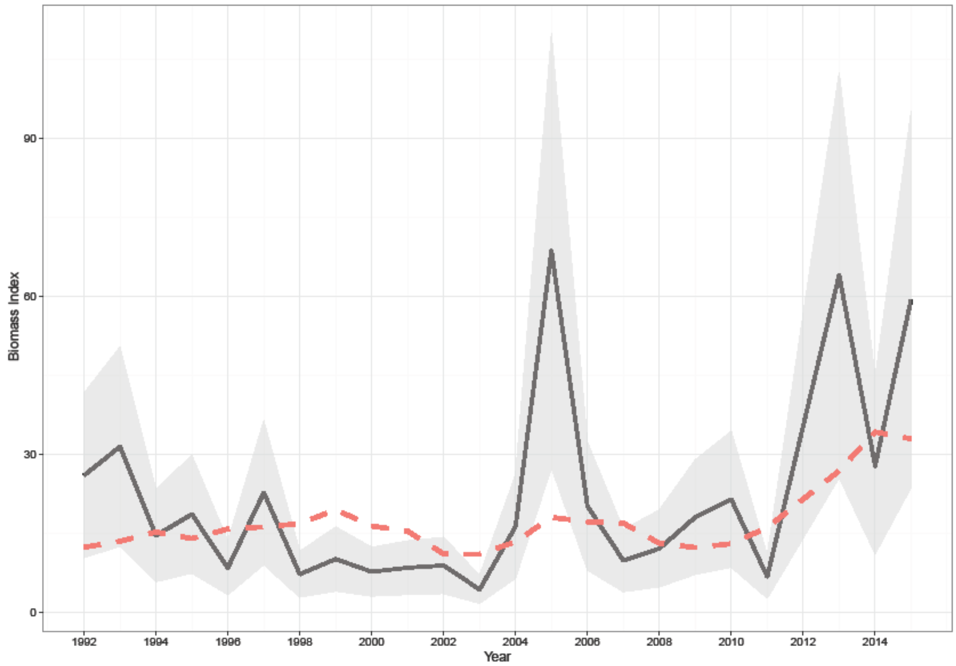


Figure 8.5.1.1. Southern horse mackerel. Historical series of biomass index estimates from the combined bottom-trawl survey (solid black line) and by the assessment model (dashed red line).

The significant increase in spawning biomass in 2014–2015 is reflecting the contribution of the survivors of the good year classes of 2011 and 2012 (proportion mature between 82% and 95%). The SSB confidence intervals (95%) are wide (mean coefficient of variance of 30%), indicating high uncertainty. The recent strong year classes of 2011 and 2012 are supported both by the survey index and the catch data (Figure 8.5.1.4). There is a significant decrease of F since 2010 and uncertainty (95% confidence intervals) of the estimated F remained at the same levels.

The retrospective analysis suggests an underestimation of SSB, an overestimation of F and changes in SSB and F compared to previous assessments (Figure 8.5.2.6). The retrospective pattern is mostly likely due to the addition of the strong recruitments in 2011 and 2012 and a change in the selection pattern to increased selectivity of young ages and decreased selectivity of older ages in recent years. This change is caused by the increase in the Portuguese bottom trawl, Portuguese purse-seine and Spanish purse-seine catches that target young ages and a decrease in the Spanish bottom trawl and in the Portuguese artisanal catches that target older ages in the last years. Since this year's assessment was an update, the selectivity vectors (stock annex) were not changed.

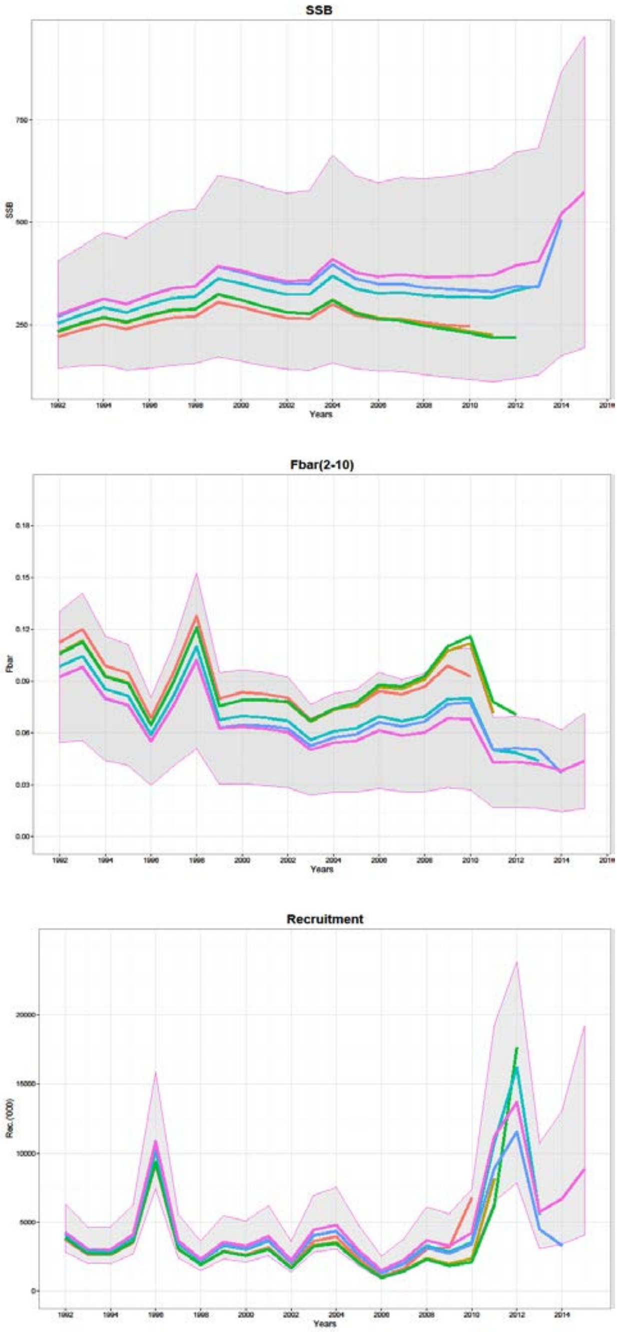


Figure 8.5.2.6. Southern horse mackerel. Retrospective analysis results. Trajectories of SSB, Recruitment and F (mean ages 2–10) are shown. (Grey: the 95% confidence intervals for 2016 assessment).

8.4 Short-term predictions

Deterministic short-term forecasts were made with the software MFDP, assuming a constant recruitment corresponding to the geometric mean recruitment of the period 1992–2015 (4.060 million fish). The weights-at-age in the stock and in the population, and the fishing mortality used for the forecasts were those of the last assessment year (Stock Annex). The abundance at-age 1 in 2016 are the survivors of the geometric mean recruitment assumed for 2015. The input data used for the forecasts are presented in Table 8.6.1.

Table 8.6.1. Southern horse mackerel. Input for short-term forecast (2016–2018).

2016								
Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	4060000	0.9	0	0.08	0.08	0.038	0.0121	0.038
1	1630998	0.6	0	0.08	0.08	0.041	0.0474	0.041
2	1408890	0.4	0.36	0.08	0.08	0.056	0.0624	0.056
3	765186	0.3	0.82	0.08	0.08	0.090	0.0542	0.090
4	1284155	0.2	0.95	0.08	0.08	0.121	0.0507	0.121
5	818994	0.15	0.97	0.08	0.08	0.150	0.0380	0.150
6	254378	0.15	0.99	0.08	0.08	0.177	0.0360	0.177
7	159197	0.15	1	0.08	0.08	0.191	0.0382	0.191
8	143028	0.15	1	0.08	0.08	0.208	0.0382	0.208
9	71614	0.15	1	0.08	0.08	0.233	0.0382	0.233
10	38506	0.15	1	0.08	0.08	0.265	0.0382	0.265
11+	434379	0.15	1	0.08	0.08	0.345	0.0382	0.345
2017								
Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	4060000	0.9	0	0.08	0.08	0.038	0.0121	0.038
1	.	0.6	0	0.08	0.08	0.041	0.0474	0.041
2	.	0.4	0.36	0.08	0.08	0.056	0.0624	0.056
3	.	0.3	0.82	0.08	0.08	0.090	0.0542	0.090
4	.	0.2	0.95	0.08	0.08	0.121	0.0507	0.121
5	.	0.15	0.97	0.08	0.08	0.150	0.0380	0.150
6	.	0.15	0.99	0.08	0.08	0.177	0.0360	0.177
7	.	0.15	1	0.08	0.08	0.191	0.0382	0.191
8	.	0.15	1	0.08	0.08	0.208	0.0382	0.208
9	.	0.15	1	0.08	0.08	0.233	0.0382	0.233
10	.	0.15	1	0.08	0.08	0.265	0.0382	0.265
11+	.	0.15	1	0.08	0.08	0.345	0.0382	0.345
2018								
Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	4060000	0.9	0	0.08	0.08	0.038	0.0121	0.038
1	.	0.6	0	0.08	0.08	0.041	0.0474	0.041
2	.	0.4	0.36	0.08	0.08	0.056	0.0624	0.056
3	.	0.3	0.82	0.08	0.08	0.090	0.0542	0.090
4	.	0.2	0.95	0.08	0.08	0.121	0.0507	0.121
5	.	0.15	0.97	0.08	0.08	0.150	0.0380	0.150
6	.	0.15	0.99	0.08	0.08	0.177	0.0360	0.177
7	.	0.15	1	0.08	0.08	0.191	0.0382	0.191
8	.	0.15	1	0.08	0.08	0.208	0.0382	0.208
9	.	0.15	1	0.08	0.08	0.233	0.0382	0.233
10	.	0.15	1	0.08	0.08	0.265	0.0382	0.265
11+	.	0.15	1	0.08	0.08	0.345	0.0382	0.345

Table 8.6.2 shows the management options table from the deterministic short-term forecasts. At current fishing mortality (F_{bar} of 0.044), SSB in 2016 is estimated to be 621 563 tonnes. Predicted SSB levels for 2018 are 648 084 tonnes, sustained by the good year classes of 2011 and 2012.

Table 8.6.2. Short-term forecast (2016–2018) for southern horse mackerel. SSB corresponds to both sexes combined at spawning time.

MFDP VERSION 1A

2016						
Biomass	SSB	FMult	FBar	Landings		
928153	621563	1	0.0438	31595		
2017					2018	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
929522	646156	0	0	0	957642	678351
.	645731	0.2	0.0088	6147	951173	672183
.	645306	0.4	0.0175	12243	944760	666073
.	644881	0.6	0.0263	18290	938403	660020
.	644457	0.8	0.035	24288	932101	654024
.	644033	1	0.0438	30237	925854	648084
.	643609	1.2	0.0526	36139	919661	642199
.	643186	1.4	0.0613	41992	913521	636371
.	642763	1.6	0.0701	47798	907435	630596
.	642340	1.8	0.0788	53557	901402	624876
.	641917	2	0.0876	59269	895421	619209
.	641495	2.2	0.0964	64935	889492	613596
.	641073	2.4	0.1051	70556	883614	608035
.	640862	2.5	0.1095	73349	880695	605274
.	639808	3	0.1314	87147	866284	591662
.	638757	3.5	0.1533	100668	852183	578366
.	637707	4	0.1752	113920	838385	565378
.	637078	4.3	0.1884	121743	830248	557731
.	636659	4.5	0.1971	126907	824881	552691
.	635612	5	0.219	139635	811667	540298
.	634568	5.5	0.2409	152111	798735	528192
.	633525	6	0.2628	164338	786079	516365
.	591278	27	1.1827	511128	437990	202226
.	586638	29.4	1.2878	535901	414289	181962
.	585484	30	1.3141	541761	408717	177230
.	566587	40	1.7521	622937	333168	114518
.	562146	42.4	1.86	638528	319082	103191

Input units are thousands and kg - output in tonnes.

The forecasts are deterministic; hence no estimate of uncertainty is calculated. Sources of uncertainty in the outcomes is the recruitment assumed for 2015, the assumptions on mean fishing mortality with a significant decreasing trend since 2010 and the likely changes in the fishery selection pattern in most recent years.

8.5 Reference points and harvest control rules for management purposes

Given the stability in the exploitation and dynamics of the southern horse mackerel during the assessment time period, and the lack of a well-defined stock–recruitment relationship, $F_{35\%SPR}$ was adopted as a proxy for F_{MSY} (Table 8.7.1).

Table 8.7.1. Summary table of current stock reference points.

LEVEL	VALUE	TECHNICAL BASIS
Current B_{lim}	Not defined	
Current B_{pa}	Not defined	
Current F_{lim}	Not defined	
Current F_{pa}	Not defined	
Current F_{MSY}	0.11	Proxy based on $F_{35\%\ SPR}$ from deterministic YPR (ICES, 2012)
Current MSY $B_{trigger}$	Not defined	

Biological Reference Points for southern horse mackerel (B_{lim}, B_{pa}, MSY $B_{trigger}$, F_{lim}, F_{pa} and F_{MSY}) were estimated using the outputs of the stock assessment, performed with the 1992–2015 data (Section 8.5.1) and following ICES framework and guidelines (Azevedo *et al*., 2016, Annex 2).

All statistical analyses were carried out in R environment. The southern horse mackerel stock data were converted to an FLStock object using the "FLCore" package (version 2.5.20160504). Simulations analyses were conducted within package "msy" using the Eqsim routines (version downloaded 02/06/2016), a stochastic equilibrium reference point software that provides MSY reference points based on the equilibrium distribution of stochastic projections (details in ICES, 2016, WKMSYREF4). The methodology followed the framework proposed in ICES, 2016 and the ICES (draft, June 2016) guidelines for fisheries management reference point for category 1 stocks.

The Ricker, Beverton–Holt and Hockey Stick (also called Segmented Regression) stock–recruitment models were fitted to the observed stock–recruitment data, accounting for estimation uncertainty using weighted linear and non-linear estimation. The three models were also fitted by the default "Buckland" method in the EqSim software. A number of scenarios and options were tested, using S–R segmented regressions with two different forced breakpoints, using historical variation in biological/productivity parameters and assuming or not population assessment error and autocorrelation in the advisory year and setting or not MSY $B_{trigger}$. Model and data selection settings are presented in Table 8.7.2.

Table 8.7.2. Model and data selection settings.

Data and Parameters	Setting	comments
SSB-recruitment data	Full series 1992–2015	Stock exploited well below F_{MSY} over the whole time-series. Stock with a narrow dynamic range of SSB and no evidence that recruitment is or has been impaired (Figure 8.7.1). Occasional strong recruitments are observed independent of SSB values probably environmentally driven. No indication of cannibalism and density-dependent growth in the stock.
Exclusion of extreme values (option extreme.trim)	No	
Trimming of R values	No	Standard (-3,+3 Standard deviations) trimming makes no change, recruitment values are within 3 sd.
Mean weights and proportion mature; natural mortality	2005–2015	No trends over the last ten years in weight-at-age. The proportion mature and natural mortality are age dependent and assumed constant.
Exploitation pattern	2005–2015	Small change in the selection pattern to increased selectivity of young ages and decreased selectivity of older ages in recent years.
Assessment error in the advisory year. CV of F	0.233	No robust estimates for this stock because of changes in stock unit and assessment method in 2011. Default value used from ICES, 2015 (WKMSYREF3).
Autocorrelation in assessment error in the advisory year	0.423	No robust estimates for this stock because of changes in stock unit and assessment method in 2011. Default value used from ICES, 2015 (WKMSYREF3).

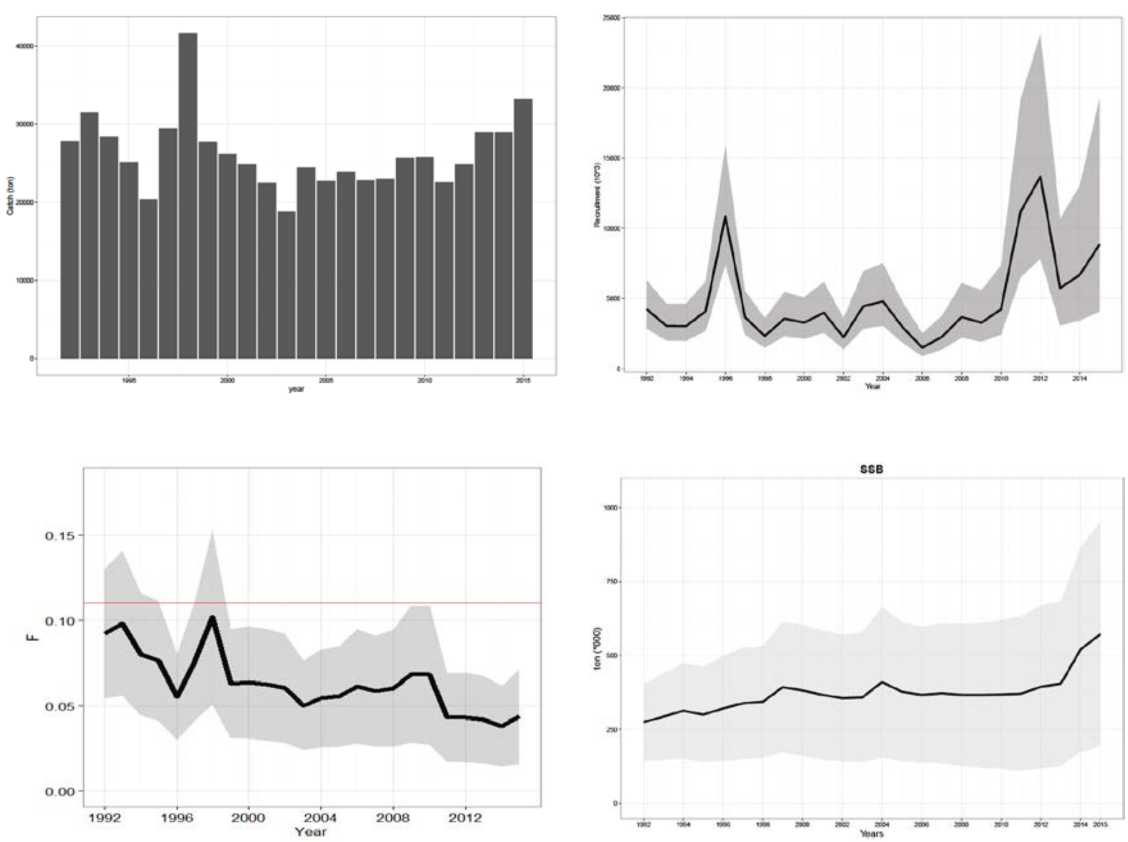


Figure 8.7.1. Southern horse mackerel. Stock summary used as the basis for the BRP evaluation. Upper panel: Yield (left) and Recruitment (right). Lower panel: Fishing mortality with the current F_{MSY} proxy (0.11) (right) and Spawning–Stock Biomass (left).

8.5.1.1 Results

Stock–recruitment relationship

The full available SSB–R data were used to fit stock–recruitment models. The weighted parameter estimation (accounting for the observed σ^2 of the SSB–R data) of the Ricker model showed very poor model fit, the Beverton–Holt did not fit to data and the segmented regression fits with a breakpoint high in the SSB data cloud (Figure 8.7.2). Given the lack of evidence supporting a specific S–R model, the EqSim software was also run using the three models weighted by the default "Buckland" method. However, both the Ricker and Beverton–Holt curves increased without reaching a plateau and the segmented regression fits with a high breakpoint well outside the range of observed SSB (Figure 8.7.2).

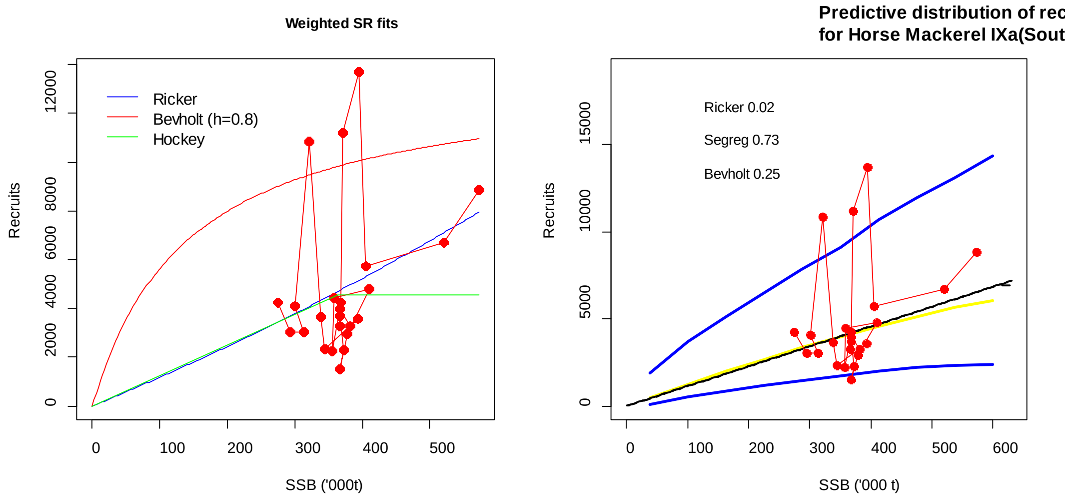


Figure 8.7.2. Stock–recruitment relationships: left panel: weighted fits to Ricker (blue) Hockey-stick (green) and forced Beverton–Holt at steepness h=0.8 (red). Right panel: EqSim summary of the default "Buckland" method for Ricker (yellow), Hockey-stick (black dotted) and Beverton–Holt (black dashed) with 90% intervals (blue).

The southern horse mackerel shows no obvious S–R relationship. SSB shows a stable and narrow dynamic range and erratic recruitments with occasional strong year classes. There is no evidence of reduced reproductive capacity at any of the observed SSB levels. It was decided that given the high biomass condition of the stock associated with low fishing mortality, below the current F_{MSY} proxy, there was support to fit a segmented regression with a forced breakpoint at 181 kt. as the mean of the lower bound of the 90% CI of the observed SSB (Figure 8.7.3). The 90% CI most probably encompasses the true B_{MSY} and the 5th percentile of the observed SSB was proposed as a candidate for $B_{trigger}$.

The Hockey-stick model has the advantage to do minimal assumptions for the stock–recruitment relationship, with constant recruitment after the breakpoint being a neutral option compared to Beverton–Holt (where recruitment slightly increases after a certain biomass level) or Ricker (where recruitment decreases after a certain biomass level) (ICES, 2016 WKMSYREF4).

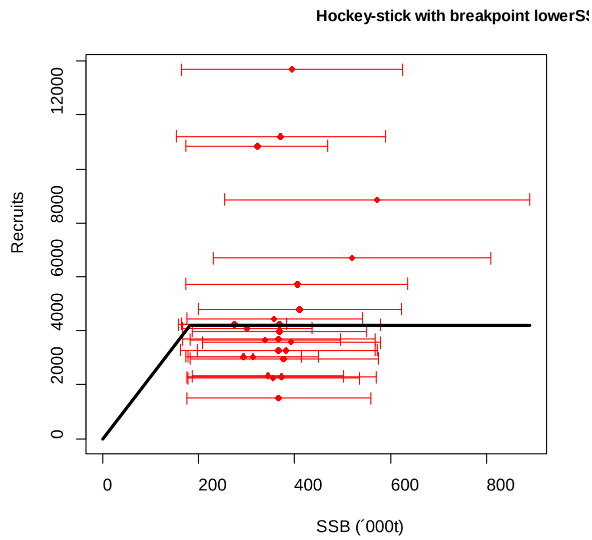


Figure 8.7.3. Southern horse mackerel stock–recruitment data with 90% CI of the SSB data (red lines) and the proposed segmented regression model with a forced breakpoint at 181 kt.

B_{lim} and B_{pa}

B_{lim} has not been defined for the southern horse mackerel stock. In order to analyse an F_{MSY} candidate in relation to precautionary limits, i.e. prob(SSB < B_{lim}), a B_{lim} needs to be defined. Lowest observed SSB and breakpoints of segmented regressions are both approved ways of deriving BRP. Considering the above stated historical considerations for this stock a proxy for B_{lim} was derived as $B_{lim} = B_{pa} * \exp(-1.645\ \sigma) = 103$, where B_{pa} is the segmented regression breakpoint with $\sigma = 0.34$ as the standard deviation of SSB in the final assessment year.

Eqsim analysis

A run (not shown) with error in population and productivity parameters but with no error in the advice was carried out to estimate F_{lim} at 0.19 and to derive $F_{pa} = F_{lim} * \exp(-1.645\ \sigma) = 0.11$, with $\sigma = 0.32$ as the standard deviation of F in the final assessment year (Table 8.7.3).

Reference points were calculated based on the proposed segmented regression with a fixed breakpoint. Population, productivity parameters and assessment error and autocorrelation were used (Table 8.7.2) and, when used, $B_{trigger}$ was set at 181 kt. Results with the segmented regression and no $B_{trigger}$ (i.e, without applying the ICES MSY AR) for both yield and SSB are shown in Figure 8.7.4. The median F_{MSY} estimated by Eqsim applying a fixed F harvest strategy was estimated at 0.15. Based on the ICES general guidelines for determining F_{MSY}, it was also tested whether fishing at F_{MSY} is precautionary in the sense that the probability of SSB falling below B_{lim} in a year in long-term simulations with fixed F is ≤ 5% (Fp.05). The Fp.05 was estimated at 0.15 and therefore the F_{MSY} (0.15) is not restricted because of this precautionary limit, but since F_{MSY} is above F_{pa} then $F_{MSY} = F_{pa}$.

The ICES MSY AR was applied to check that F_{MSY} and $B_{trigger}$ combination adheres to the precautionary considerations (F_{MSY} ≤ Fp.05). Results of the Eqsim run with $B_{trigger}$ for both yield and SSB are shown in Figure 8.7.5. Simulations with $B_{trigger}$ returned a little higher F_{MSY} level at 0.16 but well below Fp.05 = 0.23 implying that fishing at F_{MSY} and the proposed $B_{trigger}$ is precautionary.

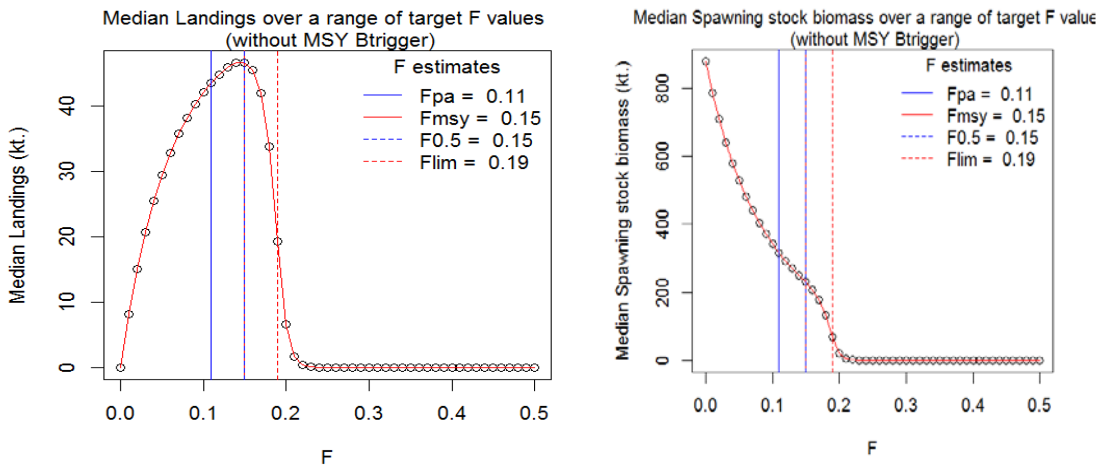


Figure 8.7.4. Southern horse mackerel median landings yield curve (left panel) and median SSB curve (right panel) with estimated reference points (without MSY $B_{trigger}$). Blue lines: F_{pa} estimate (solid) and Fp.05 (dotted). Red lines: F_{MSY} estimate (solid) and F_{lim} (dotted).

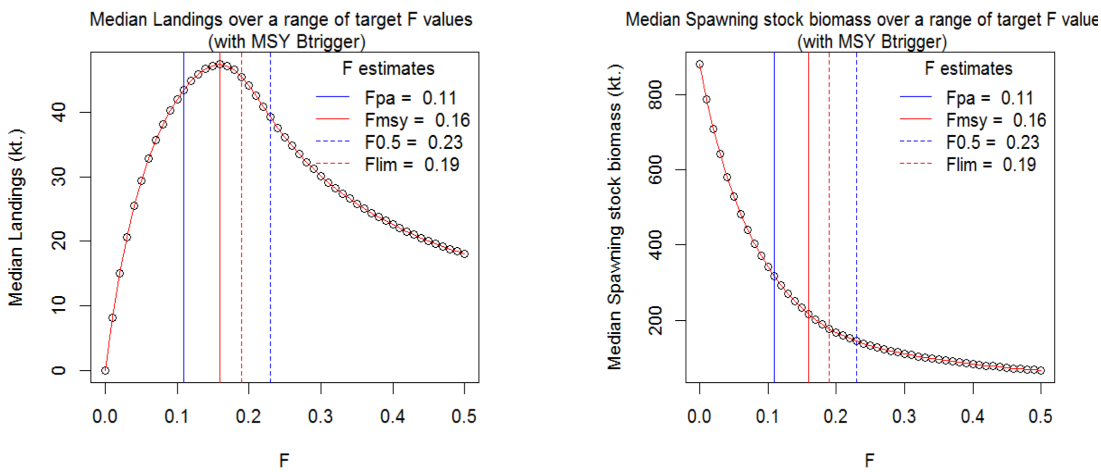


Figure 8.7.5. Southern horse mackerel median landings yield curve (left panel) and median SSB curve (right panel) with estimated reference points (with ICES MSY AR). Blue lines: F_{pa} estimate (solid) and Fp.05 (dotted). Red lines: F_{MSY} estimate (solid) and F_{lim} (dotted).

Biomass reference points without considerations involving historical fishing mortality

On a trial basis and disregarding all the historical considerations for this stock, stochastic simulations were run following the ICES (draft, June 2016) guidelines for fisheries management reference point for category 1 stocks. The guidelines have established methods for defining stock type based on stock–recruitment data and reference point's estimation methods. The southern horse mackerel stock–recruitment data characteristics falls within type 6 category stocks defined as "stocks with a narrow dynamic range of SSB with only low fishing mortality and no evidence that recruitment is or has been impaired" and, "If the fishing mortality is low judged by conventional reference points, then this may actually be a stable stock for which the B_{pa} should be defined as the B_{loss} value". Accordingly, B_{pa} was set to 274 kt (SSB in 1992) and B_{lim} derived as 157 kt. $B_{trigger}$ cannot be higher than B_{pa} therefore, $B_{trigger}$ was set at 274 kt. Exploratory runs were made (not shown) following the same settings as in Table 8.7.2 and with a SR segmented regression with B_{lim} as breakpoint. F_{lim} was estimated at 0.20, F_{pa} derived as 0.12 and F_{MSY} estimated as 0.16, above Fp.05 (0.15) and F_{pa}. The simulations with F_{MSY}=F_{pa}=0.12 and B_{lim} at 157 kt estimated BF_{MSY} as 299 kt (median) and the 5% percentile BF_{MSY} as 219 kt.

Discussion

Defining Biomass reference points without considerations involving historical fishing mortality of southern horse mackerel stock, $B_{trigger}$ is set at 274 kt, being well above the 5% percentile of BF_{MSY} (5%BF_{MSY}) and close to the median BF_{MSY} (the expected equilibrium biomass when fishing at F_{MSY}) from stochastic simulations. In fact, it is inconsistent that $B_{trigger}$ is much higher than 5%BF_{MSY} since $B_{trigger}$ should be the lower bound to the biomass for MSY exploitation. The stock time-series does not suggest any recruitment impairment within the observable stock levels and this trial run confirmed that B_{loss} is not applicable as a B_{pa} proxy (or to derive MSY $B_{trigger}$ = B_{pa}) for this particular stock with exploitation well below F_{MSY} over the entire time-series (1992–2015).

Proposed reference points

Table 8.7.3. Summary table of reference points for southern horse mackerel.

BRP	Value	Technical basis
B_{lim}	103	Derived from B_{pa} and assessment uncertainty B_{lim} = B_{pa} * exp(-1.645 x 0.34)
B_{pa}	181	MSY $B_{trigger}$
$B_{trigger}$	181	Lower bound (average) of 90% CI of the SSB time-series in a stock being exploited well below F_{MSY}
F_{lim}	0.19	Stochastic long-term simulations (50% probability of SSB>B_{lim})
F_{pa}	0.11	Derived from F_{lim} and assessment uncertainty F_{pa}=F_{lim} exp(-1.645 x 0.32)
F_{MSY}	0.11	Constrained by F_{pa}. Stochastic long-term simulations using a segmented regression with breakpoint at MSY $B_{trigger}$

Sensitivity

Recruitment for this stock has occasional strong year classes (i.e. 1996, 2011, 2012, 2015), exploratory runs were made to investigate the sensitivity of the results to the occasional high recruitments. By removing these strong recruitments from the long-term simulations we are assuming a shallower slope in the fitted segmented regression for the long term simulations. Because we are assuming a lower stock resilience and productivity, the sensitivity test did give slightly lower F_{lim} (0.16), F_{pa} (0.09), F_{MSY} (0.12) and $F_{p.05}$ (0.13) values with lower Yields and SSB levels. From historical data there is no reason to believe that this stock in the long term will never produce strong year classes, but despite the strong unrealistic assumption the results were relatively insensitive (change in F´s ≈ - 0.02). The proposed BRP´s seem robust to current recruitment assumptions.

A second sensitivity test was carried out using fewer years for selectivity (five years vs ten years) because of the small changes in the selection pattern to increased selectivity of young ages and decreased selectivity of older ages in recent years. The results were unchanged from the proposed BRP´s.

The proportion mature and natural mortality for this stock are age-dependent but assumed constant over the historical time-series. The sensitivity of the model to the inclusion of additional stochastic variability in proportion mature and/or natural mortality as a proxy for e.g. environmental driven changes could also be further tested.

8.6 Management considerations

The traditional fishery across several fleets has for a long time-targeted juvenile age classes. This exploitation pattern combined with a fishing mortality well below F_{MSY} over the whole time-series does not seem to have been detrimental to the dynamics of the stock. The basis for the advice is the same as last year: the MSY approach, which implies increasing current fishing mortality to 0.11 (a factor of 2.5) and gives estimated catches in 2017 of 73 349 tonnes. Although a negative retrospective bias (underestimation of SSB) is observed the estimated high levels of SSB and stock biomass are reflecting the good year classes of 2011 and 2012. In fact, the analysis carried out with the stochastic long-term simulations estimate an equilibrium catch at F_{MSY} of 44 thousand tonnes. If managers wish to maximize catch stability following such recruitment events it may be preferable not to increase F to F_{MSY} immediately, spreading the yield from the two recent large year classes over a longer period than would be the case when fishing at F_{MSY}, given the long lifespan and the low natural mortality for this species. Keeping the fishing mortality in 2017 at the level of 2016 (0.044) would imply catches of 30 237 t which is close to recent levels.

A management plan for southern horse mackerel, aiming to be consistent with MSY and precautionary, is being developed by the Pelagic AC (PELAC). The stock assessment outputs and the Biological Reference points estimated during WGHANSA (B_{lim}, MSY $B_{trigger}$ and F_{MSY}) will be used to perform simulations under several stock and exploitation scenarios to evaluate the effect on the stock and the fisheries.

9 Blue Jack Mackerel (*Trachurus picturatus*) in the waters of Azores

The *T. picturatus* is the only species of genus *Trachurus* that occurs in the Azores region (Northeastern Atlantic). It is a pelagic species found around the islands shelves, banks and sea mounts up to 300 m depth. However, a different size structure was observed between islands shelf and offshore areas. The island shelf areas seems to function as nursery or growth zones, while the seamount/bank offshore areas as feeding zones where adults predominate (Menezes *et al*., 2006).

In the Azores, the *T. picturatus* is exploited by different fleets and métiers. The main catches are those of the artisanal fleet that operates with several types of surface nets, the most important being the purse-seines, and bottom longline. Purse-seines are also used by the tuna bait boat fleet, which targets the *T. picturatus* to be used as live bait for tuna. The blue jack mackerel is also a very popular species among the recreational fisherman that fish along the coast of all islands.

The *T. picturatus* landings were considerably high during the 1980s, however changes in the local markets lead to a strong reduction in the catches afterwards. This reduction was also accompanied by a sharp decrease in the fleet targeting small pelagic fishes. Since this period, the catches maintained at a low level due to a voluntary auto regulation adopted by the fishermen associations. Despite this reduction in the landings, this fishery still has a strong impact on some fishermen communities, which directly depends on the income of this fishery.

9.1 General Blue Jack Mackerel in ICES areas

The blue jack mackerel, *Trachurus picturatus* Bowdich, 1825 (*Carangidae*) has a broad geographical distribution within the Eastern Atlantic waters and can be found from the southern Bay of Biscay to southern Morocco, including the Macaronesian archipelagos, Tristan de Cunha and Gough Islands and also in the western part of the Mediterranean Sea and the Black Sea (Smith-Vaniz, 1986). It is a pelagic fish species which characteristic habitat includes the neritic zones of islands shelves, banks and seamounts (Smith-Vaniz, 1986). It has a shoal behaviour and prey mainly on crustaceans, being common in the islands of Madeira, Azores, and Canaries and Portuguese continental waters.

No studies specifically addressing the existence of distinct populations in the distribution range of this species have been attempted so far. Some studies on growth and biological characteristics from Madeira, Azores and Canary islands (Garcia *et al*., 2015; Isidro, 1990; Jesus, 1992; Gouveia, 1993; Vasconcelos *et al*., 2006; Jurado-Ruzafa and Santamaría, 2013) indicated similar growth rates and reproductive season. However, biological differences on age at first maturity seem to exist between individuals from the Azores compared with those from the Madeira and Canary islands (Jesus, 1992; Jurado-Ruzafa and Santamaría, 2013). The morphometric studies carried out on *T. picturatus* from Azores archipelago (Isidro, 1990), western coast of Portugal (Mendes *et al*., 2004) and western Mediterranean (Merella *et al*., 1997) revealed similar population parameters for the estimated relationships. On the contrary, some variation was found between different geographic areas in the number of soft spines from the second dorsal fin (Shaboneyev and Kotlyar, 1979; Smith-Vaniz, 1986). However, meristic characters are heavily influenced by the environmental conditions experienced by the fish while in the larval stages, therefore in the case of migratory oceanic species, such as *T. picturatus*, are usually considered of reduced utility for the identification of stock units.

A number of studies have successfully used parasites as biological markers. Gaevskaya and Kovaleva (1985) conducted a survey of the parasites of *T. picturatus* from the Azores and Western Sahara. Their study identified a number of protozoan and helminth parasites showing differences in prevalence. The myxosporean *Kudoa nova* was found in samples from the Western Sahara, but not from banks of the Azores archipelago. Similarly, some species of digeneans (Platyhelminths: *Digenea*) found in the banks of the Azores, were not observed in the samples from the Western Sahara and vice versa. The apicomplexan, *Goussia cruciata* which is common in *T. picturatus* from the Mediterranean (Kalfa-Papaioannou and Athanassopoulou-Raptopoulou, 1984) and more recently from Madeira waters (Gonçalves, 1996), was not found in the Azores or from the Western Sahara. These variations in the occurrence of parasites could be indicative of the existence of different populations of *T. picturatus*. Further studies concentrating the occurrence of helminth parasites indicate some differences in both species diversity and parasitic infections levels (Costa *et al*., 2000, 2003).

The blue jack mackerel is an economically important resource, especially in the Micronesian islands of Azores and Madeira, where is the main pelagic fish species being caught in the local fisheries. The landings of this species in the Portuguese mainland have suffered strong fluctuations, which may be related, at least partially to fluctuations in abundance or availability. From 2005 to 2007 the landings have tripled, being 2007 the year with the highest landings recorded. In the Azores archipelago the landings have also fluctuated, while in Madeira the average of the landings from 1986 to 1991 was three times higher than the average landings from 1992 to 2007. The hypothesis that the fluctuations in landings can be due to changes in availability or abundance, and not just by changes in fishing effort, is supported for the Portuguese mainland by the observation of fluctuations in the abundance indices obtained from research surveys.

9.2 ACOM Advice applicable to 2017

The advice for this stock is biennial and so the 2016 advice is valid for 2017 and 2018 (see ICES, 2014): ICES advises on the basis of the approach for data-limited stocks that catches should be no more than 1318 tonnes.

9.3 The fishery in 2015

Commercial catches for 2015 include landings, landings not commercialised (withdrawn), discards, tuna bait catches, and recreational catches. In 2015, the discards observer programme did not occur due to financial constraints, and so the longline discards (including bait consumption by this fleet) were estimated taking into account the interviews program and the results from the previous years. However, the discards programme from previous years served to reveal minimal values for discards but substantial values for bait consumption by this fleet.

In 2015, length frequencies and ages from landings sampling were collected and commercial abundance indices from the main fleets catching juveniles were also updated (LPUE_PurseSeiners and CPUE_BaitBoat).

9.3.1 Fishing fleets in 2015

The blue jack mackerel is mostly landed by the artisanal fleet, using purse-seines. These fleet landings represent around 82% of the total landings and the catches about 63% of the total catches of blue mackerel, in Azores.

The artisanal purse-seines fleet is composed by small open deck vessels, mostly with less than 12 meters of overall length. The composition of this fleet presents a regular decrease in the recent years, with a reduction of 213 vessels in 2010 to 46 active vessels in 2015 in the small pelagic fishery. The contribution of this fleet to the landings and the number of vessels of each size category, for the last 15 years is shown in Figure 9.3.1.1.

9.3.2 Catches

Commercial catches including landings, discards, and tuna bait catches and recreational catches, for the period 1978 to 2015, are presented in Table 9.3.2.1.

Total estimated catches of blue jack mackerel in the Azores, for the considered period in Figure 9.3.2.1 (2002–2015), are around 1600 tonnes; while landings, in same period, are in average 1100 tonnes. In the last three years, the average catches and landings decreased to about 1180 and 845 tonnes, respectively.

An important reduction was observed in the catches of all fishing gears in 2012, but particularly for those targeting the juveniles, such as the artisanal purse-seine fleet and the tuna bait boats fleet. The cause of this reduction is unknown, but catches have increased in the following years. Concerning the longliners, the increase observed in 2015 is mostly related to the practice of using the blue jack mackerel for bait, since their market price is too low. These values increased since 2013, although are still below the average of the preceding ten years.

9.3.3 Effort and catch per unit of effort

The fishing effort in number of days at sea is presented by year and by vessel size category in Figure 9.3.3.1. The majority of the effort is conducted by the small segment of the fleet (VL0010; vessel with less than 10 m), followed by the fleet segment VL1012 (vessels between 10 and 12 meters).

For the last twelve years, and with the reduction of this fleet in the 1990s, the threshold of 5000 fishing days has never been exceeded.

The standardized cpue/lpue series were updated for the small purse-seine fleet (Figure 9.3.3.2) and the tuna bait boat fleet (Figure 9.3.3.3) of blue jack mackerel, up to 2014. Scaled standardized lpue from small purse-seiners and cpue from the bait boat tuna fishery are presented in Figure 9.3.3.4.

Landings of blue jack mackerel from the longliners are less representative once a considerable part of the catch is not landed being used as bait. The source of data for updating cpue series from this fleet is through the discards observer sampling programme but, since it was not possible to conduct it in 2015, the cpue series for the longliners was not updated.

9.3.4 Catches by length

Size frequencies for the blue jack mackerel caught in the Azores are available since 1980. In Figure 9.3.4.1 is presented the size distribution of the landings (catch-at-size) for the years 2010 to 2015. The two main fisheries target on different size categories, the surface fleets catch the juvenile fraction of the population while the longliners target the adult stock.

9.3.4.1 Assessment of the state of the stock

The assessment method is described in the stock annex.

9.4 Management considerations

The Azores Administration, put in place in October 2014 a specific management measure for the purse-seine fleet with the aim of regulate markets. This measure allows only 200 kg per vessel, per day: Also states that fishing and consequent landings shall also be forbidden on weekends (Portaria n.º 66/2014 de 8 de Outubro de 2014).

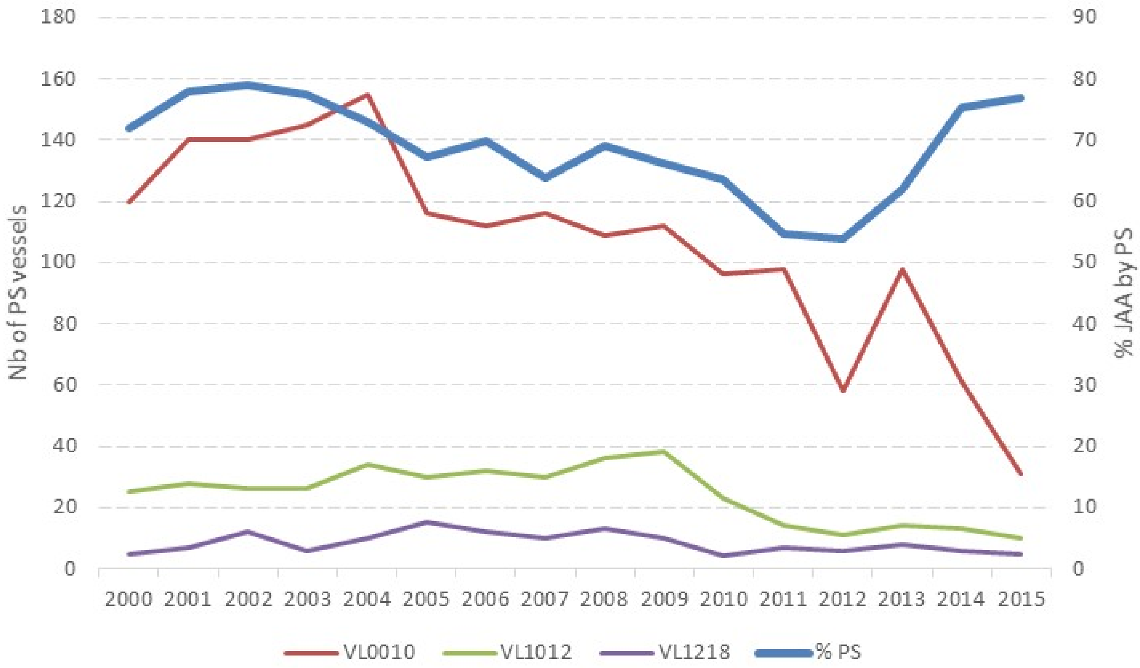


Figure 9.3.1.1. Number of small purse-seine vessels, by length category, and their contribution to the total catch of blue jack mackerel (*T. picturatus*) in the Azores (ICES Subdivision 10.a2) from 2000 to 2015.

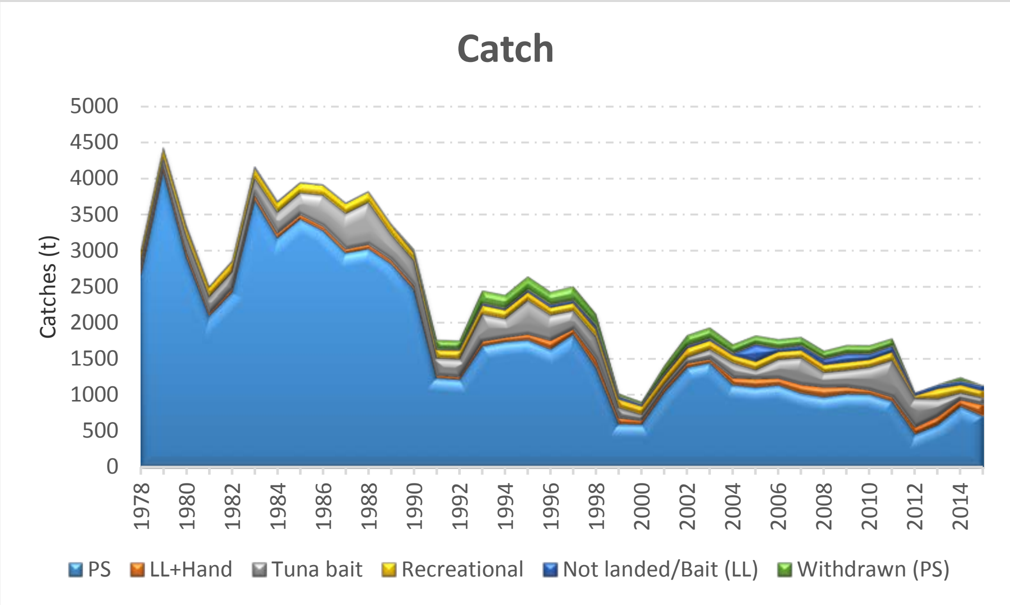


Figure 9.3.2.1. Estimated catches of blue jack mackerel (*T. picturatus*) in the Azores (ICES Subdivision 10.a2) from 1978 to 2015.

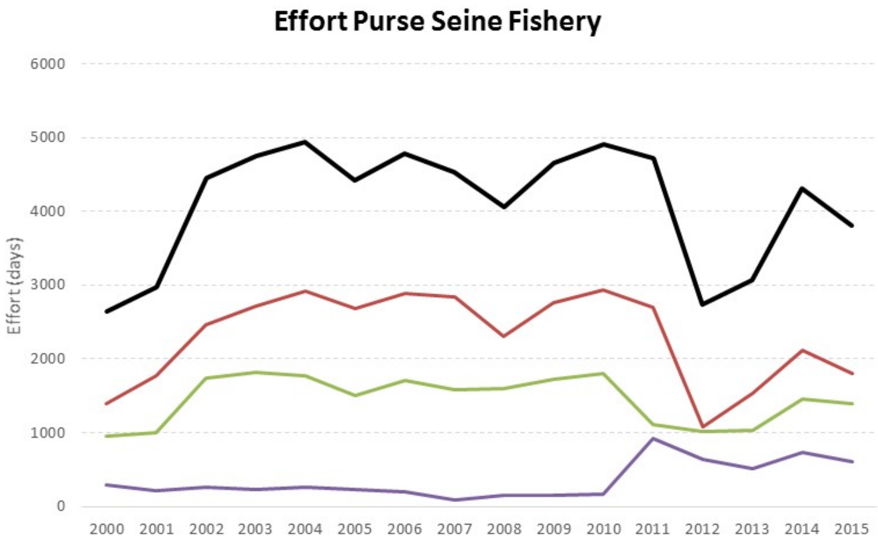


Figure 9.3.3.1. Nominal effort (number of days) of the purse-seine fleet, total and by vessel size category for the period 2000–2015.

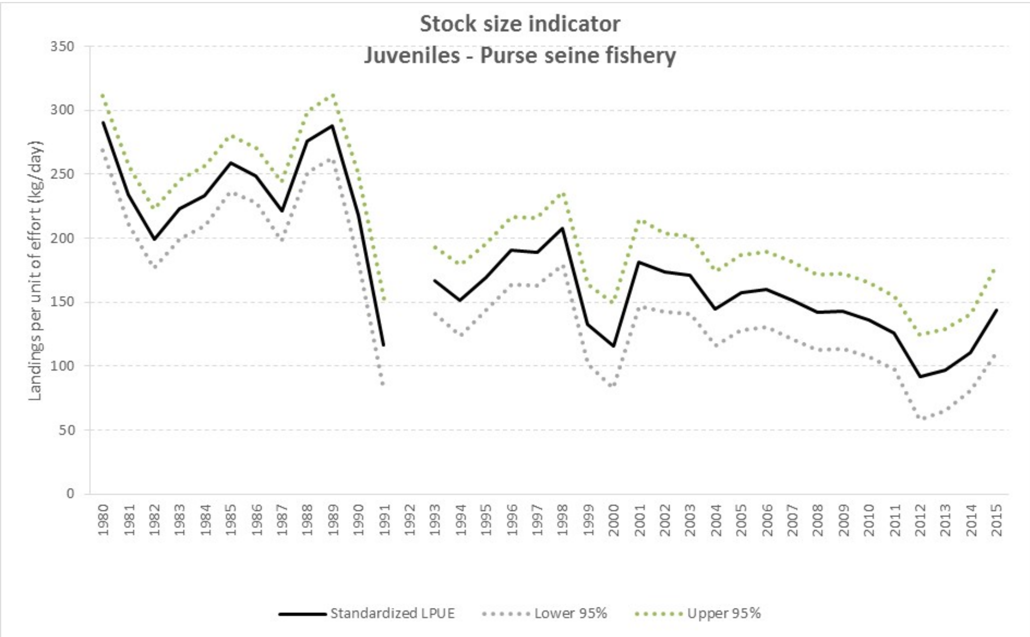


Figure 9.3.3.2. Standardized lpue for blue jack mackerel from the Azores small purse-seine fishery, for the years 1980–2015. Broken lines indicate 95% confidence intervals.

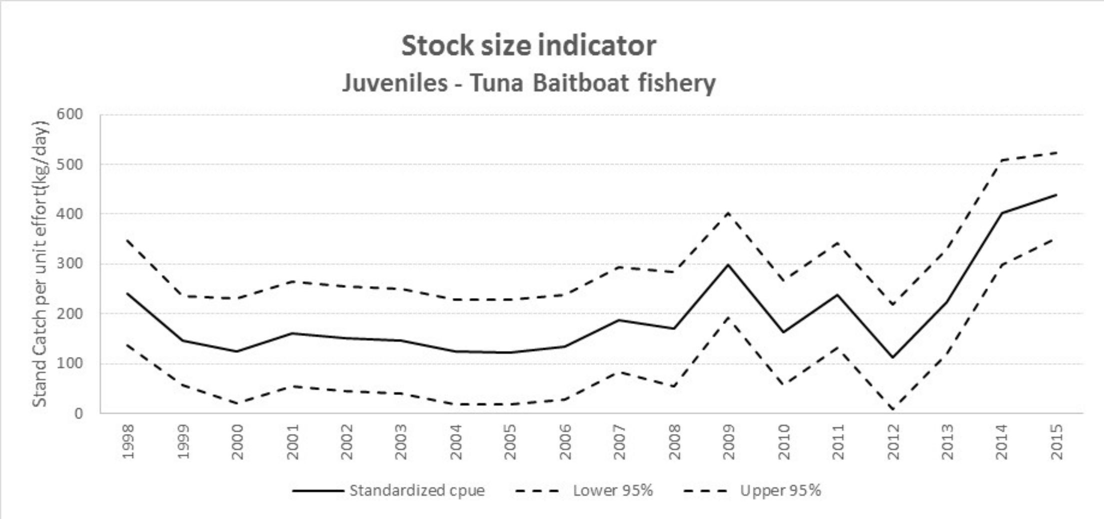


Figure 9.3.3.3. Standardized cpue for blue jack mackerel from the Azorean bait boat tuna fishery, for the years 1998–2015. Broken lines indicate 95% confidence intervals.

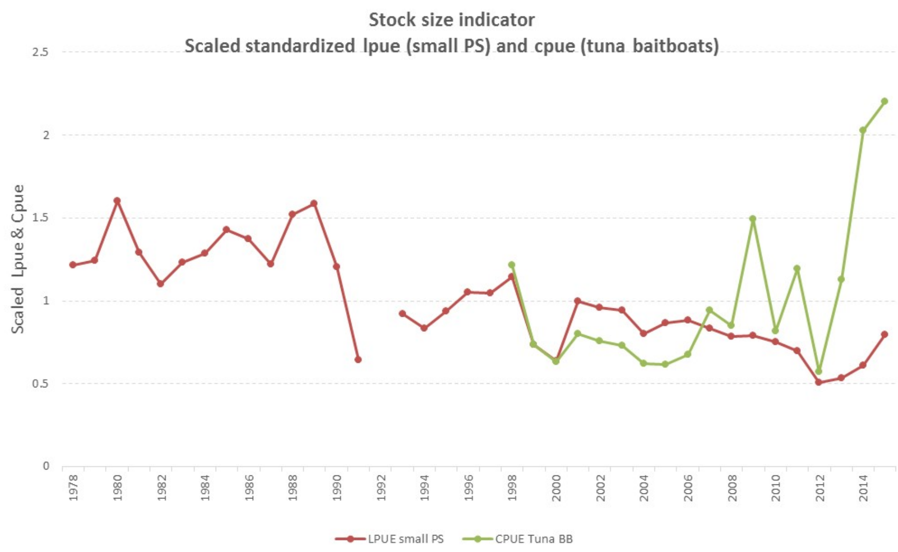


Figure 9.3.3.4. Scaled standardized lpue from small purse-seiners and cpue from the bait boat tuna fishery, for blue jack mackerel in Azores.

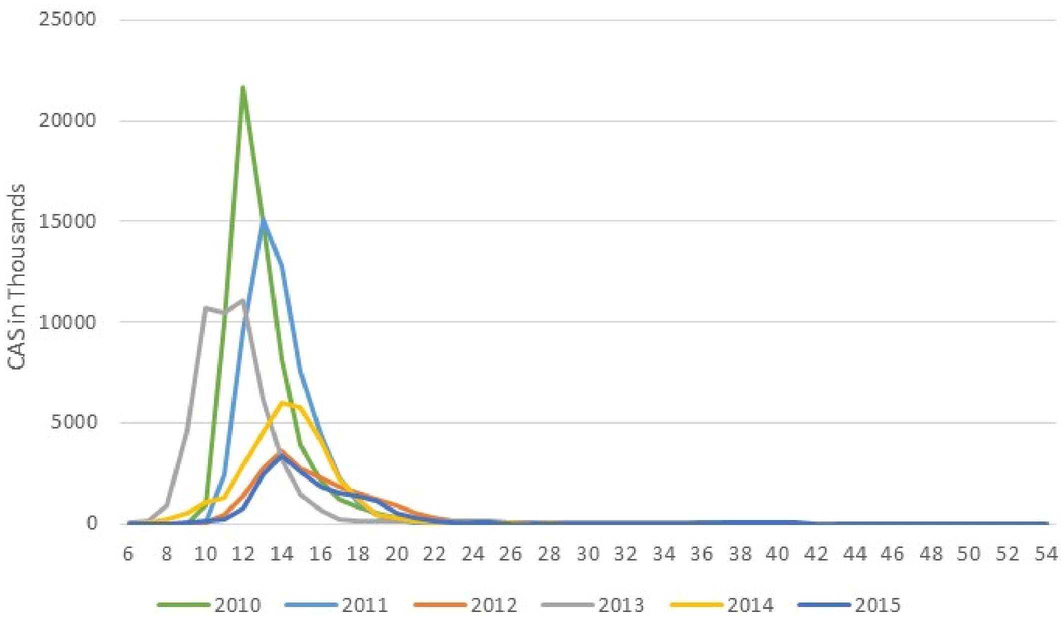


Figure 9.3.4.1. Annual size frequencies of the catches of blue jack mackerel (*T. picturatus*) in the Azores, from 2010 to 2015.

Table 9.3.2.1. Estimated catches of blue jack mackerel (*T. picturatus*) by fishery, in the Azores from 1978 to 2015.

Year	Tuna bait	Recreational	Discards/Bait (LL)	Withdrawn (PS)	PS	LL+Hand	Total
1978	115	129	15	0	2657	78	2995
1979	118	130	15	0	4114	61	4439
1980	210	132	22	0	2920	70	3354
1981	229	135	9	0	2104	39	2516
1982	239	142	10	0	2429	43	2862
1983	231	142	21	0	3711	67	4172
1984	295	135	17	0	3180	62	3689
1985	303	136	11	0	3442	60	3952
1986	433	135	9	0	3282	58	3918
1987	491	139	8	0	2974	53	3666
1988	586	143	8	0	3032	55	3824
1989	352	138	9	0	2824	50	3373
1990	345	117	11	27	2472	48	3021
1991	242	115	6	127	1247	33	1770
1992	249	121	6	126	1226	35	1762
1993	375	130	22	173	1684	70	2454
1994	264	125	18	179	1745	59	2390
1995	474	119	24	182	1769	79	2648
1996	351	110	38	173	1642	123	2437
1997	259	110	31	192	1849	72	2513
1998	308	111	52	151	1387	120	2129
1999	141	119	37	35	609	84	1024
2000	83	117	23	32	602	53	910
2001	59	121	24	110	1046	55	1415
2002	82	132	28	145	1387	63	1837
2003	140	128	21	150	1455	47	1941
2004	208	111	19	125	1148	98	1709
2005	124	120	236	123	1111	120	1834
2006	264	111	40	124	1145	96	1781
2007	370	115	58	115	1032	122	1812
2008	205	110	75	111	980	139	1620
2009	230	119	115	112	1023	98	1697
2010	313	114	75	116	1021	57	1696
2011	510	118	79	105	920	62	1794
2012	399	42	41	Not available	467	94	1043
2013	237	147	54	Not available	592	123	1153
2014	96	112	49	52	852	91	1252
2015	92	103	67	Not available	714	874	1136

10 General Recommendations

WGHANSA 2016 General Recommendations	To
The WGHANSA recommends that anchovy catches in the western part of Division 9.a are sampled whenever an outburst of the population in the area is detected.	PGDATA, WGCATCH, RCM's
The WGHANSA considers each of the survey series directly assessing anchovy in Division 9.a as an essential tool for the direct assessment of the population in their respective survey areas (subdivisions) and recommends their continuity in time, mainly in those series that are suffering of interruptions through its recent history.	
The WGHANSA recommends the extension of the BIOMAN survey to the north to cover the potential area of sardine spawners in 8.a. This extension should be funded by DCMAP.	
The WGHANSA recommends a pelagic survey to be carried out on an annual basis in autumn on the western Portuguese coast to provide information on the recruitment of small pelagics (particularly sardine and anchovy) in that region.	
The WGHANSA recommends a pelagic survey to be carried out on an annual basis in spring in the English Channel (7.d, 7.e, 7.h) to provide information on the status of small pelagics (particularly sardine and anchovy) in that region.	
The WGHANSA recommends that length distributions and biological parameters of catches are collected for sardine in Area 7 by countries operating in those waters.	
The consort PELGAS survey (18 days of joint survey with fishing vessels) should be renewed and funded on a long-term basis.	DCMAP, French national administration
	WGACEGG 2016
The WGHANSA requests from WGACEGG 2016 that estimates of the uncertainty of the joint PELAGO and PELACUS acoustic survey time-series are provided to be used in the next sardine benchmark (early 2017).	
The WGHANSA requests from WGACEGG 2016 that available knowledge on possible reasons for different trends (in some periods) in the acoustic and DEPM surveys covering the Iberian sardine stock is presented and comment on the current and potential use of these surveys in the assessment are provided.	

WGHANSA 2016 General Recommendations	To
In Section 1.3, the participants requested ICES to consider the possibility of having the meeting moved to mid-/end of November, at the same time and place than WGACEGG. Once a benchmark has been scheduled, an early involvement of the external experts is recommended in the preparatory process (leading to data compilation workshop) so that the selection of tools and modelling approach could be narrowed as early as possble. Stock coordinators could, that way, 1) get early guidance on the approach to try/follow and/or 2) have more time to prepare the second (modelling) meeting. The Benchmark for anchovy in 9.a is recommended to be delayed to 2018, basically due to limited manpower over the data compilation and modelling approach to be taken.	ICES secretariat, ACOM

11 References

Barange, M., Bernal, M., Cercole, M.C., Cubillos, L.A., Cunningham, C.L., Daskalov, G.M., De Oliveira, J.A.A., Dickey-Collas, M., Hill, K., Jacobson, L.D., Köster, F.W., Masse, J., Nishida, H., Ñiquen, M., Oozeki, Y., Palomera, I., Saccardo, S.A., Santojanni, A., Serra, R., Somarakis, S., Stratoudakis, Y., van der Lingen, C.D., Uriarte, A., and Yatsu, A. 2009. Current trends in the assessment and management of small pelagic fish stocks. In Climate change and small pelagic fish. Edited by D.M. Checkley, C. Roy, Y. Oozeki and J. Alheit. Cambridge University Press, Cambridge, UK. pp. 191–255.

Blaye N, Duhamel E. 2016. Achievement of an atlas of sardine catches from 2007 to 2015 from Gibraltar to Scotland. Presentation to the Working group WGHANSA, Lorient, 24 -29 June 2016.

Boyra G., U. Martinez, U. Cotano, M. Santos, X. Irigoien, and A. Uriarte. 2013. Acoustic surveys for juvenile anchovy in the Bay of Biscay: abundance estimate as an indicator of the next year's recruitment and spatial distribution patterns. ICES Journal of Marine Science; doi:10.1093/icesjms/fst096.

Cadigan, N. G., and Farrell, P. J. 2005. Local influence diagnostics for the retrospective problem in sequential population analysis. ICES Journal of Marine Science, 62: 256–265.

Caneco, B., Silva, A., Morais, A. 2004. Morphometric variation among anchovy (*Engraulis encrasicholus*, L.) populations from the Bay of Biscay and Iberian waters. ICES CM 2004/EE:24.

COM. 2009.Proposal for a council regulation establishing a long-term plan for the anchovy stock in the Bay of Biscay and the fisheries exploiting that stock.

Costa, G., Chubb, J.C, Veltkamp, C.J. 2000. Cystacanths of Bolbosoma vasculosum in the black scabbard fish, *Aphanopus carbo*, oceanic horse-mackerel, *Trachurus picturatus* and common dolphin, *Delphinus delphis*. Journal of Helminthology, 74: 113–120.

Costa, G., Pontes, T., Mattiucci, S., D'Amélio, S. 2003. The occurrence and infection dynamics of Anisakis larvae in the black-scabbard fish, *Aphanopus carbo*, chub mackerel, *Scomber japonicus*, and oceanic horse mackerel, *Trachurus picturatus* from Madeira, Portugal. Journal of Helminthology 77: 163–166.

De Oliveira, J.A.A., and Butterworth, D.S. 2005. Limits to the use of environmental indices to reduce risk and/or increase yield in the South African anchovy fishery. Afr. J. Mar. Sci. 27(1): 191–203.

De Oliveira, J.A.A., Uriarte, A., and Roel, B. 2005. Potential improvements in the management of Bay of Biscay anchovy by incorporating environmental indices as recruitment predictors. Fisheries Research 75(1–3): 2–14.

Fernandes, J. A., Irigoien, X., Goikoetxea, N., Lozano, J. A., Inza, I., Pérez, A., Bode, A. 2010. Fish recruitment prediction, using robust supervised classification methods. Ecological modelling 221: 338–352.

Fernandes AC, Feijó D (2016) Analysis of sardine catches from onboard sampling in Portuguese purse seine fleet. Working Document for the ICES WGHANSA, Lorient, France, 24-29 June 2016, 2pp.

Gaevskaya, A.V., Kovaleva, A.A. 1985. The parasite fauna of the oceanic horse-mackerel, *Trachurus picturatus picturatus* and eco-geographical characteristics of its formation. Ekologiya moray 20: 80–84 (translated from Russian).

Ganias, M. Rakka, T. Vavalidis, C. Nunes. 2010. Measuring batch fecundity using automated particle counting. Fisheries Research 106(3): 570–574.

Garcia, A.; Pereira, J.G.; Canha, A.; Reis, D. and Diogo, H. 2015. Life history parameters of blue jack mackerel *Trachurus picturatus* (Teleostei: Carangidae) from Northeast Atlantic. Journal of the Marine Biological Association of the United Kingdom, 95, pp 401–410.

González-Ortegón, E., M. D. Subida, J. A. Cuesta, A. M. Arias, C. Fernández-Delgado, P. Drake. 2010. The impact of extreme turbidity events on the nursery function of a temperate European estuary with regulated freshwater inflow. *Estuarine, Coastal and Shelf Science 87*: 311–324.

Gonçalves, M.C.B. 1996. Parasitas internos do chicharro, *Trachurus picturatus* (Bowdich, 1825) da Madeira. Histopatologia e Prevalência. DiplomThesis, Universidade da Madeira: 42pp.

Gouveia, MEP. 1993. Aspectos da biologia do chicharro, *Trachurus picturatus* (Bowdich, 1825) da Madeira. Diplom thesis, University of Lisbon, Science Faculty: 153 pp.

Huret, M., Sourisseau, M., Petitgas, P., Struski, C., Léger, F. and Lazure, P. 2013. A multi-decadal hindcast of a physical-biogeochemical model and derived oceanographic indices in the Bay of Biscay. Journal of Marine Systems, 109–110: S77–S94.

Ibaibarriaga, L., Fernandez, C., Uriarte, A and Roel, B.A. 2008. A two-stage biomass dynamic model for the Bay of Biscay anchovy: A Bayesian Approach. ICES Journal of Marine Science, 65: 191–205.

Ibaibarriaga, L., Fernández, C., and Uriarte, A. 2011. Gaining information from commercial catch for a Bayesian two-stage biomass dynamic model: application to Bay of Biscay anchovy. ICES Journal of Marine Science, 68: 1435–1446.

ICES. 2009. Report of the Benchmark Workshop on Short-lived Species (WKSHORT), 31 August–4 September 2009, Bergen, Norway. ICES CM 2009/ACOM:34. 166 pp.

ICES. 2009. Report of the Workshop on Age reading of European anchovy (WKARA). ICES CM 2009/ACOM: 43.

ICES. 2011. Report of the Workshop on Age Reading of European Atlantic Sardine (WKARAS) , 14-18 February 2011, Lisbon, Portugal. ICES CM 2011/ACOM:42. 91 pp.

ICES. 2012. Report of the Working Group on Southern Horse Mackerel, Anchovy and Sardine (WGHANSA), 23–28 June 2012, Azores (Horta), Portugal. ICES CM 2012/ACOM:16. 544pp.

ICES. 2012. Report of the Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VIII and IX (WGACEGG), 26–30 November 2012, Fuenguirola, Spain. ICES CM 2012/SSGESST:16. 221 pp.

ICES. 2013. Report of the Benchmark Workshop on Pelagic Stocks (WKPELA 2013), 4–8 February 2013, Copenhagen, Denmark. ICES CM 2013/ACOM:46. 483 pp.

ICES. 2013. Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VIII and IX (WGACEGG), By Correspondence and 25–29 November 2013, Lisbon, Portugal. ICES CM 2013/SSGESST:20. 127 pp.

ICES. 2013. Report of the Working Group on Southern Horse Mackerel, Anchovy and Sardine (WGHANSA), 21–26 June 2013, Bilbao, Spain. ICES CM 2013/ACOM:16. 685pp.

ICES. 2014. Report of the Planning Group on Commercial Catches, Discards and Biological Sampling (ICES PGCCDBS). ICES CM 2014/ACOM: 34.

ICES. 2015. First Interim Report of the Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VII, VIII and IX (WGACEGG), 17–21 November 2014, Vigo, Spain. ICES CM 2014/SSGESST:21. 553 pp.

INE. 2012. Estatísticas da Pesca 2012. Instituto Nacional de Estatística, I.P. www.ine.pt.

Isidro, H.A. 1990. Age and growth of T. picturatus from the Azores. Arquipelago 8: 45–54.

Jiménez, M.P, Tornero, J., González, C., Ramos, F., Sánchez-Leal, R. 2014. *BOCADEVA* 0714: Gulf of Cadiz Anchovy Egg Survey and 2014 SSB preliminary estimates. Working document presented to the ICES the Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VII, VIII and IX (WGACEGG), 17–21 November 2014, Vigo, Spain. 15 pp.

Jesus, G.T. 1992. Estudo do crescimento e reprodução da espécie Trachurus picturatus (Bowdich, 1825) da Madeira. Direcção Regional das Pescas, Direcção de Serviços de Estudos e Investigação das Pescas: 66 pp.

Jurado-Ruzafa, A. ; García Santamaría, M. T. 2013. Reproductive biology of the blue jack mackerel, *Trachurus picturatus* (Bowdich, 1825), off the Canary Islands. J. Appl. Ichthyol. 29: 526–531.

Kalfa-Papaioannou, AM, Athanassopoulou-Raptopoulou, F. 1984. Incidence of coccidiosis in horse-mackerel (*Trachurus trachurus*, *T. mediterraneus*, *T. picturatus*) and sardines (*Clupea pilchardus*) from the North-Aegean Sea. Zbl. Vet. Med. B 31: 530–536.

Marques, V., Silva, A., Angélico M.M.., Soares E. 2013. Sardine acoustic survey carried out in April–-May 2013 off the Portuguese Continental Waters and Gulf of Cadiz, onboard RV "Noruega" .Working Document to be presented to the Working Group on Anchovy and Sardine, Bilbao, 21–26 June 2013.

Masse, J.; Duhamel E., Direct assessment of small pelagic fish by the PELGAS10 acoustic survey. Working Document to be presented to the Working Group on Anchovy and Sardine, Lisbon, June 2010.

Mendes, B., Fonseca, P. and Campos, A. 2004. Weightlength relationships for 46 fish species of the Portuguese west coast. J. of Applied Icht., 20: 355–361.

Menezes G.M., Sigler M.F., Silva H.M. and Pinho M.R. 2006. Structure and zonation of demersal fish assemblages off the Azores Archipelago (Mid-Atlantic). Marine Ecology Progress Series 324: 241–260.

Merella, P., Quetglas, A., Alemany, F. and A. Carbonell. 1997. Length–weight relationship of fishes and cephalopods from the Balearic Islands (western Mediterranean). Naga, ICLARM Q. 20, 66–68.

Methot, R.D. 1986. Synthetic estimates of historical abundance and mortality for northern anchovy, *Engraulis mordax*. NMFS Southwest Fisheries Science Center Admin. Rep. 12-86-29.

Methot, R.D. 1989. Synthetic estimates of historical and current biomass of northern anchovy, *Engraulis mordax*. Am. Fish. Soc. Sympos. 6, 66–82.

Moreno A, Garrido S, Meneses I, Silva AV, Soares . (2016) Pelago 2016 – Age of juvenile sardines in Cadiz area. Working Document to the Working group WGHANSA, Lorient, 24 -29 June 2016.

Pestana, M.G. 1989. Manacial Ibérico-Atlântico de sardinha (*Sardina pilchardus*, Walb.) Sua avaliação e medidas de gestão. Dissertaçao, Instituto Nacional de Investigação Científica, Lisbon, 192 pp.

Petitgas, P., Goarant, A., Masse, J., and Bourriau, P. 2009. Combining acoustic and CUFES data for the quality control of fish-stock survey estimates. ICES J. Mar. Sci. 66(6): 1384–1390.

Petitgas, P., Huret, M., Doray, M. 2013. Coherence between CUFES and Acoustic PELGAS survey indices. Working Document to be presented to the Working Group on Anchovy and Sardine, Bilbao, 21–26 June 2013.

Petitgas, P., Duhamel, E., M., Doray, M. 2013. Coherence between Egg (BIOMAN) and Acoustic (PELGAS). Working Document to be presented to the Working Group on Anchovy and Sardine, Bilbao, 21–26 June 2013.

Ramos, F. 2015. On the population structure of the European anchovy (*Engraulis encrasicolus*) in ICES Division IXa: a short review of the state of art. Working document presented in the ICES Stock Identification Methods Working Group (SIMWG). 10–12 June 2015.

Ramos F., Uriarte A., Millán M. and Villamor B. 2001.Trial analytical assessment for anchovy (*Engraulis encrasicolus*, L.) in ICES Subdivision IXa-South. Working Document presented to the ICES Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine and Anchovy. ICES, C.M. 2002/ACFM:06.

Riveiro, I., Carrera, P., Iglesias, M., Miquel, J. and Oñate, D. 2013. Preliminary results of the pelacus0313 survey: estimates of sardine abundance and biomass in Galicia and Cantabrian waters. Working document for the WGHANSA, 21–26/06/2013, Bilbao Spain.

Ribeiro, R., Reis, J., Santos, C, Gonçalves, F., Soares, A.M.V.M. 1996. Spawning of anchovy *Engraulis encrasicolus* in the Mondego estuary, Portugal. Estuarine, Coastal and Shelf Science 42(4): 467–482.

Ruíz, J., García-Isarch, E., Huertas, I.E. *et al*. 2006. Meteorological forcing and ocean dynamics controlling *Engraulis encrasicolus* early life stages and catches in the Gulf of Cadiz. Deep-Sea Res. II 53:1363–1376.

Ruíz, J., González-Quirós, R., Prieto, L. and García-Lafuente, J. 2007. Anchovy in the Gulf of Cadiz: a case of BOTTOP control. GLOBEC International Newsletter 13:10–12.

Ruíz, J., González-Quirós, R., Prieto, L., Navarro, G. 2009. A Bayesian model for anchovy (*Engraulis encrasicolus*): the combined forcing of man and environment. Fish. Oceanogr. 18:1, 62–76.

Silva, A., Uriarte, A., Riveiro, I., Santos, B., Azevedo, M., Murta, A., Carrera, P., Ibaibarriaga, L., Skagen, D. 2013. Reference points for the Iberian sardine stock (ICES Areas VIIIc and IXa). Working Document to ICES-ACOM. 5 June 2013.

Silva A, Riveiro I. (2016) - Progress on the revision of the Iberian sardine assessment for the benchmark. Working Document to the Working group WGHANSA, Lorient, 24 -29 June 2016.

Silva et al. (2016) - Progress on the revision of the Iberian sardine assessment for the benchmark: model structure and area-based dynamics. Presentation to the Working group WGHANSA, Lorient, 24 -29 June 2016.

Shaboneyev, I Ye, Ryazantseva, I, Ye. 1977. Population structure of the oceanic horse mackerel (*Trachurus picturatus picturatus*). J. Ichthyology 17 (6): 954–958.

Shaboneyev, I. Ye; Kotlyar, A.N. 1979. A comparative morphoecological analysis of the eastern pacific forms of *Trachurus symmetricus* and the Atlantic oceanic horse mackerel *Trachurus picturatus picturatus*. J. Ichthyology 19 (2): 24–29.

Smith-Vaniz, W.F. 1986. Carangidae. In "Whitehead, PJP, Bauchot, ML, Hureau, JC, Nielsen, J, Tortonese, E. Fishes of the Northeastern Atlantic and the Mediterranean. Vol. II, Unesco, UK: 815–844.

Soares, E., A. Silva, B. Villamor, C. Dueñas Liaño. 2012. Age determination of the anchovy (*Engraulis encrasicolus*, L. 1758) off the Portuguese coast in 2011. Working Document presented to the ICES Working Group on Southern Horse Mackerel, Anchovy and Sardine (WGHANSA), 23–28 June 2012, Azores (Horta), Portugal.

Scientific, Technical and Economic Committee for Fisheries. STECF. 2013. Advice on the Harvest Control Rule and Evaluation of the Anchovy Plan COM(2009) 399 Final (STECF-13-24). 2013. Publications Office of the European Union, Luxembourg, EUR 26326 EN, JRC 86109, 71 pp.

Scientific, Technical and Economic Committee for Fisheries. STECF. 2014. Evaluation/scoping of Management plans - Data analysis for support of the impact assessment for the management plan of Bay of Biscay anchovy (COM(2009)399 final). (STECF-14-05). 2014. Publications Office of the European Union, Luxembourg, EUR 26611 EN, JRC 89792, 128 pp.

Vasconcelos, J., A. Alves, E. Gouveia and G. Faria. 2006. Age and growth of the blue jack mackerel, *Trachurus picturatus* Bowdich, 1825 (Pisces: Teleostei) off Madeira archi-pelago. Arquipélago. Life and Marine Sciences 23A: 47–57.

Villamor, B., A. Uriarte (Coordinators.) In preparation. Otolith exchange results of European Anchovy (*Engraulis encrasicolus*) 2014. Working Document presented to ICES Working Group on Biological Parameters (WGBIOP), Malaga (Spain), 31 August–04 September 2015.

Wilberg, M.J., J. T. Thorson, B. C. Linton, J. Berkson. 2010. Incorporating Time-Varying Catchability into Population Dynamic Stock Assessment Models. Reviews in Fisheries Science, 18(1):7–24.

Wise, L., Silva, A., Ferreira, M., Silva, M.A., Siqueira, M. 2007. Interactions between small cetaceans and the purse-seine fishery in western Portuguese waters. Scientia Marina 71(2): 405–412.

Zarraonaindia, I., Iriondo, M., Albaina, A., Pardo, M.A., Manzano, C., Grant, W.S., Irigoien, X., Estonba, A. 2012. Multiple SNP Markers Reveal Fine-Scale Population and Deep Phylogeographic Structure in European Anchovy (*Engraulis encrasicolus* L.). PLoS ONE 7(7): e42201. doi:10.1371/journal.pone.0042201.

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Annex 02

Working Group on Southern Horse Mackerel, Anchovy and Sardine (WGHANSA), 24–29 June 2016, Lorient, France

Biological Reference Points for Horse mackerel (*Trachurus trachurus*) in Division IXa (Southern stock)

Manuela Azevedo[1], Hugo Mendes[1], Gersom Costas[2]

[1]IPMA, [2] IEO-Vigo

Current reference points

Table 1. Summary table of current stock reference points

LEVEL	VALUE	TECHNICAL BASIS
Current Blim	Not defined	
Current Bpa	Not defined	
Current Flim	Not defined	
Current Fpa	Not defined	
Current FMSY	0.11	Proxy based on F35% SPR from deterministic YPR (ICES, 2012)
Current MSY Btrigger	Not defined	NA

Source of data

Data used in the Biological Reference Points (BRP) analysis for the Horse mackerel (*Trachurus trachurus*) in Division IXa (Southern stock) were taken from the stock assessment with the AMISH model performed during WGHANSA (2016b), following the stock Annex (ICES, 2016b).

Methods used

All statistical analyses were carried out in R environment. The southern horse mackerel stock information was converted to FLStock object using the "FLCore" package (version 2.5.20160504). Simulations analyses were conducted within package "msy" using the Eqsim routines (version downloaded 02/06/2016), a stochastic equilibrium reference point software that provides MSY reference points based on the equilibrium distribution of stochastic projections (details in ICES, 2016, WKMSYREF4).

The methodology followed the framework proposed in ICES, 2016 and the ICES (draft, June 2016) guidelines for fisheries management reference point for category 1 stocks. The Ricker, Beverton–Holt and Hockey Stick (also called Segmented Regression) stock recruitment models were fitted to the observed stock–recruitment data, accounting for the precision in stock–recruitment data using weighted linear and non-linear estimation. The three models were also fitted by the default "Buckland" method in the EqSim software. A number of scenarios and options were tested, using S-R segmented regressions with two different forced breakpoints, using historical variation in biological/productivity parameters and assuming or not population assessment error and autocorrelation in the advisory year and setting or not MSY $B_{trigger}$. Model and data selection settings are presented in Table 2.

Settings

Table 2. Model and data selection settings

DATA AND PARAMETERS	SETTING	COMMENTS
SSB-recruitment data	Full series 1992-2015	Stock exploited well below F_{MSY} over the whole time-series. Stock with a narrow dynamic range of SSB and no evidence that recruitment is or has been impaired (Figure 1). Occasional strong recruitments are observed independent of SSB values probably environmentally driven. No indication of cannibalism and density-dependent growth in the stock.
Exclusion of extreme values (option extreme.trim)	No	
Trimming of R values	No	Standard (-3,+3 Standard deviations) trimming makes no change, recruitment values are within 3 sd.
Mean weights and proportion mature; natural mortality	2005-2015	No trends over the last ten years in weight-at-age. The proportion mature and natural mortality are age dependent and assumed constant.
Exploitation pattern	2005-2015	Small change in the selection pattern to increased selectivity of young ages and decreased selectivity of older ages in recent years.
Assessment error in the advisory year. CV of F	0.233	No robust estimates for this stock because of changes in stock unit and assessment method in 2011. Default value used from ICES, 2015 (WKMSYREF3).
Autocorrelation in assessment error in the advisory year	0.423	No robust estimates for this stock because of changes in stock unit and assessment method in 2011. Default value used from ICES, 2015 (WKMSYREF3).

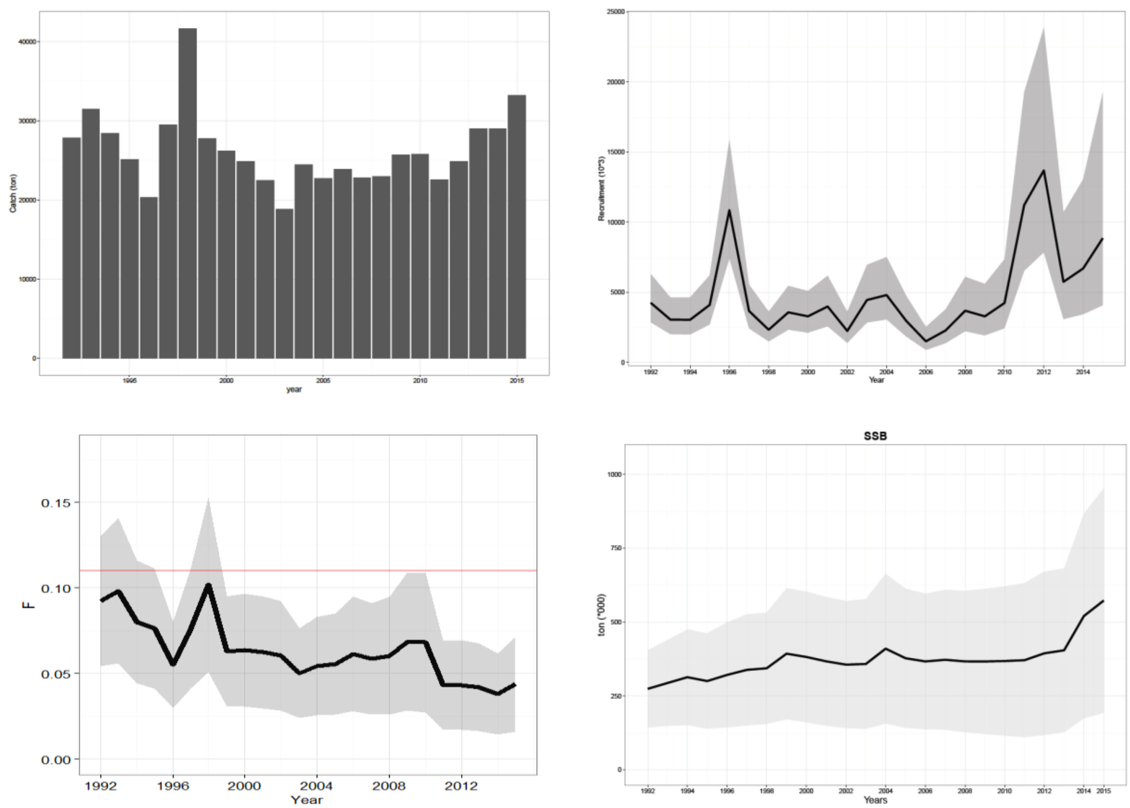

Figure 1. Horse mackerel (*Trachurus trachurus*) in Division IXa (Southern stock). Stock summary used as the basis for the BRP evaluation. Upper panel: Yield (left) and Recruitment (right). Lower panel: Fishing Mortality with the current F_{msy} proxy level (right) and Spawning Stock Biomass (left).

Results

Stock recruitment relation

The full available SSB-R data were used to fit stock recruitment models. The weighted parameter estimation (accounting for the observed σ^2 of the SSB-R data) of the Ricker model showed very poor model fit, the Beverton-Holt did not fit to data and the segmented regression fits with a breakpoint high in the SSB data cloud (Figure 2). Given the lack of evidence supporting a specific S-R model, the EqSim software was also run using the three models weighted by the default "Buckland" method. However, both the Ricker and Beverton–Holt curves increased without reaching a plateau and the segmented regression fits with a high breakpoint well outside the range of observed SSB (Figure 2).

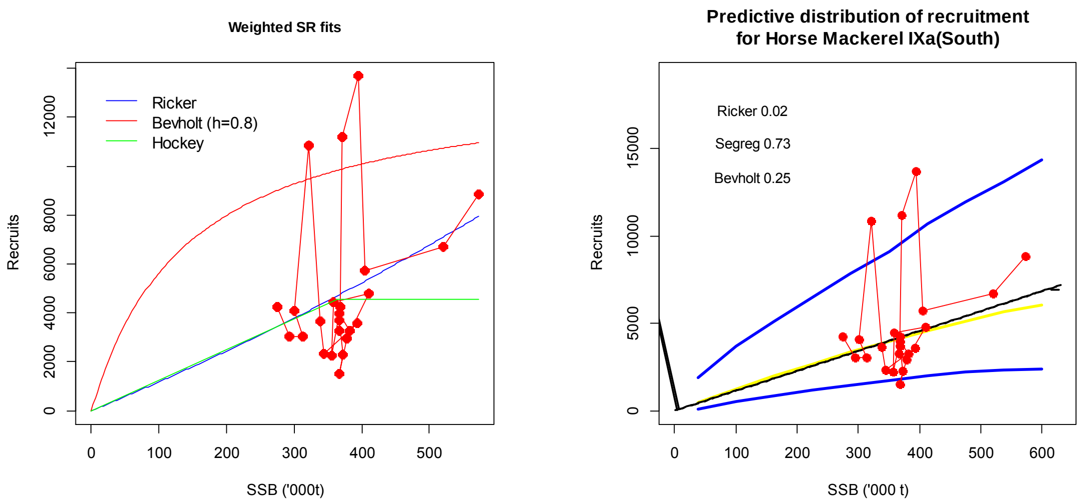

Figure 2. Stock recruitment relationships: left panel: weighted fits to Ricker (blue) Hockey-stick (green) and forced Beverton–Holt at steepness h=0.8 (red). Right panel: EqSim summary of the default "Buckland" method for Ricker (yellow), Hockey-stick (black dotted) and Beverton-Holt (black dashed) with 90% intervals (blue).

The southern horse mackerel shows no obvious S-R relationship. SSB shows a stable and narrow dynamic range and erratic recruitments with occasional strong year classes. There is no evidence of reduced reproductive capacity at any of the observed SSB levels. It was decided that given the high biomass condition of the stock associated with low fishing mortality, below the current F_{MSY} proxy, there was support to fit a segmented regression with a forced breakpoint at 181 kt. as the mean lower bound of the 90% CI of the observed SSB (Figure 3). The 90% CI most probably encompasses the true B_{MSY} and the 5th percentile of the observed SSB was proposed as a candidate for $B_{trigger}$.

The Hockey stick model has the advantage to do minimal assumptions for the stock–recruitment relationship, with constant recruitment after the breakpoint being a neutral option compared to Beverton–Holt (where recruitment slightly increases after a certain biomass level) or Ricker (where recruitment decreases after a certain biomass level) (ICES 2016).

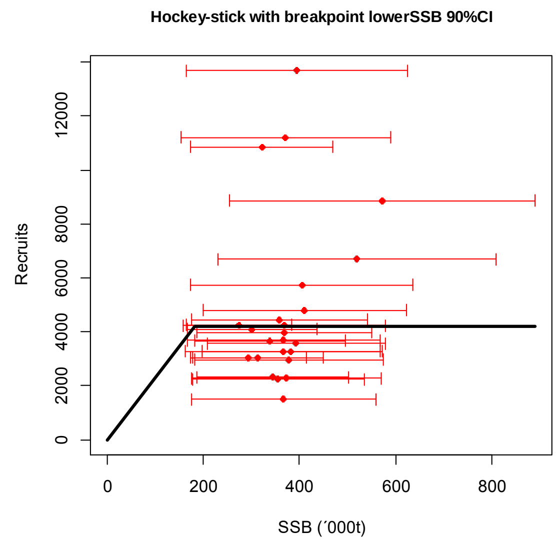

Figure 3. Southern horse mackerel stock recruitment data with 90% CI of the SSB data (red lines) and the proposed segmented regression model with a forced breakpoint at 181 kt.

B_{lim} and B_{pa}

B_{lim} has not been defined for the southern horse mackerel stock. In order to analyze an F_{MSY} candidate in relation to precautionary limits, i.e. prob(SSB< B_{lim}), a B_{lim} needs to be defined. Lowest observed SSB and breakpoints of segmented regressions are both approved ways of deriving BRP. For the purpose of this study and considering the above stated historical considerations for this stock a proxy for B_{lim} was derived as $B_{lim} = B_{pa} * \exp(-1.645\ \sigma) = 103$, where B_{pa} is the segmented regression breakpoint with $\sigma = 0.34$ as the standard deviation of SSB in the final assessment year.

Eqsim analysis

A run (not shown) with error in population and productivity parameters but with no error in the advice was carried out to estimate F_{lim} at 0.19 and $F_{pa} = F_{lim} * \exp(-1.645\ \sigma) = 0.11$, with $\sigma = 0.32$ as the standard deviation of F in the final assessment year (Table 3).

Reference points were calculated based on the proposed segmented regression with a fixed breakpoint. Population, productivity parameters and assessment error and autocorrelation were used (Table 2) and, when used, $B_{trigger}$ was set at 181kt. Results with the segmented regression and no $B_{trigger}$ (i.e, without applying the ICES MSY AR) for both yield and SSB are shown in Figure 4. The median F_{MSY} estimated by Eqsim applying a fixed F harvest strategy was estimated at 0.15. Based on the ICES general guidelines for determining F_{MSY}, it was also tested whether fishing at F_{MSY} is precautionary in the sense that the probability of SSB falling below B_{lim} in a year in long term simulations with fixed F is ≤ 5% ($F_{p.05}$). The $F_{p.05}$ was estimated at 0.15 and therefore the F_{MSY} (0.15) is not restricted because of this precautionary limit, but since F_{MSY} is above F_{pa} then $F_{MSY} = F_{pa}$.

The ICES MSY AR was applied to check that F_{MSY} and $B_{trigger}$ combination adheres to the precautionary considerations ($F_{MSY} \leq F_{p.05}$). Results of the Eqsim run with $B_{trigger}$ for both yield and SSB are shown in Figure 5. Simulations with $B_{trigger}$ returned a little higher F_{MSY} level at 0.16 but well below $F_{p.05} = 0.23$ implying that fishing at F_{MSY} and the proposed $B_{trigger}$ is precautionary.

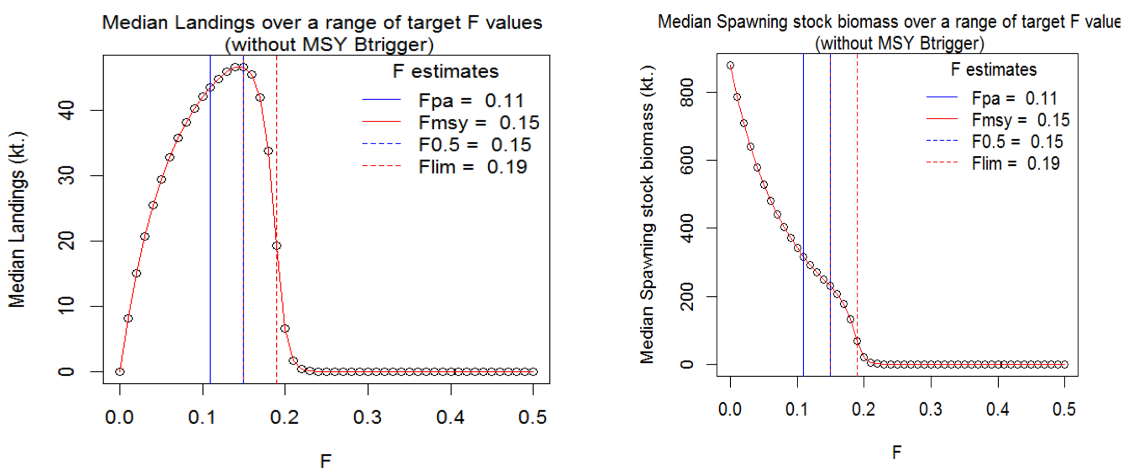

Figure 4. Southern horse mackerel median landings yield curve (left panel) and median SSB curve (right panel) with estimated reference points (without MSY Btrigger). Blue lines: F_{pa} estimate (solid) and $F_{p.05}$ (dotted). Red lines: F_{msy} estimate (solid) and F_{lim} (dotted).

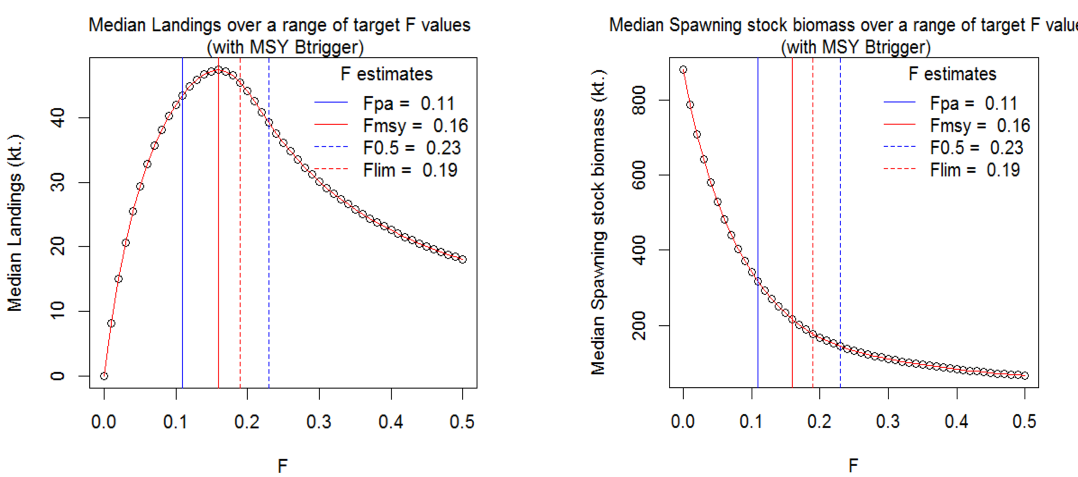

Figure 5. Southern horse mackerel median landings yield curve (left panel) and median SSB curve (right panel) with estimated reference points (with ICES MSY AR). Blue lines: F_{pa} estimate (solid) and $F_{p.05}$ (dotted). Red lines: F_{msy} estimate (solid) and F_{lim} (dotted).

<u>Biomass reference points without considerations involving historical fishing mortality</u>

On a trial basis and disregarding all the historical considerations for this stock, stochastic simulations were run following the ICES (draft, June 2016) guidelines for fisheries management reference point for category 1 stocks. The guidelines have established methods for defining stock type based on stock recruitment data and reference point's estimation methods. The southern horse mackerel stock recruitment data characteristics falls within type 6 category stocks defined as "stocks with a narrow dynamic range of SSB with only low fishing mortality and no evidence that recruitment is or has been impaired" and, "If the fishing mortality is low judged by conventional reference points …, then this may actually be a stable stock for which the B_{pa} should be defined as the B_{loss} value". Accordingly, B_{pa} was set to 274 kt (SSB in 1992) and B_{lim} derived as 157 kt. $B_{trigger}$ cannot be higher than B_{pa} therefore, $B_{trigger}$ was set at 274 kt. Exploratory runs were made (not shown) following the same settings as in Table 2 and with a SR segmented regression with B_{lim} as breakpoint. F_{lim} was estimated at 0.20, F_{pa} derived as 0.12 and F_{MSY} estimated as 0.16, above $F_{p.05}$ (0.15) and F_{pa}. The simulations with F_{MSY}=F_{pa}=0.12 and B_{lim} at 157 kt estimated median B_{FMSY} as 299 kt (median) and the 5% percentile B_{FMSY} as 219 kt.

Discussion

Defining Biomass reference points without considerations involving historical fishing mortality of southern horse mackerel stock, $B_{trigger}$ is set at 274 kt, being well above the 5% percentile of B_{FMSY} (5%B_{FMSY}) and close to the median B_{FMSY} (the expected equilibrium biomass when fishing at F_{MSY}) from stochastic simulations. In fact, it is inconsistent that $B_{trigger}$ is much higher than 5%B_{FMSY} since $B_{trigger}$ should be the lower bound to the biomass for MSY exploitation. The stock time series does not suggest any recruitment impairment within the observable stock levels and this trial run confirmed that B_{loss} is not applicable as a B_{pa} proxy (or to derive MSY $B_{trigger}$ = B_{pa}) for this particular stock with exploitation well below F_{MSY} over the entire time series (1992-2015).

Proposed reference points

Table 3. Summary table of proposed stock reference points

BRP	Value	Technical basis
B_{lim}	103	B_{lim} = B_{pa} * exp(-1.645 σ) σ = 0.34
B_{pa}	181	B_{pa} = $B_{trigger}$
$B_{trigger}$	181	Lower bound (average) of 90%CI of $SSB_{1992-2015}$
F_{lim}	0.19	Stochastic long-term simulations (50% probability SSB > B_{lim})
F_{pa}	0.11	F_{pa} = F_{lim} * exp(-1.645 σ) σ = 0.32
F_{MSY}	0.11	Stochastic long-term simulations; constrained by Fpa (F_{MSY}=F_{pa})

Sensitivity

Recruitment for this stock has occasional strong year classes (i.e. 1996, 2011, 2012, 2015), exploratory runs were made to investigate the sensitivity of the results to the occasional high recruitments. By removing these strong recruitments from the long-term simulations we are assuming a shallower slope in the fitted segmented regression for the long term simulations. Because we are assuming a lower stock resilience and productivity, the sensitivity test did give slightly lower F_{lim} (0.16), F_{pa} (0.09), F_{MSY} (0.12) and $F_{p.05}$ (0.13) values with lower Yields and SSB levels. From historical data there is no reason to believe that this stock on the long term will never produce strong year classes, but despite the strong unrealistic assumption the results were relatively insensitive (change in F´s ≈ -0.02). The proposed BRP´s seem robust to current recruitment assumptions.

A second sensitivity test was carried out using fewer years for selectivity (5yrs *vs* 10yrs) because of the small changes in the selection pattern to increased selectivity of young ages and decreased selectivity of older ages in recent years. The results were unchanged from the proposed BRP´s.

The proportion mature and natural mortality for this stock are age dependent but assumed constant over the historical time series. The sensitivity of the model to the inclusion of additional stochastic variability in proportion mature and/or natural mortality as a proxy for e.g. environmental driven changes could also be further tested.

References

ICES. 2012. Report of the Working Group on Southern Horse Mackerel, Anchovy and Sardine (WGHANSA), 23–28 June 2012, Azores (Horta), Portugal. ICES CM 2012/ACOM:16. 544pp.

ICES. 2015. Report of the Joint ICES–MYFISH Workshop to consider the basis for FMSY ranges for all stocks (WKMSYREF3), 17–21 November 2014, Charlottenlund, Denmark. ICES CM 2014/ACOM:64. 156 pp.

ICES. 2016. Report of the Workshop to consider FMSY ranges for stocks in ICES categories 1 and 2 in Western Waters (WKMSYREF4), 13–16 October 2015, Brest, France. ICES CM 2015/ACOM:58. 187 pp.

ICES 2016b. Report of the Working Group on Southern Horse Mackerel, Anchovy and Sardine (WGHANSA), 24-29 June 2016, Lorient, France. ICES CM 2016/ACOM:XX.

Annex 03 Working Documents

List of working documents

WD1: Marques *et al.* PELAGO16

WD2: Morenao *et al.* Otholiths Cadiz 2016

WD3: Riveiro and Carrera PELACUS0316

WD4: DEPM Anchovy BoB Bioman 2016

WD5: Ramos *et al.* ECOCADIZ 2015-07_WGHANSA 2016

WD6: Ramos *et al.* ECOCADIZ-RECLUTAS 2015-10_WGHANSA 2016

Working Document to be presented to the WGHANSA, Lorient, 24 -29June 2016

Spring 2016 Acoustics and DEPM surveys in ICES area IXa. (PELAGO16 and PT-DEPM16-HOM)

Sardine and Anchovy echo-acoustics estimations

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ABSTRACT

In 2016 the acoustic survey PELAGO16 and the horse-mackerel DEPM survey were carried out simultaneously onboard RV "Noruega", from the 11st of March (beginning of data collection) to the 01st of May. Acoustic surveying was conducted during the day while during the night, plankton samples and CTDF casts were obtained for the DEPM (horse-mackerel and sardine). Fishing hauls were performed taking into account the objectives of the joint surveys. This document presents the acoustics estimations for sardine and anchovy to be addressed to WGHANSA whilst at present the egg distributions and DEPM results are only partially available.

The main objective of the PELAGO16 survey was to describe the sardine and anchovy spatial distributions and to estimate their abundance off the Portuguese and the Spanish Gulf of Cadiz shelves. The estimated sardine biomass was 172 thousand tonnes, representing an important increase in relation to the 2015 survey and reflecting mainly the abundance in a restricted area of the OCS (ICES IXaCS) and Algarve (ICES IXaS) areas. In the Gulf of Cadiz, one of the main recruitment areas of the Iberian sardine stock, there was a marked increase of sardine abundance, mainly of juveniles (99.8%).

Anchovy estimated biomass was very high (103.6 thousand tonnes), above the historical mean, mainly due to the Gulf of Cadiz anchovy biomass estimation (65.4 thousand tonnes). However this value must be regarded with care and be confirmed by the IEO ECOCADIZ survey in July. Off the Portuguese West coast there was also an anchovy "boom" and the resulting estimation (38.3 thousand tonnes) was also above the historical mean.

The survey started at the Portugal-Galicia border and proceeded from there south but due to adverse weather and some logistics constraints it was not carried out sequentially hence the apparent discontinuity in the sea surface distribution. Globally, the surface water temperatures were below the values observed for other years during similar period (~12-18ºc). This was more evident, during the first leg of the survey on the northern shelf where quite an extended area was occupied by surface waters with temperatures between 12-13ºC.

Preliminary results, from one of the paired CalVET nets, showed sardine eggs distribution overlapping quite well with the main sardine schools identified by acoustics. Egg abundances were however very low, in fact the lowest of the DEPM historic series, even considering 2014 when the survey was also delayed. In addition, the spawning area defined for both the western and the southern shores were the smallest of the whole data series. Consequently these initial results indicate very low egg production estimations for the period of the survey. These observations may be partially explained by the size structure of the population which included a very large proportion of young sardines, likely first year spawners or even still immature individuals.

1. INTRODUCTION

The acoustics surveys, PELAGO series, and DEPM surveys (for sardine and for horse-mackerel) are funded via EU-DCF and national programmes The Portuguese acoustic survey , takes place each year during spring covering the shelf waters of Portugal and Cadiz Bay being coordinated within the ICES –WGACEGG (Working Group on Acoustics and Egg Surveys) with the Spanish and French surveys. The main objectives of the campaign include monitoring the abundance distribution through echo-integration, and the study of several biological parameters for sardine (*Sardina pilchardus*), anchovy (*Engraulis encrasicolus*), chub-mackerel (*Scomber colias*), horse-mackerel (*Trachurus trachurus*) and other small pelagic fishes. Surveying also considers continuous observations of fish egg and larvae along the acoustic transects (CUFES-Continuous Underway Fish Egg Sampler) and hydrological and biological characterization of the water column. Additionally, census of marine birds and mammals are conducted during the survey trajectory.

Surveys directed at the estimation of the spawning stock biomass (SSB) through the Daily Egg Production Method (DEPM) are conducted on a triennial basis and in different years for sardine and for horse-mackerel (and AEPM for mackerel). The survey PT-DEPM16-HOM is coordinated within ICES-WGMEGS (Working Group on Mackerel and Horse-mackerel Egg Surveys) and is part of the international effort which covers the area from Cadiz Bay to the Faroe Islands. The Portuguese survey is scheduled to comprise the area of the horse mackerel southern stock in January-February. The DEPM methodology involves surveying of the target species distribution area for plankton collection (and CTD casts) along a pre-defined grid of stations for spawning area definition and egg density and production estimations. Concurrently fish hauls are performed for adult parameter estimation: female mean weight, sex-ratio, batch fecundity and daily spawning fraction. The DEPM plankton survey design for horse mackerel and sardine are very similar (with an extended area for horse mackerel compared to the sardine stock limits but with a larger distance between transects) and therefore the samples obtained can be used for egg production estimations for both species. Therefore in 2016 it was also decided to collect extra fish samples in order to gather ovaries for daily fecundity estimations not only for horse mackerel but also for sardine.

In 2016, operational constraints retarded the horse mackerel DEPM survey, due to start in January, in several weeks, this fact led then to the decision to carry out both surveys, DEPM and acoustics (due to occur in spring), concurrently and using the same vessel. Nonetheless, the western Galician coast, part of the southern stock area for horse mackerel, was not surveyed owing to permissions misunderstandings. In addition, due to adverse weather conditions and technical issues, the survey was interrupted several times and the coverage was not synoptic, neither in time nor in space. Despite the fact that the joint survey took 31 working days to be completed there was a time span of nearly eight weeks between the start and the end dates (11st March to 1st May). Table 1 presents the survey summary by geographical area.

2. ACOUSTIC SURVEY

MATERIAL AND METHODS

Acoustics

Survey execution and abundance estimation followed the methodologies adopted by the ICES WGACEGG. The survey area, over the shelf until the 200 m isobath, was covered following a parallel grid with a mean distance between transects of 8 nautical miles. Average survey speed was 8 knots and the acoustic signals were integrated over one nautical mile intervals. Echo integration was carried out with a Simrad 38 kHz EK500 scientific echo sounder. The acoustic data was recorded in MOVIES+ (Weill *et al*., 1993), which was also used to integrate the fish acoustic energy. The echogram bottom was manually corrected prior to the acoustic energy extraction. In the beginning of the survey, an acoustic calibration with a copper sphere was carried out, following the standard procedures (Foote *et al.*, 1981). For presentation purposes and results comparison, the surveyed area was divided, as usual, into 4 sub-areas or regions: OCN (from Caminha to Nazaré), OCS (from Nazaré to Cape S. Vicente), Algarve (from Cape S. Vicente to V. R. Santo António) and Cadiz (from V. R. Santo António to Cape Trafalgar).

Adult fish

To collect the biological data, pelagic and a bottom trawls were used. The trawl samples were also used to identify the species and to split the acoustic energy by species and by length, within each species. Fishing was carried out according to the echogram information. Nevertheless, due to the presence of fixed commercial fishing gears it was not always possible to make hauls in some areas. Biological sampling of sardine and anchovy was performed in each haul. Ovaries from horse-mackerel, sardine and mackerel were preserved for fecundity estimations. In addition, otoliths were collected for sardine, anchovy, horse-mackerel and mackerel. Otoliths are used for age reading and for the production of the Age Length Keys (ALK's). For each species, the abundance (x 1 000) by age group and area is estimated from the combination of the ALK and the estimates of abundance at length from the echo-integration in each area.

RESULTS

TRAWL HAULS

During the survey 52 trawl hauls were performed (Figure 2.1); 23 of these hauls had sardine sampled and 19 of them had anchovy sample. Sardine was usually captured together with other pelagic species, being the most abundant bogue (*Boops boops*), chub mackerel (*Scomber colias*) and horse mackerel (*Trachurus trachurus*). Off the south coast, some Mediterranean horse mackerel (*Trachurus mediterraneus*) were also found. Anchovy was mainly found off Cadiz Bay, but it was also caught, in the west coast, from Matosinhos to Nazaré. Offshore, near the shelf edge, the more abundant species was blue whiting.

Spatial Distribution and abundance

Sardine

As seen in Figure 2.2, in the Occidental North zone (OCN- Caminha to Nazaré), sardine was mainly distributed from Porto to South of Figueira da Foz. In this area 1315 million sardines were estimated, corresponding to 30 thousand tonnes.

In the Occidental South Zone (OCS – Nazaré to Cabo S. Vicente) sardine was concentrated near Ericeira and Cascais. Sardine in this zone presented an estimated biomass of 50 thousand tonnes, consisting in 1322 million individuals.

In the Algarve area, sardine was mainly found between Lagos and Faro. The abundance result for this area was 1249 million sardines (76.7 thousand tonnes).

In the Gulf of Cadiz sardine was found between Huelva and Cadis and was constituted by very young individuals. It was estimated 5558 million individuals, which corresponds to 15.3 thousand tonnes.

Anchovy

Anchovy was found between Porto and Nazaré, being more abundant than in previous years (Figures 2.7 and 2.8). In the West coast, an estimation of 3198 million anchovies was obtained, corresponding to a biomass of 38.3 thousand tonnes.

Anchovy was not found in the OCS zone and in the Algarve.

In the Cadiz Bay, anchovy was mainly distributed from Huelva to Cadiz, usually inside a dense plankton layer. In this area, the biomass and abundance estimated (65.3 thousand tonnes and 9811 million anchovies, respectively) were one of the highest of the whole series. However these values should be later corroborated by the IEO ECOCADIZ survey, because the anchovy acoustic energy in this area was masked by the referred dense plankton layer.

Length and age structure

Sardine

In the OCN zone, sardine presented a trimodal length structure with modes at 11.5 cm, 15.0 cm and 19.5 cm (Figure xx) and was mainly composed of 1 year-old individuals (Figure xx).
Sardine length structure in the OCS zone presented 3 modes (Figure xx): 13.5 cm, 17.0 cm and 20.5 cm. The age structure was also dominated by age 1 sardines (Figure xx).
Off the Algarve, sardine presented a length distribution with a mode around 20.0 cm (Figure xx) and 3 and 5 age groups were the strongest (Figure xx).
In Cadiz, sardines modal length was 6.5 cm and age group 1 dominated.

Anchovy

The anchovy length structure was unimodal in the OCN zone (mode 12.5 cm-13.0 cm) (Figure XXX), and bimodal in Cadiz, with the modal lengths 9.0 cm and 11.5 cm (Figure xxx). The age structure was dominated by age group 1 anchovies in OCN zone (Figure xx) and age groups 1 and 2 in Cadiz Bay (Figure xxx).

OTHER SMALL PELAGIC FISH DISTRIBUTION

Other pelagic species, like chub mackerel (*Scomber colias*) and jack mackerel (*Trachurus trachurus*), were less abundant than usual.

3. PLANKTON AND ENVIRONMENTAL SURVEYING

Methodology

Gear for plankton and hydrology surveying:

- CUFES: mesh size 335 µm, continuous sampling at the surface (~ 3m)
- CalVET: adapted structure (double nets CalVET (40cm mouth opening) + CTDF), mesh size 150 µm, vertical tows through the whole water column
- BONGO: double nets with 60cm mouth opening (mesh size: 200, 500µm), oblique tows through the whole water column
- continuous surface observations of temperature, salinity and fluorescence using onboard sensors associated to the CUFES system
- temperature, salinity and fluorescence (chlorophyll) profiles using a CTDF probe (RBR - Concerto)

During the day the regular surveying, along the acoustic transects, was carried out. Zooplankton samples using the CUFES system and temperature, salinity and fluorescence observations were gathered (Figure 3.1). The data, together with GPS information were compiled using the EDAS software.

DEPM surveying was carried out when acoustics surveying was not running, mainly during the night period. On the pre-defined stations along the DEPM transects CalVET samples (every 3 or 6 nmiles and down to 200m maximum) and CTDF casts were obtained. In addition, CUFES samples were gathered continuously along the path between the vertical plankton tows. To complete the zooplankton surveying, oblique zooplankton tows through the whole water column, were undertaken with Bongo nets at inner and mid shelf locations, alternately, one per transect. CUFES, Bongo and one of the paired CalVET samples, per station, were preserved onboard with buffered formaldeyde solution at 4% in distilled water for further processing in the laboratory. The second of the paired CalVET samples, one per station, were preserved in ethanol to allow genetics analyses for *Trachurus* spp eggs.

Temperature, salinity and fluorescence (chlorophyll$_a$) distributions

In 2016 the joint DEPM and PELAGO survey started on the 11th March off river Minho and ended on the 1st May in front of Lisbon after 31 effective days of work at sea. Due to technical problems and weather constraints the campaign suffered several interruptions which led to temporal and also spatial sampling discontinuities. The temporal and spatial coverage and surveying direction are indicated in table 1 and figure 3.1, which also shows surface temperature, salinity and fluorescence distributions. The sea surface temperature distribution patterns observed reflect the survey discontinuities, with lower values (12-14ºC) at the start, over the NW shelf, where usually the temperature is comparatively lower than in the more southern regions, but below average temperature for early spring were also observed on western Algarve shores. Overall the water temperature was lower than during other corresponding periods in previous years, with only the inner Bay of Cadiz reaching close to 18ºC. During early spring, fresh water effects were still apparent mainly in the NW coast and due particularly to some rainy events which preceded the campaign. Higher fluorescence spots were mostly associated to the colder waters and/or to regions of river influence.

Egg distribution and production estimation

Zooplankton samples were collected with CalVET and Bongo nets and the CUFES system, a summary of the information gathered is presented in table 1. Laboratorial processing is underway and at present the data available derives from one of the paired CalVET nets. The complete results will be presented at the 2016 WGACEGG meeting, in November.

A total of 353 CalVET samples were collected along the 57 transects of the horse-mackerel DEPM survey grid, from the northern Portugal-Spain border to Cape Trafalgar, in the Cadiz bay. Figure 3.2 shows the preliminary results for sardine egg distribution. Although the observations are restricted to one of the paired CalVET it is clear the low egg abundances, and the patchiness of the distribution, in particular in the NW shore and Cadiz area. In fact, the number of eggs collected in the 2016 survey was the lowest of the historic data series and even lower than in 2014 (2653, 1 net, 393 CalVET stations), when the survey took place during a similar period. The highest values in the data set were obtained in 2008, when 11000 eggs were captured in the paired CalVET system (double rings of 25cm diameter). In the spring of 2016 the campaign covered an area of around 32000km^2 in the west coast, of which only just over 10% were defined as spawning ground, and in the southern region, from the 18000km^2 surveyed about a quarter was estimated as the positive egg stratum. These spawning areas were the smallest ever, for both strata, west and south. In agreement with the observations, the egg production estimates were very low (P0_tot S: 0.27 x 10^{12} eggs/m2/day; P0_tot W: 0.12 x 10^{12} eggs/m2/day), lower than in 2011 and 2014 and only comparable to the values of 2002 in the southern region. These preliminary estimates will be updated when the data from the second paired CalVET net are available. The low egg abundances and egg production estimates can be partially explained by the composition of the sardine population which evidenced a high proportion of young fish which were first year spawners or even imature individuals (in particular in the NW and Cadiz regions, figure 3.4); however globally the majority of the fish captured were considered, through macroscopic classification, active spawners. In accordance with the egg density data distribution, the proportion of spawning active sardines, was higher in the Algarve, where more, larger, fish, were observed. Further analyses are also needed in order to better investigate the regional (and temporal) egg production patterns in relation to the population size composition.

During the 2016 survey more anchovy eggs were collected than sardine egg (Figure 3.2). Similar observations have occurred before, in the more recent years when the survey has been taking place later in the season (closer to the anchovy peak spawning period) and also as a result of the increase in the anchovy abundances. Curiously, the higher egg densities were observed in the Cadiz bay, which is usual, but anchovies of the same size range in the west (where the population has been also increasing) were not active and therefore no eggs were there observed (figure 3.5). It is however worth nothing that by the time the first leg of the survey was conducted, in early-mid March, in the NW coast, the water temperature was below 14ºC and when the Cadiz area was surveyed (and where SST is always higher), approximately a month later, the temperatures were well above 16ºC.

ACKNOWLEDGEMENTS

Acknowledges are due to IPMA staff that participated in this survey, for the fellowship and good work. Acknowledges are also due to the “Noruega” crew for the good cooperation.

REFERENCES

Checkley, D. M. Jr; P. B. Ortner; L. R. Settle and S. R. Cummings. 1997. A continuous, underway, fish egg sampler. *Fisheries Oceanography* 6 (2): 58-73.

Foote, K. G., Knudsen, H. P., Vestnes, G., Brede, R., Nielsen, R. L., 1981. Improved Calibration of

Hydroacoustic Equipment with Copper Sphere. *ICES, CM* 1981/B:20, 18p.

Weill, A., Scalabrin, C. and Diner, N., 1993. MOVIESB: An acoustic detection description software. Application to shoal species classification. *Aquatic Living Resources* 6: 255-267.

Table 1. PNAB-IPMA: PT-DEPM16-HOM & PELAGO16. Survey summary, per area.

	OCN (NW)	OCS (SW)	ALG	Cadiz
Research vessel	Noruega	Noruega	Noruega	Noruega
Dates	11-19/03	19-21/03; 1-2/04; 27/04-1/05	9-15/04	21-25/04
Temperature surface (ºC) max/mean/min	14.0/13.2/11.9	16.1/14.7/13.5	16.6/15.2/13.6	17.8/16.9/15.5
SURVEY EGGS & HYDROGRAPHY				
Transects	12	14	9	7
CalVET stations	120	131	70	72
Positive stations PIL	12	11	23	11
Positive stations ANE	0	3	7	22
Tot egg PIL	49	103	757	89
Tot egg ANE	0	11	150	2295
Max egg/m2 PIL	980	2060	15320	1780
Max egg/m2 ANE	0	220	3000	45900
CUFES stations DEPM	178	143	81	76
CUFES stations PELAGO	224	196	86	90
Bongo stations	10	12	9	7
CTDF casts	120	131	70	72
SURVEY ACOUSTICS & FISH				
Number of acoustics transects (nmiles)	17(453)	29(415)	14(166)	11(194)
Number hauls R/V (pelagic/bottom)	13/9	6 /4	8/3	7 /2
Number hauls (comercial vessels) PIL	0	1	0	0
Number hauls (comercial vessels) HOM	2	0	2	0
Number hauls (comercial vessels) MAC	1	0	0	0
Number RV (+) trawls - PIL	8	4	6	4
Number RV (+) trawls - HOM	5	4	6	1
Number RV (+) trawls - MAC	4	0	0	0
Number RV (+) trawls - ANE	8	0	0	4
Depth range (m) of (pelagic/bottom) fishing operations	20-85/73-157	19-49/55-174	20-41/51-117	17-85/51-165
Period of the day for fishing hauls (pelagic/bottom)	8:55-18:55/ 12:12 -17:12	8:32-16:29/ 9:32-18:03	7:51-17:31/ 10:07-17:03	6:31-15:29/ 9:23-15:30
Total PIL sampled	598	337	503	220
Total HOM sampled	281	301	435	63
Total ANE sampled	451	0	0	244
Total MAC sampled	302	0	0	0
Ovaries preserved - PIL	170	120	150	**0?**
Ovaries preserved - HOM	36	1?	168	**0?**
Ovaries preserved - MAC	133	0	0	0
Otoliths - PIL	372	179	237	153
Otoliths - HOM	176	161	273	63
Otoliths - ANE	165	0	0	102
Otoliths - MAC	162	0	0	0

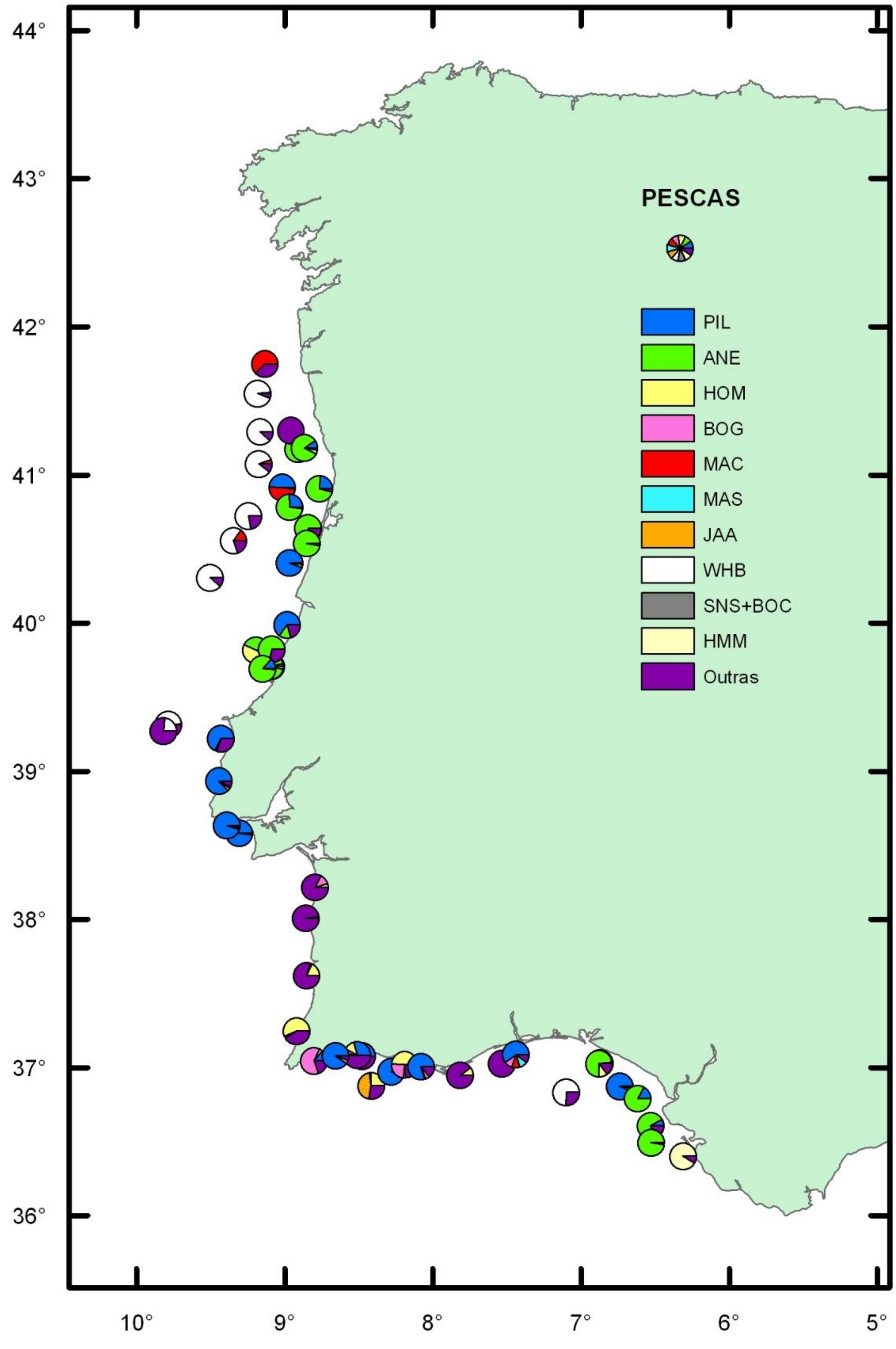

Figure xx – PELAGO16: Fishing trawl location and haul species composition (in number). (PIL-sardine, ANE-anchovy; BOG-bogue, HOM-jack mackerel, MAC-mackerel, MAS-chub mackerel) WHB- blue whiting, JAA- black jack mackerel, HMM- Mediterranean horse mackerel, SNS- snipe fish, BOC- boar fish).

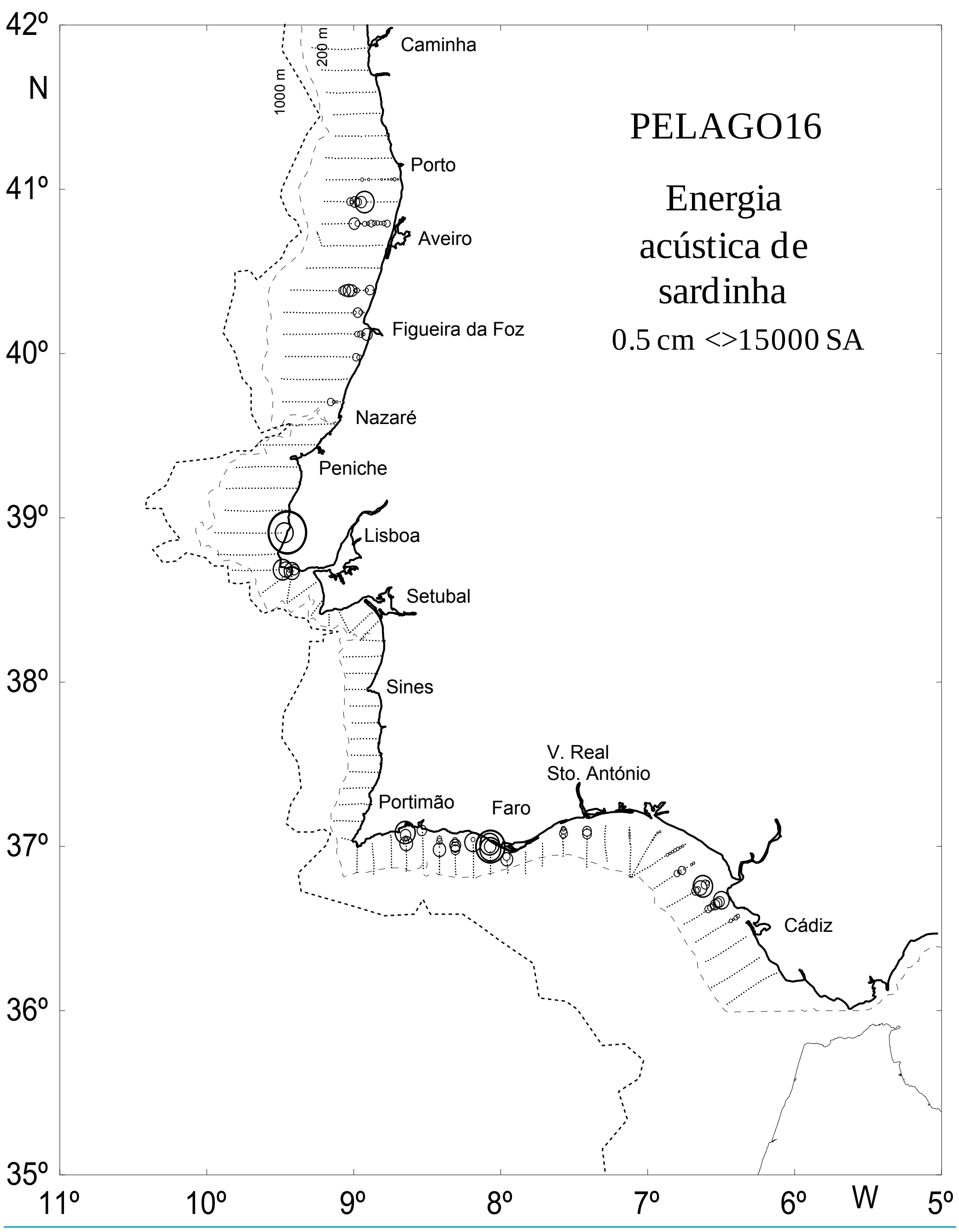

Figure xx – Sardine acoustic energy spatial distribution. Circle area is proportional to the acoustic energy (S_A m^2/nm^2). Sardine abundance and length structure for each zone.

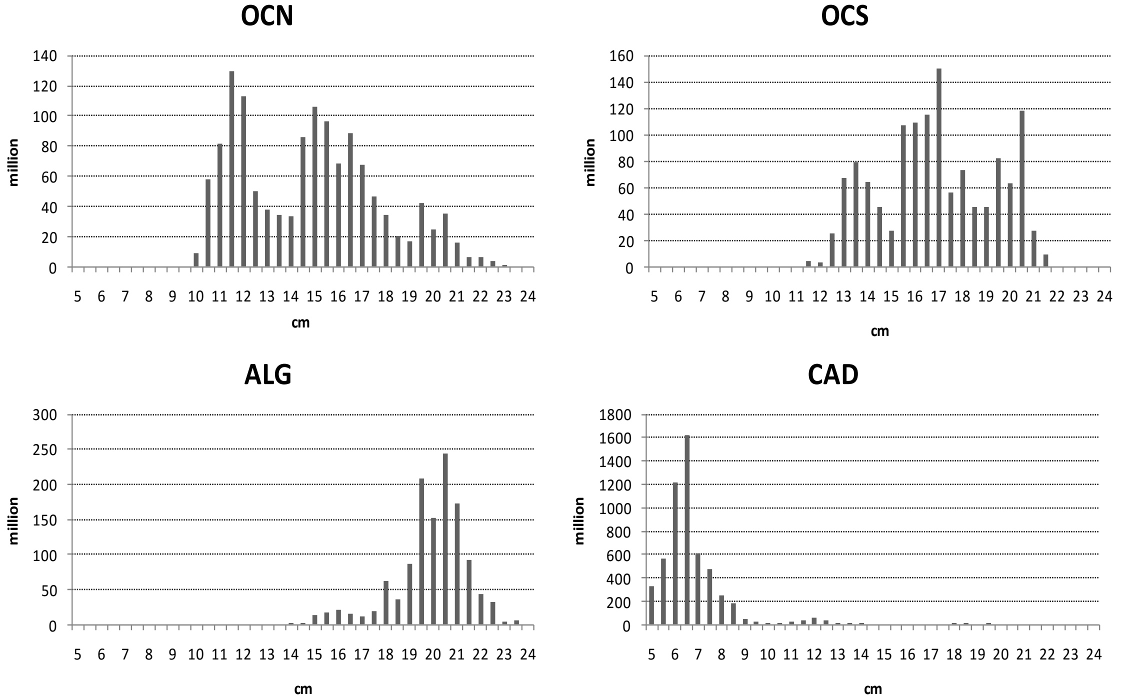

Figure xx – Sardine abundance length distribution, for each zone.

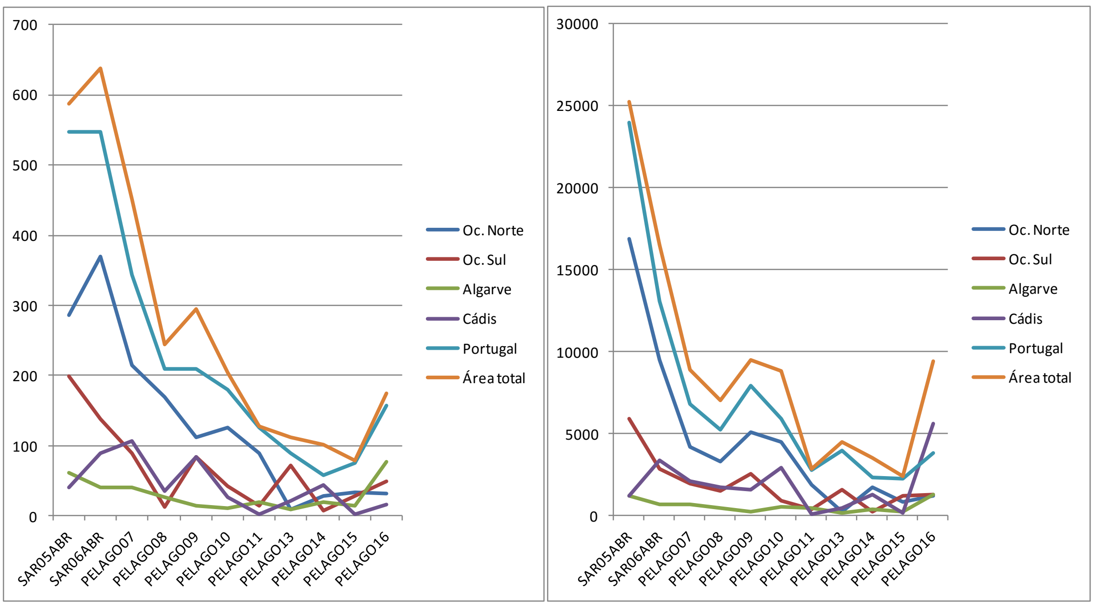

Figure xx– Sardine biomass (thousand tonnes) and abundance (million), in each zone, Portugal and in the total area, along the acoustic survey series since 2005.

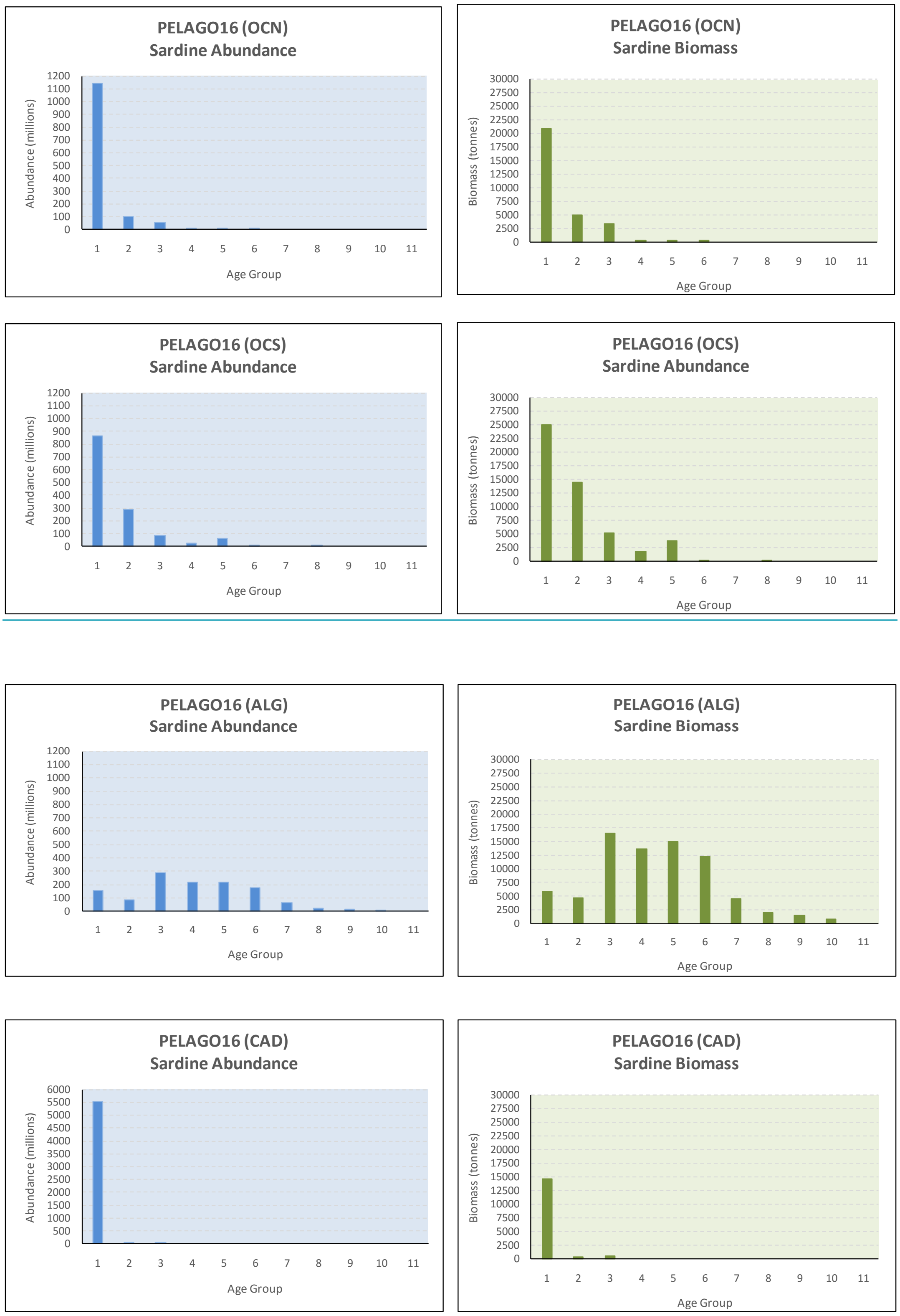

Figure xx– PELAGO16: sardine abundance and biomass, by age group, for the considered geographic areas and for the Total area.

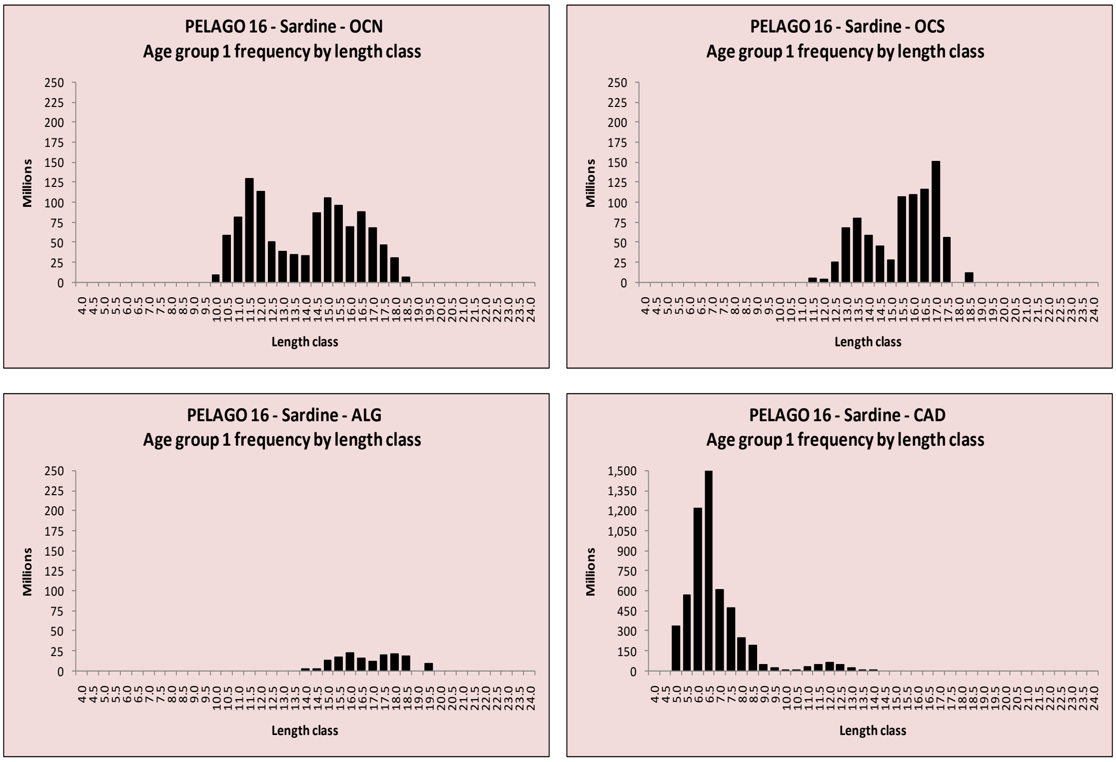

Figure xx- Sardine age group 1 length distribution for each zone.

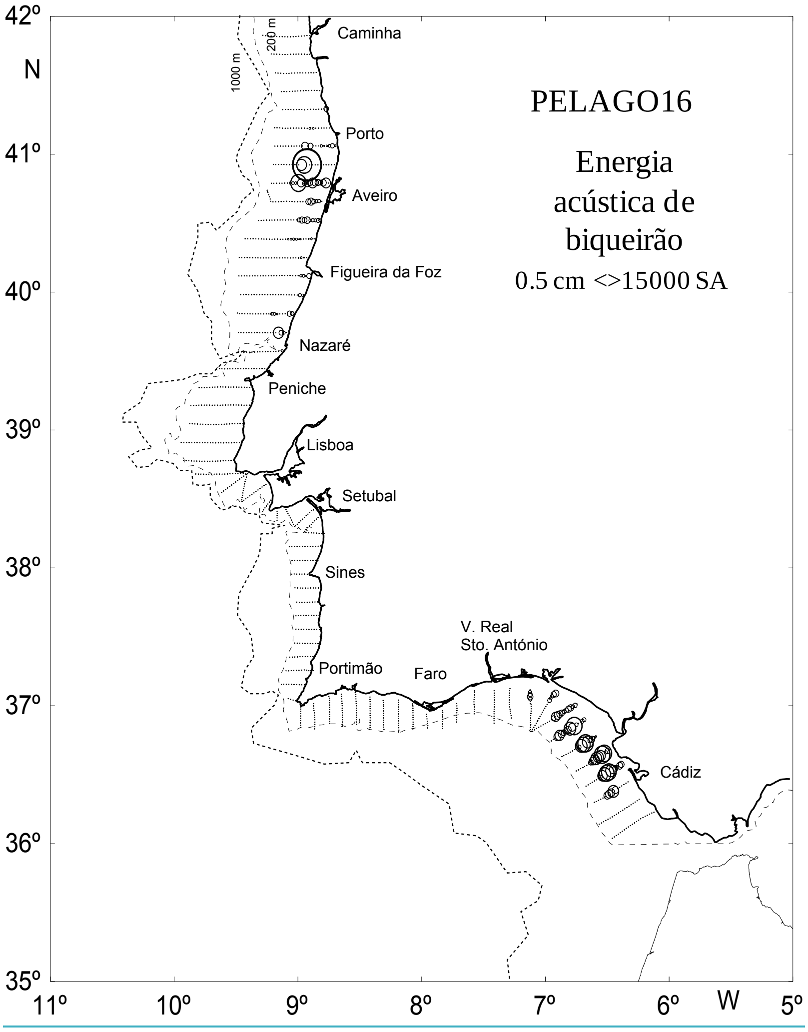

Figure xx– Anchovy acoustic energy spatial distribution. Circle area is proportional to the acoustic energy (S_A m^2/nm^2). Sardine abundance and length structure for each zone.

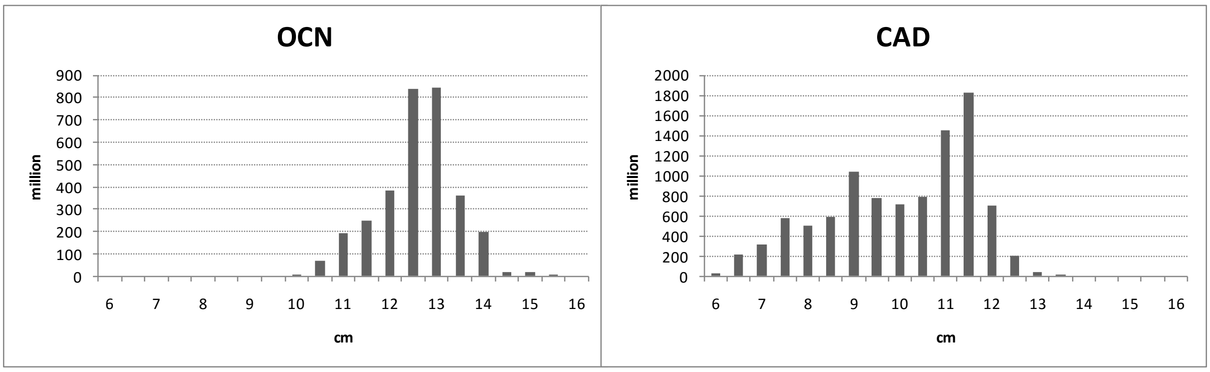

Figure xx – Anchovy abundance length distribution, for each zone.

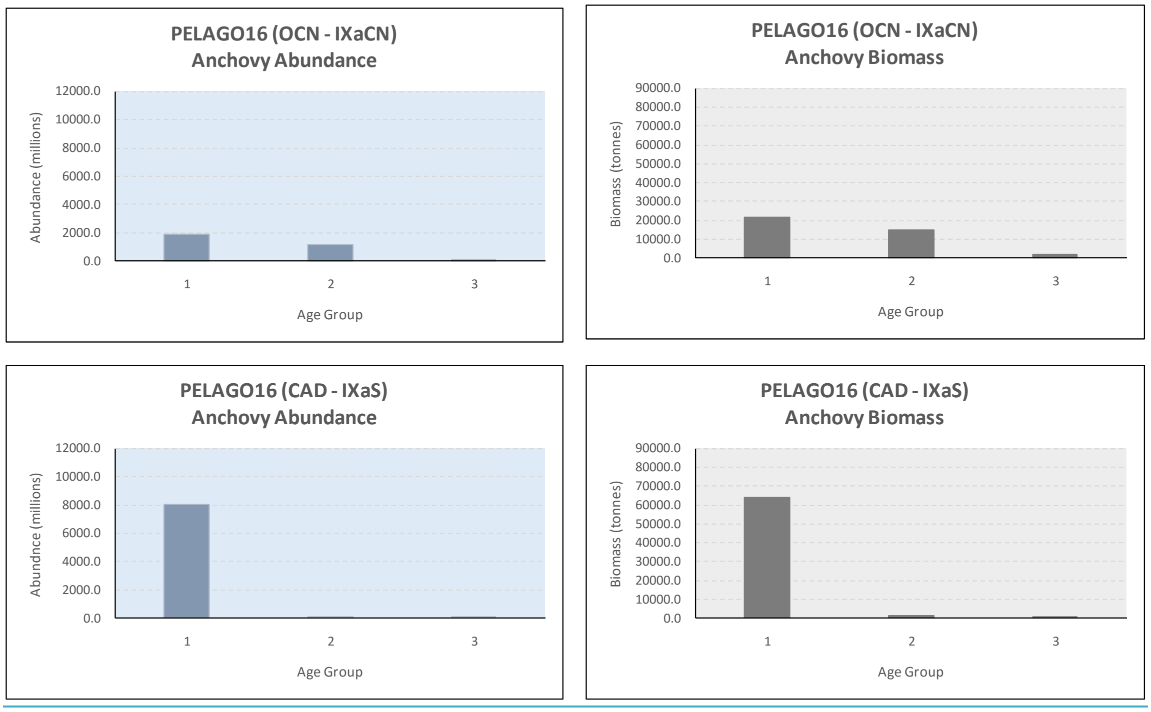

Figure xx – PELAGO16: Anchovy abundance in each age group, for the considered geographic areas.

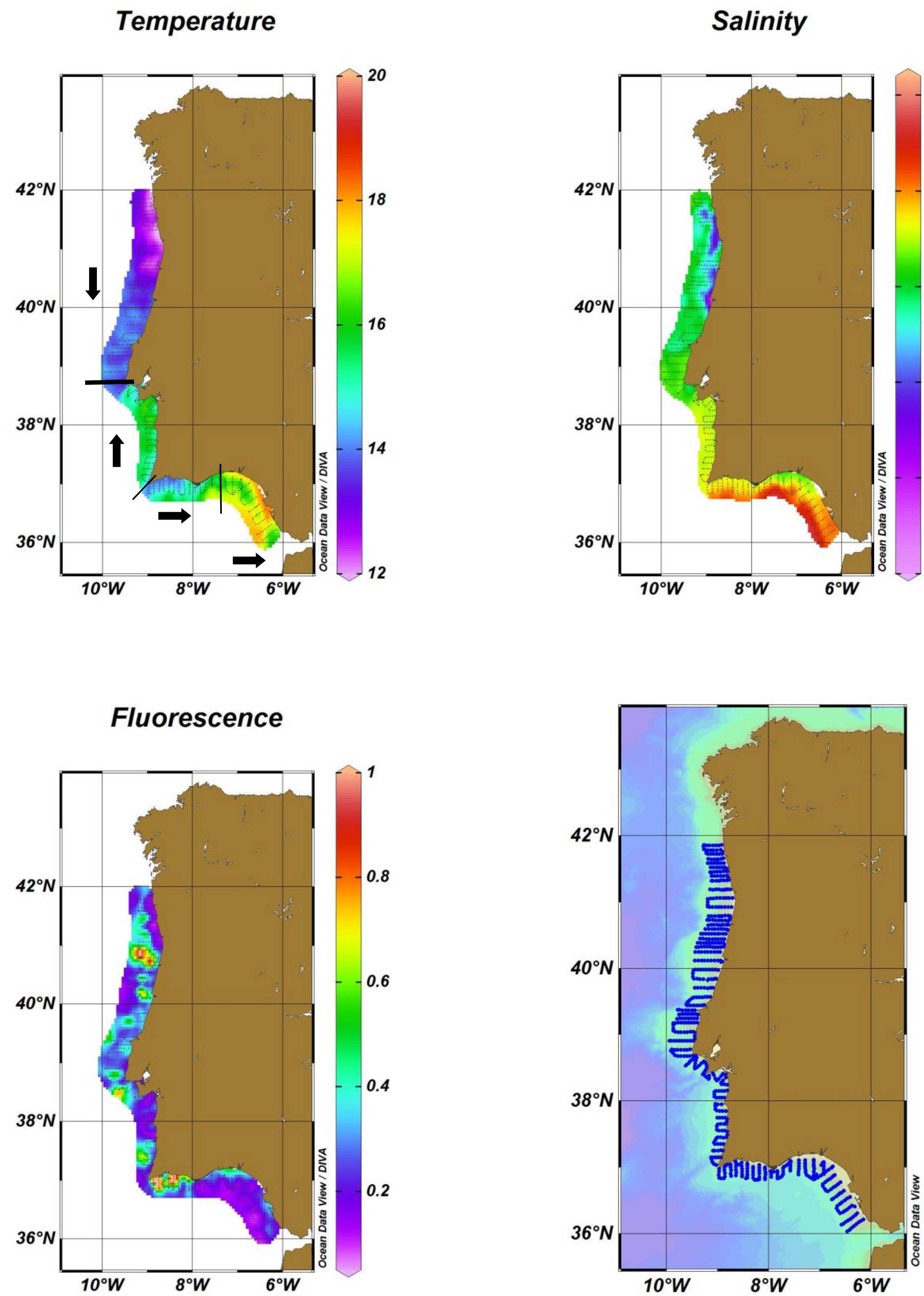

Figure 3.1 – Temperature (ºC) (top left panel), salinity (top right panel) and fluorescence (volt) (bottom left panel) distributions using the data obtained by the sensors associated to the CUFES-EDAS system and location of the CUFES samples (bottom right panel). In the top left panel the black lines indicate the temporal discontinuities in surveying and the black arrows indicate the navigation direction.

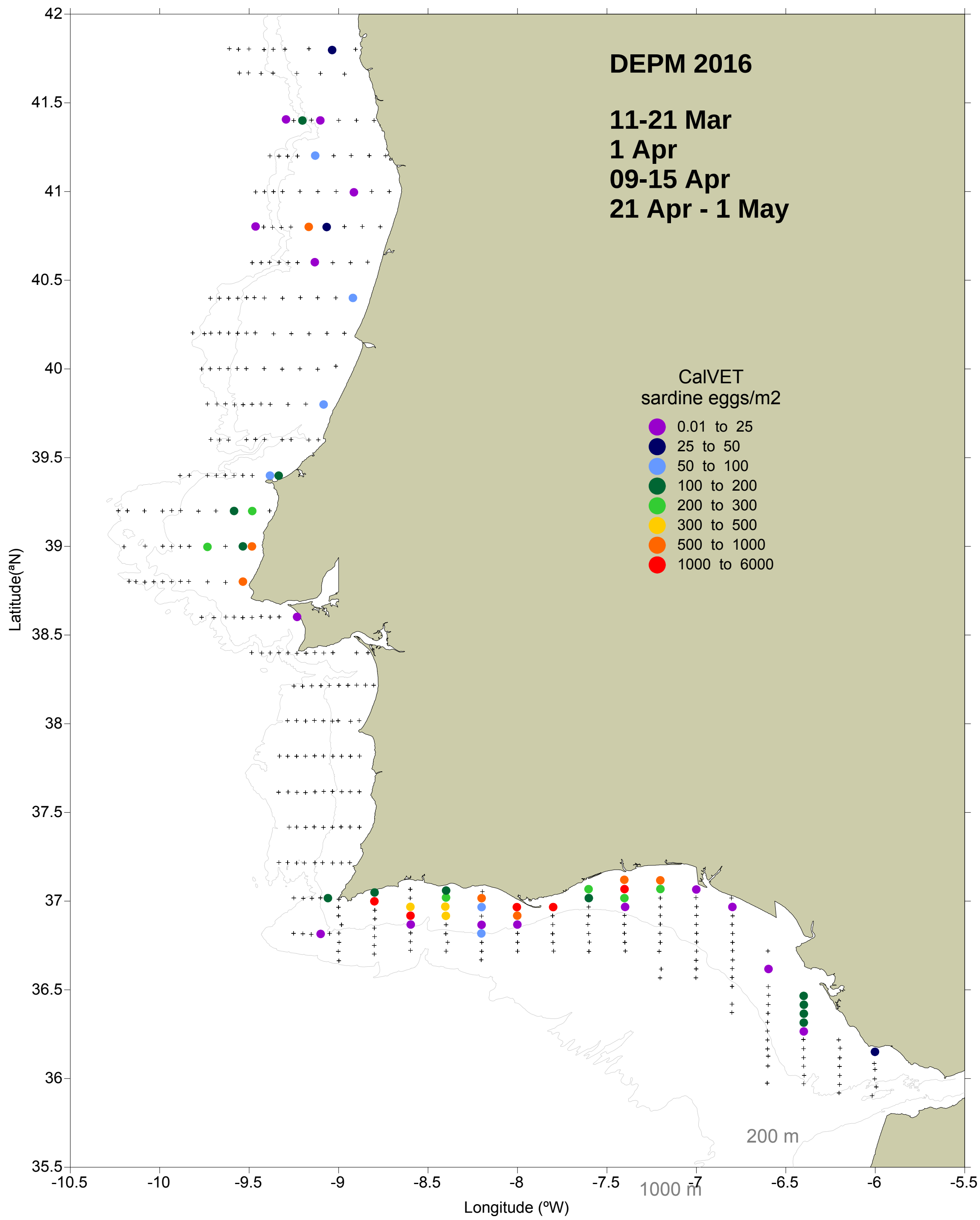

Figure 3.2 – Sardine egg distributions (eggs/m^2). Data from one of the paired CalVET nets (the samples, from the second paired CalVET net and from the CUFES system are being processed and will be available for the 2016 WGACEG meeting).

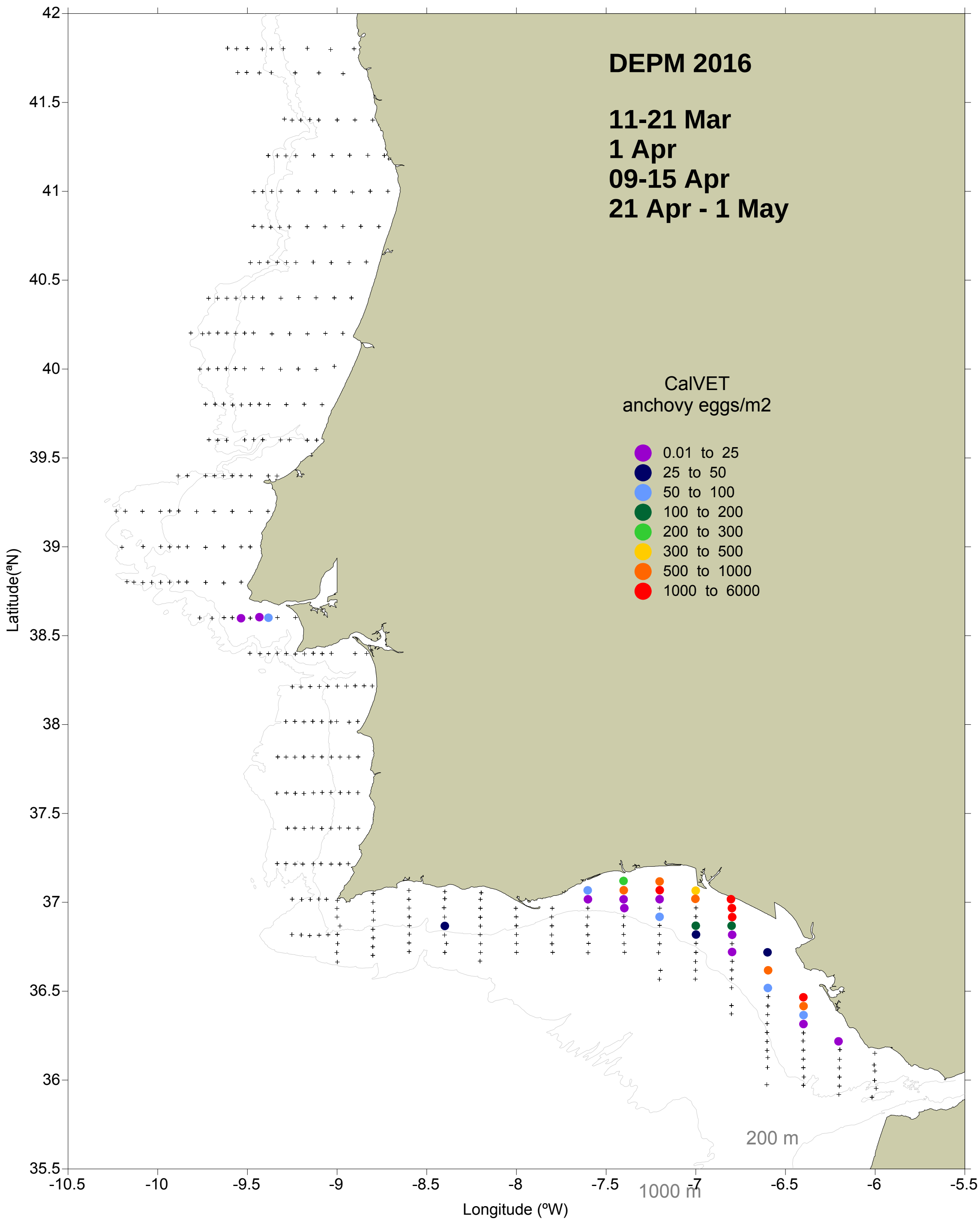

Figure 3.3 – Anchovy egg distributions (eggs/m^2). Data from one of the paired CalVET nets (the samples, from the second paired CalVET net and from the CUFES system are being processed and will be available for the 2016 WGACEG meeting).

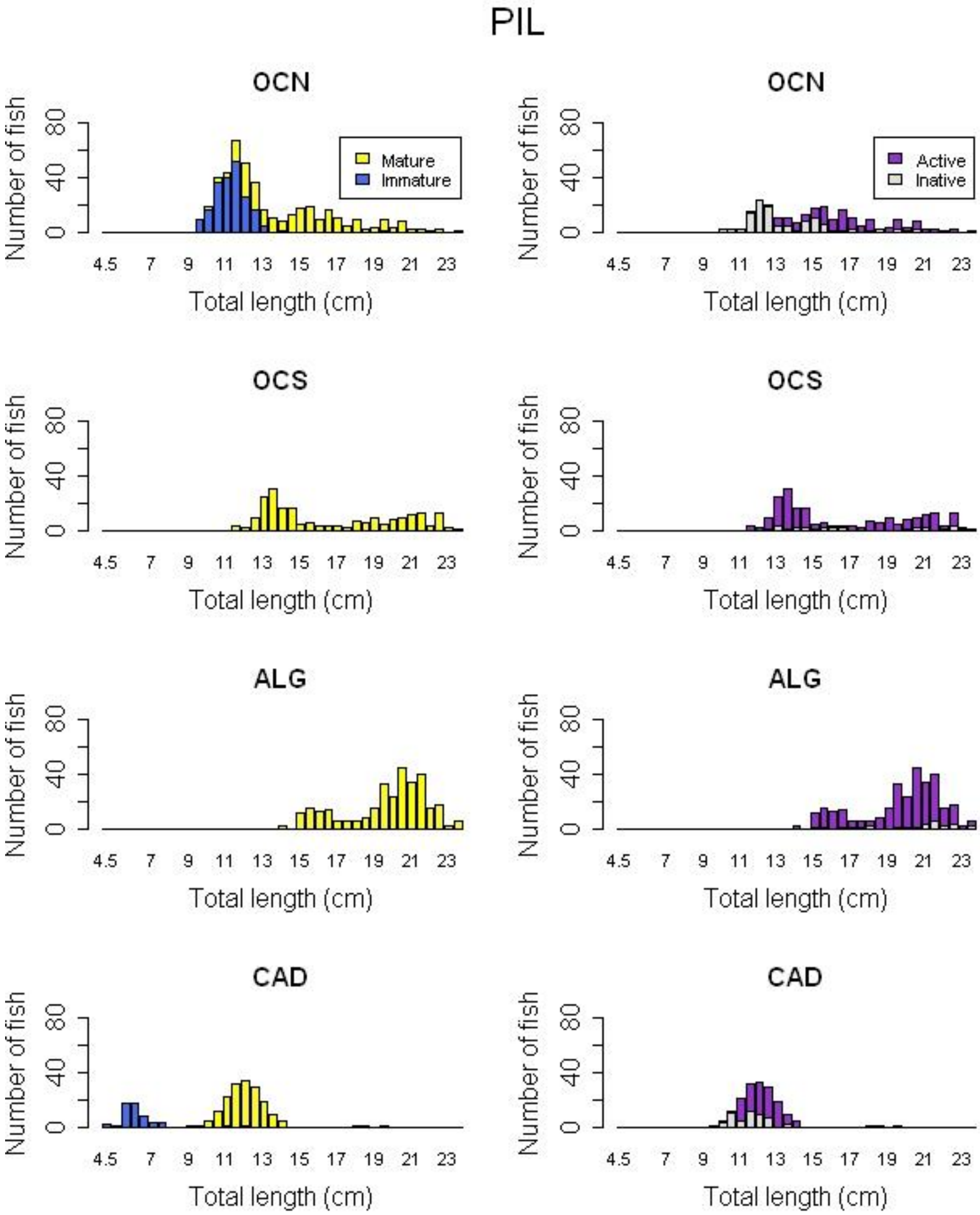

Figure 3.4 – Number of, macroscopically classified, mature vs immature (left panels) and spawning active vs inactive (right panels) sardines, by size distribution in the RV fishing trawls.

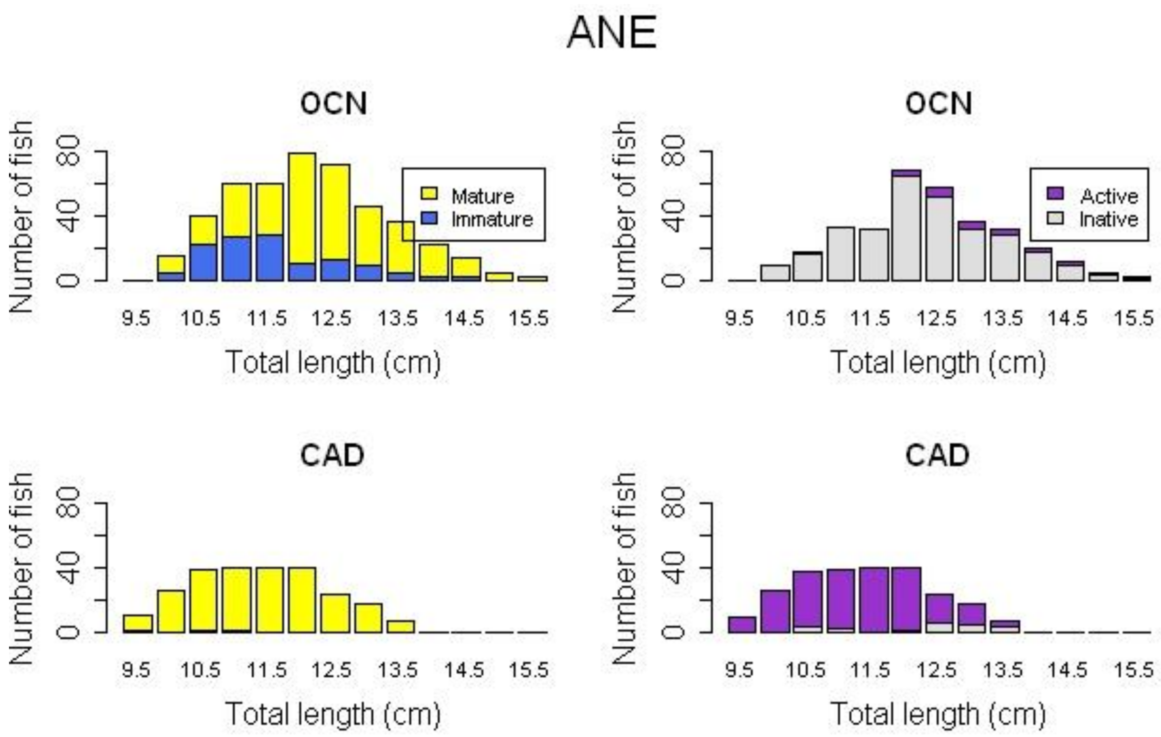

Figure 3.5 – Number of, macroscopically classified, mature vs immature (left panels) and spawning active vs inactive (right panels) anchovies, by size distribution in the RV fishing trawls.

Working Document presented to the WGHANSA, Lorient, 24 -29 June 2016

Pelago 2016 – Age of juvenile sardines in Cadiz area

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Background

For management purposes it is essential to have precise age determinations for captured fish, particularly for recruits, because the assignment of age 0 or age 1 for fish will have enormous impacts in the outputs of the assessment models. Age determinations for *Sardina pilchardus* have been conducted using the microstructure of the otoliths counting daily increments in the larvae and early juveniles and using the macrostructure of the otoliths counting yearly increments for juvenile and adult fish. However, as described below, this methodology has several problems that should be addressed to improve age estimations of sardines, particularly juvenile fish.

Otolith reading and age determination are particularly complicated for small pelagic fishes because it is hard to validate the periodicity of the annual rings due to the structure of their otoliths, where the classical pattern of opaque and translucent seasonal rings are not always easy to detect. A method to overcome this problem is to analyse the marginal increment formation at the macroscopic level, which involves following with samples during the years the formation of the opaque margin, which generally correspondent with the fast growing season (Campana, 2001). The birthdate criterion and the associated interpretation of the otolith margin is an important issue for stock assessment. For age determination purposes, it is assumed that sardines are born on the 1st of January and age is counted as civil years. Opaque zones are formed mainly during summer (fast growing season). Thus, a hyaline margin observed within the first half of the year is assumed to represent the last winter (slow growing season) and counted as an annual growth ring. A hyaline margin observed within the second half of the year corresponds to the following winter and it is not counted as an annual growth ring.

Off the Western and Southern Iberian Peninsula, sardine has an extended spawning season (October-March). Individuals born at the start of the season may be classified in two different year-classes during their first year due to the aging criteria. This may confound year-class strength estimation and bias the initial growth trajectory of successive cohorts (see an example in Figure 1). The importance of these issues was acknowledged in the past, namely during the "Workshop on Sardine Otolith Age Reading and Biology" held in Lisbon in 2005 (Soares et al. 2005).

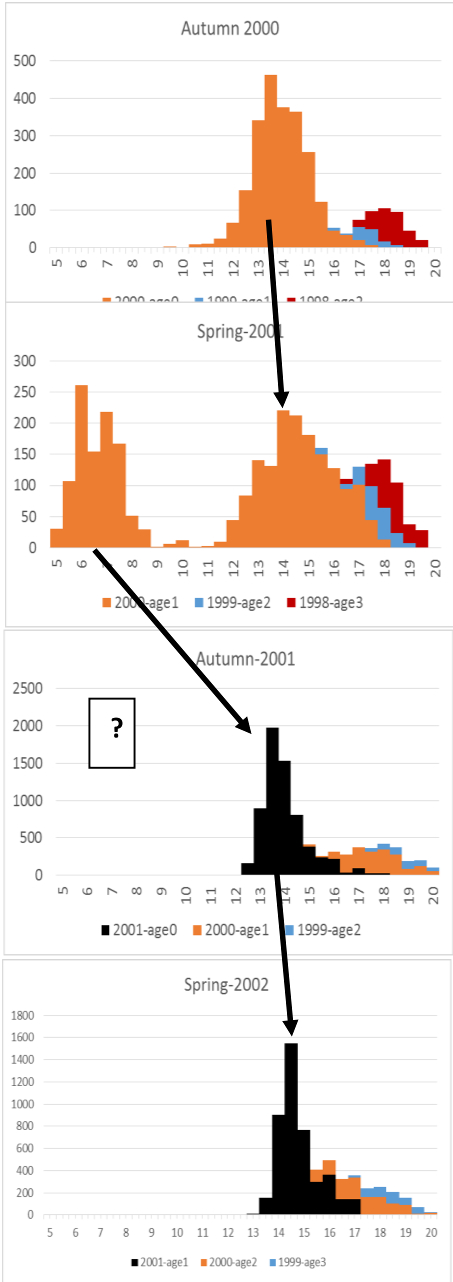


Figure 1. Progression of 2000 and 2001 cohorts in Cadiz.

Workshop participants agreed that changing the otolith margin convention for juveniles during the first semester of the year, could solve the inconsistency of year-class classification. The need for a more detailed analysis of otoliths of juvenile fish and a broader discussion on this subject in other Working Groups for a clear perception of all the problems involved and of the consequences for stock assessment of adopting any alternative birthdate or margin convention was identified. Since that workshop, several works have studied the otolith microstructure of larvae and juvenile sardines from the wild or captured in the wild, but definitive data is still missing and alternatives to the current method of age determination were not yet revised or discussed in the Working Groups.

In order to understand juvenile growth, several age prediction models were developed for juvenile sardines based on daily ring counting in the otoliths (e.g. Alemany et al. 2006; Silva et al., 2015). These authors estimated mean growth rates of 0.041 $cm.d^{-1}$ (Figure 2).

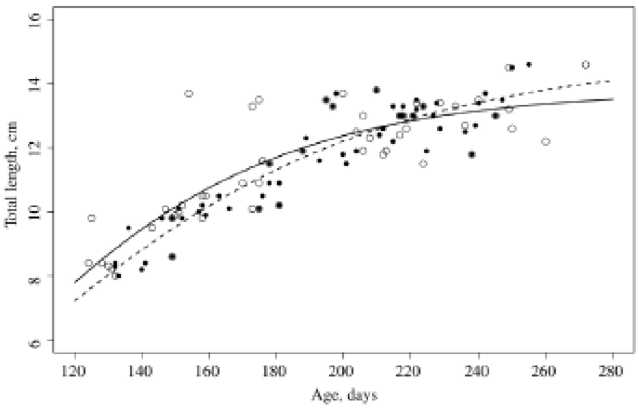


Figure 2 – Gompertz curves of juvenile sardine based on observed ages in the otoliths (open circles and solid line) and model-predicted ages (full circles and dashed line). From Silva et al (2015).

Recent laboratory studies tried to validate age determinations based on otolith microstructure in sardine larvae reared at different temperatures and with different food concentrations (Garrido et al., Soares et al., *in preparation*). These studies showed that increments of sardine larvae are very narrow, particularly at early development, and are below the limit of detection of the universal microscope (were only detected in the scanning electron microscope). Moreover, the deposition of the increments varies with temperature and food availability. On average, larvae with 40 days post-hatch would have 25 increment counts in the otoliths, and will be incorrectly aged 25 days post-hatching, resulting in an overestimation of the growth rate. Therefore age-determinations of sardine larvae age based on counting rings in otoliths analysed in the inverted microscope are unreliable and different methods of age-determination for larvae/ early juveniles should be explored.

To our knowledge, there are no laboratory studies validating the age-determinations for juvenile and adult sardines using otolith microstructure, therefore age-readings using this method must be used with caution. However, it can be seen in sardine otoliths a pattern of alternative hyaline and opaque bands, corresponding to periods of slow and fast growth and such a validation would help determine the timing of the formation of the first ring and knowing if the yearly deposition of increments in the otoliths is valid for this species.

Few published works have reared sardines and determined growth rates in captivity (Blaxter et al. 1969, Iglesias and Fuentes 2014, Caldeira et al. 2014, Silva et al. 2014, Garrido et al., pending revisions). Only the first two reared fish well through the juvenile stage. Results of Caldeira et al. (2014), Silva et al. (2014) and Garrido et al. (pending revisions) growing sardine larvae with different food concentrations and temperatures (13ºC, 15ºC, 17ºC) until 50 days post-hatch are in accordance with Blaxter 1969 results (growing sardines at 15-16ºC), showing that a 2 cm sardine would be roughly 2 months of age (Figures 3 and 4). This growth rate is significantly lower than age determinations estimated for wild fish by analysing the otolith microstructure. This difference can be explained by the lack of validation of daily increments for this species where otolith-derived ages will be consistently underestimated and, consequently, growth rates overestimated. On the other hand, a recent work rearing sardines at higher temperatures (~19ºC, Iglesias and Fuentes 2014, Figure 5) described extremely high growth rates for this species, even higher than those determined for wild fish, where fish would reach on average 7.8 cm at the early age of 3 months old. Therefore sardines with 4 cm would be assigned, according to Blaxter 1969, ≈6 months old whereas according to Iglesias and Fuentes (2014) would be assigned ≈2 months old. This is an impressive difference that must be confirmed in future works and challenges the use of these laboratory estimates without further exploration of the variability of growth for sardine larvae and juveniles and validation of the yearly increments.

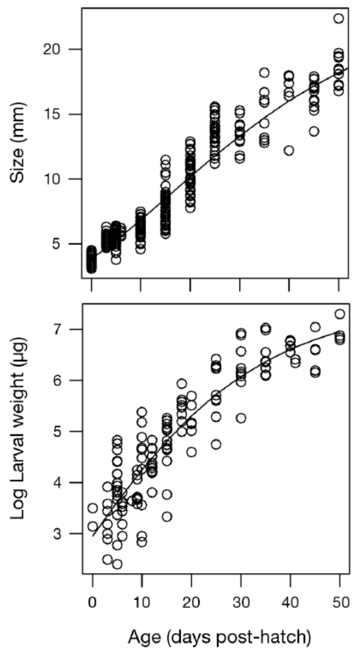


Figure 3 – Results of Caldeira et al. 2014 rearing sardine larvae at 15ºC until 50 days after hatch. Eggs spawned from females caught from Peniche (W Portugal).

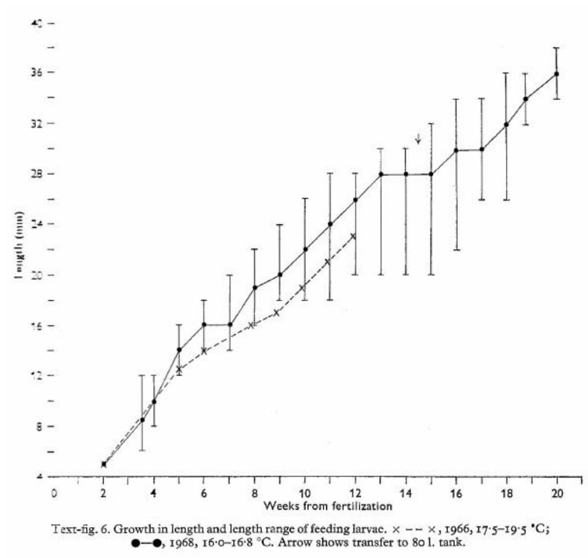


Figure 4 – Results of Blaxter (1969) rearing sardine larvae at 16-17ºC until 18 months after hatch. Eggs caught from Plymouth (UK).

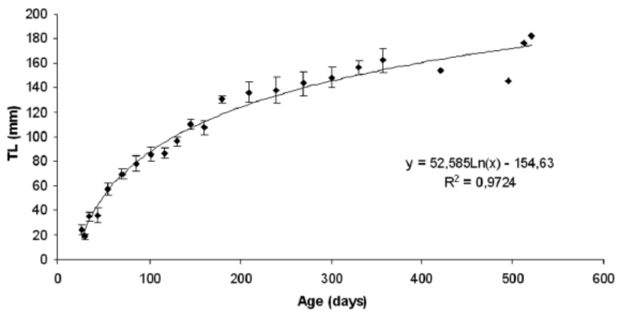


Figure 5 - Results of the Iglesias and Fuentes (2014) rearing sardine larvae at >19ºC until 18 months after hatch. Eggs caught from Ria de Vigo.

Cadiz Sardines from Pelago 2016

Otoliths of a sub-sample of sardines captured in the Gulf of Cadiz during the May 2016 acoustic research cruise carried out by IPMA were analysed. In what follows it is described the main conclusions of its analyses.

1. Otolith margin observation

The macrostructure of a sample of otoliths (n=42) was examined revealing that fish smaller than 7.5 cm only have an opaque growth zone, which corresponds to the fast growing of the early stages, i.e, no evidence of growth macro-increments (Figure 6 and Table 1). The otoliths of sardines larger than 9 cm had a clear hyaline edge that may indicate growth during the previous winter. Some individuals of that length class had already an opaque margin following the hyaline. Some otoliths of 8 cm sardines were totally opaque; others had a hyaline margin. Based on the interpretation of the macrostructure, sardines with total length lower than 8 cm would be classified as age 0. These juveniles do not show any evidence of a hyaline ring from the previous winter and therefore it is expected that the fast summer growth (opaque zone) will follow. Consequently, in spring 2017 these sardines will have only one hyaline ring and will be assigned to age 1. On the other hand, most juveniles measuring between 9 and 14 cm total length during the spring of 2016 will likely show 2 hyaline rings at the spring of 2017 and will then be assigned age 2.

2. Age prediction from Silva et al. 2015 model

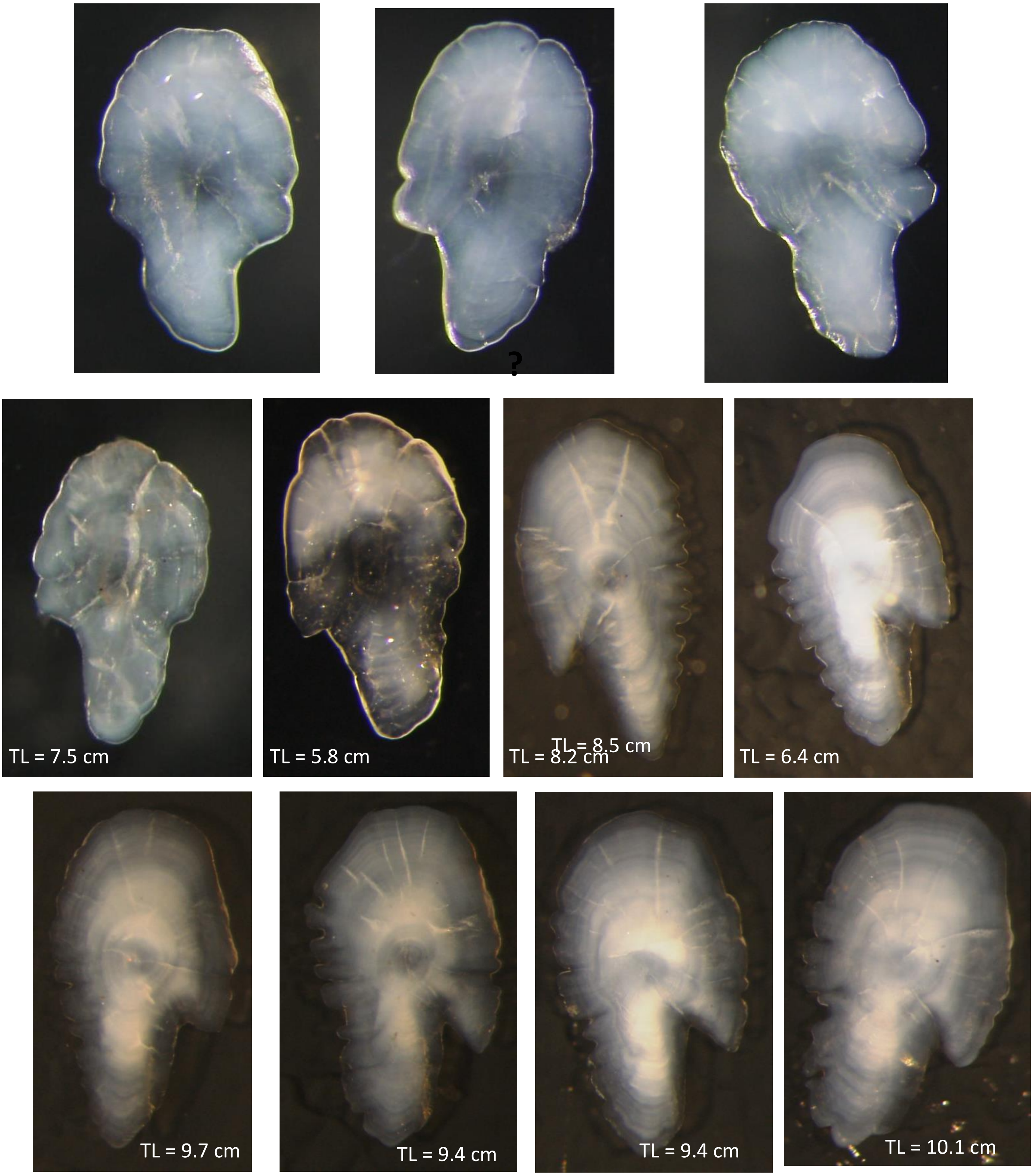
An age prediction model based on individual and otolith and morphometric characteristics was developed for juvenile sardine from northern Portugal (Silva et al. 2015). According to this model, all sardines (TL = 4-14 cm) captured in April during the Pelago 2016 in Cadiz would be less than 1yr old (age = 81 to 309 days). However this must be interpreted with caution because environmental conditions of northern Portuguese coast are very different from the Cadiz area. As the authors state "since growth and survival varies spatially and temporally, relationships between age and otolith/fish morphometry should not be extrapolated outside sampled periods, areas and fish size/age".

3. Age prediction from captive studies

Blaxter 1969 only reared sardines in sufficient numbers until roughly 4.5 months old, and these had approximately 4 cm TL. Given that after that age growth is not expected to increase, fish captured in Cadiz (4-14 cm TL) would be from 4 month old to > 14 months old. On the other hand, considering the results of Iglesias and Fuentes (2014), sardines from 4 to 14 cm would correspond to fish from 2.5 months to 18 months, although the mean temperature in Cadiz is significantly lower than that used in this particular rearing experiment. According to these works, the great majority of sardines captured in Cadiz would have less than 1yr old. However, as stated before, there is an impressive difference of the growth rate of sardines between the different works available and this must be confirmed in the future.

Table 1. Margin observations in a small sample of Pelago 2016 sardine otoliths from the Cadiz area.

TL cm	Without rings	Hyaline Margin	Hyaline ring + fine Opaque margin
4.6	1		
5.2	1		
5.6	1		
5.7	1		
5.7	1		
6.2	1		
6.2	1		
6.4	1		
7.5	1		
7.5	1		
7.5	1		
7.7	1		
8.1	1		
8.2	1		
8.5	1		
8.5		1	
8.5	1		
8.5	1		
9.4		1	
9.7		1	
10		1	
10.1		1	
10.1		1	
10.6		1	
10.8		1	
10.9		1	
11.1		1	
11.2		1	
11.5		1	
11.8		1	
11.9		1	
12.2			1
12.4			1
12.7			1
12.7		1	
13.2		1	
13.5		1	
13.6		1	
13.8		1	
14.0		1	
14.0			1
14.0		1	


?
TL = 7.5 cm
TL = 5.8 cm
TL = 8.5 cm
TL = 8.2 cm
TL = 6.4 cm
TL = 9.7 cm
TL = 9.4 cm
TL = 9.4 cm
TL = 10.1 cm

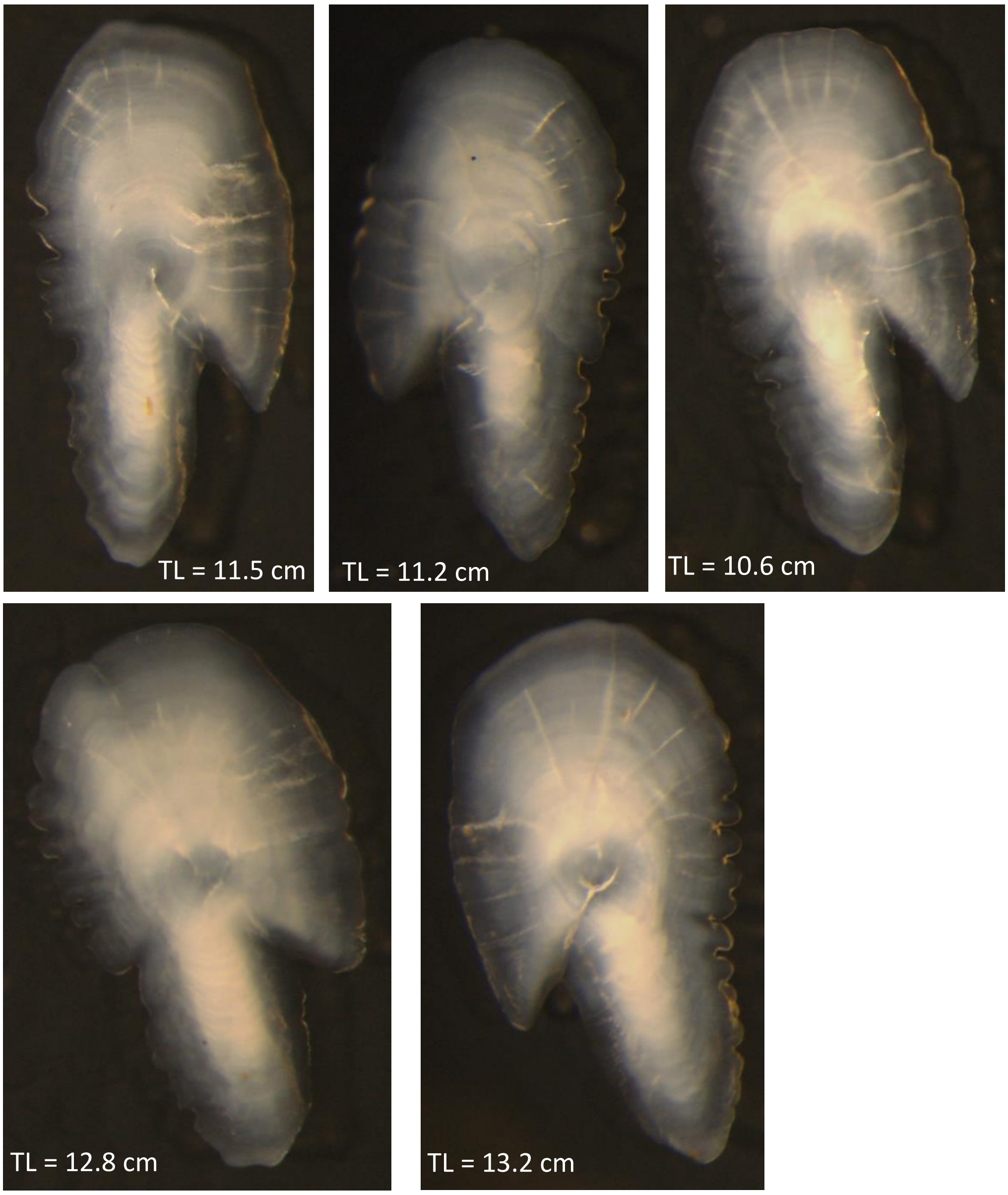


Figure 6 – Sardine otoliths from Cadiz area collected during Pelago 2016

References

Alemany F., Álvarez I., García A., et al. (2006) Post larvae and juvenile daily growth patterns of the Alboran Sea sardine (*Sardina pilchardus*, Walbaum): influence of wind. Sci. Mar. 70S2: 93-104.

Campana SE (2001) Accuracy, precision and quality control in age determination, including a review of the use and abuse of age validation methods. J Fish Biol 59 (2):197–242.

Blaxter JHS (1969) Experimental rearing of pilchard larvae, *Sardina pilchardus*. J Mar Biol Assoc UK 49: 557−575.

Caldeira C., Santos AM, Ré P, Garrido S (2014) Effect of prey concentration on the Ingestion rates of Sardine (Sardina pilchardus) larvae reared in laboratory conditions. Marine Ecology Progress Series, 517:217-228

Silva, L, Faria, A.M., Chícharo, M.A., Garrido,S. (2014) Ontogeny of swimming behaviour in Sardine (Sardina pilchardus) larvae and effect of larval nutritional condition on critical speed. Marine Ecology Progress Series 504:287-300

Silva AV, Meneses I, Silva A (2015) Predicting the age of sardine juveniles (*Sardina pilchardus*) from otolith and fish morphometric characteristics. Scientia Marina 79(1):1-7.

Soares E, Silva A, Morais A (2005) Report of the Workshop on sardine otolith age reading and biology. Workshop held within the framework of the EU Data Collection Regulation (DCR), Lisbon 27 June – 1 July, 2005, 34 pp.

Working document for the WGHANSA 24-29/06/2016, IFREMER Lorient, France

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

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Abstract

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

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

Introduction

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

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

Material and methods

The methodology was similar to that of the previous surveys.

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

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

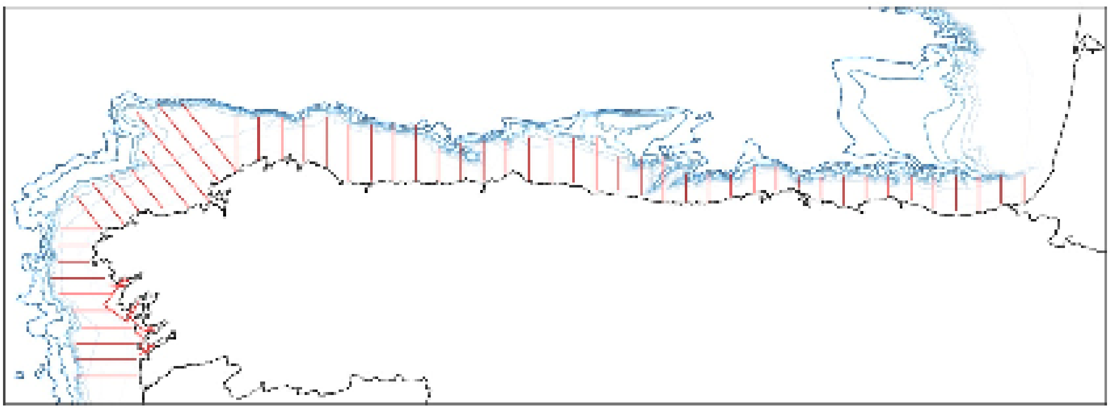


Figure 1. 2016 Survey track

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

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

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

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

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

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

Results

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

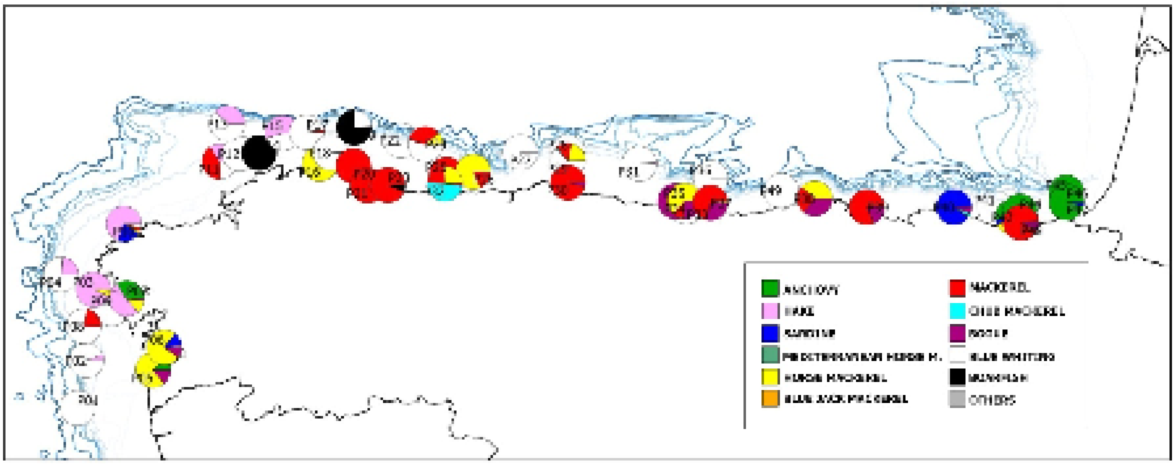


Figure 2: PELACUS0316 Fish proportion (abundance) at each fishing station

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

Table 1. PELACUS0316 Catch composition.

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

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

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

Table 2. PELACUS0316 Catch composition.

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

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

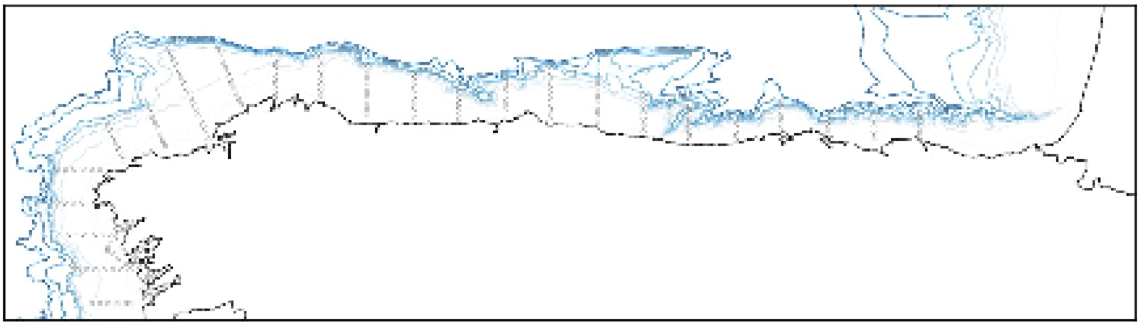
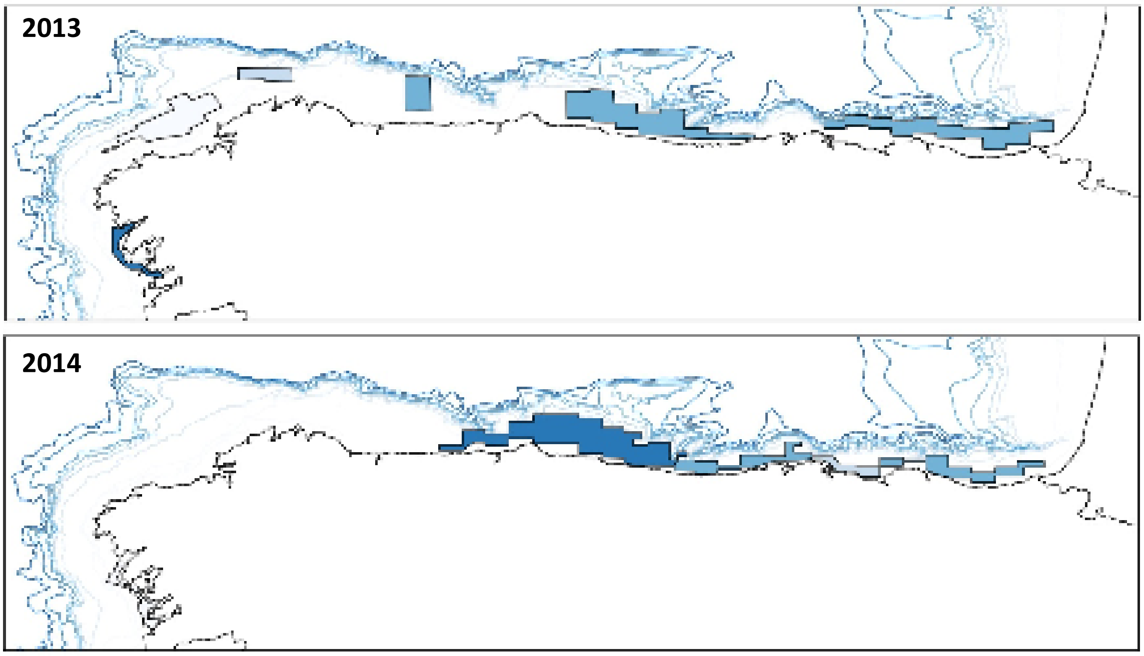


Figure 3. PELACUS0316 CUFES stations.

Acoustic
Sardine distribution and assessment

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



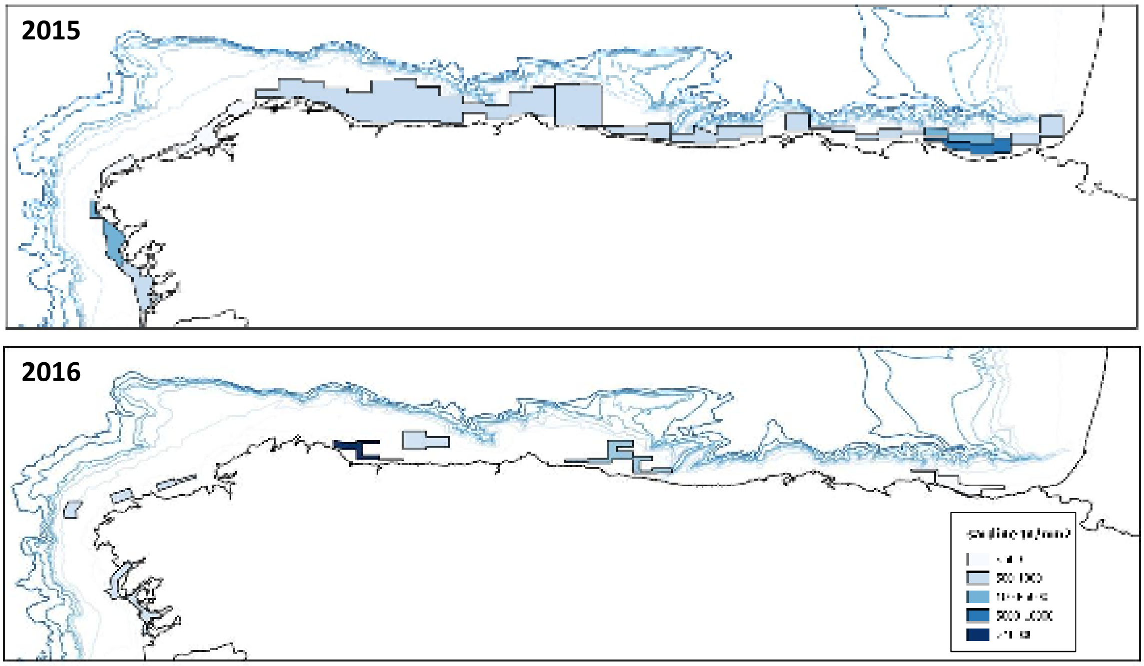


Figure 4. Sardine: spatial distribution of energy allocated to sardine during 2013-2016 PELACUS surveys. Polygons are drawn to encompass the observed echoes, and polygon colour indicates sardine density in nm^2 within each polygon.

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

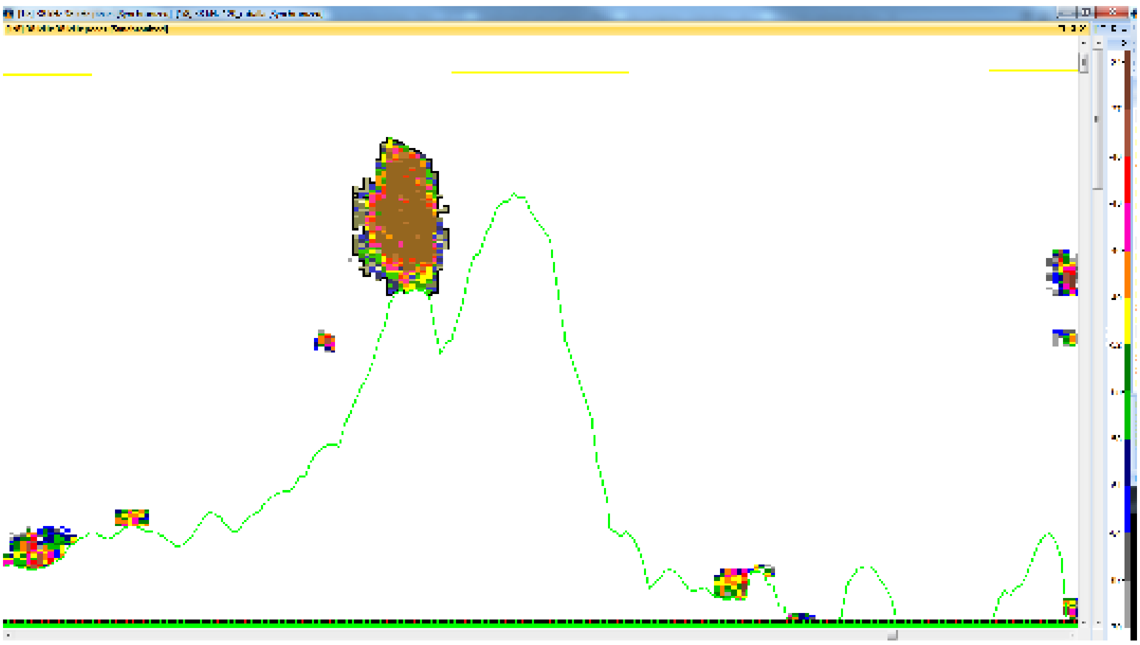


Figure 5. Echotrace attributed to a sardine school. A Mask, to remove other backscatters than those belonging to swimbladder fish, has been applied

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

Table 2. Sardine acoustic assessment

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

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

Table 3. Sardine acoustic assessment

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

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

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

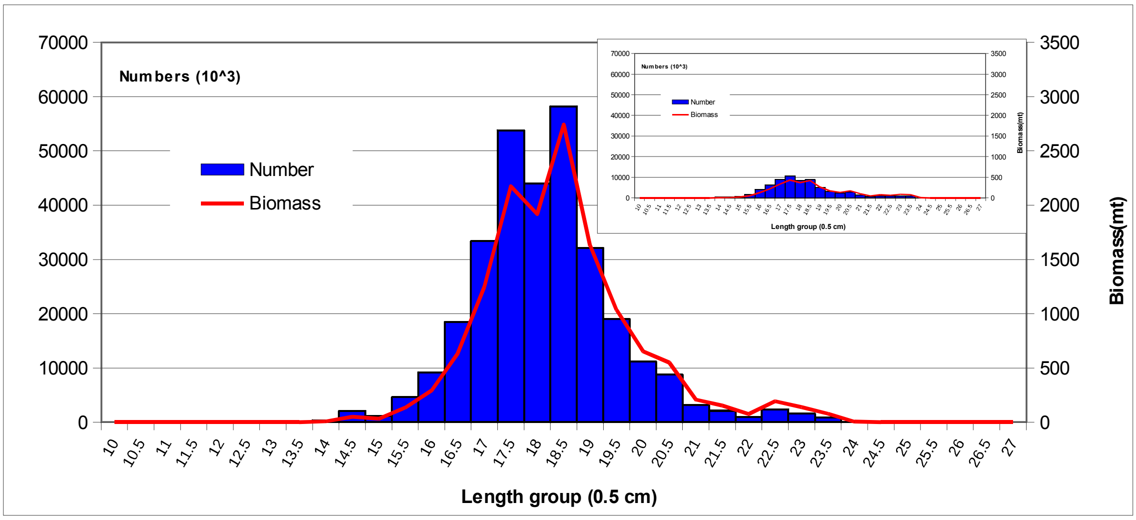


Figure 6. Sardine: fish length distribution in biomass and abundance during PELACUS0316 survey (including VIIIb subdivision). In the small chart, the estimates when excluded the schools accounted as probably sardine.

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

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

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

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

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

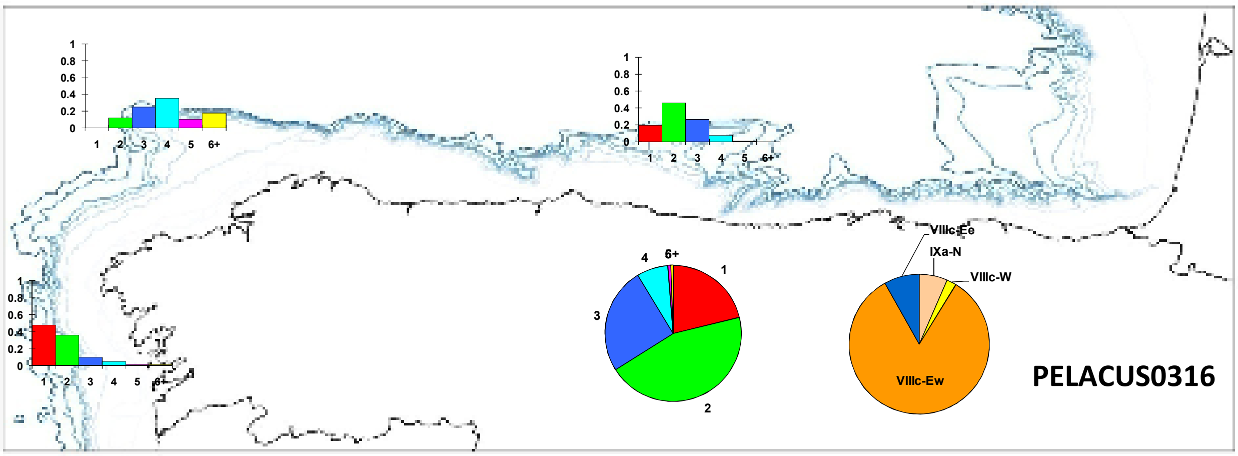


Figure 7. Sardine: relative abundance at age in each sub-area estimated in the PELACUS0316. The pie chart shows the contribution of each sub-area and each age group to the total stock numbers.

<u>Sardine egg abundance</u>

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

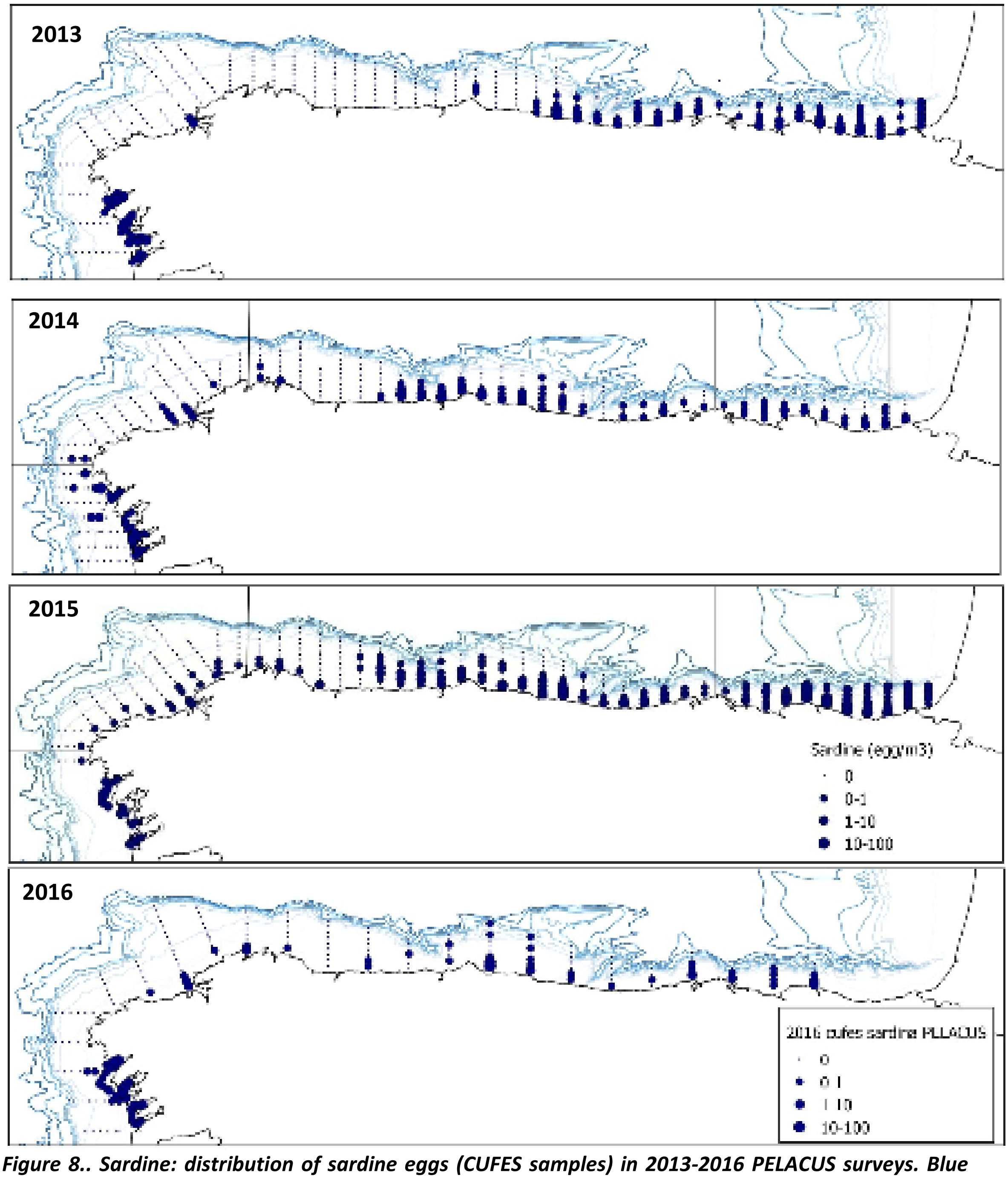


Figure 8.. Sardine: distribution of sardine eggs (CUFES samples) in 2013-2016 PELACUS surveys. Blue circles indicate positive stations with diameter proportional to egg density.

Acoustic Anchovy distribution and assessment

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

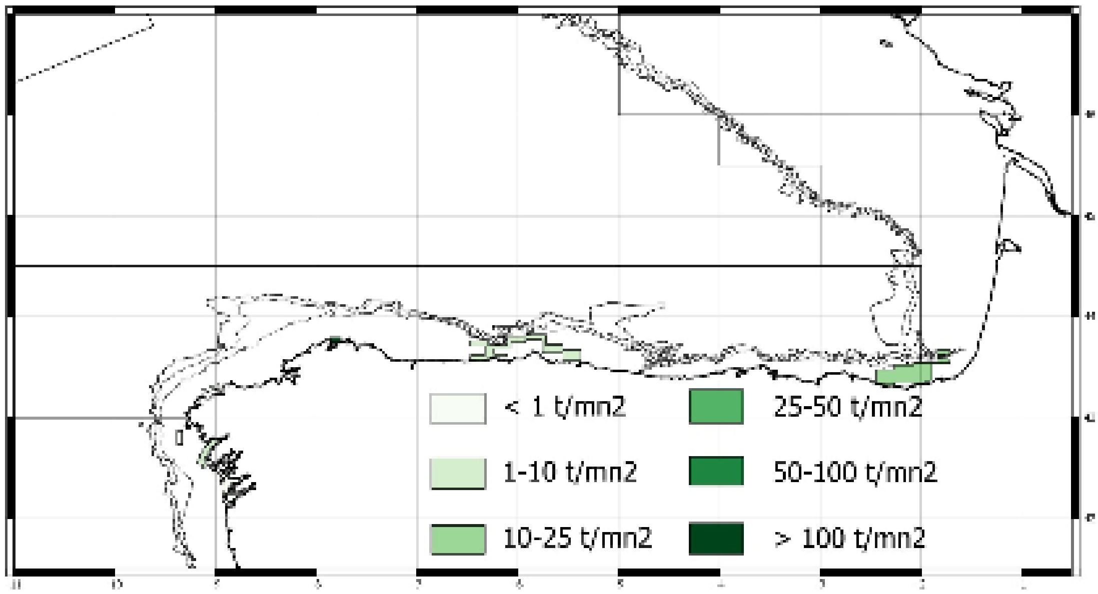


Figure 9. Spatial distribution of energy allocated to anchovy during PELACUS0316 survey. Polygons are drawn to encompass the observed echoes, and polygon colour indicates density in mt/ nm² within each polygon.

Table 6 shows the anchovy assessment for the whole surveyed area. Total biomass was estimated to be 13223 mt corresponding to 544 million fish. As observed in sardine, the bulk of the biomass were located in only few schools. In the case of anchovy, these schools were located within the Ria of Ortigueira, near Ortegal Cape. They occurred close to the coast, in roughly hard bottom (i.e. difficult to fish); this together with the bad weather conditions did not allow a haul be performed. Nevertheless, as shown in figure 10 schools characteristics were those compatibles with thick anchovy schools.

Table 6. Anchovy acoustic assessment

Zone	Area	No	Mean	Area	Fishing st.	PDF	No (million fish)	Biomass (tonnes)	Density (Tn/nmi-2)
IXa	Rias Baixas	59	2.92	79	P05	S01	3	21	0
	Muros	30	23.78	47	P07	S02	6	184	4
	Total	*89*	*9.95*	*126*			*8*	*205*	2
VIIIc-W	Fisterra	2	1.75	18	P10	S02	0	4	0
	Artabro	2	0.30	17	P10	S02	0	1	0
	Total	*4*	*1.02*	*35*			*0*	*5*	0
VIIIc-Ew	Masma	3	3267.26	17	P40-P42-P47	S03	329	7999	466
	Asturias	28	23.78	252	P40-P42-P47	S03	35	856	3
	Total	**31**	*337.67*	**269**			*364*	*8855*	33
VIIIc-Ee,VIIIb	Euskadi	40	104.62	278	P40-P42-P47	S03	171	4157	15
	Total	**40**	*104.62*	**278**			**171**	**4157**	15
	Total IXa	*89*	*10*	*126*			*8*	*205*	2
	Total VIIIbc	*75*	*195*	*583*			*535*	*13017*	22
	Total Spain	*164*	*94.77*	*709*			*544*	*13223*	19

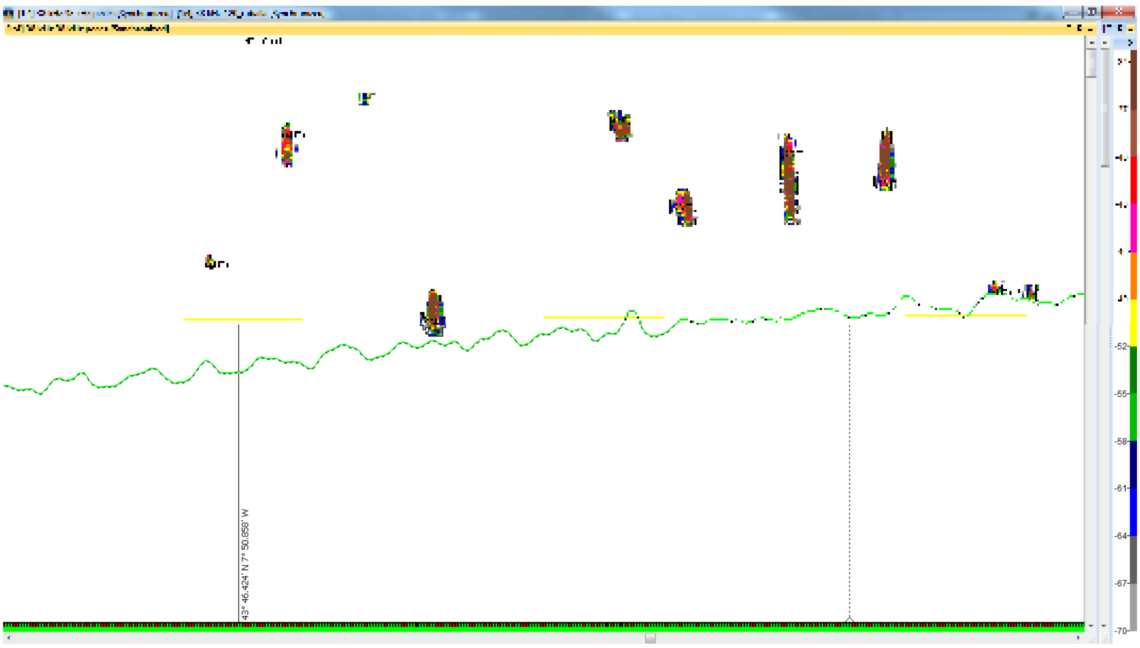


Figure 10. Echotraces attributed to anchovy schools. A mask, to remove other backscatters than those belonging to swimbladder fish, has been applied

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

Table 7. Anchovy assessment in IXa-N

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

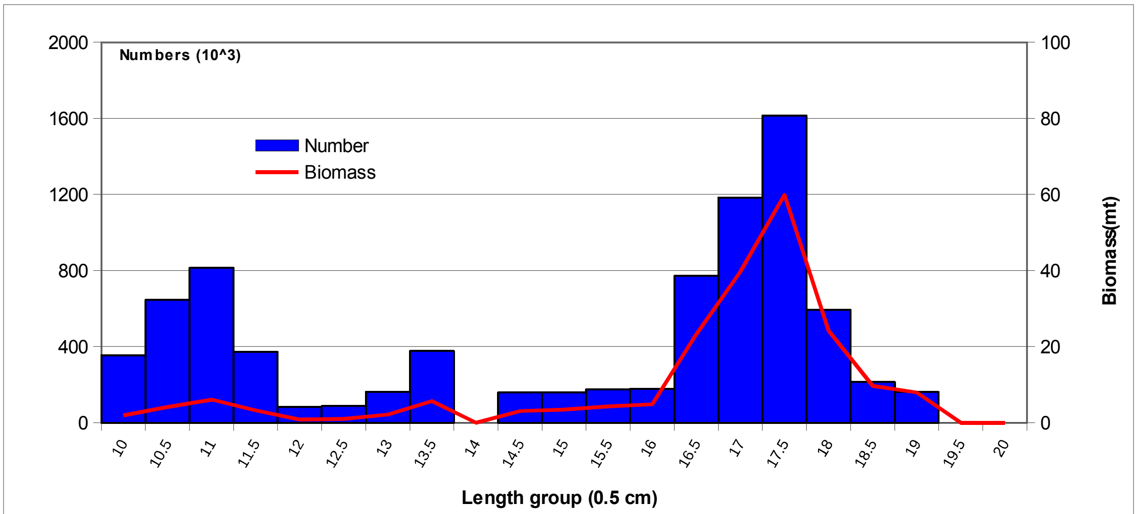


Figure 11. Anchovy fish length distribution in biomass and abundance during the PELACUS0316 survey in IXa-N

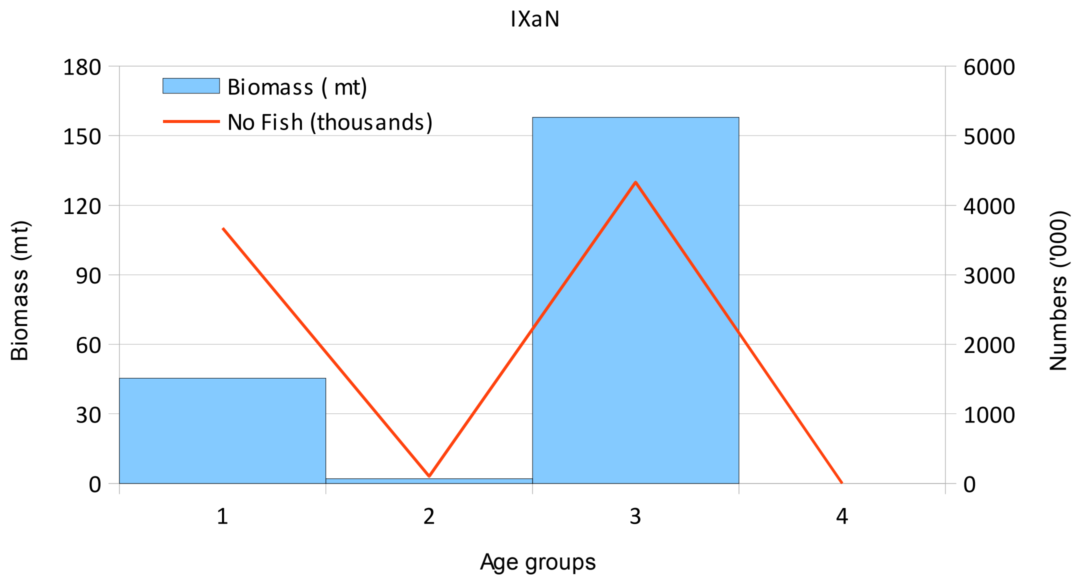


Figure 12. Anchovy fish age distribution in biomass and abundance during PELACUS0316 survey in IXa-N

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

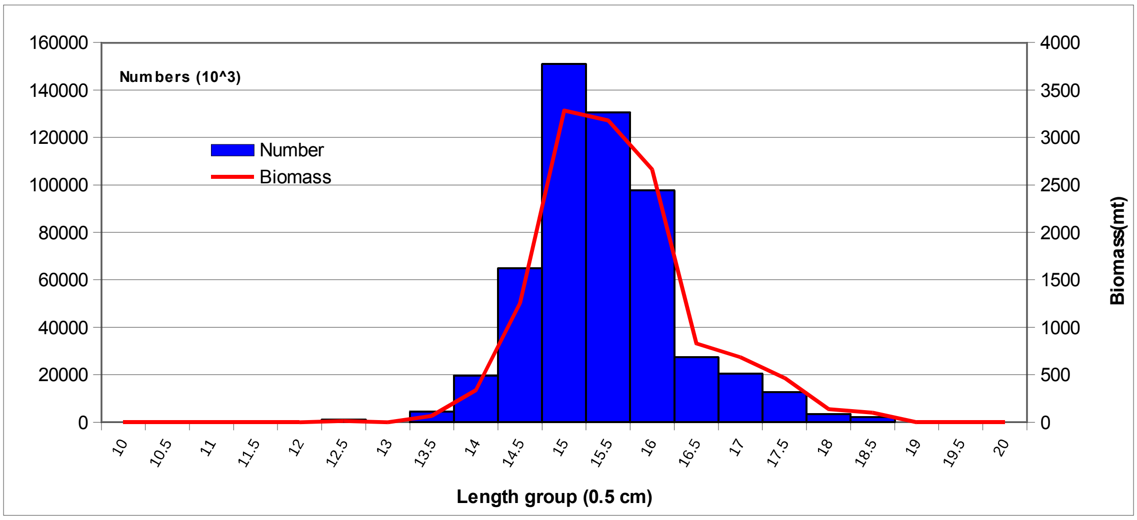


Figure 13. Anchovy fish length distribution in biomass and abundance during PELACUS0316 survey in VIIIc

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

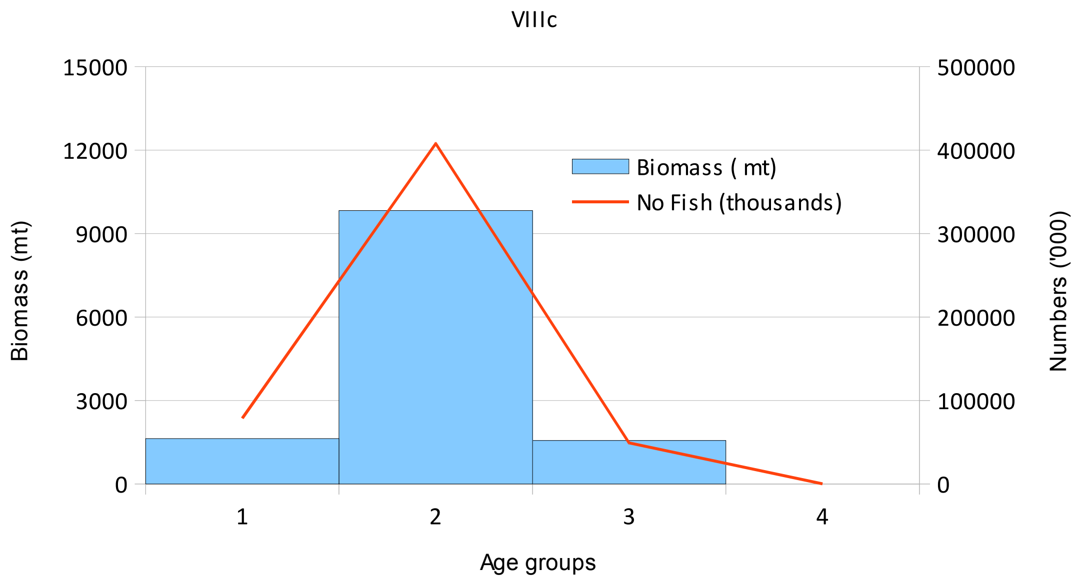


Figure 14. Anchovy fish age distribution in biomass and abundance during PELACUS0316 survey in VIIIc

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

Length	1	2	3	4	Total	No fish (thousands)
10						
10.5						
11						
11.5						
12						
12.5	13				13.19	1137
13						
13.5	34	34			68.58	4533
14	225	113			337.87	19704
14.5	314	942			1255.76	64882
15	679	2491	113		3283.26	150901
15.5	251	2844	84		3179.12	130469
16	116	2313	231		2659.45	97801
16.5		632	197		829.29	27419
17		343	343		685.63	20445
17.5		117	350		466.64	12587
18			138		137.65	3368
18.5			101		100.90	2245
19						
19.5						
20						
Biomass (mt)	1633	9828	1557	0	13017.35	535491
%	12.54	75.50	11.96			
M. weight	20.63	23.90	31.37		24.10	
No Fish (thousands)	78533	408012	48946	0	535491	
%	14.67	76.19	9.14			
M. length	15.02	15.66	16.93		15.68	
s.d.	0.64	0.66	0.95		0.82	

Anchovy egg abundance

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

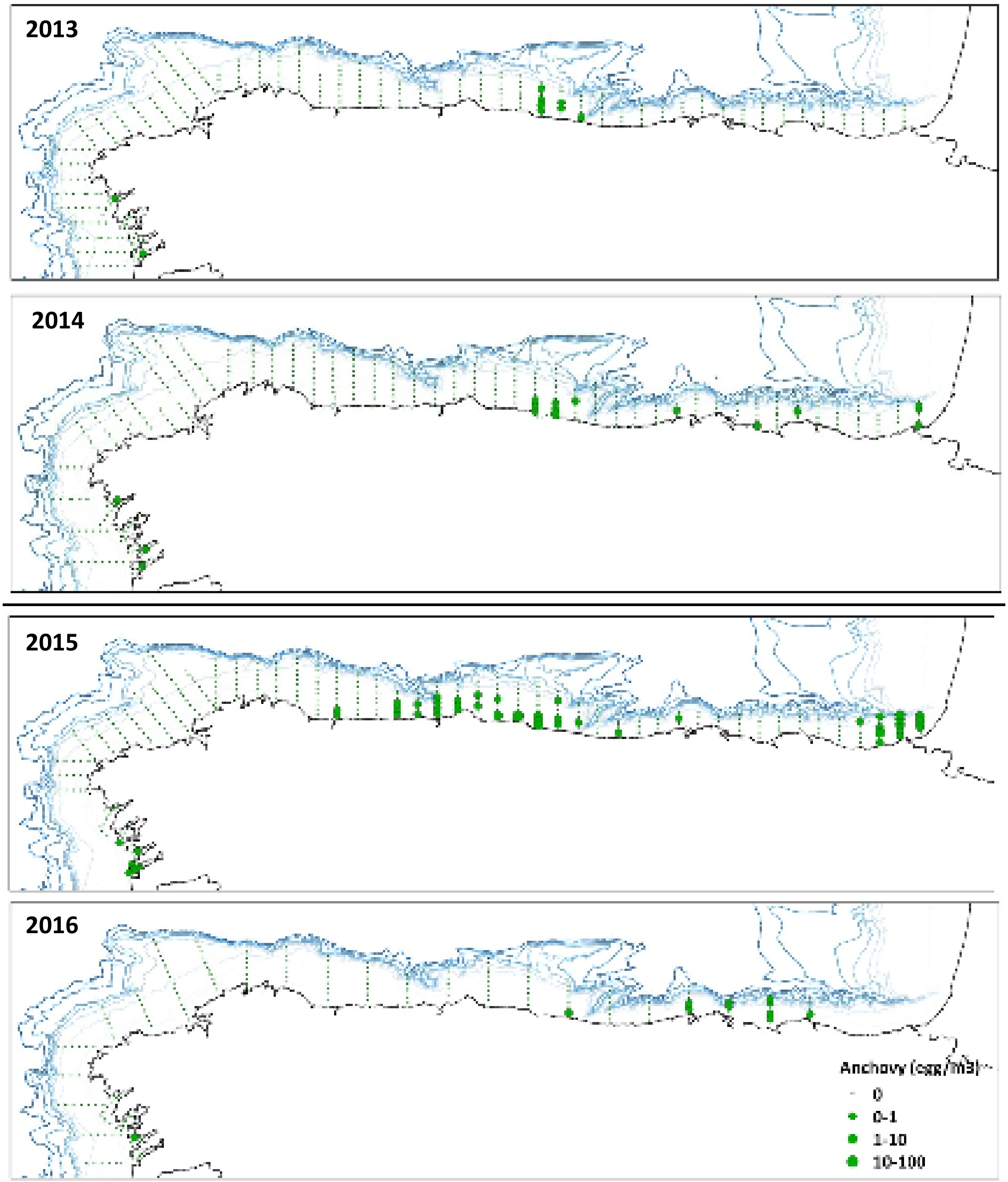


Figure 15. Anchovy: distribution of anchovy eggs (CUFES samples) in 2013-2016 PELACUS surveys. Green circles indicate positive stations with diameter proportional to egg density.

Acoustic Horse mackerel distribution and assessment

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

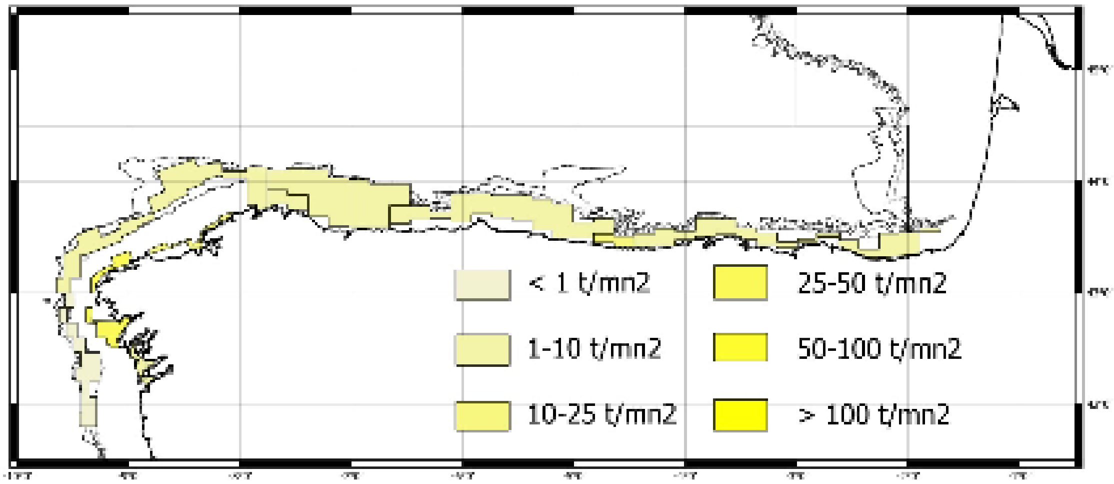


Figure 15. Spatial distribution of energy allocated to horse mackerel during PELACUS0316 survey. Polygons are drawn to encompass the observed echoes, and polygon colour indicates density in mt/ nm^2 within each polygon.

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

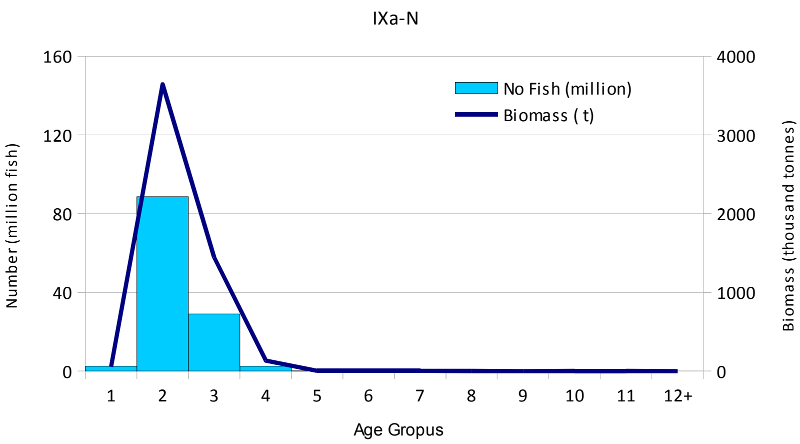
Table 9. Summary of the horse mackerel assessment

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

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

Table 10. Horse mackerel assessment in IXaN

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



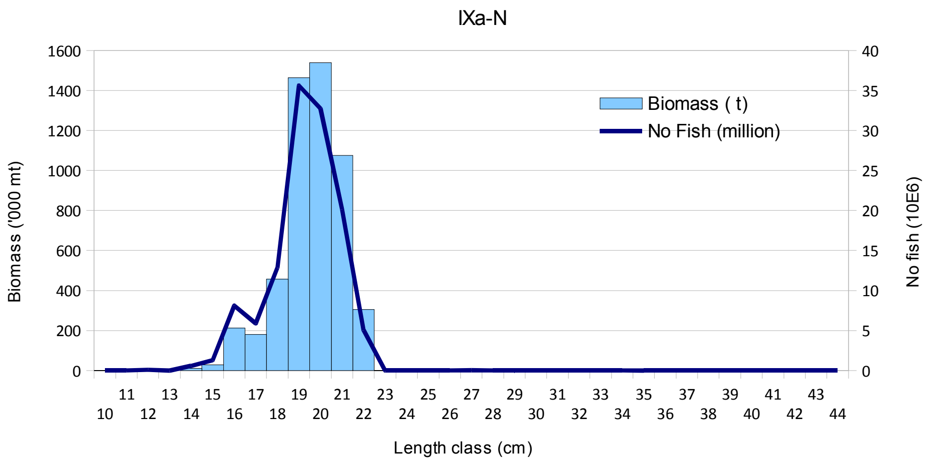


Figure 16. Horse mackerel fish age (above) and length (below) distributions in biomass and abundance during PELACUS0316 survey in IXaN

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

Table 10. Horse mackerel assessment in VIIIc

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

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

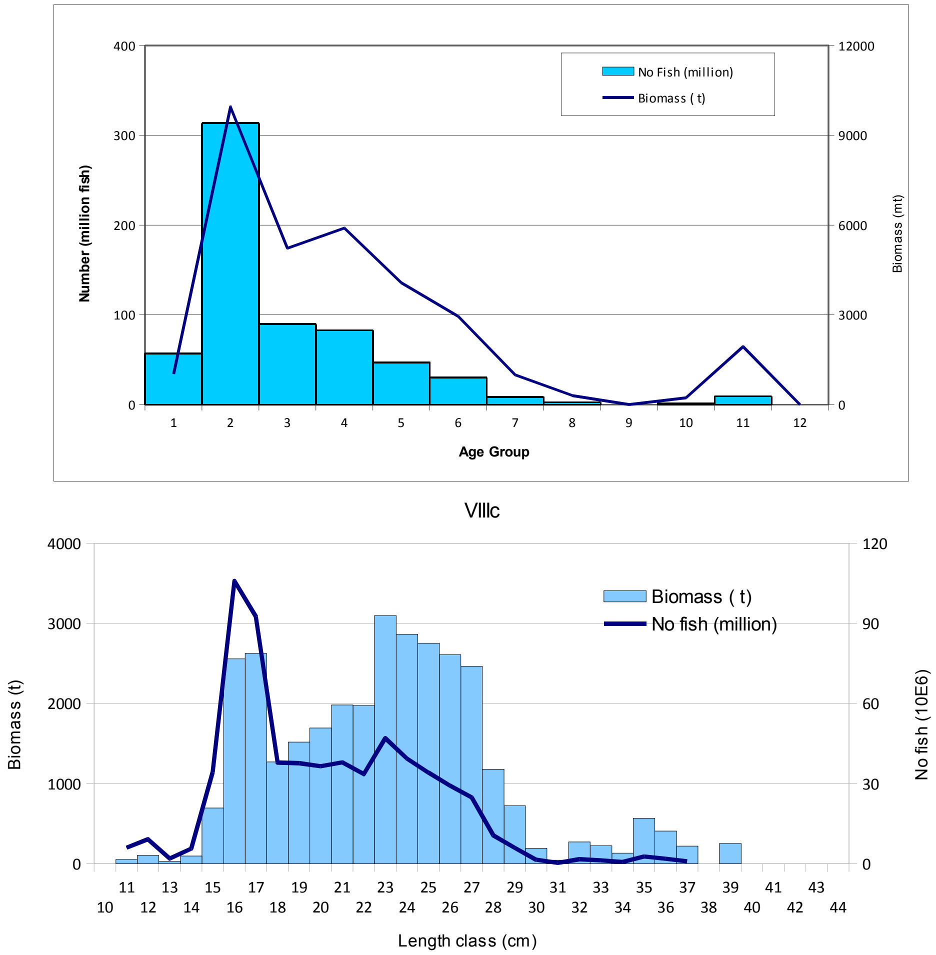


Figure 17. Horse mackerel fish age (above) and length (below) distributions in biomass and abundance during PELACUS0316 survey in VIIIc

<u>Main conclusions</u>

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

Acknowledgements

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

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References

Anon., 2006. Report of the Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine, and Anchovy. ICES CM 2006/ ACFM: XX.

Carrera, P. and Porteiro, C. 2003. Stock dynamics of the Iberian sardine (Sardina pilchardus, W.) and its implication on the fishery off Galicia (NW Spain). Sci. Mar. 67, 245-258.

Foote, K.G., Knudsen, H.P., Vestnes, G., MacLennan, D.N. and Simmonds, E.J. 1987. Calibration of acoustic instruments for fish density estimation: a practical guide. ICES Coop. Res. Rep. 144, 57 pp.

MacLennan, D.N., Fernándes, P.G. and Dalen, J. 2002. A consistent approach to definitions and symbols in fisheries acoustics. ICES J. Mar. Sci. 59, 365-9.

Marques, V., Silva, A., Angélico, M. M., Dominguez, R. and Soares, E. 2010. Sardine acoustic survey carried out in April 2010 off the Portuguese Continental Waters and Gulf of Cadiz, onboard RV "Noruega". WD presented at the WG on Anchovy and Sardine, Lisbon, 24-28 June 2010, 10 pp.

Working Document to WGHANSA, 24-29 June 2016, Lorient, France

Preliminary biomass estimate of Bay of Biscay anchovy (*Engraulis encrasicolus*, L.) in 2016 and sardine (*Sardina pilchardus*) total egg abundance

by
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Abstract

The research survey BIOMAN 2016 for the application of the Daily Egg Production Method (DEPM) to the Bay of Biscay anchovy was conducted in May 2016 from the 5th to the 25th covering the whole spawning area of the species. Two vessels were used: the R/V Ramón Margalef to collect the plankton samples and the pelagic trawler Emma Bardán to collect the adult samples. The total area covered was 98,866 Km^2 and the spawning area was 55,092 Km^2 for anchovy and 31,653 Km^2 for sardine. During the survey 680 vertical plankton samples were obtained, 1,649 CUFES samples and 44 pelagic trawls were performed, from which 36 contained anchovy and 32 of them were selected for the analysis. Moreover, 2 extra samples were obtained from the commercial fleet. In total there were 34 samples for anchovy adult parameters estimates.

The spawning limit to the West in the Cantabrian coast was found at 5º38'W and in the French platform there were eggs all over the platform up to 200m depth until 46ºN. From 46ºN to 47º23'N the egg were inside the 100m depth isoline. The northern distribution limit was found at the height of Nantes (47º23'N). A mean SST of 14.8ºC and SSS of 34.57 were encountered.

Total egg production (P_{tot}) was calculated as the product of spawning area and daily egg production rate (P_0), which was obtained from the exponential decay mortality model fitted as a Generalized Linear Model to the egg daily cohorts. The adult parameters, Sex Ratio and Weight of mature females, were estimated based on the adult samples obtained during the survey. However, the daily fecundity (DF) was obtained as a mean of the historical series because the batch fecundity and spawning frequency are in process. Two options were considered: a) a mean of the whole historical series (95eggs/g.) or b) a mean of the last 6 years (70eggs/g), just after the open of the fishery. Along the historical series until the open of the fishery in 2010, the mean of the DF is 101 egg/g. and the mean considering the last 6 years just after the open of the fishery is of 70eggs/g, for this reason this two options were considered. In consequence, the index of total biomass estimate resulted in 120,934 t with a coefficient of variation of 24% considering the whole historical series mean for DF or 164,411 t considering the last 6 years. Total abundance of sardine was 8.9 E12 eggs, including the whole area, and 8.6 E12 eggs removing the area of the cantabric coast and the North area, higher than last year estimate.

Introduction

Anchovy (*Engraulis encrasicolus*) is one of the commercial species of high economic importance in the Bay of Biscay. The economy of the Spanish purse seine fleets (Basque Country, Cantabria and Galicia) and the French fleet rely greatly on this resource (Uriarte *et al*., 1996 and Arregi *et al*., 2004). In order to provide advice on the fishery management, it is necessary to conduct annually a monitoring of the population. Thanks to that monitoring, ICES recommended a limited TAC of 25,000 t for 2016. Afterwards in 2016 the TAC was increased to 33,000t.

Anchovy is a short-lived species, for which the evaluation of its biomass has to be conducted by direct assessment methods as the daily egg production method (DEPM) (Barange *et al*, 2009). This method consists of estimating the spawning stock biomass (*SSB*) as the ratio between the total daily egg production (P_{tot}) and the daily fecundity (*DF*) estimates. In consequence, this method requires a survey to collect anchovy eggs (plankton sampling) for estimating the P_{tot} and to collect anchovy adults (adult sampling) for estimating the *DF*. In the case of anchovy the SSB is equal to the total biomass during the peak of spawning, in May-June, when the survey is developed.

Since 1987, AZTI (Marine and Food Technological Centre, Basque country, Spain), either alone or in collaboration with other institutes, has conducted annually specific surveys to obtain anchovy biomass indices (Somarakis *et al*., 2004; Motos *et al*., 2005, Santos *et al*, 2010). In addition, the Basque fishery on anchovy has been continuously monitored. This information has been submitted annually to ICES, to advice on the exploitation of the fishery.

The DEPM survey to estimate the Bay of Biscay anchovy biomass is one of the two surveys which give information about the anchovy population. The other one carried out at the same time in May is the acoustic French survey. The biomass indices provided by the acoustic and DEPM surveys together with the information supplied by the fleet and the information on the recruitment from the survey Juvena (acoustic survey focus on juveniles) are used as input variables for a two stage biomass model used to assess the Bay of Biscay anchovy population (Ibaibarriaga *et al*., 2008). Apart from the anchovy Biomass estimates the DEPM survey in the Bay of Biscay gives information on the distribution and abundance of sardine eggs and environmental conditions due to the collection sea surface temperature, sea surface salinity, temperature and salinity in the water column, currents and winds.

This working document describes the BIOMAN2016 survey for the application of the DEPM for the Bay of Biscay anchovy in 2016. First, the data collection, the estimation of the total egg production and the reproductive parameters are described in detail except for the spawning frequency and batch fecundity that will be ready for WGHANSA-sub, in this report a mean historical series for the Daily fecundity is used. Then, a preliminary total biomass index and preliminary age structure of the population are given. The final total biomass index estimate will be ready for WGHANSA-sub in November and will be used for the assessment and posterior management of this stock. Moreover, the sardine total egg abundance is presented. Finally the historical trajectory of the population is reviewed.

Material and Methods

Survey description

The BIOMAN2016 survey was carried out in May, at the spawning peak covering the whole spawning area of anchovy in the Bay of Biscay. During the survey, ichthyoplankton and adult samples were obtained for the estimation of total daily egg production and total daily fecundity respectively for anchovy. The age structure of the population was also estimated. In addition, extra plankton samples with the MIK net were collected for other issues and Bongo samples to collaborate with the triannual mackerel and horse mackerel surveys.

The collection of plankton samples was carried out on board R/V Ramón Margalef from the 5th to the 25th May. The area covered was the southeast of the Bay of Biscay (**Fig. 1**), which corresponds to the main spawning area and spawning season of anchovy. The sampling strategy was adaptive. The survey started from the West (transect 7, at 4º56'W), but as there were found anchovy eggs in this transect two more transects were prospected to the west until 5º 37'W. The west spawning limit at cantabrian coast was found at 5º18' W at the height of Gijon and covered the Cantabrian Coast eastwards up to Pasajes (transect 25, approx. 1º50'W) (**Fig. 1**). Then, the survey continued to the north, in order to find the Northern limit of the spawning area. When the egg abundances found were relatively high, additional transects separated by 7.5 nm were completed. This occurred in the east part of the Cantabrian coast and in the area of influence of the Adour and Garonne rivers. There were eggs all over the platform until 46ºN. From 46ºN to 47º23'N the egg were inside the 100m depth. The northern distribution limit was found at the height of Nantes (47º23'N). The sampling was stopped for 36 hours to refuel. The stern's stay of cufes was broken and was mended but didn't disturb the survey.

The strategy of egg sampling was identical to that used in previous years, i.e. a systematic central sampling scheme with random origin and sampling intensity depending on the egg abundance found (Motos, 1994). Stations were situated at intervals of 3 nmi along 15 nmi apart transects perpendicular to the coast.

At each station a vertical plankton haul was performed using a PairoVET net (Pair of Vertical Egg Tow, Smith *et al*., 1985 in Lasker, 1985) with a net mesh size of 150 µm for a total retention of the anchovy eggs under all likely conditions. The net was lowered to a maximum depth of 100 m or 5 m above the bottom in shallower waters. After allowing 10 seconds at the maximum depth for stabilisation, the net was retrieved to the surface at a speed of 1 m s^{-1}. A 45 kg depressor was used to allow for correctly deploying the net. "G.O. 2030" flowmeters were used to detect sequential clogging of the net during a series of tows.

Immediately after the haul, the nets were washed and the samples obtained were fixed in formaldehyde 4% buffered with sodium tetra borate in sea water, mixing the samples obtained in each of the nets that compound the PairoVET frame. After six hours of fixing, anchovy, sardine and other eggs species were identified, sorted out and counted on board. Afterwards, in the laboratory, a percentage of the samples were checked to assess the quality of the sorting made at sea. According to that, a portion of the samples were sorted again to ensure no eggs were left in the sample. In the laboratory, anchovy eggs were classified into morphological stages (Moser and Alshtrom, 1985).

Sample depth, temperature, salinity and fluorescence profiles were obtained at each sampling station using a CTD RBR-XR420 coupled to the PairoVET. At some points determinate before the survey, water was filtered from the surface to obtain chlorophyll samples to calibrate the data from the fluorimeter.

The Continuous Underway Fish Egg Sampler (CUFES, Checkley *et al*., 1997) was used to record the eggs found at 3m depth with a net mesh size of 350µm not to lose eggs. The samples obtained were immediately checked under the microscope so that the presence/absence of anchovy eggs was detected in real time. When anchovy eggs were not found in six consecutive CUFES samples in the oceanic area transect was abandoned. The CUFES system had a CTD to record simultaneously temperature and salinity at 3 m depth, a flowmeter to measure the volume of the filtered water, a fluorimeter and a GPS (Geographical Position System) to provide sampling position and time. All these data were registered at real time using the integrated EDAS (Environmental Data Acquisition System) with custom software.

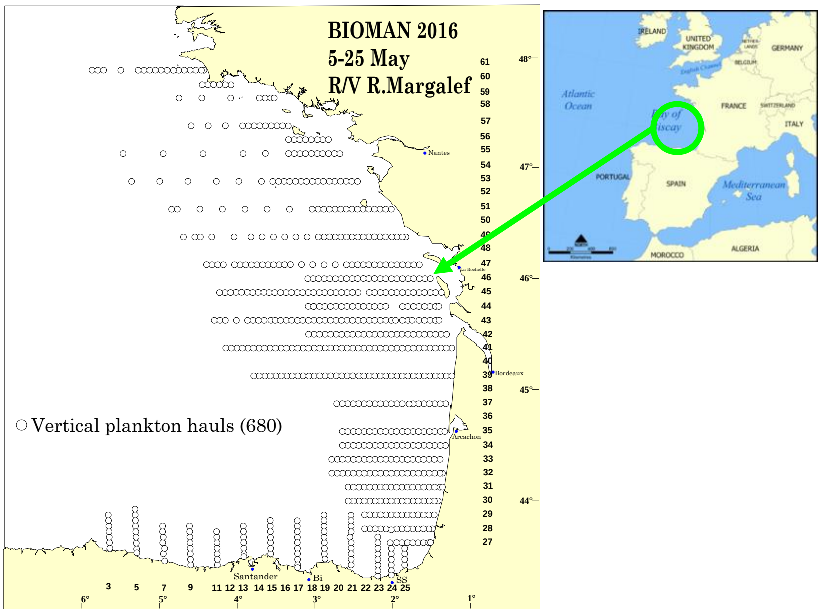

Figure 1: Plankton stations during BIOMAN 2016.

Adult samples were obtained on board R/V Emma Bardán (pelagic trawler) from the 7th to the 27th May coinciding in space and time with the plankton sampling. When the plankton vessel encountered areas with anchovy eggs, the R/V Emma Bardán was directed to those areas to fish. In each haul, immediately after fishing, anchovy were sorted from the bulk of the catch and a sample of two kg was selected at random. A minimum of one kg or 60 anchovies were weighted, measured and sexed and from the mature females the gonads of 25 non-hydrated females (NHF) were preserved. If the target of

25 NHF was not completed 10 more anchovies were taken at random and processed in the same manner. Sampling was stopped when 120 anchovies had to be sexed to achieve the target of 25 NHF. Otoliths were extracted on board and read in the laboratory to obtain the age composition per sample. In each haul 100 individuals of each species were measured.

This year 2 additional anchovy adult samples were obtained from the commercial Basque purse seine fleet when the egg sampling was crossing the area of Cape Breton where the purse seiners were operating.

Total egg production

Total daily egg production (P_{tot}) was calculated as the product between the spawning area (*SA*) and the daily egg production (P_0) estimates:

(1) $$P_{tot} = P_0 \, SA.$$

A standard PairoVET sampling station represented a surface of 45 Nm^2 (i.e. 154 km^2). Since the sampling was adaptive, the area represented by each station was corrected according to the sampling intensity and the cut of the coast. The total area was calculated as the sum of the area represented by each station. The spawning area (*SA*) was delimited with the outer zero anchovy egg stations although it could contain some inner zero anchovy egg stations embedded. The spawning area was computed as the sum of the area represented by the stations within the spawning area.

The daily egg production per area unit (P_0) was estimated together with the daily mortality rate (Z) from a general exponential decay mortality model of the form:

(2) $$P_{i,j} = P_0 \exp\left(- Z \, a_{i,j}\right),$$

where $P_{i,j}$ and $a_{i,j}$ denote respectively the number of eggs per unit area in cohort j in station i and their corresponding mean age. Let the density of eggs in cohort j in station i, $P_{i,j,}$ be the ratio between the number of eggs $N_{i,j}$ and the effective sea area sampled R_i (*i.e.* $P_{i,j} = N_{i,j} / R_i$). The model was written as a generalised linear model (GLM, McCullagh and Nelder, 1989; ICES, 2004) with logarithmic link function:

(3) $$\log\left(E[N_{i,j}]\right) = \log(R_i) + \log\left(P_0\right) - Z \, a_{i,j} \;,$$

where the number of eggs of daily cohort j in station i (N_{ij}) was assumed to follow a negative binomial distribution. The logarithm of the effective sea surface area sampled ($\log(R_i)$) was an offset accounting for differences in the sea surface area sampled and the logarithm of the daily egg production log(P_0) and the daily mortality Z rates were the parameters to be estimated.

The eggs collected at sea and sorted into morphological stages had to be transformed into daily cohort frequencies and their mean age calculated in order to fit the above model. For that purpose the Bayesian ageing method described in ICES (2004), Stratoudakis *et al*., (2006) and Bernal *et al.*, (2011) was used. This ageing method is based on the probability density function (pdf) of the age of an egg *f(age | stage, temp),* which is constructed as:

(4) $$f(age \mid stage, temp) \propto f(stage \mid age, temp)\, f(age)\,.$$

The first term *f(stage | age, temp)* is the pdf of stages given age and temperature. It represents the temperature dependent egg development, which is obtained by fitting a multinomial model like extended continuation ratio models (Agresti, 1990) to data from temperature dependent incubation experiments (Ibaibarriaga *et al.,* 2007, Bernal *et al.,* 2008). The second term is the prior distribution of age. A priori the probability of an egg that was sampled at time τ of having an age *age* is the product of the probability of an egg being spawned at time τ - *age* and the probability of that egg surviving since then (*exp(-Z age)*):

(5) $$f(age) \propto f(spawn = \tau - age)\exp(-Z\ age)\ .$$

The pdf of spawning time *f(spawn=*τ *- age)* allows refining the ageing process for species with spawning synchronicity that spawn at approximately certain times of the day (Lo, 1985a; Bernal *et al*., 2001). Anchovy spawning time was assumed to be normally distributed with mean at 23:00h GMT and standard deviation of 1.25 (ICES, 2004). The peak of the spawning time was also used to define the age limits for each daily cohort (spawning time peak plus and minus 12 hours). Details on how the number of eggs in each cohort and the corresponding mean age are computed from the pdf of age are given in Bernal *et al* (2011). The incubation temperature considered was the one obtained from the CTD at 10m in the way down.

Given that this ageing process depends on the daily mortality rate which is unknown, an iterative algorithm in which the ageing and the model fitting are repeated until convergence of the *Z* estimates was used (Bernal *et al*., 2001; ICES, 2004; Stratoudakis *et al.*, 2006). The procedure is as follows:

Step 1. Assume an initial mortality rate value

Step 2. Using the current estimates of mortality calculate the daily cohort frequencies and their mean age.

Step 3. Fit the GLM and estimate the daily egg production and mortality rates. Update the mortality rate estimate.

Step 4. Repeat steps (1)-(3) until the estimate of mortality converged (i.e. the difference between the old and updated mortality estimates was smaller than 0.0001).

Incomplete cohorts, either because the bulk of spawning for the day was not over at the time of sampling, or because the cohort was so old that its constituent eggs had started to hatch in substantial numbers, were removed in order to avoid any possible bias. At each station, younger cohorts were dropped if they were sampled before twice the spawning peak width after the spawning peak and older cohorts were dropped if their mean age plus twice the spawning peak width was over the critical age at which less than 99% eggs were expected to be still unhatched. In addition, eggs younger than 4 hours and older than 90% of the survey incubation time (Motos, 1994) were removed.

Once the final model estimates were obtained the coefficient of variation of P_0 was given by the standard error of the model intercept (log (P_0)) (Seber, 1982) and the coefficient of variation of Z was obtained directly from the model estimates.

The analysis was conducted in R (www.r-project.org). The ”MASS” library was used for fitting the GLM with negative binomial distribution and the ”egg” library (http://sourceforge.net/projects/ichthyoanalysis/) for the ageing and the iterative algorithm.

Daily fecundity

The daily fecundity (DF) is usually estimated as follows:

(6) $$DF = \frac{R \cdot F \cdot S}{W_f} ,$$

where R is the sex ratio in weight, F is the batch fecundity (eggs per batch per female weight), S is the spawning frequency (percentage of females spawning per day) and W_f is the female mean weight.

At the moment of his working group, the anchovy adults from the survey to estimate F and S were in process so the DF was obtained as a mean of the historical series. Two considerations were proposed: a) DF as the mean of the whole historical series and b) DF as a mean of the last 6 years, just after the open of the fishery in 2010.

The final DF estimate will be provided in November for WGHANSA-sub when all the anchovy adults samples will be processed and the adult parameters estimated .

A linear regression model between total female weight (W_f) and gonad free weight (W_{gf}) was fitted to data from non-hydrated females:

(7) $$E[W_f] = a + b * W_{gf} \quad .$$

This model was used to correct the weight increase due to hydration of hydrated females. **The female mean weight (*W_f*)** per sample was calculated as the average of the individual female weights.

From 1987 to 1993 the **sex ratio (*R*)** in numbers resulted to be not significantly different from 50%. Therefore, since 1994 the sex ratio in numbers is assumed to be 0.5 and the sex ratio in weight per sample is estimated as the ratio between the average female weight and the sum of the average female and male weights of the anchovies in each of the samples.

SSB and numbers at age

The Spawning Stock Biomass (*SSB*) that in the case of anchovy is equal to total biomass at the spawning peak when the survey occurred, was estimated as the ratio between the total egg production (P_{tot}) and daily fecundity (*DF*) estimates and its variance was computed using the Delta method (Seber, *1982*). As two DF were proposed, two total biomass estimates were obtained depending on the considered DF.

To deduce the numbers at age 6 regions: South West (SW), South East (SE),Centre (C),Garonne (G), North(N) and North West (NW) were defined depending on the distribution of the adult samples (size, weight and age) and the distribution of anchovy eggs (**Figure 2**). Mean and variance of anchovy mean weights and proportions at age in the adult population were computed as a weighted average of the mean weight and age composition per samples (**equations 9 and 10**) where the weights were proportional to the population (in numbers) in each region. In particular, the weighting factors were proportional to the egg abundance divided by the numbers of adult samples in the region and the mean weight of anchovy per sample.

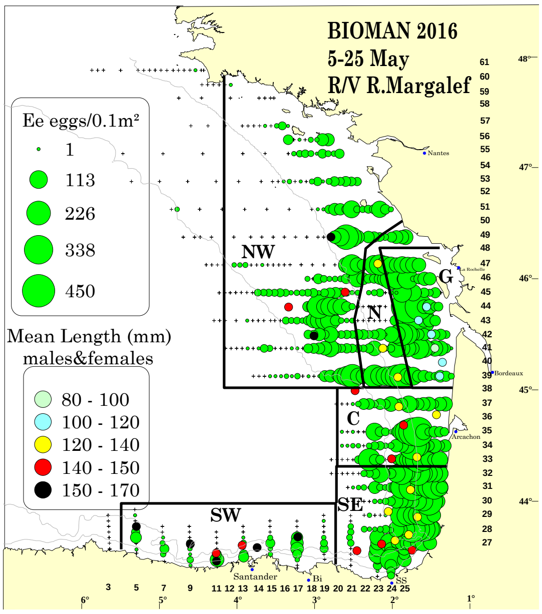

Figure 2: 6 regions defined to estimate the numbers at age. The black lines represent the border of the regions, the green bubbles de abundance of anchovy eggs in each station and the small colour bubbles represent the mean size (mm) of individuals within each haul.

Results

This year the West spawning limit in the Cantabrian coast was found at 5º17'W at the height of Gijón. In the French platform there were eggs all over the platform until 46ºN. From 46ºN to 47º23'N the egg were inside the 100m depth isoline. The northern distribution limit was found at the height of Nantes (47º23'N) (**Figure 3**). The sampling was stopped for 36h hours to refuel. The stern's stay of cufes was broken and was mended but didn't disturb the survey.

The total area covered was 98,866 km² and the spawning area was 55,092 km². During the survey 680 vertical plankton samples were obtained, 465 had anchovy eggs (69%) with an average of 550 eggs m^{-2} per station in the positive stations and a maximum of 7,530 eggs m^{-2} in a station. A total of 25,564 anchovy eggs were encountered and classified. 1,648 CUFES samples (horizontal sampling at 3m depth, mesh size net 335) were achieved, 1,050 had anchovy eggs (64%) with an average of 20 eggs m^{-3} per station in the positive stations and a maximum of 225 eggs m^{-3}.

A mean abundance of 8.87 E+12 sardine eggs was encountered in all the area surveyed, 1.47 times higher than last year; very few eggs were encountered along Cantabrian coast, close to it. In the French platform the eggs were between coast and 100m depth isoline, all along the coast, from south of France to 48ºN, where the north spawning limit was found (**Fig. 4**). In PairoVET from 680 stations a total of 266 (39%) stations had sardine eggs with an average of 290 eggs per m^{-2} per station in the positive station and a maximum of 6,690 eggs m^{-2}.

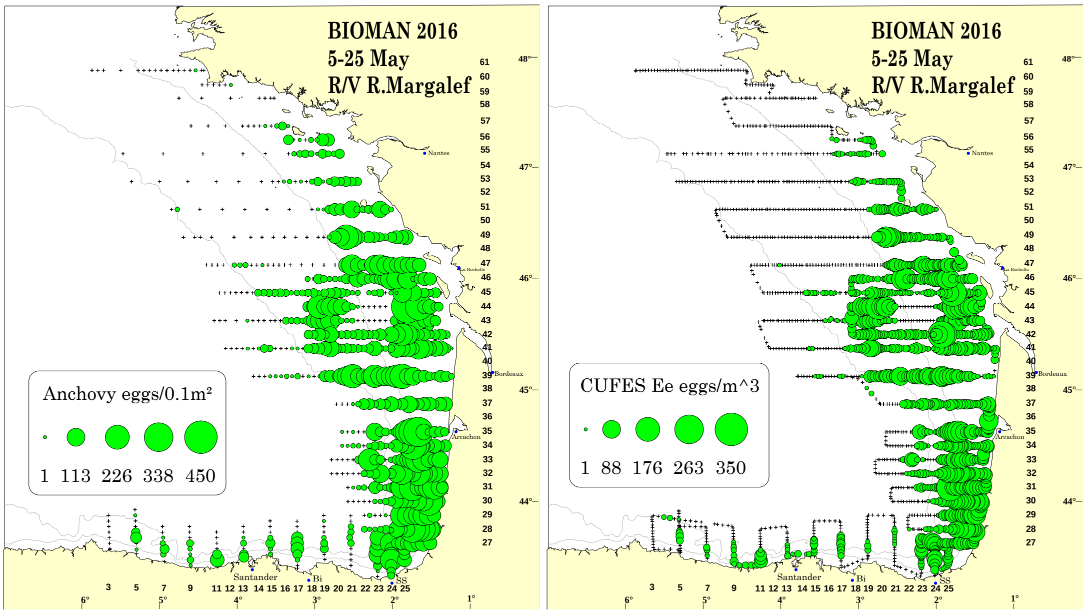

Figure 3: Distribution of anchovy egg abundances obtained with PairoVET (left) (eggs per 0.1m^2) and CUFES (right) (Egg per m^3) from the DEPM survey BIOMAN2016.

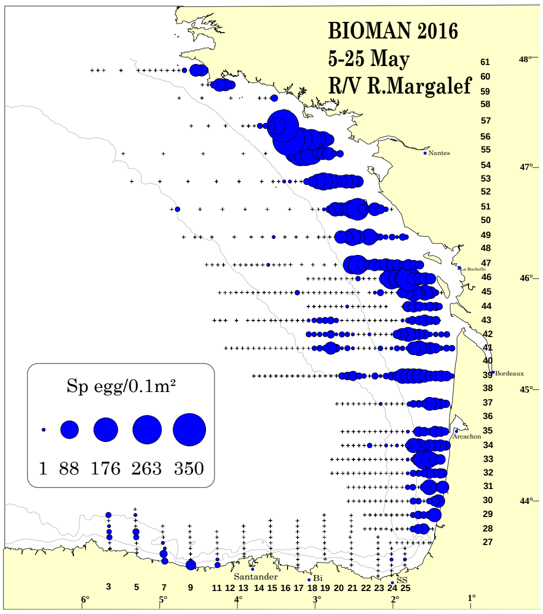

Figure 4: Distribution sardine egg abundances (eggs per 0.1m^2) from DEPM survey BIOMAN2016 obtained with PairoVET.

Figure 5 shows the sea surface temperature and sea surface salinity maps overlapped with the abundance of anchovy eggs as observed during the BIOMAN2016 survey.

This year the mean SST of the survey, 14.8ºC, was higher than last year (15.1). The mean SSS, 34.57 UPS, was at levels of last year (34.49 UPS).

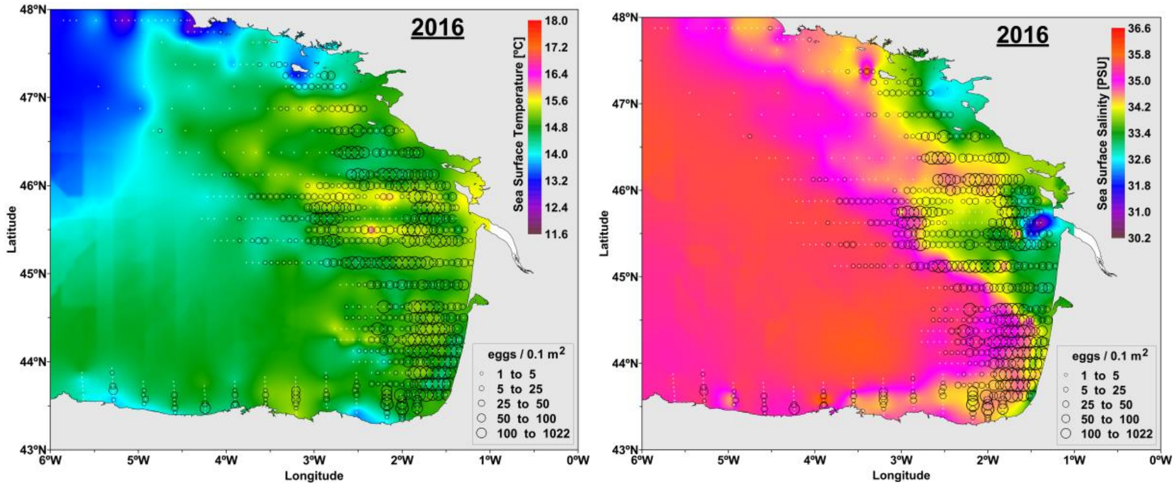

Figure 5: SST and SSS maps (left and right respectively) with anchovy egg distribution 2016.

The adult samples covered adequately the positive spawning area as shown in **Figure 2.** Overall 44 pelagic trawls were performed of these, 36 provide anchovy and 32 were selected for the analysis because the other 4 had a small amount of anchovy. Moreover 2 samples from purse seines were added, in total 34 samples for the analysis.

The spatial distribution of the samples and their species composition is shown in **Figure 6.** The most abundant species in the trawls ware: anchovy, sardine, horse mackerel, mackerel, hake and sprat. Anchovy adults were found in the same places where the anchovy eggs were found.

Spatial distribution of mean length and weight (males and females) is shown in **Figure 9**. Less weight individuals were found all along the French coast while heavier anchovies were found offshore in the French platform and in the cantabric coast.

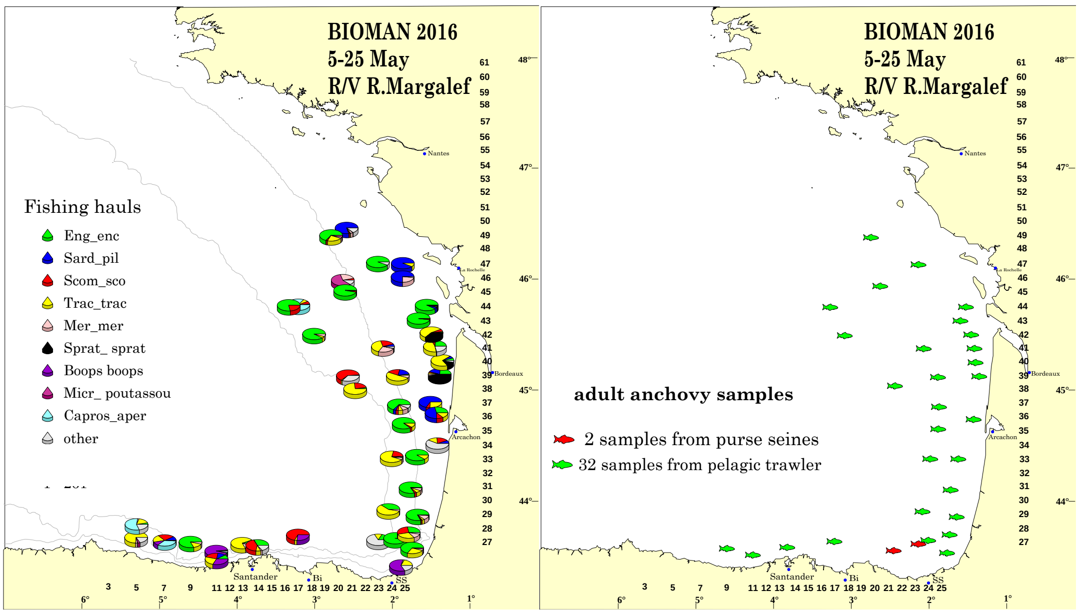

Figure 6: Spatial distribution of fishing hauls from R/V Emma Bardán in 2016. On the left the species composition by haul and on the right the hauls with anchovy selected for the analysis.

Total daily egg production estimates

As a result of the adjusted GLM (**Fig. 7**) the daily egg production (P_0) was 207 egg m^{-2} day $^{-1}$ with a standard error of 19.74 and a CV of 0.095. The daily mortality z was 0.32 with a standard error of 0.046 and a CV of 0.14. Then, the total daily egg production as the product of spawning area and daily egg production was 1.14 E+13 with a standard error of 1.1E+12 and a CV of 0.095.

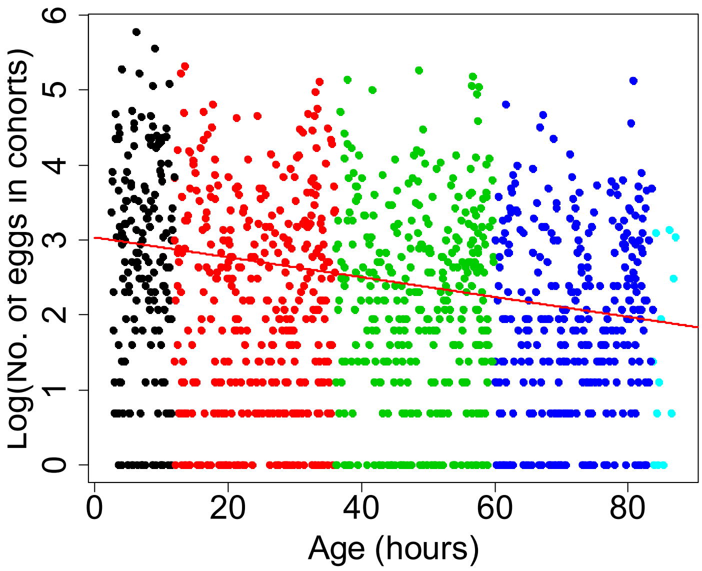

Figure 7: Exponential mortality model adjusted applying a GLM to the data obtained in the ageing following the Bayesian method (spawning peak 23:00h).The red line is the adjusted line. Data in Log scale.

Daily fecundity, total biomass and numbers at age

The results of the adjusted linear regression model between gonad-free-weight and total weight fitted to non-hydrated females (hydrated females identified *a visu* as stages 3, 5 based on the macroscopic maturity scale from WKSPMAT, 2008) is given in **Table 1**. The extra females taken not in random, for batch fecundity, were not considered. The model fitted the data adequately (**Figure 8**, R^2=99.7%, n= 688). The **female mean weight** was obtained as the weighted mean of the average female weights per sample (Lasker, 1985).

Table 1: Coefficients resulted from the linear regression model between gonad-free-weight and total weight fitted to non-hydrated females with their standard error and the P-Value.

Parameter	Estimate	Standard error	P-Value
Intercept	-0.2713	0.0360	0
Slope	1.0995	0.0022	0

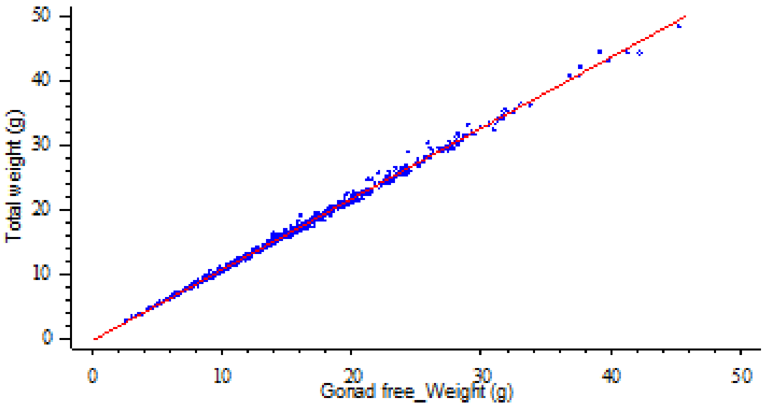

Figure 8: linear regression model between gonad-free-weight and total weight fitted to non-hydrated females.

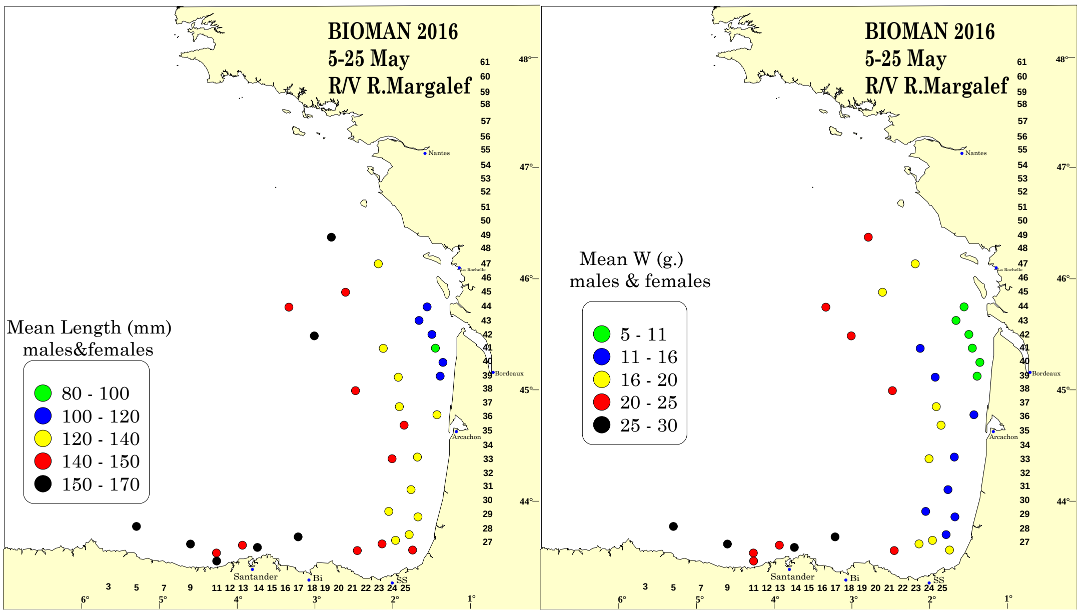

Figure 9: Anchovy (male and female) mean size (left) and mean weight (right) per haul in 2016

The index of total biomass estimated considering the whole historical mean of DF was 120,934t with a CV of 24% and considering just the last 6 years (after the open of the fishery) was164,411t with a CV of 15% (**Table 2 *a*&*b***).

Table 2*a*) Total egg production, daily fecundity considering all year's mean and total biomass estimates.

Ptot (eggs)			DF (eggs/gramme)			Total biomass(Ton.)		
Model	Estimate	Var	Predic.Model	Estimate	Var.Pred.	Estimate	Var	Cv
GLM	1.14E+13	1.2E+24	all years mean	94.63	419.43	120,934	8.2.E+08	0.2364

Table 2 *b*) Total egg production, daily fecundity considering last 6 years mean and total biomass estimates.

Ptot (eggs)			DF (eggs/gramme)			Total biomass (Ton.)		
Model	Estimate	Var	Predic.Model	Estimate	Var.Pred.	Estimate	Var	Cv
GLM	1.14E+13	1.2E+24	6 years mean	69.60	66.19	164,411	6.1.E+08	0.1506

For the purposes of producing population at age estimates, the age readings based on 2,122 otoliths from 32 samples were available. Estimates of anchovy mean weights and proportions at age in the population were the average of proportions at age in the samples, weighted by the population each sample represents.

Given that mean length of anchovies change between different regions (**Figure 2**) proportionality between the amount of samples and a proxy of the total biomass, indices by regions was checked. The approximate index of biomass by regions was set equal to egg abundance divided by the number of adult samples assigned to each region (**Table 3**). According to that table, the 34 samples selected cannot be considered to be balanced between these regions and differential weighting factors were applied to each sample coming from one or the other region for the purposes of the number at age estimates and biomass estimates. The proportion by age, numbers by age, weight at age and biomass by age, length and weight by age estimates are given in **Table 4 (a&b), Figure 12 (**for instance considering the DF as the mean of the last 6 years). 53% of the population in numbers and 43% in mass correspond to age 1. **Figure 10** shows the distribution of anchovy age composition in space.

Table 3: Balance adult sampling to egg abundance by 6 regions (South West (SW), South East (SE), Centre (C), Garonne (G), North (N) and North West (NW) in the Bay of Biscay (**Figure 2**). The 5th row of the table corresponds to the weighting factor for each sample depending on the region where they are. Mean weight by regions arise from the 34 adult samples selected for the analysis.

Region	SW	SE	C	G	N	NW	Addition
Total egg abundance	6.5E+11	6.1E+12	4.4E+12	5.6E+12	3.5E+12	5.7E+12	2.6E+13
% egg abundance	3%	24%	17%	22%	14%	22%	100%
Nº of adult samples	7	8	5	6	3	5	34
% Egg/sample	0.004	0.029	0.034	0.036	0.045	0.044	
% of Biomass relative to N region	0.08	0.65	0.75	0.80	1.00	0.98	
W. factor proportional to the population	0.08/wi	0.65/wi	0.75/wi	0.80/wi	1/wi	0.98/wi	
Mean weight of anchovies by region	24.7	15.8	16.4	8.2	13.7	21.4	
Standard Deviation	2.6	3.8	2.9	1.5	2.1	2.1	
CV	11%	24%	17%	19%	15%	10%	

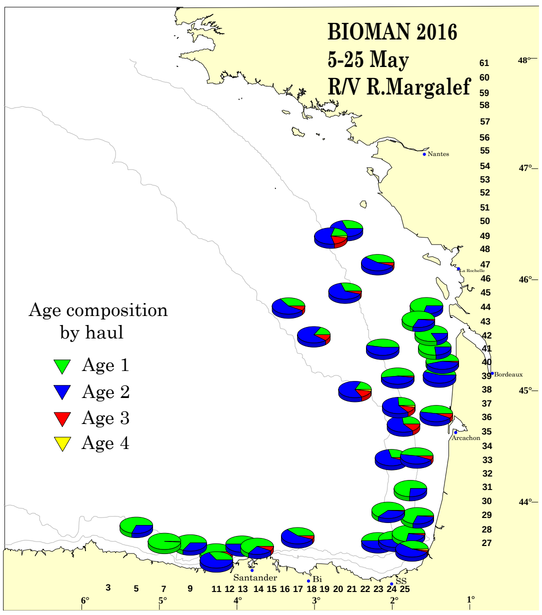

Figure 10: Anchovy age composition per haul in space

Table 4 *a* & *b*: 2016 total biomass (B) estimates, total weight (Wt), population in millions and percentage in numbers, percentage in mass, mass, weight and length at age estimates and correspondent standard error (S.e.) and coefficient of variation (CV). ***a*)** Considering DF as the whole historical mean ***b*)** considering just the last 6 years mean

Parameter	Estimate	S.e.	CV	Parameter	Estimate	S.e.	CV
Total Biomass (Tons)	120,934	28,585	0.2364	Total Biomass (Tons)	164,411	24,767	0.1506
Tot.mean W (g)	13.38	1.09	0.0816	Tot.mean W (g)	13.3817	1.09	0.0816
Population (millions)	9,037	2259.8	0.2501	Population (millions)	12,286	2104.8	0.1713
Percent age 1	0.53	0.0387	0.0734	Percent age 1	0.53	0.0387	0.0734
Percent age 2	0.44	0.0337	0.0758	Percent age 2	0.44	0.0337	0.0758
Percent age 3+	0.03	0.0065	0.2479	Percent age 3+	0.03	0.0065	0.2479
Numbers at age 1	4,770	1243.2	0.2606	Numbers at age 1	6,485	1208.7	0.1864
Numbers at age 2	4,014	1048.8	0.2613	Numbers at age 2	5,457	1022.3	0.1874
Numbers at age 3+	238	83.8	0.3521	Numbers at age 3+	324	97.5	0.3014
Weight at age 1	10.9	0.98	0.0900	Weight at age 1	10.9	0.98	0.0900
Weight at age 2	15.5	1.00	0.0643	Weight at age 2	15.5	1.00	0.0643
Weight at age 3+	25.7	1.33	0.0498	Weight at age 3+	25.7	1.33	0.0498
Length at age 1	119.9	3.60	0.0300	Length at age 1	119.9	3.60	0.0300
Length at age 2	133.9	2.91	0.0217	Length at age 2	133.9	2.91	0.0217
Length at age 3+	160.7	2.17	0.0135	Length at age 3+	160.7	2.17	0.0135
B at age 1 in mass	52,341			B at age 1 in mass	71,158		
B at age 2 in mass	62,459			B at age 2 in mass	84,913		
B at age 3+ in mass	6,134			B at age 3+ in mass	8,339		
Percent age 1 in mass	0.43	0.035	0.0817	Percent age 1 in mass	0.43	0.04	0.0817
Percent age 2 in mass	0.52	0.028	0.0545	Percent age 2 in mass	0.52	0.03	0.0545
Percent age 3+ in mass	0.05	0.011	0.2178	Percent age 3+ in mass	0.05	0.01	0.2178

Historical perspective

The whole series of total biomass index estimated with the DEPM, including the preliminary estimate of total biomass for 2016, considering *a*)DF as the whole historical mean and *b*) considering just the last 6 years mean, are presented in **figure 11**. The historical series of numbers at age in numbers is shown in **figure 12.** In order to provide a broader point of view for the interpretation of current survey results, distribution maps of the anchovy and sardine egg abundances in the last 20 DEPM surveys were compiled (**Fig 14**).

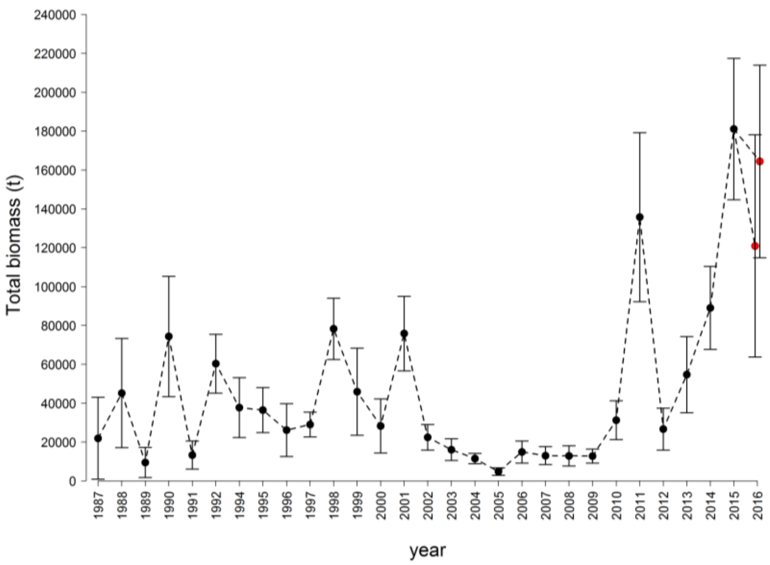

Figure 11: Series of total Biomass estimates (tonnes) obtained from the DEPM since 1987. Considering *a*) DF as the whole historical mean and *b*) considering the last 6 years mean.

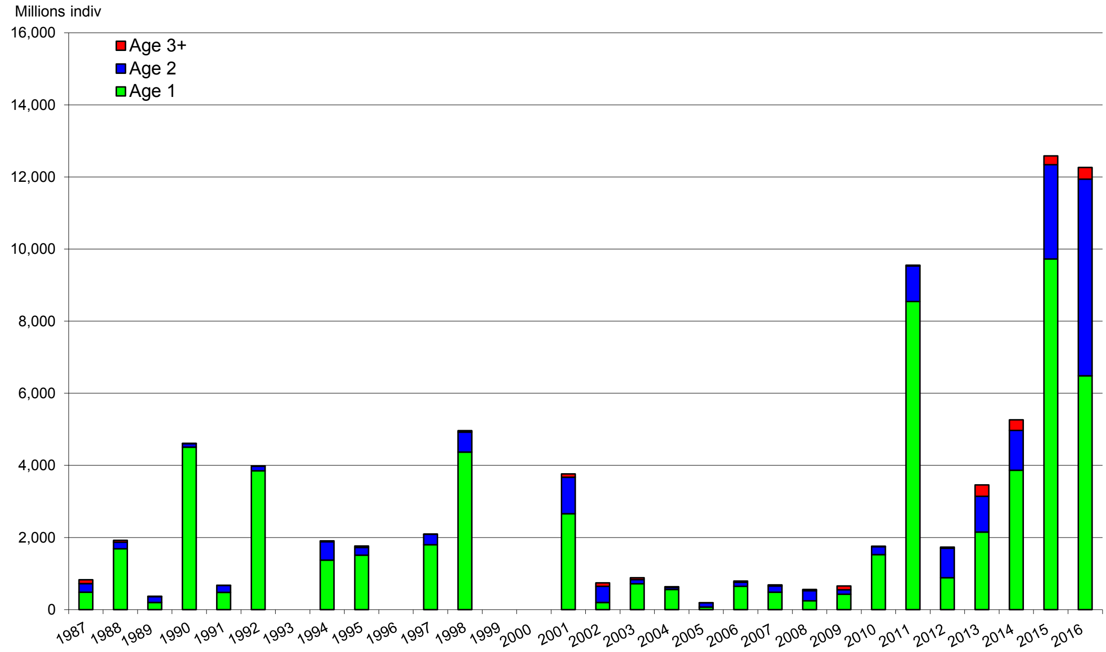

Figure 12: Historical series of numbers at age from 1987 to 2016 for instance considering the DF as the mean of the last 6 years.

Sardine total egg abundance

Total egg abundance for sardine was estimate as the sum of the numbers of eggs per m^2 in each station multiply by the area each station represent. This year estimate was 6.03 E+12 eggs, near to the average in relation with the time series. The historical series of egg abundances is shown in **figure 13, table 5**. The sardine egg distribution is shown in **figure 4** and the historical series of egg abundances distribution in **figure 15**. This egg abundance series and the estimate of this year do not contained the eggs in the cantabric coast to be incorporated as an input in the assessment of sardine in VIIIab.

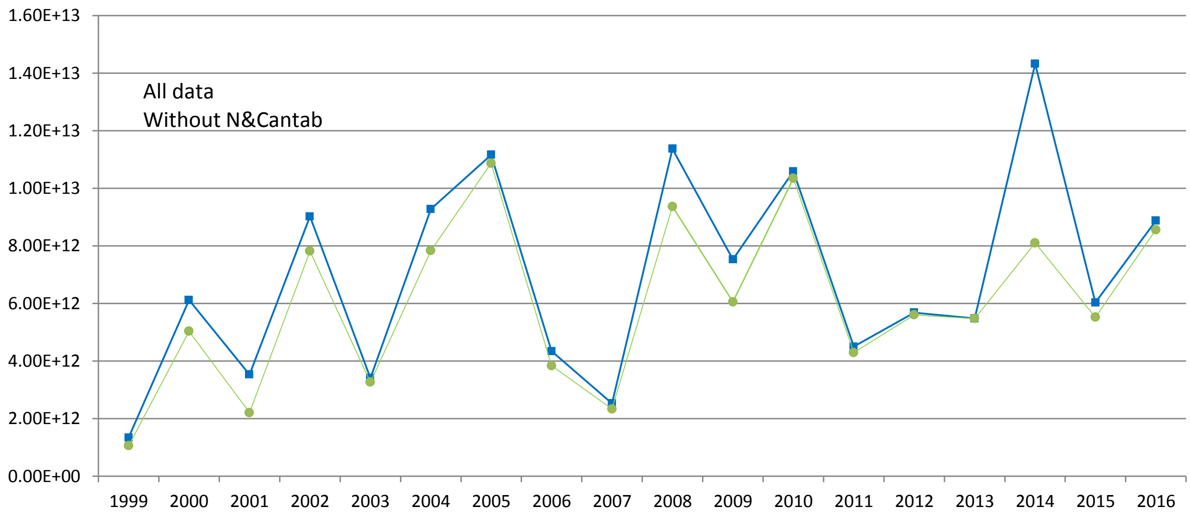

Figure 13: historical series of sardine egg abundances without the eggs from the cantabric coast and part of the North.

Table 5: historical series of sardine egg abundances without the eggs from the cantabric coast and part of the North

Year	TotAb_whithoutN&Cant
1999	1.06E+12
2000	5.03E+12
2001	2.20E+12
2002	7.82E+12
2003	3.26E+12
2004	7.83E+12
2005	1.09E+13
2006	3.84E+12
2007	2.33E+12
2008	9.37E+12
2009	6.05E+12
2010	1.03E+13
2011	4.29E+12
2012	5.60E+12
2013	5.474E+12
2014	8.209E+12
2015	5.52E+12
2016	8.56E+12

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References

Agresti, A. 1990. *Categorical data analysis*. John Wiley & Sons, Inc. New York

Arregi, L., Puente, E., Lucio, P., Sagarminaga, Y., Castro and Uriarte, An. Costal fisheries and demersal estuarine fauna. In: Oceanography and marine environment of the Basque Country. (ed. A. Borja and M. Collins) Elsevier oceanography series.

Barange, M., Bernal, M., Cercole, M.C., Cubillos, L.A., Cunningham, C.L., Daskalov, G.M., De Oliveira, J.A.A., Dickey-Collas, M., Hill, K., Jacobson, L.D., Köster, F.W., Masse, J., Nishida, H., Ñiquen, M., Oozeki, Y., Palomera, I., Saccardo, S.A., Santojanni, A., Serra, R., Somarakis, S., Stratoudakis, Y., van der Lingen, C.D., Uriarte, A. and Yatsu, A. 2009. Current trends in the assessment and management of small pelagic fish stocks. Chapter 10 in:

Checkley, D.M. Jr, Roy, C., Oozeki, Y. and Alheit J. (Eds.) Climate Change and Small Pelagic Fish. Cambridge University Press.

Bernal, M., Ibaibarriaga, L., Lago de Lanzós, A., Lonergan, M., Hernández, C., Franco, C., Rasines, I., et al. 2008. Using multinomial models to analyse data from sardine egg incubation experiments; a review of advances in fish egg incubation analysis techniques. *ICES Journal of Marine Science*, 65: 51–59.

Bernal, M., Borchers, D. L., Valde´s, L., Lago de Lanzo´ s, A., and Buckland, S. T. 2001. A new ageing method for eggs of fish species with daily spawning synchronicity. *Canadian Journal of Fisheries and Aquatic Sciences*, 58: 2330–2340.

Checkely D.M., Ortner P.B., Settle L.R., S.R. Cummings (1997). A continuous, un-derway fish egg sampler. *Fisheries Oceanography* 6: 58–73.

Ferrer, L., Fontán, A., Chust, G., Mader, J., González, M., Valencia, V., Uriarte, Ad., Collins, M.B., 2009. Low salinity plumes in the oceanic region of the Basque Country. Cont. Shelf Res., 29 (8), 970-984.

Hunter, J.R. and Macewicz, B.J. (1985) Measurement of spawning frequency in multiple spawning fishes. In: *An Egg Production Method for Estimating Spawning Biomass of Pelagic Fish: Application to the Northern Anchovy, Engraulis mordax* (ed. R. Lasker), NOAA Technical Report NMFS, US Department of Commerce, Springfield, VA, USA, 79–93.

Ibaibarriaga, L., Bernal, M., Motos, L., Uriarte, A., Borchers, D. L.,Lonergan, M., and Wood, S. 2007. Estimation of development properties of stage-classified biological processes using multinomial models: a case study of Bay of Biscay anchovy (*Engraulis encrasicolus* L.) egg development. *Canadian Journal of Fisheries and Aquatic Sciences*, 64: 539–553.

ICES. 2010. Report of the Working Group on Anchovy and Sardine (WGANSA), 24–28 June 2010, Lisbon, Portugal. ICES CM 2010/ACOM:16. 290 pp.

ICES. 2004. The DEPM estimation of spawning-stock biomass for sardine and anchovy. *ICES Cooperative Research Report*, 268.91 pp.

Lasker, R., 1985. *An Egg Production Method for Estimating Spawning Biomass of pelagic fish: Application to the Northern Anchovy, Engraulis mordax*. NOAA Technical report NMFS 36:100p.

Lo, N.C.H. (1985a). A model for temperature-dependent northern anchovy egg development and an automated procedure for the assignment of age to staged eggs. In: *An Egg Production Method for Estimating Spawning Biomass of Pelagic Fish: Application to the Northern Anchovy, Engraulis mordax* (ed. R. Lasker), NOAA Technical Report NMFS, US Department of Commerce, Springfield, VA, USA, 43–50.

McCullagh, P., and Nelder, J.A. 1989. Generalised linear models. Chapman & Hall, London.

Moser HG, Ahlstrom EH (1985). Staging anchovy eggs. In: Lasker R. (ed.) *An Egg Production Method for Estimating Spawning Biomass of Pelagic Fish: Application to the Northern*

Anchovy, *Engraulis mordax*. pp 99–101. NOAA Technical Report 36: 37–41.

Motos, L., Uriarte, A., Prouzet, P., Santos, M., Alvarez, P., Sagarminaga, Y., 2005. *Assessing the Bay of Biscay anchovy population by DEPM: a review 1989–2001*. In: Castro, L.R., P. Freón, C. D. van der Lingen and A. Uriarte, editors, Report of the SPACC Meeting on Small Pelagic Fish Spawning Habitat Dynamics and the Daily Egg Production Method (DEPM). GLOBEC Report 22, xiv, pp. 88-90.

Motos, L., 1994. Estimación de la biomasa desovante de la población de anchoa del Golfo de Vizcaya *Engraulis encrasicolus* a partir de su producción de huevos. Bases metodológicas y aplicación. Ph. D. thesis UPV/EHU, Leioa.

Parker, K., 1980. A direct method for estimating northern anchovy, *Engraulis mordax*, spawning biomass. *Fisheries. Bulletin*., 78: 541-544

Picquelle, S and G. Stauffer. 1985. Parameter estimation for an egg production method of anchovy biomass assessment. In: R. Lasker (ed.). *An egg production method for estimating spawning biomass of pelagic fish: Application to the northern anchovy, Engraulis mordax*, pp. 7-16. U.S. Dep. Commer.,NOAA Tech. Rep. NMFS 36.

Sanz, A. and A. Uriarte. 1989. Reproductive cycle and batch fecundity of the Bay of Biscay anchovy (*Engraulis encrasicholus*) in 1987. CalCOFI Rep., 30: 127-135

Seber, G.A.F. *The estimation of animal abundance and related parameters*. Charles Griffin and Co., London, 2nd edition, 1982.

Shchepetkin, A.F., McWilliams, J.C., 2005. The regional oceanic modeling system (ROMS): a split-explicit, free-surface, topography-following-coordinate oceanic model. Ocean Model., 9, 347-404.

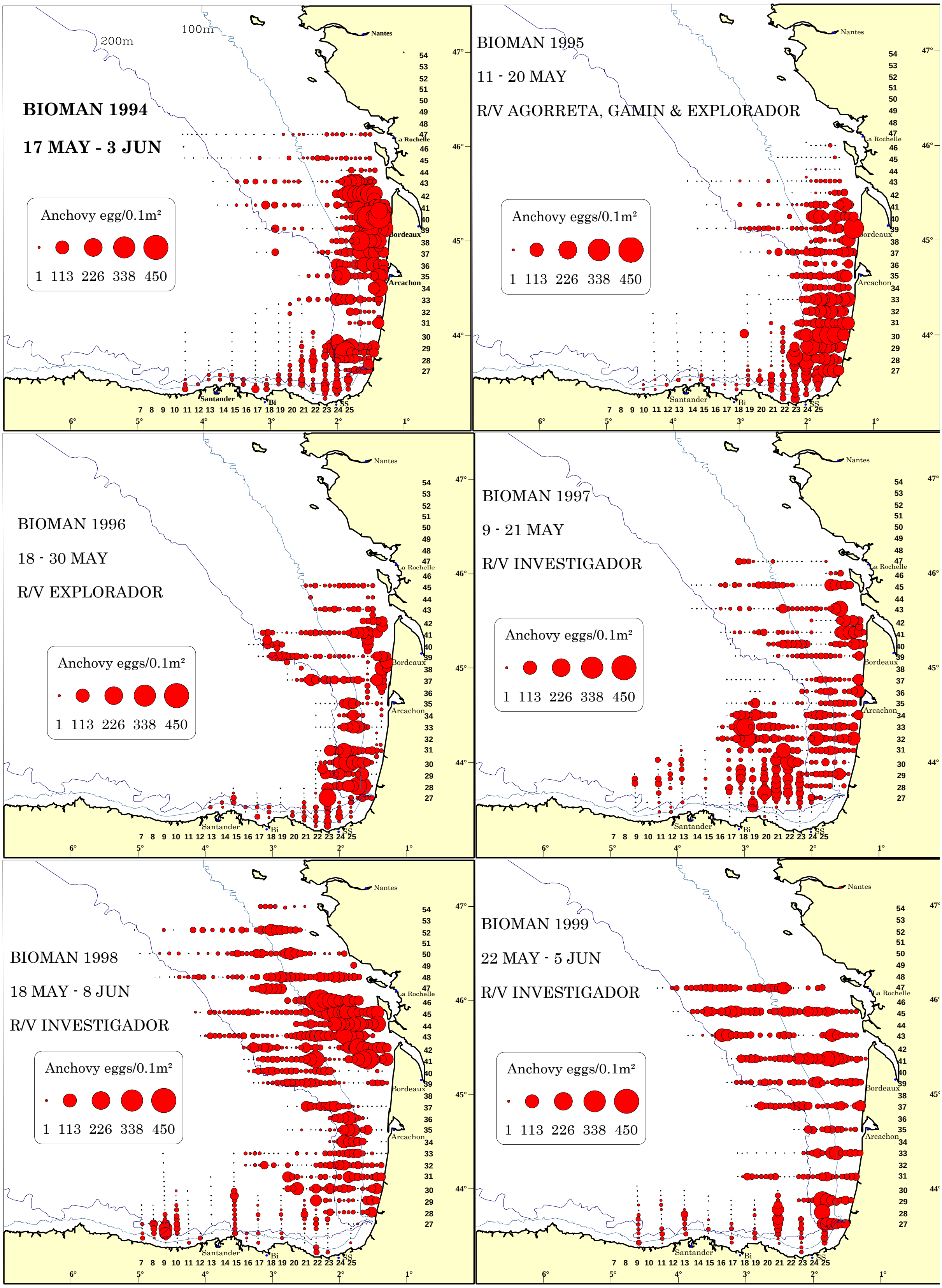
Somarakis, S., Palomera, I., García, A., Quintanilla, L., Koutsikopoulos, C., Uriarte, A., Motos, L., 2004. Daily egg production of anchovy in European waters. *ICES Journal Marine Science*. 61, 944-958.

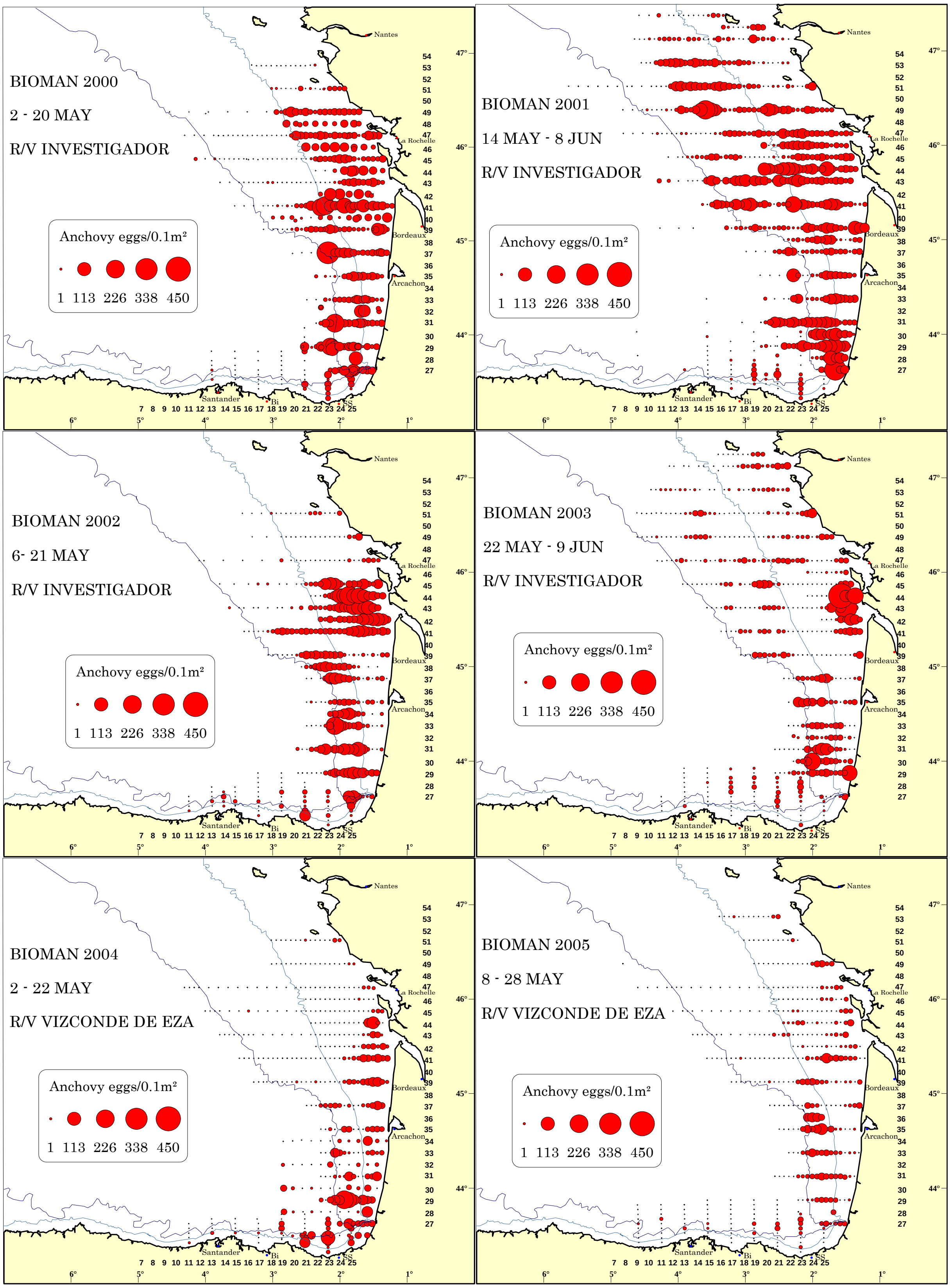
Smith, P.E., W. Flerx and R.H. Hewitt, 1985. The CalCOFI Vertical Egg Tow (CalVET) Net. In R. Lasker (editor), *An egg production method for estimating spawning biomass of pelagic fish: Application to the northern anchovy, Engraulis mordax,* p. 27-32. U.S. Dep. Commer., NOAA Tech. Rep. NMFS 36.

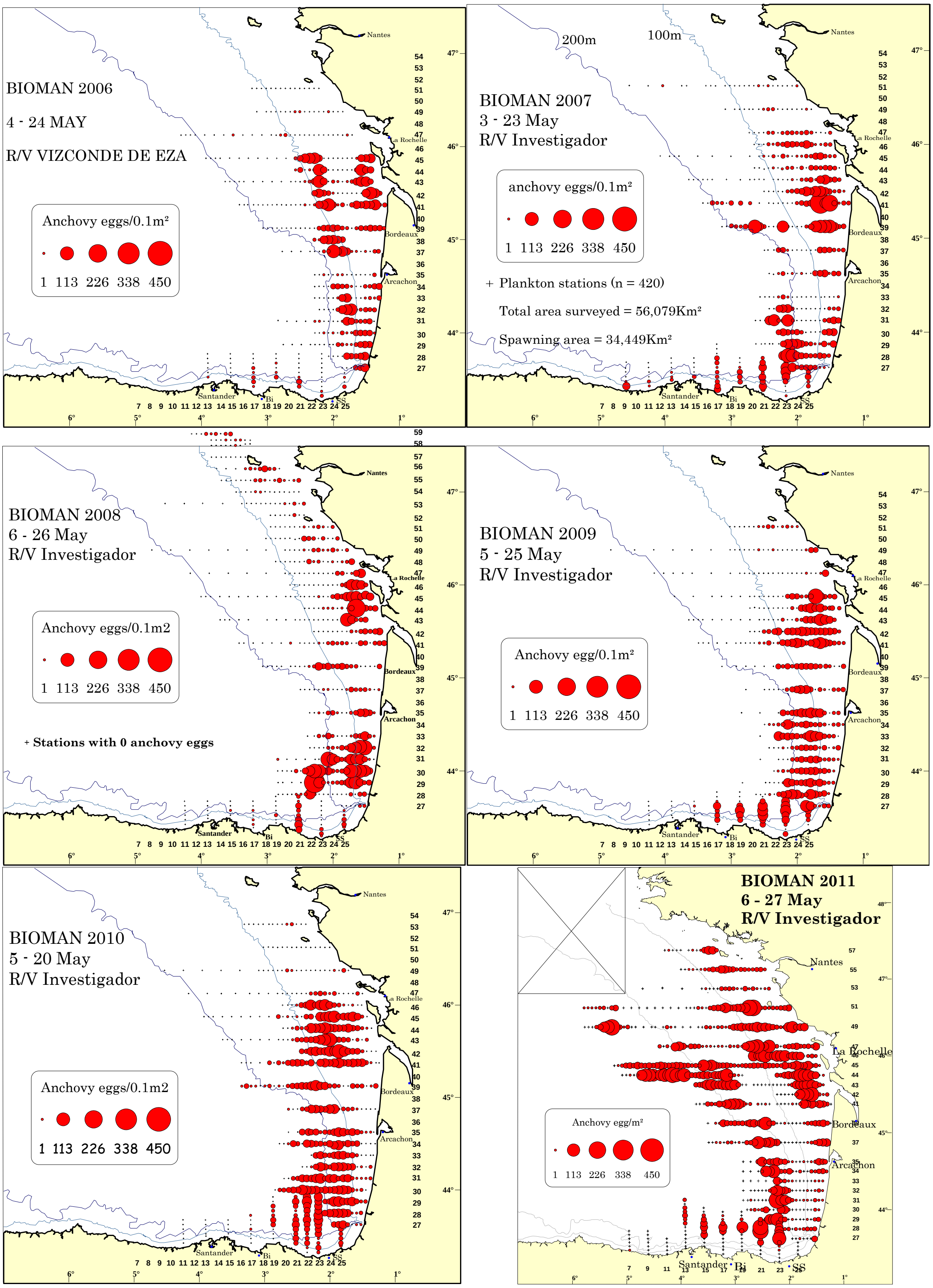
Stratoudakis, Y., Bernal, M., Ganias, K., and Uriarte, A. 2006. The daily egg production methods: recent advances, current applications and future challenges. *Fish and Fisheries*, 7: 35–57.

Uriarte A., Prouzet, P. Villamor B. 1996. Bay of Biscay and Ibero-Atlantic anchovy populations and their fisheries. *Scientia Marina*, 60 (Supl.2): 237-255.

Uriarte A., Alday A., Santos M, and Motos L., 2012: A re-evaluation of the spawning fraction estimation procedures for Bay of Biscay anchovy, a species with short interspawning intervals. Fisheries Research 117–118; 96-111 (doi:10.1016/ j.fishres.2011.03.002)


BIOMAN 1994
17 MAY - 3 JUN
Anchovy egg/0.1m²
1 113 226 338 450
BIOMAN 1995
11 - 20 MAY
R/V AGORRETA, GAMIN & EXPLORADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 1996
18 - 30 MAY
R/V EXPLORADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 1997
9 - 21 MAY
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 1998
18 MAY - 8 JUN
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 1999
22 MAY - 5 JUN
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450
Nantes
La Rochelle
Bordeaux
Arcachon
Santander
200m
100m


BIOMAN 2000
2 - 20 MAY
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 2001
14 MAY - 8 JUN
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 2002
6- 21 MAY
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 2003
22 MAY - 9 JUN
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 2004
2 - 22 MAY
R/V VIZCONDE DE EZA
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 2005
8 - 28 MAY
R/V VIZCONDE DE EZA
Anchovy eggs/0.1m²
1 113 226 338 450
Nantes
La Rochelle
Bordeaux
Arcachon
Santander
Bi
SS
47°
46°
45°
44°
6°
5°
4°
3°
2°
1°


BIOMAN 2006
4 - 24 MAY
R/V VIZCONDE DE EZA
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 2007
3 - 23 May
R/V Investigador
200m
100m
anchovy eggs/0.1m²
1 113 226 338 450
+ Plankton stations (n = 420)
Total area surveyed = 56,079Km²
Spawning area = 34,449Km²
BIOMAN 2008
6 - 26 May
R/V Investigador
Anchovy eggs/0.1m2
1 113 226 338 450
+ Stations with 0 anchovy eggs
BIOMAN 2009
5 - 25 May
R/V Investigador
Anchovy egg/0.1m²
1 113 226 338 450
BIOMAN 2010
5 - 20 May
R/V Investigador
Anchovy eggs/0.1m2
1 113 226 338 450
BIOMAN 2011
6 - 27 May
R/V Investigador
Anchovy egg/m²
1 113 226 338 450
Nantes
La Rochelle
Bordeaux
Arcachon
Santander
Bi
SS

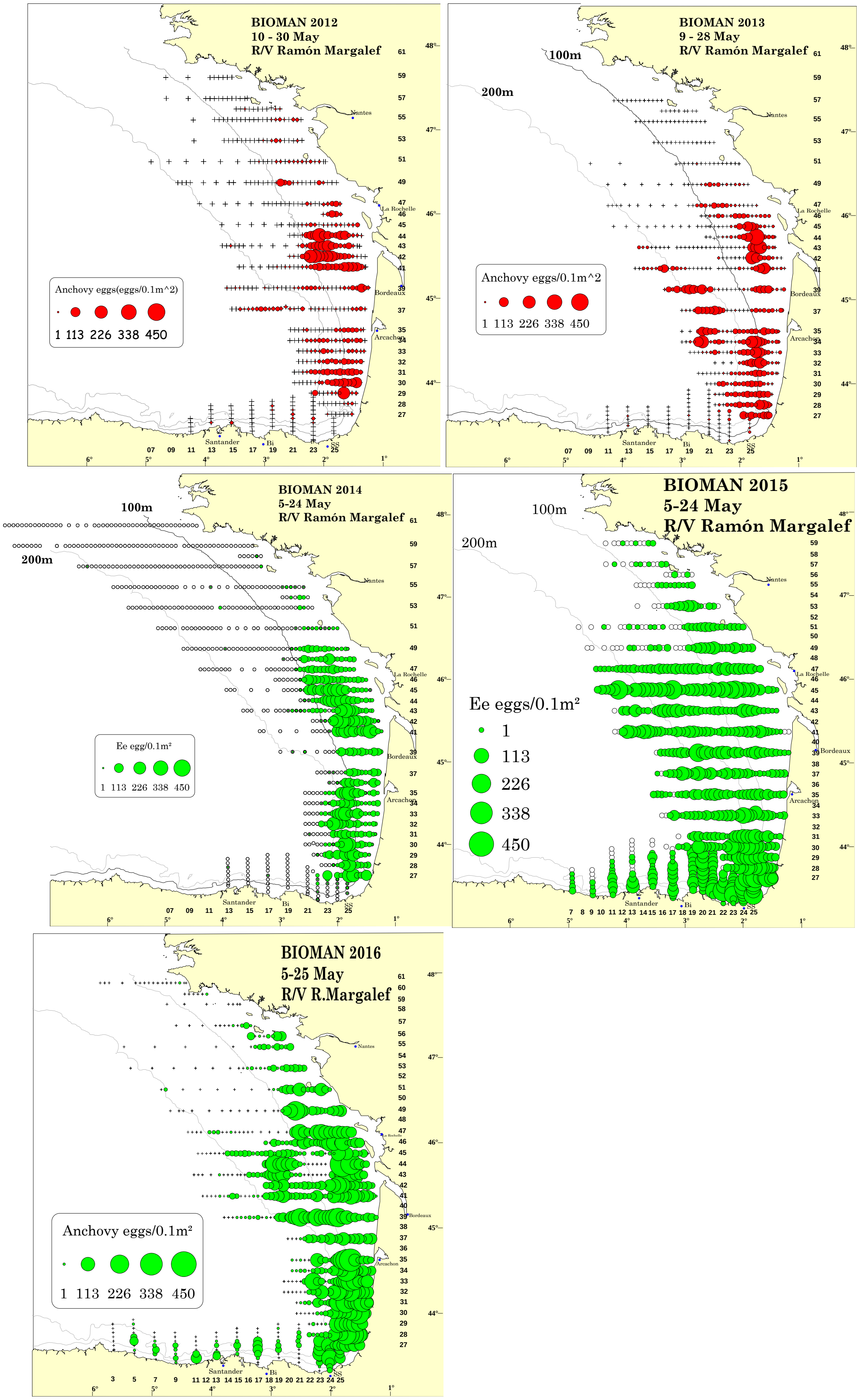
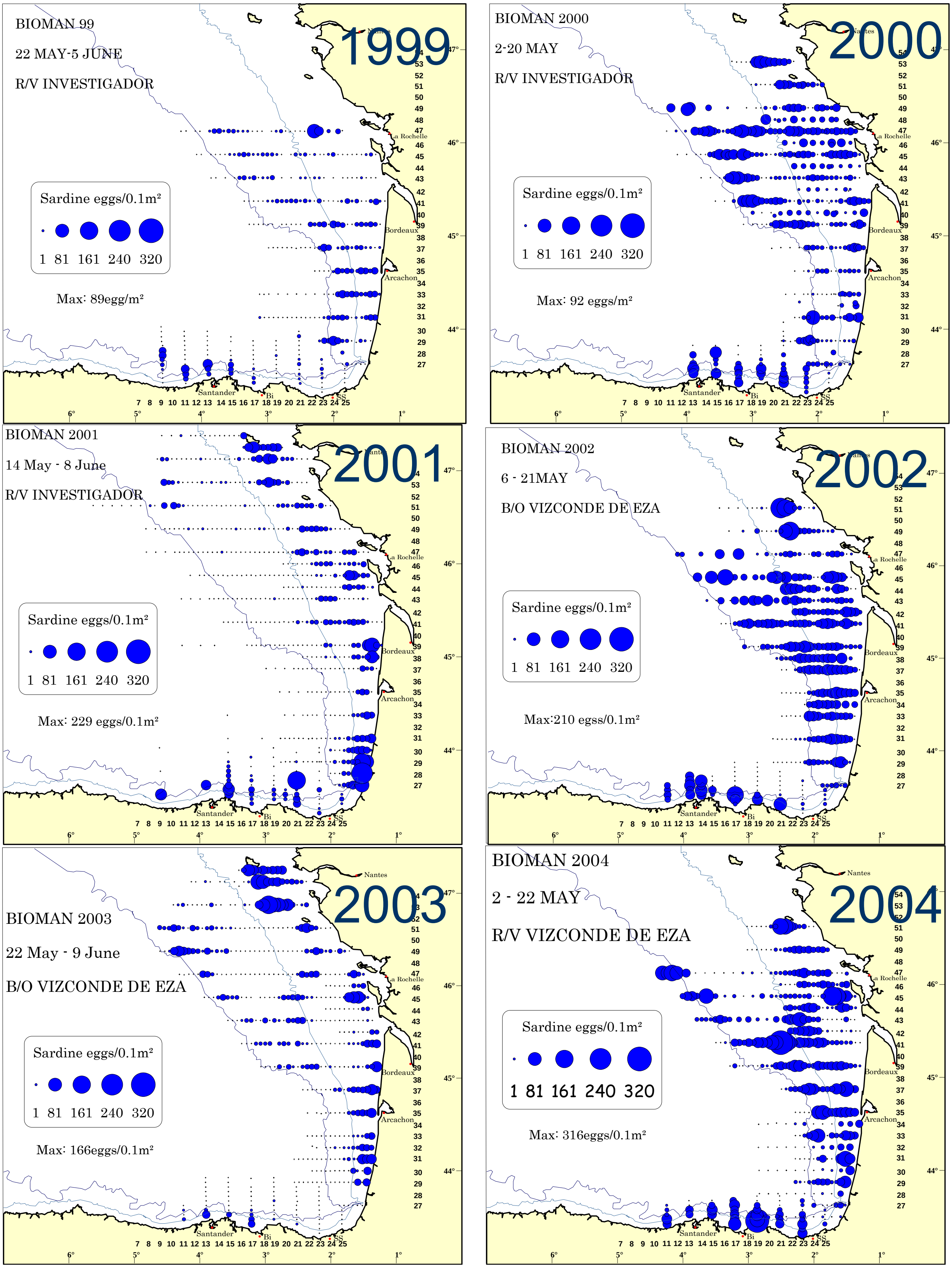
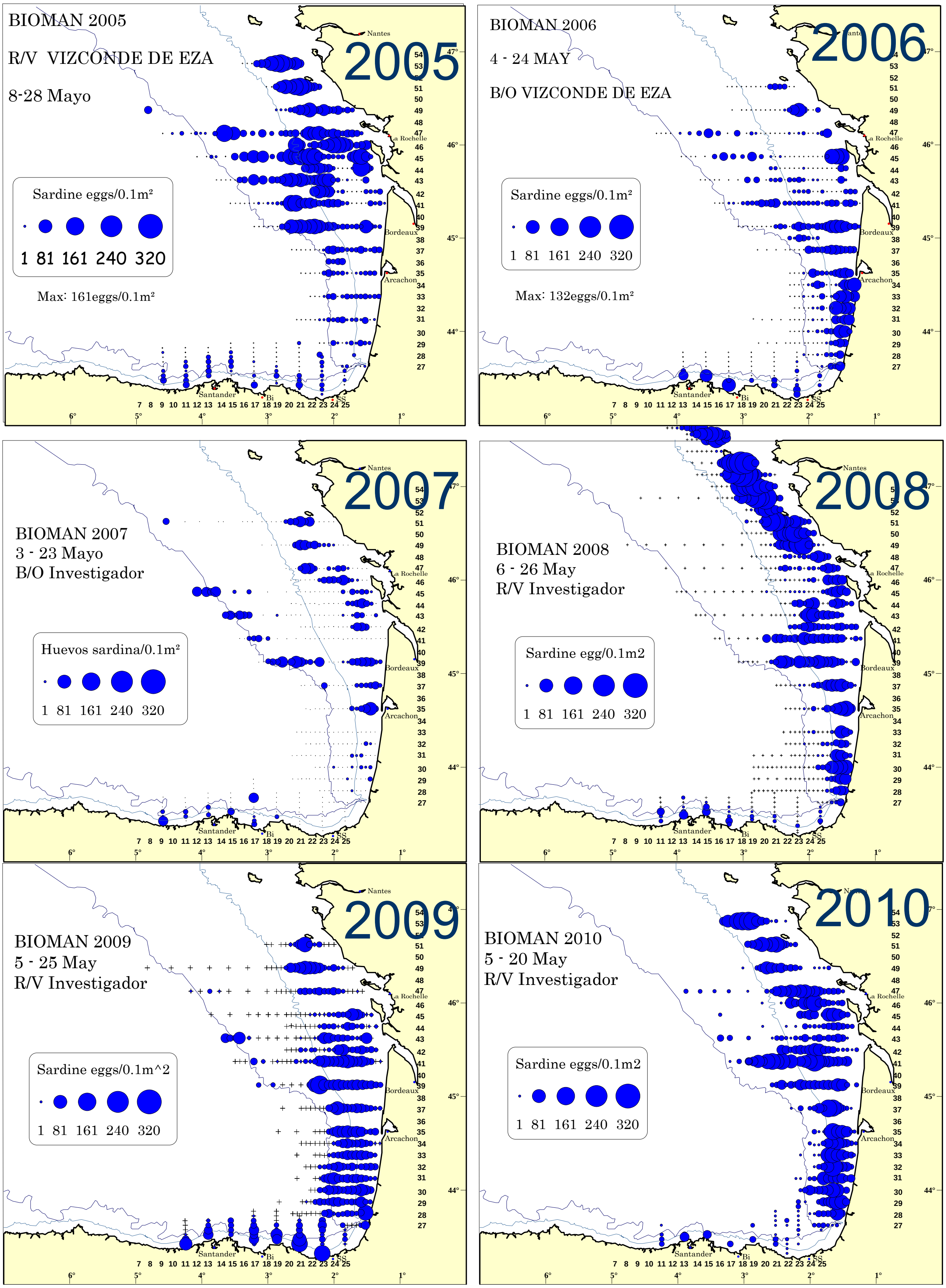


Figure 14: Anchovy egg distribution and abundance from 1994 to 2016.


BIOMAN 99
22 MAY-5 JUNE
R/V INVESTIGADOR
1999
Sardine eggs/0.1m²
1 81 161 240 320
Max: 89egg/m²
BIOMAN 2000
2-20 MAY
R/V INVESTIGADOR
2000
Sardine eggs/0.1m²
1 81 161 240 320
Max: 92 eggs/m²
BIOMAN 2001
14 May - 8 June
R/V INVESTIGADOR
2001
Sardine eggs/0.1m²
1 81 161 240 320
Max: 229 eggs/0.1m²
BIOMAN 2002
6 - 21MAY
B/O VIZCONDE DE EZA
2002
Sardine eggs/0.1m²
1 81 161 240 320
Max:210 egss/0.1m²
BIOMAN 2003
22 May - 9 June
B/O VIZCONDE DE EZA
2003
Sardine eggs/0.1m²
1 81 161 240 320
Max: 166eggs/0.1m²
BIOMAN 2004
2 - 22 MAY
R/V VIZCONDE DE EZA
2004
Sardine eggs/0.1m²
1 81 161 240 320
Max: 316eggs/0.1m²
Nantes
La Rochelle
Bordeaux
Arcachon
Santander
Bi
SS
47°
46°
45°
44°
6°
5°
4°
3°
2°
1°


BIOMAN 2005
R/V VIZCONDE DE EZA
8-28 Mayo
2005
Sardine eggs/0.1m²
1 81 161 240 320
Max: 161eggs/0.1m²
BIOMAN 2006
4 - 24 MAY
B/O VIZCONDE DE EZA
2006
Sardine eggs/0.1m²
1 81 161 240 320
Max: 132eggs/0.1m²
BIOMAN 2007
3 - 23 Mayo
B/O Investigador
2007
Huevos sardina/0.1m²
1 81 161 240 320
BIOMAN 2008
6 - 26 May
R/V Investigador
2008
Sardine egg/0.1m2
1 81 161 240 320
BIOMAN 2009
5 - 25 May
R/V Investigador
2009
Sardine eggs/0.1m^2
1 81 161 240 320
BIOMAN 2010
5 - 20 May
R/V Investigador
2010
Sardine eggs/0.1m2
1 81 161 240 320
Nantes
La Rochelle
Bordeaux
Arcachon
Santander
Bi
SS
7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
6° 5° 4° 3° 2° 1°
47° 46° 45° 44°

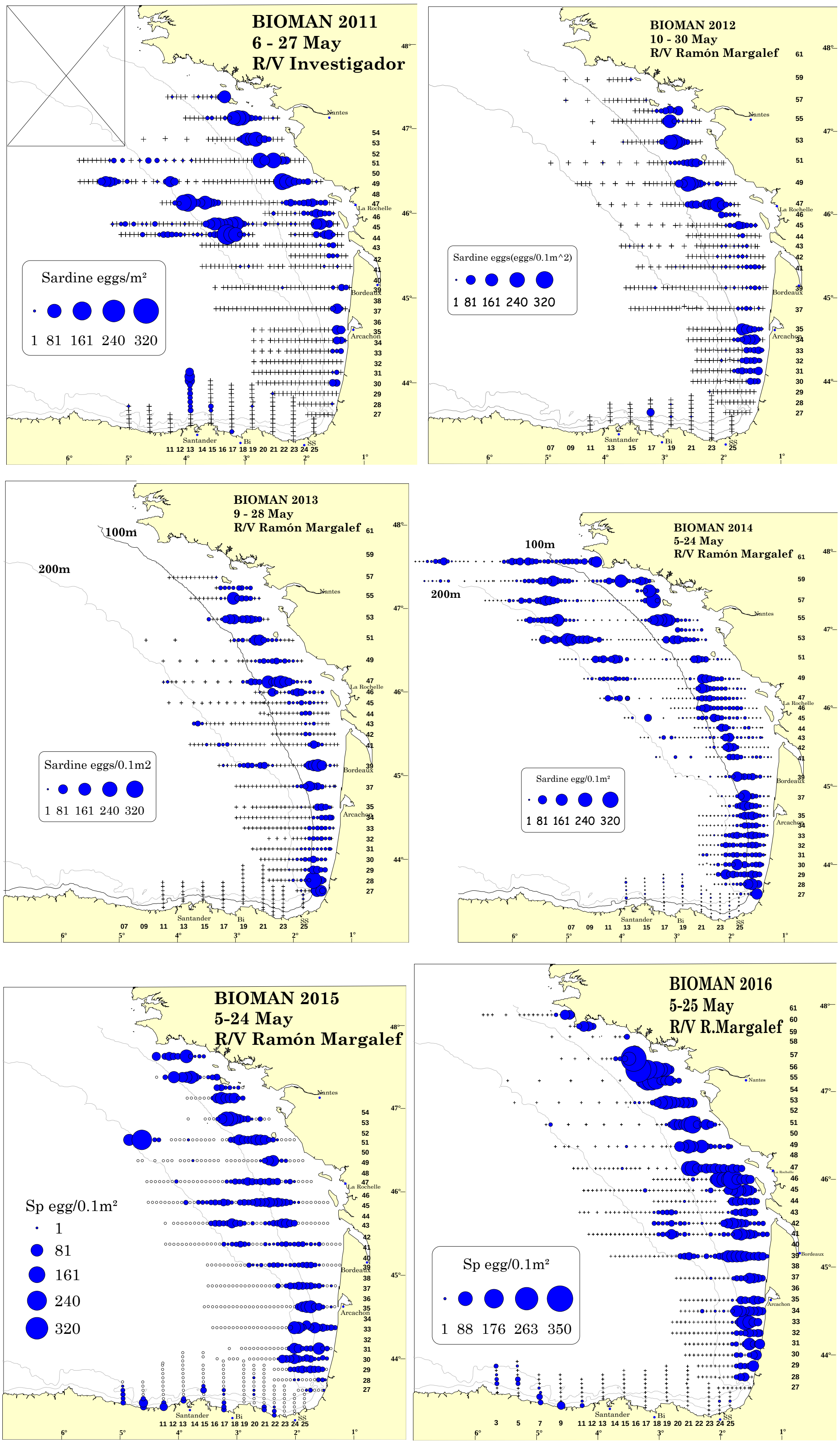


Figure 15: Sardine egg distribution and abundance from 1999 to 2016.

Working document presented in the ICES Working Group on Southern Horse Mackerel, Sardine and Anchovy (WGHANSA). Lorient, France, 24-29 June 2016.
(An updated and extended version of a previous Working document presented in the ICES Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VII, VIII and IX (WGACEGG). Lowestoft, UK, 16-20 November 2015.)

Acoustic assessment and distribution of the main pelagic fish species in ICES Subdivision IXa South during the *ECOCADIZ 2015-07* Spanish survey (July-August 2015).

By

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ABSTRACT

The *ECOCADIZ 2017-07* Spanish (pelagic ecosystem-) acoustic survey was conducted by IEO between 28th July and 10th August 2015 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 19 valid fishing hauls were carried out for echo-trace ground-truthing purposes. CUFES sampling (117 stations) was carried during the survey in order to describe the extension of the anchovy spawning area. A census of top predator species was also carried out along the sampled acoustic transects. A total of 157 CTD (with coupled altimeter, oximeter, fluorimeter and transmissometer sensors) -LADCP casts, and sub-superficial thermosalinograph-fluorimeter and VMADCP continuous sampling were carried out to oceanographically characterize the surveyed area (results are reported in Sánchez *et al*., 2015). Abundance and biomass estimates are given for all the mid-sized and small pelagic fish species susceptible of being acoustically assessed according to their occurrence and abundance levels in the study area. The distribution of these species is also shown from the mapping of their back-scattering energies. Sardine was the most frequent species in the fishing hauls, followed by horse mackerel, chub mackerel, anchovy and mackerel. However, the most abundant species in these hauls was anchovy, followed at quite a distance by blue jack mackerel, sardine, horse mackerel and chub mackerel. As usual, the bulk of the anchovy population was concentrated in the central part of the surveyed area, with the smallest anchovies mainly occurring in the surroundings of the Guadiana and Guadalquivir river mouths and Bay of Cadiz, and larger/older anchovies occurring in the westernmost waters. The total biomass estimated for anchovy, 21.3 kt (2 506 million fish), was slightly below the historical average, but it still in the range of population levels featuring to a recovered population. The comparison of these estimates with their spring counterparts from the PELAGO survey evidences almost identical values for the Portuguese waters, whereas the ECOCADIZ survey estimated in summer at about 1000 million and 11800 t less of anchovy in the Spanish waters. Such differences might be attributable to a possible overestimation of the acoustic energy attributed to anchovy in the Spanish waters of the Gulf by the PELAGO survey because of the difficulties in the discrimination of anchovy echoes in this area from a dense plankton layer where the species was embedded. Sardine was widely distributed all over the surveyed area but in the easternmost waters closer to the Strait of Gibraltar and showed two main nuclei of density: the coastal waters of the central part of the Gulf, and the inner-mid shelf waters between Cape San Vicente and Cape Santa Maria. Sardine yielded a total of 23.5 kt (883 million fish), population levels which have showed some recovery from the lowest historical values recorded in the two previous years, but still below the historical average. In contrast to the abovementioned for anchovy, ECOCADIZ survey estimated in summer 4 fold more sardine in Spanish waters than PELAGO survey in spring, with the juvenile fraction being the dominant in both seasons. The progressive incorporation (recruitment) of juveniles coming from successive spawning events may be the reason for such seasonal differences**.**

INTRODUCTION

ECOCADIZ surveys constitute a series of yearly acoustic surveys conducted by IEO in the Subdivision IXa 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 summarises the main results from the *ECOCADIZ 2015-07* survey. Ramos *et al.* (2015) provided in a preliminary version of the present WD the acoustic estimates (not age-structured) and spatial distribution of anchovy and sardine as well as some 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 2015-07* survey was carried out between 28th July and 10th August 2015 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 *Myriax Software Echoview™* software package (by *Myriax Software Pty. Ltd.,* ex *SonarData Pty. Ltd.*). Acoustic equipment was previously calibrated during the *MEDIAS 07 2015* 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 more recently 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 ca. 16 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. 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 and with additional preservation of gonads in anchovy mature females), 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
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), 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 the anchovy egg abundance and to collect some hydrographical variables (sub-surface sea temperature, salinity, and *in vivo* fluorescence; **Figure 2**). Vertical profiles of hydrographical variables were also recorded by night from 157 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 3**). *VMADCP RDI 150 kHz* records were also continuously recorded by night between CTD stations. Information on presence and abundance of sea birds, turtles and mammals was also recorded during the acoustic sampling by one onboard observer.

ECOCADIZ 2015-07 was also utilized this year as an observational platform for the IFAPA (Instituto de Investigación y Formación Agraria y Pesquera)/IEO research project entitled *Ecology of the early stages of the anchovy life-cycle: the role of the coupled Guadalquivir estuary-coastal zone of influence in the species' recruitment process (ECOBOGUE)*. Thus, 4 *Bongo 90* coastal stations were carried out at sunset in the surroundings of the Guadiana (2 stations) and Guadalquivir (2 stations) river mouths to collect anchovy larvae for genetics studies (**Figure 2**).

RESULTS

Acoustic sampling

The acoustic sampling started on 29th July in the coastal end of the transect RA01 and finalized on 07th 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 to deeper waters in order to avoid the occurrence of open-sea fish farming/fattening cages.

Groundtruthing hauls

Twenty two (22) fishing operations, with 19 of them being considered as valid ones according to a correct gear performance and resulting catches, were carried out (**Table 2**, **Figure 4**). Null hauls were actually composed by 2 initial trials for checking the behaviour and configuration of the available fishing gears (fishing stations # 01 and 02) and one fishing haul (fishing station # 17) carried out in pure pelagic fashion which finally resulted unsuccessful.

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. Given that all of these situations were not very uncommon in the sampled area, 42% of valid hauls (8 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 38-172 m.

During the survey were captured 4 Chondrichthyan, 39 Osteichthyes, 4 Cephalopod, 8 Crustacean, 5 Echinoderm, 2 Polychaeta, 1 Sipunculidea, 2 Porifera, 4 Cnidarian and 1 Thaliacean 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, sardine was the most frequent captured species in the valid hauls (18 hauls, 95% presence index) followed by horse mackerel, chub mackerel, anchovy and mackerel (with relative occurrences between 70-80%). Bogue and blue jack mackerel showed a medium relative frequency of occurrence (ca. 50-60%), whereas Mediterranean horse mackerel showed a low occurrence in the whole surveyed area (21%). The occurrence of blue whiting and boarfish in fishing hauls was incidental.

For the purposes of the acoustic assessment, anchovy, sardine, mackerel species, horse & jack mackerel species, blue whiting, bogue 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 10.5 tonnes and 307 thousand fish (**Table 3**). 28% of this fished biomass corresponded to blue-jack mackerel, 19% to sardine, 18% to chub mackerel, anchovy and horse mackerel 13% each, 3% to Mediterranean horse mackerel, and contributions lower than 1% by the remaining species. However, the most abundant species in ground-truthing trawl hauls was anchovy (51%) followed by a long distance by blue jack mackerel (17%), sardine (15%), horse mackerel (9%) and chub mackerel (6%).

Species	# of fishing stations	Occurrence (%)	Total weight (kg)	Total number
Merluccius merluccius	19	100	169,218	2745
Sardina pilchardus	18	95	1956,451	45055
Loligo spp	17	89	5,409	1809
Trachurus trachurus	16	84	1399,624	26394
Scomber colias	15	79	1914,333	17822
Engraulis encrasicolus	15	79	1401,372	155790
Scomber scombrus	14	74	38,035	183
Boops boops	11	58	22,575	188
Trachurus picturatus	10	53	2956,827	50765
Alosa fallax	8	42	3,519	14
Spondyliosoma cantharus	8	42	14,108	78
Diplodus annularis	6	32	2,638	52
Eledone moschata	6	32	1,442	10
Aphia minuta	6	32	0,346	164
Pagellus erythrinus	6	32	94,348	568
Pagellus bellottii bellottii	5	26	7,978	56
Diplodus bellottii	5	26	3,668	67
Chelidonichthys lucerna	5	26	0,426	5
Diplodus vulgaris	4	21	13,038	89
Trachurus mediterraneus	4	21	325,372	1910

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 spawning season, with the largest fish being distributed in the westernmost waters and the smallest ones concentrated in the surroundings of the Guadalquivir river mouth and adjacent shallow waters, including those ones in front of the Bay of Cadiz. This summer small anchovies were also recorded in the coastal area close to the Guadiana river mouth (**Figure 6**). Sardine was even more frequent and widely distributed than anchovy, with the highest yields being mainly recorded in the westernmost waters of the surveyed area. Juvenile sardines were almost exclusively captured in the shallowest hauls conducted in front of the Guadiana and Guadalquivir river mouths and the Bay of Cadiz (**Figure 7**). Mackerel, 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.

<u>Back-scattering energy attributed to the “pelagic assemblage” and individual species</u>

A total of 315 nmi (ESDU) from 21 transects has been acoustically sampled by echo-integration for assessment purposes. From this total, 207 nmi (11 transects) were sampled in Spanish waters, and 108 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.	Anchovy	Sardine	Mackerel	Chub mack.	Horse mack.	Medit. h-mack.	Blue jack-mack.	Bogue	Blue whiting	Boarfish
Total Area	104460	34311	15772	19	23790	10073	8354	10636	562	942	1
%	100	32,8	15,1	0,02	22,8	9,6	8	10,2	0,5	0,9	0
Portugal	56412	2355	8744	1	23650	9719	0	10546	454	942	1
%	54,0	6,9	55,4	6,7	99,4	96,5	0,0	99,2	80,8	100,0	100,0
Spain	48048	31956	7028	18	140	354	8354	90	108	0	0
%	46,0	93,1	44,6	93,3	0,6	3,5	100,0	0,8	19,2	0,0	0,0

For this "pelagic fish assemblage" has been estimated a total of 104 460 m^2 nmi^{-2}. Portuguese waters accounted for 54% of this total back-scattering energy and the Spanish waters the remaining 46%. 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 8**. By species, anchovy (33%), chub mackerel (23%) and sardine (15%) were the most important species in terms of their contributions to the total back-scattering energy. Blue jack mackerel and Horse mackerel were the following species in importance with 10% each. Mediterranean horse mackerel only contributed with 8%, followed by negligible energetic contributions by mackerel, bogue, boarfish (*Capros aper*) and blue whiting (*Micromesistius poutassou*). Round sardinella was not recorded during the survey.

Some inferences on the species' distribution may be carried out from regional contributions to the total energy attributed to each species: Mediterranean horse mackerel, mackerel and anchovy seemed to show greater densities in the Spanish waters, whereas blue whiting, boarfish, chub mackerel, blue jack mackerel, horse mackerel, and bogue 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 were finally anchovy, sardine, mackerel, chub mackerel, blue jack mackerel, horse mackerel, Mediterranean horse mackerel, bogue, blue whiting and boarfish.

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 9**. The estimated abundance and biomass by size and age class are given in **Tables 5** and **6**, and **Figures 10** and **11**.

Anchovy avoided the easternmost waters of the Gulf. The bulk of the population was mainly distributed all over the shelf between the Guadiana river mouth and Bay of Cadiz, especially over the outer shelf waters of the central part of the Gulf, between the Guadiana river mouth and Matalascañas. A secondary nucleus of anchovy density was recorded in the western Portuguese Algarve, between Cape San Vicente and Albufeira, with the species being quite scarce in the surroundings of the Cape of Santa Maria (**Figure 9**).

The size class range of the assessed population varied between the 6.5 and 17 cm size classes, with two modal classes at 8.0 and 10.5 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 fish being distributed in the westernmost waters and the smallest ones concentrated in the surroundings of the Guadalquivir river mouth and adjacent shallow waters, including those ones in front of the Bay of Cadiz

(**Tables 5** and **6**, **Figures 9**, **10** and **11**, see also **Figure 6**). This summer small anchovies were also recorded in the coastal area close to the Guadiana river mouth. As it has been happening in the last years, during the 2015 survey some recruitment has also been recorded, probably as a consequence of the delayed survey dates. This fact seems to have been much more evident this summer than in previous years because the markedly low mean length and weight estimated for the whole estimated population (106 mm; 8.0 g), the lowest record for both variables in the whole series.

Ten coherent post-strata have been differentiated according to the S_A value distribution and the size composition in the fishing stations. The acoustic estimates by homogeneous post-stratum and total area are shown in **Tables 5** and **6**, and **Figures 10** and **11**. Overall acoustic estimates in summer 2015 were of 2674 million fish and 21305 tonnes. By geographical strata, the Spanish waters yielded 93.7% (2506 million) and 90% (19168 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 168 million and 2137 t.

The Gulf of Cadiz anchovy egg distribution from CUFES sampling is shown in **Figure 12**. Anchovy egg distribution in summer 2015 resembled the abovementioned distribution for adult fish, with higher egg densities being mainly recorded in the middle-outer shelf waters located between the Guadiana and Tinto-Odiel river mouths. The highest egg density (121 eggs m^{-3}) was recorded in one station at a mean depth of 80.3 m located in the westernmost Spanish transect.

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 13**. Estimated abundance and biomass by size and age class are given in **Tables 7** and **8** and **Figures 14** and **15**.

Excepting the easternmost waters closer to the Strait of Gibraltar, where the species was absent, sardine was widely distributed all over the remaining surveyed area, preferably over the inner shelf, with the highest densities being recorded in two distinct zones: the coastal waters in front of the area comprised between Matalascañas and Chipiona, in the Spanish waters, and the inner-mid shelf waters between Cape San Vicente and Cape Santa Maria, in the Portuguese waters (**Figure 13**).

Sizes of the assessed population ranged between 7.5 and 22.5 cm size classes. The length frequency distribution of the population was clearly bimodal, with one main mode at 10.5 cm size class and a secondary one at 20.0 cm (**Table 7**; **Figure 14**). The 2015 summer estimate of mean size (135 mm) is the lowest one within the series. This fact might be explained by the dominance of the juvenile fraction in the estimated population (main mode at 10.5 cm), which was mainly located in relatively shallow waters in front of the Guadiana and Guadalquivir river mouths and the Bay of Cadiz (**Tables 7** and **8**, **Figures 14** and **15,** see also **Figure 7**). However, such a decrease in mean size is not coupled with a similar decreasing trend in the mean weight (26.6 g), which was even somewhat higher than the historical average. It could be probable that the contribution in biomass of the adult fraction in the assessed population (around at a secondary modal size class at 20 cm) is enough to compensate the greater relative contribution of juveniles.

Nine size-based homogeneous sectors were delimited for the acoustic assessment. The estimates of Gulf of Cadiz sardine abundance and biomass in summer 2015 were 883 million fish and 23460 t. Portuguese waters accounted for 27.6% of abundance (244 million fish) and 72.6% of the total estimated biomass (17038 t), values from which could be inferred a large body size on average. In contrast, the estimates from the Spanish area (640 million fish – 72.4% of abundance –; 6422 t – 27.4% of biomass –), denote a dominance of the smallest (age 0) sardines.

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 16**. Estimated abundance and biomass by size class are given in **Table 9** and **Figure 17**.

Mackerel was mainly distributed over the central part of the Gulf, inhabiting the mid- and outer shelf waters, although was also frequent in shallower waters in front of Tinto-Odiel Rivers mouths, and with a null occurrence in both extremes of the surveyed area (**Figure 16**). As described above, the relatively high occurrence frequency recorded in the fishing hauls was not accompanied by high yields in numbers resulting in a very low relative importance of mackerel in the species composition of these hauls. This scarcity in hauls has obviously impacted in the subsequent acoustic estimation process, with the species' contribution to the total acoustic energy attributed to the pelagic fish assemblage being quite below the minimum threshold usually considered to provide an acoustic estimate. Nevertheless, the acoustic estimates of abundance and biomass have been computed, but they should be considered with caution because the low representativeness of the available length frequency distributions in positive hauls due to the same abovementioned reasons. Actually, one only coherent post-stratum was possible to be originally defined, which encompassed the whole spatial distribution of the acoustic energy allocated to the species. For operational purposes aimed to provide regional estimates, this post-stratum was split in two post-strata. The acoustic estimates were of 3 million fish and 720 t, with more than 90% of the abundance and biomass being located in the Spanish waters (**Table 9**, **Figure 17**).

Sizes of the assessed population ranged between 23.5 and 38.0 cm size classes. The estimated population showed a mixed distribution, but no clear modes are possible to be clearly differentiated given the low representativeness of the original raw LFDs. Nevertheless, at least two modes could be guessed at around 27.5 and 31.0 cm size classes (**Table 9**, **Figure 17**).

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 18**. Estimated abundance and biomass by size class are given in **Table 10** and **Figure 19**.

Although practically occurring all over the surveyed area, chub mackerel showed the highest densities westward the Guadiana River mouth (**Figure 18**). The size class range for the assessed population was comprised between 16.0 and 33.0 cm size classes. The whole estimated population showed a main modal class at 24.0 cm and a secondary one at 19.5 cm (**Table 10**, **Figure 19**).

A total of six coherent post-strata were identified for the purposes of the acoustic assessment. Chub mackerel in the sampled area was the second most important species in terms of assessed biomass and the sixth in abundance, rendering estimates of 21 593 t and 28 million fish (**Table 10**, **Figure 19**). At about 99% of the total estimated abundance and biomass was recorded in Portuguese waters.

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 20**. Estimated abundance and biomass by size class are given in **Table 11** and **Figure 21**.

The distribution pattern of blue jack mackerel almost mimics the previously described one for chub mackerel, suggesting the occupation of similar habitats by both species, although blue jack mackerel was absent in the most part of the Spanish waters (**Figure 20**, see also **Figure 18** for comparison). The highest integrations were recorded between the mid and outer shelf of the westernmost Portuguese waters in the Algarve.

The sampled population was mainly characterised by juveniles/sub-adult fishes ranging between 11.5 and 26.0 cm size classes and three modal classes, the two smallest ones, of similar great importance, at 15.0 and 18.0 cm, and the largest one, of a secondary importance, at 21.0 cm. The easternmost area of the species' distribution range was exclusively composed by juvenile fish with sizes comprised between 12.0 and 16.5 cm size classes (mode at 13.0 cm size class) (**Table 11**, **Figure 21**).

Six post-strata were considered in the assessment. A total of 7 543 t and 156 million fish were estimated for the whole surveyed area. The species stood out as the third most important one in numbers and the sixth in biomass (**Table 11**, **Figure 21**). Again, as described for chub mackerel, the bulk of the estimated population was located in the Portuguese waters.

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 22**. Estimated abundance and biomass by size class are given in **Table 12** and **Figure 23**.

Horse mackerel also showed widely distributed over the surveyed area, sharing the same distribution pattern than the above described for chub mackerel and blue jack mackerel. Again, the westernmost Portuguese shelf waters were those ones where the species recorded the highest densities (**Figure 22**). The estimated population showed a relatively wide size range, comprised between the 9.0 and 29.5 size classes, and a very mixed size composition, with a main mode at 22.0 cm size class and a secondary one at 10.5 cm size class. The smallest modal component (juveniles) was the dominant one in the Spanish waters. The acoustic estimates were of 8148 t and 124 million fish, with Portuguese waters accounting 99% and 91% of the total estimated biomass and abundance, respectively (**Table 12**, **Figures 22** and **23**).

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 24**. Estimated abundance and biomass by size class are given in **Table 13** and **Figure 25**.

Mediterranean horse-mackerel was only present over the Spanish inner shelf waters, with the densest concentrations being recorded in the coastal fringe between Cadiz Bay and Cape Trafalgar (**Figure 24**). The size range of the estimated population oscillated between 24.0 and 37.5 cm size classes, with one modal class at 26.5 cm size class. Larger fish occurred in the westernmost waters of their distribution range. Three coherent post-strata were defined for the purposes of the acoustic assessment. Acoustic estimates were 8788 t and 51 million fish (**Table 13**, **Figures 24** and **25**).

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 26**. Estimated abundance and biomass by size class are given in **Table 14** and **Figure 27**.

Although showing a relatively widespread distribution over the shelf, bogue showed their higher acoustic densities in the westernmost Portuguese inner shelf waters (**Figure 26**). The size range of the assessed population was comprised between 18.0 and 28.5 cm size classes, with a main mode at 22.0 cm size class.

For the whole surveyed area was estimated a total of 3 million fish which yielded a total of 365 t. Portuguese waters accounted for 87% of the total estimated abundance and 80% of the total biomass, respectively (**Table 14**, **Figures 26** and **27**).

Blue whiting

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 28**. Estimated abundance and biomass by size class are given in **Table 15** and **Figure 29**.

Blue whiting showed a very restricted distribution which was confined to the outer shelf of the westernmost Portuguese waters (**Figure 28**). The sampled population was composed by juvenile/sub-adult fishes measuring between 14.0 and 16.5 cm (mode at 14.5 cm size class). Only one coherent post-stratum was defined. A total of 290 t and 15 million fish were estimated (**Table 15**, **Figures 28** and **29**).

Boarfish

Parameters of the survey's length-weight relationship for boarfish are shown in **Table 4**. Back-scattering energy attributed to this species is shown in **Figure 30**. Estimated abundance and biomass by size class are given in **Table 16** and **Figure 31**.

Boarfish showed an incidental occurrence in the surveyed area, which was restricted to the outer shelf waters just to the east of Cape Santa Maria. The sampled population was composed by juvenile fishes measuring between 5.5 and 7.0 cm size classes (mode at 6.5 cm size class). Acoustic estimates from the only coherent post-stratum and for the whole survey area were 0.026 t and 0.005 million fish.

Oceanographic conditions

A detailed description of the oceanographic conditions in that survey based on *in situ* and remotely sensed data is given in Sánchez-Leal *et al*. (2015).

(SHORT) DISCUSSION

The historical series of anchovy biomass estimates is shown in **Figure 32**. The summer 2015 abundance estimate continues the notable increasing trend which started last year and rises up the population levels well above those corresponding to the historical average. This increasing trend in abundance is not completely coupled to the trend exhibited by the biomass, which showed a relatively low decrease in relation to the previous year estimate. Even so, the 2015 biomass estimate situates only slightly below the historical average.

For this same surveyed area, the Portuguese spring survey PELAGO 15 estimated two months before 3689 million fish and 33100 t (158 million and 2156 t in Portuguese waters, 3531 million and 30944 t in Spanish ones; see Marques *et al*., 2015, WD). The comparison of these estimates with their summer counterparts evidences almost identical values for the Portuguese waters, whereas the ECOCADIZ survey estimated in summer at about 1000 million and 11800 t less of anchovy in the Spanish waters. Even assuming a total mortality (Z) accumulated between surveys, the magnitude of such differences should be explainable by causes other than the above one. Marques *et al*. (2015, WD) warn about the need of corroborating the PELAGO spring estimates with the ECOCADIZ ones because of some uncertainty in the estimation. These authors advanced the possibility of a certain overestimation of the acoustic energy attributed to anchovy in the Spanish waters of the Gulf because this energy in this area was strongly masked by a dense plankton layer. ECOCADIZ surveys also routinely face to this same problem, since this situation is not uncommon in the area, by acoustically surveying in a multi-frequency fashion, an approach that partially enables a more efficient discrimination of echoes.

Regarding sardine, although its population levels have showed some recovery from the lowest values recorded in the two previous years, the 2015 estimates are still below the historical average (**Figure 31**). The comparison of the ECOCADIZ 2015-07 estimates with their spring counterparts reveals some differences (see Marques et *al*., 2015, WD). PELAGO survey estimated 400 million and 16663 t of Gulf of Cadiz sardine (238 million and 15031 t in Portuguese waters, 162 million and 1632 t in Spanish ones). As it could be easily deduced from the above values, spring and summer estimates from the Portuguese Algarve area were quite similar. However, ECOCADIZ survey estimated in summer 4 fold more sardine in the Spanish waters than PELAGO survey in spring, with the juvenile fraction being the dominant in both seasons. The progressive incorporation (recruitment) of juveniles coming from successive spawning events may be the reason for such differences.

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., C. O'Donnell, J.M. Jech, 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.

Nakken, O., A. Dommasnes, 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*.

Ramos, F., J. Miquel, J. Tornero, D. Oñate, P. Jiménez, 2015. Acoustic assessment and distribution of anchovy and sardine in ICES Subdivision IXa South during the *ECOCADIZ 2015-07* Spanish survey (July-August 2015) with notes on the distribution of other pelagic species. Working document presented to the ICES Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VIII and IX (WGACEGG), 16-20 November 2015, Lowestoft, UK. 35 pp.

Sánchez-Leal, R., V. Pita, J. Rodríguez, 2015. Physical oceanography conditions during ECOCADIZ 2015 cruises. Working document presented to the Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VII, VIII and IX (WGACEGG), 16-20 November 2015, Lowestoft, UK. 11 pp.

Table 1. *ECOCADIZ 2015-07 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	29/07/15	36º 13.597' N	5º 07.650 ' W	06:04	25	36º 02.168' N	6º 28.736' W	08:15	180
R02	Sancti-Petri	29/07/15	36º 08.782' N	6º 33.470' W	09:07	216	36º 19.203' N	6º 14.817' W	11:01	27
R03	Cádiz	30/07/15	36º 27.127' N	6º 19.269' W	06:11	32	36º 16.250' N	6º 37.899' W	10:18	246
R04	Rota	30/07/15	36º 23,429' N	6º 42.054' W	11:20	256	36º 34.556' N	6º 23.076' W	18:10	21
R05	Chipiona	31/07/15	36º 40.078' N	6º 29.990' W	06:04	23	36º 30.970' N	6º 46.291' W	07:41	197
R06	Doñana	31/07/15	36º 37.019' N	6º 53.573' W	10:21	203	36º 46.447' N	6º 35.889' W	13:35	23
R07	Matalascañas	01/08/15	36º 43.959' N	6º 58.038' W	06:21	177	36º 53.689' N	6º 40.752' W	09:56	20
R08	Mazagón	01/08/15	37º 15.670' N	6º 44.432' W	10:53	21	36º 49.652' N	7º 06.395' W	14:34	104
R09	Punta Umbría	02/08/15	36º 49.694' N	7º 06.360' W	07:22	165	37º 03.332' N	6º 56.760' W	11:07	20
R10	El Rompido	02/08/15	37º 06.881' N	7º 06.895º W	12:08	23	36º 49.822' N	7º 06.803' W	14:46	219
R11	Isla Cristina	03/08/15	37º 06.955' N	7º 16.991' W	05:59	23	36º 53.200' N	07º 16.714' W	09:29	144
R12	V.R. do Sto. Antonio	03/08/15	36º 56.377' N	7º 26.502' W	14:35	160	37º 06.321' N	7º 26.516' W	15:34	22
R13	Tavira	04/08/15	36º 57.223' N	7º 36.072' N	06:07	123	37º 04.910' N	7º 36.085' W	06:48	20
R14	Fuzeta	04/08/15	36º 55.905' N	7º 45.988' W	13:53	160	36º 59.233' N	7º 45.876' W	14:19	80
R15	Cabo Sta. María	05/08/15	36º 55.104' N	7º 56.026' W	06:08	75	36º 52.102' N	7º 55.999' W	06:26	158
R16	Cuarteira	05/08/15	36º 50.191' N	8º 05.871' W	07:32	114	37º 01.264' N	8º 05.895' W	10:18	20
R17	Albufeira	06/08/15	36º 49.383' N	08º 15.490' W	06:05	196	37º 02.430' N	8º 15.428' W	09:10	26
R18	Alfanzina	06/08/15	37º 03.963' N	8º 25.288' N	10:50	35	36º 50.324' N	8º 25.303' W	12:21	217
R19	Portimao	07/08/15	37º 05.382' N	8º 35.410' W	06:02	34	36º 51.380' N	8º 35.400' W	07:26	209
R20	Burgau	07/08/15	36º 52.436' N	8º 44.940' W	10:19	109	37º 03.855' N	8º 45.005' W	11:41	29
R21	Punta de Sagres	07/08/15	37º 00.430' N	8º 55.024' W	12:43	24	36º 50.616' N	8º 55.007' W	13:42	192

Table 2. *ECOCADIZ 2015-07* survey. Descriptive characteristics of the fishing stations. Null hauls in light grey.

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	28-07-2015	36º 28.2810 N	6º 28.9879 W	36º 27.3140 N	6º 28.4989 W	16:32	16:45	56,84	55,30	00:13	n.a	1,04	n.a.	TEST HAULS
02	28-07-2015	36º 23.2678 N	6º 27.4259 W	36º 23.4269 N	6º 27.3890 W	17:42	17:45	60,45	60,34	00:03	00:33	0,16	n.a	
03	29-07-2015	36º 16.0768 N	6º 20.4979 W	36º 13.9151 N	6º 23.9889 W	11:59	12:52	52,12	47,45	00:53	01:16	3,55	R02i	Sancti-Petri
04	30-07-2015	36º 25.3319 N	6º 24.1559 W	36º 22.4079 N	6º 22.3459 W	07:43	08:33	47,02	47,00	00:50	01:14	3,27	R03	Cádiz
05	30-07-2015	36º 30.6919 N	6º 29.9479 W	36º 29.0750 N	6º 32.6220 W	13:47	14:27	71,42	55,33	00:40	01:03	2,69	R04	Rota
06	30-07-2015	36º 30.4319 N	6º 27.3649 W	36º 32.7900 N	6º 29.6270 W	16:28	17:08	47,42	46,53	00:40	01:06	2,98	R04	Rota
07	31-07-2015	36º 32.1890 N	6º 43.8599 W	36º 33.9099 N	6º 40.9610 W	08:11	08:51	91,05	116,11	00:40	01:13	2,90	R05	Chipiona
08	31-07-2015	36º 42.2129 N	6º 43.7989 W	36º 40.5919 N	6º 46.7429 W	12:08	12:50	97,10	67,92	00:42	01:12	2,87	R06	Doñana
09	31-07-2015	36º 40.1559 N	6º 36.1929 W	36º 41.9270 N	6º 38.2270 W	15:57	16:33	37,67	38,30	00:36	00:59	2,41	No data	No data
10	01-08-2015	36º 45.7310 N	6º 54.8749 W	36º 44.5930 N	6º 57.0380 W	07:23	07:53	131,12	110,11	00:30	01:14	2,08	R07	Matalascañas
11	01-08-2015	36º 53.4738 N	6º 59.1979 W	36º 55.1390 N	6º 56.6409 W	13:06	13:44	69,20	93,43	00:38	01:16	2,64	R08	Mazagón
12	02-08-2015	36º 53.1990 N	7º 03.5749 W	36º 50.6160 N	7º 04.8579 W	08:26	09:07	130,89	104,76	00:41	01:14	2,78	No data	No data
13	03-08-2015	37º 00.5039 N	7º 15.4910 W	37º 00.5039 N	7º 12.9119 W	07:44	08:13	72,48	73,57	00:29	01:00	2,07	No data	No data
14	03-08-2015	36º 55.5198 N	7º 13.7529 W	36º 56.3809 N	7º 16.9010 W	11:38	12:17	110,84	111,74	00:39	01:18	2,67	R11	Isla Cristina
15	04-08-2015	37º 02.1679 N	7º 37.8149 W	37º 02.9720 N	7º 35.6199 W	07:44	08:15	50,65	61,04	00:31	00:56	1,93	R13	Tavira
16	04-08-2015	37º 00.1430 N	7º 35.9080 W	36º 57.3060 N	7º 35.9339 W	11:38	12:20	172,28	96,77	00:42	01:16	2,83	R13	Tavira
17	04-08-2015	36º 55.4850 N	7º 45.5340 W	36º 57.4188 N	7º 46.4499 W	14:59	15:27	87,60	107,63	00:28	00:49	2,07	R14	Fuzeta
18	05-08-2015	36º 53.4990 N	8º 05.7380 W	36º 51.6169 N	8º 05.7679 W	08:15	08:42	110,27	95,71	00:27	01:00	1,88	R16	Cuarteira
19	05-08-2015	36º 56.9801 N	8º 02.9600 W	36º 56.9579 N	8º 04.8430 W	11:33	11:55	43,93	43,65	00:22	00:56	1,51	R16	Cuarteira
20	06-08-2015	36º 54.3800 N	8º 15.6069 W	36º 52.0390 N	8º 15.5600 W	07:02	07:35	114,12	96,95	00:33	01:03	2,34	R17	Albufeira
21	06-08-2015	36º 56.9989 N	8º 19.3429 W	36º 57.0169 N	8º 22.3990 W	14:33	15:09	80,31	77,36	00:36	00:54	2,45	R17	Albufeira
22	07-08-2015	36º 52.0619 N	8º 35.4089 W	36º 53.7950 N	8º 35.3470 W	08:11	08:37	111,72	116,30	00:26	01:14	1,73	R19	Portimao

Table 3. *ECOCADIZ 2015-07* survey. Catches by species in number (upper panel) and weight (in kg, lower panel) from valid fishing stations.

ABUNDANCE (nº)												
Fishing station	***Anchovy***	***Sardine***	***Chub mack.***	***Mackerel***	***Horse-mack.***	***Blue Jack-mack.***	***Medit. Horse-mack.***	***Bogue***	***Blue whiting***	***Boarfish***	**Other spp.**	**TOTAL**
03	0	0	10	0	0	0	1695	0	0	0	212	**1917**
04	155	22	0	0	0	0	133	1	0	0	316	**627**
05	8197	3856	0	2	4	0	0	4	0	0	37	**12100**
06	6701	1106	1	0	6	0	65	8	0	0	154	**8041**
07	9156	335	2	4	4	0	0	0	0	0	128	**9629**
08	21701	2961	2	3	8	0	0	1	0	0	153	**24829**
09	8440	6585	3	0	3	0	17	4	0	0	110	**15162**
10	28617	600	0	4	905	2	0	0	0	0	118	**30246**
11	7674	506	4	71	3	0	0	1	0	0	117	**8376**
12	25052	760	3	13	44	58	0	0	0	0	180	**26110**
13	30597	2069	0	1	0	0	0	0	0	0	141	**32808**
14	7837	551	9	9	212	65	0	0	0	0	249	**8932**
15	0	10930	6064	25	10	27	0	37	0	0	176	**17269**
16	7	189	6116	3	789	1913	0	0	0	105	30	**9152**
18	87	10	221	21	6086	881	0	0	4569	0	711	**12586**
19	0	21	164	0	62	16	0	2	0	0	167	**432**
20	104	8	22	18	16498	271	0	4	24	0	397	**17346**
21	1465	6250	4645	5	1376	46	0	81	0	0	357	**14225**
22	0	8296	556	4	384	47486	0	45	101	7	60	**56939**
TOTAL	**155790**	**45055**	**17822**	**183**	**26394**	**50765**	**1910**	**188**	**4694**	**112**	**3813**	**306726**

BIOMASS (kg)												
Fishing station	***Anchovy***	***Sardine***	***Chub mack.***	***Mackerel***	***Horse-mack.***	***Blue Jack-mack.***	***Medit. Horse-mack.***	***Bogue***	***Blue whiting***	***Boarfish***	**Other spp.**	**TOTAL**
03	0	0	3,194	0	0	0	281,800	0	0	0	45,402	**330,396**
04	1,186	0,548	0	0	0	0	26,150	0,226	0	0	42,210	**70,320**
05	44,500	44,100	0	0,538	0,270	0	0	0,614	0	0	2,722	**92,744**
06	32,950	13,212	0,242	0	0,162	0	13,850	1,662	0	0	13,614	**75,692**
07	84,200	4,306	0,210	0,528	0,122	0	0	0	0	0	7,571	**96,937**
08	133,700	35,810	0,402	0,632	0,178	0	0	0,148	0	0	7,189	**178,059**
09	28,750	62,926	0,700	0	0,142	0	3,572	0,658	0	0	34,792	**131,540**
10	280,850	7,650	0	0,806	8,500	0,068	0	0	0	0	19,482	**317,356**
11	59,450	5,752	0,512	13,450	0,056	0	0	0,202	0	0	7,544	**86,966**
12	321,900	10,488	0,180	2,192	0,386	1,124	0	0	0	0	40,941	**377,211**
13	259,800	25,550	0	0,226	0	0	0	0	0	0	6,738	**292,314**
14	119,650	10,050	0,412	1,546	2,648	1,398	0	0	0	0	21,150	**156,854**
15	0	761,420	768,076	5,949	0,741	1,585	0	5,173	0	0	34,064	**1577,008**
16	0,204	11,550	468,300	0,532	11,650	93,800	0	0	0	0,614	3,514	**590,164**
18	1,602	0,422	25,485	3,984	582,350	59,950	0	0	88,650	0	34,062	**796,505**
19	0	1,390	20,200	0	4,250	1,008	0	0,208	0	0	28,776	**55,832**
20	2,640	0,458	1,884	4,768	680,650	11,700	0	0,416	0,508	0	26,548	**729,572**
21	29,990	466,830	582,570	1,284	103,412	2,806	0	8,650	0	0	20,468	**1216,010**
22	0	493,989	41,966	1,600	4,107	2783,388	0	4,618	1,768	0,034	4,857	**3336,327**
TOTAL	**1401,372**	**1956,451**	**1914,333**	**38,035**	**1399,624**	**2956,827**	**325,372**	**22,575**	**90,926**	**0,648**	**401,644**	**10507,807**

Table 4. *ECOCADIZ 2015-07* survey. Parameters of the size-weight relationships for survey's target species. FAO codes for the species: PIL: *Sardina pilchardus*; ANE: *Engraulis encrasicolus*; MAS: *Scomber colias*; MAC: *Scomber scombrus*; JAA: *Trachurus picturatus;* HOM: *Trachurus trachurus*; HMM: *Trachurus mediterraneus*; BOG: *Boops boops*; WHB: *Micromesistius poutassou*; BOC: *Capros aper*.

Parameter	PIL	ANE	MAS	MAC	JAA	HOM	HMM	BOG	WHB	BOC
n	832	935	346	147	375	779	167	102	67	104
a	0,0032841	0,0025842	0,0037685	0,0011541	0,0045714	0,0063080	0,0288680	0,0144710	1,1600958	0,0275365
b	3,3258776	3,3588280	3,2463239	3,5490388	3,2085855	3,0986631	2,6106969	2,8711550	1,0360549	2,8409697
r^2	0,9881491	0,9799551	0,9683588	0,9671916	0,9820176	0,9946606	0,8350312	0,9553940	0,2086417	0,8461715

Table 5. *ECOCADIZ 2015-07* 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 9**.

***ECOCADIZ 2015-07*. *Engraulis encrasicolus*. ABUNDANCE (in number and million fish)**																
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	**POL09**	**POL10**	***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**
6,5	0	0	83224	0	563323	0	0	0	0	0	83224	563323	646547	**0,1**	**1**	**1**
7	0	0	332895	0	2253295	0	9668684	0	0	0	332895	11921979	12254874	**0,3**	**12**	**12**
7,5	0	0	1748750	0	11836929	0	125546382	0	0	0	1748750	137383311	139132061	**2**	**137**	**139**
8	0	0	2415592	0	16350649	0	251166011	8955528	0	0	2415592	276472188	278887780	**2**	**276**	**279**
8,5	0	0	1415855	0	9583635	0	170666904	82567194	0	0	1415855	262817733	264233588	**1**	**263**	**264**
9	0	0	499342	0	3379941	0	38674731	143227947	0	0	499342	185282619	185781961	**0,5**	**185**	**186**
9,5	0	0	720954	0	4879991	0	12891577	137394611	2352741	599718	720954	158118638	158839592	**1**	**158**	**159**
10	0	0	5074524	310517	34348415	1943326	6445792	106566167	16879684	1759172	5385041	167942556	173327597	**5**	**168**	**173**
10,5	0	0	20161712	776870	136470504	4861929	3222893	68179072	79551178	1839134	20938582	294124710	315063292	**21**	**294**	**315**
11	0	0	16925684	2098723	114566489	13134560	0	45095297	119168678	1199435	19024407	293164459	312188866	**19**	**293**	**312**
11,5	0	0	8601135	5483546	58219323	34318002	0	16411715	118218004	479774	14084681	227646818	241731499	**14**	**228**	**242**
12	1059733	18848	2785264	10779193	18852880	67460064	0	12022733	64637723	119944	14643038	163093344	177736382	**15**	**163**	**178**
12,5	4178377	83124	2035197	11790257	13775835	73787667	0	2968197	26995896	79962	18086955	117607557	135694512	**18**	**118**	**136**
13	11869012	224008	833290	11708481	5640368	73275886	0	0	20568164	79962	24634791	99564380	124199171	**25**	**100**	**124**
13,5	16077667	322849	499342	7459560	3379941	46684608	0	1978797	5738474	79962	24359418	57861782	82221200	**24**	**58**	**82**
14	7327298	141969	249671	4298906	1689972	26904101	0	0	1024998	0	12017844	29619071	41636915	**12**	**30**	**42**
14,5	3148922	77693	0	1984884	0	12422116	0	0	2663482	0	5211499	15085598	20297097	**5**	**15**	**20**
15	363337	34438	0	914965	0	5726179	0	0	0	0	1312740	5726179	7038919	**1**	**6**	**7**
15,5	363337	82166	0	228741	0	1431545	0	0	0	0	674244	1431545	2105789	**1**	**1**	**2**
16	0	85552	83224	0	563323	0	0	0	0	0	168776	563323	732099	**0,2**	**1**	**1**
16,5	0	63318	0	0	0	0	0	0	0	0	63318	0	63318	**0,1**	**0**	**0,1**
17	0	22235	0	0	0	0	0	0	0	0	22235	0	22235	**0,02**	**0**	**0,02**
17,5	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**
TOTAL *n*	44387683	1156200	64465655	57834643	436354813	361949983	618282974	625367258	457799022	6237063	167844181	2505991113	2673835294	**168**	**2506**	**2674**
Millions	**44**	**1**	**64**	**58**	**436**	**362**	**618**	**625**	**458**	**6**						

Table 5. *ECOCADIZ 2015-07* survey. Anchovy (*E. encrasicolus*). Cont'd.

ECOCADIZ 2015-07. *Engraulis encrasicolus*. BIOMASS (t)													
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	**POL09**	**POL10**	**PORTUGAL**	**SPAIN**	**TOTAL**
6	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
6,5	0	0	0,131	0	0,888	0	0	0	0	0	**0,131**	**0,888**	**1,019**
7	0	0	0,667	0	4,517	0	19,383	0	0	0	**0,667**	**23,90**	**24,567**
7,5	0	0	4,386	0	29,688	0	314,878	0	0	0	**4,386**	**344,566**	**348,952**
8	0	0	7,474	0	50,591	0	777,139	27,710	0	0	**7,474**	**855,440**	**862,914**
8,5	0	0	5,338	0	36,133	0	643,456	311,299	0	0	**5,338**	**990,888**	**996,226**
9	0	0	2,269	0	15,358	0	175,735	650,816	0	0	**2,269**	**841,909**	**844,178**
9,5	0	0	3,910	0	26,463	0	69,908	745,062	12,758	3,252	**3,910**	**857,443**	**861,353**
10	0	0	32,551	1,992	220,334	12,466	41,348	683,587	108,278	11,285	**34,543**	**1077,298**	**1111,841**
10,5	0	0	151,767	5,848	1027,280	36,598	24,260	513,217	598,821	13,844	**157,615**	**2214,02**	**2371,635**
11	0	0	148,427	18,404	1004,673	115,181	0	395,456	1045,031	10,518	**166,831**	**2570,859**	**2737,690**
11,5	0	0	87,288	55,649	590,836	348,275	0	166,553	1199,729	4,869	**142,937**	**2310,262**	**2453,199**
12	12,370	0,220	32,513	125,827	220,073	787,472	0	140,343	754,527	1,400	**170,93**	**1903,815**	**2074,745**
12,5	55,790	1,110	27,174	157,423	183,934	985,210	0	39,631	360,448	1,068	**241,497**	**1570,291**	**1811,788**
13	180,331	3,403	12,661	177,892	85,697	1113,314	0	0	312,502	1,215	**374,287**	**1512,728**	**1887,015**
13,5	276,638	5,555	8,592	128,352	58,157	803,273	0	34,048	98,738	1,376	**419,137**	**995,592**	**1414,729**
14	142,146	2,754	4,844	83,397	32,785	521,928	0	0	19,885	0	**233,141**	**574,598**	**807,739**
14,5	68,590	1,692	0	43,235	0	270,579	0	0	58,016	0	**113,517**	**328,595**	**442,112**
15	8,852	0,839	0	22,291	0	139,506	0	0	0	0	**31,982**	**139,506**	**171,488**
15,5	9,865	2,231	0	6,211	0	38,868	0	0	0	0	**18,307**	**38,868**	**57,175**
16	0	2,580	2,510	0	16,988	0	0	0	0	0	**5,090**	**16,988**	**22,078**
16,5	0	2,114	0	0	0	0	0	0	0	0	**2,114**	**0**	**2,114**
17	0	0,819	0	0	0	0	0	0	0	0	**0,819**	**0**	**0,819**
17,5	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**
TOTAL	**754,582**	**23,317**	**532,502**	**826,521**	**3604,395**	**5172,67**	**2066,107**	**3707,722**	**4568,733**	**48,827**	**2136,922**	**19168,454**	**21305,376**

Table 6. *ECOCADIZ 2015-07* 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**	**POL05**	**POL06**	**POL07**	**POL08**	**POL09**	**POL10**	**PT**	**ES**	**TOTAL**
	Number	**Number**	**Number**	**Number**	**Number**	**Number**	**Number**	**Number**	**Number**	**Number**	**Number**	**Number**	**Number**
0	4983	99	35255	10689	239197	66897	598088	463060	185843	3479	51026	1556002	1607027
I	38138	914	29027	45792	196478	286583	20195	162223	270611	2753	113871	938844	1052715
II	1267	144	100	1353	680	8469	0	84	1344	5	2865	10582	13447
III	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	44388	1156	64382	57835	436355	361950	618283	625367	457799	6237	167761	2505428	2673189

Age class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	**POL09**	**POL10**	**PT**	**ES**	**TOTAL**
	Weight	**Weight**	**Weight**	**Weight**	**Weight**	**Weight**	**Weight**	**Weight**	**Weight**	**Weight**	**Weight**	**Weight**	**Weight**
0	81	2	258	133	1749	831	1975	2522	1678	26	474	8780	9254
I	648	18	272	667	1842	4173	91	1184	2869	23	1605	10182	11787
II	25	4	2	27	14	169	0	1	21	0	58	205	264
III	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	755	23	532	827	3604	5173	2066	3708	4569	49	2137	19168	21304

Table 7. *ECOCADIZ 2015-07* 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 13**.

***ECOCADIZ 2015-07*. *Sardina pilchardus*. ABUNDANCE (in number and million fish)**															
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	**POL09**	***n***			**millions**		
										PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
7	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
7,5	0	0	0	7305	0	197399	0	0	0	7305	197399	204704	**0,01**	**0,2**	**0,2**
8	0	0	0	32227	0	870879	0	0	0	32227	870879	903106	**0,03**	**1**	**1**
8,5	0	0	0	39531	0	1068278	0	0	0	39531	1068278	1107809	**0,04**	**1**	**1**
9	0	0	0	24922	0	673480	0	0	0	24922	673480	698402	**0,02**	**1**	**1**
9,5	0	0	0	18047	0	487692	0	0	0	18047	487692	505739	**0,02**	**0,5**	**1**
10	0	0	0	22507	0	608204	0	122006765	0	22507	122614969	122637476	**0,02**	**123**	**123**
10,5	0	0	0	292628	0	7907822	0	212672346	117919	292628	220698087	220990715	**0,3**	**221**	**221**
11	0	0	0	1174259	0	31732573	0	103202054	3601884	1174259	138536511	139710770	**1**	**139**	**140**
11,5	0	0	0	1610526	21828	43522023	23989	43803039	9479733	1632354	96828784	98461138	**2**	**97**	**98**
12	0	0	0	766362	574791	20709766	631704	3134117	6374908	1341153	30850495	32191648	**1**	**31**	**32**
12,5	0	0	0	325618	807617	8799340	887584	0	2530870	1133235	12217794	13351029	**1**	**12**	**13**
13	0	0	0	64687	1462442	1748056	1607246	3134117	1180673	1527129	7670092	9197221	**2**	**8**	**9**
13,5	0	0	0	29172	465653	788322	511760	0	235061	494825	1535143	2029968	**0,5**	**2**	**2**
14	0	0	1624	11329	509308	306161	559737	149242	0	522261	1015140	1537401	**1**	**1**	**2**
14,5	0	0	0	8049	145517	217523	159925	223865	0	153566	601313	754879	**0,2**	**1**	**1**
15	0	0	0	8049	21828	217523	23989	596976	0	29877	838488	868365	**0,03**	**1**	**1**
15,5	0	0	0	8049	0	217523	0	895464	0	8049	1112987	1121036	**0,01**	**1**	**1**
16	0	0	0	4025	0	108761	0	373111	0	4025	481872	485897	**0,00**	**0,5**	**0,5**
16,5	0	136956	1624	0	0	0	0	596976	0	138580	596976	735556	**0,1**	**1**	**0,7**
17	1500732	546470	0	0	0	0	0	298488	0	2047202	298488	2345690	**2**	**0,3**	**2**
17,5	0	1777020	19487	0	0	0	0	74623	0	1796507	74623	1871130	**2**	**0,1**	**2**
18	3001465	3774009	50343	0	0	0	0	149242	0	6825817	149242	6975059	**7**	**0,1**	**7**
18,5	14305683	4792190	58462	0	0	0	0	0	0	19156335	0	19156335	**19**	**0**	**19**
19	26350523	4419867	82822	0	0	0	0	0	0	30853212	0	30853212	**31**	**0**	**31**
19,5	36894631	3637778	47095	0	0	0	0	149242	0	40579504	149242	40728746	**41**	**0,1**	**41**
20	45158403	1926381	40599	0	0	0	0	0	23358	47125383	23358	47148741	**47**	**0,02**	**47**
20,5	43657671	629735	4872	0	0	0	0	0	0	44292278	0	44292278	**44**	**0**	**44**
21	26350523	268675	0	0	0	0	0	0	0	26619198	0	26619198	**27**	**0**	**27**
21,5	12044840	44988	0	0	0	0	0	0	0	12089828	0	12089828	**12**	**0**	**12**
22	760111	0	0	0	0	0	0	0	0	760111	0	760111	**1**	**0**	**1**
22,5	3001465	0	0	0	0	0	0	0	0	3001465	0	3001465	**3**	**0**	**3**
23	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
TOTAL *n*	213026047	21954069	306928	4447292	4008984	120181325	4405934	491459667	23544406	243743320	639591332	883334652	**244**	**640**	**883**
Millions	**213**	**22**	**0**	**4**	**4**	**120**	**4**	**491**	**24**						

Table 7. *ECOCADIZ 2015-07* survey. Sardine (*S. pilchardus*). Cont'd

***ECOCADIZ 2015-07*. *Sardina pilchardus*. BIOMASS (t)**												
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	**POL09**	**PORTUGAL**	**SPAIN**	**TOTAL**
7	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
7,5	0	0	0	0,022	0	0,588	0	0	0	**0,022**	**0,588**	**0,610**
8	0	0	0	0,118	0	3,194	0	0	0	**0,118**	**3,194**	**3,312**
8,5	0	0	0	0,176	0	4,765	0	0	0	**0,176**	**4,765**	**4,941**
9	0	0	0	0,134	0	3,614	0	0	0	**0,134**	**3,614**	**3,748**
9,5	0	0	0	0,115	0	3,118	0	0	0	**0,115**	**3,118**	**3,233**
10	0	0	0	0,170	0	4,592	0	921,183	0	**0,170**	**925,775**	**925,945**
10,5	0	0	0	2,589	0	69,954	0	1881,340	1,043	**2,589**	**1952,337**	**1954,926**
11	0	0	0	12,083	0	326,534	0	1061,967	37,064	**12,083**	**1425,565**	**1437,648**
11,5	0	0	0	19,151	0,260	517,538	0,285	520,879	112,727	**19,411**	**1151,429**	**1170,840**
12	0	0	0	10,468	7,851	282,879	8,629	42,810	87,076	**18,319**	**421,394**	**439,713**
12,5	0	0	0	5,081	12,601	137,297	13,849	0	39,489	**17,682**	**190,635**	**208,317**
13	0	0	0	1,147	25,933	30,997	28,501	55,576	20,936	**27,08**	**136,01**	**163,090**
13,5	0	0	0	0,585	9,340	15,812	10,265	0	4,715	**9,925**	**30,792**	**40,717**
14	0	0	0,037	0,256	11,504	6,915	12,643	3,371	0	**11,797**	**22,929**	**34,726**
14,5	0	0	0	0,204	3,686	5,510	4,051	5,671	0	**3,890**	**15,232**	**19,122**
15	0	0	0	0,228	0,618	6,156	0,679	16,896	0	**0,846**	**23,731**	**24,577**
15,5	0	0	0	0,254	0	6,854	0	28,215	0	**0,254**	**35,069**	**35,323**
16	0	0	0	0,141	0	3,802	0	13,044	0	**0,141**	**16,846**	**16,987**
16,5	0	5,296	0,063	0	0	0	0	23,083	0	**5,359**	**23,083**	**28,442**
17	63,993	23,302	0	0	0	0	0	12,728	0	**87,295**	**12,728**	**100,023**
17,5	0	83,328	0,914	0	0	0	0	3,499	0	**84,242**	**3,499**	**87,741**
18	154,368	194,101	2,589	0	0	0	0	7,676	0	**351,058**	**7,676**	**358,734**
18,5	804,958	269,649	3,29	0	0	0	0	0	0	**1077,897**	**0**	**1077,897**
19	1618,328	271,448	5,087	0	0	0	0	0	0	**1894,863**	**0**	**1894,863**
19,5	2467,622	243,305	3,150	0	0	0	0	9,982	0	**2714,077**	**9,982**	**2724,059**
20	3282,209	140,013	2,951	0	0	0	0	0	1,698	**3425,173**	**1,698**	**3426,871**
20,5	3441,276	49,638	0,384	0	0	0	0	0	0	**3491,298**	**0**	**3491,298**
21	2248,229	22,923	0	0	0	0	0	0	0	**2271,152**	**0**	**2271,152**
21,5	1110,311	4,147	0	0	0	0	0	0	0	**1114,458**	**0**	**1114,458**
22	75,570	0	0	0	0	0	0	0	0	**75,570**	**0**	**75,570**
22,5	321,296	0	0	0	0	0	0	0	0	**321,296**	**0**	**321,296**
23	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
TOTAL	15588,160	1307,150	18,465	52,922	71,793	1430,119	78,902	4607,920	304,748	**17038,49**	**6421,689**	**23460,179**

Table 8. *ECOCADIZ 2015-07* survey. Sardine (*S. 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	POL07	POL08	POL09	PT	ES	TOTAL
	Number	Number	Number	Number	Number	Number	Number	Number	Number	Number	Number	Number
0	0	11	2	4386	3907	118523	4294	488421	23521	8596	636457	645053
I	43322	12167	161	21	99	563	109	2727	4	85996	2650	88646
II	73266	5485	86	1	3	27	3	230	13	73909	248	74156
III	48745	2575	36	0	0	0	0	55	4	39746	29	39775
IV	26567	1204	17	0	0	0	0	14	3	22565	8	22573
V	9745	419	5	0	0	0	0	14	1	7342	2	7345
VI	11380	93	0,3	0	0	0	0	0	0	8584	0	8584
TOTAL	213026	21954	307	4408	4009	119113	4406	491460	23544	246737	639394	886131

Age class	POL01	POL02	POL03	POL04	POL05	POL06	POL07	POL08	POL09	PT	ES	TOTAL
	Weight	Weight	Weight	Weight	Weight	Weight	Weight	Weight	Weight	Weight	Weight	Weight
0	0	0	0,04	52	69	1409	76	4497	303	115	5420	5536
I	2687	670	9	1	2	17	3	96	0,3	4989	88	5077
II	5336	351	6	0,03	0,1	1	0,1	10	1	5050	10	5059
III	3742	167	2	0	0	0	0	3	0,3	2826	2	2828
IV	2026	81	1	0	0	0	0	1	0,2	1666	1	1666
V	773	29	0,4	0	0	0	0	1	0,05	540	0,1	541
VI	1024	8	0,02	0	0	0	0	0	0	808	0	808
TOTAL	15588	1307	18	53	72	1426	79	4608	305	15994	5520	21514

Table 9. *ECOCADIZ 2015-07* survey. Mackerel (*S. 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 16**.

***ECOCADIZ 2015-07*. *Scomber scombrus*. ABUNDANCE (in numbers and million fish)**								
Size class	**POL01**	**POL02**	***n***			**millions**		
			PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
23	0	0	0	0	0	**0**	**0**	**0**
23,5	862	10080	862	10080	10942	**0,001**	**0,01**	**0,01**
24	0	0	0	0	0	**0**	**0**	**0**
24,5	1117	13061	1117	13061	14178	**0,001**	**0,01**	**0,01**
25	17594	205741	17594	205741	223335	**0,02**	**0,2**	**0,2**
25,5	1392	16283	1392	16283	17675	**0,001**	**0,02**	**0,02**
26	1006	11760	1006	11760	12766	**0,001**	**0,01**	**0,01**
26,5	16185	189265	16185	189265	205450	**0,02**	**0,2**	**0,2**
27	14430	168742	14430	168742	183172	**0,01**	**0,2**	**0,2**
27,5	16865	197211	16865	197211	214076	**0,02**	**0,2**	**0,2**
28	15503	181279	15503	181279	196782	**0,02**	**0,2**	**0,2**
28,5	1785	20870	1785	20870	22655	**0,002**	**0,02**	**0,02**
29	6428	75165	6428	75165	81593	**0,01**	**0,1**	**0,1**
29,5	2123	24821	2123	24821	26944	**0,002**	**0,02**	**0,03**
30	13333	155906	13333	155906	169239	**0,01**	**0,2**	**0,2**
30,5	7787	91056	7787	91056	98843	**0,01**	**0,1**	**0,1**
31	33947	396962	33947	396962	430909	**0,03**	**0,4**	**0,4**
31,5	16051	187687	16051	187687	203738	**0,02**	**0,2**	**0,2**
32	9955	116407	9955	116407	126362	**0,01**	**0,1**	**0,1**
32,5	33906	396480	33906	396480	430386	**0,03**	**0,4**	**0,4**
33	14773	172750	14773	172750	187523	**0,01**	**0,2**	**0,2**
33,5	11154	130427	11154	130427	141581	**0,01**	**0,1**	**0,1**
34	1646	19243	1646	19243	20889	**0,002**	**0,02**	**0,02**
34,5	0	0	0	0	0	**0**	**0**	**0**
35	0	0	0	0	0	**0**	**0**	**0**
35,5	5531	64679	5531	64679	70210	**0,01**	**0,1**	**0,1**
36	0	0	0	0	0	**0**	**0**	**0**
36,5	4526	52919	4526	52919	57445	**0,005**	**0,1**	**0,1**
37	1006	11760	1006	11760	12766	**0,001**	**0,01**	**0,01**
37,5	0	0	0	0	0	**0**	**0**	**0**
38	4526	52919	4526	52919	57445	**0,005**	**0,1**	**0,1**
38,5	0	0	0	0	0	**0**	**0**	**0**
TOTAL *n*	253431	2963473	253431	2963473	3216904	**0,3**	**3**	**3**
Millions	**0,3**	**3**						

Table 9. *ECOCADIZ 2015-07* survey. Mackerel (*S. scombrus*). Cont'd.

ECOCADIZ 2015-07 . *Scomber scombrus* . BIOMASS (t)					
Size class	**POL01**	**POL02**	**PORTUGAL**	**SPAIN**	**TOTAL**
23	0	0	**0**	**0**	**0**
23,5	0,076	0,887	**0,076**	**0,887**	**0,963**
24	0	0	**0**	**0**	**0**
24,5	0,114	1,331	**0,114**	**1,331**	**1,445**
25	1,924	22,503	**1,924**	**22,503**	**24,427**
25,5	0,163	1,909	**0,163**	**1,909**	**2,072**
26	0,126	1,476	**0,126**	**1,476**	**1,602**
26,5	2,173	25,406	**2,173**	**25,406**	**27,579**
27	2,069	24,190	**2,069**	**24,190**	**26,259**
27,5	2,579	30,155	**2,579**	**30,155**	**32,734**
28	2,526	29,532	**2,526**	**29,532**	**32,058**
28,5	0,309	3,618	**0,309**	**3,618**	**3,927**
29	1,185	13,854	**1,185**	**13,854**	**15,039**
29,5	0,415	4,859	**0,415**	**4,859**	**5,274**
30	2,769	32,378	**2,769**	**32,378**	**35,147**
30,5	1,714	20,043	**1,714**	**20,043**	**21,757**
31	7,913	92,526	**7,913**	**92,526**	**100,439**
31,5	3,958	46,282	**3,958**	**46,282**	**50,240**
32	2,595	30,342	**2,595**	**30,342**	**32,937**
32,5	9,334	109,143	**9,334**	**109,143**	**118,477**
33	4,291	50,182	**4,291**	**50,182**	**54,473**
33,5	3,416	39,949	**3,416**	**39,949**	**43,365**
34	0,531	6,210	**0,531**	**6,210**	**6,741**
34,5	0	0	**0**	**0**	**0**
35	0	0	**0**	**0**	**0**
35,5	2,078	24,301	**2,078**	**24,301**	**26,379**
36	0	0	**0**	**0**	**0**
36,5	1,875	21,928	**1,875**	**21,928**	**23,803**
37	0,437	5,112	**0,437**	**5,112**	**5,549**
37,5	0	0	**0**	**0**	**0**
38	2,161	25,274	**2,161**	**25,274**	**27,435**
38,5	0	0	**0**	**0**	**0**
TOTAL	**56,731**	**663,390**	**56,731**	**663,390**	**720,121**

Table 10. *ECOCADIZ 2015-07* survey. Chub mackerel (*S. 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 18**.

***ECOCADIZ 2015-07* . *Scomber colias* . ABUNDANCE (in numbers and million fish)**												
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	***n***			**millions**		
							PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
16	0	5837	30367	0	0	0	36204	0	36204	**0,04**	**0**	**0,04**
16,5	0	5837	30367	0	0	0	36204	0	36204	**0,04**	**0**	**0,04**
17	0	5837	30367	0	0	0	36204	0	36204	**0,04**	**0**	**0,04**
17,5	0	16052	83509	0	0	0	99561	0	99561	**0,1**	**0**	**0,1**
18	783277	72443	376883	1420	0	0	1232603	1420	1234023	**1**	**0**	**1**
18,5	783277	178902	930736	9967	0	0	1892915	9967	1902882	**2**	**0,01**	**2**
19	2375156	274175	1426388	29928	0	0	4075719	29928	4105647	**4**	**0,03**	**4**
19,5	3334776	175432	912680	24221	0	0	4422888	24221	4447109	**4**	**0,02**	**4**
20	1709713	156881	816173	27060	0	0	2682767	27060	2709827	**3**	**0,03**	**3**
20,5	992328	116205	604552	16398	0	0	1713085	16398	1729483	**2**	**0,02**	**2**
21	1542687	110368	574185	16398	0	0	2227240	16398	2243638	**2**	**0,02**	**2**
21,5	1308157	100136	520956	14254	0	0	1929249	14254	1943503	**2**	**0,01**	**2**
22	1951525	71974	374441	9271	0	0	2397940	9271	2407211	**2**	**0,01**	**2**
22,5	4474953	105017	546348	10691	0	0	5126318	10691	5137009	**5**	**0,01**	**5**
23	10871641	62665	326014	6403	0	0	11260320	6403	11266723	**11**	**0,01**	**11**
23,5	26049341	9292	48340	724	0	0	26106973	724	26107697	**26**	**0,001**	**26**
24	36732604	57331	298263	2840	0	0	37088198	2840	37091038	**37**	**0,003**	**37**
24,5	32851985	27726	144243	0	0	0	33023954	0	33023954	**33**	**0**	**33**
25	22578581	16052	83509	0	0	0	22678142	0	22678142	**23**	**0**	**23**
25,5	11644774	25344	131849	724	0	0	11801967	724	11802691	**12**	**0,001**	**12**
26	6054738	0	0	0	0	0	6054738	0	6054738	**6**	**0**	**6**
26,5	3930651	16052	83509	0	0	0	4030212	0	4030212	**4**	**0**	**4**
27	896138	0	0	0	0	0	896138	0	896138	**1**	**0**	**1**
27,5	874493	10215	53142	0	0	0	937850	0	937850	**1**	**0**	**1**
28	884948	0	0	0	0	0	884948	0	884948	**1**	**0**	**1**
28,5	321357	0	0	0	0	0	321357	0	321357	**0,3**	**0**	**0,3**
29	157108	0	0	0	0	0	157108	0	157108	**0,2**	**0**	**0,2**
29,5	0	5837	30367	0	113266	85793	36204	199059	235263	**0,04**	**0,2**	**0,2**
30	0	0	0	0	7902	5986	0	13888	13888	**0**	**0,01**	**0,01**
30,5	0	0	0	0	7902	5986	0	13888	13888	**0**	**0,01**	**0,01**
31	0	0	0	0	26341	19952	0	46293	46293	**0**	**0,05**	**0,05**
31,5	0	0	0	0	50048	37909	0	87957	87957	**0**	**0,1**	**0,1**
32	0	0	0	0	15805	11971	0	27776	27776	**0**	**0,03**	**0,03**
32,5	0	0	0	0	7902	5986	0	13888	13888	**0**	**0,01**	**0,01**
33	0	0	0	0	7902	5986	0	13888	13888	**0**	**0,01**	**0,01**
33,5	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
TOTAL *n*	173104208	1625610	8457188	170299	237068	179569	183187006	586936	183773942	**28**	**0,2**	**28**
Millions	**173**	**2**	**8**	**0,2**	**0,2**	**0,2**						

Table 10. *ECOCADIZ 2015-07* survey. Chub mackerel (*S. colias*). Cont'd.

***ECOCADIZ 2015-07 . Scomber colias* . BIOMASS (t)**									
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**PORTUGAL**	**SPAIN**	**TOTAL**
16	0	0,188	0,976	0	0	0	**1,164**	**0**	**1,164**
16,5	0	0,207	1,077	0	0	0	**1,284**	**0**	**1,284**
17	0	0,228	1,185	0	0	0	**1,413**	**0**	**1,413**
17,5	0	0,687	3,574	0	0	0	**4,261**	**0**	**4,261**
18	36,691	3,393	17,654	0,067	0	0	**57,738**	**0,067**	**57,805**
18,5	40,055	9,149	47,596	0,510	0	0	**96,800**	**0,510**	**97,31**
19	132,294	15,271	79,449	1,667	0	0	**227,014**	**1,667**	**228,681**
19,5	201,868	10,620	55,248	1,466	0	0	**267,736**	**1,466**	**269,202**
20	112,246	10,300	53,584	1,777	0	0	**176,130**	**1,777**	**177,907**
20,5	70,517	8,258	42,961	1,165	0	0	**121,736**	**1,165**	**122,901**
21	118,436	8,473	44,082	1,259	0	0	**170,991**	**1,259**	**172,250**
21,5	108,307	8,291	43,132	1,180	0	0	**159,730**	**1,18**	**160,910**
22	173,946	6,415	33,375	0,826	0	0	**213,736**	**0,826**	**214,562**
22,5	428,707	10,061	52,341	1,024	0	0	**491,109**	**1,024**	**492,133**
23	1117,679	6,442	33,516	0,658	0	0	**1157,637**	**0,658**	**1158,295**
23,5	2869,571	1,024	5,325	0,080	0	0	**2875,920**	**0,08**	**2876,0**
24	4329,573	6,757	35,155	0,335	0	0	**4371,485**	**0,335**	**4371,82**
24,5	4137,411	3,492	18,166	0	0	0	**4159,069**	**0**	**4159,069**
25	3034,323	2,157	11,223	0	0	0	**3047,703**	**0**	**3047,703**
25,5	1667,79	3,630	18,884	0,104	0	0	**1690,304**	**0,104**	**1690,408**
26	923,037	0	0	0	0	0	**923,037**	**0**	**923,037**
26,5	637,075	2,602	13,535	0	0	0	**653,212**	**0**	**653,212**
27	154,245	0	0	0	0	0	**154,245**	**0**	**154,245**
27,5	159,671	1,865	9,703	0	0	0	**171,239**	**0**	**171,239**
28	171,224	0	0	0	0	0	**171,224**	**0**	**171,224**
28,5	65,822	0	0	0	0	0	**65,822**	**0**	**65,822**
29	34,032	0	0	0	0	0	**34,032**	**0**	**34,032**
29,5	0	1,336	6,950	0	25,923	19,635	**8,286**	**45,558**	**53,844**
30	0	0	0	0	1,909	1,446	**0**	**3,355**	**3,355**
30,5	0	0	0	0	2,013	1,525	**0**	**3,538**	**3,538**
31	0	0	0	0	7,072	5,357	**0**	**12,429**	**12,429**
31,5	0	0	0	0	14,148	10,717	**0**	**24,865**	**24,865**
32	0	0	0	0	4,700	3,560	**0**	**8,260**	**8,260**
32,5	0	0	0	0	2,471	1,871	**0**	**4,342**	**4,342**
33	0	0	0	0	2,595	1,966	**0**	**4,561**	**4,561**
33,5	0	0	0	0	0	0	**0**	**0**	**0**
TOTAL	**20724,520**	**120,846**	**628,691**	**12,118**	**60,831**	**46,077**	**21474,057**	**119,026**	**21593,083**

Table 11. *ECOCADIZ 2015-07* survey. Blue jack-mackerel (*T. picturatus*). 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 2015-07*. *Trachurus picturatus*. ABUNDANCE (in numbers and million fish)**												
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	***n***			**millions**		
							PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
11	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
11,5	9430	0	0	0	0	0	9430	0	9430	**0,01**	**0**	**0,01**
12	0	0	0	0	7632	21407	7632	21407	29039	**0,01**	**0,02**	**0,03**
12,5	0	808843	0	60677	65809	184591	935329	184591	1119920	**1**	**0,2**	**1**
13	0	2156915	0	69144	153279	429943	2379338	429943	2809281	**2**	**0,4**	**3**
13,5	60271	8806645	0	69144	70564	197929	9006624	197929	9204553	**9**	**0,2**	**9**
14	0	8806645	0	104421	36515	102422	8947581	102422	9050003	**9**	**0,1**	**9**
14,5	0	8491717	0	121354	49312	138320	8662383	138320	8800703	**9**	**0,1**	**9**
15	0	11187860	0	77610	25067	70312	11290537	70312	11360849	**11**	**0,1**	**11**
15,5	9430	9342065	0	215897	23834	66854	9591226	66854	9658080	**10**	**0,1**	**10**
16	28290	7431337	0	163687	7221	20254	7630535	20254	7650789	**8**	**0,02**	**8**
16,5	75441	8775600	0	215897	3405	9551	9070343	9551	9079894	**9**	**0,01**	**9**
17	201723	10952131	0	173564	0	0	11327418	0	11327418	**11**	**0**	**11**
17,5	511415	10682517	0	215897	0	0	11409829	0	11409829	**11**	**0**	**11**
18	901331	11245171	13317	276574	0	0	12436393	0	12436393	**12**	**0**	**12**
18,5	861971	10127481	26634	182031	0	0	11198117	0	11198117	**11**	**0**	**11**
19	483125	8848150	13317	242708	0	0	9587300	0	9587300	**10**	**0**	**10**
19,5	435974	6827177	5327	215897	0	0	7484375	0	7484375	**7**	**0**	**7**
20	369416	2066286	5327	129821	0	0	2570850	0	2570850	**3**	**0**	**3**
20,5	683891	2312475	5327	69144	0	0	3070837	0	3070837	**3**	**0**	**3**
21	214844	3345618	0	52210	0	0	3612672	0	3612672	**4**	**0**	**4**
21,5	223180	2335900	0	8467	0	0	2567547	0	2567547	**3**	**0**	**3**
22	211153	3322191	0	25400	0	0	3558744	0	3558744	**4**	**0**	**4**
22,5	94302	2806389	0	0	0	0	2900691	0	2900691	**3**	**0**	**3**
23	94302	2468034	0	8467	0	0	2570803	0	2570803	**3**	**0**	**3**
23,5	28290	1751358	0	0	0	0	1779648	0	1779648	**2**	**0**	**2**
24	0	740102	0	0	0	0	740102	0	740102	**1**	**0**	**1**
24,5	18860	246188	0	0	0	0	265048	0	265048	**0,3**	**0**	**0,3**
25	18860	0	0	0	0	0	18860	0	18860	**0,02**	**0**	**0,02**
25,5	9430	0	0	0	0	0	9430	0	9430	**0,01**	**0**	**0,01**
26	0	246188	0	0	0	0	246188	0	246188	**0,2**	**0**	**0,2**
26,5	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
TOTAL *n*	5544929	146130983	69249	2698011	442638	1241583	154885810	1241583	156127393	**155**	**1**	**156**
Millions	**6**	**146**	**0,1**	**3**	**0,4**	**1**						

Table 11. *ECOCADIZ 2015-07* survey. Blue jack-mackerel (*T. picturatus*). Cont'd.

***ECOCADIZ 2015-07*. *Trachurus picturatus*. BIOMASS (t)**									
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**PORTUGAL**	**SPAIN**	**TOTAL**
11	0	0	0	0	0	0	0	0	0
11,5	0,117	0	0	0	0	0	0,117	0	0,117
12	0	0	0	0	0,108	0,303	0,108	0,303	0,411
12,5	0	13,033	0	0,978	1,060	2,974	15,071	2,974	18,045
13	0	39,319	0	1,260	2,794	7,838	43,373	7,838	51,211
13,5	1,237	180,80	0	1,420	1,449	4,063	184,906	4,063	188,969
14	0	202,755	0	2,404	0,841	2,358	206,000	2,358	208,358
14,5	0	218,380	0	3,121	1,268	3,557	222,769	3,557	226,326
15	0	320,197	0	2,221	0,717	2,012	323,135	2,012	325,147
15,5	0,299	296,529	0	6,853	0,757	2,122	304,438	2,122	306,56
16	0,993	260,760	0	5,744	0,253	0,711	267,750	0,711	268,461
16,5	2,918	339,375	0	8,349	0,132	0,369	350,774	0,369	351,143
17	8,573	465,468	0	7,377	0	0	481,418	0	481,418
17,5	23,822	497,600	0	10,057	0	0	531,479	0	531,479
18	45,899	572,642	0,678	14,084	0	0	633,303	0	633,303
18,5	47,871	562,448	1,479	10,109	0	0	621,907	0	621,907
19	29,195	534,694	0,805	14,667	0	0	579,361	0	579,361
19,5	28,605	447,947	0,350	14,166	0	0	491,068	0	491,068
20	26,263	146,897	0,379	9,229	0	0	182,768	0	182,768
20,5	52,577	177,783	0,410	5,316	0	0	236,086	0	236,086
21	17,828	277,631	0	4,333	0	0	299,792	0	299,792
21,5	19,955	208,859	0	0,757	0	0	229,571	0	229,571
22	20,308	319,518	0	2,443	0	0	342,269	0	342,269
22,5	9,740	289,858	0	0	0	0	299,598	0	299,598
23	10,444	273,327	0	0,938	0	0	284,709	0	284,709
23,5	3,354	207,662	0	0	0	0	211,016	0	211,016
24	0	93,822	0	0	0	0	93,822	0	93,822
24,5	2,553	33,321	0	0	0	0	35,874	0	35,874
25	2,722	0	0	0	0	0	2,722	0	2,722
25,5	1,449	0	0	0	0	0	1,449	0	1,449
26	0	40,245	0	0	0	0	40,245	0	40,245
26,5	0	0	0	0	0	0	0	0	0
TOTAL	**356,722**	**7020,870**	**4,101**	**125,826**	**9,379**	**26,307**	**7516,898**	**26,307**	**7543,205**

Table 12. *ECOCADIZ 2015-07* survey. Horse mackerel (*T. trachurus*). 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 22**.

***ECOCADIZ 2015-07*. *Trachurus trachurus*. ABUNDANCE (in numbers and million fish)**											
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	***n***			**millions**		
						PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
8	0	0	0	0	0	0	0	0	**0**	**0**	**0**
8,5	0	0	0	0	0	0	0	0	**0**	**0**	**0**
9	17031	0	0	0	29173	17031	29173	46204	**0,02**	**0,03**	**0,05**
9,5	51094	529303	12558	7872	1546066	592955	1553938	2146893	**1**	**2**	**2**
10	221407	2748525	43953	27553	3392152	3013885	3419705	6433590	**3**	**3**	**6**
10,5	562034	5391190	411684	258071	2539943	6364908	2798014	9162922	**6**	**3**	**9**
11	306564	3924299	779908	488897	893870	5010771	1382767	6393538	**5**	**1**	**6**
11,5	187345	2536804	751899	471339	241010	3476048	712349	4188397	**3**	**1**	**4**
12	34063	2748525	348782	218640	129180	3131370	347820	3479190	**3**	**0,3**	**3**
12,5	34063	2536804	203108	127321	0	2773975	127321	2901296	**3**	**0,1**	**3**
13	68125	1374263	73521	46088	0	1515909	46088	1561997	**2**	**0,05**	**2**
13,5	0	754256	19298	12097	0	773554	12097	785651	**1**	**0,01**	**1**
14	17031	0	0	0	0	17031	0	17031	**0,02**	**0**	**0,02**
14,5	0	0	0	0	0	0	0	0	**0**	**0**	**0**
15	0	0	12558	7872	0	12558	7872	20430	**0,01**	**0,01**	**0,02**
15,5	377986	330814	0	0	29173	708800	29173	737973	**1**	**0,03**	**1**
16	377986	0	0	0	0	377986	0	377986	**0,4**	**0**	**0,4**
16,5	755972	330814	0	0	0	1086786	0	1086786	**1**	**0**	**1**
17	377986	0	0	0	0	377986	0	377986	**0,4**	**0**	**0,4**
17,5	531268	0	0	0	0	531268	0	531268	**1**	**0**	**1**
18	5543976	0	0	0	0	5543976	0	5543976	**6**	**0**	**6**
18,5	4284206	0	0	0	0	4284206	0	4284206	**4**	**0**	**4**
19	4580881	0	0	0	0	4580881	0	4580881	**5**	**0**	**5**
19,5	3893035	0	0	0	0	3893035	0	3893035	**4**	**0**	**4**
20	3515049	0	0	0	0	3515049	0	3515049	**4**	**0**	**4**
20,5	3024436	390481	1685	1056	0	3416602	1056	3417658	**3**	**0,001**	**3**
21	3879300	696334	0	0	0	4575634	0	4575634	**5**	**0**	**5**
21,5	2731607	1496784	0	0	0	4228391	0	4228391	**4**	**0**	**4**
22	4635271	8839237	0	0	0	13474508	0	13474508	**13**	**0**	**13**
22,5	5053913	7914581	0	0	0	12968494	0	12968494	**13**	**0**	**13**
23	545003	8318054	1685	1056	0	8864742	1056	8865798	**9**	**0,001**	**9**
23,5	153282	5888494	1685	1056	0	6043461	1056	6044517	**6**	**0,001**	**6**
24	616425	3458633	0	0	0	4075058	0	4075058	**4**	**0**	**4**
24,5	153282	1819478	0	0	0	1972760	0	1972760	**2**	**0**	**2**
25	85157	909739	0	0	0	994896	0	994896	**1**	**0**	**1**
25,5	0	0	0	0	0	0	0	0	**0**	**0**	**0**
26	0	0	0	0	0	0	0	0	**0**	**0**	**0**
26,5	85157	578925	0	0	0	664082	0	664082	**0,7**	**0**	**0,7**
27	85157	0	0	0	0	85157	0	85157	**0,1**	**0**	**0,1**
27,5	0	0	0	0	0	0	0	0	**0**	**0**	**0**
28	0	0	0	0	0	0	0	0	**0**	**0**	**0**
28,5	0	0	0	0	0	0	0	0	**0**	**0**	**0**
29	0	0	0	0	0	0	0	0	**0**	**0**	**0**
29,5	85157	0	0	0	0	85157	0	85157	**0,1**	**0**	**0,1**
30	0	0	0	0	0	0	0	0	**0**	**0**	**0**
30,5	0	0	0	0	0	0	0	0	**0**	**0**	**0**
TOTAL *n*	46870249	63516337	2662324	1668918	8800567	113048910	10469485	123518395	**113**	**10**	**124**
Millions	**47**	**64**	**3**	**2**	**9**						

Table 12. *ECOCADIZ 2015-07* survey. Horse mackerel (*T. trachurus*). Cont'd.

***ECOCADIZ 2015-07*. *Trachurus trachurus*. BIOMASS (t)**								
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**PORTUGAL**	**SPAIN**	**TOTAL**
8	0	0	0	0	0	**0**	**0**	**0**
8,5	0	0	0	0	0	**0**	**0**	**0**
9	0,106	0	0	0	0,181	**0,106**	**0,181**	**0,287**
9,5	0,374	3,874	0,092	0,058	11,317	**4,340**	**11,375**	**15,715**
10	1,892	23,490	0,376	0,235	28,991	**25,758**	**29,226**	**54,984**
10,5	5,567	53,403	4,078	2,556	25,160	**63,048**	**27,716**	**90,764**
11	3,496	44,753	8,894	5,575	10,194	**57,143**	**15,769**	**72,912**
11,5	2,445	33,103	9,812	6,151	3,145	**45,360**	**9,296**	**54,656**
12	0,506	40,809	5,179	3,246	1,918	**46,494**	**5,164**	**51,658**
12,5	0,573	42,637	3,414	2,140	0	**46,624**	**2,140**	**48,764**
13	1,290	26,021	1,392	0,873	0	**28,703**	**0,873**	**29,576**
13,5	0	16,019	0,410	0,257	0	**16,429**	**0,257**	**16,686**
14	0,404	0	0	0	0	**0,404**	**0**	**0,404**
14,5	0	0	0	0	0	**0**	**0**	**0**
15	0	0	0,368	0,230	0	**0,368**	**0,230**	**0,598**
15,5	12,227	10,702	0	0	0,944	**22,929**	**0,944**	**23,873**
16	13,471	0	0	0	0	**13,471**	**0**	**13,471**
16,5	29,594	12,951	0	0	0	**42,545**	**0**	**42,545**
17	16,209	0	0	0	0	**16,209**	**0**	**16,209**
17,5	24,892	0	0	0	0	**24,892**	**0**	**24,892**
18	283,102	0	0	0	0	**283,102**	**0**	**283,102**
18,5	237,884	0	0	0	0	**237,884**	**0**	**237,884**
19	275,969	0	0	0	0	**275,969**	**0**	**275,969**
19,5	253,926	0	0	0	0	**253,926**	**0**	**253,926**
20	247,739	0	0	0	0	**247,739**	**0**	**247,739**
20,5	229,897	29,682	0,128	0,080	0	**259,707**	**0,080**	**259,787**
21	317,457	56,983	0	0	0	**374,44**	**0**	**374,44**
21,5	240,241	131,640	0	0	0	**371,881**	**0**	**371,881**
22	437,411	834,122	0	0	0	**1271,533**	**0**	**1271,533**
22,5	510,915	800,109	0	0	0	**1311,024**	**0**	**1311,024**
23	58,935	899,495	0,182	0,114	0	**958,612**	**0,114**	**958,726**
23,5	17,705	680,166	0,195	0,122	0	**698,066**	**0,122**	**698,188**
24	75,950	426,140	0	0	0	**502,090**	**0**	**502,090**
24,5	20,119	238,814	0	0	0	**258,933**	**0**	**258,933**
25	11,892	127,041	0	0	0	**138,933**	**0**	**138,933**
25,5	0	0	0	0	0	**0**	**0**	**0**
26	0	0	0	0	0	**0**	**0**	**0**
26,5	14,220	96,674	0	0	0	**110,894**	**0**	**110,894**
27	15,060	0	0	0	0	**15,060**	**0**	**15,060**
27,5	0	0	0	0	0	**0**	**0**	**0**
28	0	0	0	0	0	**0**	**0**	**0**
28,5	0	0	0	0	0	**0**	**0**	**0**
29	0	0	0	0	0	**0**	**0**	**0**
29,5	19,767	0	0	0	0	**19,767**	**0**	**19,767**
30	0	0	0	0	0	**0**	**0**	**0**
30,5	0	0	0	0	0	**0**	**0**	**0**
TOTAL	**3381,235**	**4628,628**	**34,520**	**21,637**	**81,850**	**8044,383**	**103,487**	**8147,870**

Table 13. *ECOCADIZ 2015-07* survey. Mediterranean horse-mackerel (*T. 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 24**.

***ECOCADIZ 2015-07*. *Trachurus mediterraneus*. ABUNDANCE (in numbers and million fish)**									
Size class	**POL01**	**POL02**	**POL03**	***n***			**millions**		
				PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
23	0	0	0	0	0	0	**0**	**0**	**0**
23,5	0	0	0	0	0	0	**0**	**0**	**0**
24	0	149200	14522	0	163722	163722	**0**	**0,2**	**0,2**
24,5	61276	0	0	0	61276	61276	**0**	**0,1**	**0,1**
25	183829	857900	83503	0	1125232	1125232	**0**	**1**	**1**
25,5	122552	2853450	277739	0	3253741	3253741	**0**	**3**	**3**
26	370485	5557701	540956	0	6469142	6469142	**0**	**6**	**6**
26,5	615590	7982201	776943	0	9374734	9374734	**0**	**9**	**9**
27	1417837	5408500	526434	0	7352771	7352771	**0**	**7**	**7**
27,5	924799	3841900	373949	0	5140648	5140648	**0**	**5**	**5**
28	1796806	1995550	194236	0	3986592	3986592	**0**	**4**	**4**
28,5	1618634	428950	41752	0	2089336	2089336	**0**	**2**	**2**
29	2983679	857900	83503	0	3925082	3925082	**0**	**4**	**4**
29,5	1802462	428950	41752	0	2273164	2273164	**0**	**2**	**2**
30	1309425	279750	27229	0	1616404	1616404	**0**	**2**	**2**
30,5	866351	149200	14522	0	1030073	1030073	**0**	**1**	**1**
31	621246	279750	27229	0	928225	928225	**0**	**1**	**1**
31,5	551486	149200	14522	0	715208	715208	**0**	**1**	**1**
32	183829	149200	14522	0	347551	347551	**0**	**0,3**	**0,3**
32,5	186657	149200	14522	0	350379	350379	**0**	**0,4**	**0,4**
33	186657	0	0	0	186657	186657	**0**	**0,2**	**0,2**
33,5	186657	0	0	0	186657	186657	**0**	**0,2**	**0,2**
34	0	0	0	0	0	0	**0**	**0**	**0**
34,5	0	0	0	0	0	0	**0**	**0**	**0**
35	125381	0	0	0	125381	125381	**0**	**0,1**	**0,1**
35,5	61276	0	0	0	61276	61276	**0**	**0,1**	**0,1**
36	0	149200	14522	0	163722	163722	**0**	**0,2**	**0,2**
36,5	61276	0	0	0	61276	61276	**0**	**0,1**	**0,1**
37	0	0	0	0	0	0	**0**	**0**	**0**
37,5	61276	0	0	0	61276	61276	**0**	**0,1**	**0,1**
38	0	0	0	0	0	0	**0**	**0**	**0**
38,5	0	0	0	0	0	0	**0**	**0**	**0**
TOTAL *n*	16299466	31667702	3082357	0	51049525	51049525	**0**	**51**	**51**
Millions	**16**	**32**	**3**						

Table 13. *ECOCADIZ 2015-07* survey. Mediterranean horse-mackerel (*T. mediterraneus*). Cont'd.

***ECOCADIZ 2015-07*. *Trachurus mediterraneus*. BIOMASS (t)**						
Size class	**POL01**	**POL02**	**POL03**	**PORTUGAL**	**SPAIN**	**TOTAL**
23	0	0	0	**0**	**0**	**0**
23,5	0	0	0	**0**	**0**	**0**
24	0	17,752	1,728	**0**	**19,480**	**19,480**
24,5	7,690	0	0	**0**	**7,690**	**7,690**
25	24,306	113,431	11,041	**0**	**148,778**	**148,778**
25,5	17,055	397,099	38,651	**0**	**452,805**	**452,805**
26	54,213	813,258	79,158	**0**	**946,629**	**946,629**
26,5	94,628	1227,012	119,431	**0**	**1441,071**	**1441,071**
27	228,744	872,570	84,931	**0**	**1186,245**	**1186,245**
27,5	156,454	649,957	63,263	**0**	**869,674**	**869,674**
28	318,484	353,711	34,428	**0**	**706,623**	**706,623**
28,5	300,349	79,595	7,747	**0**	**387,691**	**387,691**
29	579,134	166,519	16,208	**0**	**761,861**	**761,861**
29,5	365,688	87,026	8,471	**0**	**461,185**	**461,185**
30	277,474	59,280	5,770	**0**	**342,524**	**342,524**
30,5	191,612	32,999	3,212	**0**	**227,823**	**227,823**
31	143,311	64,534	6,281	**0**	**214,126**	**214,126**
31,5	132,601	35,874	3,492	**0**	**171,967**	**171,967**
32	46,041	37,368	3,637	**0**	**87,046**	**87,046**
32,5	48,665	38,899	3,786	**0**	**91,350**	**91,350**
33	50,629	0	0	**0**	**50,629**	**50,629**
33,5	52,640	0	0	**0**	**52,640**	**52,640**
34	0	0	0	**0**	**0**	**0**
34,5	0	0	0	**0**	**0**	**0**
35	39,610	0	0	**0**	**39,610**	**39,610**
35,5	20,084	0	0	**0**	**20,084**	**20,084**
36	0	50,707	4,936	**0**	**55,643**	**55,643**
36,5	21,583	0	0	**0**	**21,583**	**21,583**
37	0	0	0	**0**	**0**	**0**
37,5	23,151	0	0	**0**	**23,151**	**23,151**
38	0	0	0	**0**	**0**	**0**
38,5	0	0	0	**0**	**0**	**0**
TOTAL	**3194,146**	**5097,591**	**496,171**	0	8787,908	8787,908

Table 14. *ECOCADIZ 2015-07* survey. Bogue (*B. boops*). 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 2015-07*. *Boops boops*. ABUNDANCE (in numbers and million fish)**									
Size class	**POL01**	**POL02**	**POL03**	***n***			**millions**		
				PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
17	0	0	0	0	0	0	**0**	**0**	**0**
17,5	0	0	0	0	0	0	**0**	**0**	**0**
18	34040	0	0	34040	0	34040	**0,03**	**0**	**0,03**
18,5	0	0	0	0	0	0	**0**	**0**	**0**
19	136162	0	0	136162	0	136162	**0,1**	**0**	**0,1**
19,5	238283	0	0	238283	0	238283	**0,2**	**0**	**0,2**
20	34040	0	0	34040	0	34040	**0,03**	**0**	**0,03**
20,5	340405	0	0	340405	0	340405	**0,3**	**0**	**0,3**
21	442526	22419	0	464945	0	464945	**0,5**	**0**	**0,5**
21,5	340405	12811	0	353216	0	353216	**0,4**	**0**	**0,4**
22	442526	60852	0	503378	0	503378	**0,5**	**0**	**0,5**
22,5	306364	35230	0	341594	0	341594	**0,3**	**0**	**0,3**
23	374445	0	0	374445	0	374445	**0,4**	**0**	**0,4**
23,5	0	12811	8966	12811	8966	21777	**0,01**	**0,01**	**0,02**
24	34040	0	71726	34040	71726	105766	**0,03**	**0,1**	**0,1**
24,5	0	0	143451	0	143451	143451	**0**	**0,1**	**0,1**
25	0	0	17931	0	17931	17931	**0**	**0,02**	**0,02**
25,5	0	0	17931	0	17931	17931	**0**	**0,02**	**0,02**
26	34040	0	8966	34040	8966	43006	**0,03**	**0,01**	**0,04**
26,5	0	0	0	0	0	0	**0**	**0**	**0**
27	0	0	26897	0	26897	26897	**0**	**0,03**	**0,03**
27,5	0	0	17931	0	17931	17931	**0**	**0,02**	**0,02**
28	0	0	17931	0	17931	17931	**0**	**0,02**	**0,02**
28,5	0	0	98623	0	98623	98623	**0**	**0,1**	**0,1**
29	0	0	0	0	0	0	**0**	**0**	**0**
29,5	0	0	0	0	0	0	**0**	**0**	**0**
TOTAL *n*	2757276	144123	430353	2901399	430353	3331752	**3**	**0,4**	**3**
Millions	**3**	**0,1**	**0,4**						

Table 14. *ECOCADIZ 2015-07* survey. Bogue (*B. boops*).Cont'd.

***ECOCADIZ 2015-07 . Boops boops .* BIOMASS (t)**						
Size class	**POL01**	**POL02**	**POL03**	**PORTUGAL**	**SPAIN**	**TOTAL**
17	0	0	0	0	0	0
17,5	0	0	0	0	0	0
18	2,060	0	0	2,060	0	2,060
18,5	0	0	0	0	0	0
19	9,602	0	0	9,602	0	9,602
19,5	18,087	0	0	18,087	0	18,087
20	2,776	0	0	2,776	0	2,776
20,5	29,775	0	0	29,775	0	29,775
21	41,447	2,100	0	43,547	0	43,547
21,5	34,084	1,283	0	35,367	0	35,367
22	47,297	6,504	0	53,801	0	53,801
22,5	34,901	4,013	0	38,914	0	38,914
23	45,405	0	0	45,405	0	45,405
23,5	0	1,651	1,156	1,651	1,156	2,807
24	4,658	0	9,815	4,658	9,815	14,473
24,5	0	0	20,815	0	20,815	20,815
25	0	0	2,756	0	2,756	2,756
25,5	0	0	2,915	0	2,915	2,915
26	5,848	0	1,540	5,848	1,54	7,388
26,5	0	0	0	0	0	0
27	0	0	5,145	0	5,145	5,145
27,5	0	0	3,614	0	3,614	3,614
28	0	0	3,804	0	3,804	3,804
28,5	0	0	22,001	0	22,001	22,001
29	0	0	0	0	0	0
29,5	0	0	0	0	0	0
TOTAL	**275,940**	**15,551**	**73,561**	**291,491**	**73,561**	**365,052**

Table 15. *ECOCADIZ 2015-07* survey. Blue whiting (*M. poutassou*). 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 28**.

***ECOCADIZ 2015-07*. *Micromesistius poutassou*. ABUNDANCE (in numbers and million fish)**							
Size class	**POL01**	***n***			**millions**		
		PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
13	0	0	0	0	**0**	**0**	**0**
13,5	0	0	0	0	**0**	**0**	**0**
14	752679	752679	0	752679	**1**	**0**	**1**
14,5	4438213	4438213	0	4438213	**4**	**0**	**4**
15	4353861	4353861	0	4353861	**4**	**0**	**4**
15,5	3685534	3685534	0	3685534	**4**	**0**	**4**
16	1339899	1339899	0	1339899	**1**	**0**	**1**
16,5	249812	249812	0	249812	**0,2**	**0**	**0,2**
17	0	0	0	0	**0**	**0**	**0**
17,5	0	0	0	0	**0**	**0**	**0**
TOTAL *n*	14819998	14819998	0	14819998	**15**	**0**	**15**
Millions	**15**						

Table 15. *ECOCADIZ 2015-07* survey. Blue whiting (*M. poutassou*). Cont'd.

***ECOCADIZ 2015-07*. *Micromesistius poutassou*. BIOMASS (t)**				
Size class	**POL01**	**PORTUGAL**	**SPAIN**	**TOTAL**
13	0	0	0	0
13,5	0	0	0	0
14	13,694	13,694	0	13,694
14,5	83,683	83,683	0	83,683
15	84,977	84,977	0	84,977
15,5	74,378	74,378	0	74,378
16	27,93	27,930	0	27,930
16,5	5,373	5,373	0	5,373
17	0	0	0	0
17,5	0	0	0	0
TOTAL	**290,035**	**290,035**	**0**	**290,035**

Table 16. *ECOCADIZ 2015-07* survey. Boarfish (*C. aper*). 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 30**.

***ECOCADIZ 2015-07*. *Capros aper*. ABUNDANCE (in numbers and million fish)**							
Size class	**POL01**	***n***			**millions**		
		PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
4	0	0	0	0	**0**	**0**	**0**
4,5	0	0	0	0	**0**	**0**	**0**
5	0	0	0	0	**0**	**0**	**0**
5,5	796	796	0	796	**0,001**	**0**	**0,001**
6	1827	1827	0	1827	**0,002**	**0**	**0,002**
6,5	2061	2061	0	2061	**0,002**	**0**	**0,002**
7	187	187	0	187	**0,0002**	**0**	**0,0002**
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**
TOTAL *n*	4871	4871	0	4871	**0,005**	**0**	**0,005**
Millions	**0,005**	**0,005**	**0**	**0,005**			

Table 16. *ECOCADIZ 2015-07* survey. Boarfish (*C. aper*). Cont'd.

***ECOCADIZ 2015-07*. *Capros aper*. BIOMASS (t)**				
Size class	**POL01**	**PORTUGAL**	**SPAIN**	**TOTAL**
4	0	0	0	0
4,5	0	0	0	0
5	0	0	0	0
5,5	0,003	0,003	0	0,003
6	0,009	0,009	0	0,009
6,5	0,013	0,013	0	0,013
7	0,001	0,001	0	0,001
7,5	0	0	0	0
8	0	0	0	0
8,5	0	0	0	0
TOTAL	**0,026**	**0,026**	**0**	**0,026**

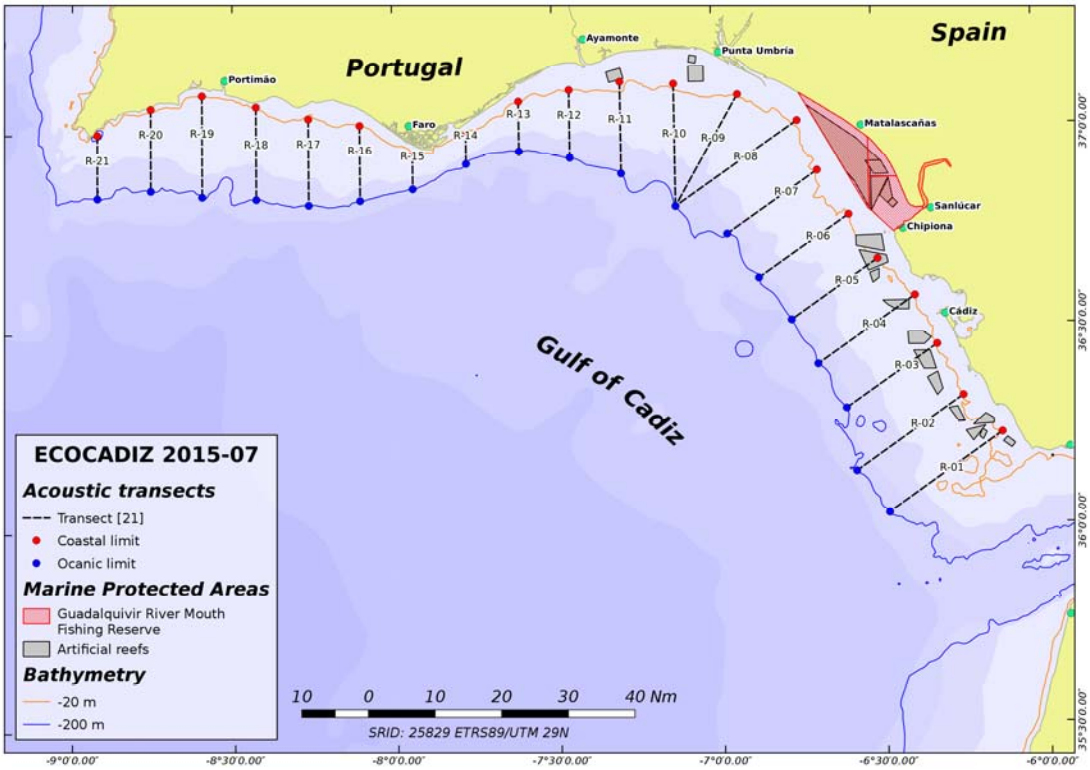


Figure 1. *ECOCADIZ 2015-07* survey. Location of the acoustic transects sampled during the survey. The different protected areas inside the Guadalquivir river mouth Fishing Reserve and artificial reef polygons are also shown.

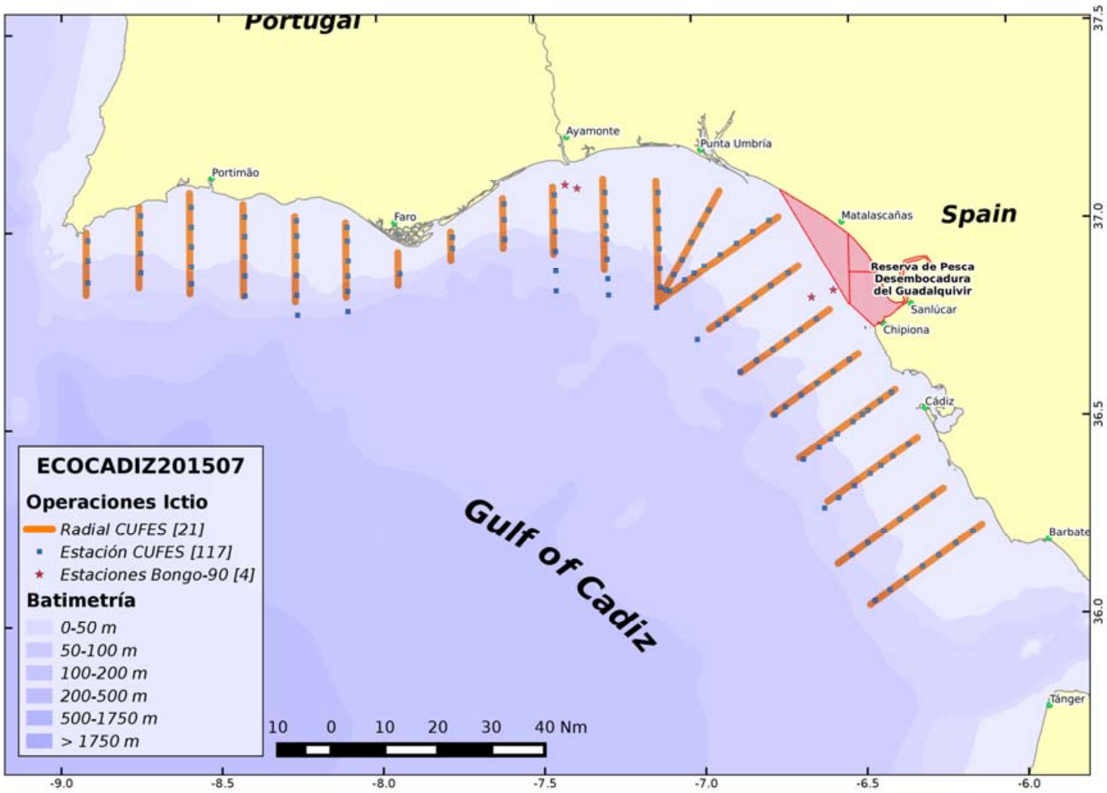


Figure 2. *ECOCADIZ 2015-07* survey. Location of CUFES and Bongo-90 sampling stations.

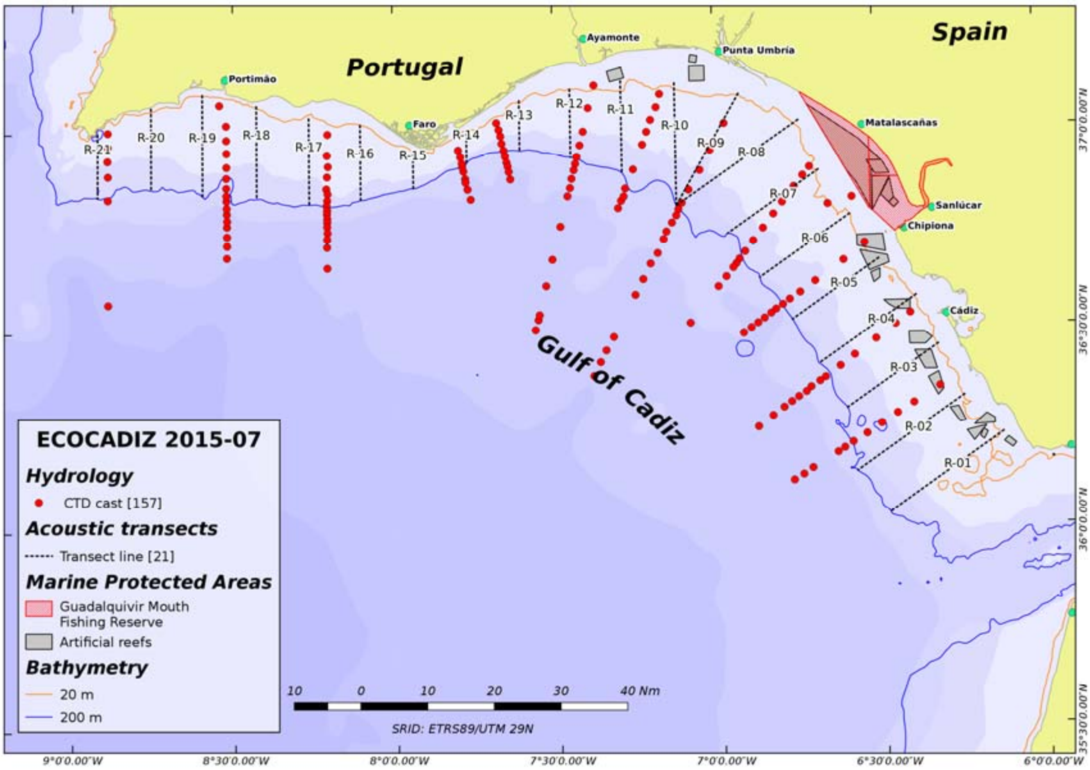


Figure 3. *ECOCADIZ 2015-07* survey. Location of CTD-LADCP stations.

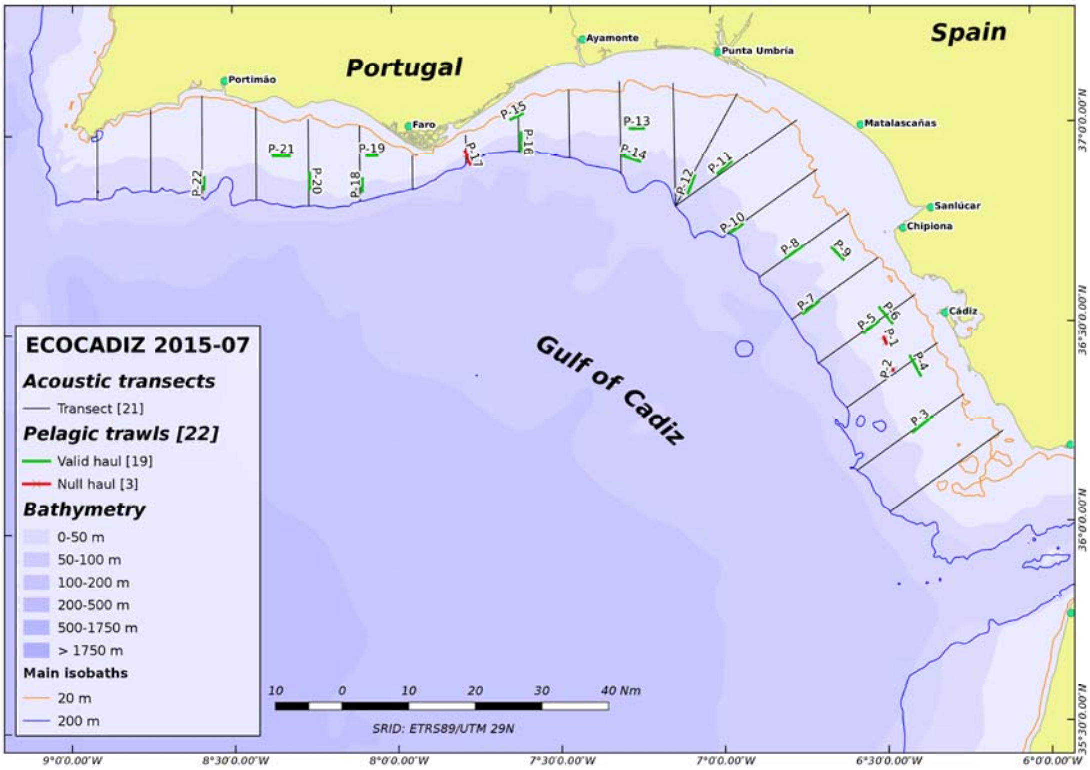


Figure 4. *ECOCADIZ 2015-07* survey. Location of ground-truthing fishing hauls. Null hauls in red.

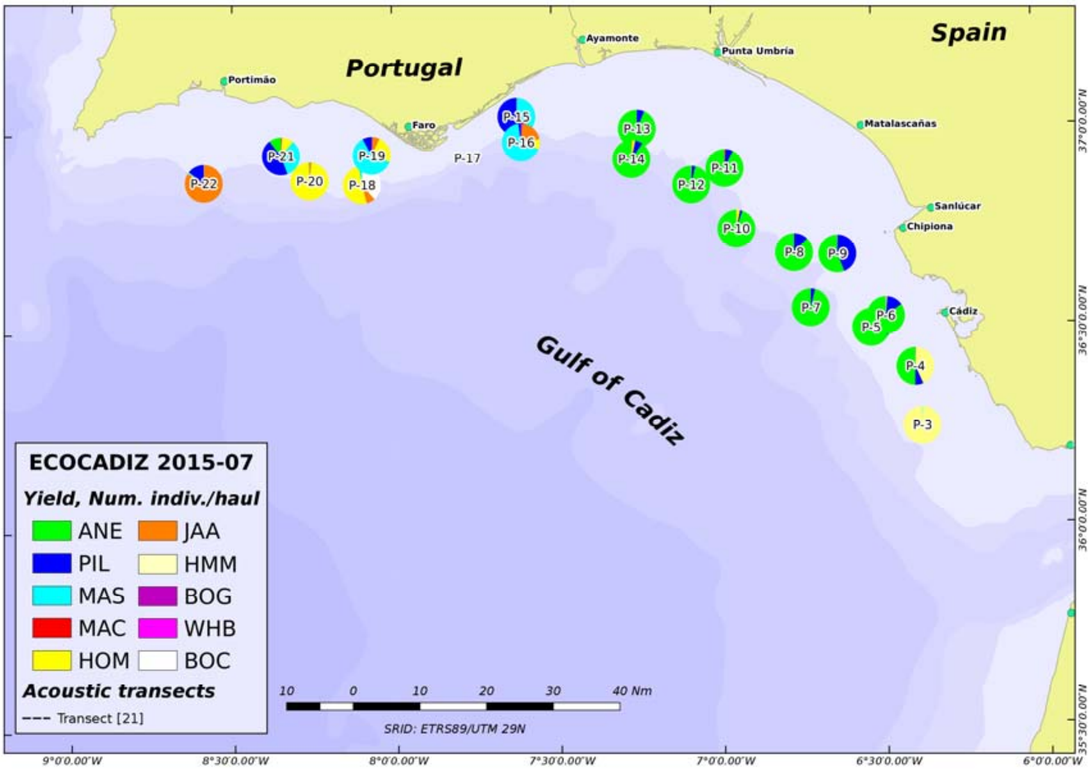


Figure 5. *ECOCADIZ 2015-07* survey. Species composition (percentages in number) in fishing hauls.

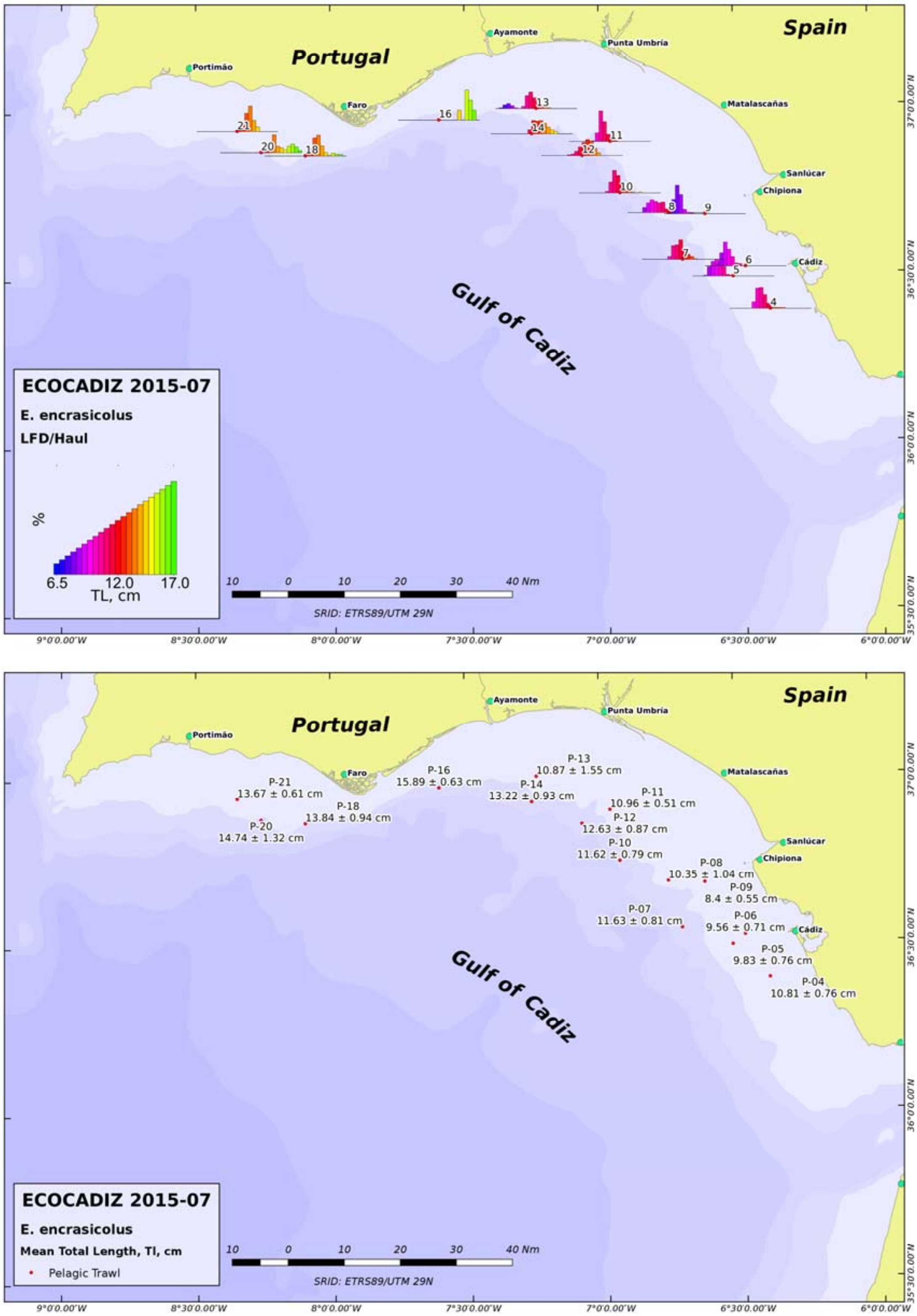


Figure 6. *ECOCADIZ 2015-07* survey. *Engraulis encrasicolus*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

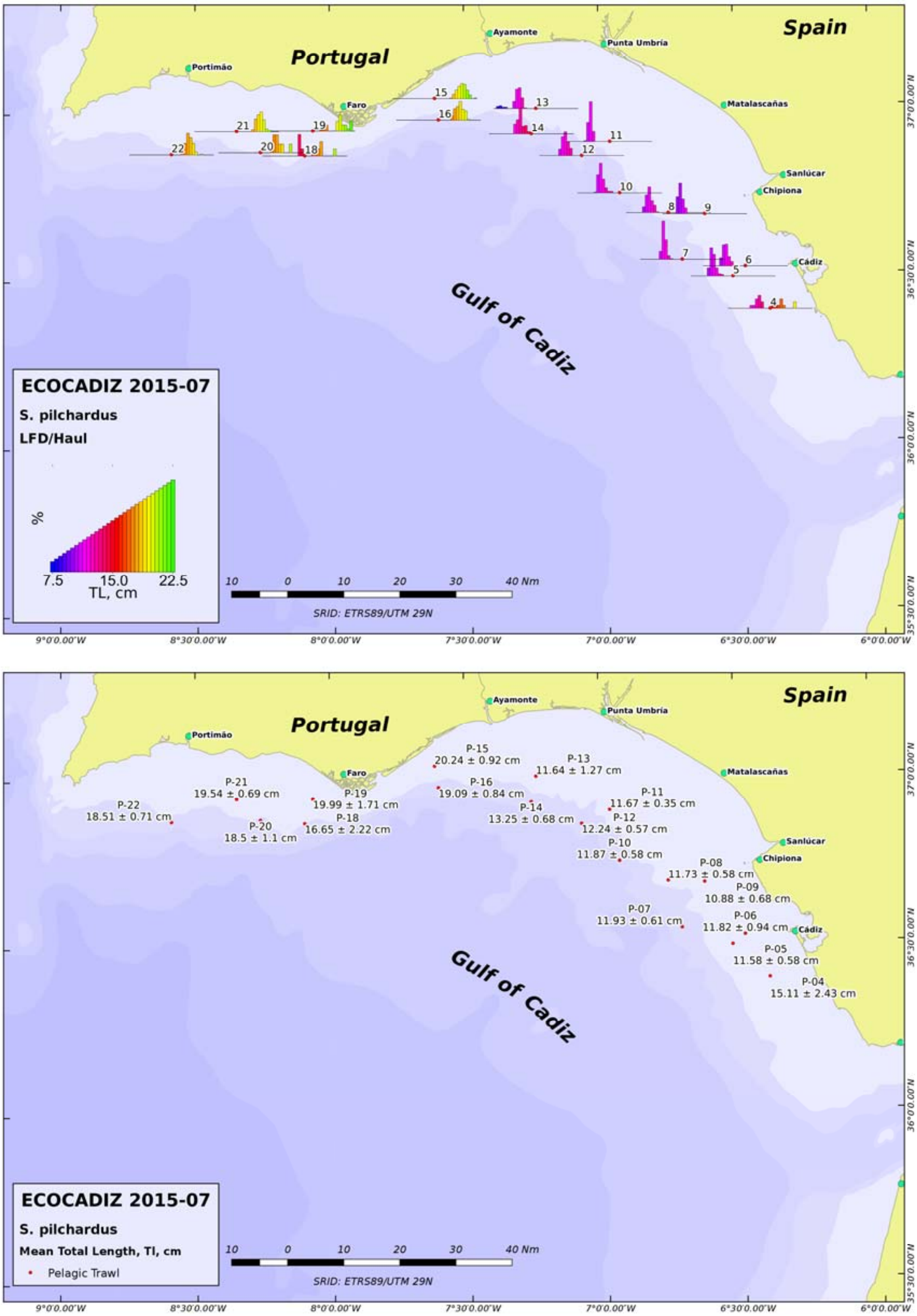


Figure 7. *ECOCADIZ 2015-07* survey. *Sardina pilchardus*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

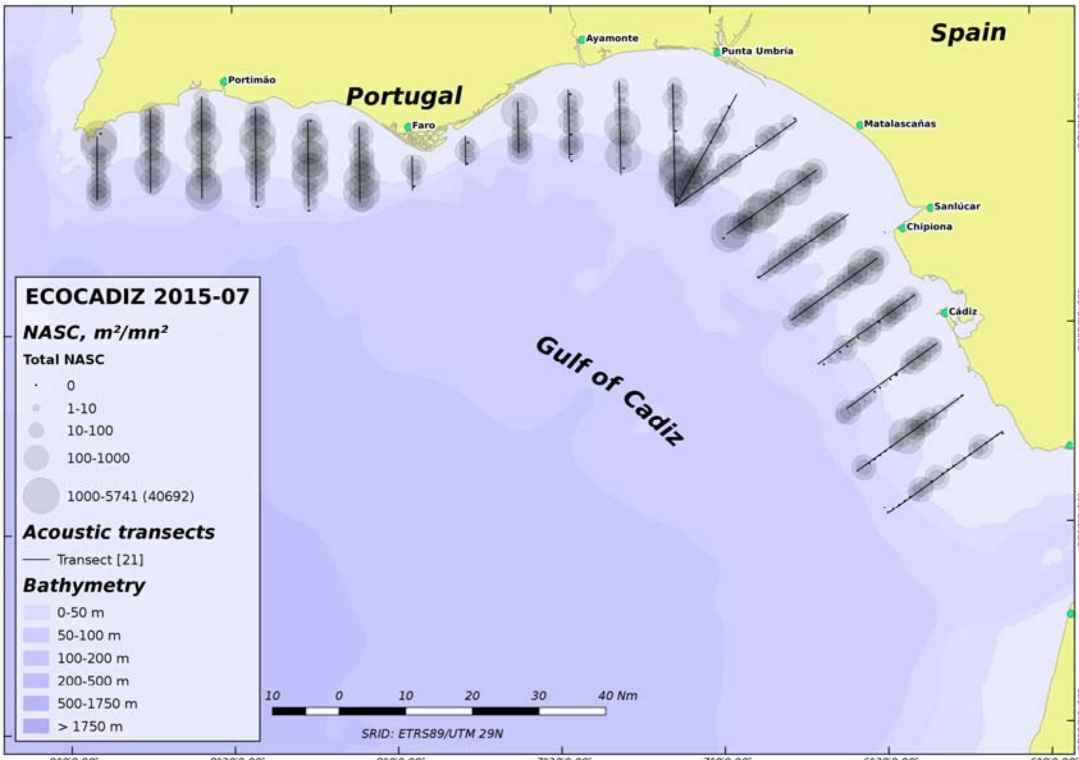


Figure 8. *ECOCADIZ 2015-07* survey. Distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the pelagic fish species assemblage.

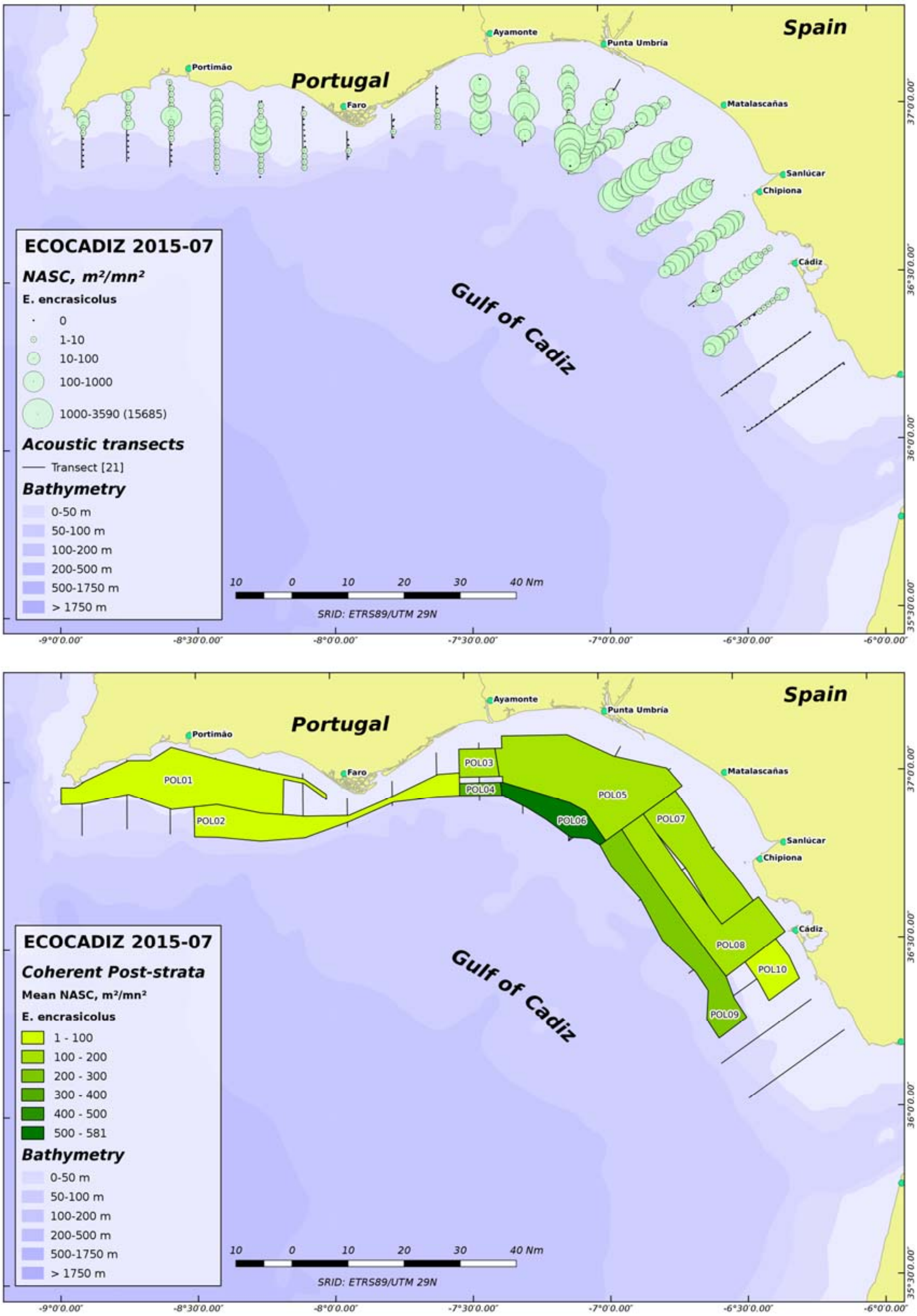


Figure 9. *ECOCADIZ 2015-07* survey. Anchovy (*Engraulis encrasicolus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

***ECOCADIZ 2015-07*: Anchovy (*E. encrasicolus*)**

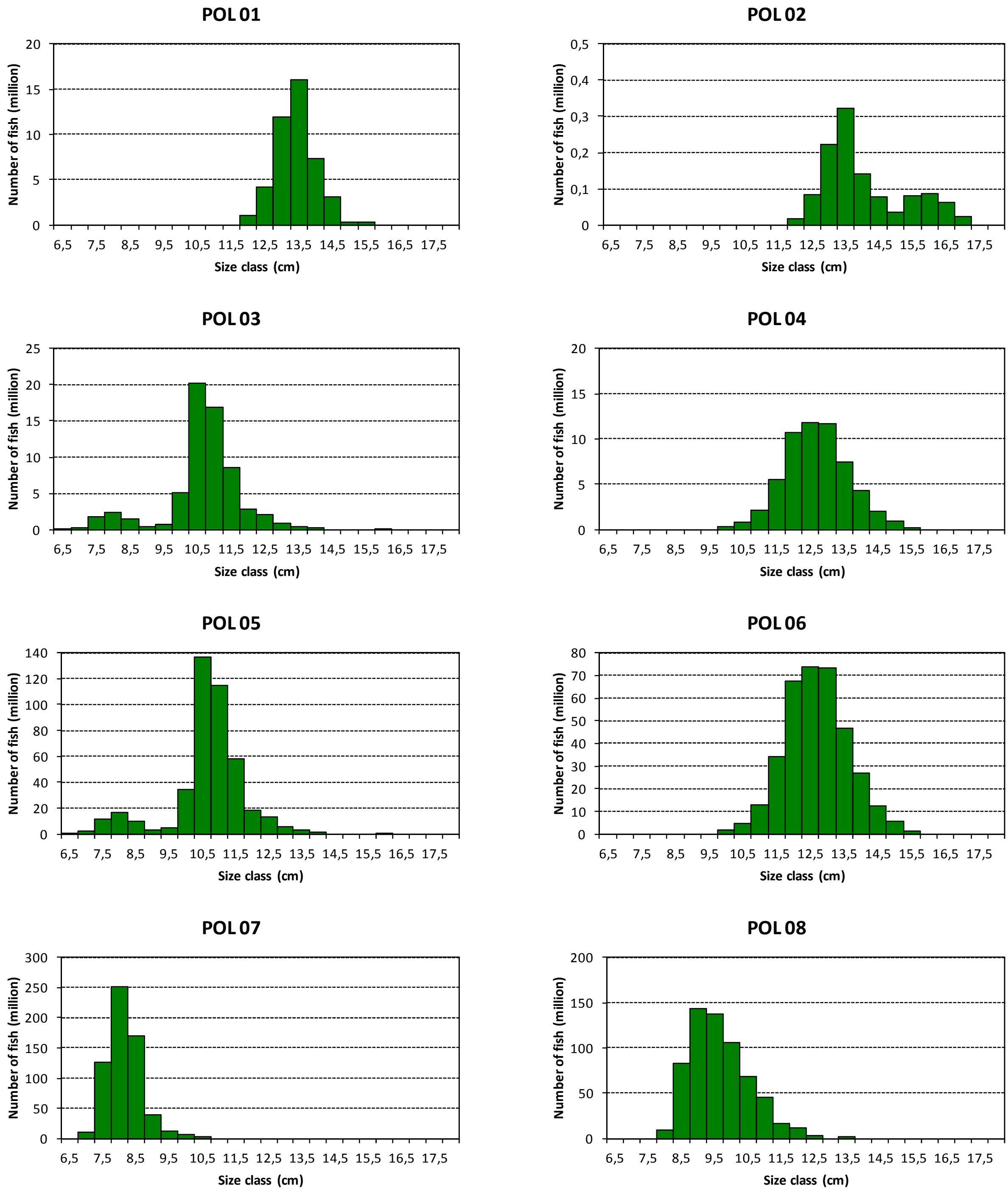


Figure 10. *ECOCADIZ 2015-07* survey. Anchovy (*E. encrasicolus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 9**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

***ECOCADIZ 2015-07*: Anchovy (*E. encrasicolus*)**

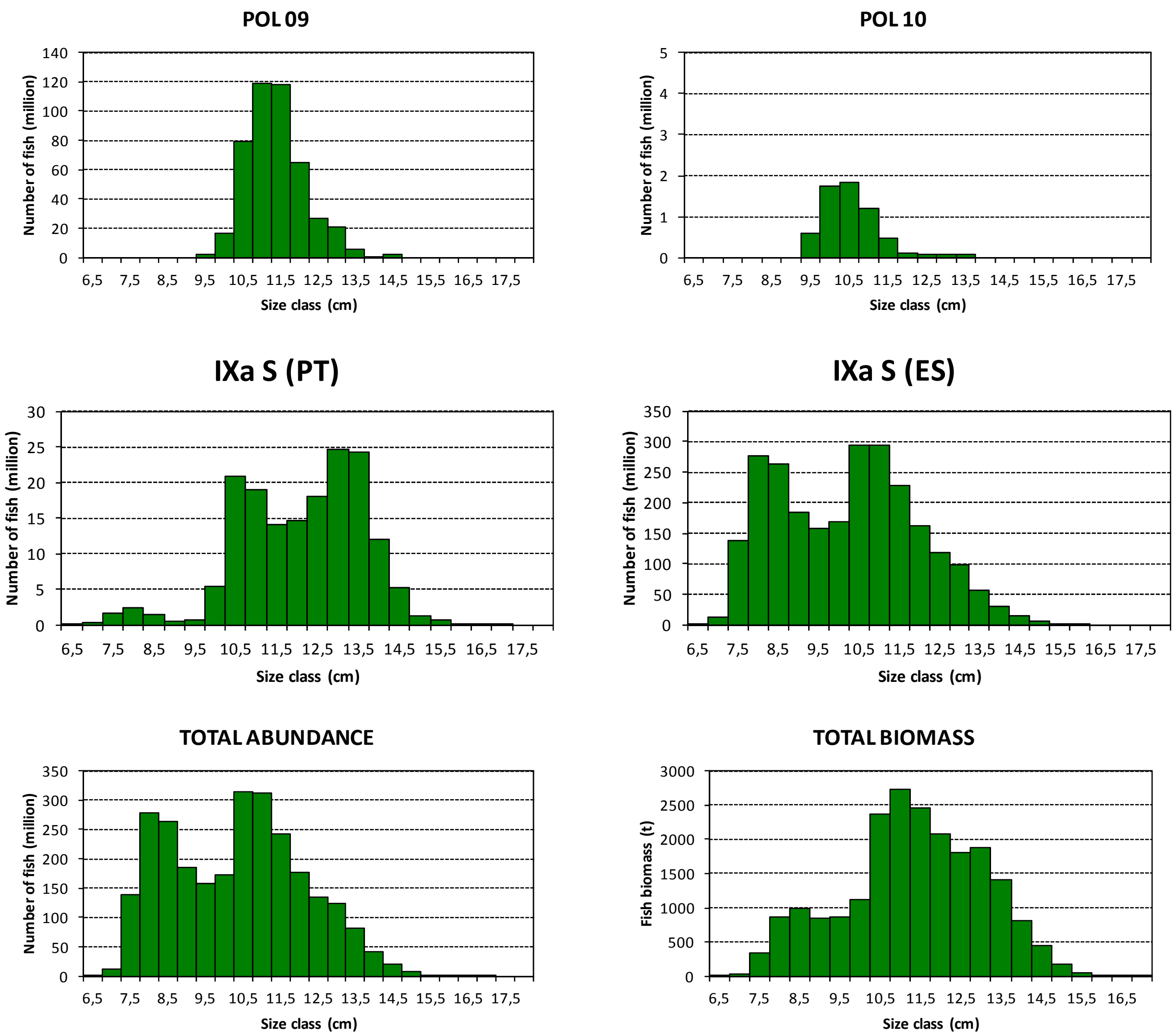


Figure 10. *ECOCADIZ 2015-07* survey. Anchovy (*E. encrasicolus*). Cont'd.

***ECOCADIZ 2015-07*: Anchovy (*E. encrasicolus*)**

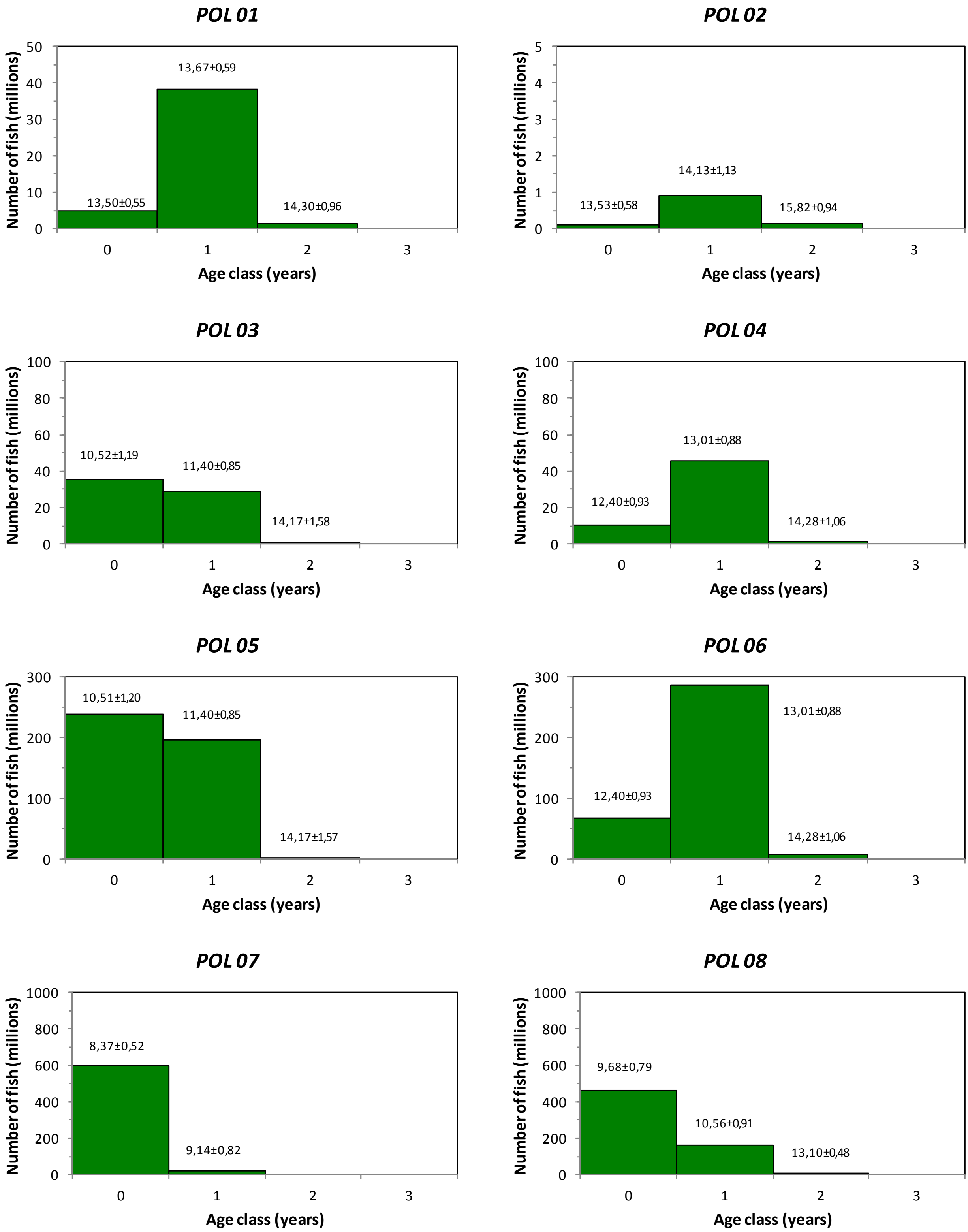


Figure 11. *ECOCADIZ 2015-07* survey. Anchovy (*E. encrasicolus*). Estimated abundances (number of fish in millions) by age class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 9**) and total sampled area. Post-strata ordered in the W-E direction. Mean length (±SD) by age group is also shown.The estimated biomass (t) by age class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

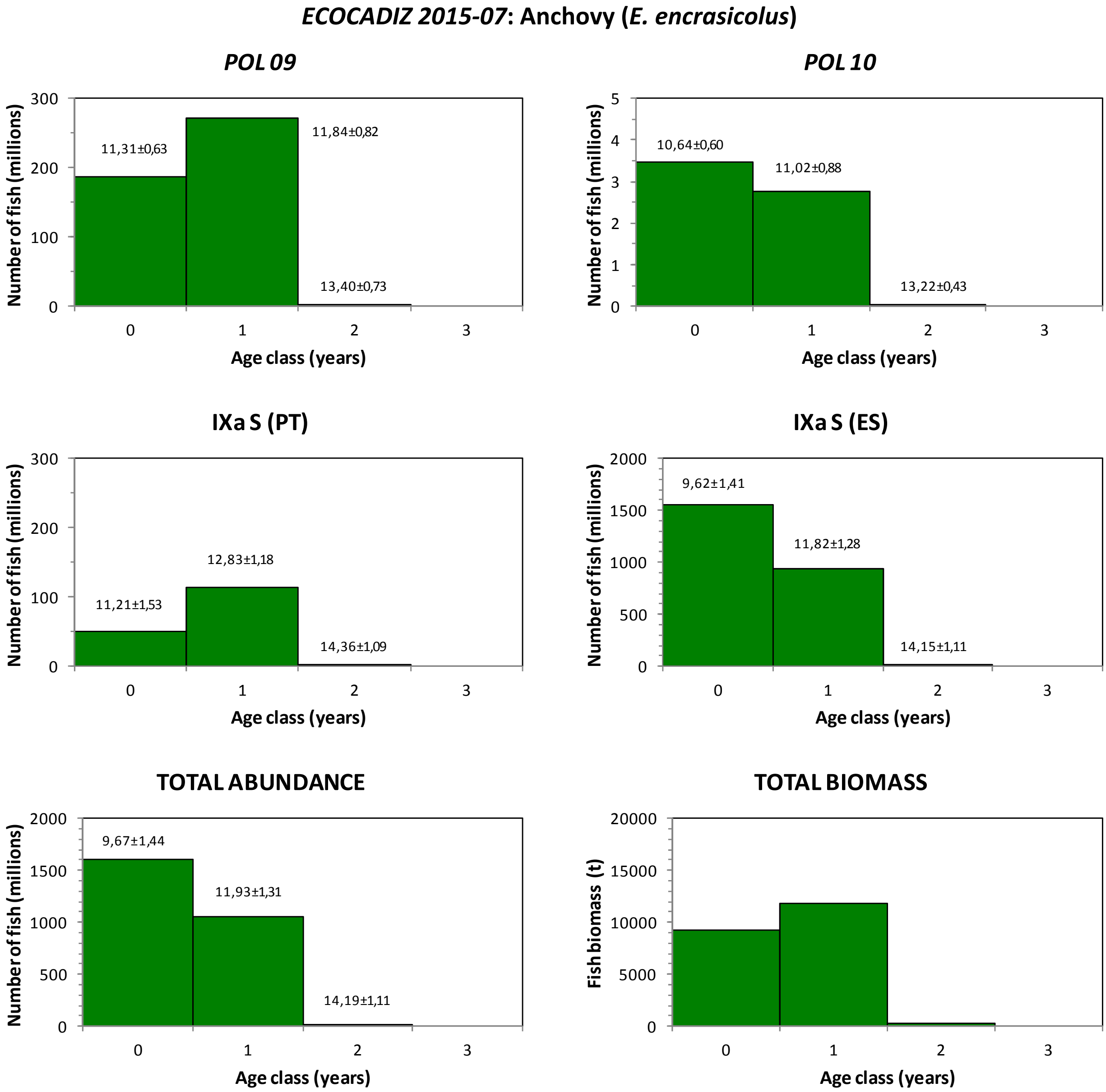
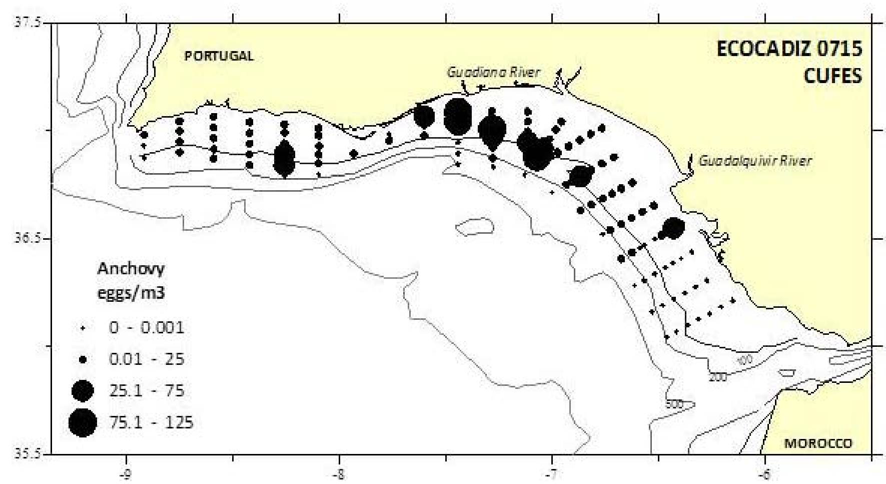


Figure 11. *ECOCADIZ 2015-07* survey. Anchovy (*E. encrasicolus*). Cont'd.



ECOCADIZ 2015-07 CUFES sampling		Spanish waters	Portuguese waters	Gulf of Cadiz
	#Transects	11	10	21
	#Stations	76	41	117
Anchovy eggs	# total	4640	3966	8606
	# max.	649	743	743
	Total density (eggs/m^3)	566.0	443.7	1009.7
	Max. density (eggs/m^3)	120.7	115.0	120.7
	Mean density (eggs/m^3)	7.5	10.8	8.6

Figure 12. *ECOCADIZ 2015-07* survey. Anchovy (*E. encrasicolus*). Distribution of anchovy egg densities as sampled by CUFES (eggs m^{-3}).

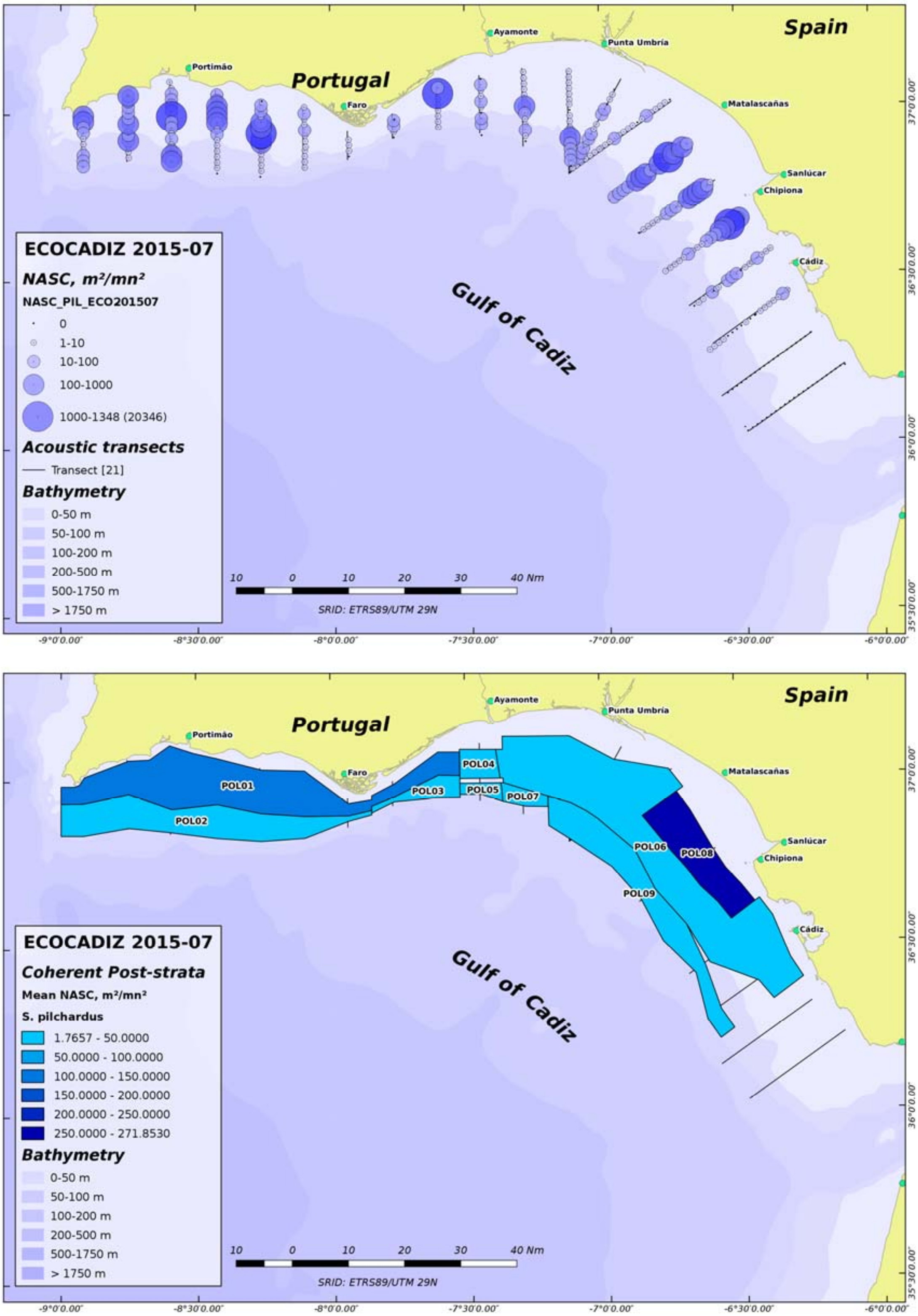


Figure 13. *ECOCADIZ 2015-07* survey. Sardine (*Sardina pilchardus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

***ECOCADIZ 2015-07*: Sardine (*S. pilchardus*)**

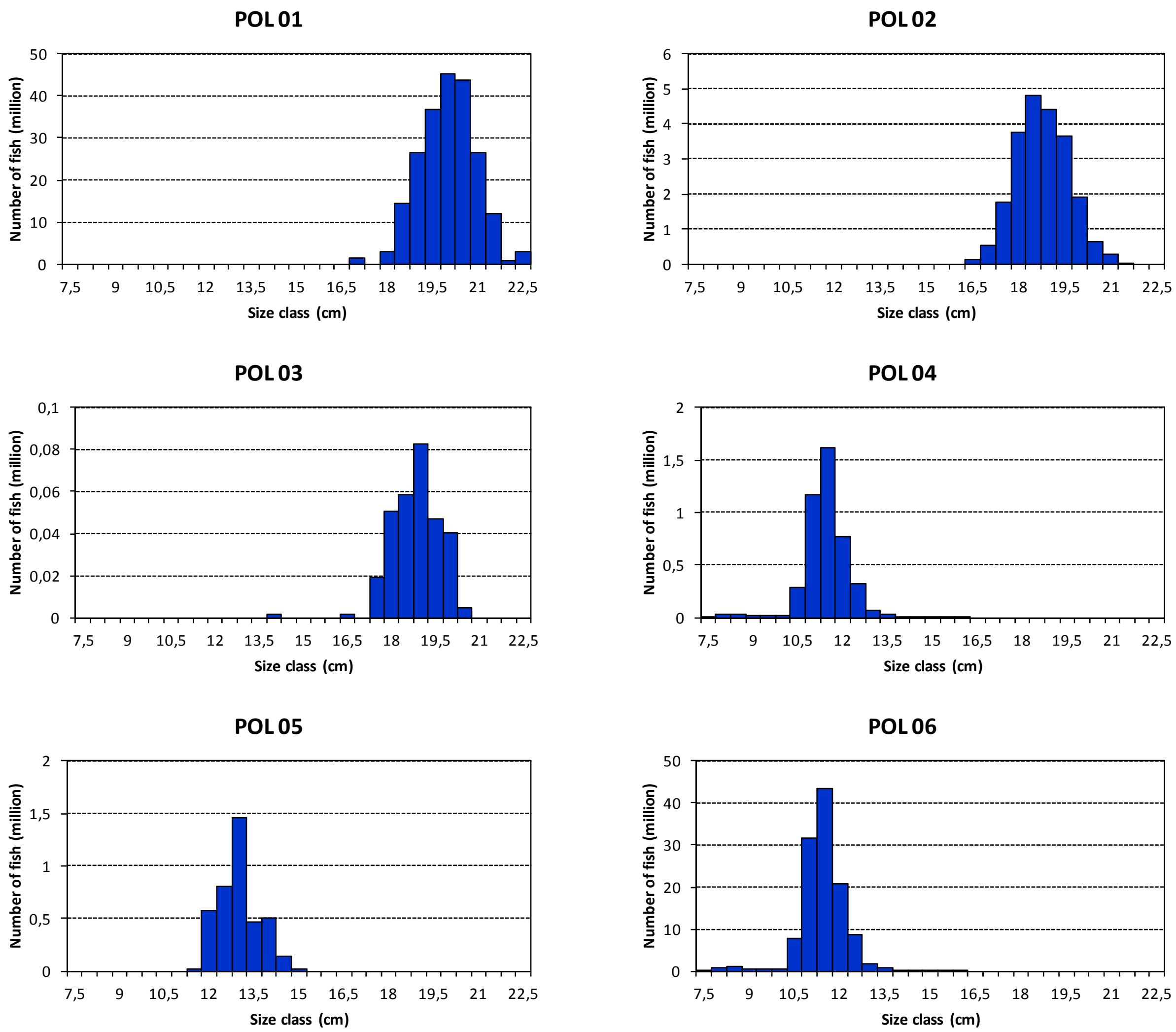


Figure 14. *ECOCADIZ 2015-07* survey. Sardine (*S. pilchardus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 13**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

***ECOCADIZ 2015-07*: Sardine (*S. pilchardus*)**

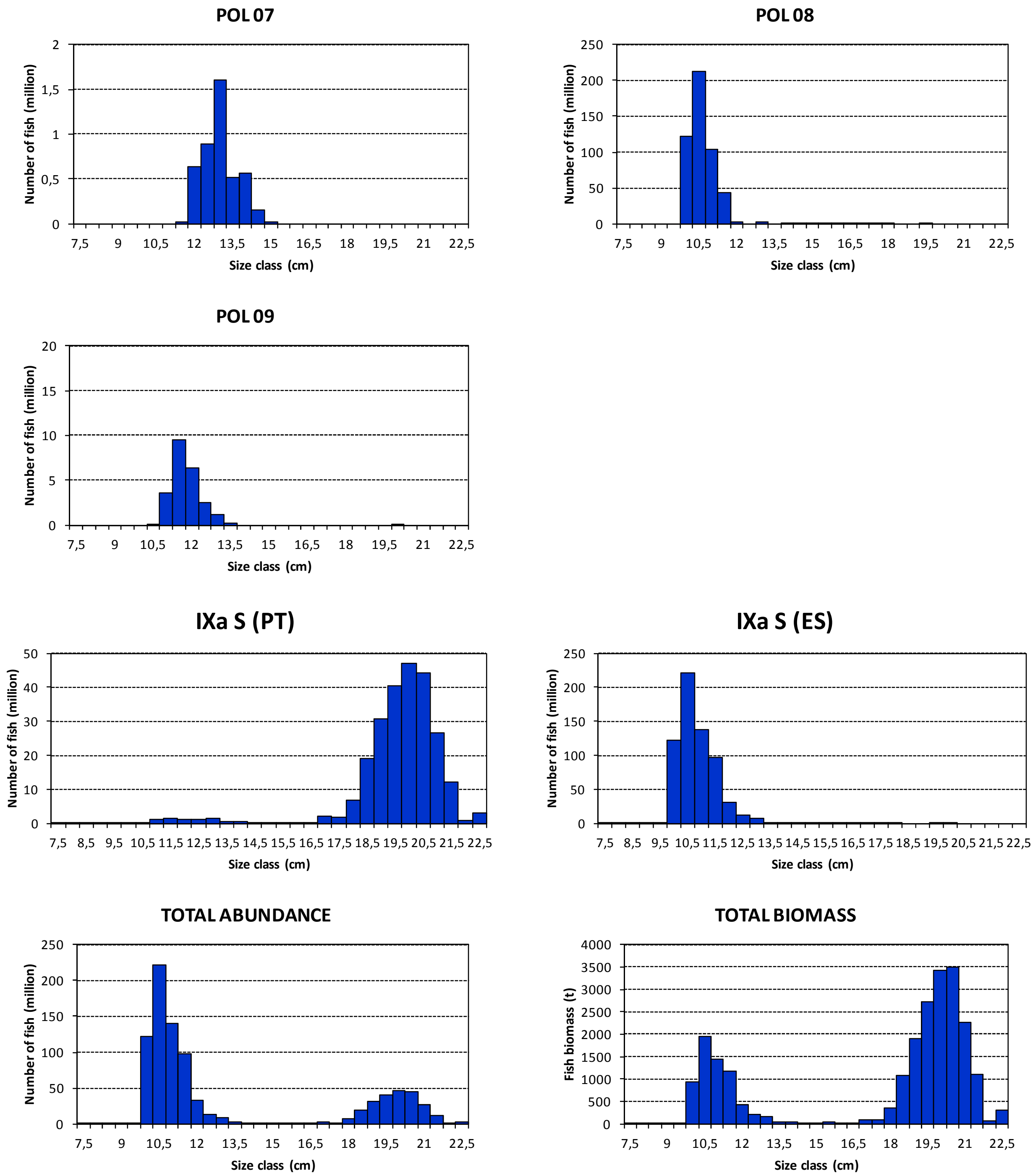


Figure 14. *ECOCADIZ 2015-07* survey. Sardine (*S. pilchardus*). Cont'd.

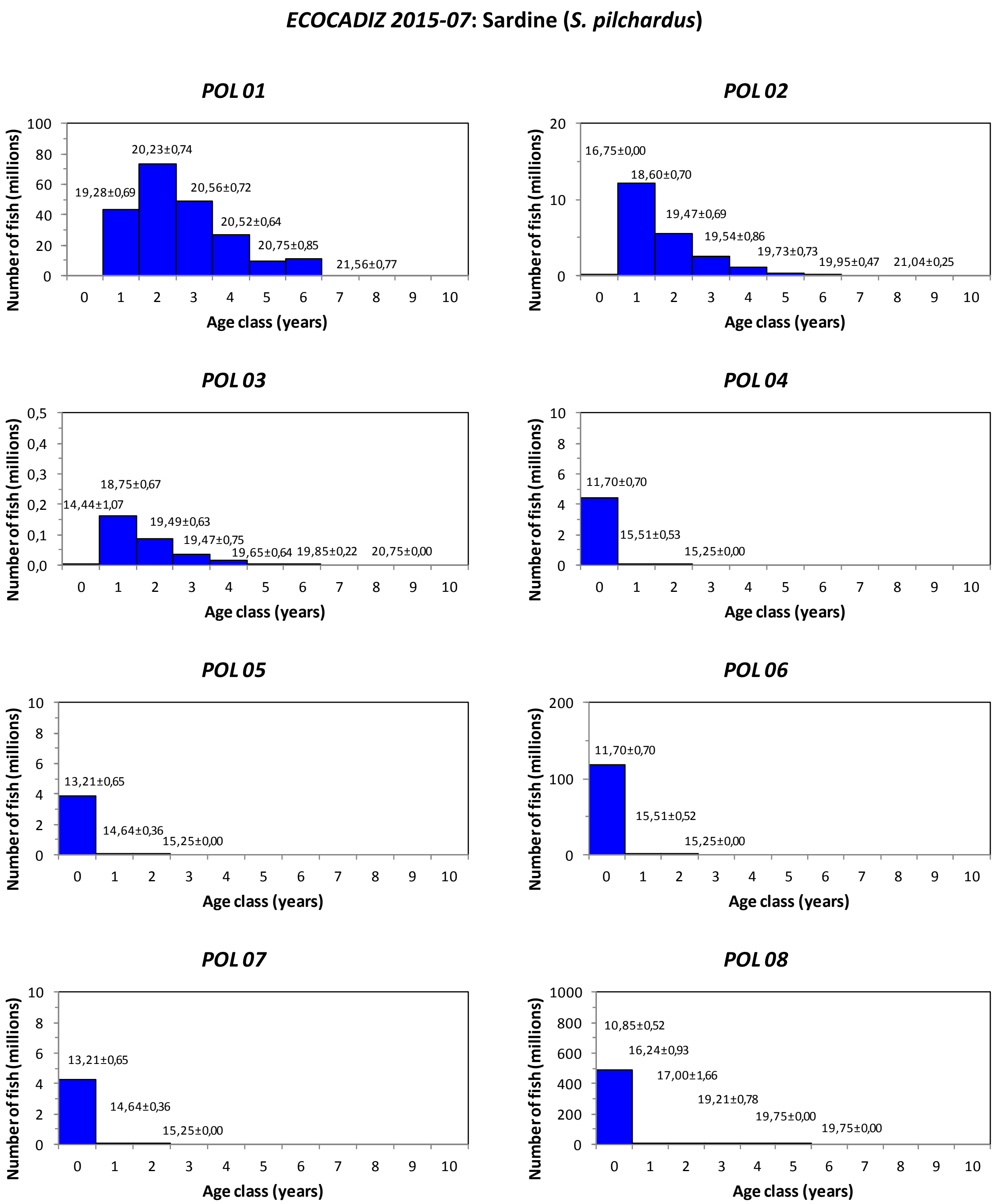


Figure 15. *ECOCADIZ 2015-07* survey. Sardine (*S. pilchardus*). Estimated abundances (number of fish in millions) by age class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 13**) and total sampled area. Post-strata ordered in the W-E direction. Mean length (±SD) by age group is also shown.The estimated biomass (t) by age class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

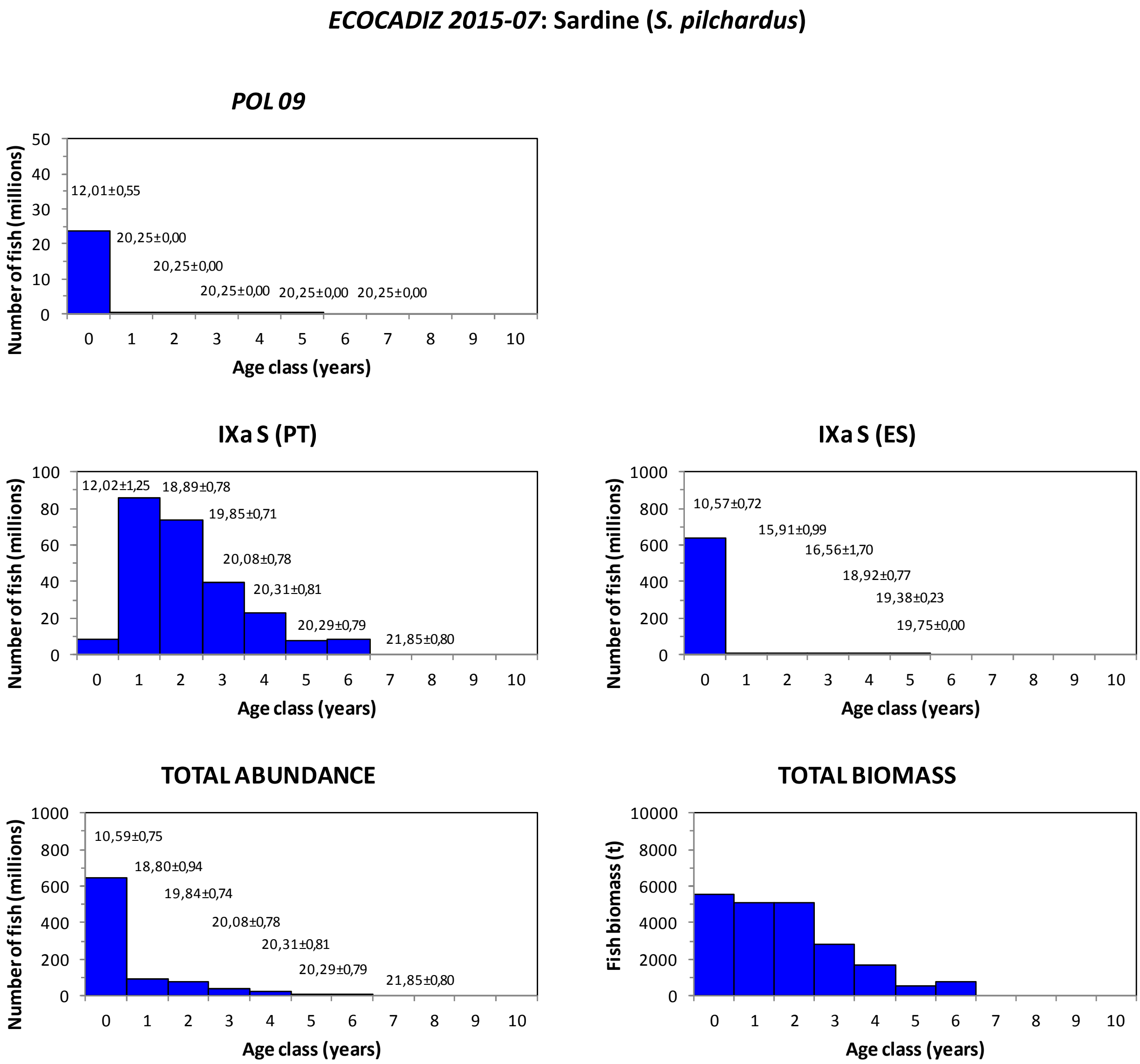
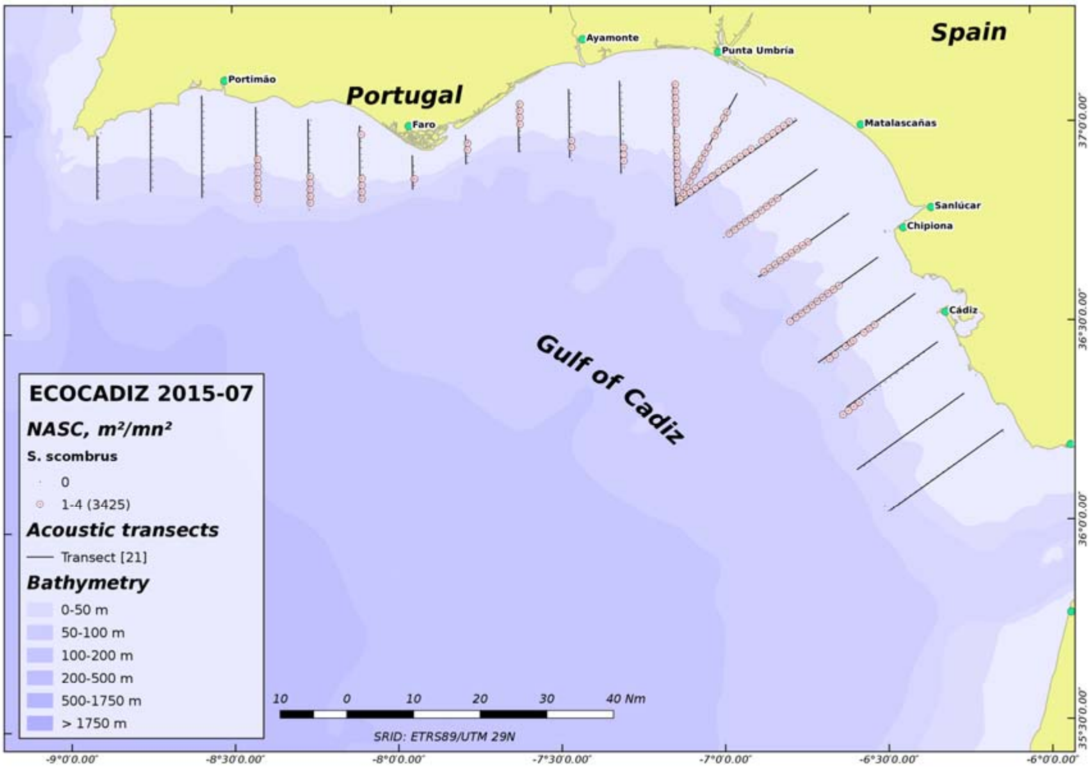


Figure 15. *ECOCADIZ 2015-07* survey. Sardine (*S. pilchardus*). Cont'd.



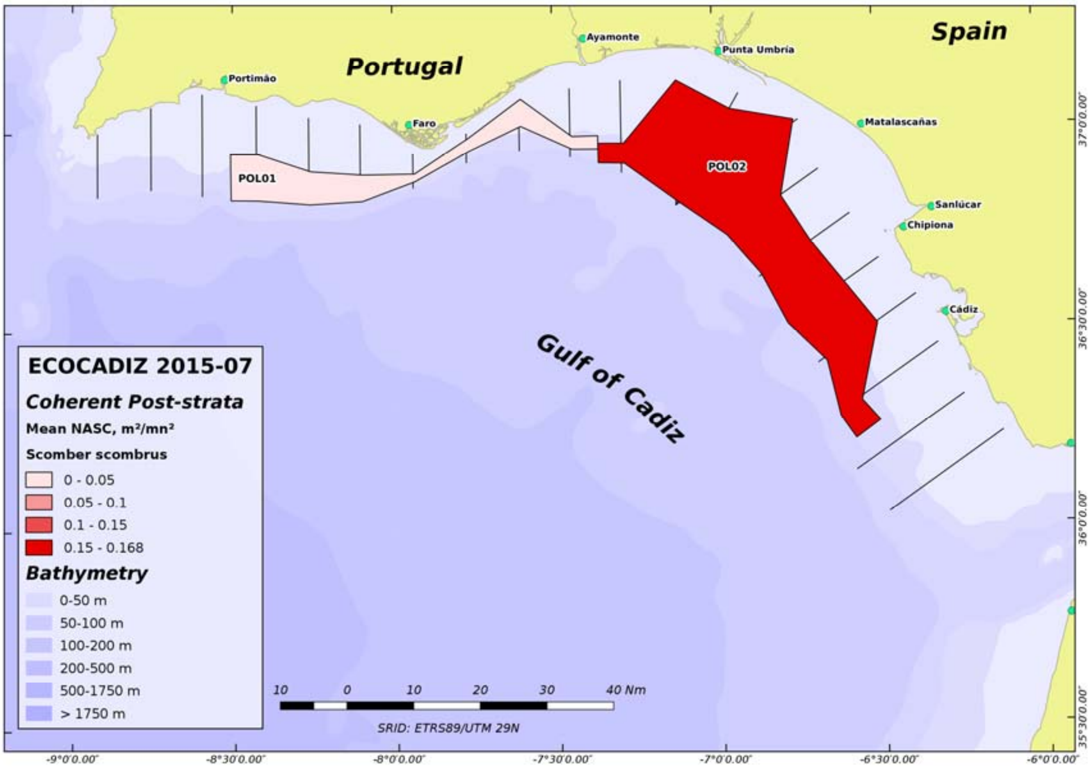


Figure 16. *ECOCADIZ 2015-07* survey. Mackerel (*Scomber scombrus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

***ECOCADIZ 2015-07*: Mackerel (*S. scombrus*)**

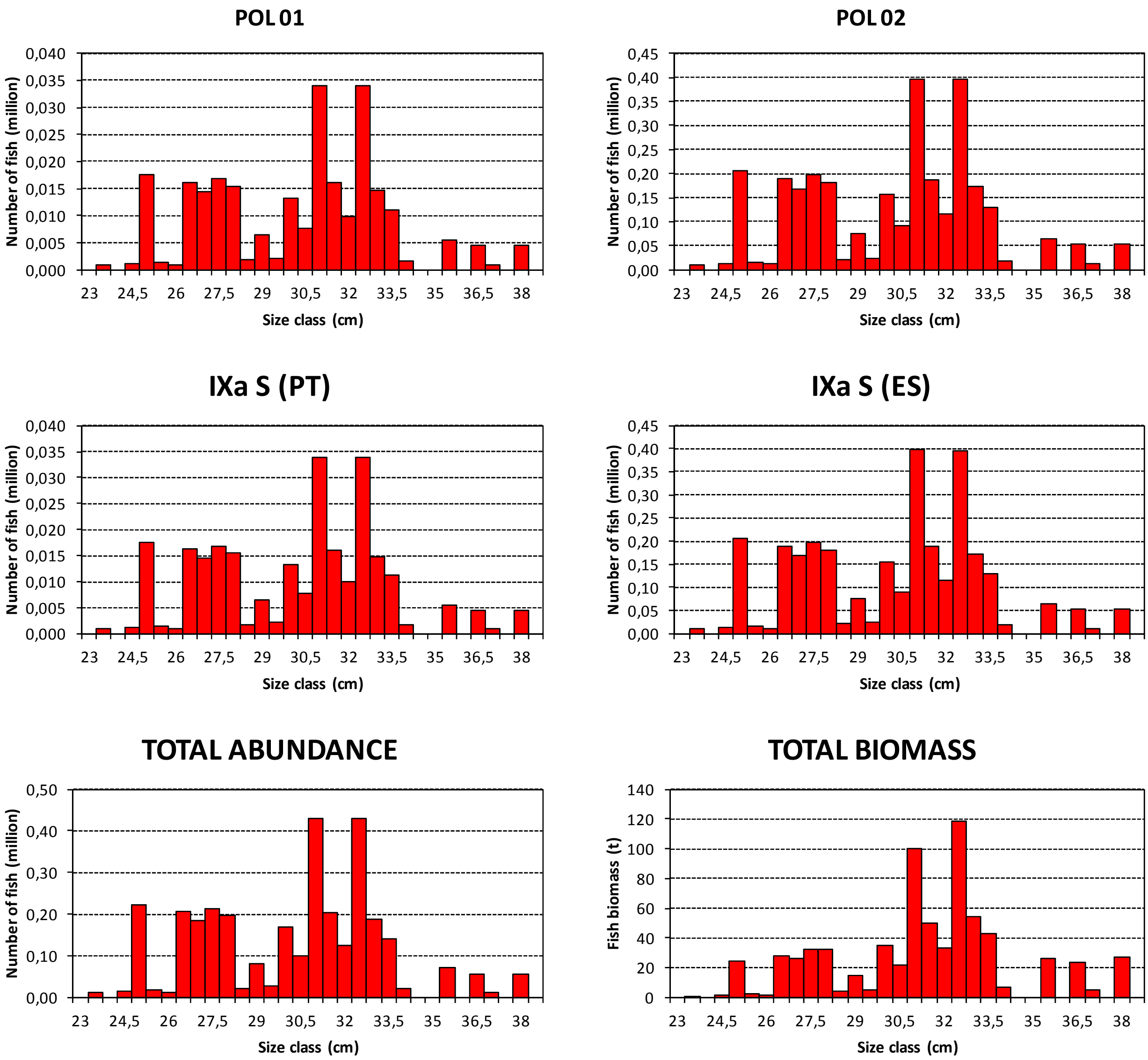


Figure 17. *ECOCADIZ 2015-07* survey. Mackerel (*S. scombrus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 16**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

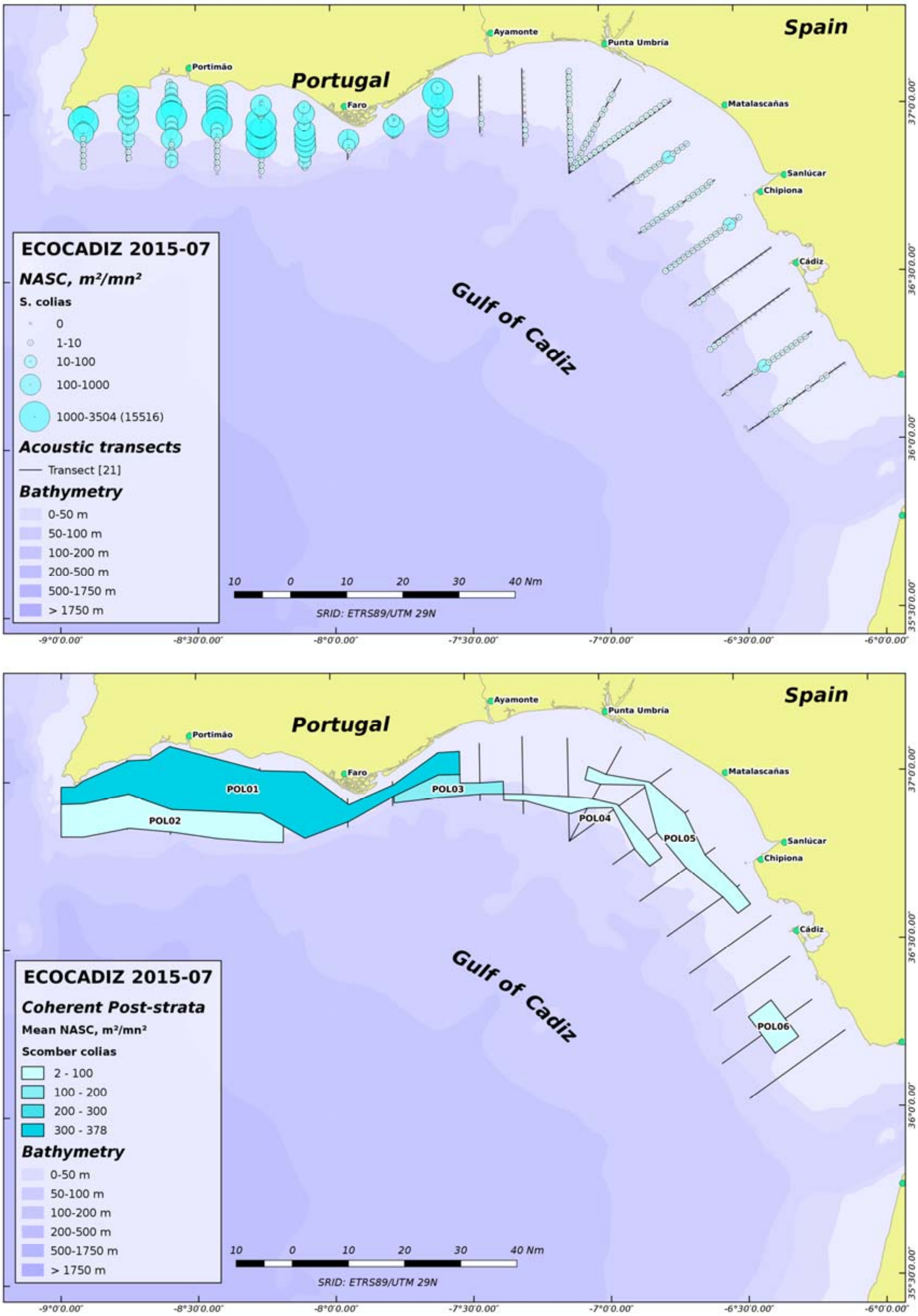


Figure 18. *ECOCADIZ 2015-07* survey. Chub mackerel (*Scomber colias*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

***ECOCADIZ 2015-07*: Chub mackerel (*S. colias*)**

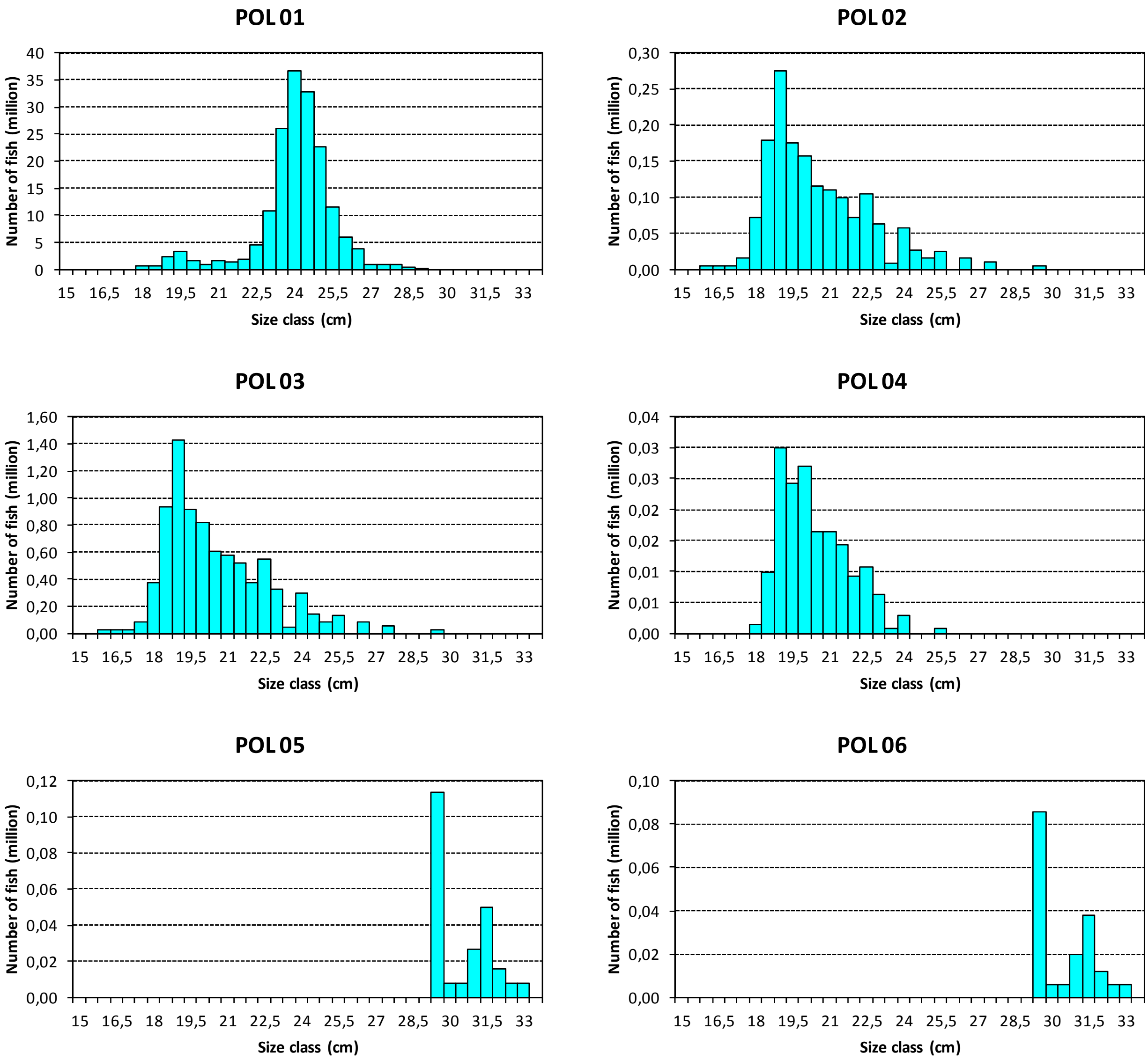


Figure 19. *ECOCADIZ 2015-07* survey. Chub mackerel (*S. colias*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 18**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

***ECOCADIZ 2015-07*: Chub mackerel (*S. colias*)**

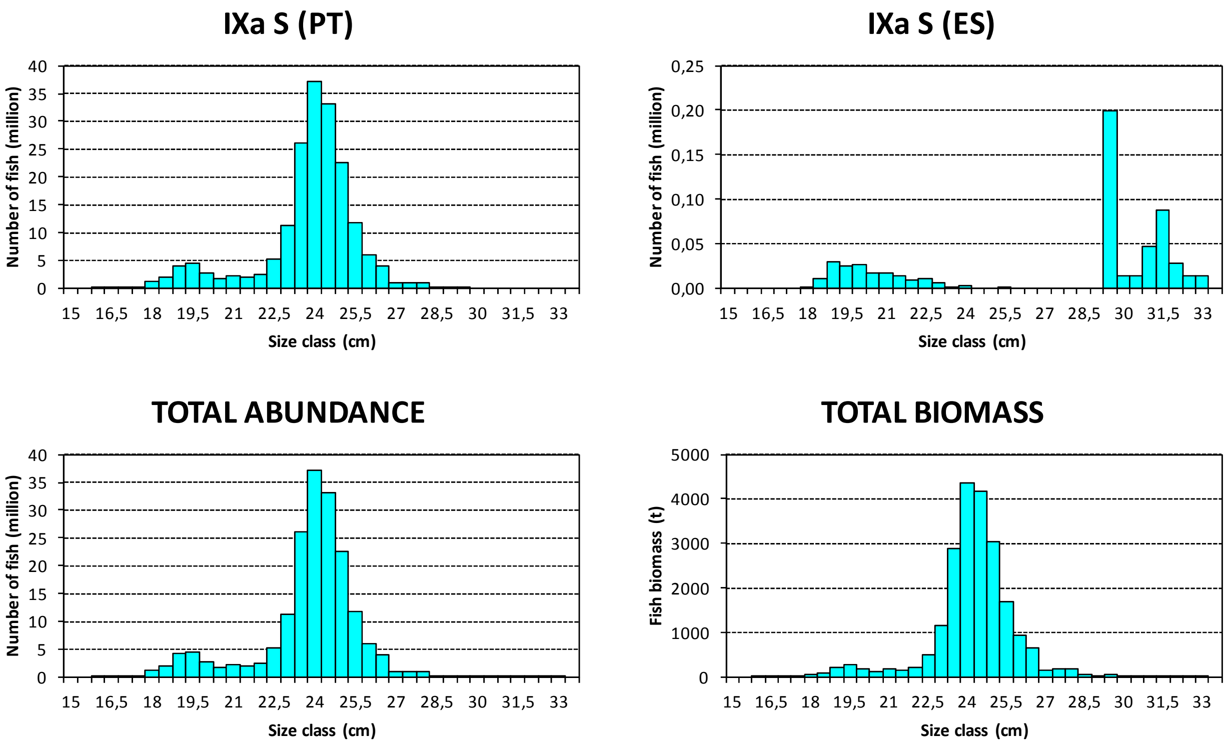


Figure 19. *ECOCADIZ 2015-07* survey. Chub mackerel (*S. colias*). Cont'd.

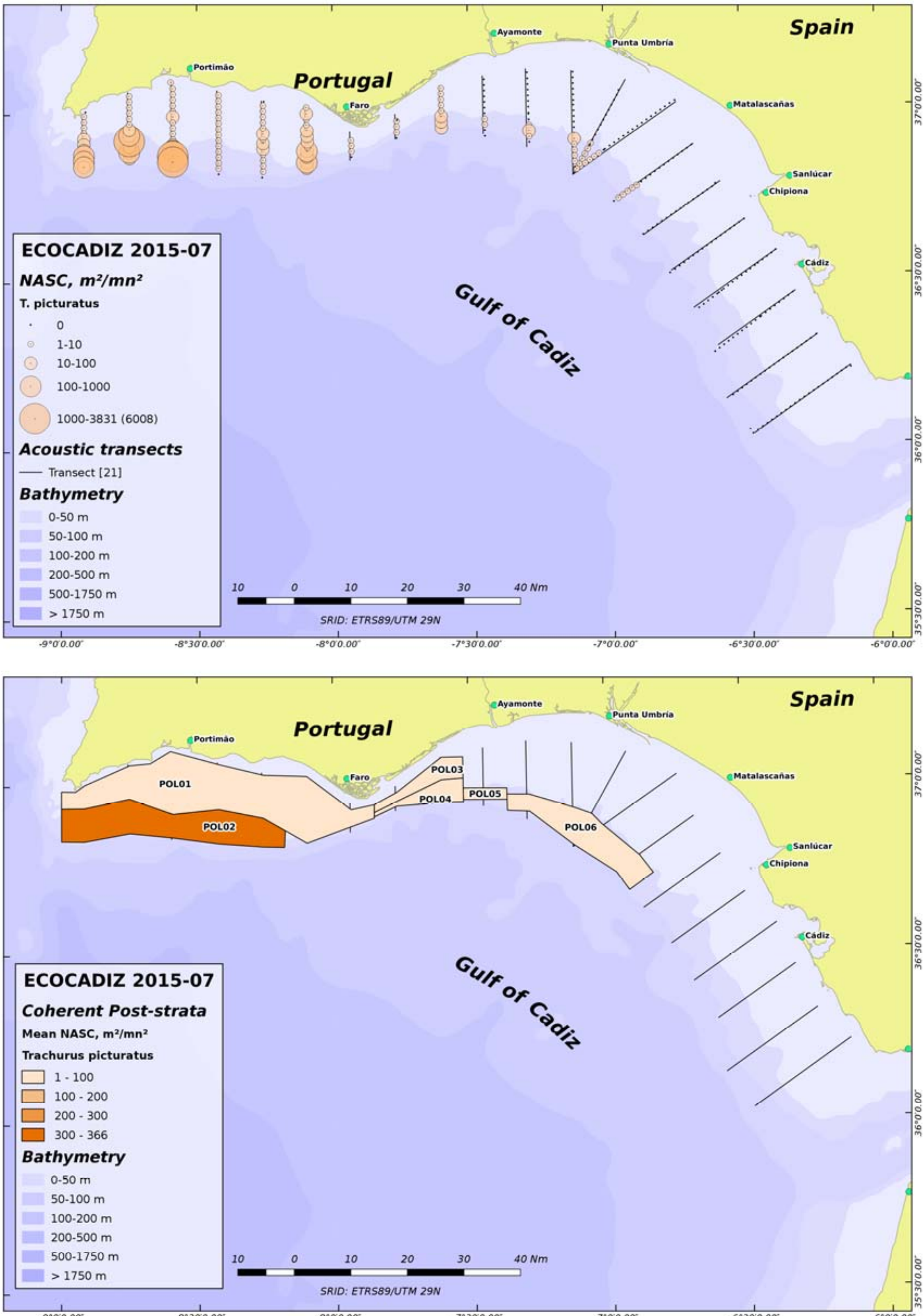


Figure 20. *ECOCADIZ 2015-07* survey. Blue jack mackerel (*Trachurus picturatus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

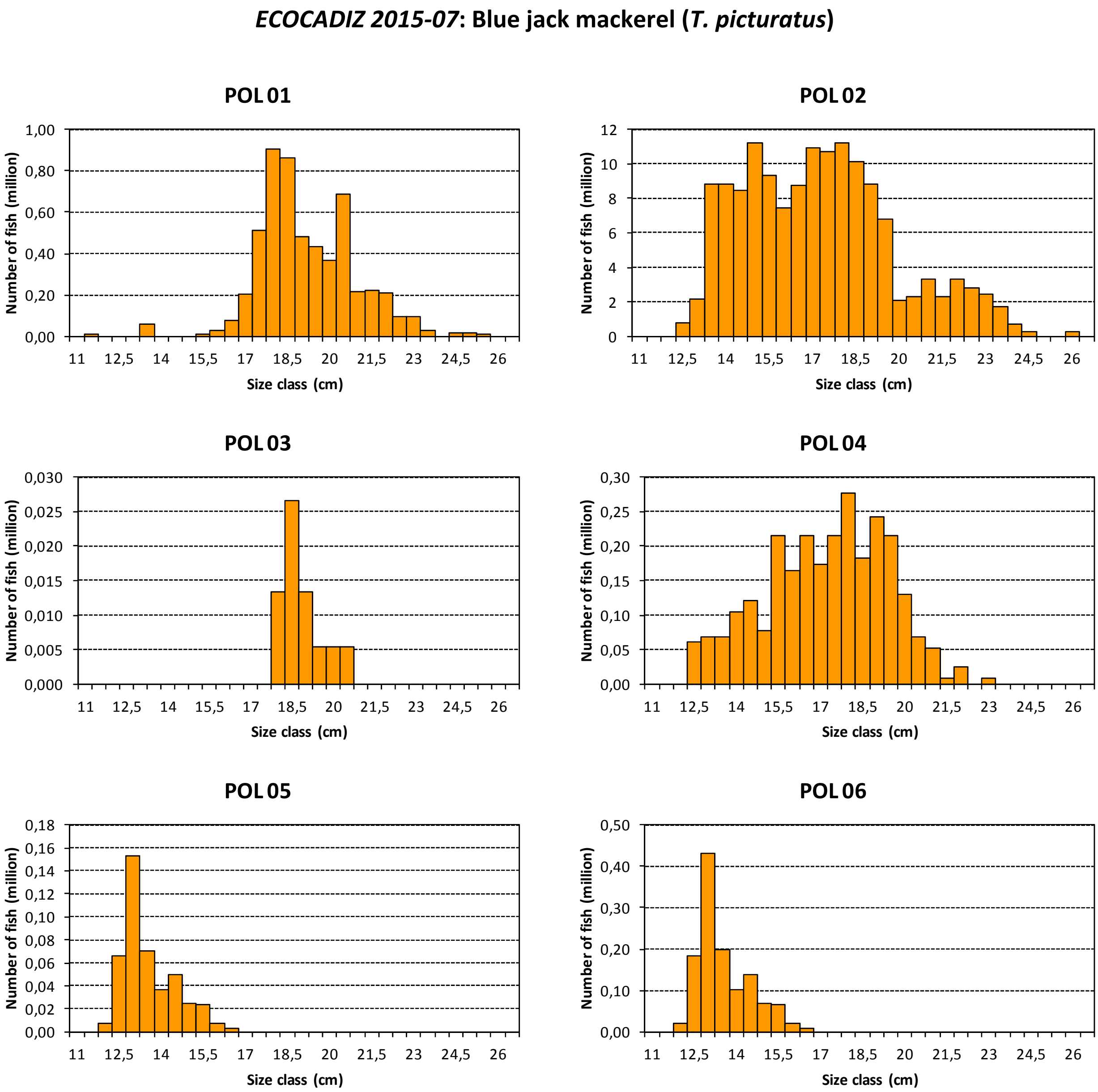


Figure 21. *ECOCADIZ 2015-07* survey. Blue jack mackerel (*T. picturatus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 20**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

***ECOCADIZ 2015-07*: Blue jack mackerel (*T. picturatus*)**

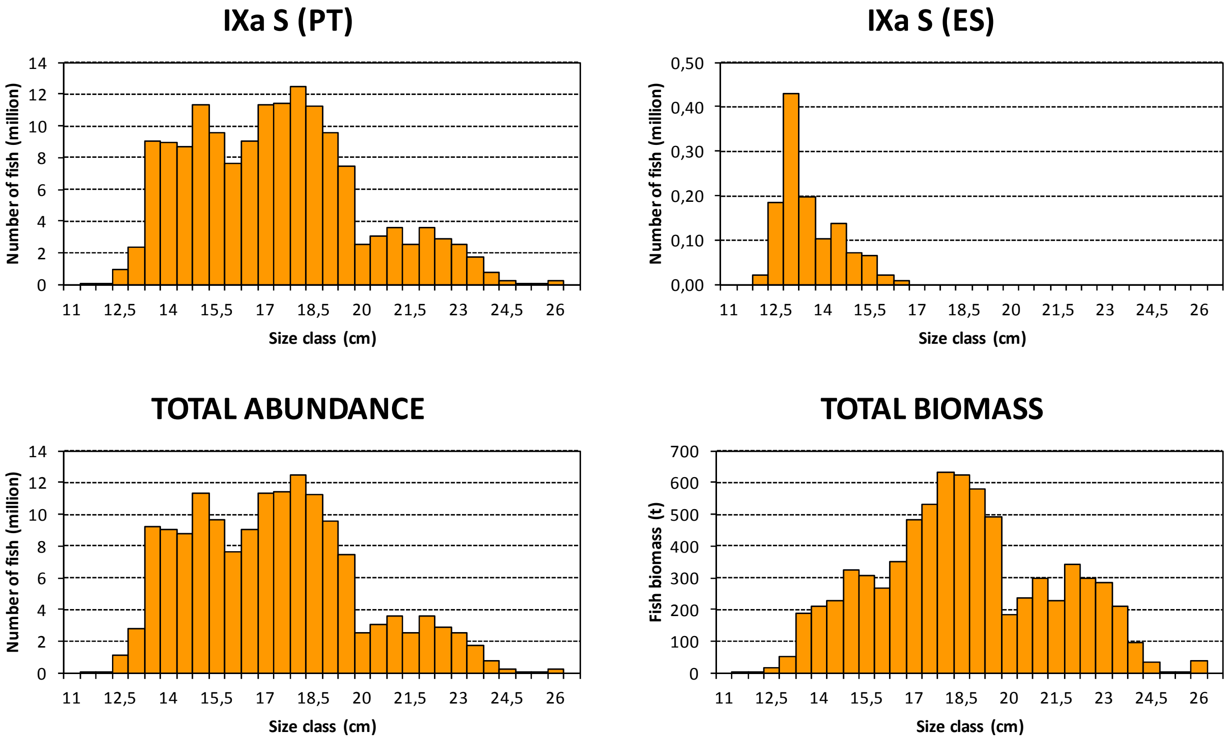
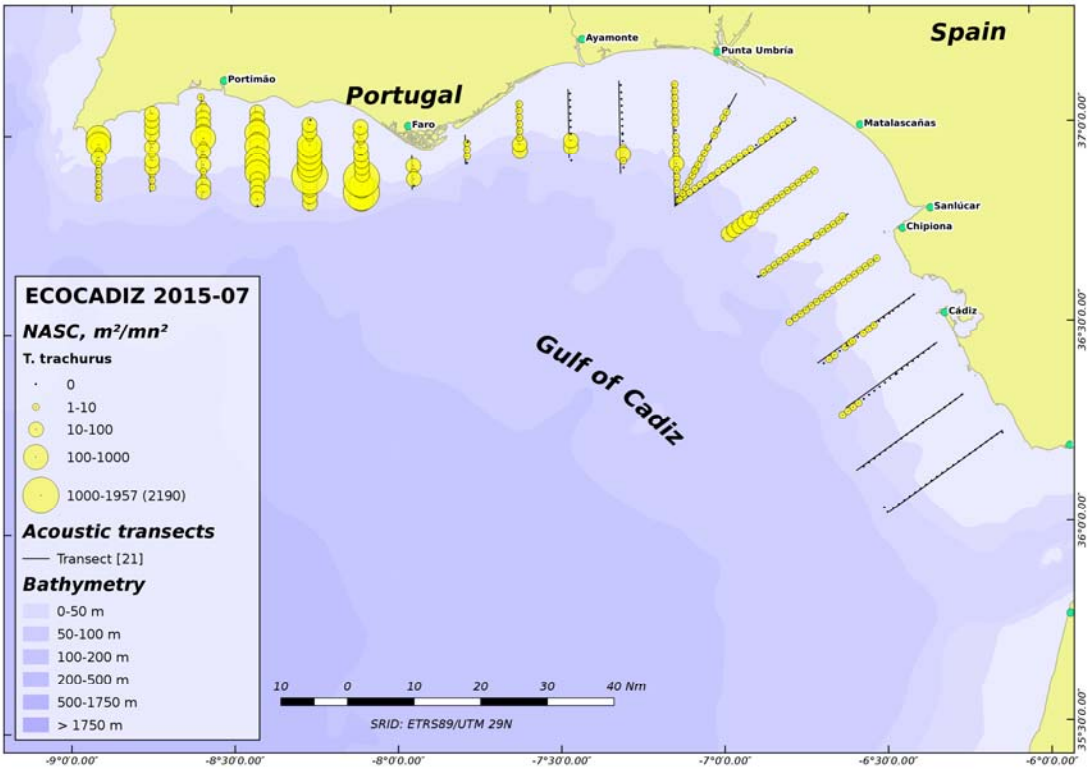


Figure 21. *ECOCADIZ 2015-07* survey. Blue jack mackerel (*T. picturatus*). Cont'd.



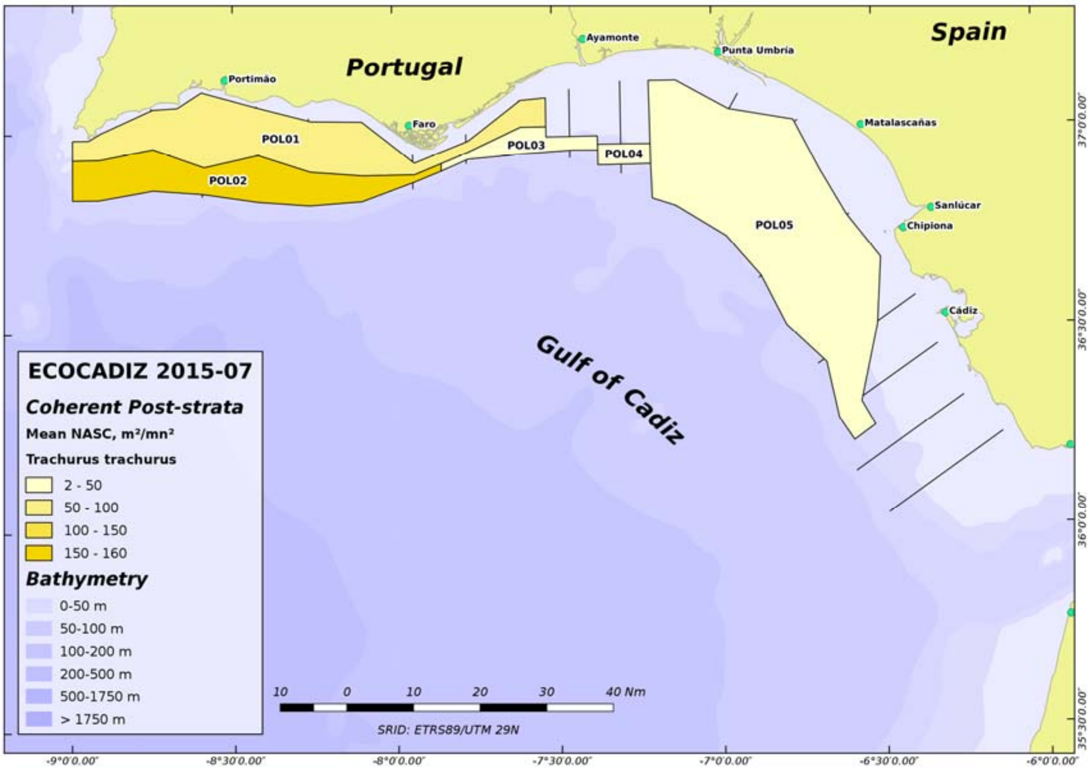


Figure 22. *ECOCADIZ 2015-07* survey. Horse mackerel (*Trachurus trachurus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

***ECOCADIZ 2015-07*: Horse mackerel (*T. trachurus*)**

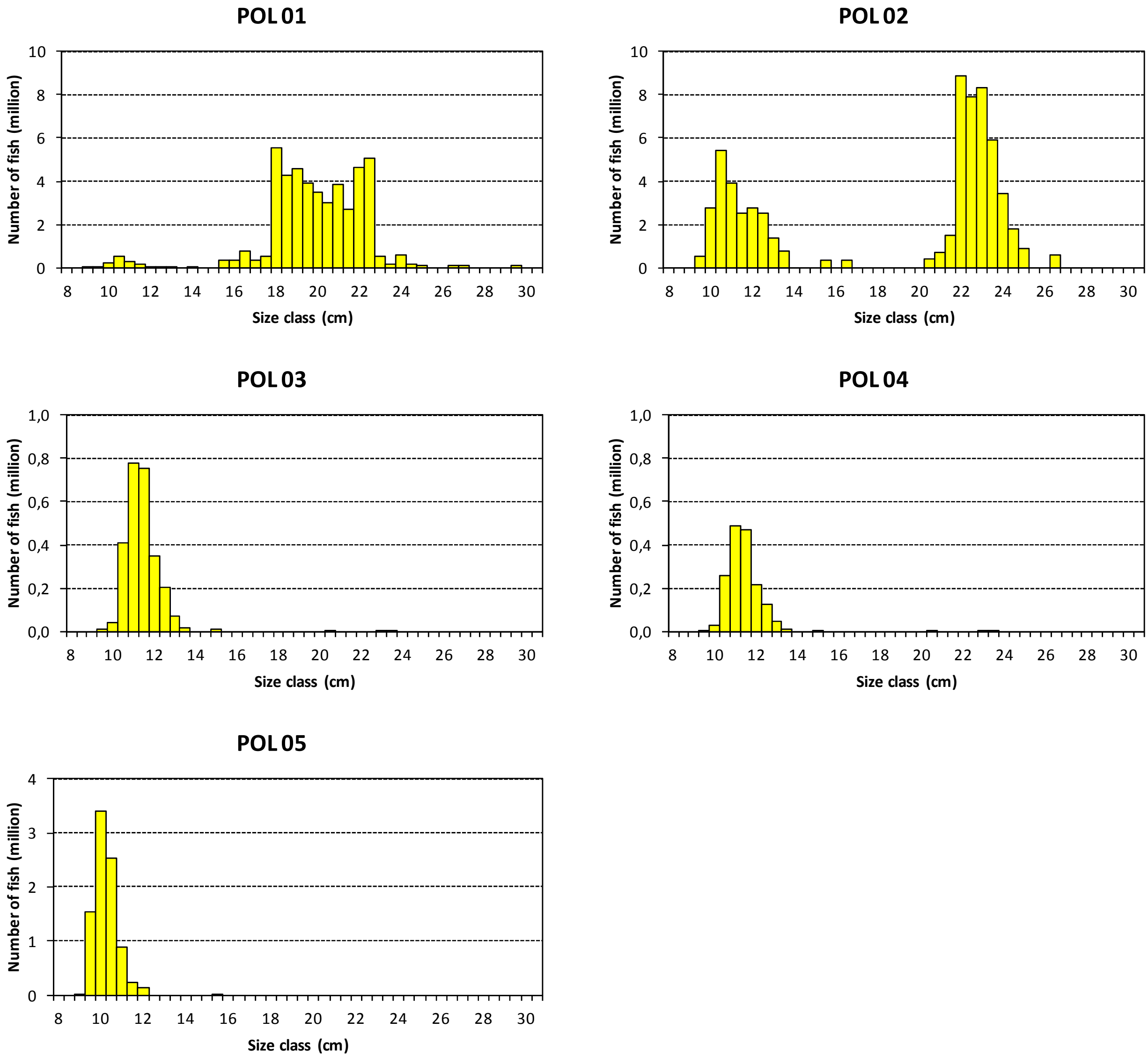


Figure 23. *ECOCADIZ 2015-07* survey. Horse mackerel (*T. trachurus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 22**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

ECOCADIZ 2015-07: Horse mackerel (*T. trachurus*)

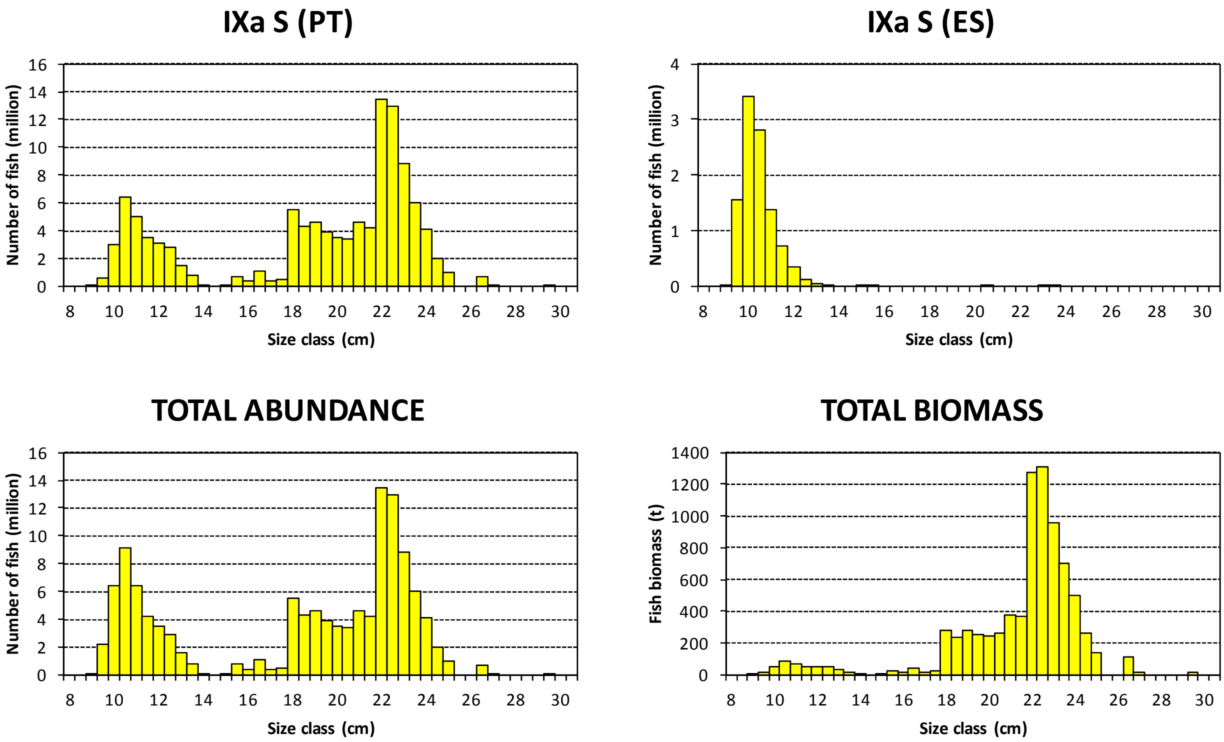
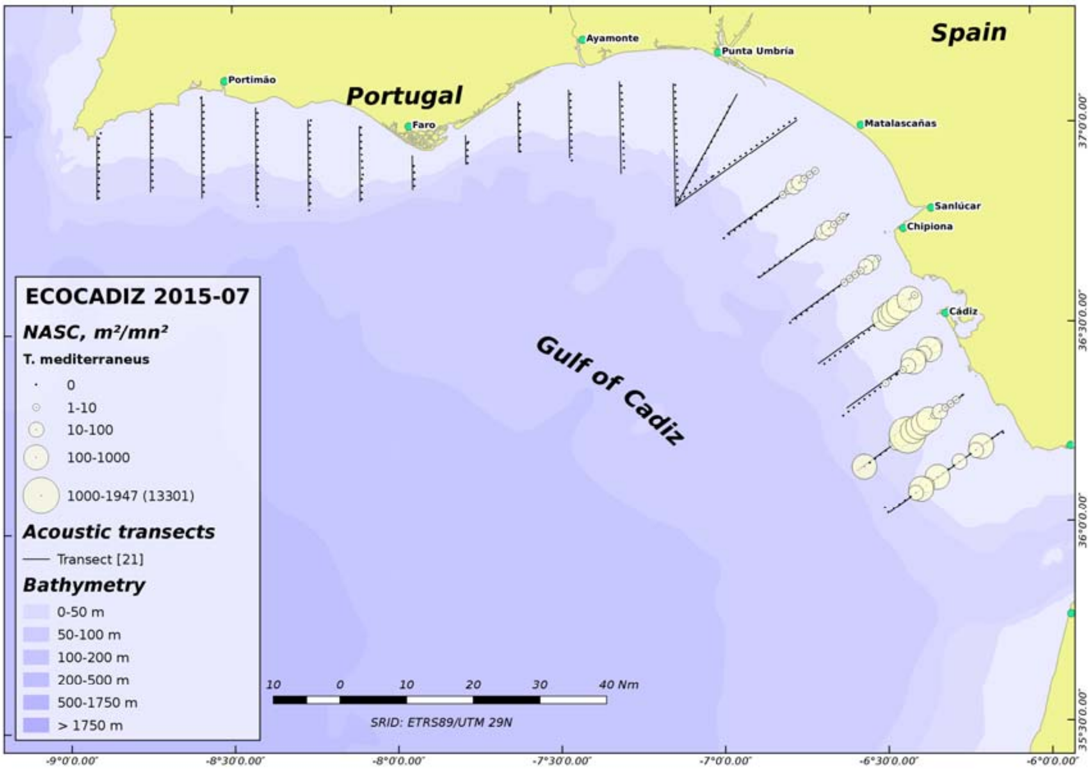


Figure 23. *ECOCADIZ 2015-07* survey. Horse mackerel (*T. trachurus*). Cont'd.



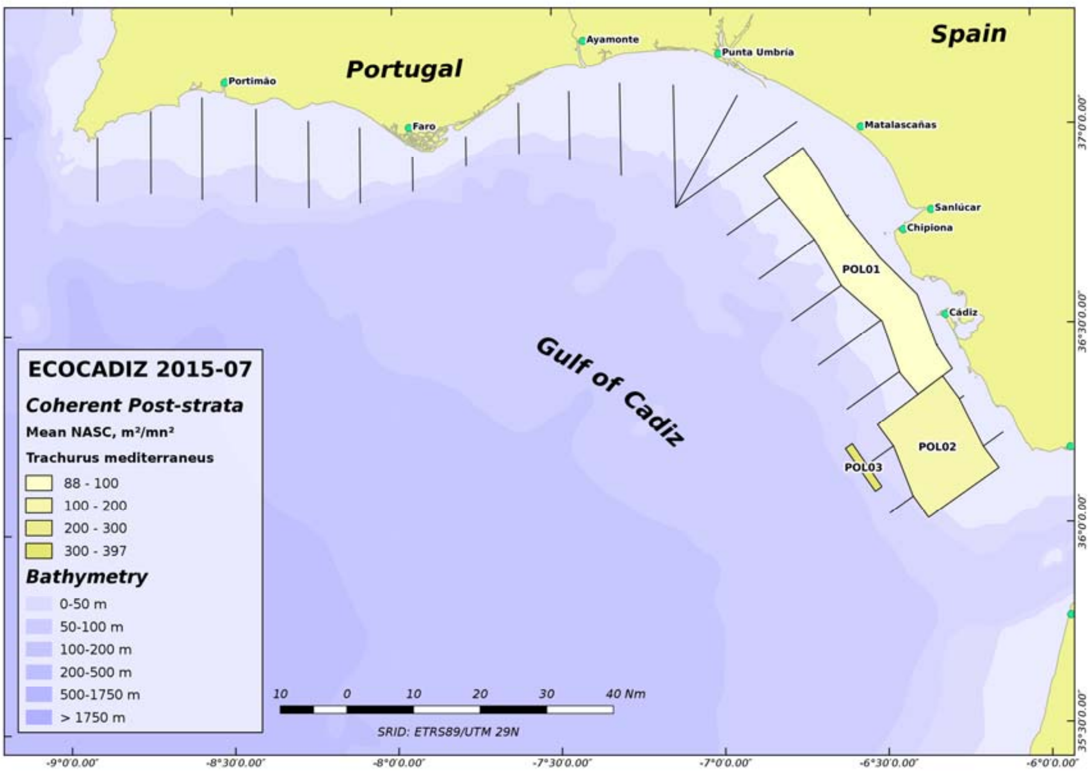


Figure 24. *ECOCADIZ 2015-07* survey. Mediterranean horse mackerel (*Trachurus mediterraneus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

***ECOCADIZ 2015-07*: Mediterranean horse mackerel (*T. mediterraneus*)**

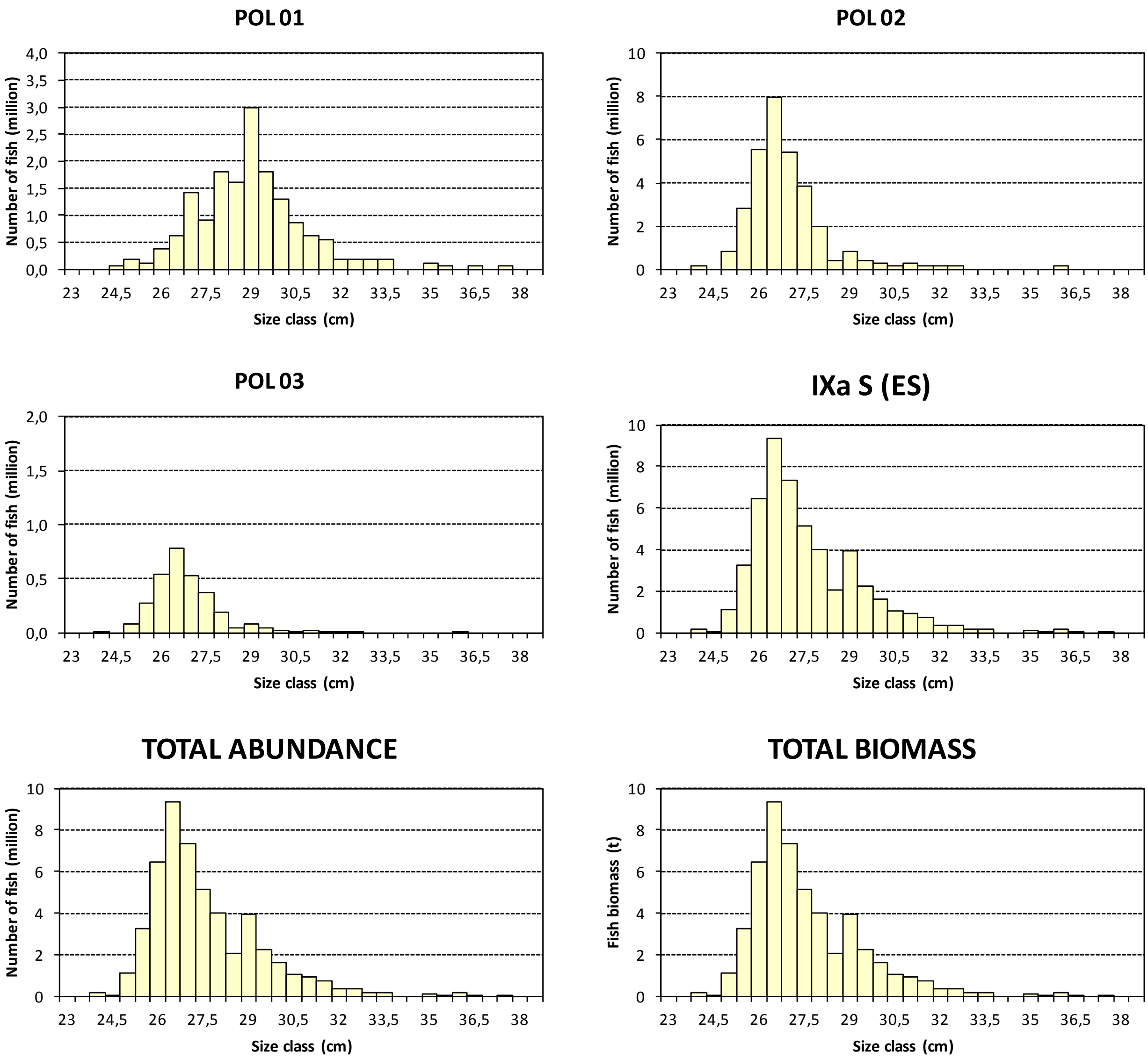


Figure 25. *ECOCADIZ 2015-07* survey. Mediterranean horse mackerel (*T. mediterraneus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 24**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

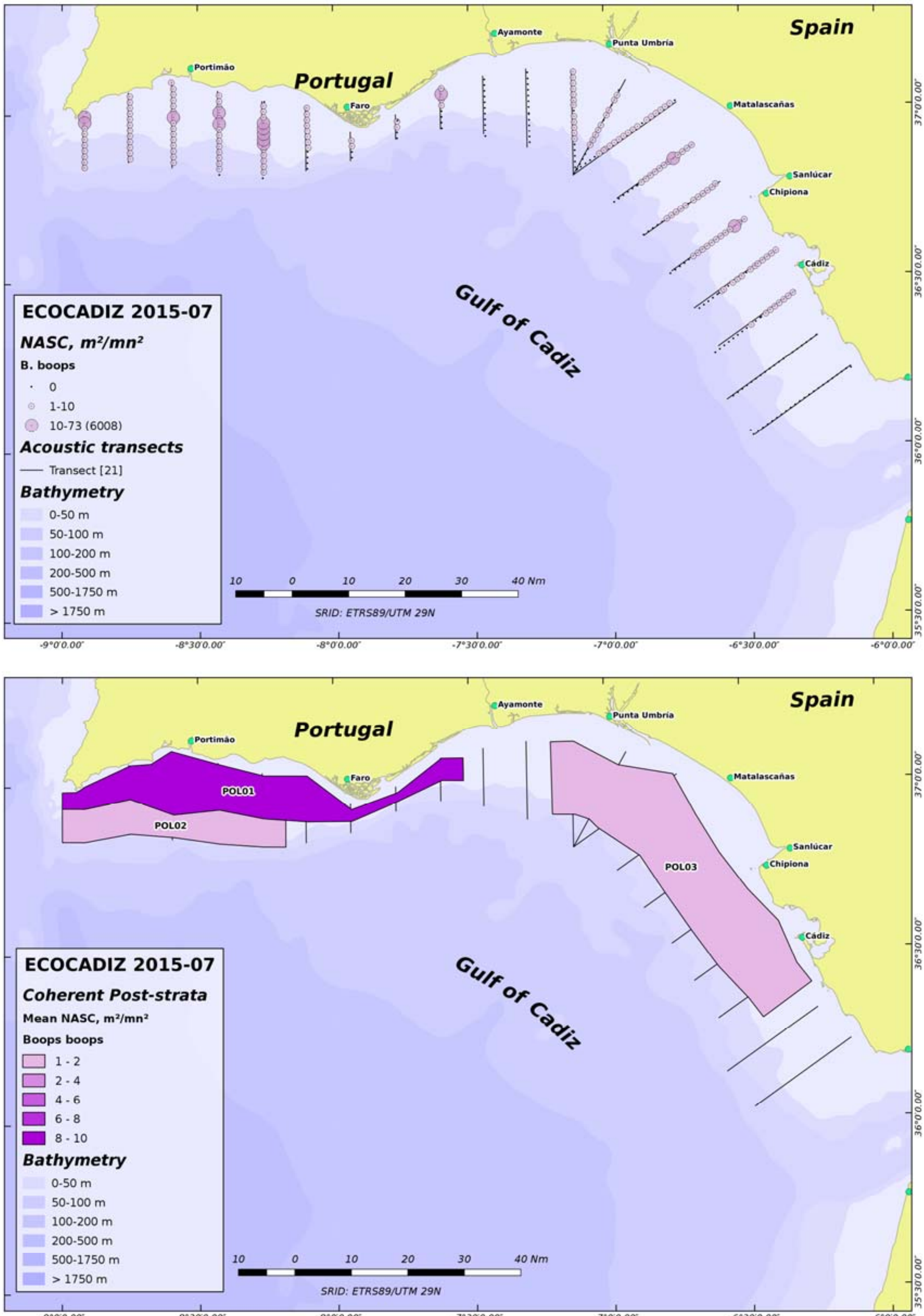


Figure 26. *ECOCADIZ 2015-07* survey. Bogue (*Boops boops*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

***ECOCADIZ 2015-07*: Bogue (*B. boops*)**

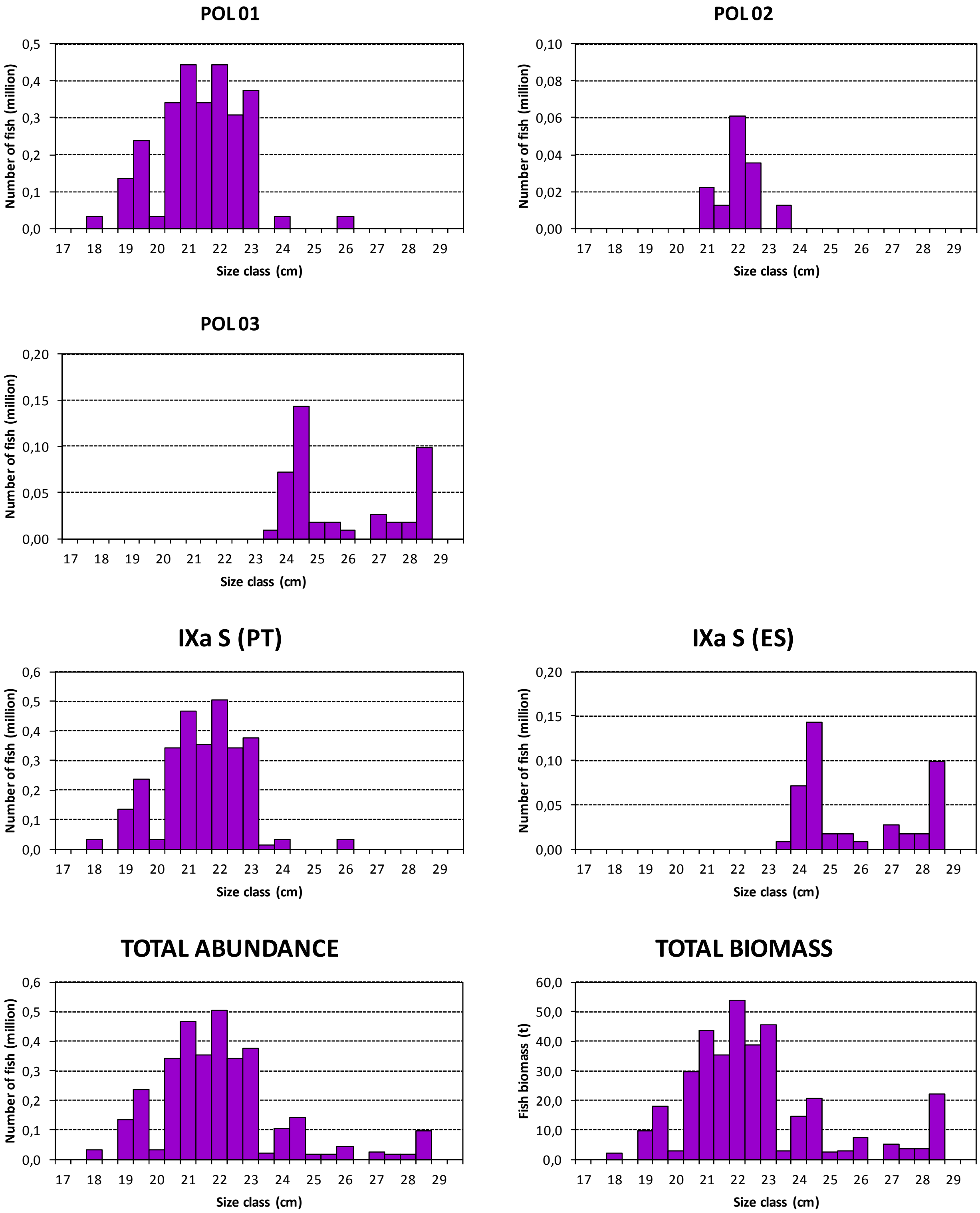
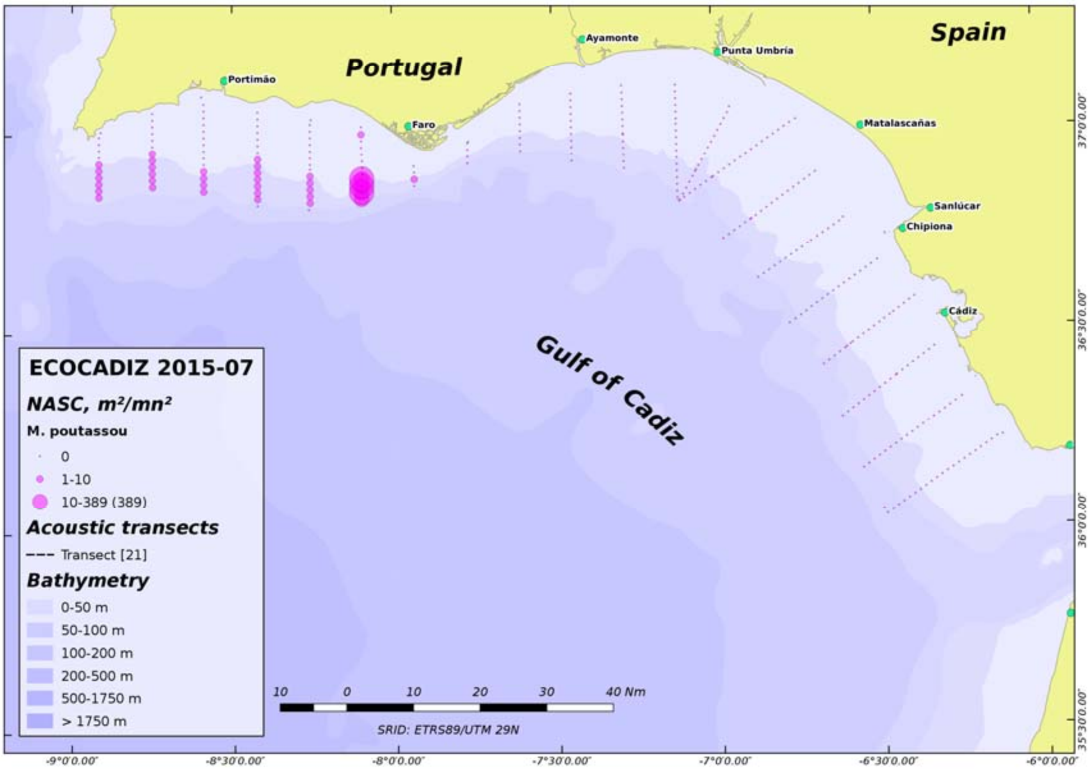


Figure 27. *ECOCADIZ 2015-07* survey. Bogue (*B. boops*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 26**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.



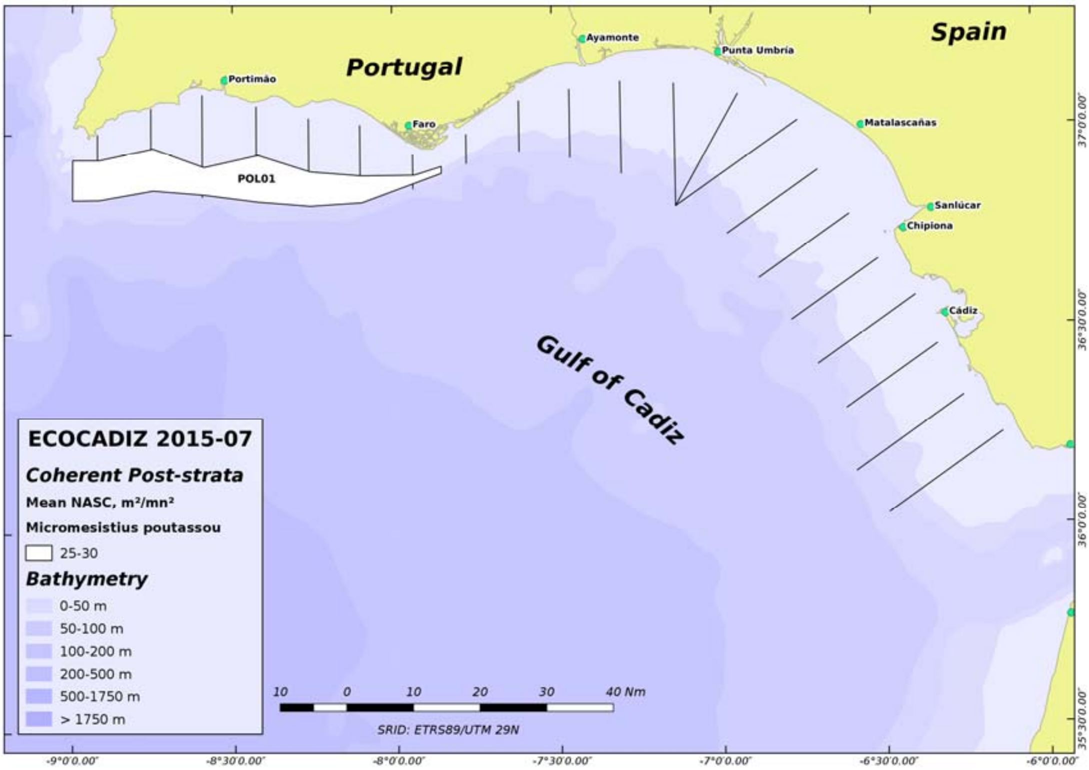


Figure 28. *ECOCADIZ 2015-07* survey. Blue whiting (*Micromesistius poutassou*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

***ECOCADIZ 2015-07*: Blue whiting (*M. poutassou*)**

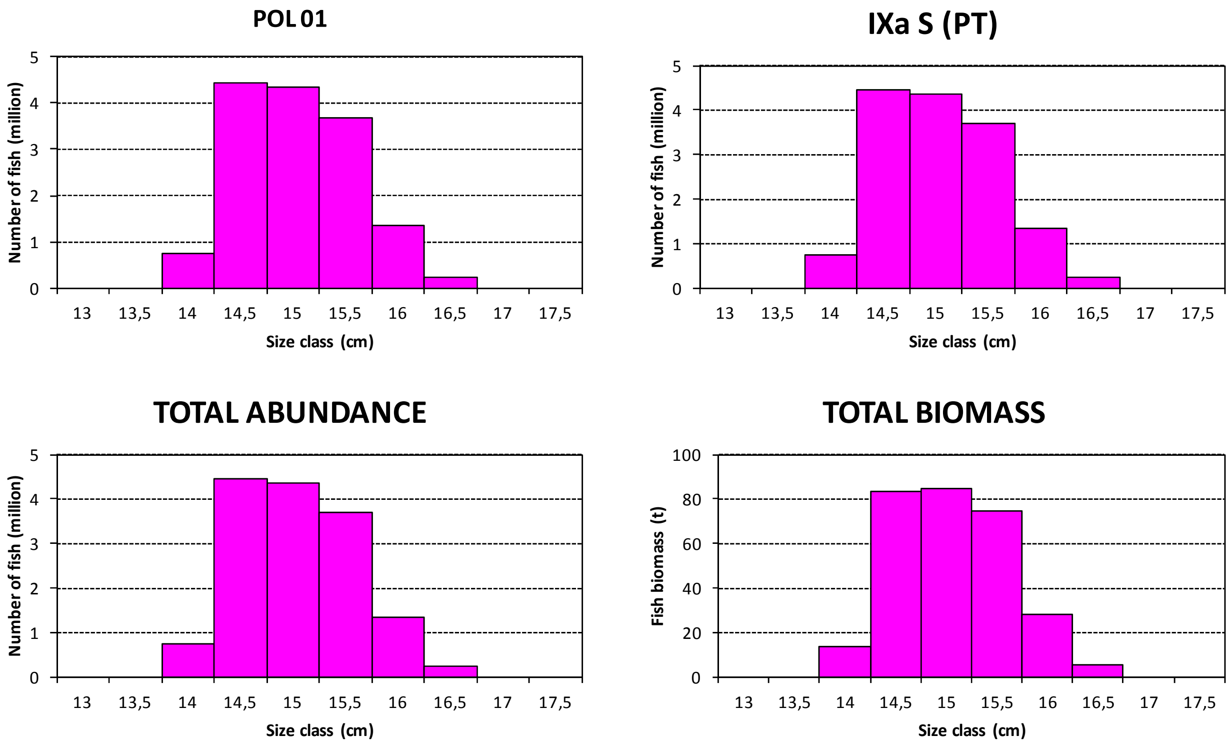


Figure 29. *ECOCADIZ 2015-07* survey. Blue whiting (*M. poutassou*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 28**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

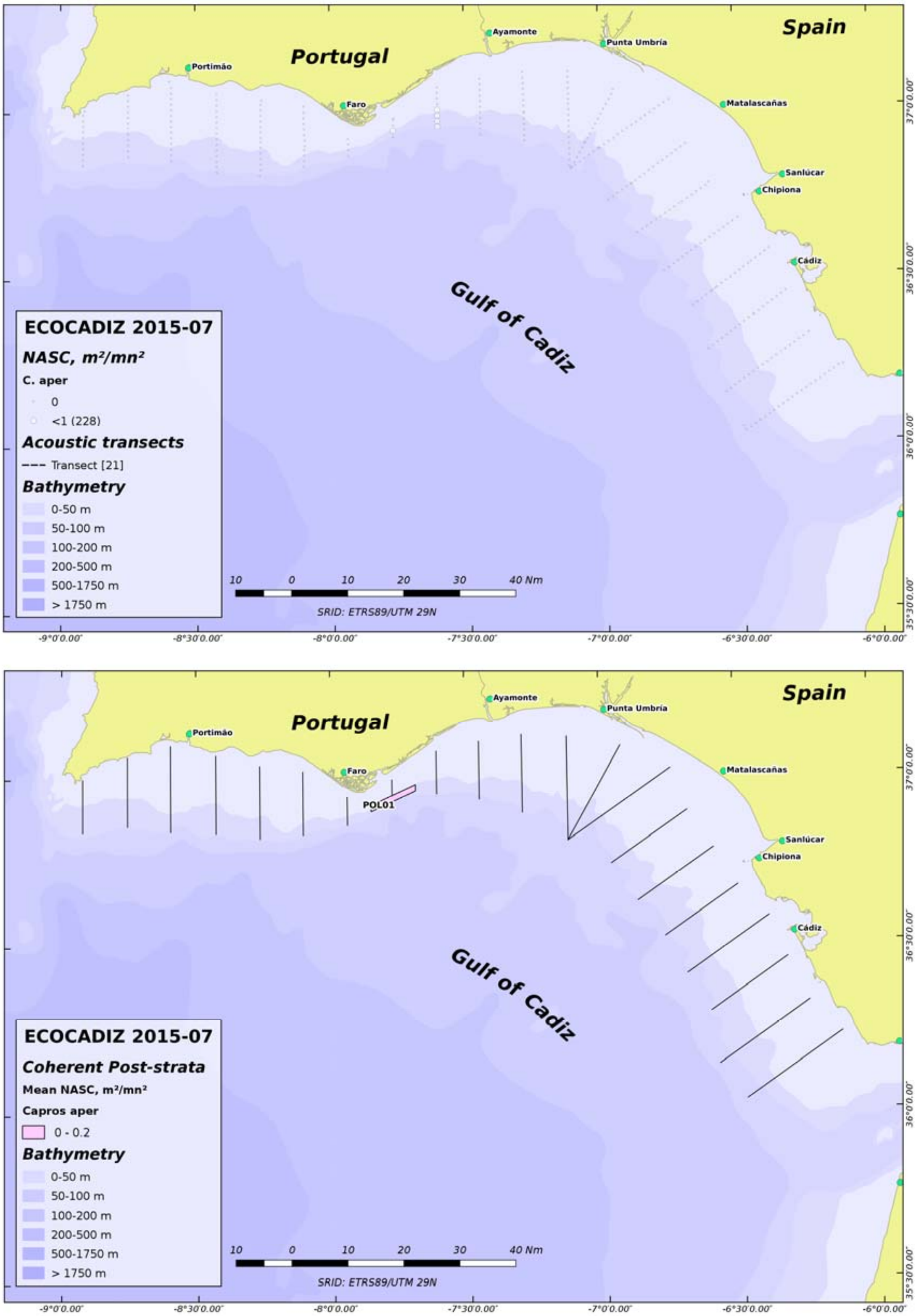


Figure 30. *ECOCADIZ 2015-07* survey. Boarfish (*Capros aper*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

***ECOCADIZ 2015-07*: Boarfish (*C. aper*)**

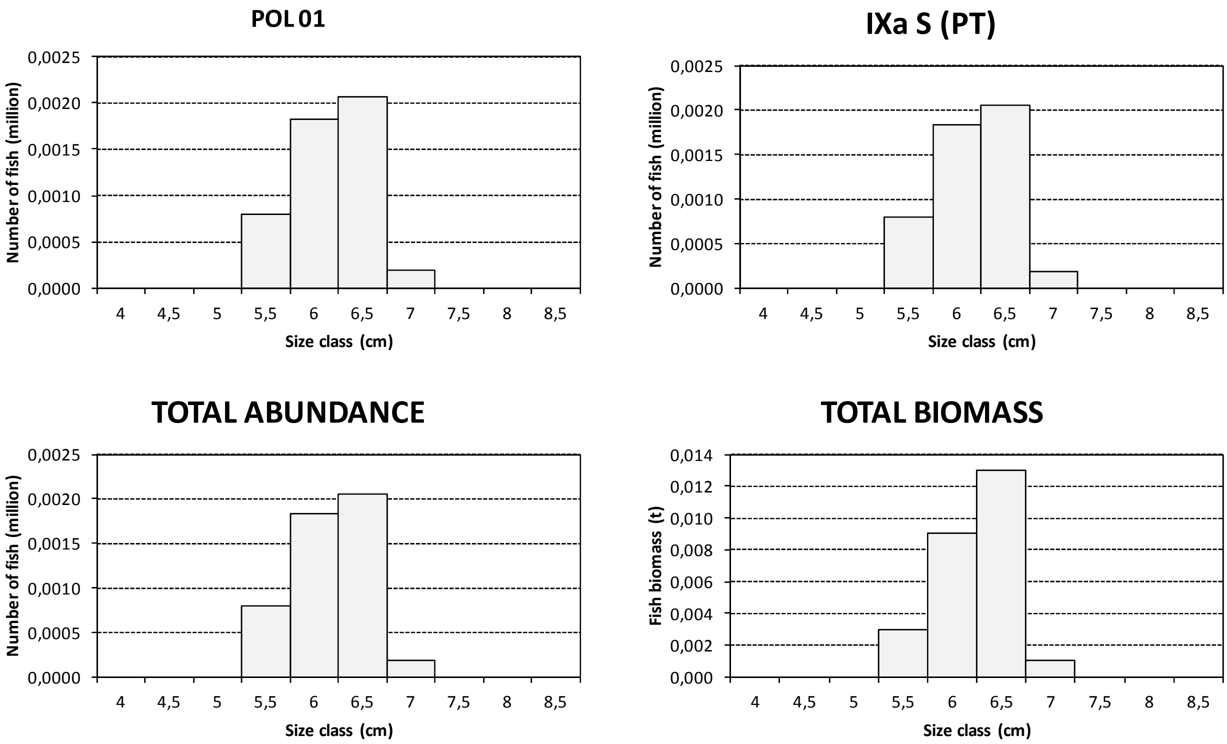
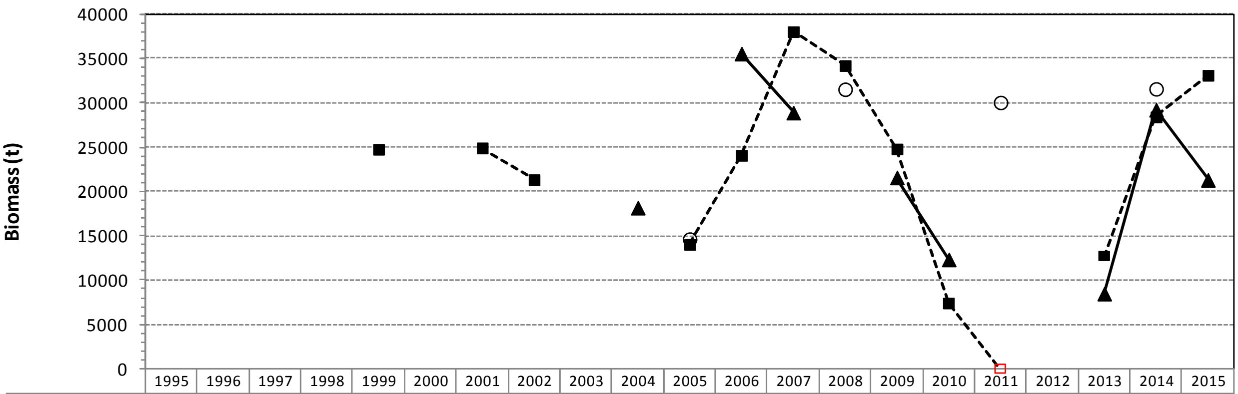


Figure 31. *ECOCADIZ 2015-07* survey. Boarfish (*C. aper*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 30**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

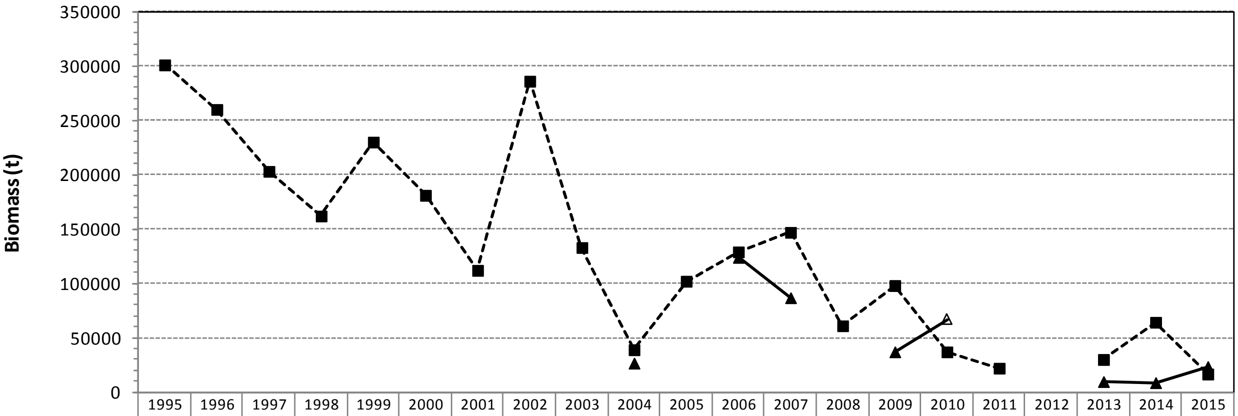
Biomass trends (in tons)

Anchovy biomass estimates



	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
PELAGO					24763		24913	21335			14041	24082	38020	34200	24800	7395	0		12700	28408	33100
ECOCADIZ										18177		35539	28882		21580	12339			8487	29219	21305
BOCADEVA											14637			31527			30037			31569	

Sardine biomass estimates



	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
PELAGO	301000	260000	203000	162000	230000	181000	112000	286000	133000	39000	102000	129000	147000	61000	98000	37000	22000		30000	64227	16663
ECOCADIZ										26568		123849	86777		37020	66964			9670	8697	23460

Figure 32. Trends in biomass estimates (in tons) for the main assessed species in Portuguese (*PELAGO*) and Spanish (*ECOCADIZ*) survey series. Gaps for the 2005, 2008 and 2011 anchovy acoustic estimates in the *ECOCADIZ* series are filled with the *BOCADEVA* Spanish egg survey estimates. 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.

Working document presented in the ICES Working Group on Southern Horse Mackerel, Sardine and Anchovy (WGHANSA). Lorient, France, 24-29 June 2016.
(An updated and extended version of a previous Working document presented in the ICES Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VII, VIII and IX (WGACEGG). Lowestoft, UK, 16-20 November 2015.)

Acoustic assessment and distribution of the main pelagic fish species in ICES Subdivision IXa South during the *ECOCADIZ-RECLUTAS 2015-10* Spanish survey (October 2015).

By

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ABSTRACT

The present working document summarises the main results obtained during the *ECOCADIZ-RECLUTAS 2015-10* Spanish (pelagic ecosystem-) acoustic survey. The survey was conducted by IEO between 10th and 29th October 2015 in the Portuguese and Spanish shelf waters (20-200 m isobaths) off the Gulf of Cadiz onboard the R/V *Ramón Margalef*. 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. Gulf of Cadiz anchovy abundance and biomass in autumn 2015 were of 5 227 million fish and 30 827 t, the highest values within its short series. The abundance and biomass of age 0 anchovies in the surveyed area were estimated at 5117 million fish and 29219 t. This juvenile fraction accounted for 98% and 95% of the total estimated population abundance and biomass respectively. Spanish waters concentrated 99% of the juveniles in the Gulf, both in terms of number (5 042 million) and biomass (28 789 t), although this autumn the recruitment area showed a greater extension, even reaching the coastal waters of the eastern Algarve. As compared with the previous last years, these estimates and observations suggest a better recruitment scenario that the one provided by the 2014 survey. Similar perception is also obtained from the autumn 2015 estimates for Gulf of Cadiz sardine: 861 million fish and 30 992 t, values which represent with respect to those estimated in 2014 a notable increase in abundance but not in biomass, which experienced a slight decrease. Such a pattern is caused by the increase of the juvenile fraction in the population in the autumn 2015 survey in terms both absolute and relative. These juveniles were mainly distributed in the Spanish coastal waters as well. Thus, sardine juveniles (age 0 sardines) accounted in autumn 2015 for 59% (509 million) and 31% (8 645 t) of the overall estimated abundance and biomass respectively.

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 IXa (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 (anchovy and sardine), as well as the mapping of both the oceanographic and biological conditions featuring the recruitment areas of these species in the Division IXa. 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. *ECOCADIZ-RECLUTAS 2014-10* survey was the next one and it was conducted with the R/V *Ramón Margalef*.

ECOCADIZ-RECLUTAS 2015-10 survey is the third one within its series. The working document by Ramos *et al.* (2015) provided to the 2015 ICES WGACEGG preliminary results from this survey, namely the acoustic estimates (not age-structured) and spatial distribution of anchovy and sardine as well as to inferences on the spatial distribution of other pelagic species from the distribution of the acoustic energy attributed to each of them. The present working document is an updated version of the former and provides age-structured estimates for anchovy and the acoustic estimates of the remaining species which were not contemplated in the previous WD.

MATERIAL AND METHODS

The *ECOCADIZ-RECLUTAS 2015-10* survey was carried out between 10th and 29th October 2015 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 during 11th and 13th October in the Bay of Algeciras following the new ICES 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 more recently 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 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 (*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
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* 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 170 $CTDO_2$-LADCP 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. Census of top predators was not recorded during the survey.

RESULTS

Acoustic sampling

The acoustic sampling was carried out between 15th and 27th October. The complete grid (21 transects) was sampled. However, the sampling scheme followed to accomplish this grid was highly conditioned by two events of different nature: the realization of joint NATO naval exercises in the Spanish waters during a great part of the survey and the entry of a persistent system of low pressure threatening with strong storms in the westernmost part of the surveyed area during the last days of the survey. As described above, the consecutive implementation of different naval exercises' polygons conditioned the order of realization of the acoustic transects during the survey's first leg. Thus, the acoustic sampling started by the coastal end of the transect R05 on 15th October and proceeded eastward up to the R01 on 17th. The acoustic sampling stopped on 18th-19th October in order to satisfy the R/V's refueling and victualling needs. Transects from R06 to R15 were carried out in the usual way (in the westward direction) between 20th and 24th. In order to avoid the abovementioned incoming system of low pressure, the westernmost section of the sampling grid (transects R16 – R21) was sampled in the W-E direction (**Table 1**; **Figure 1**).

In order to perform the acoustic sampling with daylight, this sampling started at 06:45 UTC until 25th October and at 07:45 UTC since 26th October on, 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 twenty one (21) fishing operations for echo-trace ground-truthing (all of them valid according to a correct gear performance and resulting catches), were carried out during the survey (**Table 2**, **Figure 3**). Four additional trial fishing hauls were carried out during the two previous days to 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 41-155 m.

During the survey were captured 1 Chondrichthyan, 33 Osteichthyes, 6 Cephalopod, 3 Echinoderm, 1 Cnidarian and 1 Bryozoan 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, anchovy was the most frequent species in the valid hauls (95% presence index), followed by sardine, chub-mackerel and horse mackerel (with relative occurrences between 60-70%). Mackerel showed a medium relative frequency (57%), and blue jack mackerel, bogue and Mediterranean horse mackerel were rare species during the survey (20-40%).

For the purposes of the acoustic assessment, anchovy, sardine, mackerel species, horse & jack mackerel species, bogue, blue whiting 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".

Species	# of fishing stations	Occurrence (%)	Total weight (kg)	Total number
Engraulis encrasicolus	20	95	1145,293	191529
Merluccius merluccius	19	90	25,617	273
Sardina pilchardus	15	71	7653,437	99986
Scomber colias	14	67	1230,73	10530
Trachurus trachurus	13	62	143,033	1221
Scomber scombrus	12	57	18,756	108
Lepidopus caudatus	11	52	2,641	151
Trachurus picturatus	8	38	282,636	4526
Boops boops	7	33	4,844	33
Trachurus mediterraneus	5	24	38,07	185

According to the above premises, during the survey were captured a total of 10 677 kg and 311 thousand fish (**Table 3**). 72% of this "total" fished biomass corresponded to sardine, 11% to chub mackerel, 11% to anchovy, 3% to blue jack-mackerel, 1% to horse mackerel and contributions lower than 1% for the remaining species. The most abundant species in ground-truthing trawl hauls were anchovy and sardine (61% and 32% respectively) followed by chub mackerel (3%), with each of the remaining species accounting for less than 1.5%.

The species composition of these fishing hauls (as expressed in terms of percentages in number) is shown in **Figure 4**. First impressions on the species' distribution patterns could be inferred from the relative contribution of the species in the fishing hauls. Thus, anchovy was widely distributed all over the surveyed area, although showed the highest yields in those hauls carried out in the Spanish waters. The size composition of anchovy catches indicates that smallest recruits showed this year a more widespread distribution than in previous surveys within its series, with high occurrences in the coastal waters off the eastern Algarve, surroundings of the Guadiana and Guadalquivir river mouths and Bay of Cadiz (**Figure 5**). Sardine was a frequent species in the hauls conducted over the shelf fringe comprised between Cape Santa Maria and Bay of Cadiz, showing exceptional yields in those waters surrounding Cape Santa Maria. However, the occurrence of sardine in the hauls conducted in the westernmost waters was relatively rare. The sardine size composition in the positive hauls indicates that juveniles were mainly distributed over the coastal waters comprised between the Guadiana river mouth and Bay of Cadiz whereas the largest sardines were captured in the Portuguese waters (**Figure 6**). Mackerel, although relatively frequent in those hauls conducted over the middle-outer shelf waters of the whole surveyed area, showed, however, very low yields. Although in a lesser extent, that also was the case of chub-mackerel, only outstanding the yields from two hauls conducted in the outer shelf waters in front of Punta Umbría (Spanish waters) and Cuarteira (to the west of Cape Santa Maria). Blue jack mackerel and boarfish were restricted to the Portuguese waters only and Mediterranean horse mackerel to the easternmost Spanish ones. Horse mackerel, although relatively frequent from the central waters of the Gulf to the west, only showed relatively important yields in the westernmost waters.

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. 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	Mackerel	Chub mack.	Horse mack.	Medit. h-mack.	Blue jack-mack.	Bogue	Blue whiting	Boarfish
Total Area	97463	53102	21205	11	7932	994	4537	8831	115	321	415
%	100	54,5	21,8	0,01	8,1	1,0	4,7	9,1	0,1	0,3	0,4
Portugal	31305	1741	13151	6	5887	954	0	8831	2	317	415
%	32,1	3,3	62,0	55,1	74,2	96,0	0,0	100	1,6	98,9	100
Spain	66158	51361	8054	5	2045	40	4537	0	114	3	0
%	67,9	96,7	38,0	44,9	25,8	4,0	100	0	98,4	1,1	0

For this “pelagic fish assemblage” has been estimated a total of 97 463 m^2 nmi^{-2}. The highest NASC values have been recorded in the sector of Alfanzina-Portimao (R18 – R19), although the zone between Tavira (R13) and Rota (R04) recorded the bulk of the acoustic energy (**Figure 7**). By species, anchovy accounted for 54% of this total back-scattered energy, followed by sardine (22%), blue-jack mackerel (9%), chub mackerel (8%), Mediterranean horse mackerel (5%), horse mackerel (1%), and the remaining species with relative contributions of acoustic energies lower than 1%.

From the regional contributions to the total energy attributed to each species it could be inferred that blue-jack mackerel, boarfish, blue whiting and horse mackerel have been typically Portuguese species. Chub mackerel and sardine also showed greater acoustic densities in Portuguese waters. Conversely, anchovy, Mediterranean horse mackerel and bogue were exclusively recorded in Spanish waters.

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, blue whiting and boarfish.

Spatial distribution and abundance/biomass estimates

Anchovy

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

Anchovy avoid in autumn 2005, as it also did in summer, the easternmost waters of the Gulf, and showed a spatial pattern of distribution of the acoustic density very similar to the one described in summer, with the bulk of the population being mainly concentrated in an area comprising the shelf waters between the Guadiana river mouth and Bay of Cadiz. Anchovy acoustic densities in the westernmost waters were not relevant (**Figure 8**).

The size range recorded for the estimated population was comprised between 8 and 17.5 cm size classes, with a marked mode at 9 cm size class and a very residual secondary mode at 15 cm. A similar size composition is also recorded for the estimated biomass, although the main mode is located at 9.5 cm size class (**Table 5**, **Figure 9**). The mean size and weight of the estimated population were 100 mm and 5.9 g respectively. The anchovy size composition by coherent post-strata in the autumn 2015 survey evidences that juveniles were mainly distributed in the coastal waters between the Guadiana river mouth and Bay of Cadiz, although this autumn the recruitment area showed a greater extension, even reaching the coastal waters of the eastern Algarve (**Table 5**, **Figure 9**).

Gulf of Cadiz anchovy abundance and biomass in autumn 2015 were of 5 227 million fish and 30 827 t, the highest values within its short series. Spanish waters concentrated 97.8% (5 113 million) and 95.7% (29 491 t) of the total estimated abundance and biomass respectively. Portuguese estimates amounted to 115 million and 1 335 t only.

Although 0, 1 and 2 years old fish were recorded, the bulk of the population was composed by age 0 fish (recruits; **Table 6**, **Figure 10**), with a mean size and weight for the whole sampled area of 9.98 cm and 5.71 g respectively (**Figure 10**). The abundance and biomass of age 0 anchovies in the surveyed area were estimated at 29219 t and 5117 million fish, respectively, *i.e.* 95% and 98% of the total estimated anchovy biomass and abundance. Spanish waters concentrated 99% of the juveniles in the Gulf, both in terms of number (5042 million) and biomass (28789 t).

Sardine

Parameters of the survey's size-weight relationship for sardine are shown in **Table 4**. The mapping of the backscattering energy (nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species and the coherent strata considered for the acoustic estimation are shown in **Figure 11**. Estimated abundance and biomass by size and age class are given in **Tables 7** and **8** and **Figures 12** and **13**.

As it was observed in summer, sardine also avoided in autumn the easternmost waters of the Gulf. In the remaining surveyed area the species, although widely distributed, showed two main nuclei of acoustic density: the most important one located in the westernmost coastal Algarve waters, and a secondary zone comprising the shelf between Matalascañas and Bay of Cadiz. In these last waters sardine showed a somewhat more widespread distribution than in summer (**Figure 11**).

The size frequency distribution of this species showed in autumn 2015 a range comprised between the 10 and 23.5 cm size classes, with three modes, both for the biomass and abundance at 11.5, 16 and 20.5 cm (**Table 7**, **Figure 12**). Mean size and weight for the whole population were estimated at 157 mm and 36.0 g, respectively. The sardine size composition by coherent post-strata in the autumn 2015 survey indicates that juveniles were mainly distributed over the coastal waters comprised between the Guadiana river mouth and Bay of Cadiz (**Table 8**; **Figures 11** and **13**).

The estimates of Gulf of Cadiz sardine abundance and biomass in autumn 2015 were 861 million fish and 30 992 t. Portuguese waters accounted for 48.9% of abundance (421 million) and 69.0% of the total estimated biomass (21 390 t), with the unbalanced percentages suggesting a larger and heavier body size on average than in the Spanish waters, where abundance and biomass estimates were of 440 million and 9 602 t. Juveniles were therefore mainly distributed in the Spanish coastal waters. Thus, sardine juveniles (age 0 sardines) accounted in autumn 2015 for 59% (509 million) and 31% (8 645 t) of the overall estimated abundance and biomass (**Tables 8** and **9**).

Mackerel

Parameters of the survey's length-weight relationship are shown in **Table 4**. The mapping of the backscattering energy (nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species is shown in **Figure 14**. Estimated abundance and biomass by size class are given in **Table 10** and **Figure 15**.

The species showed a very scattered distribution in the Gulf, mainly confined to the outer shelf waters (**Figure 14**). The size composition of the estimated population ranged between 21.5 and 35.0 size classes, with not very clearly identifiable modes at 22.0 cm (only recorded in the westernmost Portuguese waters), 28.0 and 33.0 cm size classes (**Table 10**, **Figure 15**). The surveyed population was estimated at 3 million fish and 394 t (**Table 10**, **Figure 15**).

Chub mackerel

Parameters of the survey's length-weight relationship are shown in **Table 4**. The mapping of the backscattering energy (nautical area scattering coefficient, NASC, in m2 nmi-2) attributed to the species is shown in **Figure 16**. Estimated abundance and biomass by size class are given in **Table 11** and **Figure 17**.

Chub mackerel neither showed a continuous distribution, with wide voids especially occurring in the inner-middle shelf waters in front of Doñana National Park. The highest integration values were recorded in the outer shelf waters between Tinto-Odiel river mouth and Burgau (R20), also outstanding the Algarve westernmost waters (**Figure 16**).

The size range of the estimated population was comprised between 18.0 and 31.5 size classes. The population showed a mixed size composition, with main modes at 20.0 and 24.0 cm size classes and a secondary one at 31.0 cm (**Table 11** and **Figure 17**). The surveyed population was estimated at 65 million fish and 5683 t, with the 83 % of the abundance (54 million fish) and 76 % of the biomass (4317 t) being distributed through the Portuguese shelf waters (**Table 11** and **Figure 17**).

Blue jack mackerel

Parameters of the survey's length-weight relationship are shown in **Table 4**. The mapping of the backscattering energy (nautical area scattering coefficient, NASC, in m^2 nmi^{-2}) attributed to the species is shown in **Figure 18**. Estimated abundance and biomass by size class are given in **Table 12** and **Figure 19**.

The species only occurred in the Portuguese waters, with the highest integration values being recorded in the Algarve westernmost outer shelf waters (**Figure 18**). The population showed a mixed size composition in those waters ranging between 11.0 and 27.5 cm size classes and with the most outstanding size modes at 14.5 and 18.5 cm size classes, and a secondary one at 23.5 cm (**Table 12** and **Figure 19**). The surveyed population was estimated at 111 million fish and 5771 t (**Table 12** and **Figure 19**).

Horse-mackerel

The survey's length-weight relationship for this species is shown in **Table 4**. The mapping of the backscattering energy (nautical area scattering coefficient, NASC, in m^2 nmi^{-2}) attributed to the species is represented in **Figure 20**. Estimated abundance and biomass by size class are given in **Table 13** and **Figure 21**.

Horse mackerel was practically absent in the easternmost waters of the Gulf. The occurrence of the species was somewhat more constant over the remaining surveyed area, although the highest densities are also recorded in the Algarve westernmost outer shelf waters (**Figure 20**). The population showed a mixed size composition, ranging between 5.5 and 29.5 cm size classes, although centred at around 24.0 cm modal size class (**Table 13** and **Figure 21**). The population was estimated at 9 million fish (8 millions, 89%, in Portuguese waters) and 769 t (746 t, 97%, in Portuguese waters), (**Table 13** and **Figure 21**) .

Mediterranean horse-mackerel

The survey's length-weight relationship for this species is shown in **Table 4**. The mapping of the backscattering energy (nautical area scattering coefficient, NASC, in m^2 nmi^{-2}) attributed to the species is shown in **Figure 22**. Estimated abundance and biomass by size class are given in **Table 14** and **Figure 23**.

The species was exclusively restricted to the Spanish waters, but even here showed a rather scattered distribution pattern, with the highest integration values being recorded in the eastern extreme of the surveyed area, close to the Strait of Gibraltar (**Figure 22**). The population showed a normal size distribution with mode at 28.0 size class and ranging between 26.0 and 32.5 cm size classes (**Table 14** and **Figure 23**). Population estimates were of 25 million fish and 4732 t (**Table 14** and **Figure 23**).

Bogue

Parameters of the survey's length-weight relationship are shown in **Table 4**. The mapping of the backscattering energy (nautical area scattering coefficient, NASC, in m2 nmi-2) attributed to the species is shown in **Figure 24**. Estimated abundance and biomass by size class are given in **Table 15** and **Figure 25**.

The presence of the species in Portuguese waters was accidental, whereas in the Spanish waters, although it showed a relatively continuous distribution, the acoustic integration was quite low (**Figure 24**). The surveyed population was estimated at only 0.6 million fish and 86 t (0.5 million fish, 83%, and 85 t, 99%, in Spanish waters), showing a mixed size composition, ranging between 20.0 and 29.5 cm size classes and main modes at 23.0 and 29.0 cm size classes and secondary ones at 20.5 and 24.5 cm (**Table 15** and **Figure 25**).

Blue whiting

Parameters of the survey's length-weight relationship are shown in **Table 4**. The mapping of the backscattering energy (nautical area scattering coefficient, NASC, in m^2 nmi^{-2}) attributed to the species is shown in **Figure 26**. Estimated abundance and biomass by size class are given in **Table 16** and **Figure 27**.

The species showed a very scattered distribution, restricted to the outer shelf waters in two distant zones: the central Gulf and western Algarve (**Figure 26**). The surveyed population was estimated at only 0.02 million fish and 0.4 t, with a size composition ranging between 14.5 and 17.0 size classes a one modal class at 15.5 cm (**Table 16** and **Figure 27**).

Boarfish

Parameters of the survey's length-weight relationship are shown in **Table 4**. The mapping of the backscattering energy (nautical area scattering coefficient, NASC, in m^2 nmi^{-2}) attributed to the species is shown in **Figure 28**. Estimated abundance and biomass by size class are given in **Table 17** and **Figure 29**.

The occurrence of boarfish during the survey was accidental and restricted to the westernmost outer shelf waters of the Gulf, close to Cape San Vicente (**Figure 28**). The surveyed population was estimated at 37 million fish and 835 t, with fish sizes being comprised between 7.0 and 12.0 cm size classes and one mode at 10.0 and 10.5 size classes (**Table 17** and **Figure 29**).

<u>Oceanographic conditions</u>

A detailed description of the oceanographic conditions in that survey based on *in situ* and remotely sensed data is given in Sánchez-Leal *et al*. (2015).

(SHORT) DISCUSSION

Gulf of Cadiz anchovy abundance and biomass in autumn 2015 were of 5 227 million fish and 30 827 t, the highest values within its short series (**Table 18**, **Figure 29**). Age 0 anchovies in the surveyed area were estimated at 29 219 t and 5 117 million fish, respectively, *i.e.* 95% and 98% of the total estimated anchovy biomass and abundance. Spanish waters concentrated 99% of the juveniles in the Gulf, both in terms of number (5 042 million) and biomass (28 789 t). Such a dominance of the recruit component in the assessed population has resulted in mean size and weight estimates for the whole population of 10 cm and 5.9 g respectively, which were very similar very similar values to those ones recorded in autumn 2012 (9.5 cm, 5.9 g), but very different to the high estimates obtained in autumn 2014 (129 mm, 14.9 g). Given the shortness of the series it would be too much risky to advance that this 'historic' maximum might correspond to a good recruitment scenario. Notwithstanding the above, these estimates induce to optimistically perceive the present situation when they are compared with the estimates from previous years.

Regarding sardine, the autumn 2015 values (861 million fish and 30 992 t) represent with respect to those estimated in the previous year a notable increase in abundance but not in biomass, which experienced a slight decrease. Such a pattern is mainly caused by the increase and high relative importance of juveniles in the population during the 2015 survey season, which were mainly distributed in the Spanish coastal waters. Thus, sardine juveniles (age 0 sardines) accounted in autumn 2015 for 59% (509 million) and 31% (8 645 t) of the overall estimated abundance and biomass (**Table 18**). Because of the age-structured estimates from the 2012 and 2014 surveys are not still available, the recruit fraction in those years has been assumed as the one composed by fish with sizes ≤16.5 cm as a proxy for age 0 fish. A comparison between true estimates and proxies shows that the 2015 autumn estimates are rather close to those ones recorded in 2012 (377 million, 62.5%; 9 675 t, 43.7%), but they are very different to the 2014 estimates of sardine juveniles (29 million, 5.7%; 760 t, 2.1%). The autumn 2015 estimates of overall mean size (15.7 cm) and weight (36.0 g) are relatively close to those ones recorded in 2012 (16.5 cm, 36.7 g), but they both contrast with the values estimated in autumn 2014, when Gulf of Cadiz sardine population was composed on average by very large and heavy sardines (20.0 cm, 72.1 g) as a result of a notable dominance of the adult fraction in contrast to a very scarce presence of juveniles. Conversely, Gulf of Cadiz sardine population in 2012 and 2015 showed more complex and mixed size distributions, with juveniles composing the most important modal component.

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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., C. O'Donnell, J.M. Jech, 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.

Nakken, O., A. Dommasnes, 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*.

Ramos, F., M. Iglesias, J. Miquel, D. Oñate, J. Tornero, A. Ventero, N. Díaz, 2013. Acoustic assessment and distribution of the main pelagic fish species in the ICES Subdivision IXa South during the *ECOCÁDIZ-RECLUTAS 1112* Spanish survey (November 2012). Working document presented in the ICES Working Group on Southern Horse Mackerel, Anchovy and Sardine (WGHANSA), Bilbao (Basque Country), Spain, 21-26 June 2013 and in the ICES Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VIII and IX (WGACEGG). Lisbon, Portugal, 25-29 November 2013.

Ramos, F., J. Tornero, D. Oñate, P. Córdoba, 2015. Acoustic assessment and distribution of anchovy and sardine in the ICES Subdivision IXa South during the *ECOCADIZ-RECLUTAS 2015-10* Spanish survey (October 2015), with notes on the distribution of other pelagic species. Working document presented in the ICES Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VII, VIII and IX (WGACEGG). Lowestoft, UK, 16-20 November 2015. 34 pp.

Sánchez-Leal, R., V. Pita, J. Rodríguez, 2015. Physical oceanography conditions during ECOCADIZ 2015 cruises. Working document presented to the Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VII, VIII and IX (WGACEGG), 16-20 November 2015, Lowestoft, UK.

Table 1. *ECOCADIZ-RECLUTAS 2015-10* 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	17/10/15	36º 02.170' N	6º 28.540' W	11:56	167	36º 13.910 N	6º 07.080' W	14:06	24
R02	Sancti-Petri	17/10/15	36º 19.386' W	6º 14.580' W	06:28	33	36º 08.780' N	6º 33.740' W	10:58	178
R03	Cádiz	16/10/15	36º 27.400' N	6º 19.02' W	13:50	26	36º 17.827' N	6º 36.248' W	15:33	182
R04	Rota	16/10/15	36º 34.884' N	6º 22.416' W	06:41	21	36º 24.594' N	6º 41.390' W	10:25	214
R05	Chipiona	15/10/15	36º 40.840' N	6º 28.610' W	11:03	21	36º 31.288' N	6º 46.121' W	14:45	195
R06	Doñana	20/10/15	36º 47.791 N	6º 33.572' W	06:35	20	36º 37.900' N	6º 51.710' W	10:14	224
R07	Matalascañas	20/10/15	36º 44.070' N	6º 58.380' W	11:04	180	36º 54.372' N	6º 39.510' W	15:06	20
R08	Mazagón	21/10/15	37º 01.761' N	6º 43.452' W	06:38	19	36º 49.380' N	7º 06.100' W	10:39	207
R09	Punta Umbría	21/10/15	36º 49.730' N	7º 06.430' W	12:55	192	37º 05.800' N	6º 55.040' W	16:39	18
R10	El Rompido	22/10/15	37º 08.155' N	7º 07.189' W	06:44	21	36º 49.910' N	7º 07.28' W	10:05	211
R11	Isla Cristina	22/10/15	36º 53.540' W	7º 17.300' W	11:01	146	37º 06.110' N	7º 17.330' W	14:05	26
R12	V.R. Do Sto. Antonio	23/10/15	37º 06.551' N	7º 26.824' W	06:47	27	36º 56.190' N	7º 26.850' W	10:29	209
R13	Tavira	23/10/15	36º 57.090' N	07º 36.450' W	13:06	130	37º 04.470' N	7º 37.050 'W	13:55	22
R14	Fuzeta	24/10/15	36º 59.055' N	7º 46.638' W	06:49	72	36º 55.382' N	7º 46.371' W	07:12	216
R15	Cabo Sta. María	24/10/15	36º 51.968' N	7º 56.344' W	08:01	126	36º 55.490' N	7º 56.410' W	09:57	70
R16	Cuarteira	27/10/15	36º 50.010' N	8º 6.180' W	11:52	111	37º 01.711' N	8º 06.198' W	15:52	20
R17	Albufeira	27/10/15	37º 02.306' N	8º 15.916' W	07:48	33	36º 49.302' N	8º 15.805' W	09:11	191
R18	Alfanzina	26/10/15	36º 50.474' N	8º 25.687' W	10:12	182	37º 04.272' N	8º 25.602' W	15:25	22
R19	Portimao	26/10/15	37º 6.021' N	8º 35.703 W	07:40	30	36º 51.144' N	8º 35.620' W	09:13	210
R20	Burgau	25/10/15	36º 52.290' N	8º 45.320' W	11:40	110	37º 03.924' N	8º 45.338' W	15:16	25
R21	Punta de Sagres	25/10/15	37º 59.970' N	8º 55.339' W	07:43	24	36º 50.689' N	8º 55.345' W	08:38	208

Table 2. *ECOCADIZ-RECLUTAS 2015-10* survey. Descriptive characteristics of the fishing stations. Null hauls in light grey.

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	13-10-2019	35º 59.0800 N	6º 13.2799 W	35º 59.2399 N	6º 13.5799 W	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	TEST HAULS
02	14-10-2018	36º 03.2830 N	6º 27.2080 W	36º 04.4593 N	6º 28.3053 W	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	
03	14-10-2018	36º 04.7891 N	6º 29.7353 W	36º 07.1468 N	6º 32.7894 W	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	
04	14-10-2018	36º 17.1569 N	6º 35.6245 W	36º 19.7817 N	6º 36.6497 W	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	
05	15-10-2015	36º 36.3290 N	6º 36.8989 W	36º 37.6080 N	6º 34.5639 W	12:27	13:00	61	45,49	00:33	01:16	2,273	R05	Chipiona
06	15-10-2015	36º 31.9679 N	6º 44.9079 W	36º 33.7600 N	6º 41.5730 W	15:10	16:01	138,11	99,07	00:51	01:32	3,229	R05	Chipiona
07	16-10-2015	36º 30.1320 N	6º 31.2920 W	36º 31.3000 N	6º 28.8759 W	08:01	08:36	60,64	48,64	00:35	01:05	2,27	R04	Rota
08	16-10-2015	36º 27.5340 N	6º 36.0999 W	36º 29.1751 N	6º 33.0299 W	11:27	12:13	94,06	72,10	00:46	01:26	2,969	R04	Rota
09	17-10-2015	36º 16.4360 N	6º 18.2319 W	36º 18.3959 N	6º 19.4634 W	07:52	08:25	41,50	41,88	00:33	----	2,196	R02	Sancti-Petri
10	20-10-2015	36º 42.5213 N	6º 43.6841 W	36º 43.5041 N	6º 41.5994 W	08:00	08:30	65,21	47,5	00:30	01:12	1,942	R06	Doñana
11	20-10-2015	36º 45.8257 N	6º 55.3040 W	36º 44.4132 N	6º 57.7558 W	11:50	12:27	112,44	154,96	00:37	01:23	2,423	R07	Matalascañas
12	21-10-2015	36º 55.6257 N	6º 54.7148 W	36º 56.7561 N	6º 52.4469 W	08:19	08:51	58,12	47,72	00:32	01:03	2,14	R08	Mazagón
13	21-10-2015	36º 50.0638 N	7º 04.9497 W	36º 51.1762 N	7º 02.8828 W	11:13	11:44	142,99	115,41	00:30	01:17	1,997	R08	Mazagón
14	21-10-2015	36º 57.1992 N	7º 01.2099 W	36º 55.3378 N	7º 02.5242 W	14:12	14:43	70,43	90,06	00:31	01:13	2,137	R09	Punta Umbría
15	22-10-2015	37º 01.9042 N	7º 06.5516 W	37º 02.2793 N	7º 08.3826 W	07:59	08:22	49,49	49,57	00:22	00:52	1,513	R10	El Rompido
16	22-10-2015	36º 58.4851 N	7º 17.4195 W	36º 56.0456 N	7º 17.3699 W	11:55	12:32	97,21	115,36	00:37	01:16	2,437	R11	Isla Cristina
17	23-10-2015	37º 03.0953 N	7º 25.2331 W	37º 03.0943 N	7º 28.2297 W	08:11	08:48	68,21	71,22	00:36	01:10	2,399	R12	V. R. do Sto. Antonio
18	23-10-2015	36º 57.2833 N	7º 24.2319 W	36º 57.7005 N	7º 27.3007 W	11:17	11:55	118,55	117,93	00:37	01:20	2,495	R12	V. R. do Sto. Antonio
19	23-10-2015	37º 03.6027 N	7º 34.0692 W	37º 02.6358 N	7º 37.1117 W	14:56	15:34	51,02	49,01	00:38	01:17	2,62	R13	Tavira
20	24-10-2015	36º 54.1349 N	7º 56.9514 W	36º 54.3636 N	7º 55.5737 W	08:46	09:02	83,79	85,74	00:16	01:01	1,128	R15	Cabo Sta. María
21	25-10-2015	36º 51.3152 N	8º 53.8619 W	36º 51.4428 N	8º 56.0116 W	09:23	09:47	137,47	149,83	00:24	01:13	1,73	R21	Ponta de Sagres
22	25-10-2015	36º 52.2242 N	8º 46.6308 W	36º 52.3818 N	8º 50.3875 W	12:11	12:54	130,12	128,45	00:43	01:25	3,018	R20	Burgau
23	26-10-2015	36º 51.4796 N	8º 23.5631 W	36º 51.5034 N	8º 26.7776 W	12:00	12:36	129,62	136,85	00:35	01:30	2,58	R16	Cuarteira
24	27-10-2015	36º 50.4104 N	8º 15.8558 W	36º 53.5617 N	8º 15.8366 W	09:25	10:09	120,27	102,57	00:44	01:31	3,147	R17	Albufeira
25	27-10-2015	36º 49.4671 N	8º 08.9748 W	36º 51.2215 N	8º 06.4984 W	13:20	13:56	111,98	109,44	00:35	01:32	2,65	R16	Cuarteira

Table 3. *ECOCADIZ-RECLUTAS 2015-10* survey. Catches by species in number (upper panel) and weight (in kg, lower panel) from valid fishing stations.

ABUNDANCE (nº)												
Fishing station	***Anchovy***	***Sardine***	***Chub mack.***	***Mackerel***	***Horse-mack.***	***Blue Jack-mack.***	***Medit. Horse-mack.***	***Bogue***	***Blue whiting***	***Boarfish***	**Other spp.**	**TOTAL**
05	44946	2574	0	0	0	0	10	3	0	0	17	**47550**
06	2627	0	63	3	8	0	0	0	0	0	66	**2767**
07	28817	4032	1	0	0	0	0	2	0	0	4	**32856**
08	4507	816	0	1	0	0	0	0	0	0	18	**5342**
09	0	0	1	0	0	0	169	1	0	0	66	**237**
10	25570	2450	0	0	2	0	0	2	0	0	30	**28054**
11	13880	2234	0	12	0	0	0	0	0	0	21	**16147**
12	15428	2239	0	0	1	0	1	6	0	0	52	**17727**
13	5403	0	784	17	8	0	0	0	3	0	37	**6252**
14	30882	470	0	10	3	0	2	0	0	0	48	**31415**
15	5554	257	3	0	0	0	3	0	0	0	40	**5857**
16	3678	9	5	3	1	0	0	0	0	0	26	**3722**
17	7767	147	1	0	0	0	0	0	0	0	22	**7937**
18	33	0	159	3	1	100	0	0	0	0	13	**309**
19	638	75726	22	0	0	3	0	18	0	0	29	**76436**
20	743	8844	30	2	72	344	0	0	0	0	8	**10043**
21	55	0	0	6	12	24	0	0	0	0	3	**100**
22	12	144	128	11	117	1067	0	0	92	1638	23	**3232**
23	691	41	433	0	1	1655	0	0	0	0	1	**2822**
24	297	0	2	2	107	35	0	1	656	0	113	**1213**
25	1	3	8898	38	888	1298	0	0	0	0	13	**11139**
TOTAL	**191529**	**99986**	**10530**	**108**	**1221**	**4526**	**185**	**33**	**751**	**1638**	**650**	**311157**

Table 3. *ECOCADIZ-RECLUTAS 2015-10* survey. Cont'd.

BIOMASS (kg)											
Fishing station	***Anchovy***	***Sardine***	***Chub mack.***	***Mackerel***	***Horse-mack.***	***Blue Jack-mack.***	***Medit. Horse-mack.***	***Bogue***	***Blue whiting***	***Boarfish***	**Other spp.**	**TOTAL**
05	222,930	48,120	0	0	0	0	2,716	0,722	0	0	14,444	288,932
06	20,800	0	8,940	0,518	0,063	0	0	0	0	0	2,188	32,509
07	149,850	181,842	0,258	0	0	0	0	0,526	0	0	0,576	333,052
08	37,400	29,600	0	0,160	0	0	0	0	0	0	3,362	70,522
09	0	0	0,202	0	0	0	35	0,108	0	0	18,688	53,998
10	117,720	32,351	0	0	0,130	0	0	0,228	0	0	5,404	155,833
11	132,234	43,500	0	2,758	0	0	0	0	0	0	0,939	179,431
12	76,100	42,880	0	0	0,082	0	0,228	0,860	0	0	4,622	124,772
13	53,640	0	88,760	3,012	0,300	0	0	0	0,062	0	15,238	161,012
14	203,500	9,032	0	2,870	0,098	0	0,024	0	0	0	0,384	215,908
15	29,540	5,928	0,462	0	0	0	0,102	0	0	0	3,362	39,394
16	32,080	0,548	0,708	0,688	0,020	0	0	0	0	0	2,562	36,606
17	39,440	2,380	0,208	0	0	0	0	0	0	0	1,282	43,310
18	0,519	0	10,602	0,406	0,020	6,524	0	0	0	0	1,214	19,285
19	2,900	6469,700	3,726	0	0	0,528	0	2,280	0	0	10,806	6489,94
20	5,680	776,620	3,950	0,308	12,620	33,340	0	0	0	0	1,44	833,958
21	1,266	0	0	0,418	1,408	1,031	0	0	0	0	7,417	11,540
22	0,282	9,280	9,780	0,840	9,900	71,720	0	0	1,846	36,34	2,474	142,462
23	16,840	1,420	27,920	0	0,092	67,111	0	0	0	0	2,364	115,747
24	2,546	0	0,254	0,400	11,960	4,138	0	0,120	13,380	0	4,052	36,850
25	0,026	0,236	1074,960	6,378	106,340	98,244	0	0	0	0	6,227	1292,411
TOTAL	**1145,293**	**7653,437**	**1230,730**	**18,756**	**143,033**	**282,636**	**38,070**	**4,844**	**15,288**	**36,34**	**109,045**	**10677,472**

Table 4. *ECOCADIZ-RECLUTAS 2015-10* survey. Parameters of the size-weight relationships for survey's target species. FAO codes for the species: PIL: *Sardina pilchardus*; ANE: *Engraulis encrasicolus*; MAS: *Scomber colias*; MAC: *Scomber scombrus*; JAA: *Trachurus picturatus;* HOM: *Trachurus trachurus*; HMM: *Trachurus mediterraneus*; BOG: *Boops boops*; WHB: *Micromesistius poutassou*; BOC: *Capros aper*.

Parameter	**PIL**	**ANE**	**MAS**	**MAC**	**JAA**	**HOM**	**HMM**	**BOG**	**WHB**	**BOC**
n	737	889	362	97	304	236	66	32	107	102
a	0,001983119	0,00335699	0,002454871	0,0190372	0,004206426	0,006720766	0,004801032	0,003232334	0,015974591	0,025043736
b	3,495249731	3,218559213	3,365609239	2,71907671	3,211602406	3,066669677	3,151832574	3,341745323	2,583276171	2,903514744
r^2	0,973730232	0,990704252	0,966445106	0,873747952	0,957809047	0,993093103	0,973584407	0,966143357	0,67657836	0,939962959

Table 5. *ECOCADIZ-RECLUTAS 2015-10* 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 **Figures 8** and **9**.

***ECOCADIZ-RECLUTAS 2015-10*. *Engraulis encrasicolus*. ABUNDANCE (in number and million fish)**																
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	**POL09**	**POL10**	**POL11**	***n***			**millions**		
												PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
8	0	0	2822	0	544551	5447066	0	0	17266799	3752988	0	547373	26466853	27014226	**1**	**26**	**27**
8,5	0	9361	20071	0	4198251	41994502	0	0	423430585	70468955	0	4227683	535894042	540121725	**4**	**536**	**540**
9	0	0	51431	0	23561167	235678982	4700937	878260	829594370	263147792	0	23612598	1334000341	1357612939	**24**	**1334**	**1358**
9,5	0	270334	14269	0	21770754	217769739	150009770	1073346	311088939	479046286	2444478	22055357	1161432558	1183487915	**22**	**1161**	**1183**
10	0	900162	11447	0	9081139	90837337	225014664	4808911	95074846	263898943	18390518	9992748	698025219	708017967	**10**	**698**	**708**
10,5	0	858076	0	0	5539105	55406874	248466818	33759985	51872031	32241935	62613256	6397181	484360899	490758080	**6**	**484**	**491**
11	0	543158	0	0	2267321	22679688	103131723	110227805	69138831	8260164	71165639	2810479	384603850	387414329	**3**	**385**	**387**
11,5	0	373371	0	1387162	789672	7898980	51578993	137725158	25936016	3752988	39691943	2550205	266584078	269134283	**3**	**267**	**269**
12	0	231746	0	462387	306552	3066399	23452155	95262098	8669217	0	14900851	1000685	145350720	146351405	**1**	**145**	**146**
12,5	0	108844	0	308258	0	0	4700937	36241971	0	0	3461584	417102	44404492	44821594	**0**	**44**	**45**
13	0	38635	0	154129	159675	1597210	0	12327550	0	0	1483536	352439	15408296	15760735	**0**	**15**	**16**
13,5	546005	73763	0	616517	0	0	0	7569755	0	0	1483536	1236285	9053291	10289576	**1**	**9**	**10**
14	2575156	11709	0	154129	0	0	0	5068160	0	0	960941	2740994	6029101	8770095	**3**	**6**	**9**
14,5	7195349	23419	0	154129	0	0	0	0	0	0	0	7372897	0	7372897	**7**	**0**	**7**
15	8942563	0	0	1078904	0	0	0	1073346	0	0	0	10021467	1073346	11094813	**10**	**1**	**11**
15,5	8130505	11709	0	616517	0	0	0	0	0	0	0	8758731	0	8758731	**9**	**0**	**9**
16	6039804	11709	0	154129	0	0	0	0	0	0	0	6205642	0	6205642	**6**	**0**	**6**
16,5	3246246	11709	0	0	0	0	0	0	0	0	0	3257955	0	3257955	**3**	**0**	**3**
17	998692	0	0	0	0	0	0	0	0	0	0	998692	0	998692	**1**	**0**	**1**
17,5	109201	0	0	0	0	0	0	0	0	0	0	109201	0	109201	**0**	**0**	**0**
TOTAL *n*	37783521	3477705	100040	5086261	68218187	682376777	811055997	446016345	1832071634	1124570051	216596282	114665714	5112687086	5227352800	**115**	**5113**	**5227**
Millions	**38**	**3**	**0,1**	**5**	**68**	**682**	**811**	**446**	**1832**	**1125**	**217**						

Table 5. *ECOCADIZ-RECLUTAS 2015-10* survey. Anchovy (*E. encrasicolus*). Cont'd.

ECOCADIZ-RECLUTAS 2015-10. *Engraulis encrasicolus*. BIOMASS (t)														
Size class	POL01	POL02	POL03	POL04	POL05	POL06	POL07	POL08	POL09	POL10	POL11	PORTUGAL	SPAIN	TOTAL
8	0	0	0,008	0	1,628	16,284	0	0	51,621	11,220	0	1,636	79,125	80,761
8,5	0	0,034	0,073	0	15,168	151,723	0	0	1529,822	254,599	0	15,275	1936,144	1951,419
9	0	0	0,222	0	101,796	1018,252	20,310	3,795	3584,266	1136,931	0	102,018	5763,554	5865,572
9,5	0	1,384	0,073	0	111,428	1114,596	767,785	5,494	1592,225	2451,870	12,511	112,885	5944,481	6057,366
10	0	5,412	0,069	0	54,597	546,121	1352,806	28,912	571,597	1586,581	110,565	60,078	4196,582	4256,660
10,5	0	6,013	0	0	38,819	388,296	1741,276	236,593	363,524	225,954	438,799	44,832	3394,442	3439,274
11	0	4,406	0	0	18,393	183,986	836,641	894,207	560,878	67,009	577,321	22,799	3120,042	3142,841
11,5	0	3,484	0	12,944	7,368	73,706	481,286	1285,12	242,010	35,019	370,367	23,796	2487,508	2511,304
12	0	2,473	0	4,934	3,271	32,720	250,244	1016,484	92,504	0	158,998	10,678	1550,950	1561,628
12,5	0	1,321	0	3,741	0	0	57,054	439,857	0	0	42,012	5,062	538,923	543,985
13	0	0,531	0	2,117	2,193	21,940	0	169,334	0	0	20,378	4,841	211,652	216,493
13,5	8,450	1,142	0	9,541	0	0	0	117,146	0	0	22,958	19,133	140,104	159,237
14	44,707	0,203	0	2,676	0	0	0	87,988	0	0	16,683	47,586	104,671	152,257
14,5	139,582	0,454	0	2,990	0	0	0	0	0	0	0	143,026	0	143,026
15	193,124	0	0	23,300	0	0	0	23,18	0	0	0	216,424	23,180	239,604
15,5	194,799	0,281	0	14,771	0	0	0	0	0	0	0	209,851	0	209,851
16	160,021	0,310	0	4,084	0	0	0	0	0	0	0	164,415	0	164,415
16,5	94,819	0,342	0	0	0	0	0	0	0	0	0	95,161	0	95,161
17	32,067	0	0	0	0	0	0	0	0	0	0	32,067	0	32,067
17,5	3,844	0	0	0	0	0	0	0	0	0	0	3,844	0	3,844
TOTAL	871,413	27,790	0,445	81,098	354,661	3547,624	5507,402	4308,110	8588,447	5769,183	1770,592	1335,407	29491,358	30826,765

Table 6. *ECOCADIZ-RECLUTAS 2015-10* 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 **Figures 8** and **9** and ordered from west to east.

Age class	POL01	POL02	POL03	POL04	POL05	POL06	POL07	POL08	POL09	POL10	POL11	PT	ES	TOTAL
	N	N	N	N	N	N	N	N	N	N	N	N	N	N
0	1206	3282	100	2508	67705	677241	798419	415025	1825956	1114849	210908	74800	5042398	5117198
I	29673	179	0	2326	513	5135	12637	30920	6115	9722	5688	32691	70217	102909
II	6905	16	0	253	0	0	0	72	0	0	0	7174	72	7246
III	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	37784	3478	100	5086	68218	682377	811056	446016	1832072	1124570	216596	114666	5112687	5227353

Age class	POL01	POL02	POL03	POL04	POL05	POL06	POL07	POL08	POL09	POL10	POL11	PT	ES	TOTAL
	B	B	B	B	B	B	B	B	B	B	B	B	B	B
0	25	25	0,4	28	351	3513	5412	3898	8549	5714	1704	430	28789	29219
I	678	3	0	48	3	35	95	409	39	56	67	731	701	1432
II	168	0	0	6	0	0	0	2	0	0	0	175	2	176
III	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	871	28	0,4	81	355	3548	5507	4308	8588	5769	1771	1335	29491	30827

Table 7. *ECOCADIZ-RECLUTAS 2015-10* 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 **Figures 11** and **12**.

***ECOCADIZ-RECLUTAS 2015-10*. *Sardina pilchardus*. ABUNDANCE (in number and million fish)**														
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	***n***			**millions**		
									PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
10	0	0	0	0	0	606600	0	0	0	606600	606600	**0**	**1**	**1**
10,5	0	0	2682	36072	0	2830406	923978	0	2682	3790456	3793138	**0**	**4**	**4**
11	0	0	59207	796275	0	24045393	5979710	0	59207	30821378	30880585	**0**	**31**	**31**
11,5	0	0	311487	4189219	1159661	77057292	14278084	36761	311487	96721017	97032504	**0**	**97**	**97**
12	0	0	401620	5401422	6278269	41310613	7356962	36761	401620	60384027	60785647	**0**	**60**	**61**
12,5	0	0	230003	3093328	19519945	18612695	5526438	73521	230003	46825927	47055930	**0**	**47**	**47**
13	0	0	114071	1534149	30442510	15445420	2301230	637183	114071	50360492	50474563	**0**	**50**	**50**
13,5	0	0	47858	643646	37279004	8329064	453272	796478	47858	47501464	47549322	**0**	**48**	**48**
14	0	0	14231	191401	24140520	4312159	0	588169	14231	29232249	29246480	**0**	**29**	**29**
14,5	1292232	0	2682	36072	10426312	1010607	697342	673943	1294914	12844276	14139190	**1**	**13**	**14**
15	25069325	0	8046	108215	342947	1659316	226637	355352	25077371	2692467	27769838	**25**	**3**	**28**
15,5	59959623	0	0	0	342947	606600	0	428873	59959623	1378420	61338043	**60**	**1**	**61**
16	114233421	0	10728	144287	0	163428	0	551408	114244149	859123	115103272	**114**	**1**	**115**
16,5	25069325	0	0	0	16331	84217	0	1262112	25069325	1362660	26431985	**25**	**1**	**26**
17	21192626	129761	16093	216430	65323	163428	0	1262112	21338480	1707293	23045773	**21**	**2**	**23**
17,5	0	129761	8046	108215	32662	161760	0	1066056	137807	1368693	1506500	**0**	**1**	**2**
18	0	386581	8046	108215	201471	205537	0	833239	394627	1348462	1743089	**0**	**1**	**2**
18,5	0	881545	26201	352373	370281	770028	348671	637183	907746	2478536	3386282	**1**	**2**	**3**
19	14214566	3632742	25580	344030	658908	1700148	2632468	281831	17872888	5617385	23490273	**18**	**6**	**23**
19,5	20675732	5648440	34247	460588	642577	2749919	6467850	281831	26358419	10602765	36961184	**26**	**11**	**37**
20	34890298	10262372	33626	452245	746063	1861908	7705633	159296	45186296	10925145	56111441	**45**	**11**	**56**
20,5	34890298	11396209	8046	108215	577254	1295748	8751646	36761	46294553	10769624	57064177	**46**	**11**	**57**
21	16799033	8797660	8046	108215	310285	1420405	3504145	0	25604739	5343050	30947789	**26**	**5**	**31**
21,5	3876699	3785705	8046	108215	97985	525720	1569020	0	7670450	2300940	9971390	**8**	**2**	**10**
22	0	2156903	2682	36072	16331	161760	1220349	0	2159585	1434512	3594097	**2**	**1**	**4**
22,5	0	375138	2682	36072	0	0	174336	0	377820	210408	588228	**0**	**0**	**1**
23	0	122530	0	0	0	42109	174336	0	122530	216445	338975	**0**	**0**	**0**
23,5	0	122530	0	0	0	0	0	0	122530	0	122530	**0**	**0**	**0**
TOTAL *n*	372163178	47827877	1383956	18612971	133667586	207132280	70292107	9998870	421375011	439703814	861078825	**421**	**440**	**861**
Millions	**372**	**48**	**1**	**19**	**134**	**207**	**70**	**10**						

Table 7. *ECOCADIZ-RECLUTAS 2015-10* survey. Sardine (*S. pilchardus*). Cont'd.

***ECOCADIZ-RECLUTAS 2015-10*. *Sardina pilchardus*. BIOMASS (t)**											
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	**PORTUGAL**	**SPAIN**	**TOTAL**
10	0	0	0	0	0	4,102	0	0	**0**	**4,102**	**4,102**
10,5	0	0	0,021	0,288	0	22,606	7,38	0	**0,021**	**30,274**	**30,295**
11	0	0	0,554	7,455	0	225,124	55,985	0	**0,554**	**288,564**	**289,118**
11,5	0	0	3,395	45,66	12,639	839,87	155,621	0,401	**3,395**	**1054,191**	**1057,586**
12	0	0	5,064	68,103	79,158	520,856	92,759	0,463	**5,064**	**761,339**	**766,403**
12,5	0	0	3,335	44,855	283,049	269,893	80,136	1,066	**3,335**	**678,999**	**682,334**
13	0	0	1,892	25,447	504,957	256,197	38,171	10,569	**1,892**	**835,341**	**837,233**
13,5	0	0	0,904	12,152	703,826	157,252	8,558	15,037	**0,904**	**896,825**	**897,729**
14	0	0	0,304	4,094	516,377	92,239	0	12,581	**0,304**	**625,291**	**625,595**
14,5	31,182	0	0,065	0,87	251,594	24,387	16,827	16,263	**31,247**	**309,941**	**341,188**
15	679,697	0	0,218	2,934	9,298	44,988	6,145	9,635	**679,915**	**73,000**	**752,915**
15,5	1819,710	0	0	0	10,408	18,41	0	13,016	**1819,710**	**41,834**	**1861,544**
16	3867,024	0	0,363	4,884	0	5,532	0	18,666	**3867,387**	**29,082**	**3896,469**
16,5	943,472	0	0	0,000	0,615	3,169	0	47,499	**943,472**	**51,283**	**994,755**
17	883,935	5,412	0,671	9,027	2,725	6,817	0	52,642	**890,018**	**71,211**	**961,229**
17,5	0	5,981	0,371	4,988	1,505	7,456	0	49,135	**6,352**	**63,084**	**69,436**
18	0	19,634	0,409	5,496	10,233	10,439	0	42,32	**20,043**	**68,488**	**88,531**
18,5	0	49,210	1,463	19,67	20,67	42,985	19,464	35,569	**50,673**	**138,358**	**189,031**
19	869,939	222,326	1,566	21,055	40,325	104,05	161,108	17,248	**1093,831**	**343,786**	**1437,617**
19,5	1384,013	378,101	2,292	30,831	43,013	184,077	432,952	18,865	**1764,406**	**709,738**	**2474,144**
20	2548,797	749,684	2,456	33,037	54,501	136,016	562,91	11,637	**3300,937**	**798,101**	**4099,038**
20,5	2775,624	906,601	0,64	8,609	45,922	103,08	696,219	2,924	**3682,865**	**856,754**	**4539,619**
21	1452,393	760,619	0,696	9,356	26,826	122,804	302,958	0	**2213,708**	**461,944**	**2675,652**
21,5	363,551	355,017	0,755	10,148	9,189	49,301	147,14	0	**719,323**	**215,778**	**935,101**
22	0	218,995	0,272	3,662	1,658	16,424	123,905	0	**219,267**	**145,649**	**364,916**
22,5	0	41,165	0,294	3,958	0	0	19,13	0	**41,459**	**23,088**	**64,547**
23	0	14,507	0	0	0	4,985	20,641	0	**14,507**	**25,626**	**40,133**
23,5	0	15,627	0	0	0	0	0	0	**15,627**	**0**	**15,627**
TOTAL	**17619,337**	**3742,879**	**28,000**	**376,579**	**2628,488**	**3273,059**	**2948,009**	**375,536**	**21390,216**	**9601,671**	**30991,887**

Table 8. *ECOCADIZ-RECLUTAS 2015-10* survey. Sardine (*S. pilchardus*). Estimated abundance (thousands of individuals) and biomass (tonnes) by age group. Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figures 11** and **12** and ordered from west to east.

Age class	POL01	POL02	POL03	POL04	POL05	POL06	POL07	POL08	PT	ES	TOTAL
	N	N	N	N	N	N	N	N	N	N	N
0	99063	14	1178	15845	118229	192067	37345	3574	134626	374709	509335
I	168125	7191	85	1146	12698	6636	5773	4733	154577	27548	182125
II	53063	17963	62	835	1417	4165	12848	959	70923	19470	90393
III	24746	9333	27	362	652	1992	6186	471	30500	8627	39128
IV	17059	7260	17	234	427	1395	4770	185	19858	5489	25347
V	5297	2602	6	87	142	460	1379	63	5933	1761	7694
VI	4249	2520	6	83	86	323	1461	10	4604	1456	6060
VII	561	778	1	18	16	81	436	2	701	232	933
VIII	0	166	0	3	1	12	94	0	29	16	45
TOTAL	372163	47828	1384	18613	133668	207132	70292	9999	421753	439308	861060

Age class	POL01	POL02	POL03	POL04	POL05	POL06	POL07	POL08	PT	ES	TOTAL
	B	B	B	B	B	B	B	B	B	B	B
0	3180	1	16	209	2136	2396	453	85	3903	4742	8645
I	6515	493	4	53	296	254	382	195	6181	1223	7404
II	3900	1379	4	56	99	297	965	54	4950	1329	6279
III	1894	735	2	25	47	146	475	26	2163	597	2761
IV	1322	595	1	17	31	106	379	11	1431	394	1825
V	426	219	0,5	6	11	36	114	4	426	127	554
VI	337	231	1	8	7	28	131	1	378	130	507
VII	44	74	0,1	2	1	7	41	0,1	56	20	75
VIII	0	17	0,02	0,3	0,1	1	10	0	3	2	5
TOTAL	17619	3743	28	377	2628	3273	2948	376	19491	8564	28055

Table 9. *ECOCADIZ-RECLUTAS* surveys series. Sardine (*S. pilchardus*). Acoustic estimates of biomass (t) and abundance (million fish) for the whole Gulf of Cadiz sardine population and for the juvenile fraction (*i.e*. age 0 fish, between parentheses). Because of the age-structured estimates from the 2012 and 2014 surveys are not still available, the recruit fraction in those years has been assumed as the one composed by fish with sizes ≤16.5 cm as a proxy for age 0 fish.

Estimate/Year	Total Population (Recruits at age 0 ≈ ≤16.5 cm)		
	2012	2014	2015
Biomass (t)	22119 (9675)	36571 (760)	30992 (8645)
Abundance (millions)	603 (377)	507 (29)	861 (509)

Table 10. *ECOCADIZ-RECLUTAS 2015-10* survey. 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 **Figures 14** and **15**.

***ECOCADIZ-RECLUTAS 2015-10*. *Scomber scombrus*. ABUNDANCE (in numbers and million fish)**										
Size class	**POL01**	**POL02**	**POL03**	**POL04**	***n***			**millions**		
					PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
21	0	0	0	0	0	0	0	**0**	**0**	**0**
21,5	318912	0	0	0	318912	0	318912	**0,3**	**0**	**0,3**
22	774502	0	0	0	774502	0	774502	**0,8**	**0**	**0,8**
22,5	341692	0	0	0	341692	0	341692	**0,3**	**0**	**0,3**
23	0	1280	0	0	1280	0	1280	**0,001**	**0**	**0,001**
23,5	0	0	0	0	0	0	0	**0**	**0**	**0**
24	0	0	0	0	0	0	0	**0**	**0**	**0**
24,5	68338	0	0	0	68338	0	68338	**0,07**	**0**	**0,07**
25	0	2561	0	0	2561	0	2561	**0,003**	**0**	**0,003**
25,5	0	1280	24101	59061	25381	59061	84442	**0,03**	**0,1**	**0,1**
26	0	2561	0	0	2561	0	2561	**0,003**	**0**	**0,003**
26,5	0	5122	28354	69484	33476	69484	102960	**0,03**	**0,07**	**0,1**
27	0	2561	0	0	2561	0	2561	**0,003**	**0**	**0,003**
27,5	0	7683	28354	69484	36037	69484	105521	**0,04**	**0,1**	**0,1**
28	0	2561	35797	87724	38358	87724	126082	**0,04**	**0,1**	**0,1**
28,5	0	1280	33316	81644	34596	81644	116240	**0,03**	**0,1**	**0,1**
29	0	2561	26582	65141	29143	65141	94284	**0,03**	**0,1**	**0,1**
29,5	0	3841	24101	59061	27942	59061	87003	**0,03**	**0,1**	**0,1**
30	0	1280	24101	59061	25381	59061	84442	**0,03**	**0,1**	**0,1**
30,5	0	1280	6025	14765	7305	14765	22070	**0,01**	**0,01**	**0,02**
31	0	2561	6025	14765	8586	14765	23351	**0,01**	**0,01**	**0,02**
31,5	0	3841	0	0	3841	0	3841	**0,004**	**0**	**0,004**
32	0	1280	25944	63578	27224	63578	90802	**0,03**	**0,1**	**0,1**
32,5	0	2561	32536	79733	35097	79733	114830	**0,04**	**0,1**	**0,1**
33	0	1280	44587	109264	45867	109264	155131	**0,05**	**0,1**	**0,2**
33,5	0	1280	14460	35437	15740	35437	51177	**0,02**	**0,04**	**0,1**
34	0	0	0	0	0	0	0	**0**	**0**	**0**
34,5	0	0	0	0	0	0	0	**0**	**0**	**0**
35	0	0	7230	17718	7230	17718	24948	**0,01**	**0,02**	**0,02**
35,5	0	0	0	0	0	0	0	**0**	**0**	**0**
TOTAL *n*	1503444	48654	361513	885920	1913611	885920	2799531	**2**	**1**	**3**
Millions	**2**	**0,05**	**0,4**	**1**						

Table 10. *ECOCADIZ-RECLUTAS 2015-10* survey. Mackerel (Scomber scombrus). Cont'd.

***ECOCADIZ-RECLUTAS 2015-10* . *Scomber scombrus* . BIOMASS (t)**							
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**PORTUGAL**	**SPAIN**	**TOTAL**
21	0	0	0	0	**0**	**0**	**0**
21,5	26,298	0	0	0	**26,298**	**0**	**26,298**
22	67,939	0	0	0	**67,939**	**0**	**67,939**
22,5	31,840	0	0	0	**31,840**	**0**	**31,840**
23	0	0,127	0	0	**0,127**	**0**	**0,127**
23,5	0	0	0	0	**0**	**0**	**0**
24	0	0	0	0	**0**	**0**	**0**
24,5	8,008	0	0	0	**8,008**	**0**	**8,008**
25	0	0,317	0	0	**0,317**	**0**	**0,317**
25,5	0	0,167	3,145	7,708	**3,312**	**7,708**	**11,020**
26	0	0,352	0	0	**0,352**	**0**	**0,352**
26,5	0	0,741	4,104	10,058	**4,845**	**10,058**	**14,903**
27	0	0,390	0	0	**0,390**	**0**	**0,390**
27,5	0	1,229	4,535	11,113	**5,764**	**11,113**	**16,877**
28	0	0,430	6,010	14,728	**6,440**	**14,728**	**21,168**
28,5	0	0,225	5,867	14,377	**6,092**	**14,377**	**20,469**
29	0	0,473	4,906	12,022	**5,379**	**12,022**	**17,401**
29,5	0	0,742	4,658	11,414	**5,400**	**11,414**	**16,814**
30	0	0,259	4,873	11,943	**5,132**	**11,943**	**17,075**
30,5	0	0,271	1,274	3,122	**1,545**	**3,122**	**4,667**
31	0	0,566	1,331	3,262	**1,897**	**3,262**	**5,159**
31,5	0	0,886	0	0	**0,886**	**0**	**0,886**
32	0	0,308	6,244	15,301	**6,552**	**15,301**	**21,853**
32,5	0	0,643	8,165	20,009	**8,808**	**20,009**	**28,817**
33	0	0,335	11,659	28,572	**11,994**	**28,572**	**40,566**
33,5	0	0,349	3,938	9,651	**4,287**	**9,651**	**13,938**
34	0	0	0	0	**0**	**0**	**0**
34,5	0	0	0	0	**0**	**0**	**0**
35	0	0	2,216	5,431	**2,216**	**5,431**	**7,647**
35,5	0	0	0	0	**0**	**0**	**0**
TOTAL	**134,085**	**8,810**	**72,925**	**178,711**	**215,820**	**178,711**	**394,531**

Table 11. *ECOCADIZ-RECLUTAS 2015-10* 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 **Figures 16** and **17**.

***ECOCADIZ-RECLUTAS 2015-10*. *Scomber colias*. ABUNDANCE (in numbers and million fish)**														
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	***n***			**millions**		
									PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
17	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
17,5	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
18	0	0	0	140489	0	0	0	0	140489	0	140489	**0,1**	**0**	**0,1**
18,5	0	377709	0	1123909	0	0	0	0	1501618	0	1501618	**2**	**0**	**2**
19	0	668205	0	1966841	0	0	0	0	2635046	0	2635046	**3**	**0**	**3**
19,5	0	1894121	0	4636126	0	0	0	0	6530247	0	6530247	**7**	**0**	**7**
20	0	3127907	0	6041012	0	0	46546	3518	9168919	50064	9218983	**9**	**0**	**9**
20,5	0	4204969	0	2247819	0	0	46546	3518	6452788	50064	6502852	**6**	**0**	**7**
21	4130	3735783	219980	2388307	4015	0	46546	3518	6348200	54079	6402279	**6**	**0**	**6**
21,5	0	1416083	72841	140489	0	0	186183	14070	1629413	200253	1829666	**2**	**0**	**2**
22	4130	957717	72841	1264398	4015	177207	232728	17588	2299086	431538	2730624	**2**	**0**	**3**
22,5	8259	215412	292821	1404887	8031	802643	186183	14070	1921379	1010927	2932306	**2**	**1**	**3**
23	0	287217	732781	842932	0	1428079	186183	14070	1862930	1628332	3491262	**2**	**2**	**3**
23,5	0	350168	1904064	140489	0	2011819	186183	14070	2394721	2212072	4606793	**2**	**2**	**5**
24	4130	565581	3222487	0	4015	1782492	46546	3518	3792198	1836571	5628769	**4**	**2**	**6**
24,5	20648	71804	2709686	0	20077	802643	139637	10553	2802138	972910	3775048	**3**	**1**	**4**
25	24778	104919	1831224	0	24092	312718	93091	7035	1960921	436936	2397857	**2**	**0**	**2**
25,5	20648	206560	1098443	0	20077	271022	186183	14070	1325651	491352	1817003	**1**	**0**	**2**
26	12389	62952	439960	0	12046	271022	139637	10553	515301	433258	948559	**1**	**0**	**1**
26,5	12389	0	219980	0	12046	177207	93091	7035	232369	289379	521748	**0**	**0**	**1**
27	8259	62952	0	0	8031	0	232728	17588	71211	258347	329558	**0**	**0**	**0**
27,5	0	0	147139	0	0	93815	279274	21106	147139	394195	541334	**0**	**0**	**1**
28	0	0	0	0	0	41696	139637	10553	0	191886	191886	**0**	**0**	**0**
28,5	0	71804	0	0	0	0	93091	7035	71804	100126	171930	**0**	**0**	**0**
29	0	0	0	0	0	0	93091	7035	0	100126	100126	**0**	**0**	**0**
29,5	4130	0	0	0	4015	0	93091	7035	4130	104141	108271	**0**	**0**	**0**
30	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
30,5	0	0	0	0	0	0	46546	3518	0	50064	50064	**0**	**0**	**0**
31	0	0	0	0	0	0	93091	7035	0	100126	100126	**0**	**0**	**0**
31,5	0	0	0	0	0	0	46546	3518	0	50064	50064	**0**	**0**	**0**
32	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
32,5	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
TOTAL *n*	123890	18381863	12964247	22337698	120460	8172363	2932378	221609	53807698	11446810	65254508	**54**	**11**	**65**
Millions	**0,1**	**18**	**13**	**22**	**0,1**	**8**	**3**	**0,2**						

Table 11. *ECOCADIZ-RECLUTAS 2015-10* survey. Chub mackerel (*Scomber colias*). Cont'd.

***ECOCADIZ-RECLUTAS 2015-10*. *Scomber colias*. BIOMASS (t)**											
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	**PORTUGAL**	**SPAIN**	**TOTAL**
17	0	0	0	0	0	0	0	0	**0**	**0**	**0**
17,5	0	0	0	0	0	0	0	0	**0**	**0**	**0**
18	0	0	0	6,062	0	0	0	0	**6,062**	**0**	**6,062**
18,5	0	17,849	0	53,111	0	0	0	0	**70,960**	**0**	**70,960**
19	0	34,501	0	101,552	0	0	0	0	**136,053**	**0**	**136,053**
19,5	0	106,613	0	260,949	0	0	0	0	**367,562**	**0**	**367,562**
20	0	191,513	0	369,875	0	0	2,850	0,215	**561,388**	**3,065**	**564,453**
20,5	0	279,486	0	149,403	0	0	3,094	0,234	**428,889**	**3,328**	**432,217**
21	0,297	269,018	15,841	171,985	0,289	0	3,352	0,253	**457,141**	**3,894**	**461,035**
21,5	0	110,276	5,672	10,940	0	0	14,499	1,096	**126,888**	**15,595**	**142,483**
22	0,347	80,510	6,123	106,292	0,338	14,897	19,564	1,479	**193,272**	**36,278**	**229,55**
22,5	0,748	19,515	26,528	127,274	0,728	72,714	16,867	1,275	**174,065**	**91,584**	**265,649**
23	0	27,995	71,425	82,161	0	139,196	18,147	1,371	**181,581**	**158,714**	**340,295**
23,5	0	36,665	199,368	14,710	0	210,651	19,495	1,473	**250,743**	**231,619**	**482,362**
24	0,464	63,522	361,925	0	0,451	200,196	5,228	0,395	**425,911**	**206,270**	**632,181**
24,5	2,484	8,638	325,97	0	2,415	96,556	16,798	1,269	**337,092**	**117,038**	**454,13**
25	3,188	13,500	235,632	0	3,100	40,239	11,978	0,905	**252,320**	**56,222**	**308,542**
25,5	2,838	28,392	150,984	0	2,760	37,253	25,591	1,934	**182,214**	**67,538**	**249,752**
26	1,817	9,231	64,517	0	1,766	39,744	20,477	1,547	**75,565**	**63,534**	**139,099**
26,5	1,936	0	34,374	0	1,882	27,690	14,546	1,099	**36,310**	**45,217**	**81,527**
27	1,374	10,469	0	0	1,336	0	38,704	2,925	**11,843**	**42,965**	**54,808**
27,5	0	0	26,014	0	0	16,587	49,376	3,732	**26,014**	**69,695**	**95,709**
28	0	0	0	0	0	7,829	26,217	1,981	**0**	**36,027**	**36,027**
28,5	0	14,302	0	0	0	0	18,541	1,401	**14,302**	**19,942**	**34,244**
29	0	0	0	0	0	0	19,649	1,485	**0**	**21,134**	**21,134**
29,5	0,923	0	0	0	0,897	0	20,803	1,572	**0,923**	**23,272**	**24,195**
30	0	0	0	0	0	0	0	0	**0**	**0**	**0**
30,5	0	0	0	0	0	0	11,626	0,879	**0**	**12,505**	**12,505**
31	0	0	0	0	0	0	24,548	1,855	**0**	**26,403**	**26,403**
31,5	0	0	0	0	0	0	12,948	0,978	**0**	**13,926**	**13,926**
32	0	0	0	0	0	0	0	0	**0**	**0**	**0**
32,5	0	0	0	0	0	0	0	0	**0**	**0**	**0**
TOTAL	**16,416**	**1321,995**	**1524,373**	**1454,314**	**15,962**	**903,552**	**414,898**	**31,353**	**4317,098**	**1365,765**	**5682,863**

Table 12. *ECOCADIZ-RECLUTAS 2015-10* survey. Blue jack mackerel (*Trachurus picturatus*). 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 **Figures 18** and **19**.

***ECOCADIZ-RECLUTAS 2015-10*. *Trachurus picturatus*. ABUNDANCE (in numbers and million fish)**										
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	***n***		**millions**	
							PORTUGAL	**TOTAL**	**PORTUGAL**	**TOTAL**
10	0	0	0	0	0	0	0	0	**0**	**0**
10,5	0	0	0	0	0	0	0	0	**0**	**0**
11	0	0	0	2878	0	0	2878	2878	**0,003**	**0,003**
11,5	0	0	0	0	0	0	0	0	**0**	**0**
12	0	0	0	0	0	0	0	0	**0**	**0**
12,5	0	0	0	0	0	0	0	0	**0**	**0**
13	0	0	555987	0	0	0	555987	555987	**1**	**1**
13,5	0	0	1149040	0	0	0	1149040	1149040	**1**	**1**
14	0	115486	4596163	0	0	0	4711649	4711649	**5**	**5**
14,5	0	375330	8599272	0	0	0	8974602	8974602	**9**	**9**
15	11590	0	7450231	0	0	0	7461821	7461821	**7**	**7**
15,5	0	490817	4003109	0	7620	0	4501546	4501546	**5**	**5**
16	0	721789	3447122	0	0	158759	4327670	4327670	**4**	**4**
16,5	0	1328092	1705028	0	7620	317518	3358258	3358258	**3**	**3**
17	0	952762	2854069	0	15240	1111314	4933385	4933385	**5**	**5**
17,5	0	1443578	4855623	0	24130	793796	7117127	7117127	**7**	**7**
18	0	2425211	4596163	0	24130	317518	7363022	7363022	**7**	**7**
18,5	0	2049881	6301191	0	46990	635037	9033099	9033099	**9**	**9**
19	3863	1443578	4003109	0	133349	476278	6060177	6060177	**6**	**6**
19,5	0	3147001	2594608	0	234948	1587592	7564149	7564149	**8**	**8**
20	15453	3262487	1445567	0	243838	2381388	7348733	7348733	**7**	**7**
20,5	57948	2887156	852514	0	251458	3016424	7065500	7065500	**7**	**7**
21	127487	3753304	0	2878	172719	2222629	6279017	6279017	**6**	**6**
21,5	224067	2049881	1149040	0	172719	1111314	4707021	4707021	**5**	**5**
22	247247	1818909	296527	8635	62229	1428833	3862380	3862380	**4**	**4**
22,5	200888	606303	555987	28784	71119	158759	1621840	1621840	**2**	**2**
23	115897	375330	0	5757	101599	158759	757342	757342	**1**	**1**
23,5	131350	606303	296527	11514	39370	0	1085064	1085064	**1**	**1**
24	38632	490817	0	11514	15240	0	556203	556203	**1**	**1**
24,5	57948	230973	0	11514	7620	0	308055	308055	**0**	**0**
25	50222	115486	0	8635	15240	0	189583	189583	**0**	**0**
25,5	34769	0	0	5757	0	0	40526	40526	**0**	**0**
26	0	115486	0	0	0	0	115486	115486	**0**	**0**
26,5	0	0	0	0	0	0	0	0	**0**	**0**
27	0	0	0	0	0	0	0	0	**0**	**0**
27,5	0	0	0	2878	0	0	2878	2878	**0**	**0**
28	0	0	0	0	0	0	0	0	**0**	**0**
28,5	0	0	0	0	0	0	0	0	**0**	**0**
TOTAL *n*	1317361	30805960	61306877	100744	1647178	15875918	111054038	111054038	**111**	**111**
Millions	**1**	**31**	**61**	**0,1**	**2**	**16**				

Table 12. *ECOCADIZ-RECLUTAS 2015-10* survey. Blue jack mackerel (*Trachurus picturatus*). Cont'd.

***ECOCADIZ-RECLUTAS 2015-10*. *Trachurus picturatus*. BIOMASS (t)**								
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**PORTUGAL**	**TOTAL**
10	0	0	0	0	0	0	**0**	**0**
10,5	0	0	0	0	0	0	**0**	**0**
11	0	0	0	0,029	0	0	**0,029**	**0,029**
11,5	0	0	0	0	0	0	**0**	**0**
12	0	0	0	0	0	0	**0**	**0**
12,5	0	0	0	0	0	0	**0**	**0**
13	0	0	9,399	0	0	0	**9,399**	**9,399**
13,5	0	0	21,879	0	0	0	**21,879**	**21,879**
14	0	2,466	98,153	0	0	0	**100,619**	**100,619**
14,5	0	8,954	205,149	0	0	0	**214,103**	**214,103**
15	0,308	0	197,822	0	0	0	**198,13**	**198,13**
15,5	0	14,455	117,896	0	0,224	0	**132,575**	**132,575**
16	0	23,502	112,24	0	0	5,169	**140,911**	**140,911**
16,5	0	47,664	61,192	0	0,273	11,395	**120,524**	**120,524**
17	0	37,581	112,578	0	0,601	43,835	**194,595**	**194,595**
17,5	0	62,414	209,936	0	1,043	34,320	**307,713**	**307,713**
18	0	114,640	217,262	0	1,141	15,009	**348,052**	**348,052**
18,5	0	105,686	324,87	0	2,423	32,741	**465,720**	**465,720**
19	0,217	80,991	224,591	0	7,481	26,721	**340,001**	**340,001**
19,5	0	191,715	158,063	0	14,313	96,716	**460,807**	**460,807**
20	1,020	215,367	95,427	0	16,097	157,203	**485,114**	**485,114**
20,5	4,137	206,121	60,863	0	17,952	215,350	**504,423**	**504,423**
21	9,825	289,252	0	0,222	13,311	171,289	**483,899**	**483,899**
21,5	18,607	170,227	95,419	0	14,343	92,286	**390,882**	**390,882**
22	22,087	162,485	26,489	0,771	5,559	127,639	**345,030**	**345,030**
22,5	19,273	58,168	53,341	2,762	6,823	15,231	**155,598**	**155,598**
23	11,923	38,613	0	0,592	10,452	16,333	**77,913**	**77,913**
23,5	14,469	66,786	32,663	1,268	4,337	0	**119,523**	**119,523**
24	4,550	57,806	0	1,356	1,795	0	**65,507**	**65,507**
24,5	7,287	29,046	0	1,448	0,958	0	**38,739**	**38,739**
25	6,735	15,486	0	1,158	2,044	0	**25,423**	**25,423**
25,5	4,965	0	0	0,822	0	0	**5,787**	**5,787**
26	0	17,544	0	0	0	0	**17,544**	**17,544**
26,5	0	0	0	0	0	0	**0**	**0**
27	0	0	0	0	0	0	**0**	**0**
27,5	0	0	0	0,523	0	0	**0,523**	**0,523**
28	0	0	0	0	0	0	**0**	**0**
28,5	0	0	0	0	0	0	**0**	**0**
TOTAL	**125,403**	**2016,969**	**2435,232**	**10,951**	**121,170**	**1061,237**	**5770,962**	**5770,962**

Table 13. *ECOCADIZ-RECLUTAS 2015-10* survey. Horse mackerel (*Trachurus trachurus*). 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 **Figures 20** and **21**.

***ECOCADIZ-RECLUTAS 2015-10* . *Trachurus trachurus* . ABUNDANCE (in numbers and million fish)**													
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	***n***			**millions**		
								PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
4	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
4,5	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
5	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
5,5	0	0	0	6815	9500	0	7834	6815	17334	24149	**0,01**	**0,02**	**0,02**
6	0	0	0	6815	9500	0	7834	6815	17334	24149	**0,01**	**0,02**	**0,02**
6,5	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**
7,5	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**
8,5	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
9	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
9,5	0	0	0	3408	4750	0	3917	3408	8667	12075	**0,003**	**0,01**	**0,01**
10	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
10,5	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
11	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
11,5	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
12	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
12,5	0	0	7607	20445	28500	0	23502	28052	52002	80054	**0,03**	**0,05**	**0,1**
13	104857	0	15214	6815	9500	0	7834	126886	17334	144220	**0,1**	**0,02**	**0,1**
13,5	0	0	7607	27261	38000	0	31336	34868	69336	104204	**0,03**	**0,1**	**0,1**
14	0	0	7607	30668	42750	0	35253	38275	78003	116278	**0,04**	**0,1**	**0,1**
14,5	0	0	0	9087	12667	0	10445	9087	23112	32199	**0,01**	**0,02**	**0,03**
15	0	0	15214	0	0	0	0	15214	0	15214	**0,02**	**0**	**0,02**
15,5	0	0	0	9087	12667	0	10445	9087	23112	32199	**0,01**	**0,02**	**0,03**
16	0	0	7607	9087	12667	0	10445	16694	23112	39806	**0,02**	**0,02**	**0,04**
16,5	52428	0	0	0	0	0	0	52428	0	52428	**0,05**	**0**	**0,05**
17	52428	0	0	0	0	0	0	52428	0	52428	**0,05**	**0**	**0,05**
17,5	157285	0	7607	0	0	0	0	164892	0	164892	**0,2**	**0**	**0,2**
18	157285	0	15214	0	0	0	0	172499	0	172499	**0,2**	**0**	**0,2**
18,5	209714	0	7607	0	0	0	0	217321	0	217321	**0,2**	**0**	**0,2**
19	104857	0	0	0	0	0	0	104857	0	104857	**0,1**	**0**	**0,1**
19,5	419427	0	0	0	0	49117	0	419427	49117	468544	**0,4**	**0,05**	**0,5**
20	419427	0	0	0	0	0	0	419427	0	419427	**0,4**	**0,00**	**0,4**
20,5	524284	0	0	0	0	49117	0	524284	49117	573401	**0,5**	**0,05**	**1**
21	314570	0	7607	0	0	98233	0	322177	98233	420410	**0,3**	**0,10**	**0,4**
21,5	681569	0	7607	0	0	0	0	689176	0	689176	**1**	**0,00**	**1**
22	733998	0	52684	0	0	0	0	786682	0	786682	**1**	**0,00**	**1**
22,5	524284	0	116423	3408	4750	0	3917	644115	8667	652782	**1**	**0,01**	**1**
23	366999	2977	226369	3408	4750	0	3917	599753	8667	608420	**1**	**0,01**	**1**
23,5	314570	11906	356381	0	0	0	0	682857	0	682857	**1**	**0**	**1**
24	524284	14883	363988	0	0	0	0	903155	0	903155	**1**	**0**	**1**
24,5	262142	23812	229818	0	0	0	0	515772	0	515772	**0,5**	**0**	**0,5**
25	104857	50601	104803	0	0	0	0	260261	0	260261	**0,3**	**0**	**0,3**
25,5	104857	35718	25285	0	0	0	0	165860	0	165860	**0,2**	**0**	**0,2**
26	0	14883	7607	0	0	0	0	22490	0	22490	**0,02**	**0**	**0,02**
26,5	0	11906	7607	0	0	0	0	19513	0	19513	**0,02**	**0**	**0,02**
27	0	20836	15214	0	0	0	0	36050	0	36050	**0,04**	**0**	**0,04**
27,5	0	2977	0	0	0	0	0	2977	0	2977	**0,003**	**0**	**0,003**
28	0	17859	0	0	0	0	0	17859	0	17859	**0,02**	**0**	**0,02**
28,5	0	0	7607	0	0	0	0	7607	0	7607	**0,01**	**0**	**0,01**
29	0	0	7607	0	0	0	0	7607	0	7607	**0,01**	**0**	**0,01**
29,5	0	5953	0	0	0	0	0	5953	0	5953	**0,01**	**0**	**0,01**
30	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
30,5	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
TOTAL *n*	6134122	214311	1627891	136304	190001	196467	156679	8112628	543147	8655775	**8**	**1**	**9**
Millions	**6**	**0,2**	**2**	**0,1**	**0,2**	**0,2**	**0,2**						

Table 13. *ECOCADIZ-RECLUTAS 2015-10* survey. Horse mackerel (*Trachurus trachurus*). Cont'd.

***ECOCADIZ-RECLUTAS 2015-10*. *Trachurus trachurus*. BIOMASS (t)**										
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**PORTUGAL**	**SPAIN**	**TOTAL**
4	0	0	0	0	0	0	0	**0**	**0**	**0**
4,5	0	0	0	0	0	0	0	**0**	**0**	**0**
5	0	0	0	0	0	0	0	**0**	**0**	**0**
5,5	0	0	0	0,010	0,014	0	0,011	**0,010**	**0,025**	**0,035**
6	0	0	0	0,013	0,018	0	0,015	**0,013**	**0,033**	**0,046**
6,5	0	0	0	0	0	0	0	**0**	**0**	**0**
7	0	0	0	0	0	0	0	**0**	**0**	**0**
7,5	0	0	0	0	0	0	0	**0**	**0**	**0**
8	0	0	0	0	0	0	0	**0**	**0**	**0**
8,5	0	0	0	0	0	0	0	**0**	**0**	**0**
9	0	0	0	0	0	0	0	**0**	**0**	**0**
9,5	0	0	0	0,025	0,034	0	0,028	**0,025**	**0,062**	**0,087**
10	0	0	0	0	0	0	0	**0**	**0**	**0**
10,5	0	0	0	0	0	0	0	**0**	**0**	**0**
11	0	0	0	0	0	0	0	**0**	**0**	**0**
11,5	0	0	0	0	0	0	0	**0**	**0**	**0**
12	0	0	0	0	0	0	0	**0**	**0**	**0**
12,5	0	0	0,126	0,337	0,470	0	0,388	**0,463**	**0,858**	**1,321**
13	1,948	0	0,283	0,127	0,176	0	0,145	**2,358**	**0,321**	**2,679**
13,5	0	0	0,158	0,567	0,791	0	0,652	**0,725**	**1,443**	**2,168**
14	0	0	0,177	0,712	0,992	0	0,818	**0,889**	**1,81**	**2,699**
14,5	0	0	0	0,234	0,327	0	0,270	**0,234**	**0,597**	**0,831**
15	0	0	0,435	0	0	0	0	**0,435**	**0**	**0,435**
15,5	0	0	0	0	0,400	0	0,330	**0,287**	**0,730**	**1,017**
16	0	0	0,264	0,316	0,440	0	0,363	**0,580**	**0,803**	**1,383**
16,5	1,998	0	0	0	0	0	0	**1,998**	**0**	**1,998**
17	2,187	0	0	0	0	0	0	**2,187**	**0**	**2,187**
17,5	7,161	0	0,346	0	0	0	0	**7,507**	**0**	**7,507**
18	7,798	0	0,754	0	0	0	0	**8,552**	**0**	**8,552**
18,5	11,296	0	0,410	0	0	0	0	**11,706**	**0**	**11,706**
19	6,123	0	0	0	0	0	0	**6,123**	**0**	**6,123**
19,5	26,494	0	0	0	0	3,103	0	**26,494**	**3,103**	**29,597**
20	28,605	0	0	0	0	0	0	**28,605**	**0**	**28,605**
20,5	38,534	0	0	0	0	3,610	0	**38,534**	**3,610**	**42,144**
21	24,872	0	0,601	0	0	7,767	0	**25,473**	**7,767**	**33,24**
21,5	57,873	0	0,646	0	0	0	0	**58,519**	**0**	**58,519**
22	66,824	0	4,796	0	0	0	0	**71,62**	**0**	**71,62**
22,5	51,097	0	11,347	0,332	0,463	0	0,382	**62,776**	**0,845**	**63,621**
23	38,234	0,310	23,583	0,355	0,495	0	0,408	**62,482**	**0,903**	**63,385**
23,5	34,982	1,324	39,631	0	0	0	0	**75,937**	**0**	**75,937**
24	62,150	1,764	43,148	0	0	0	0	**107,062**	**0**	**107,062**
24,5	33,082	3,005	29,003	0	0	0	0	**65,09**	**0**	**65,09**
25	14,070	6,790	14,063	0	0	0	0	**34,923**	**0**	**34,923**
25,5	14,942	5,090	3,603	0	0	0	0	**23,635**	**0**	**23,635**
26	0	2,250	1,150	0	0	0	0	**3,400**	**0**	**3,400**
26,5	0	1,907	1,218	0	0	0	0	**3,125**	**0**	**3,125**
27	0	3,532	2,579	0	0	0	0	**6,111**	**0**	**6,111**
27,5	0	0,534	0	0	0	0	0	**0,534**	**0**	**0,534**
28	0	3,381	0	0	0	0	0	**3,381**	**0**	**3,381**
28,5	0	0	1,52	0	0	0	0	**1,520**	**0**	**1,520**
29	0	0	1,602	0	0	0	0	**1,602**	**0**	**1,602**
29,5	0	1,321	0	0	0	0	0	**1,321**	**0**	**1,321**
30	0	0	0	0	0	0	0	**0**	**0**	**0**
30,5	0	0	0	0	0	0	0	**0**	**0**	**0**
TOTAL	**530,270**	**31,208**	**181,443**	**3,315**	**4,620**	**14,480**	**3,810**	**746,236**	**22,910**	**769,146**

Table 14. *ECOCADIZ-RECLUTAS 2015-10* 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 **Figures 22** and **23**.

***ECOCADIZ-RECLUTAS 2015-10*. *Trachurus mediterraneus*. ABUNDANCE (in numbers and million fish)**							
Size class	**POL01**	**POL02**	**POL03**	***n***		**millions**	
				SPAIN	**TOTAL**	**SPAIN**	**TOTAL**
25	0	0	0	0	0	**0**	**0**
25,5	0	0	0	0	0	**0**	**0**
26	1875	5055	592324	599254	599254	**1**	**1**
26,5	2812	7582	888486	898880	898880	**1**	**1**
27	6093	16428	1925052	1947573	1947573	**2**	**2**
27,5	14060	37911	4442428	4494399	4494399	**4**	**4**
28	18747	50548	5923237	5992532	5992532	**6**	**6**
28,5	10779	29065	3405861	3445705	3445705	**3**	**3**
29	8436	22746	2665457	2696639	2696639	**3**	**3**
29,5	6093	16428	1925052	1947573	1947573	**2**	**2**
30	3749	10110	1184648	1198507	1198507	**1**	**1**
30,5	2812	7582	888486	898880	898880	**1**	**1**
31	1875	5055	592324	599254	599254	**1**	**1**
31,5	469	1264	148081	149814	149814	**0,1**	**0,1**
32	469	1264	148081	149814	149814	**0,1**	**0,1**
32,5	469	1264	148081	149814	149814	**0,1**	**0,1**
33	0	0	0	0	0	**0**	**0**
33,5	0	0	0	0	0	**0**	**0**
TOTAL *n*	78738	212302	24877598	25168638	25168638	**25**	**25**
Millions	**0,1**	**0,2**	**25**				

***ECOCADIZ-RECLUTAS 2015-10*. *Trachurus mediterraneus*. BIOMASS (t)**					
Size class	**POL01**	**POL02**	**POL03**	**SPAIN**	**TOTAL**
25	0	0	0	**0**	**0**
25,5	0	0	0	**0**	**0**
26	0,267	0,721	84,480	**85,468**	**85,468**
26,5	0,426	1,148	134,484	**136,058**	**136,058**
27	0,978	2,636	308,896	**312,510**	**312,510**
27,5	2,389	6,442	754,881	**763,712**	**763,712**
28	3,370	9,087	1064,783	**1077,240**	**1077,240**
28,5	2,048	5,522	647,059	**654,629**	**654,629**
29	1,692	4,563	534,675	**540,930**	**540,930**
29,5	1,289	3,476	407,344	**412,109**	**412,109**
30	0,836	2,255	264,194	**267,285**	**267,285**
30,5	0,660	1,781	208,653	**211,094**	**211,094**
31	0,463	1,249	146,356	**148,068**	**148,068**
31,5	0,122	0,328	38,466	**38,916**	**38,916**
32	0,128	0,345	40,408	**40,881**	**40,881**
32,5	0,134	0,362	42,416	**42,912**	**42,912**
33	0	0	0	**0**	**0**
33,5	0	0	0	**0**	**0**
TOTAL	**14,802**	**39,915**	**4677,095**	**4731,812**	**4731,812**

Table 15. *ECOCADIZ-RECLUTAS 2015-10* survey. Bogue (*Boops boops*). 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 **Figures 24** and **25**.

***ECOCADIZ-RECLUTAS 2015-10*. *Boops boops*. ABUNDANCE (in numbers and million fish)**										
Size class	**POL01**	**POL02**	**POL03**	**POL04**	***n***			**millions**		
					PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
19	0	0	0	0	0	0	0	**0**	**0**	**0**
19,5	0	0	0	0	0	0	0	**0**	**0**	**0**
20	42	38	43	8637	123	8637	8760	**0,0001**	**0,01**	**0,01**
20,5	104	95	107	21593	306	21593	21899	**0,0003**	**0,02**	**0,02**
21	42	38	43	8637	123	8637	8760	**0,0001**	**0,01**	**0,01**
21,5	42	38	43	8637	123	8637	8760	**0,0001**	**0,01**	**0,01**
22	187	171	192	38868	550	38868	39418	**0,001**	**0,04**	**0,04**
22,5	229	209	234	47505	672	47505	48177	**0,001**	**0,05**	**0,05**
23	770	702	789	159791	2261	159791	162052	**0,002**	**0,2**	**0,2**
23,5	21	19	21	4319	61	4319	4380	**0,0001**	**0,004**	**0,004**
24	21	19	21	4319	61	4319	4380	**0,0001**	**0,004**	**0,004**
24,5	229	209	234	47505	672	47505	48177	**0,001**	**0,05**	**0,05**
25	146	133	149	30231	428	30231	30659	**0,0004**	**0,03**	**0,03**
25,5	62	57	64	12956	183	12956	13139	**0,0002**	**0,01**	**0,01**
26	62	57	64	12956	183	12956	13139	**0,0002**	**0,01**	**0,01**
26,5	21	19	21	4319	61	4319	4380	**0,0001**	**0,004**	**0,004**
27	21	19	21	4319	61	4319	4380	**0,0001**	**0,004**	**0,004**
27,5	0	0	0	0	0	0	0	**0**	**0**	**0**
28	0	0	0	0	0	0	0	**0**	**0**	**0**
28,5	125	114	128	25912	367	25912	26279	**0,0004**	**0,03**	**0,03**
29	312	285	320	64780	917	64780	65697	**0,001**	**0,1**	**0,07**
29,5	187	171	192	38868	550	38868	39418	**0,001**	**0,04**	**0,04**
30	0	0	0	0	0	0	0	**0**	**0**	**0**
30,5	0	0	0	0	0	0	0	**0**	**0**	**0**
TOTAL *n*	2623	2393	2686	544152	7702	544152	551854	**0,01**	**0,5**	**0,6**
Millions	**0,003**	**0,002**	**0,003**	**0,5**						

Table 15. *ECOCADIZ-RECLUTAS 2015-10* survey. Bogue (*Boops boops*). Cont'd.

***ECOCADIZ-RECLUTAS 2015-10* . *Boops boops* . BIOMASS (t)**							
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**PORTUGAL**	**SPAIN**	**TOTAL**
19	0	0	0	0	**0**	**0**	**0**
19,5	0	0	0	0	**0**	**0**	**0**
20	0,003	0,003	0,003	0,648	**0,009**	**0,648**	**0,657**
20,5	0,008	0,008	0,009	1,758	**0,025**	**1,758**	**1,783**
21	0,004	0,003	0,004	0,761	**0,011**	**0,761**	**0,772**
21,5	0,004	0,004	0,004	0,823	**0,012**	**0,823**	**0,835**
22	0,019	0,018	0,020	3,995	**0,057**	**3,995**	**4,052**
22,5	0,025	0,023	0,026	5,260	**0,074**	**5,260**	**5,334**
23	0,092	0,084	0,094	19,02	**0,270**	**19,02**	**19,294**
23,5	0,003	0,002	0,003	0,552	**0,008**	**0,552**	**0,560**
24	0,003	0,003	0,003	0,592	**0,009**	**0,592**	**0,601**
24,5	0,034	0,031	0,034	6,970	**0,099**	**6,97**	**7,069**
25	0,023	0,021	0,023	4,742	**0,067**	**4,742**	**4,809**
25,5	0,010	0,010	0,011	2,170	**0,031**	**2,170**	**2,201**
26	0,011	0,010	0,011	2,314	**0,032**	**2,314**	**2,346**
26,5	0,004	0,004	0,004	0,822	**0,012**	**0,822**	**0,834**
27	0,004	0,004	0,004	0,874	**0,012**	**0,874**	**0,886**
27,5	0	0	0	0	**0**	**0**	**0**
28	0	0	0	0	**0**	**0**	**0**
28,5	0,030	0,028	0,031	6,272	**0,089**	**6,272**	**6,361**
29	0,080	0,073	0,082	16,610	**0,235**	**16,61**	**16,845**
29,5	0,051	0,046	0,052	10,547	**0,149**	**10,55**	**10,696**
30	0	0	0	0	**0**	**0**	**0**
30,5	0	0	0	0	**0**	**0**	**0**
TOTAL	**0,408**	**0,375**	**0,418**	**84,734**	**1,201**	**84,734**	**85,935**

Table 16. *ECOCADIZ-RECLUTAS 2015-10* survey. Blue whiting (*Micromesistius poutassou*). 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 **Figures 26** and **27**.

***ECOCADIZ-RECLUTAS 2015-10*. *Micromesistius poutassou*.**									
ABUNDANCE (in numbers and million fish)									
Size class	**POL01**	**POL02**	**POL03**	***n***			**millions**		
				PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
13	0	0	0	0	0	0	**0**	**0**	**0**
13,5	0	0	0	0	0	0	**0**	**0**	**0**
14	0	0	0	0	0	0	**0**	**0**	**0**
14,5	467	0	492	467	492	959	**0,0005**	**0,0005**	**0,001**
15	2054	77	2164	2131	2164	4295	**0,002**	**0,002**	**0,004**
15,5	3455	129	3639	3584	3639	7223	**0,004**	**0,004**	**0,01**
16	1999	75	2105	2074	2105	4179	**0,002**	**0,002**	**0,004**
16,5	734	28	773	762	773	1535	**0,001**	**0,001**	**0,002**
17	332	12	349	344	349	693	**0,0003**	**0,0003**	**0,001**
17,5	0	0	0	0	0	0	**0**	**0**	**0**
18	0	0	0	0	0	0	**0**	**0**	**0**
18,5	0	0	0	0	0	0	**0**	**0**	**0**
TOTAL *n*	9041	321	9522	9362	9522	18884	**0,01**	**0,01**	**0,02**
Millions	**0,01**	**0,0003**	**0,01**						

***ECOCADIZ-RECLUTAS 2015-10*. *Micromesistius poutassou*. BIOMASS (t)**						
Size class	**POL01**	**POL02**	**POL03**	**PORTUGAL**	**SPAIN**	**TOTAL**
13	0	0	0	**0**	**0**	**0**
13,5	0	0	0	**0**	**0**	**0**
14	0	0	0	**0**	**0**	**0**
14,5	0,008	0	0,008	**0,008**	**0,008**	**0,016**
15	0,038	0,001	0,040	**0,039**	**0,040**	**0,079**
15,5	0,070	0,003	0,074	**0,073**	**0,074**	**0,147**
16	0,045	0,002	0,047	**0,047**	**0,047**	**0,094**
16,5	0,018	0,001	0,019	**0,019**	**0,019**	**0,038**
17	0,009	0	0,009	**0,009**	**0,009**	**0,018**
17,5	0	0	0	**0**	**0**	**0**
18	0	0	0	**0**	**0**	**0**
18,5	0	0	0	**0**	**0**	**0**
TOTAL	**0,188**	**0,007**	**0,197**	**0,195**	**0,197**	**0,392**

Table 17. *ECOCADIZ-RECLUTAS 2015-10* survey. Boarfish (*Capros aper*). 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 **Figures 28** and **29**.

***ECOCADIZ-RECLUTAS 2015-10*. *Capros aper*.**					
ABUNDANCE (in numbers and million fish)					
Size class	**POL01**	***n***		**millions**	
		PORTUGAL	**TOTAL**	**PORTUGAL**	**TOTAL**
6	0	0	0	**0**	**0**
6,5	0	0	0	**0**	**0**
7	362525	362525	362525	**0,4**	**0,4**
7,5	0	0	0	**0**	**0**
8	0	0	0	**0**	**0**
8,5	362525	362525	362525	**0,4**	**0,4**
9	4033091	4033091	4033091	**4**	**4**
9,5	7341132	7341132	7341132	**7**	**7**
10	9176415	9176415	9176415	**9**	**9**
10,5	9176415	9176415	9176415	**9**	**9**
11	4033091	4033091	4033091	**4**	**4**
11,5	1472758	1472758	1472758	**1**	**1**
12	1110233	1110233	1110233	**1**	**1**
12,5	0	0	0	**0**	**0**
13	0	0	0	**0**	**0**
13,5	0	0	0	**0**	**0**
TOTAL *n*	37068185	37068185	37068185	**37**	**37**
Millions	**37**				

***ECOCADIZ-RECLUTAS 2015-10*.**			
***Capros aper*. BIOMASS (t)**			
Size class	**POL01**	**PORTUGAL**	**TOTAL**
6	0	**0**	**0**
6,5	0	**0**	**0**
7	2,858	**2,858**	**2,858**
7,5	0	**0**	**0**
8	0	**0**	**0**
8,5	4,934	**4,934**	**4,934**
9	64,498	**64,498**	**64,498**
9,5	136,789	**136,789**	**136,789**
10	197,708	**197,708**	**197,708**
10,5	227,029	**227,029**	**227,029**
11	113,861	**113,861**	**113,861**
11,5	47,174	**47,174**	**47,174**
12	40,136	**40,136**	**40,136**
12,5	0	**0**	**0**
13	0	**0**	**0**
13,5	0	**0**	**0**
TOTAL	**834,987**	**834,987**	**834,987**

Table 18. *ECOCADIZ-RECLUTAS* surveys series. Acoustic estimates of biomass and abundance for the assessed species. Estimates for the anchovy and sardine recruit fractions are also shown.

Estimate/Year	Anchovy (Age 0 recruits)			Sardine (Age 0 recruits; ≤16.5 cm in 2012-2014)			Chub mack			Mackerel		
	2012	2014	2015	2012	2014	2015	2012	2014	2015	2012	2014	2015
Biomass (t)	13680 (13354)	8113 (5131)	30827 (29219)	22119 (9675)	36571 (760)	30992 (8645)	11155	17471	5683	1136	22176	394
Abundance (millions)	2649 (2619)	986 (814)	5227 (5117)	603 (377)	507 (29)	861 (509)	157	148	65	11	137	3

Estimate/Year	Horse-mack.			Medit. h-mack.			Blue jack-mack.			Bogue		
	2012	2014	2015	2012	2014	2015	2012	2014	2015	2012	2014	2015
Biomass (t)	15873	3574	769	3375	37508	4732	976	539	5771	346	Not assessed	86
Abundance (millions)	1049	36	9	148	187	25	37	6	111	7	Not assessed	0.6

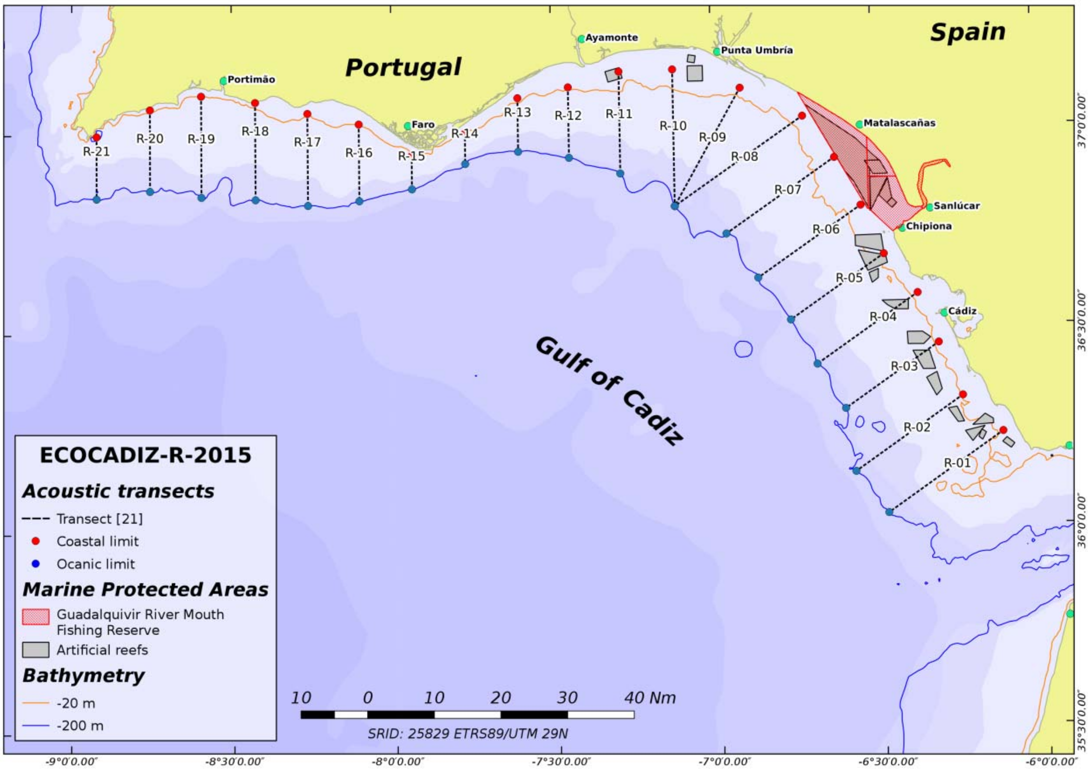


Figure 1. *ECOCADIZ-RECLUTAS 2015-10* survey. Location of the acoustic transects sampled during the survey. The different protected areas inside the Guadalquivir river mouth Fishing Reserve and artificial reef polygons are also shown.

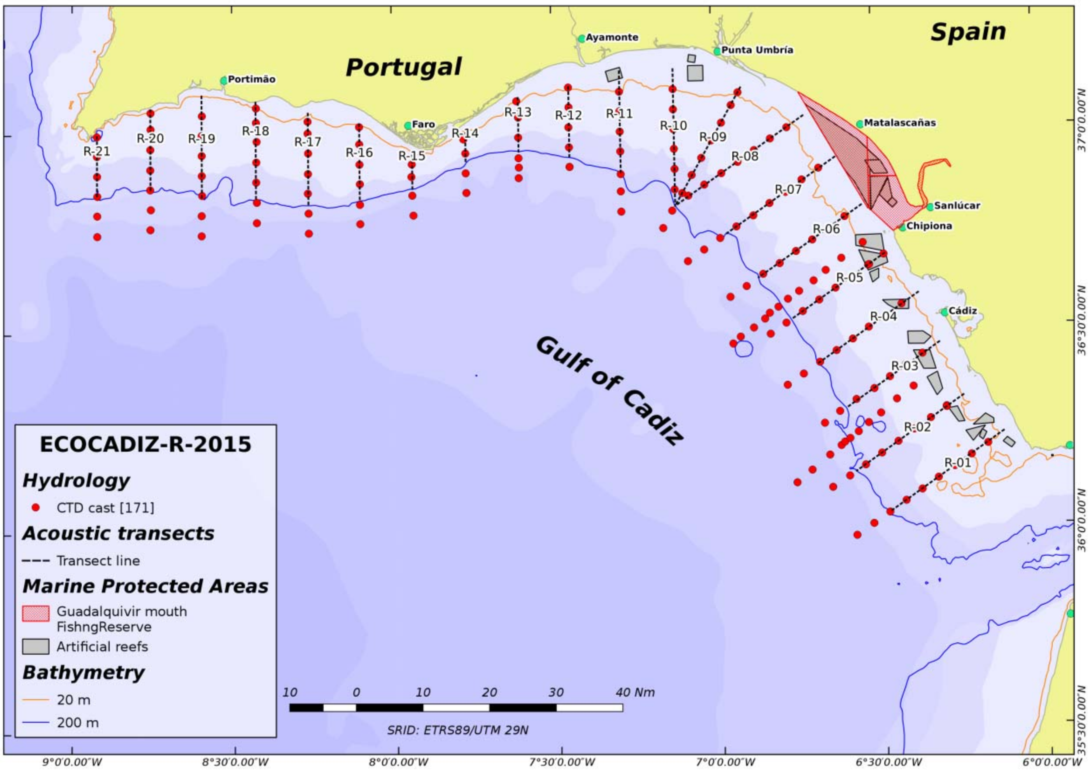


Figure 2. *ECOCADIZ-RECLUTAS 2015-10* survey. Location of CTD-LADCP stations.

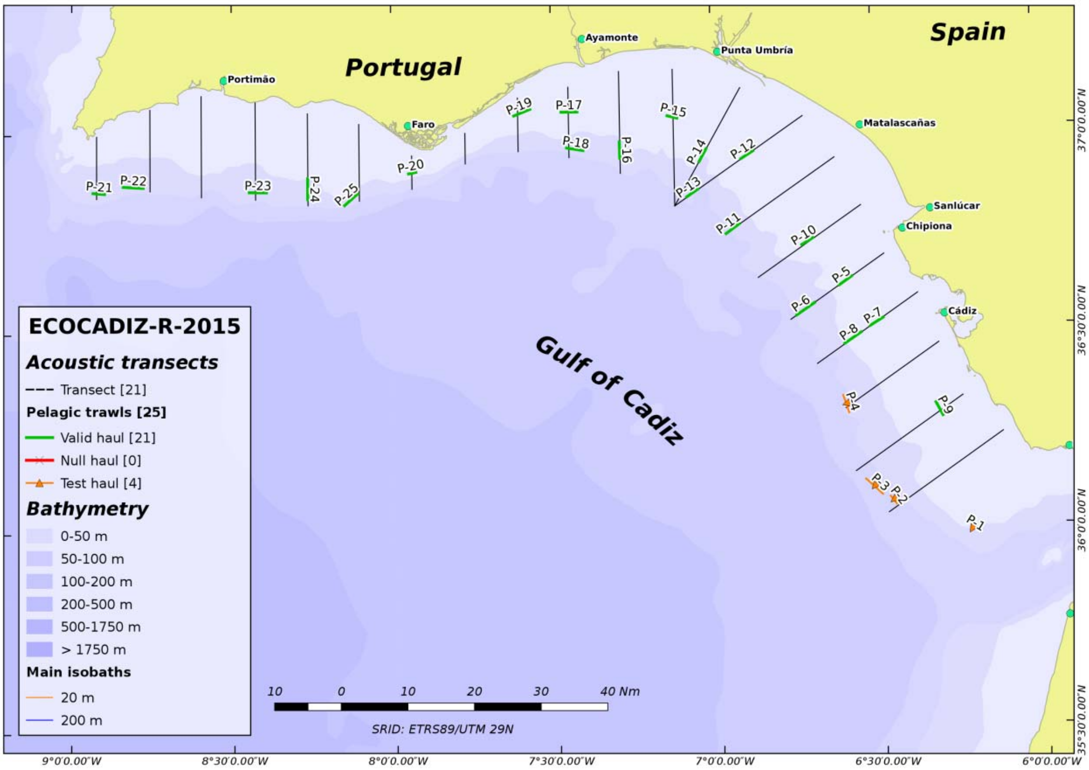


Figure 3. *ECOCADIZ-RECLUTAS 2015-10* survey. Location of groundtruthing fishing hauls. Null hauls in red.

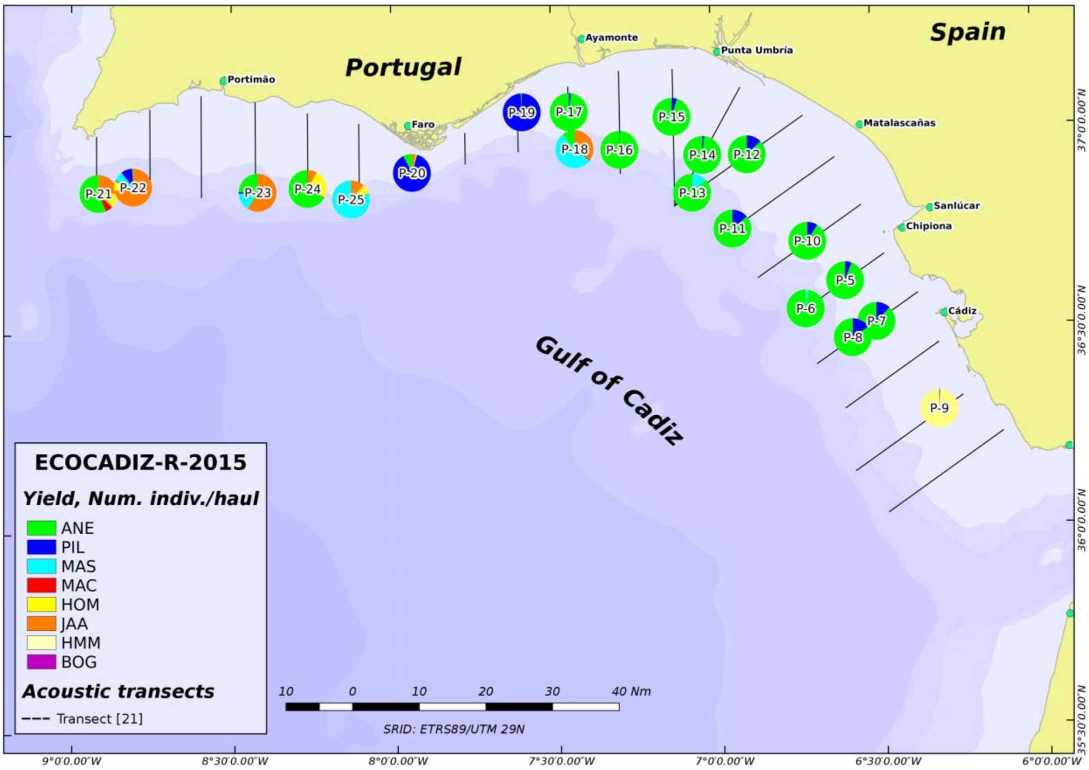


Figure 4. *ECOCADIZ-RECLUTAS 2015-10* survey. Species composition (percentages in number) in valid fishing hauls.

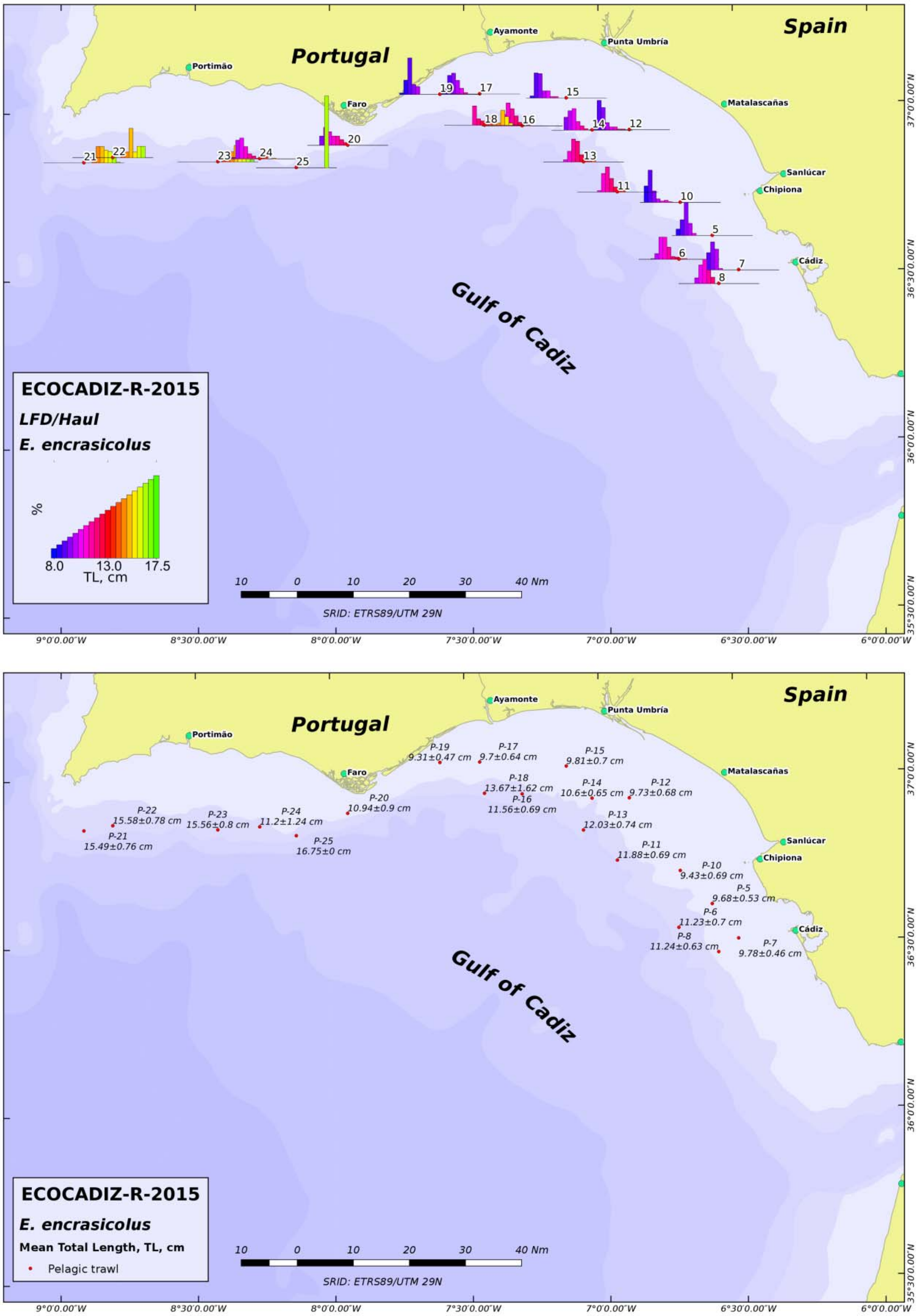


Figure 5. *ECOCADIZ-RECLUTAS 2015-10* survey. *Engraulis encrasicolus*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

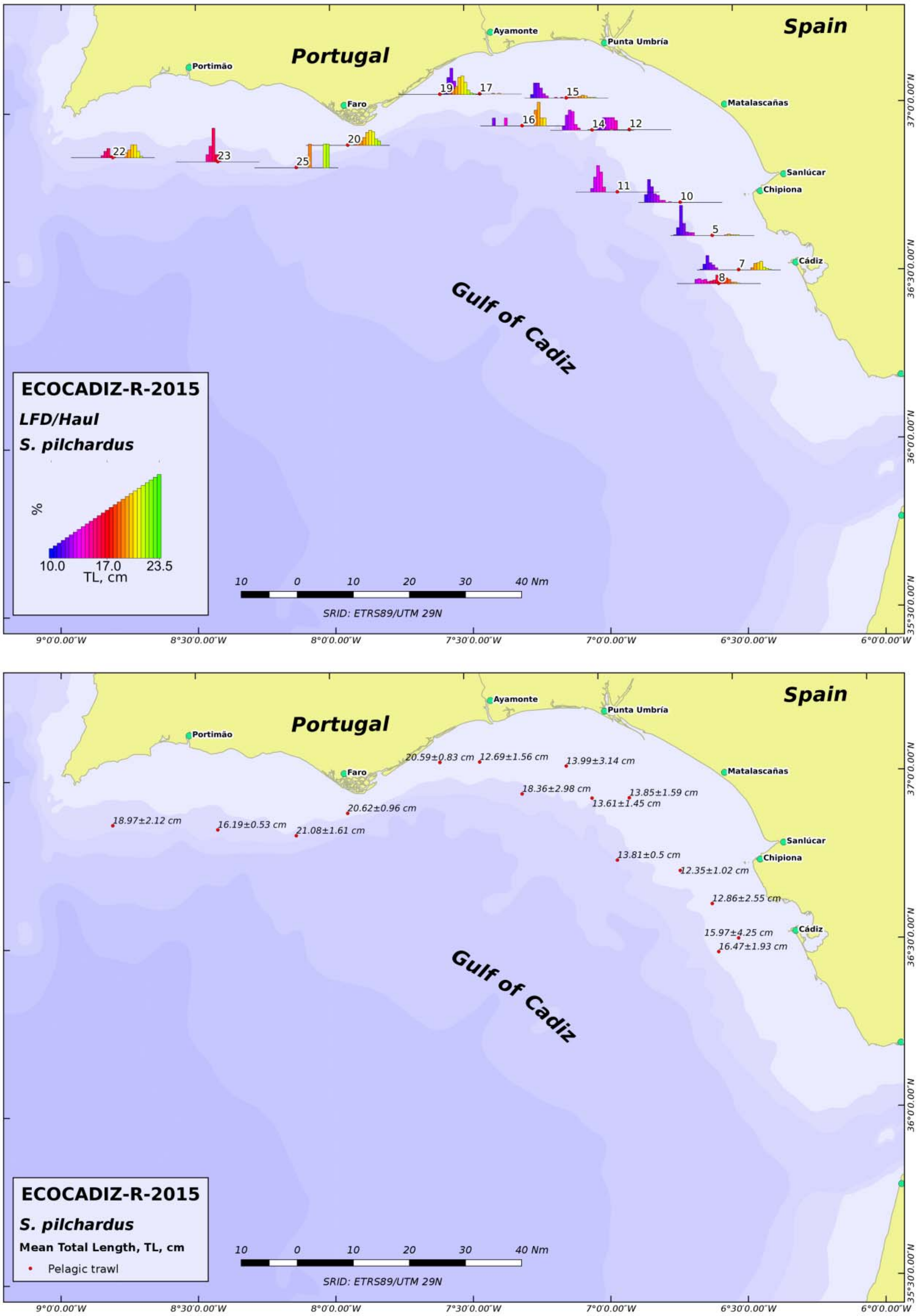


Figure 6. *ECOCADIZ-RECLUTAS 20154-10* survey. *Sardina pilchardus*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

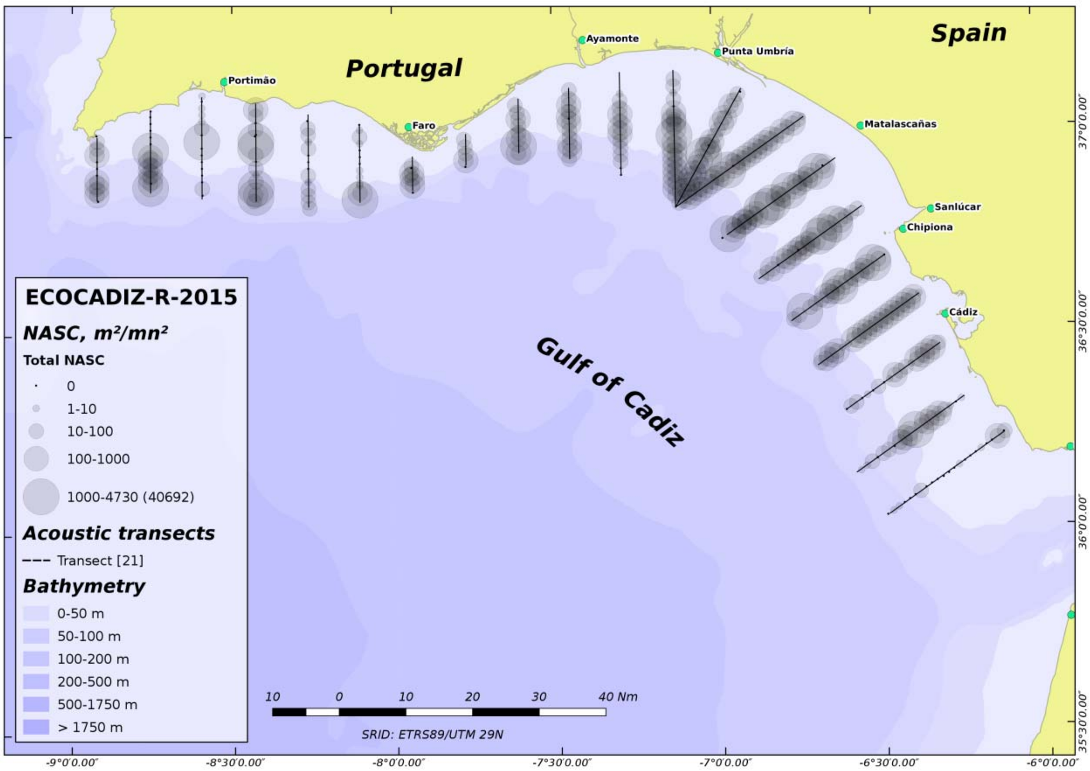
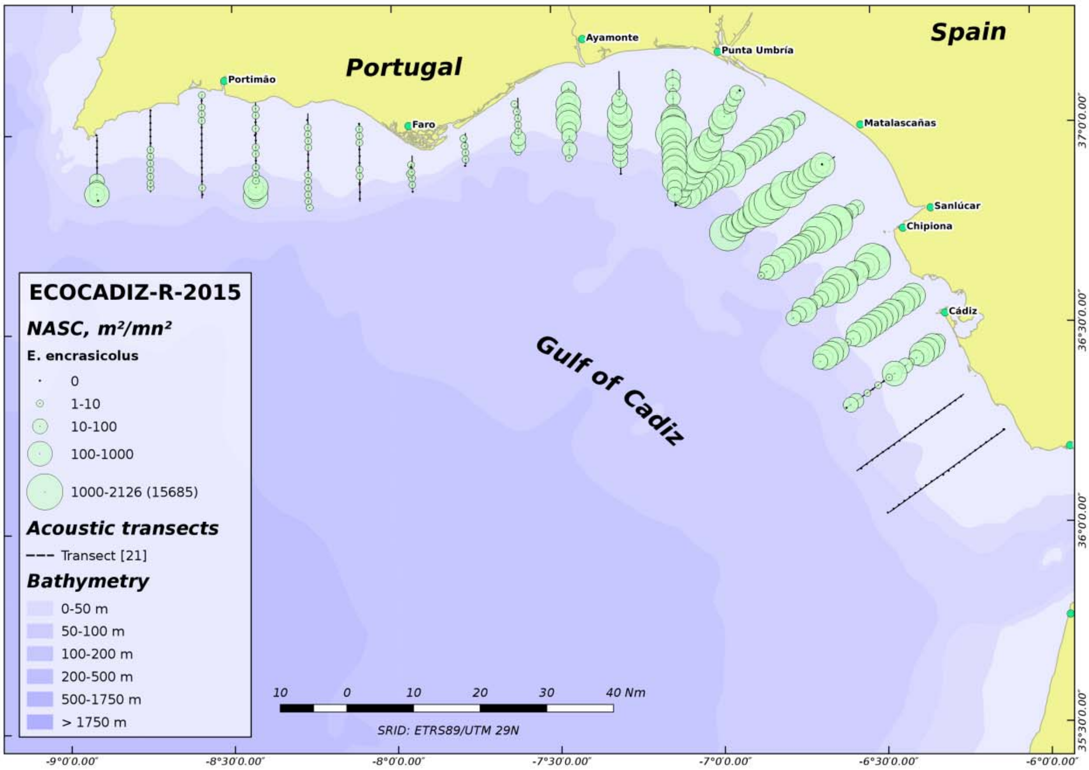


Figure 7. *ECOCADIZ-RECLUTAS 2015-10* survey. Distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the pelagic fish species assemblage.



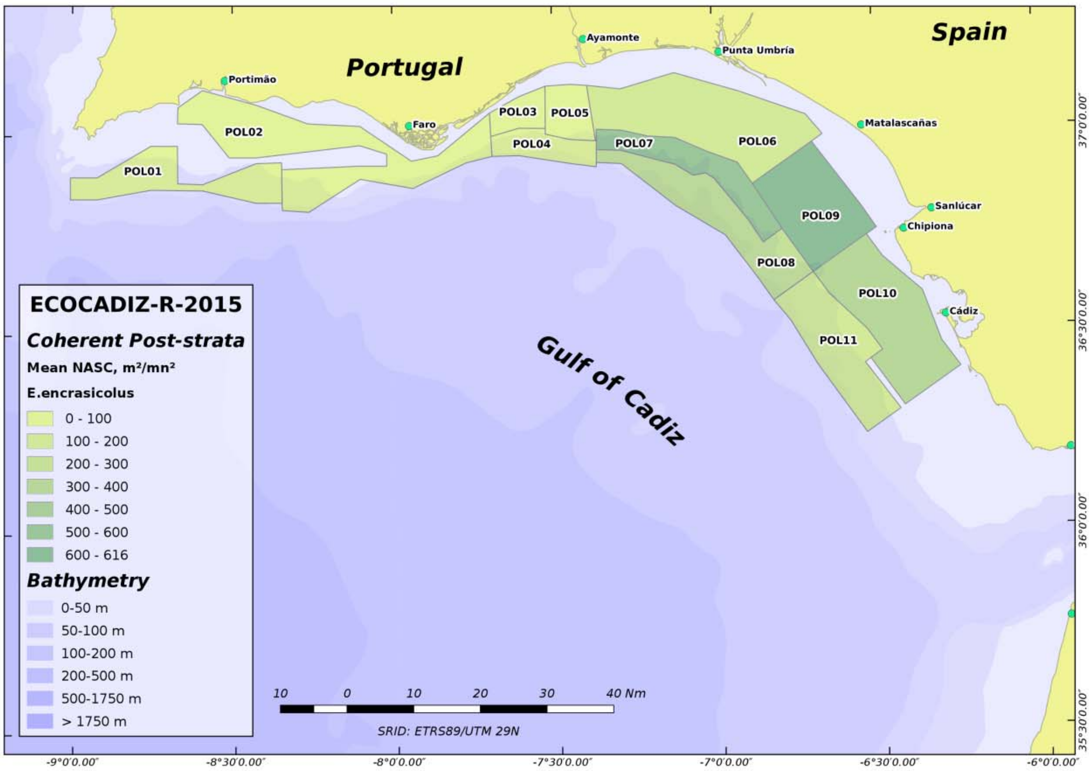


Figure 8. *ECOCADIZ-RECLUTAS 2015-10* survey. Anchovy (*Engraulis encrasicolus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

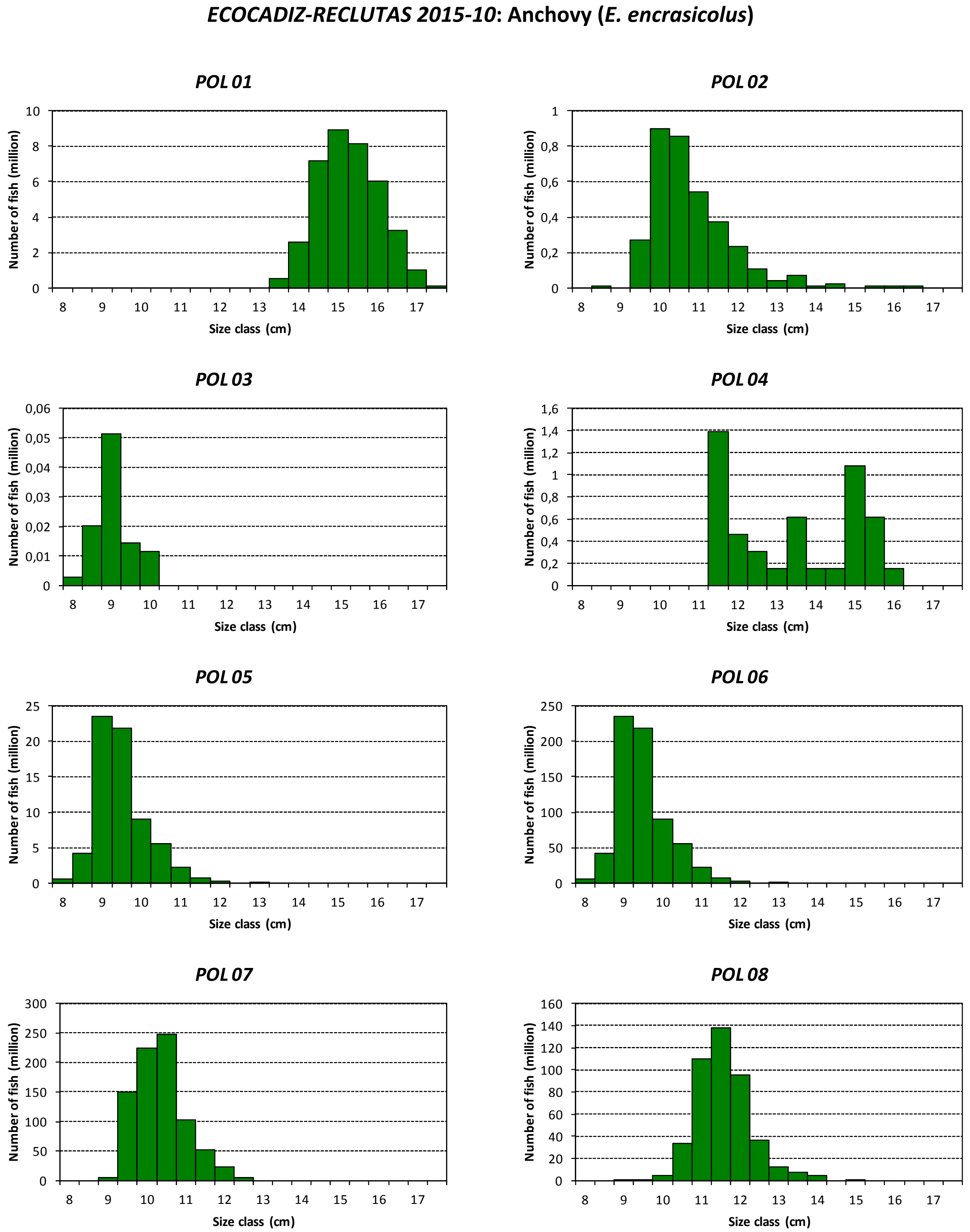


Figure 9. *ECOCADIZ-RECLUTAS 2015-10* survey. Anchovy (*E. encrasicolus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 8**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

ECOCADIZ-RECLUTAS 2015-10: Anchovy (*E. encrasicolus*)

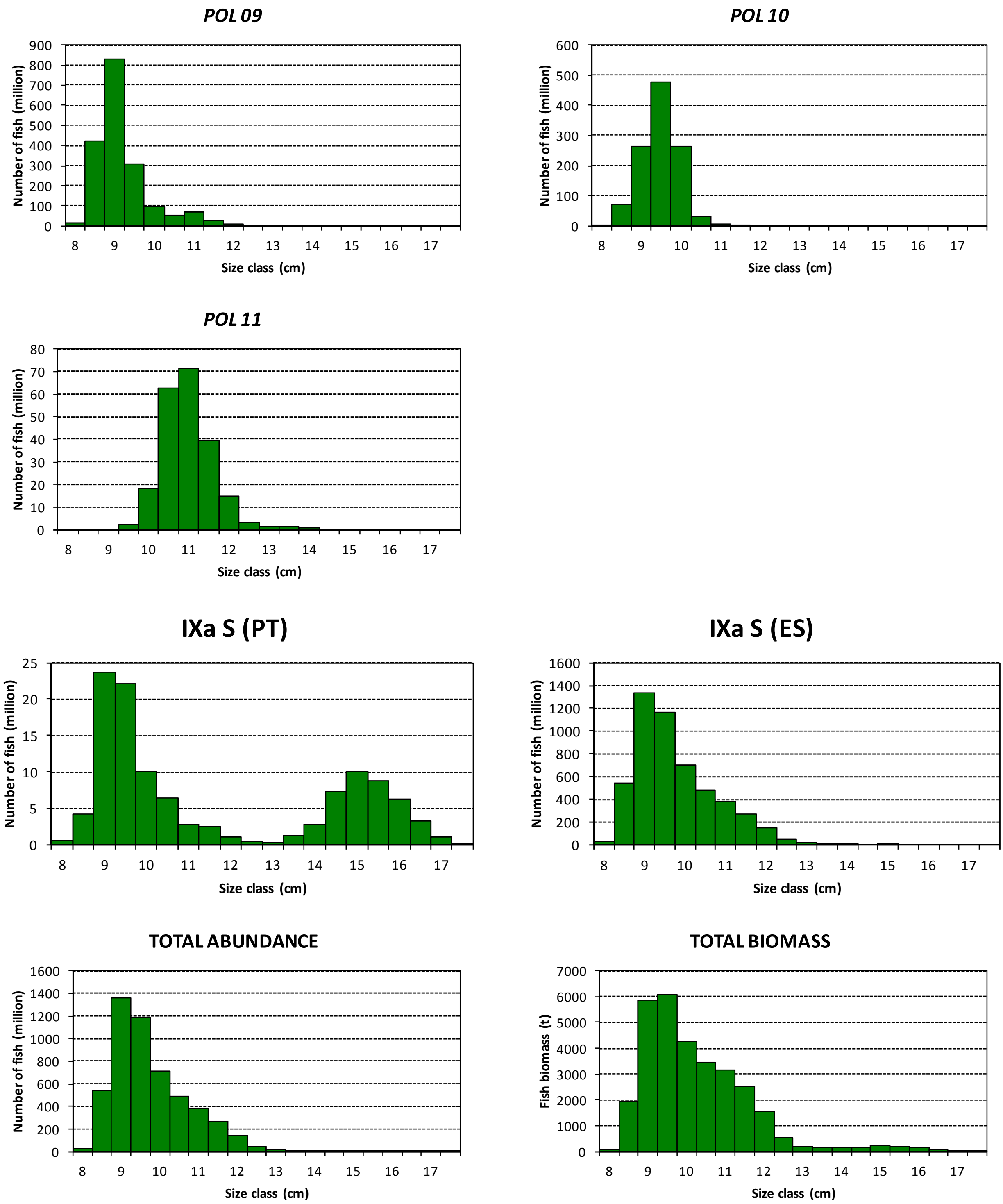


Figure 9. *ECOCADIZ-RECLUTAS 2015-10* survey. Anchovy (*E. encrasicolus*). Cont'd.

***ECOCADIZ-RECLUTAS 2015-10*: Anchovy (*E. encrasicolus*)**

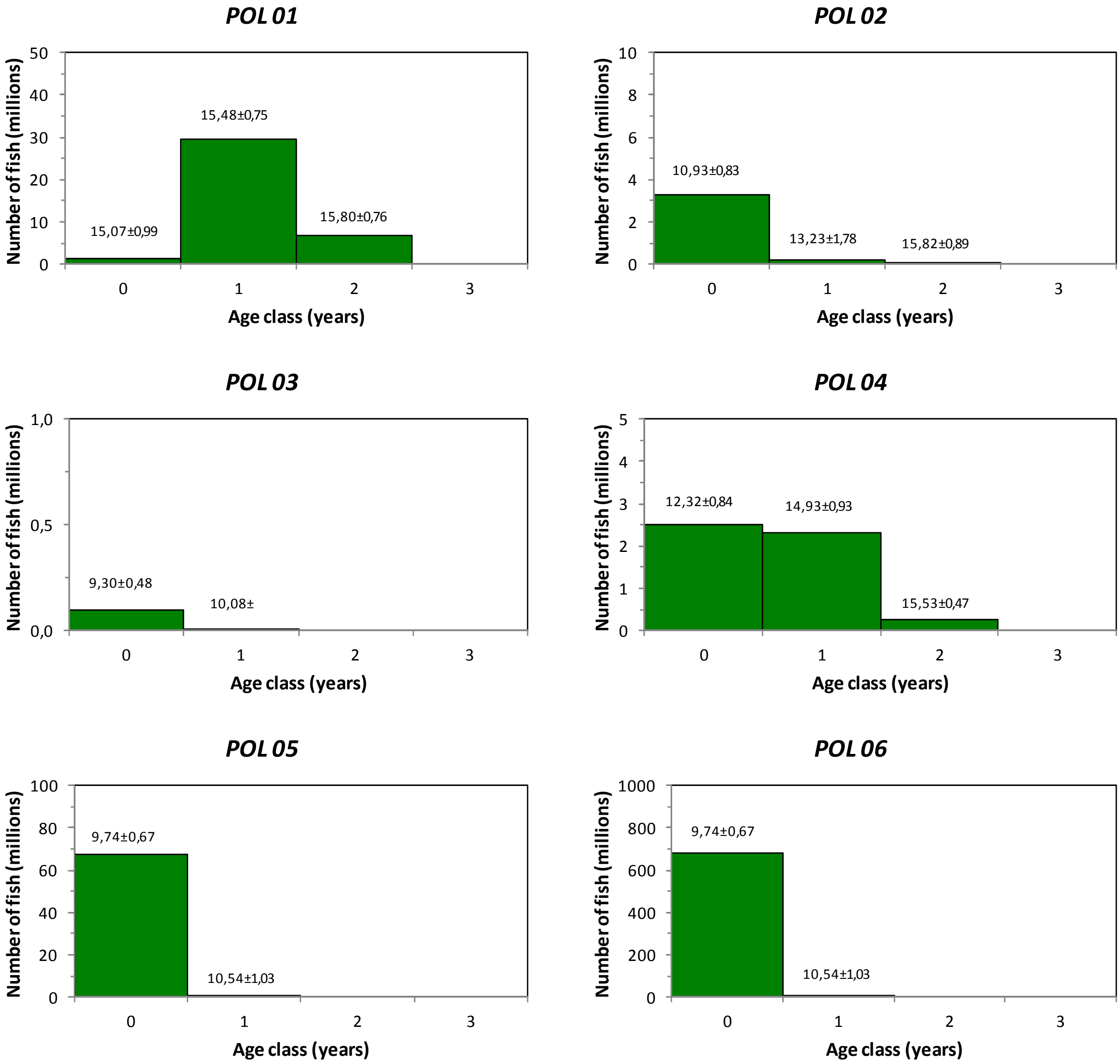


Figure 10. *ECOCADIZ-RECLUTAS 2015-10* survey. Anchovy (*E. encrasicolus*). Estimated abundances (number of fish in millions) by age class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 8**) and total sampled area. Post-strata ordered in the W-E direction. Mean length (±SD) by age group is also shown.The estimated biomass (t) by age class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

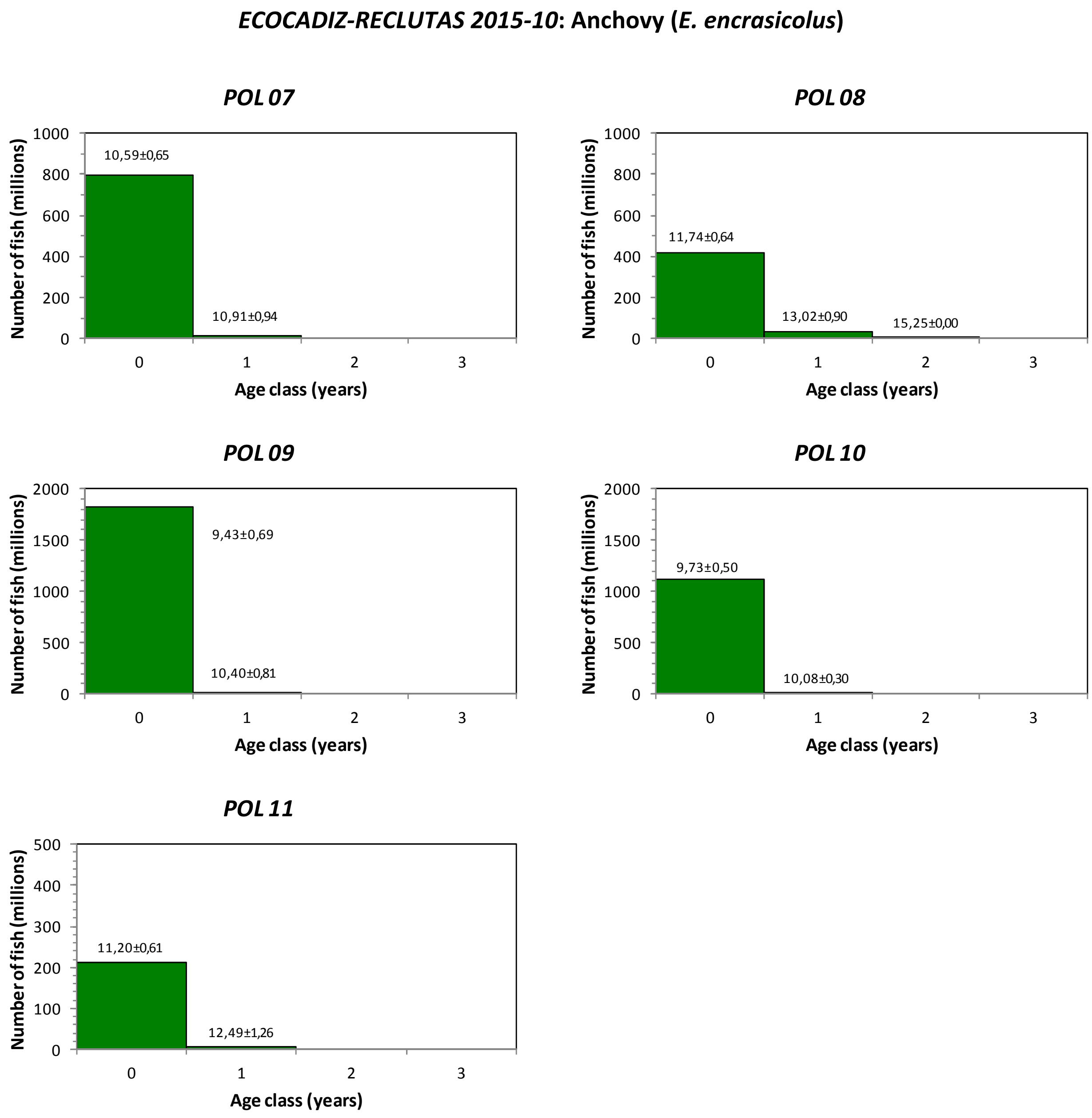


Figure 10. *ECOCADIZ-RECLUTAS 2015-10* survey. Anchovy (*E. encrasicolus*). Cont'd.

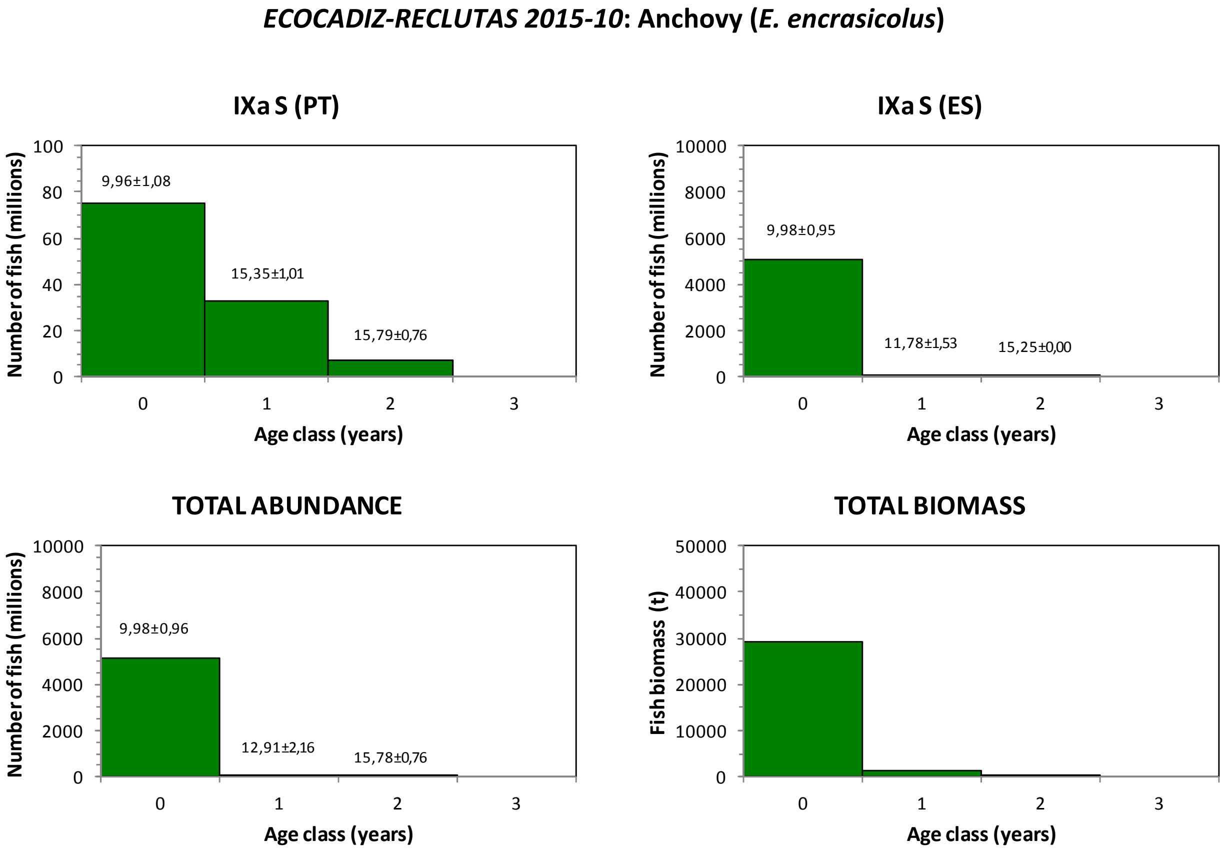


Figure 10. *ECOCADIZ-RECLUTAS 2015-10* survey. Anchovy (*E. encrasicolus*). Cont'd.

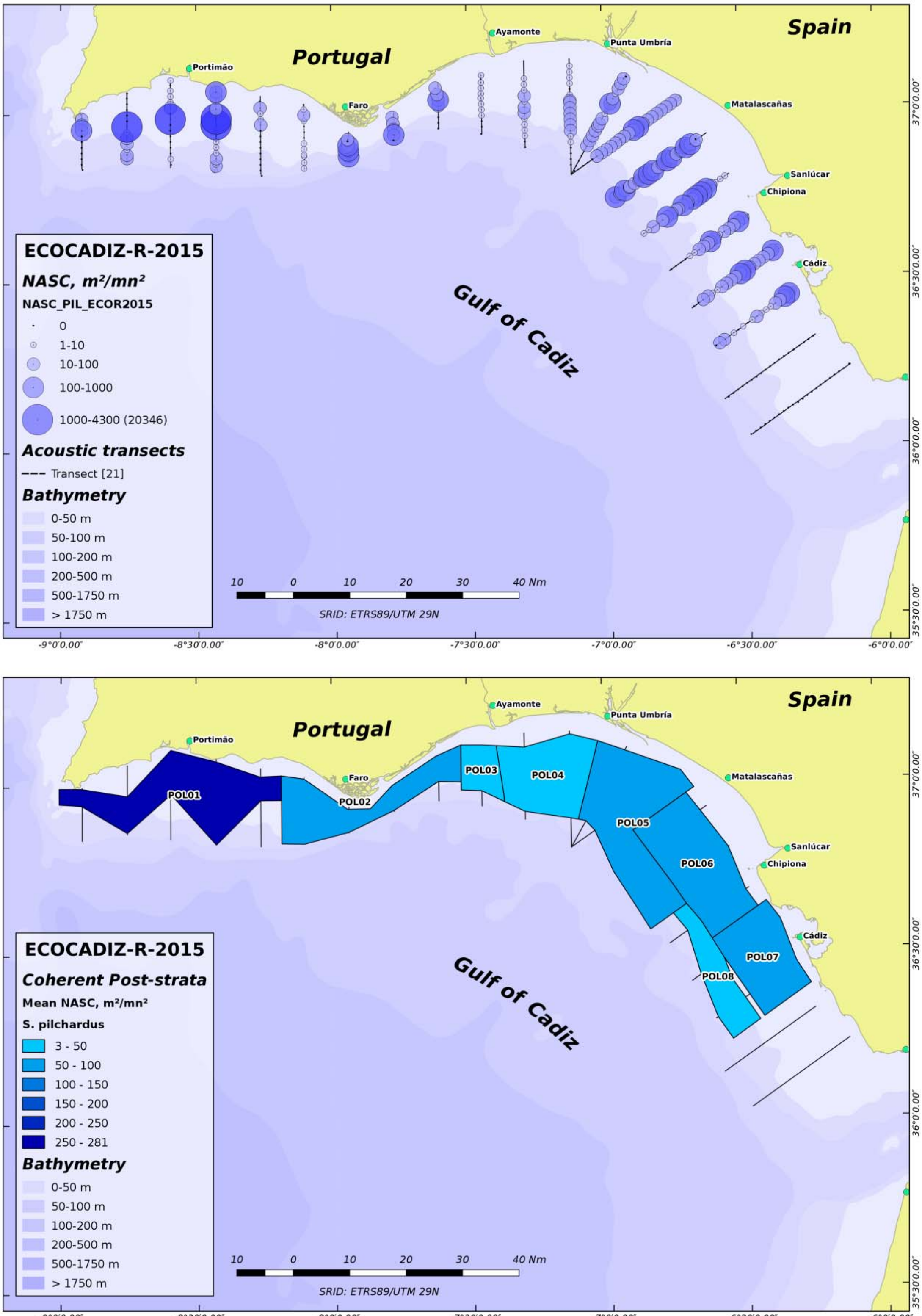


Figure 11. *ECOCADIZ-RECLUTAS 2015-10* survey. Sardine (*Sardina pilchardus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

***ECOCADIZ-RECLUTAS 2015-10*: Sardine (*S. pilchardus*)**

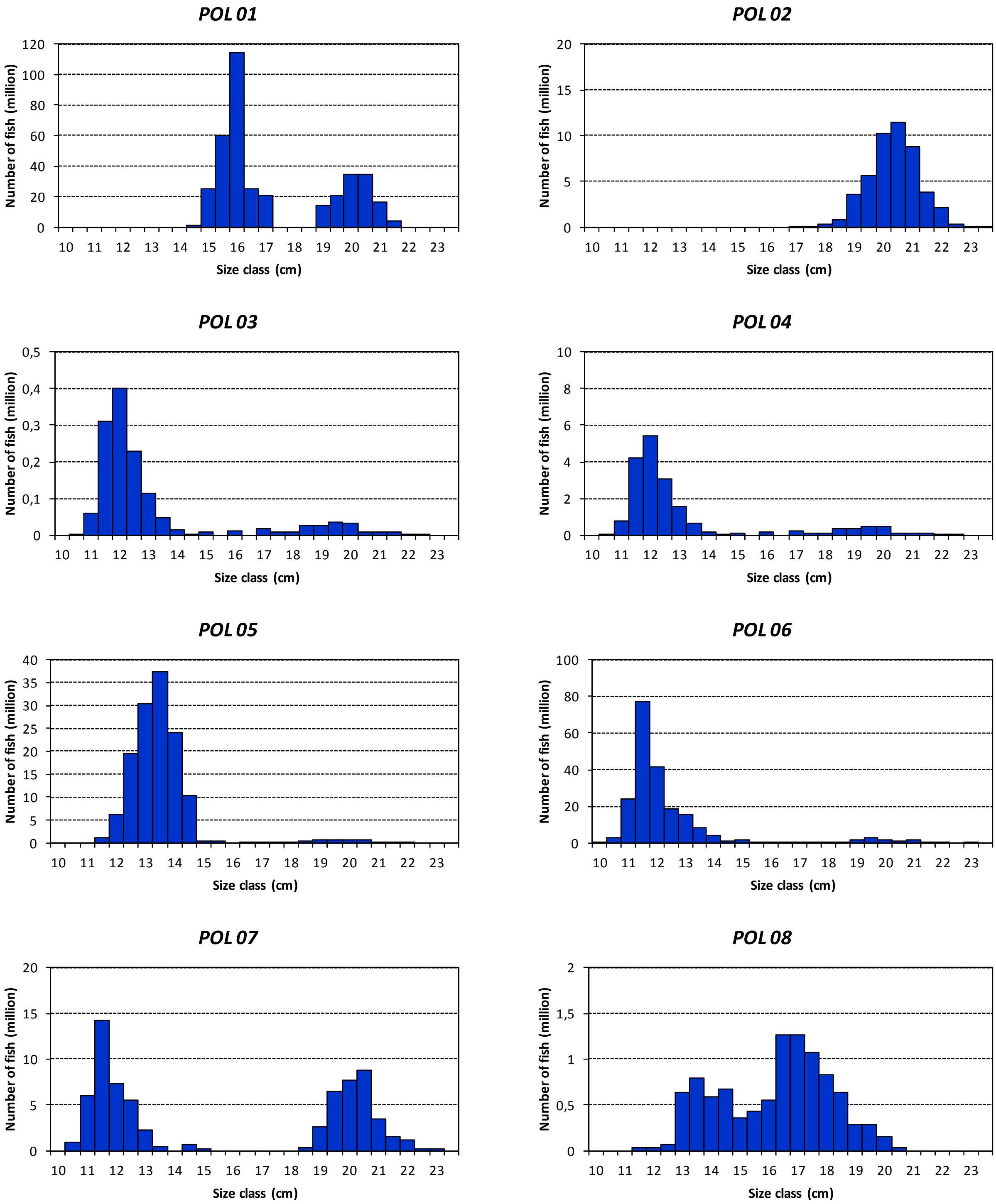


Figure 12. *ECOCADIZ-RECLUTAS 2015-10* survey. Sardine (*S. pilchardus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 11**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

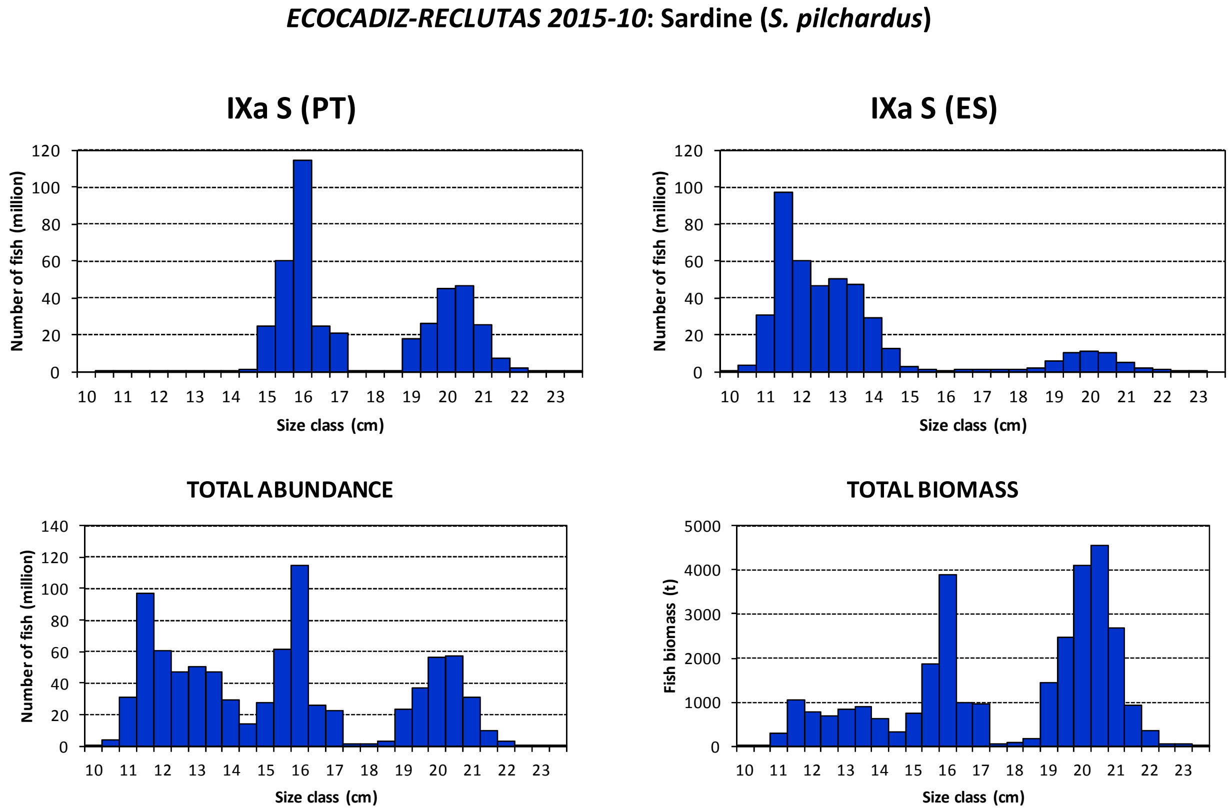


Figure 12. *ECOCADIZ-RECLUTAS 2015-10* survey. Sardine (*S. pilchardus*). Cont'd.

***ECOCADIZ-RECLUTAS 2015-10*: Sardine (*S. pilchardus*)**

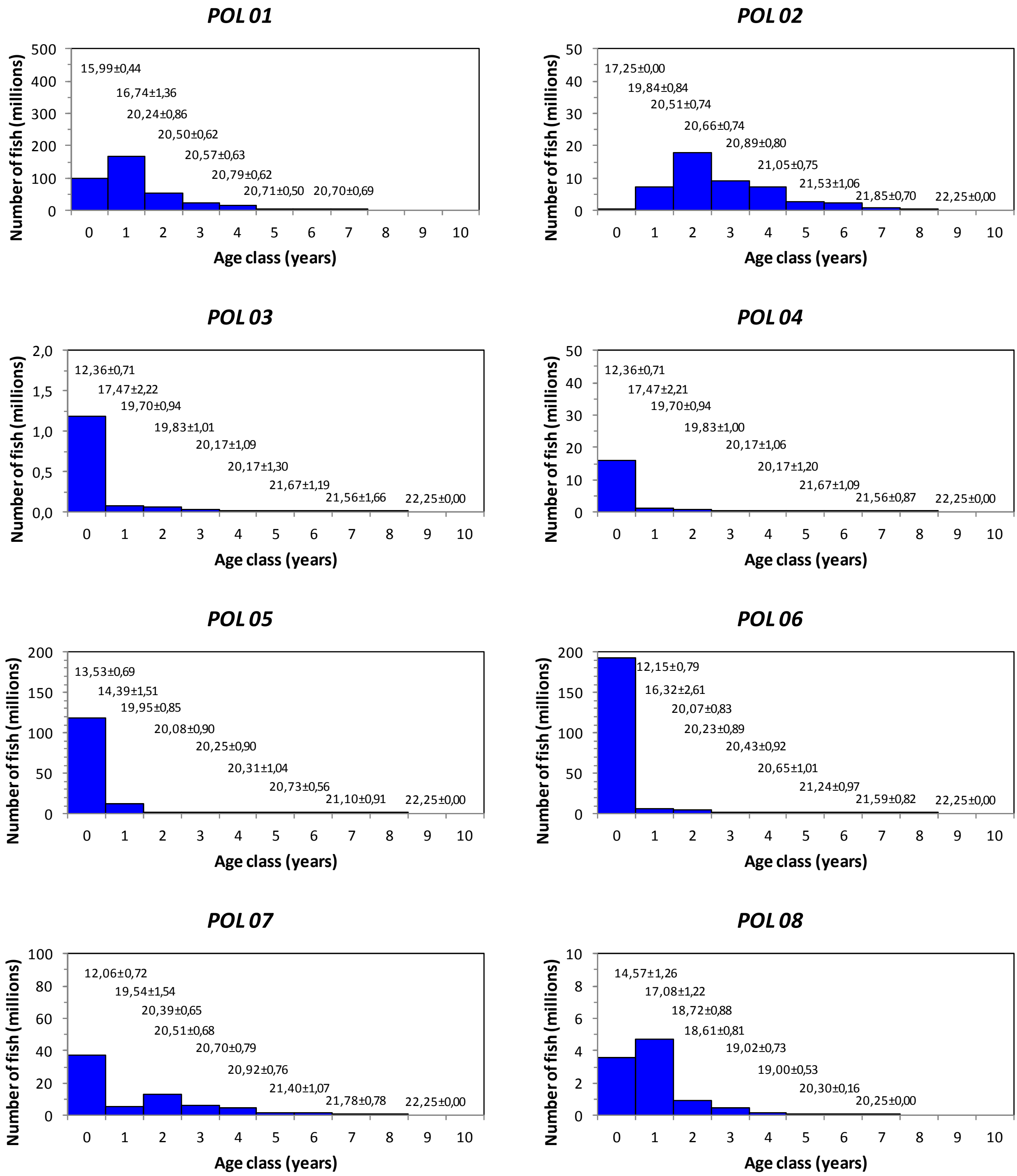


Figure 13. *ECOCADIZ-RECLUTAS 2015-10* survey. Sardine (*S. pilchardus*). Estimated abundances (number of fish in millions) by age class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 11**) and total sampled area. Post-strata ordered in the W-E direction. Mean length (±SD) by age group is also shown.The estimated biomass (t) by age class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

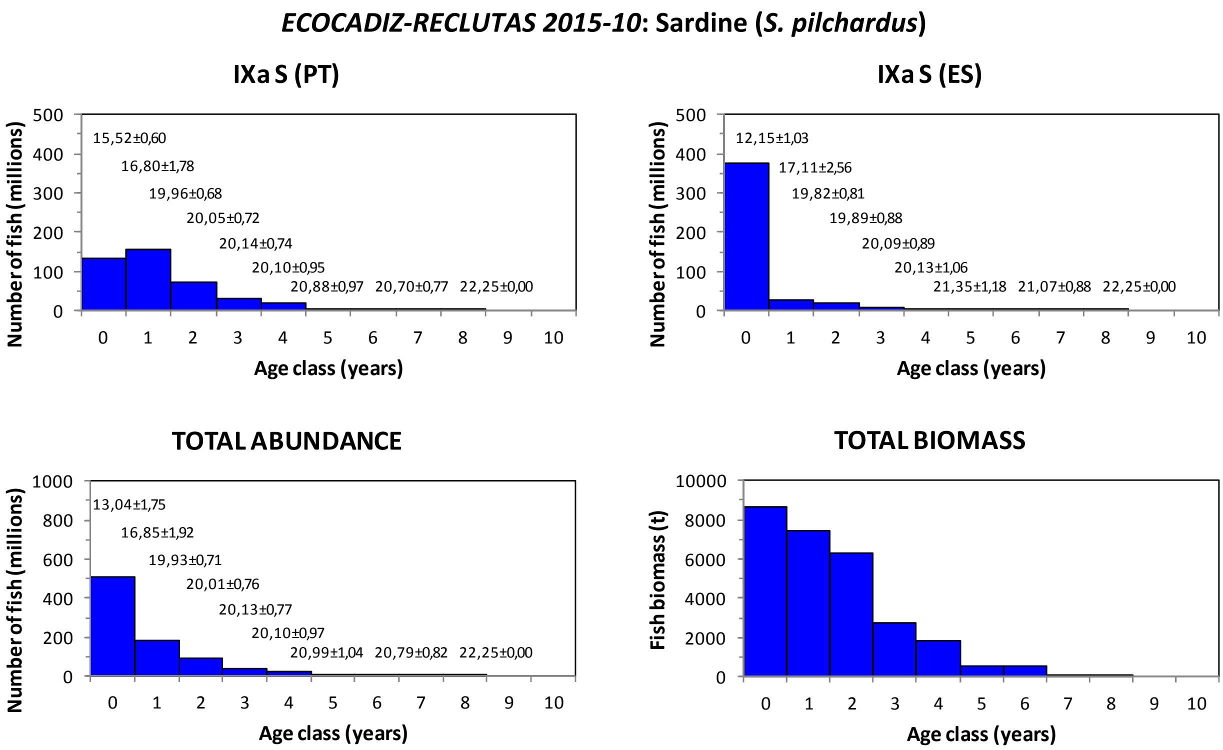
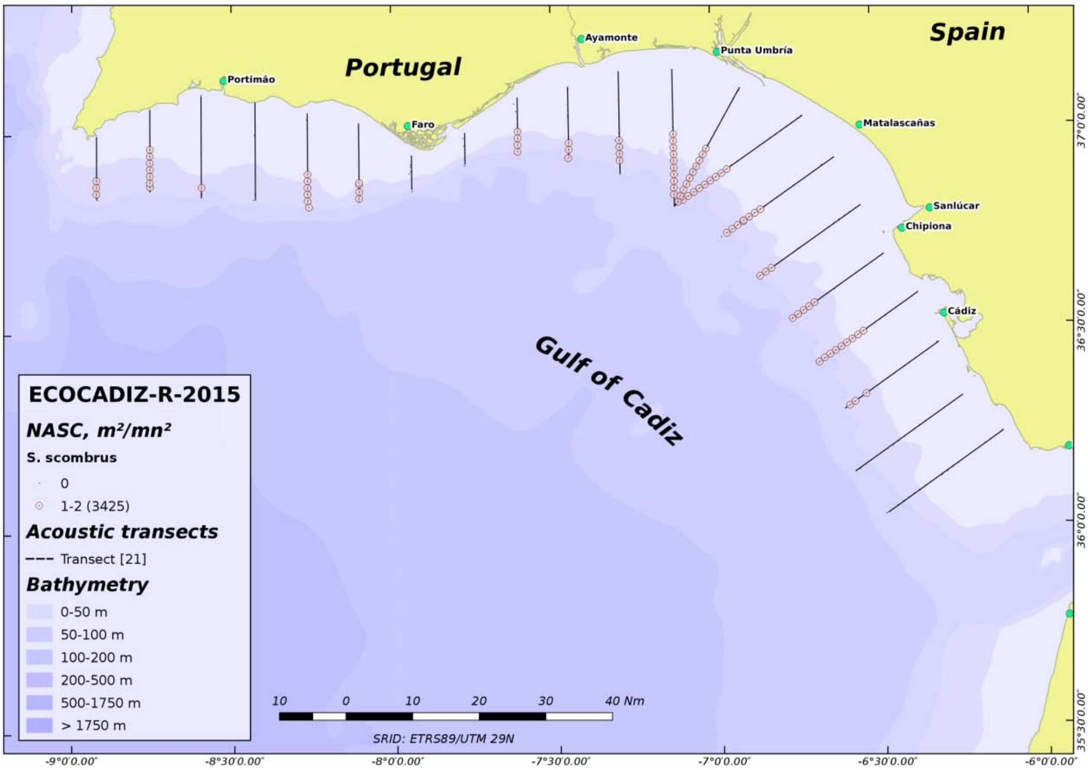


Figure 13. *ECOCADIZ-RECLUTAS 2015-10* survey. Sardine (*S. pilchardus*). Cont'd.



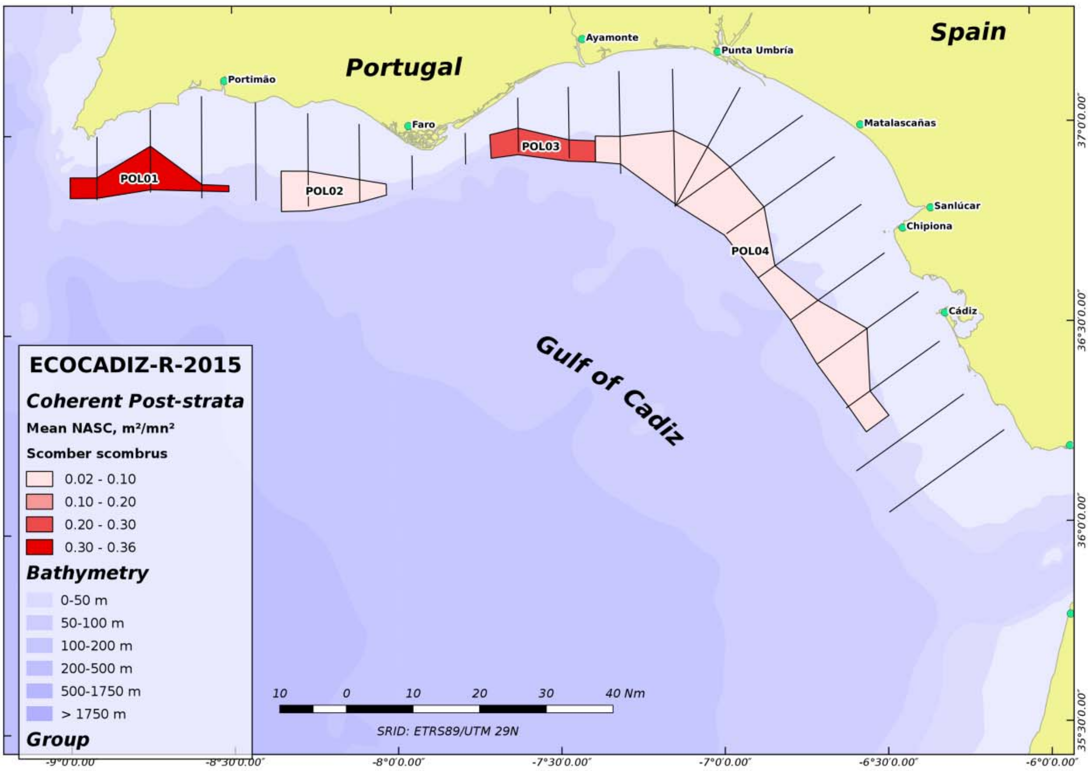


Figure 14. *ECOCADIZ-RECLUTAS 2015-10* survey. Mackerel (*Scomber scombrus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

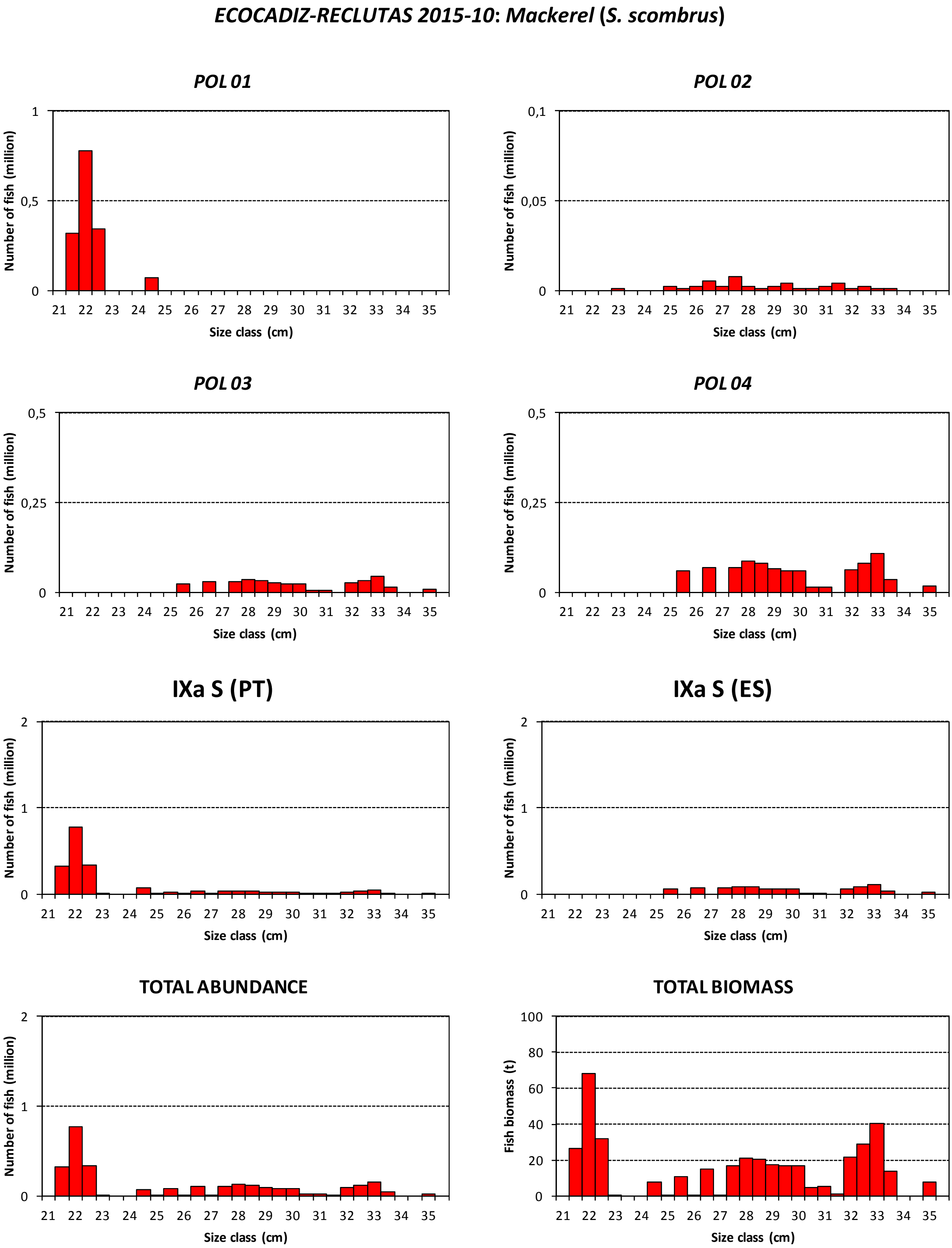


Figure 15. *ECOCADIZ-RECLUTAS 2015-10* survey. Mackerel (*Scomber scombrus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 14**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

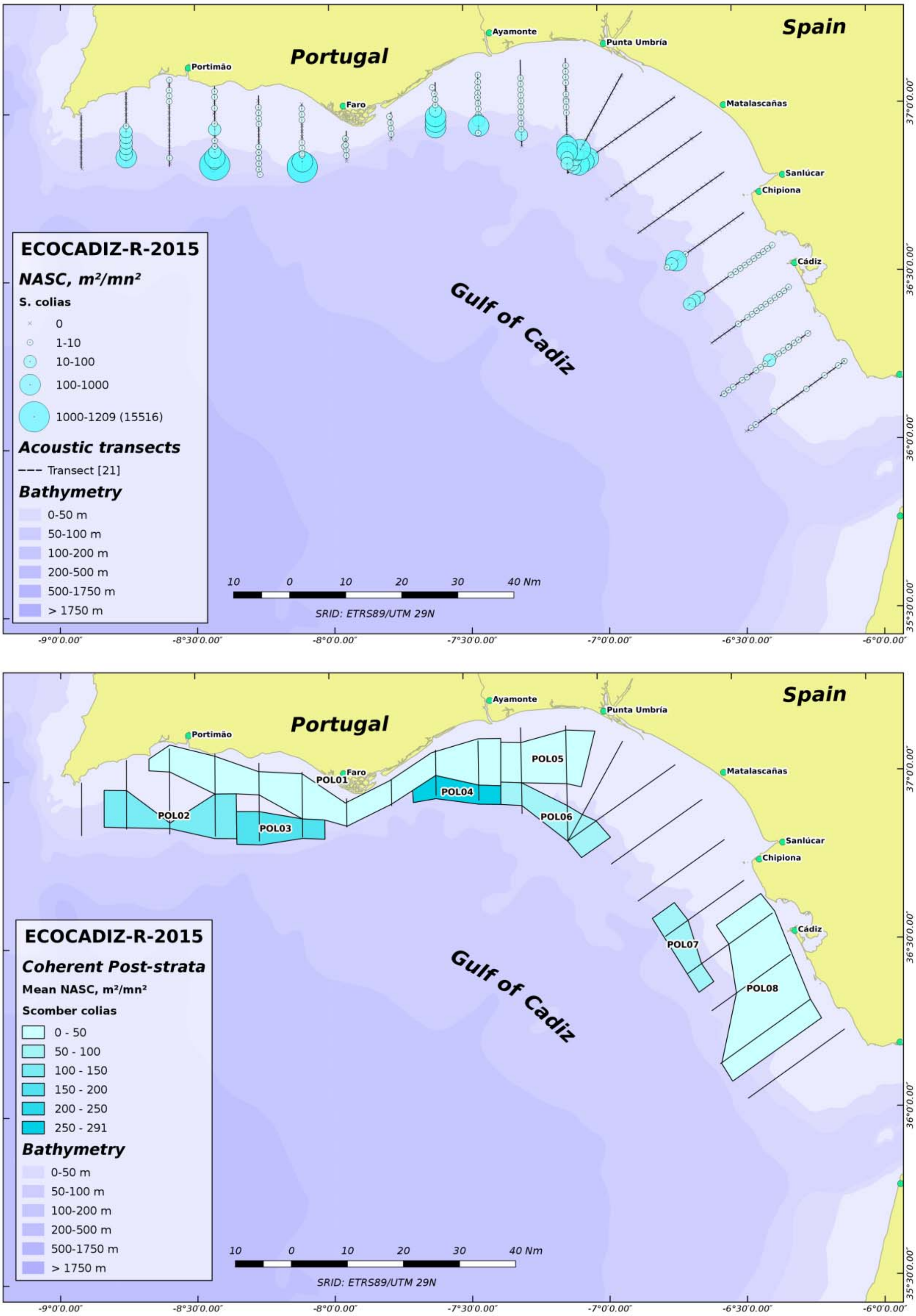


Figure 16. *ECOCADIZ-RECLUTAS 2015-10* survey. Chub mackerel (*Scomber colias*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

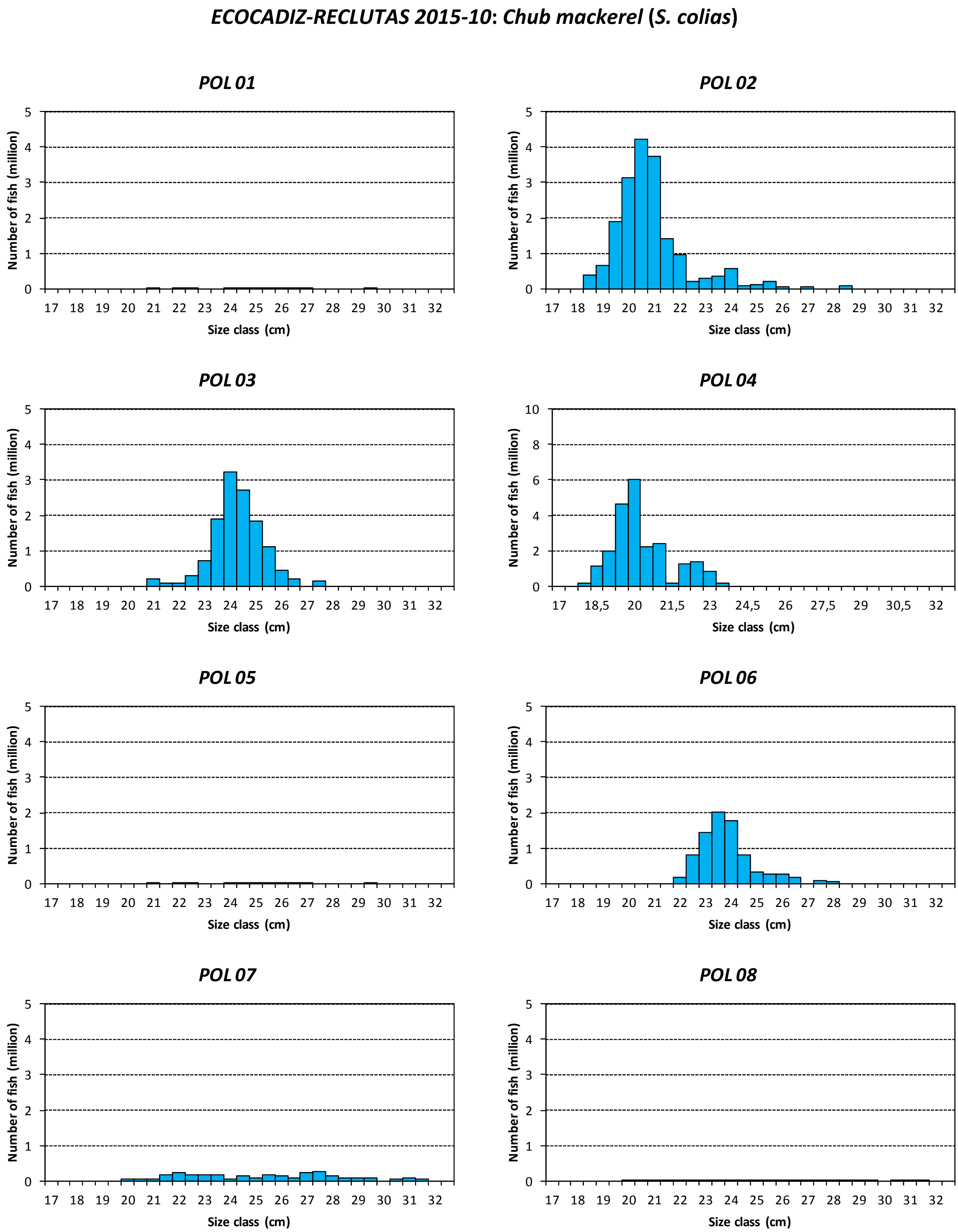


Figure 17. *ECOCADIZ-RECLUTAS 2015-10* survey. Chub mackerel (*Scomber colias*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 16**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

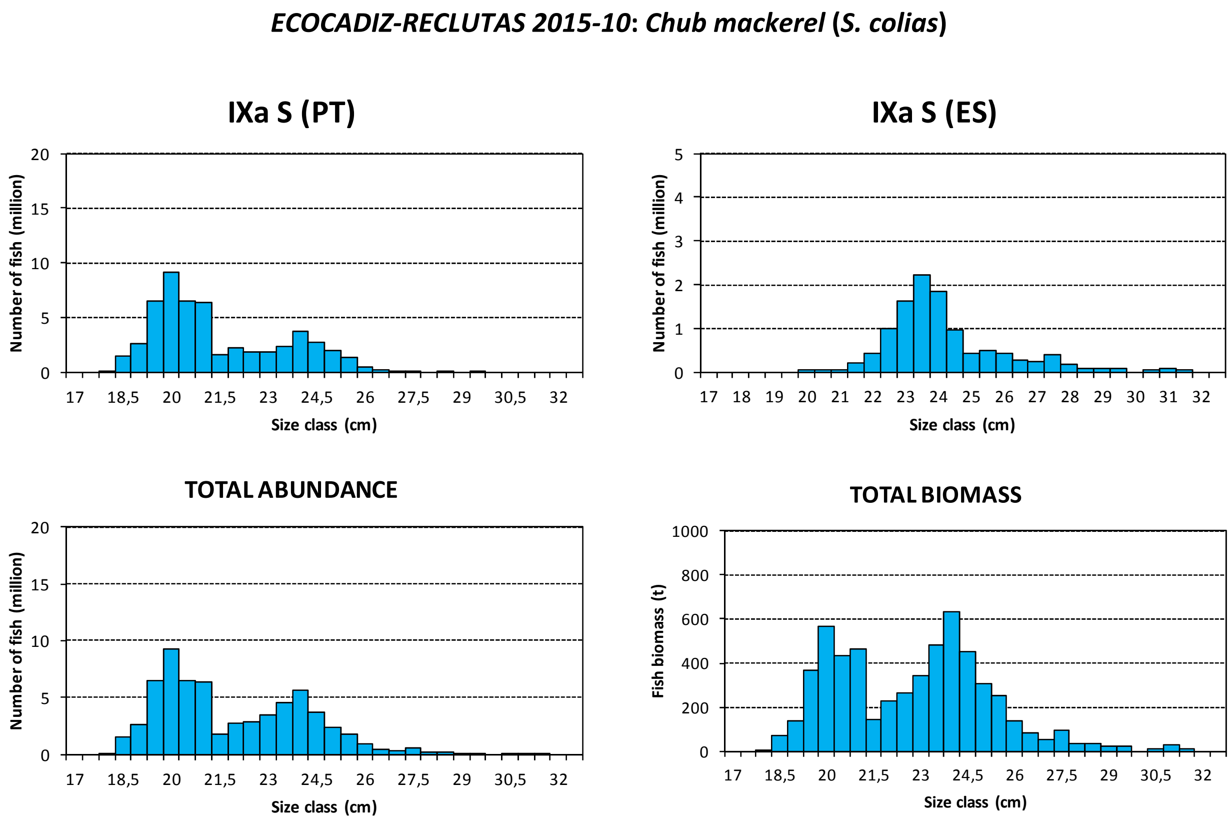


Figure 17. *ECOCADIZ-RECLUTAS 2015-10* survey. Chub mackerel (*Scomber colias*).Cont'd.

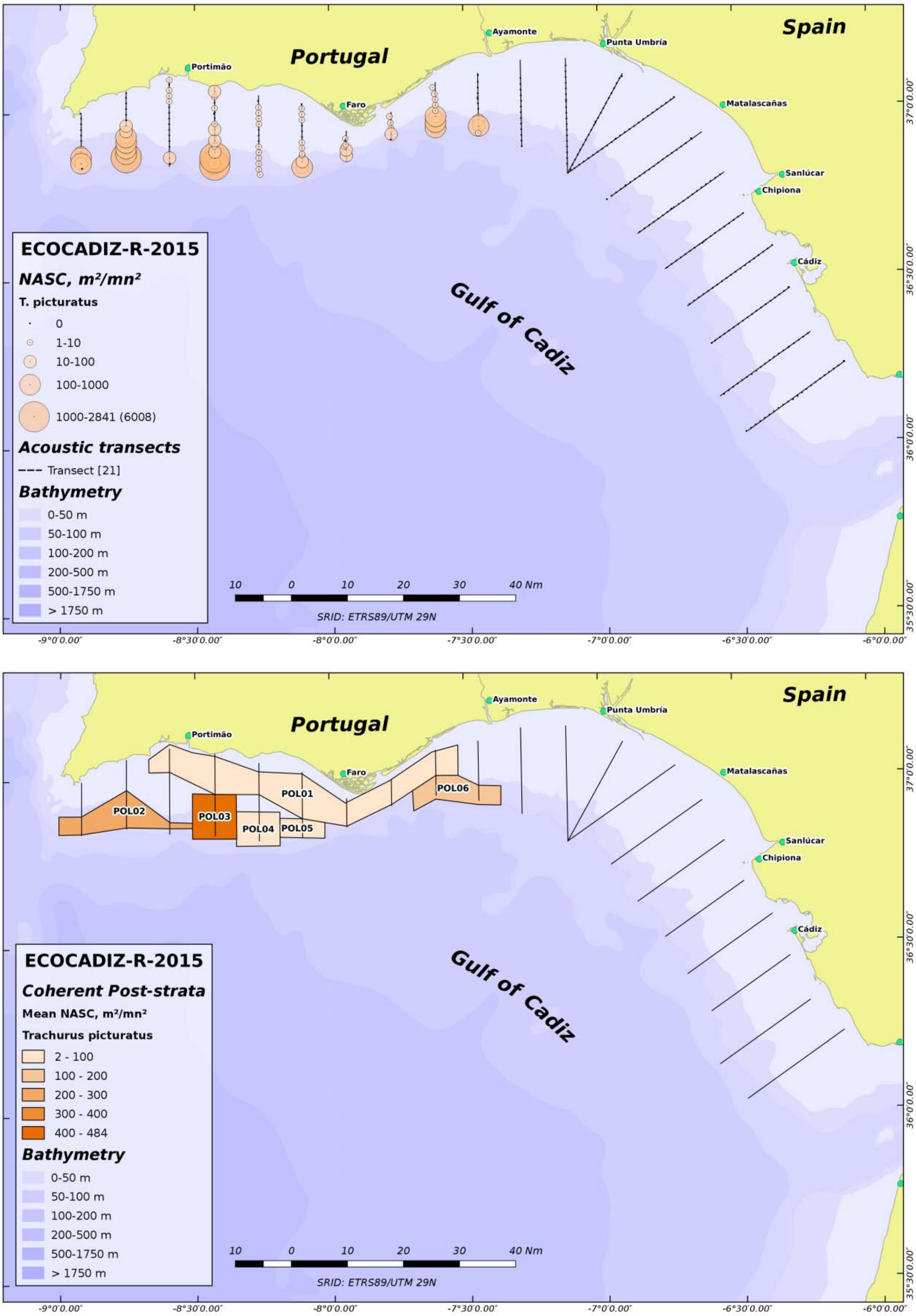


Figure 18. *ECOCADIZ-RECLUTAS 2015-10* survey. Blue jack mackerel (*Trachurus picturatus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

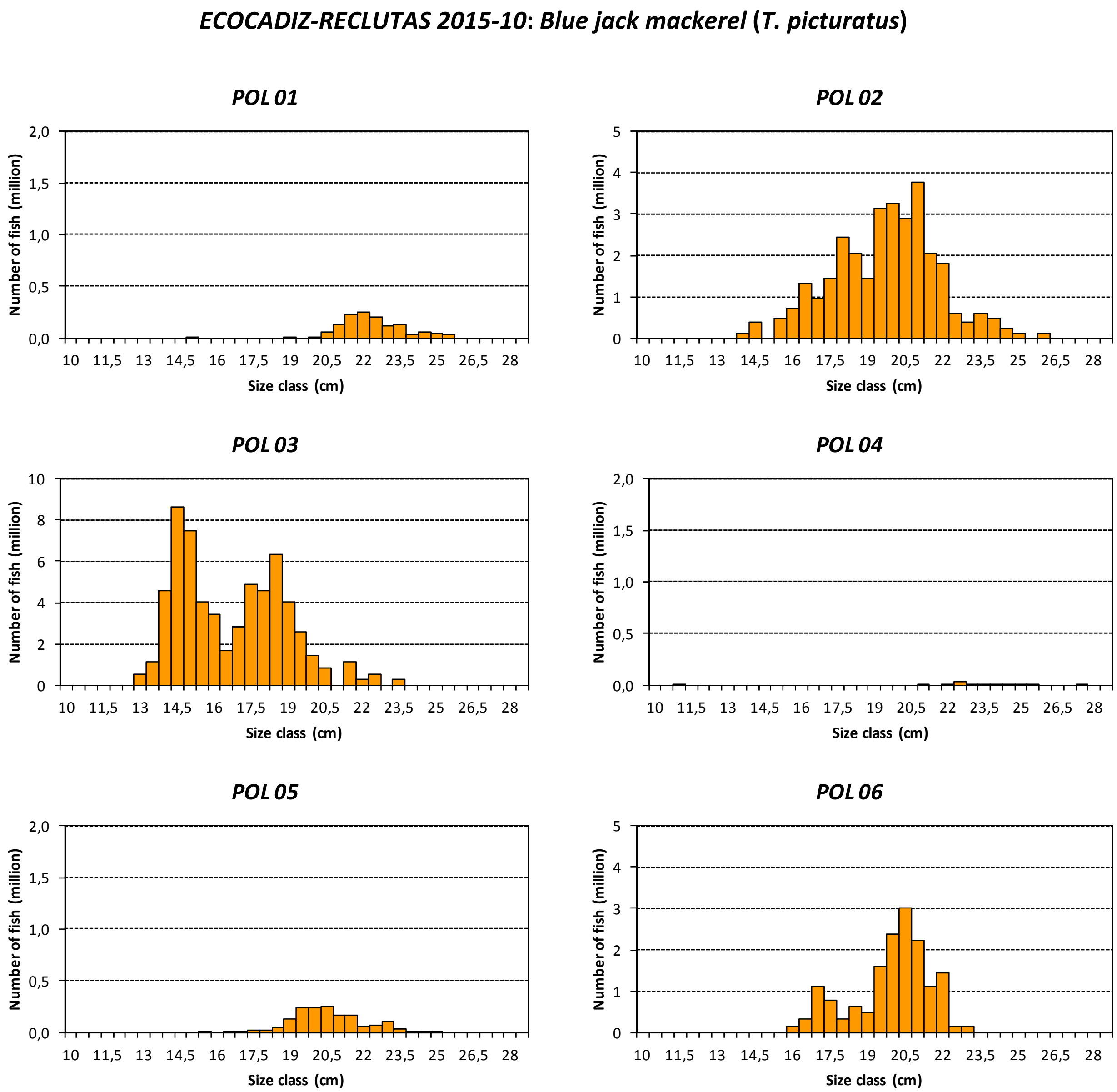
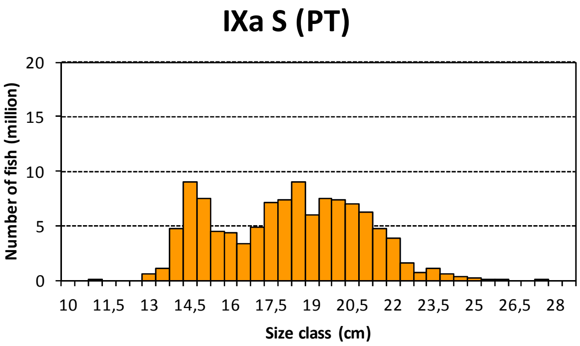
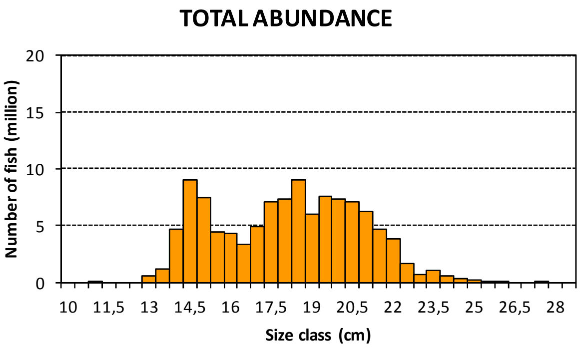


Figure 19. *ECOCADIZ-RECLUTAS 2015-10* survey. Blue jack mackerel (*Trachurus picturatus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 18**) and total sampled area. Post-strata ordered in the W-E direction. The 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 2015-10*: Blue jack mackerel (*T. picturatus*)**





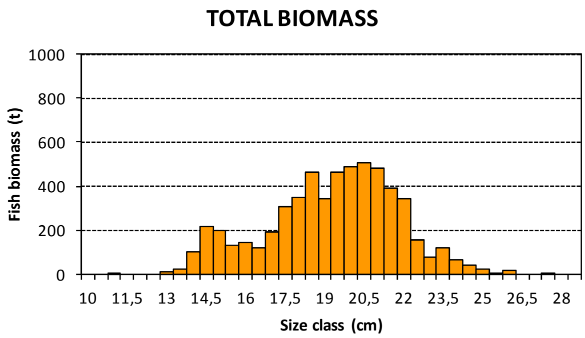
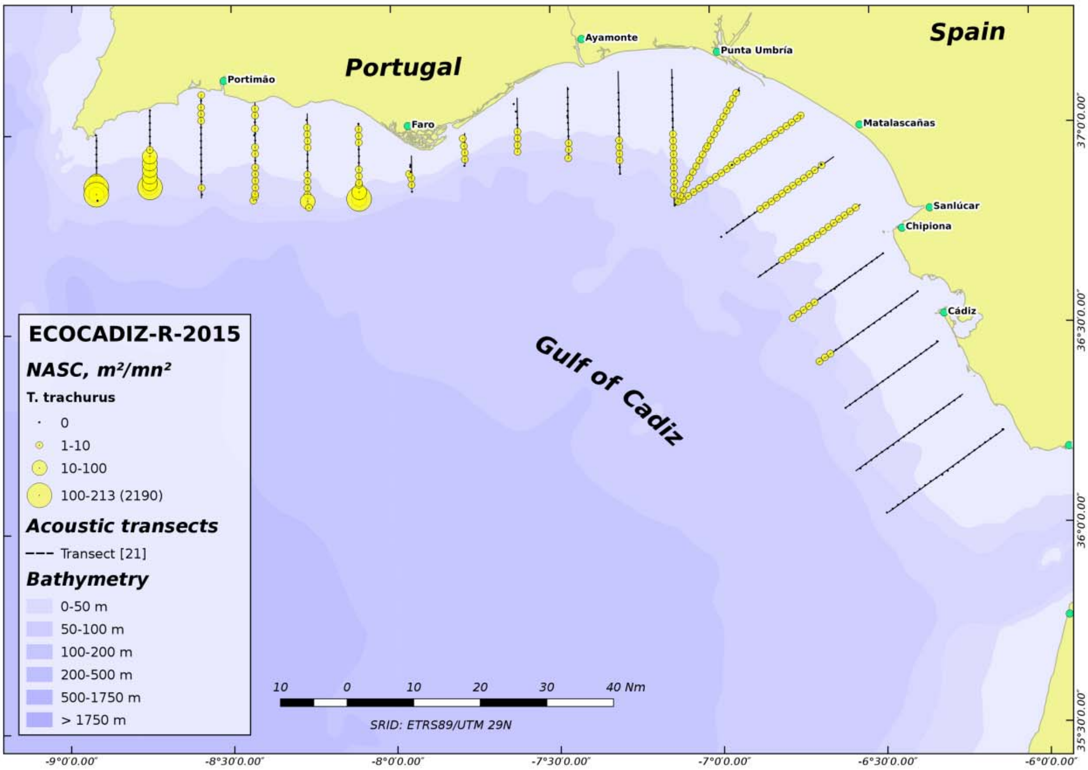


Figure 19. *ECOCADIZ-RECLUTAS 2015-10* survey. Blue jack mackerel (*Trachurus picturatus*). Cont'd.



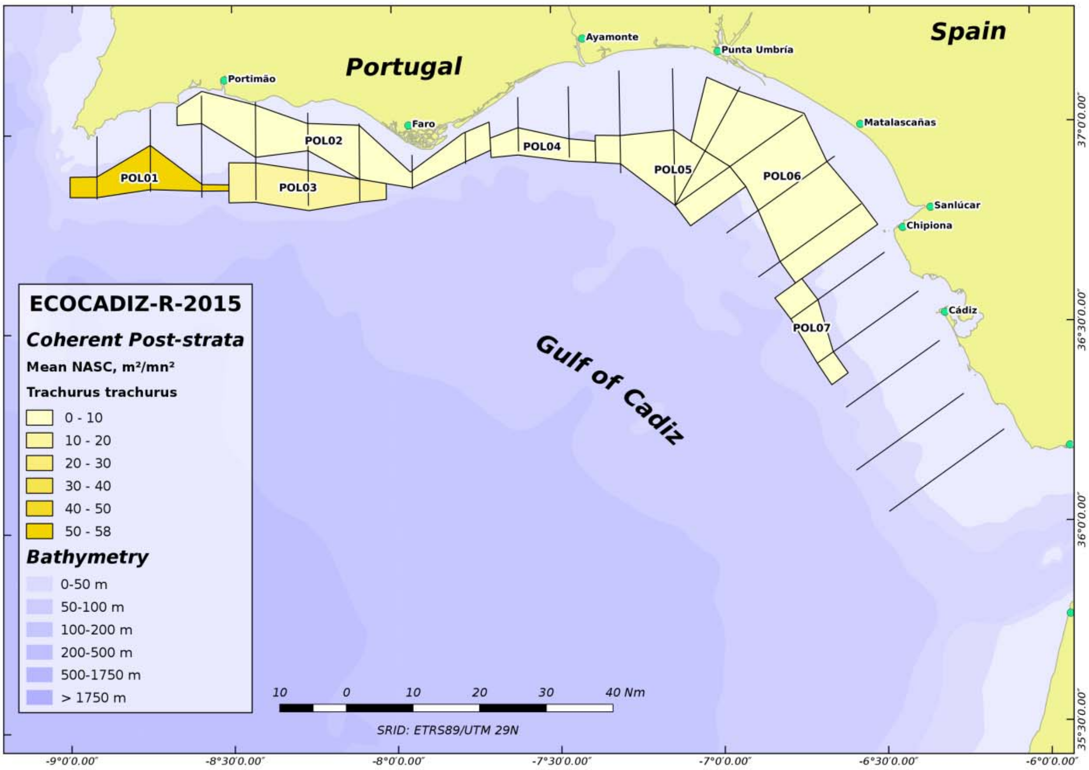


Figure 20. *ECOCADIZ-RECLUTAS 2015-10* survey. Horse mackerel (*Trachurus trachurus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

***ECOCADIZ-RECLUTAS 2015-10*: *Horse mackerel* (*T. trachurus*)**

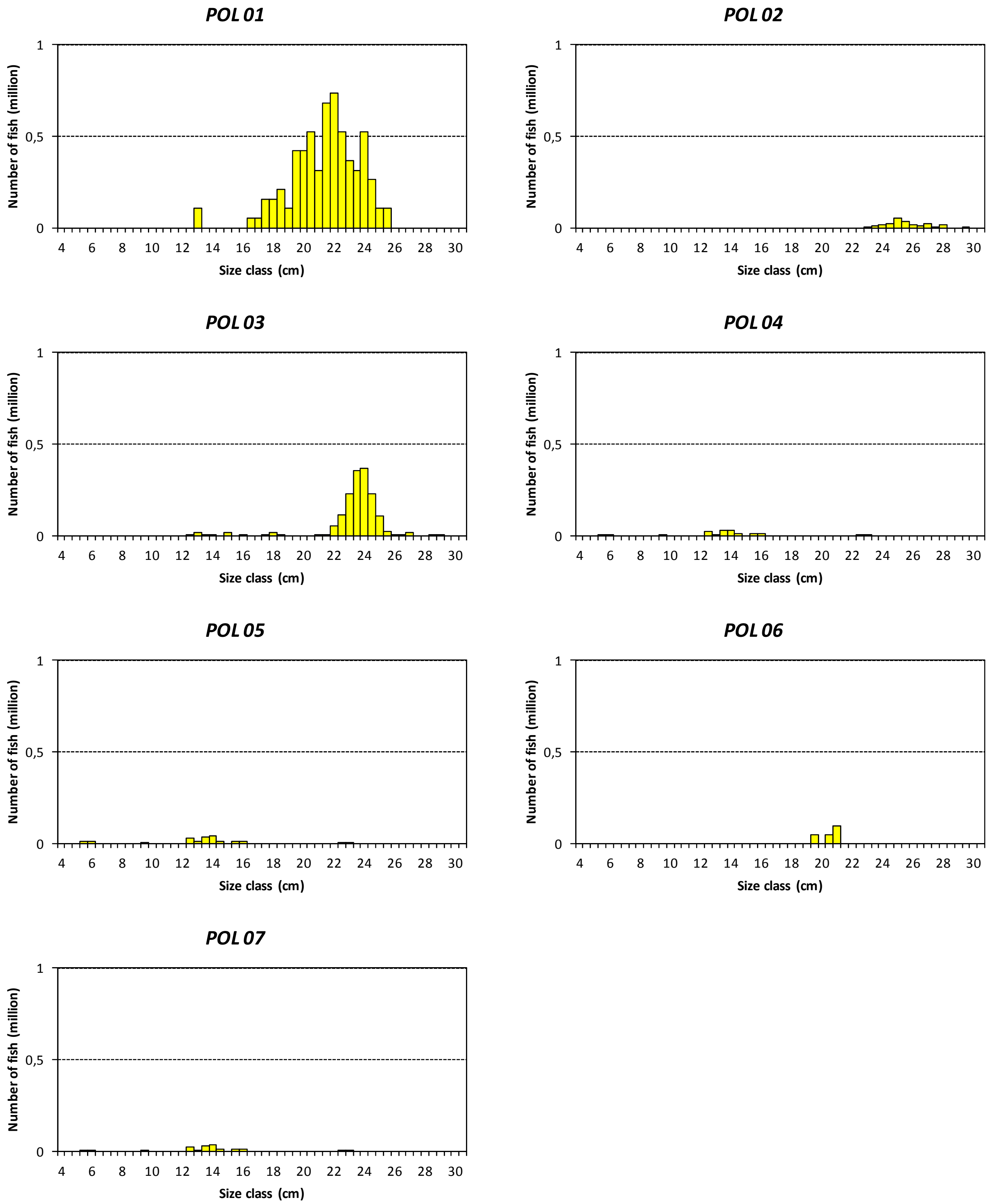


Figure 21. *ECOCADIZ-RECLUTAS 2015-10* survey. Horse mackerel (*Trachurus trachurus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 20**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

***ECOCADIZ-RECLUTAS 2015-10*: *Horse mackerel* (*T. trachurus*)**

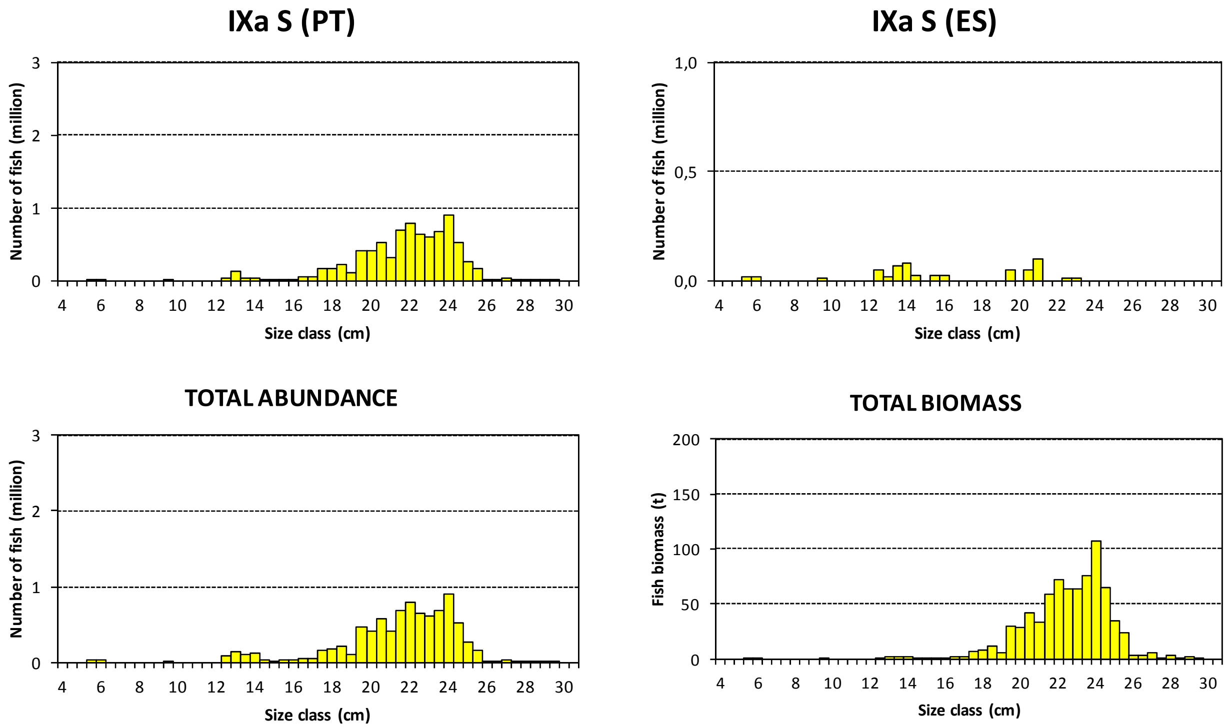
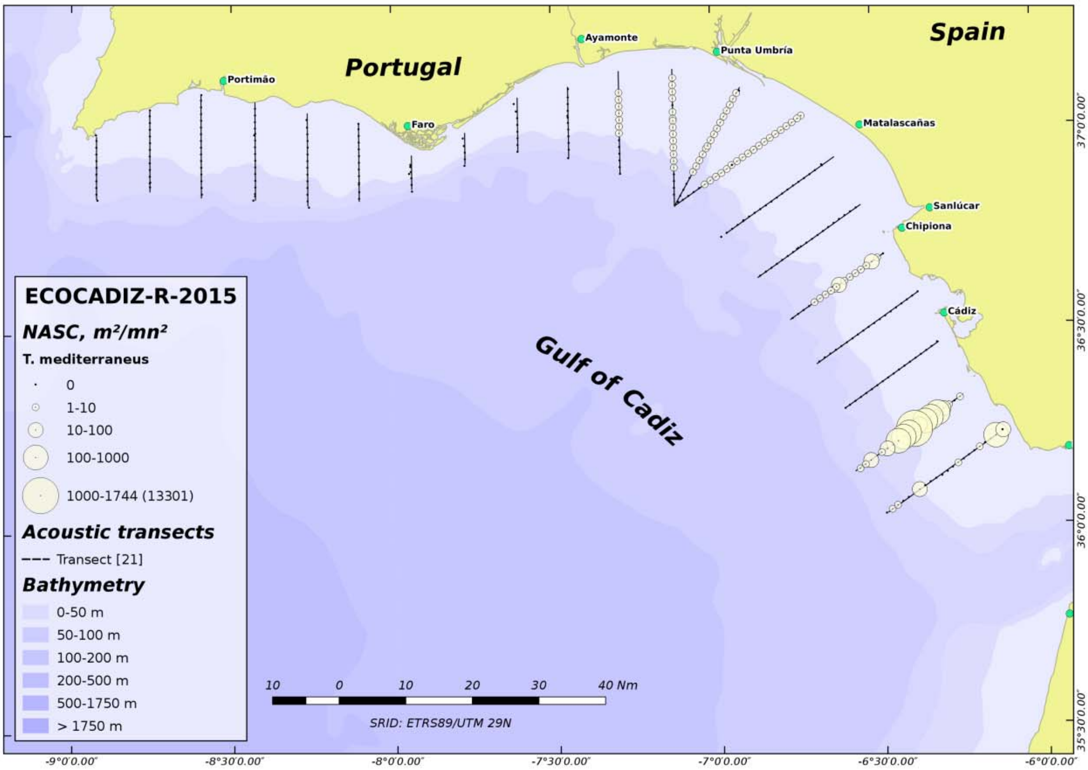


Figure 21. *ECOCADIZ-RECLUTAS 2015-10* survey. Horse mackerel (*Trachurus trachurus*). Cont'd.



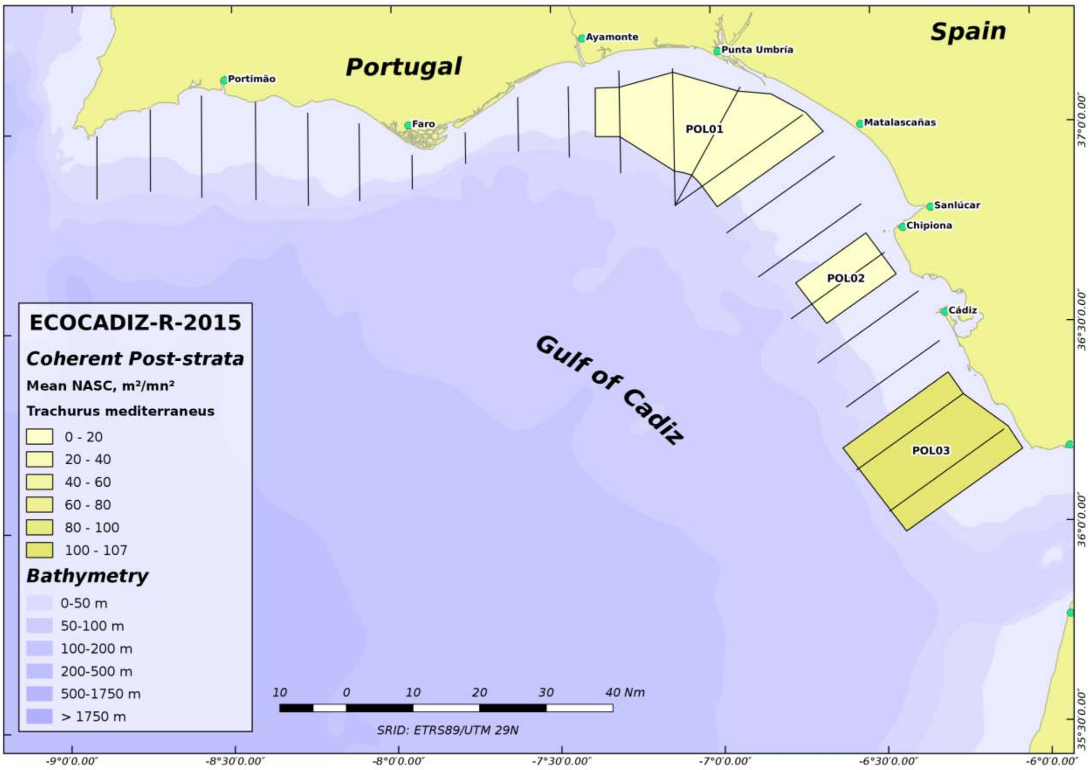


Figure 22. *ECOCADIZ-RECLUTAS 2015-10* survey. Mediterranean horse mackerel (*Trachurus mediterraneus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

ECOCADIZ-RECLUTAS 2015-10**: *Mediterranean horse mackerel* (*T. mediterraneus*)**

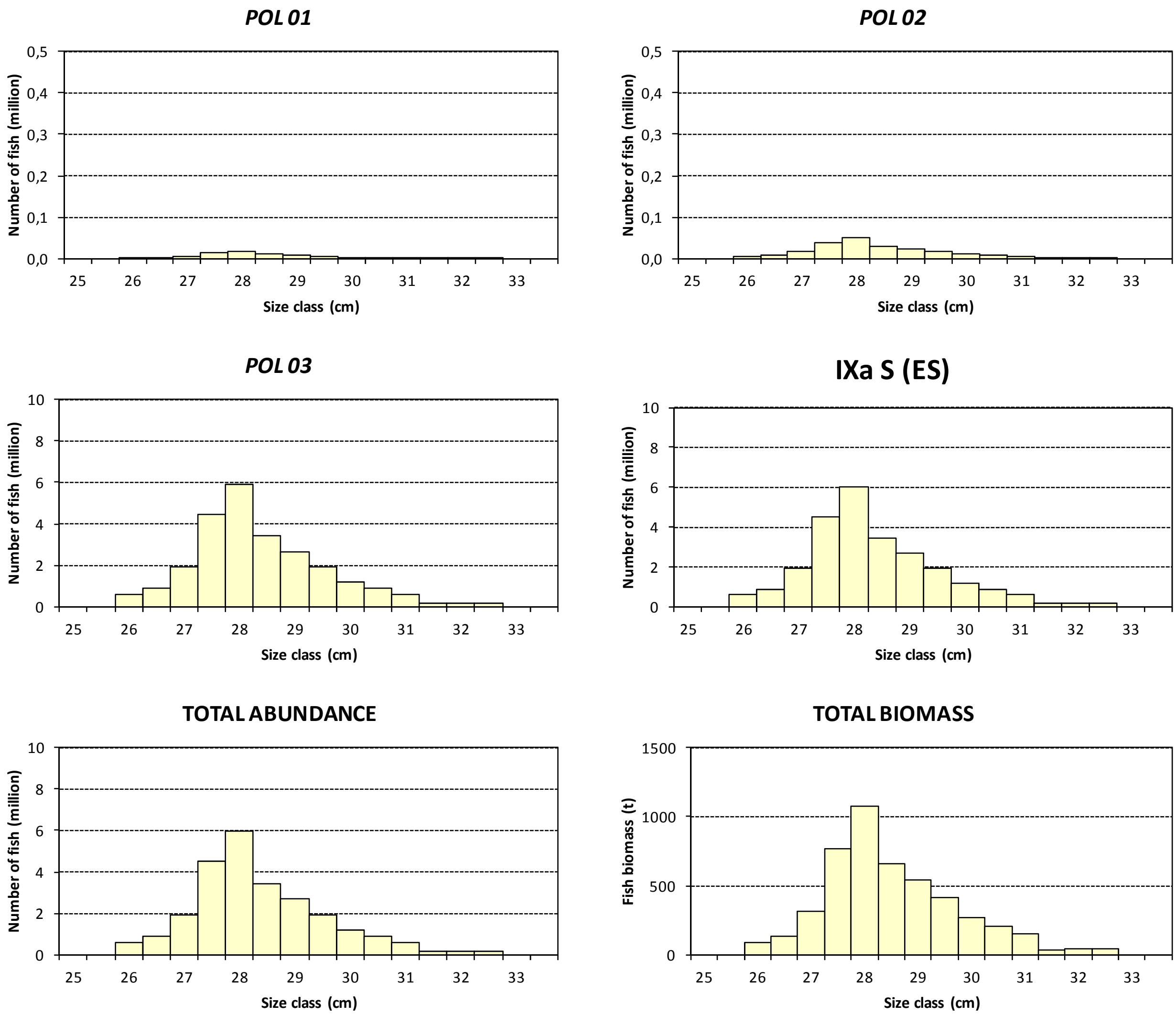


Figure 23. *ECOCADIZ-RECLUTAS 2015-10* survey. Mediterranean horse mackerel (*Trachurus mediterraneus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 22**) and total sampled area. Post-strata ordered in the W-E direction. 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.

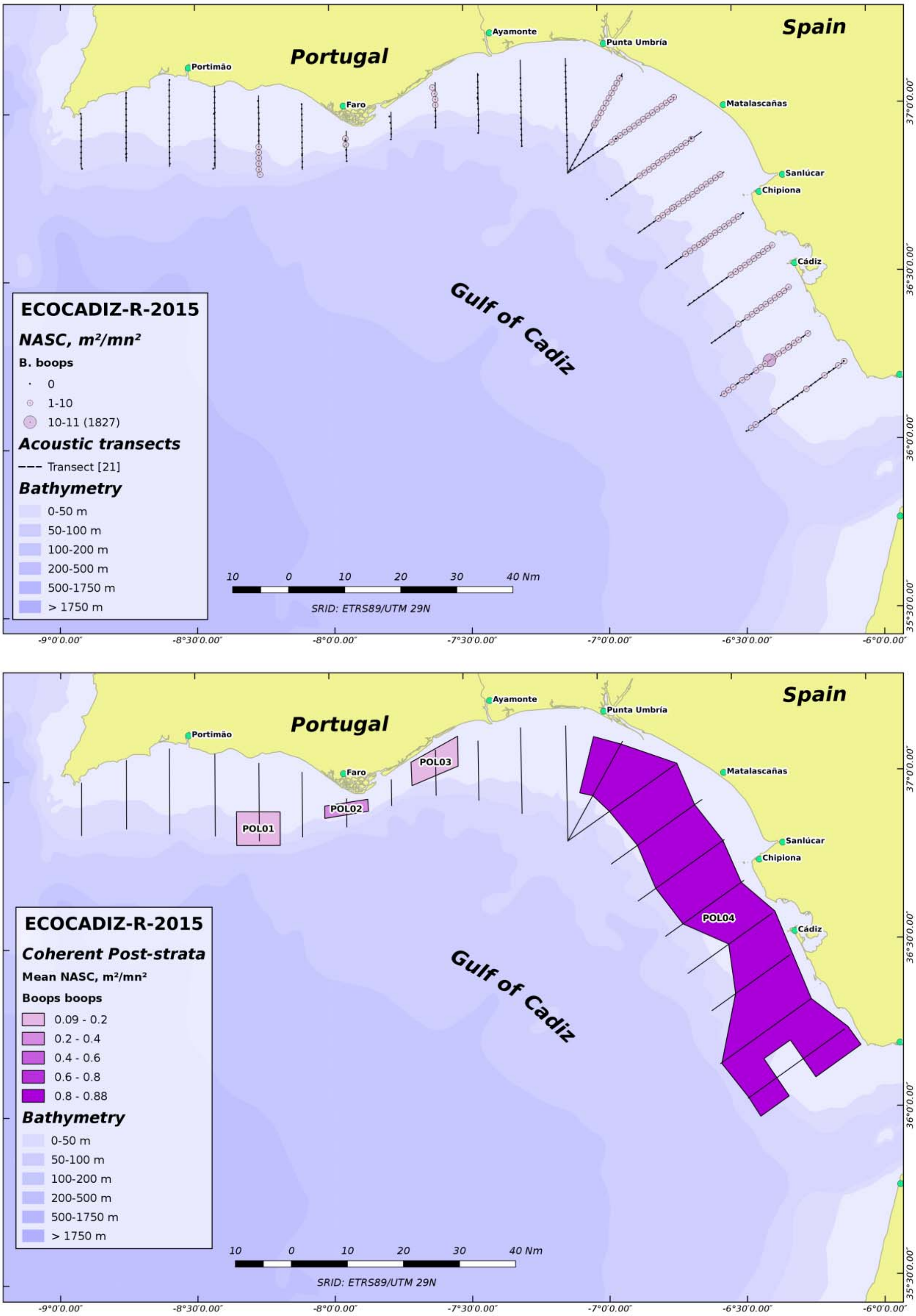


Figure 24. *ECOCADIZ-RECLUTAS 2015-10* survey. Bogue (*Boops boops*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

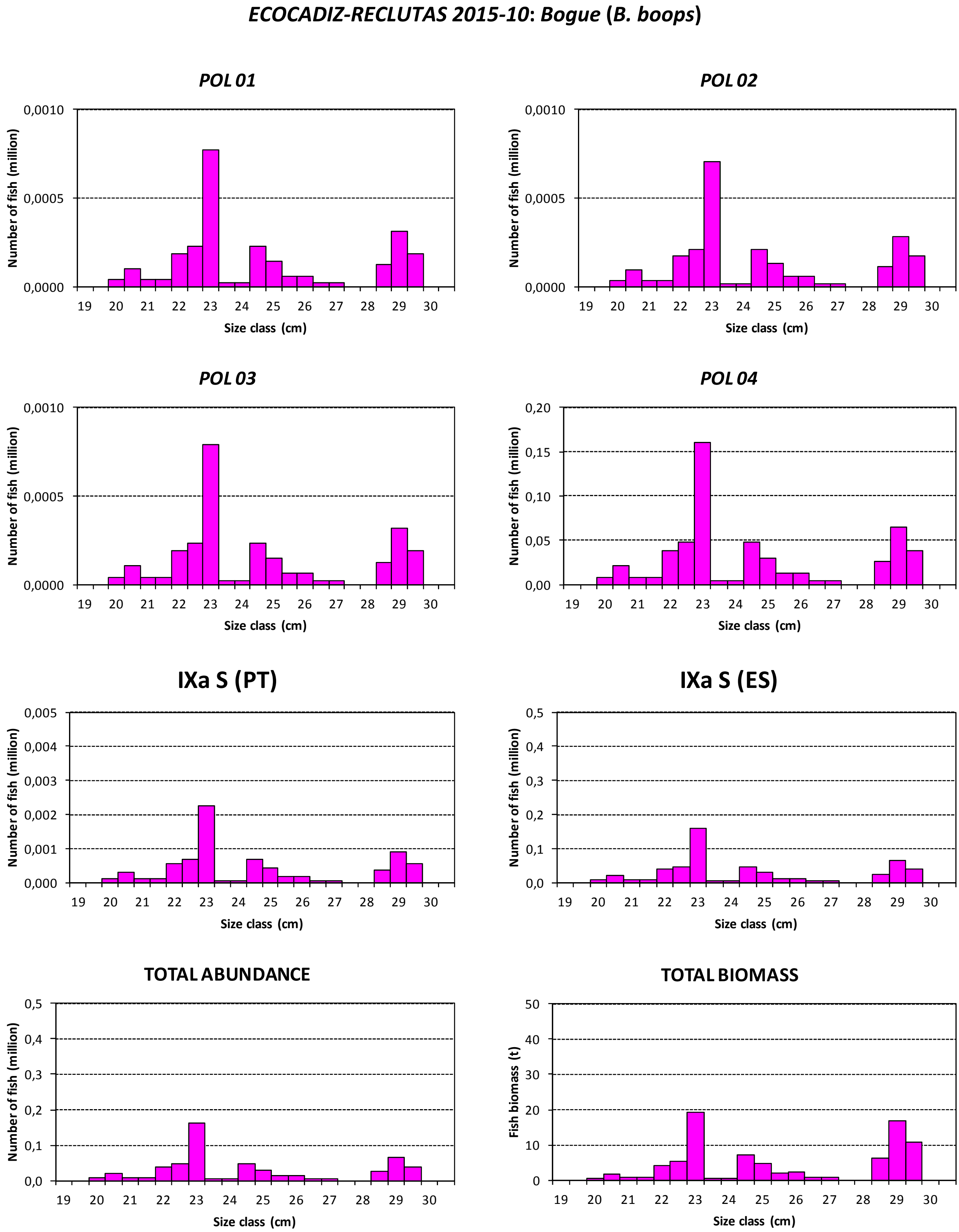
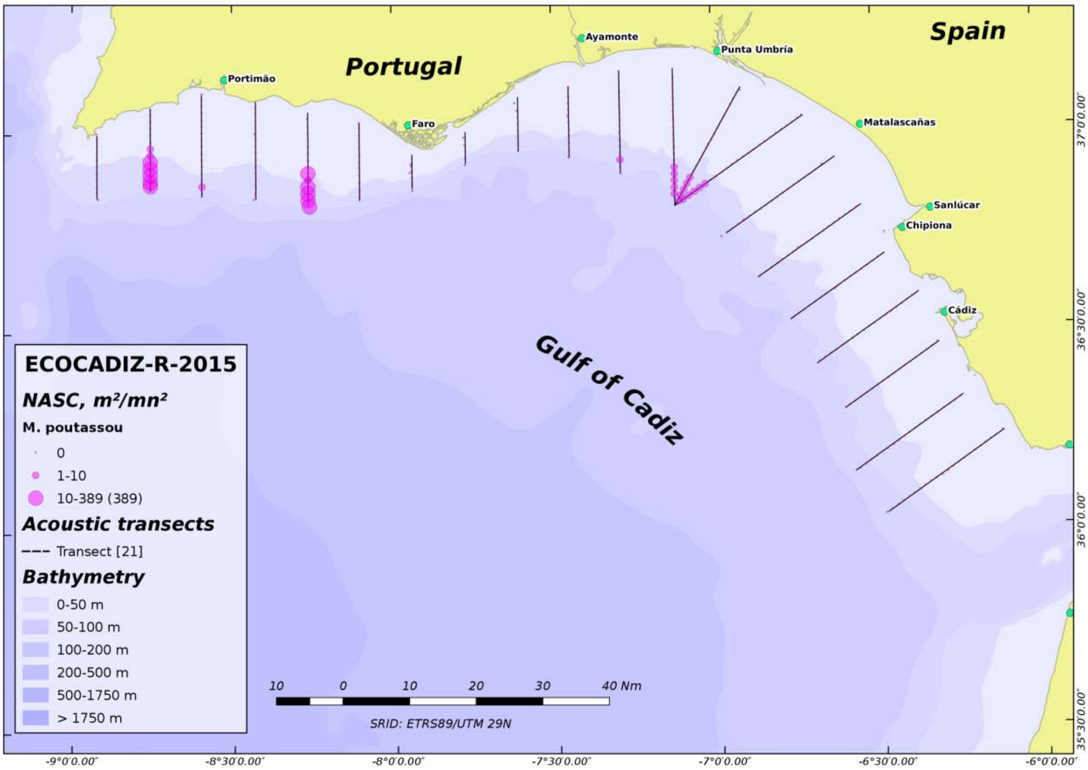


Figure 25. *ECOCADIZ-RECLUTAS 2015-10* survey. Bogue (*Boops boops*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 24**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.



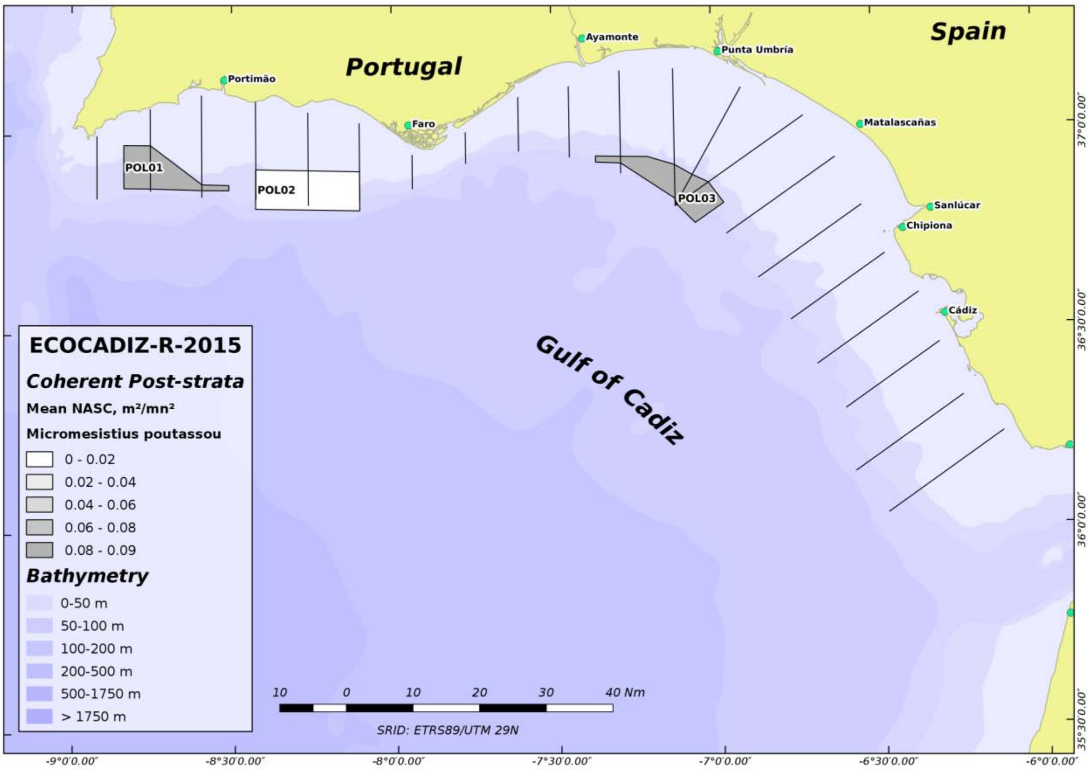


Figure 26. *ECOCADIZ-RECLUTAS 2015-10* survey. Blue whiting (*Micromesistius poutassou*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

ECOCADIZ-RECLUTAS 2015-10: *Blue whiting* (*M. poutassou*)

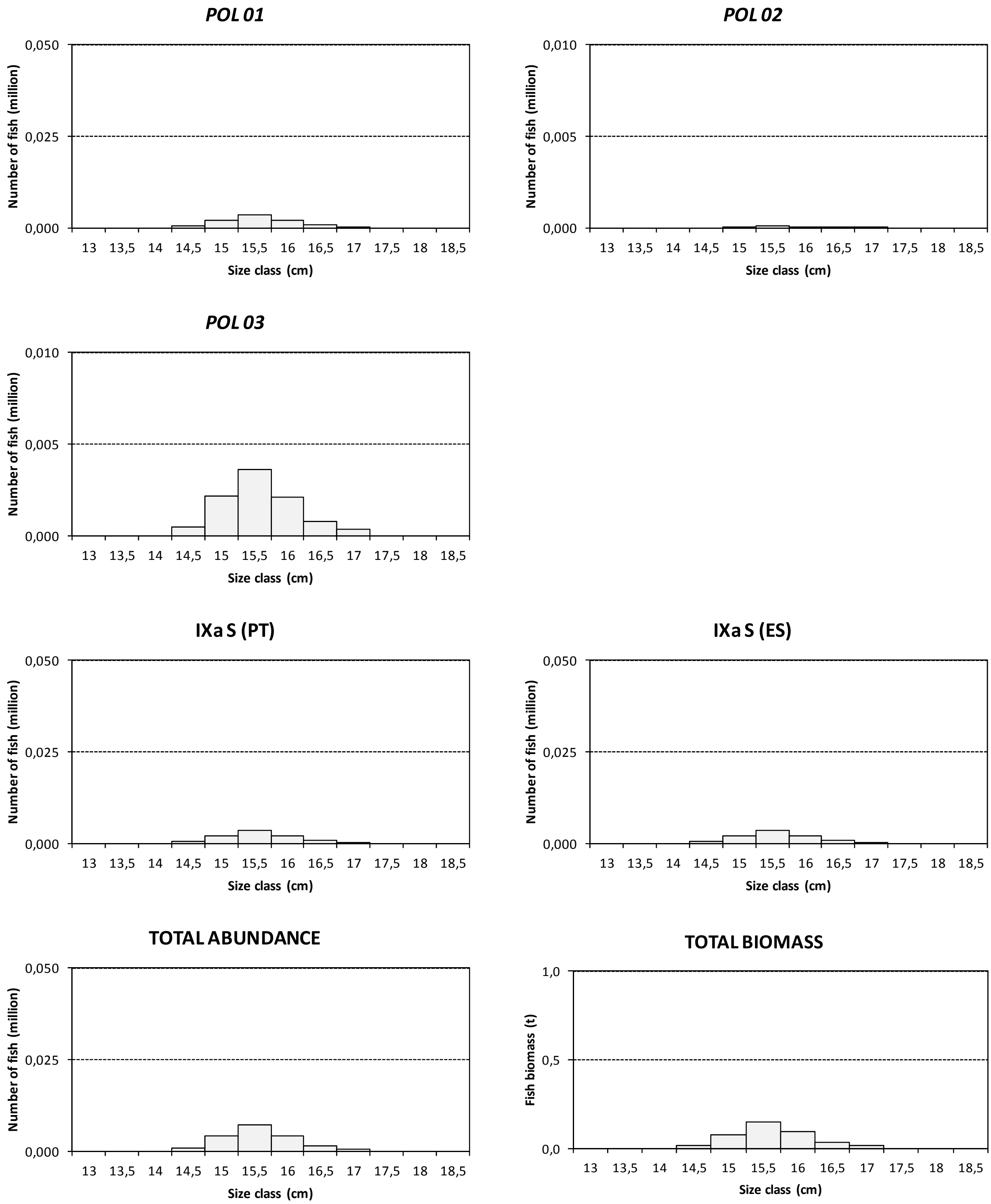
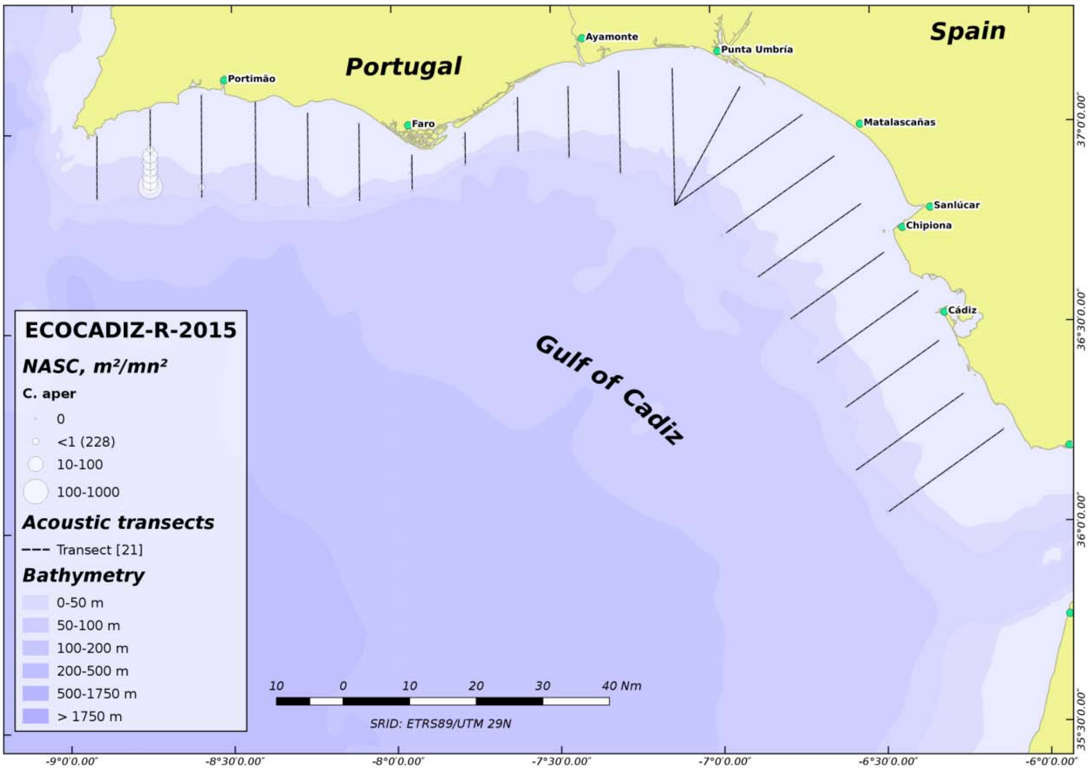


Figure 27. *ECOCADIZ-RECLUTAS 2015-10* survey. Blue whiting (*Micromesistius poutassou*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 26**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.



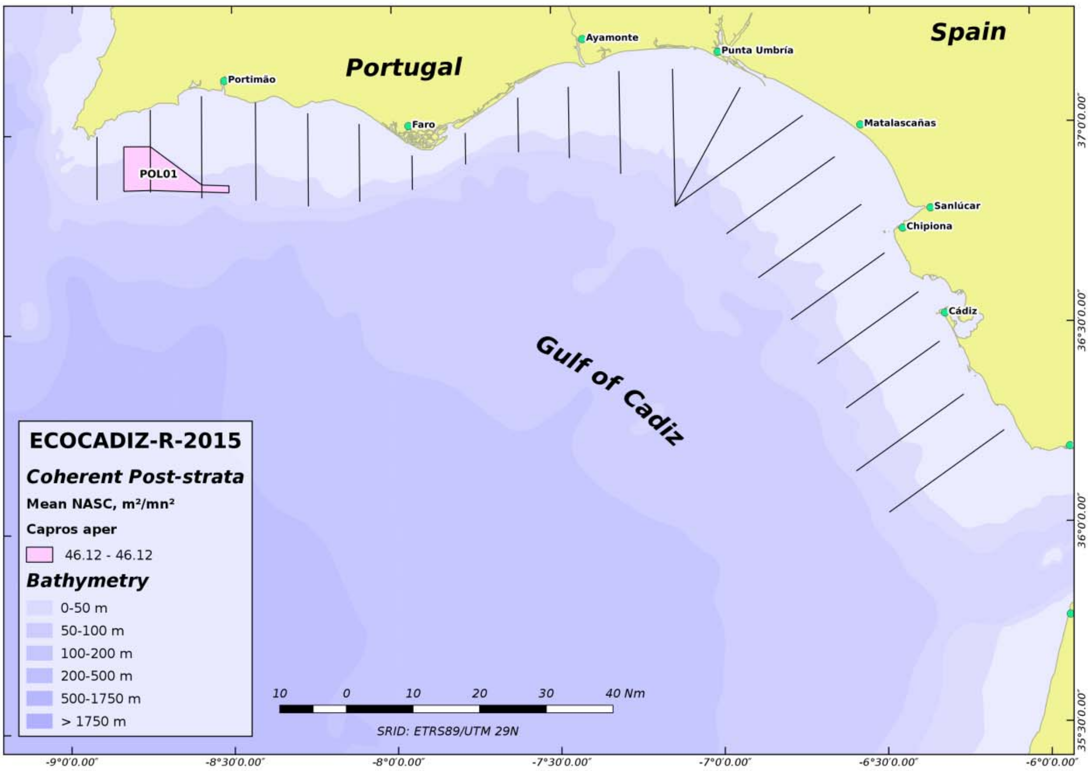


Figure 28. *ECOCADIZ-RECLUTAS 2015-10* survey. Boarfish (*Capros aper*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

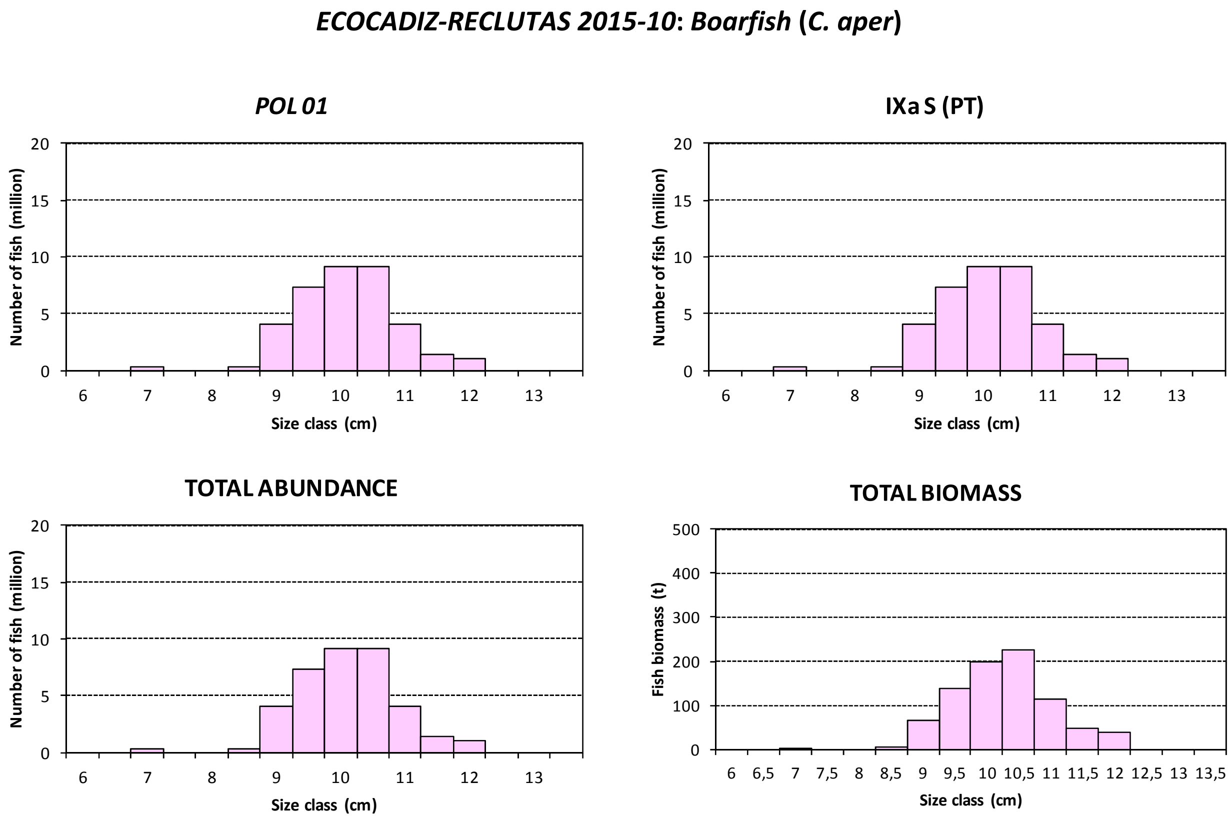


Figure 29. *ECOCADIZ-RECLUTAS 2015-10* survey. Boarfish (*Capros aper*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 28**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

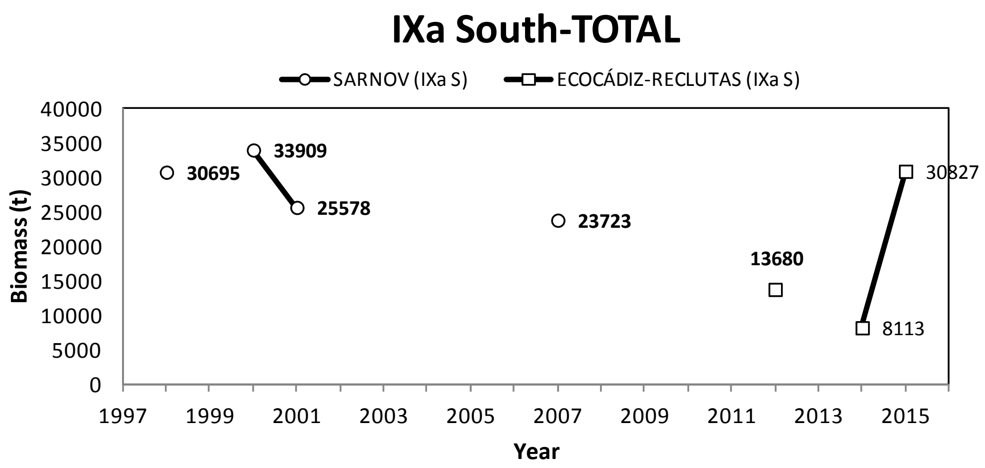


Figure 30. *ECOCADIZ-RECLUTAS* surveys series. Historical series of autumn acoustic estimates of anchovy biomass (t) in Sub-division IXa South. The graph includes the available estimates from both the Portuguese (SARNOV) and Spanish (ECOCADIZ-RECLUTAS) surveys series. The estimates are not differentiated in their regional components since such values are not available for the Portuguese series. The estimates correspond to the total biomass of the estimated population.

Annex 4: WGHANSA Stock Annexes

The table below provides an overview of the WGHANSA Stock Annexes. Stock Annexes for other stocks are available on the ICES website library under the publication type "Stock Annexes". Use the search facility to find a particular Stock Annex, refining your search in the left-hand column to include the *year*, *ecoregion*, *species,* and *acronym* of the relevant ICES expert group.

Stock ID	Stock name	Last updated	Link
ane-bisc_SA	Bay of Biscay Anchovy (Subarea 8)	June 2013	Anchovy 8
ane-pore_SA	Anchovy in Division 9.a	June 2011	Anchovy 9.a
hom-soth_SA	Horse Mackerel in Division 9.a (Southern horse mackerel)	June 2014	Southern horse mackerel
jaa-10_SA	Blue jack mackerel (*Trachurus picturatus*) in Subdivision $10.a_2$ (Azores)	June 2015	Blue jack mackerel $10.a_2$
sar-78_SA	Sardine in Subarea 7 and 8.abd	February 2013	Sardine 7&8.abd
sar-soth_SA	Sardine in Divisions 8.c and 9.a	February 2012	Sardine 8.c&9.a

Annex 5: Technical Minutes of the Review Group of Precautionary Approach Reference Points estimation

Review of ICES WGHANSA Report 2016

25 April 2016 – 20 May 2016

Reviewers: Chris Legault (chair)

Arni Magnusson

Colin Millar

Chair WG: Lionel Pawlowski.

Secretariat: Cristina Morgado

General

Horse mackerel *(Trachurus trachurus)* in Division 9.a (Atlantic Iberian Waters)

General comments

This was an unusually difficult stock to estimate reference points for given the narrow range of historical SSB, low F, no evidence of impaired recruitment, and consequently a lack of information on the stock recruitment relationship.

According to the advice sheet, B_{lim}= 103 kt and B_{pa}= 181 kt. B_{lim} is derived from B_{pa} using assessment uncertainty (σ_B=0.34), and the basis of B_{pa} is MSY $B_{trigger}$ which is itself defined as the lower bound (average) of 90% CI of the SSB time series in a stock being exploited well below F_{MSY}.

According to the advice sheet, F_{lim} = 0.19, based on stochastic long term simulations as the F that gives a 50% probability of SSB>B_{lim}. F_{pa} = 0.11 derived from F_{lim} and assessment uncertainty (σ_F = 0.32).

F_{MSY} = 0.11, was reduced to F_{pa} after stochastic long term simulations using a segmented regression SR relationship with breakpoint set at MSY $B_{trigger}$ = 181 kt. MSY $B_{trigger}$ was defined as the lower bound (average) of 90% CI of the SSB time series in a stock being exploited well below F_{MSY}

Technical comments

	Basis of underlying PA refpt is clear	Right approach to derive limit refpt from PA refpt	Limit refpt looks correct	Basis and value of σ is clear
B_{pa}	OK, B_{pa} is derived from MSY $B_{trigger}$ (stock type 6)	OK, assessment uncertainty $\sigma_B = 0.34$ was used rather than the default $\sigma_B = 0.20$	OK.	OK.

	Basis of underlying limit refpt is clear	Right approach to derive PA refpt from limit refpt	PA refpt looks correct	Basis and value of σ is clear
F_{pa}	OK, based on long term simulations.	OK.	OK.	OK.

Conclusions

8 out of 8 cells are OK, an excellent job was done.