WORKING GROUP ON SOUTHERN HORSE MACKEREL, ANCHOVY AND SARDINE (WGHANSA)

VOLUME 1 | ISSUE 34

ICES SCIENTIFIC REPORTS

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International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

H.C. Andersens Boulevard 44–46
DK-1553 Copenhagen V
Denmark
Telephone (+45) 33 38 67 00
Telefax (+45) 33 93 42 15
www.ices.dk
info@ices.dk

ISSN number: 2618-1371 I © 2020 International Council for the Exploration of the Sea

ICES Scientific Reports

Volume 1 | Issue 34

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Recommended format for purpose of citation:

ICES. 2019. Working Group on Southern Horse Mackerel, Anchovy and Sardine (WGHANSA).
ICES Scientific Reports. 1:34. 653 pp. http://doi.org/10.17895/ices.pub.4983

Editors

Alexandra (Xana) Silva

Authors

Gersom Costas • Erwan Duhamel • Susana Garrido • Leire Ibaibarriaga • Hugo Mendes • Rosana Ourens • Lionel Pawlowski • Marta Quinzan • Fernando Ramos • Isabel Riveiro • Margarita Rincón Hidalgo • Maria Santos • Andrés Uriarte • Laura Wise

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i Executive summary

The Working Group on Southern Horse Mackerel, Anchovy and Sardine (WGHANSA1) met by correspondence from 3 to 7 June 2019, and in Madrid from the 25 to the 28 of November 2019, and was chaired by Alexandra Silva (Portugal). There were 13 participants from France, Portugal, Spain and UK. The main task of WGHANSA was to assess the status the stocks of sardine in the Celtic Seas and English Channel (pil.27.7), sardine in the Bay of Biscay (pil.27.8abd), sardine in the Cantabrian Sea and Atlantic Iberian waters (pil.27.8c9a), anchovy in the Bay of Biscay (ane.27.8), anchovy in Atlantic Iberian waters (ane.27.9a; components west and south), horse mackerel in Atlantic Iberian waters (hom.27.9a) and jack mackerel in the Azores (jaa.27.10). Assessments and short-term forecasts were updated according to the stock annexes.

There is no assessment method adopted for pil.27.7 due to the lack of data.

The stock of pil.27.8abd was assessed as category 1 for the first time, following an interbenchmark. Recruitment has been above the average, the spawning–stock biomass declined and fishing mortality steeply increased in 2010–2012. SSB is fluctuating above MSY $B_{trigger}$ and F_{2018} is above F_{MSY} and below F_{pa}.

This year, the DEPM datapoint for 2017 was included in the pil.27.9a assessment for the first time, following a revision of the survey data. The stock has decreased since 2006 and stabilized to a historical low since 2012. The biomass of age 1 and older fish has been decreasing since 2006 and reached the lowest historical value in 2015. It has since increased slightly but is below B_{lim} since 2011. Recruitment has been below the time-series average since 2005. Recruitment in 2018 was around the geometric mean of the last five years. Fishing mortality has been decreasing from a peak in 2011. In 2018, it was the lowest in the time-series and below F_{pa} and F_{lim}.

The stock size indicator for anchovy in 9a.west decreased 90% from 2018 to 2019 (4129 t), after a period of an increasing trend since 2014. The harvest rate decreased 67% from management year 2017 to 2018 being below the median of the historical time-series.The relative spawning–stock biomass of the south component of the anchovy 9.a stock has fluctuated without a trend over the time-series, with most of the values above B_{pa}. From 2018 to 2019, the relative SSB decreased 5% but is still well above B_{pa}. Relative Fishing mortality (F) has fluctuated with no clear trend. From management year 2017 to 2018, relative F decreased 93%.

The SSB of horse mackerel in Division 9.a fluctuated from 1992, the beginning of the assessment period, to 2012–2013 and afterwards increased continuously to a historical maximum, in 2018. The consistently high recruitment since 2011 has contributed to the SSB increase. Fishing mortality was 0.029 year -1 in 2018, showing a 29% decrease compared to 2017. Fishing mortality has been below F_{MSY} over the whole time-series. The spawning–stock biomass has been above MSY $B_{trigger}$ over the whole time-series.

The exploration of data on anchovy abundance-at-age from juvenile surveys IBERAS-JUVESAR and ECOCADIZ-RECLUTAS indicated the series are still short to conclude about their future incorporation into the assessments. The analyses of internal consistency of the indices and of their consistency with spring acoustic surveys showed promising results for ECOCADIZ-RECLUTAS and pointed out the need to revisit the results of some of the surveys, particularly the IBERAS_JUVESAR series. For sardine, 0-group abundance from IBERAS-JUVESAR (2013–2019) combined with data from an earlier autumn survey, SAR-PT-AUT (discontinued in 2008) covering the northwestern Iberian waters, showed a significant correlation with the abundance of age 1 individuals in surveys carried out in the following spring.

ii Expert group information

Expert group name	Working Group on Southern Horse Mackerel, Anchovy and Sardine (WGHANSA)
Expert group cycle	Annual
Year cycle started	2019
Reporting year in cycle	1/1
Chair	Alexandra Silva, Portugal
Meeting venue and date	3–7 June 2019, by correspondence (13 participants) 25–28 November 2019, Madrid, Spain (11 participants)

1 Introduction

1.1 Terms of reference

The Working Group on Southern Horse Mackerel Anchovy and Sardine (WGHANSA), chaired by Alexandra Silva, Portugal, will meet by correspondence on 3–7 June 2019 (WGHANSA1) and in Madrid, Spain, on 25–28 November 2019 (WGHANSA2) to:

a) Address generic ToRs for Regional and Species Working Groups for relevant stocks (hom.27.9a and ane.27.9a in WGHANSA1 and pil.27.7, pil.27.8abd, pil.27.8c9a, ane.27.8, jaa.27.10a2 in WGHANSA2);

b) Explore data from juvenile surveys (e.g. JUVESAR, JUVENA, ECOCADIZ, RECLUTAS) for future incorporation in the assessments;

c) Propose geographical subdivisions within Division 8.c and Division 9.a. WGHANSA to report data and stock biomass trends for pil.27.8c9a and ane.27.9a.

The assessments were carried out on the basis of the stock annexes prior to and during the meetings and coordinated as indicated in the table below. The assessments were audited during the meetings (Annex 4).

Stock	**Stock code**	**Stock coordinator 1**	**Stock coordinator 2**	**Advice to be provided in 2019**	**Periodicity in years**	**Time period in the year for releasing the advice**	**Category**	**Advice basis**	**Notes**
Anchovy (*Engraulis encrasicolus*) in Division 9.a (Atlantic Iberian waters)	ane.27.9a	Fernando Ramos	Susana Garrido	x	1	28 June	3 (south component); 3 (western component)	PA, in-year advice	Benchmarked in 2018. Two stock components, western and southern, assessed separately. Advice for period 1 July 2019–30 June 2020
Horse mackerel (*Trachurus trachurus*) in Division 9.a (Atlantic Iberian waters)	hom.27.9a	Gersom Costas	Hugo Mendes	X	1	28 June	1	MSY	There is a long-term management strategy, agreed between all parties, evaluated to be precautionary by ICES. ICES was requested to provide catch advice on the basis of MSY.
Anchovy (*Engraulis encrasicolus*) in Subarea 8 (Bay of Biscay)	ane.27.8	Leire Ibaibarriaga		x	1	13 December	1	Manage ment strategy	Benchmarked in 2013
Sardine (*Sardina pilchardus*) in Subarea 7 (Southern Celtic Seas, and the English Channel)	pil.27.7	Rosana Ourens	Erwan Duhamel	X	2	13 December	5	No advice	Benchmarked in 2017; lack of reliable catch data to provide advice

Stock	Stock code	Stock coordinator 1	Stock coordinator 2	Advice to be provided in 2019	Periodicity in years	Time period in the year for releasing the advice	Category	Advice basis	Notes
Sardine (*Sardina pilchardus*) in divisions 8.a–b and 8.d (Bay of Biscay)	pil.27.8abd	Lionel Pawlowski	Andres Uriarte	X	1	13 December	1	MSY	Inter-benchmark in 2019
Sardine (*Sardina pilchardus*) in divisions 8.c and 9.a (Cantabrian Sea and Atlantic Iberian waters)	pil.27.8c9a	Isabel Riveiro	Laura Wise	X	1	13 December	1	MSY	Benchmarked in 2017; reference points changed in 2019, in the context of the evaluation of a management and recovery plan.

WGHANSA1 reported by 18 June 2019 for the attention of ACOM, on Anchovy in Division 9a (ane.27.9a) and Horse mackerel in Division 9a (hom.27.9a).

WGHANSA2 reported by 13 December to the attention of ACOM on Sardine in Subarea 7 (pil.27.7), Sardine in divisions 8a,b,d (pil.27.8abd), sardine in divisions 8c and 9a (pil.27.8c9a), anchovy in Subarea 8 (ane.27.8) and Jack mackerel in Subdivision 10.a.2 (Azores waters, jaa.27.10a2).

1.2 Report structure

Ad hoc and Generic ToR relative to the stocks for which assessment is required are dealt stock by stock in respective chapters of the report: Anchovy 8 (Chapter 3), Anchovy 9.a (Chapter 4), Sardine 8.abd (Chapter 6), Sardine 7 (Chapter 7), Sardine in 8.c and 9.a (Chapter 8), Southern Horse Mackerel (Chapter 9) and Blue jack mackerel (*Trachurus picturatus*) in the waters of the Azores (Chapter 10). Tors b) and c) are addressed in Chapters 11 and 12, respectively.

1.2.1 Answer to ToRs are dealt as follows

ToR a). The generic ToRs, assessment, evaluation of the state of the stock against reference points and provide catch options were carried out for all stocks requested (Stock table above, Sections 2 to 10)). The Mohn's Rho to assess retrospective error was calculated for all category 1 stocks. Reference points are not defined for the western component of the Anchovy 9a stock, classified in category 3. The WG did not define reference points for this stock component because current ICES guidelines on the estimation of reference points for category 3–4 are not appropriate for short-lived species. Work to explore reference points for this stock is in progress in the framework of the Workshop on Data-limited Stocks of Short-lived Species (WKDLSSLS).

The following stock annexes were updated: pil.27.8abd_SA, after the interbenchmark process (Section 6, ICES, 2019a) and pil.27.8c9a_SA, due to new biological reference points adopted in the context of the evaluation of a management and recovery plan for the stock (ICES, 2019b). There is no assessment method adopted for pil.27.7 due to the lack and quality of data. This year, the WG considered that catch data from this stock were not reliable to provide advice.

ToR b). The WG examined the acoustic surveys JUVESAR-IBERAS, and ECOCADIZ-RECLUTAS which cover 9a.west and 9a.south respectively, in the autumn, that aim to determine the abundance and distribution of anchovy and sardine juveniles (Section 11). Both the internal consistency of these surveys and their consistency with spring acoustic surveys, PELAGO and PELACUS, were explored. Data on the two anchovy components and on Sardine 8c9a were explored. For the latter stock, data were also compiled from the Portuguese autumn survey series discontinued in 2008, SAR-PT-AUT. The juvenile surveys show promising results for future incorporation in stock assessment. However, the WG considered the work should be continued intersessionally and proposes to keep this ToR for next meeting. In the case of anchovy, the available time series is still short and the topic should be revisited next year. For sardine the analysis carried out this year will be presented to WGACEGG for discussion. The WG will also perform trial assessments using a time series of autumn surveys.

ToRc) was addressed in WGHANSA2. The WG proposes the adoption of two subdivisions: 9a.west and 9a.south which correspond to the 2 components of the anchovy 9a stock. The limits of the seven smaller geographical areas used to report catch and survey data of 9a anchovy and 8c9a sardine since 1991 were clarified. These areas are not proposed as ICES subdivisions. However, the WG decided to keep the reporting practice since the areas are meaningful to track changes in distribution and biology of the speciesFinally, several annexes contain the remaining issues such as:

- Annex 1 - Participants list;
- Annex 2 - Working Documents;
- Annex 3 - Stock Annexes;
- Annex 4 - Stock audits;

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

Timing of the meeting

Last year ICES decided, following the agreement of the clients, that WGHANSA will meet twice in 2019 to address General and specific ToRs: in June, by correspondence, for the stocks of Anchovy in 9.a and Horse mackerel in 9.a and, in November, in a physical meeting, for the remaining stocks. This year it was not possible to meet back to back with WGACEGG, but the physical meeting in November will follow the meeting of WGACEGG. Therefore the surveys entering the stocks assessed in November (PELGAS, PELACUS, PELAGO, DEPM surveys) as well as surveys providing “other information” (ECOCADIZ SUMMER, ECOCADIZ-RECLUTAS, IBERAS-JUVESAR) will be scrutinized and discussed before being used in the assessments.

The incorporation of data from juvenile surveys will not be possible before 2021 for the anchovy 9.a assessments (Section 10). For sardine 8c9a the incorporation of data from autumn juvenile surveys will be explored intersessionally.

Having the meeting in November allowed to include observed catches in 2019 in the short term catch forecasts of sardine 8abd and sardine 8c9a.

The participants recognise that two meetings per year (one of them by correspondence) is not an ideal situation.

1.4 Quality of the fishery input

In 2019 (2018 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.

Landings data for Sardine in Subarea 7 are considered to be unreliable due to possible misreporting with other species in the past and under-reporting of bycatches.

1.5 Overview of the sampling activities on a national basis for 2018

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 sampling summary by stocks on national basis is the following:

Anchovy 9a

Country	Official Catch	% of catch sampled	No. samples	No. measured	No. Aged
Spain	5334	100%	329	9191	3688
Portugal	8306	100%	44	1033	843
Total	13 640	100%	373	10 224	4531

Horse Mackerel 9a

Country	Official Catch	% of catch sampled	No. samples	No.measured	No. Aged
Portugal*	19 047	100%	350	3544	322
Spain	18 041	100%	248	14 742	851
Total	37 088		598	18 286	1173

***sampling in 2017 was optimised via size category as approach described in Stock Annex.**

Anchovy 8

Country	Official Catch	% of catch sampled	No. samples	No. measured	No. Aged
Spain	27 622	100%	343	47 261	3929
France	3151	100%	16	796	1949
Total	30 773		359	48 057	5878

Sardine 8abd

Country	Official Catch	% of catch sampled	No. samples	No. measured	No. Aged
France	23 419	100%	65	3537	1641
Spain	7104	100%	155	15 392	345
Total					

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	606	100%	232	13 369	147
Total	606	100%	232	13 369	147

Sardine 8c9a

Country	Official Catch	% of catch sampled	No. samples	No.measured	No. Aged
Portugal	9738	100%	47	4057	1636
Spain	5323	100%	111	14 181	1978
Total	15 062		158	18 238	3614

Sardine 7

Country	Official Catch	% of catch sampled	No. samples	No.measured	No. Aged
France	663	0%	0	0	0
UK	8141	36%	120	13 086	0
Germany	490	0%	0	0	0
Netherlands	811	0%	0	0	0
Denmark	263	0%	0	0	0
Ireland	44	0%	0	0	0
Total	10 412		120	13 086	0

2 Anchovy in northern areas

This stock section has not been updated.

3 Anchovy in the Bay of Biscay (Subarea 8)

3.1 ACOM advice, STECF advice and political decisions

In 2013 and 2014, the STECF evaluated a set of harvest control rules for the management of the Bay of Biscay anchovy stock (STECF, 2013; STECF 2014). The European Commission, EU Member States and stakeholders chose harvest control rule named G4 with a harvest rate of 0.45. ICES reviewed this harvest control rule in 2015 and concluded that it was precautionary (Annex 5 in ICES, 2015b). Subsequently, in December 2015, ICES advised that “when the management plan is applied, catches in 2016 should be no more than 25 000 tonnes”. 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).

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”.

This new harvest control rule formed the basis of the ICES advice and the TAC subsequently established by the Council from 2017 onwards.

In January 2019 the Council established the TAC in 2019 for the Bay of Biscay anchovy stock at 33 000 tonnes (Council Regulation No 124/2019), from which 90% corresponded to Spain and 10% to France. However, these percentages might be modified due to bilateral agreements between countries.

According to the European Commission Regulation No. 185/2013, the deductions from the anchovy fishing quota allocated to Spain because of overfishing of mackerel quota in 2009 shall be applied from 2016 to 2023. This supposes a reduction of 3696 tonnes in the 2019 Spanish quota of Bay of Biscay anchovy.

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 of high survivability and *de minimis* exemptions both in the pelagic trawl fishery and the purse-seine fishery from 2015 to 2017. In November 2017, these exemptions were extended up to 2020 (Commission Delegated regulation No. 188/2018).

3.2 The fishery in 2018 and 2019

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 but less and less catches).

The total number of fishing licences for anchovy in Spain in 2018 and 2019 were 160 and 158 respectively. Since the reopening 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 since 2016 is around 28. 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 species of these vessels is sardine, and anchovy is more opportunistic in autumn.

The number of French pelagic trawlers decreased drastically during the closure of anchovy fishery (2005–2009) because they were targeting mainly anchovy and tuna. Currently around 12 pairs of trawlers (~24 vessels) are able to target anchovy. In 2018, as in previous years, a shift occurred on the French anchovy fishery. Pair pelagic trawlers mainly target tuna between July and October, and single pelagic trawlers didn't catch anchovy this year. Particularly during August and September, purse-seiners caught a bit more than 2000 tons of anchovy, while pelagic trawlers were targeting tuna.

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 2018 were 30 773 tonnes, from which 27 622 corresponded to Spain and 3151 to France. From the Spanish catches, 15 tonnes corresponded to anchovy used as live-bait for tuna fishing and 93 tonnes to discards from Spanish bottom otter trawls directed to demersal fish. These discards are less than 0.3% of the total catch and they are considered negligible for this stock.

The series of monthly catches are shown in **Table 3.2.2.2**. In 2018, most of the catches occurred between April and May, where the bulk of the Spanish fishery occur. Although catches were recorded in all the months.

The quarterly catches by division in 2018 are given in **Table 3.2.2.3**. Most of the catches took place in the second quarter (78%), followed by the third, first and fourth quarter (15%, 5% and 2% respectively). The major fishing activity of the Spanish fleet occurred in the second quarter (85%), whereas the French fleet operated mainly in the third quarter (63%). Regarding fishing areas, most of the Spanish catches in the first semester corresponded to ICES Division 8.cE and to ICES Divisions 8.cW in the second semester. The French catches corresponded to ICES divisions 8.a and 8.b.

In previous years, non-negligible catches originate in divisions 7.h and 7.e (statistical rectangles 25E5 and 25E4) have been reallocated 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. However, in 2018 no French anchovy landings have been declared in 25E5 and 25E4 and no catches have been reallocated to 8.a.

3.2.3 Catch numbers-at-age and length

Catch numbers-at-age by quarter in 2018 for Spain and France are given in **Table 3.2.3.1**. Age 1 individuals were predominant in all the quarters corresponding to 2%, 65%, 84% and 60% of the total respectively. Age 0 individuals appeared in small amounts in the third quarter and represented 6% of the total (in numbers) in the fourth quarter.

Table 3.2.3.2 records the age composition of the international catches since 1987, on a half-yearly basis. In 2018, one-year old anchovies dominated in the catches during both halves, as occurred in most of the years of the time-series.

Catch-at-length data (by 0.5 cm classes) by quarter in 2018 are given in **Table 3.2.3.3**. The length range was between 9 and 24 cm. The mean length was between 12.7 and 14.8 cm in the Spanish catches and between 14.9 and 15.5 cm in the French catches. The smallest individuals corresponded to the third and fourth quarters in the Spanish catches.

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 2018, is shown in **Table 3.2.4.1**. See the stock annex for methodological issues.

3.2.5 Preliminary fishery data in 2019

The provisional catches during the first semester of 2019 were 22 403 t, from which 21 834 t corresponded to Spain and 569 t to France. 32% of the catches (in mass) during the first semester were age 1.

It must be emphasised that 2019 fishery data are preliminary. Official logbook data for the Spanish fleet were not available and the length distributions of the Spanish catch data were not fully processed. In addition, no age structure was available yet for the French catches in the first half of the year, and they were assumed to have the same age composition as the Spanish catches in June, when most of the French catches of the first semester take place. For the assessment, 2018 November and December catches were assumed to be 3.3% of the total annual catch (which is the average of the percentage of the catches in November and December in 2010–2017, after the re-opening of the fishery). Therefore, the total catch in November and December was taken as 879 t, resulting in 4219 t for the second semester 2019.

Table 3.2.2.1. Bay of Biscay anchovy: Annual catches (in tonnes) as estimated by the Working Group members.

COUNTRY	FRANCE	SPAIN	SPAIN	UNALLOCATED	OTHER COUNTRIES	INTERNATIONAL
YEAR	VIIIab	VIIIbc	Live Bait Catches			VIII
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	2,300	18,060	310			20,670
2017	3,153	22,955	332	9		26,450
2018	3,151	27,607	15			30,773
2019 (Up to end of Octo	2,056	23,687				25,743
AVERAGE (1960-2004)	6,394	26,337				32,824
AVERAGE (2010-2018)	3,715	16,120				19,969

** : Experimental fishery

Table 3.2.2.2. Bay of Biscay anchovy: Monthly catches by country (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
2015	0	0	1011	6089	4482	7833	505	1305	6331	590	106	0	28253
2016	41	11	1432	8746	3811	1339	657	1760	687	58	1758	62	20360
2017	21	16	1915	5854	9839	5118	559	937	1307	289	238	15	26108
2018	10	10	1498	8895	12956	2131	1736	1831	1166	508	9	8	30758

Table 3.2.2.3. Bay of Biscay anchovy: Catches in the Bay of Biscay by country and divisions in 2018 (without live bait catches).

COUNTRIES	DIVISIONS	QUARTERS				CATCH (t)	
		1	2	3	4	ANNUAL	%
SPAIN	8abd	532	3846	8	12	4397	15.9%
	8cE	476	18627	881	13	19996	72.4%
	8cW	510	920	1784	0	3213	11.6%
	TOTAL	1517	23392	2672	25	27607	100.0%
	%	5.5%	84.7%	9.7%	0.1%	100.0%	
FRANCE	8abd		590	2062	500	3151	100.0%
	8cE	0	0	0	0	0	0.0%
	8cW	0	0	0	0	0	0.0%
	TOTAL	0	590	2062	500	3151	100.0%
	%	0.0%	18.7%	65.4%	15.9%	100.0%	
INTERNATIONAL	8abd	532	4435	2069	512	7548	24.5%
	8cE	476	18627	881	13	19996	65.0%
	8cW	510	920	1784	0	3213	10.4%
	TOTAL	1517	23982	4734	525	30758	100.0%
	%	4.9%	78.0%	15.4%	1.7%	100.0%	

Table 3.2.3.1. Bay of Biscay anchovy: catch-at-age in thousands for 2017 by country and quarter (without the catches from the live bait tuna fishing boats).

	QUARTERS	1	2	3	4	Annual total
	AGE	VIIIabc	VIIIabc	VIIIabc	VIIIabc	VIIIabc
TOTAL Subarea 8	0	0	0	612	1,159	1,770
	1	1,250	681,668	166,133	12,215	861,266
	2	120	399,811	30,681	6,893	437,506
	3	7	39,475	1,081	129	40,693
	4	1	291	0	0	292
	5	0	0	0	0	0
	TOTAL(n)	70,288	1,052,336	198,506	20,396	1,341,527
	W MED.	21.57	22.75	23.04	24.31	22.76
	CATCH. (t)	1517	23982	4734	525	30758
	SOP	1516	23945	4574	496	30530
	VAR. %	99.90%	99.85%	96.61%	94.49%	99.26%

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 and from 2016 onwards). Units: Thousands.

Units: Thousands

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	######	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	######	510,015	######	766,523	######	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		2016		2017		2018	
Age	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
0	0	37,068	0	443	0	74,571	0	23,725	0	1,770
1	228,729	187,159	560,920	251,508	261,072	136,044	469,609	82,487	682,918	178,348
2	336,224	12,181	357,044	128,579	363,465	58,740	425,906	48,549	399,932	37,574
3	53,703	3,035	27,236	6,914	45,212	2,287	92,731	7,660	39,483	1,210
4	4,271	0	173	0	231	0	2,339	0	292	0
5	0	0	0	0	0	0	0	0	0	0
Total #	622,927	239,443	945,373	387,443	669,979	271,642	990,585	162,421	1,122,624	218,902

Table 3.2.3.3. Bay of Biscay anchovy: Catch numbers-at-length by country and quarters in 2018.

	QUARTER 1		QUARTER 2		QUARTER 3		QUARTER 4	
Length (half cm)	France	Spain	France	Spain	France	Spain	France	Spain
3.5								
4								
4.5								
5								
5.5								
6								
6.5								
7								
7.5								
8								
8.5								
9		17		13		6		18
9.5		51						
10		192		37		5		8
10.5		321	0	408		1		2
11		1,009	0	1,382		132		299
11.5		1,030	0	1,452		4		7
12		2,293		6,940		1,577		452
12.5		2,835	164	23,905		5,661		70
13		6,334	1313	74,487	582	13,755		514
13.5		6,636	1805	127,668	582	20,372	195	1
14		9,557	2625	147,545	2524	20,217	1173	275
14.5		9,828	5743	143,932	9318	16,732	2247	1
15		10,185	4923	141,687	19412	15,899	3518	146
15.5		7,298	3282	129,906	18830	13,334	4690	
16		4,658	3446	100,085	12230	7,143	4006	38
16.5		3,662	820	64,913	6988	3,988	1857	
17		2,441	656	35,859	3300	2,697	586	0
17.5		1,058		18,722	2329	864	293	
18		741		6,568	194	352		
18.5		47		1,766		40		
19		21		348				
19.5		31		23				
20		17						
20.5		4						
21		8						
21.5		8						
22								
22.5								
23								
23.5		4						
24								
24.5								
25								
25.5								
26								
Total ('000)		70288	24778	1027646	76290	122777	18565	1831
Catch (t)		1517	590	23393	2062	2686	500	25
Mean Length(cm)		14.5	14.9	14.8	15.5	14.4	15.5	12.7

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

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		2016		2017		2018	
Sources:	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
Age 0	na	16.1	0.0	9.4	na	14.3	na	8.5	na	12.5
1	18.3	26.3	17.0	19.9	19.3	20.0	19.8	23.3	20.7	22.1
2	25.1	33.3	25.5	28.1	24.5	24.1	25.1	26.8	25.0	28.3
3	28.9	45.8	28.7	38.5	31.7	32.8	28.8	30.7	33.7	28.8
4	26.0	na	25.5	na	32.6	na	29.9	0.0	27.8	0.0
5	na	na	na	na	na	na	na	na	na	na
Total	22.9	25.3	20.5	22.9	23.0	19.4	23.0	22.6	22.7	23.2

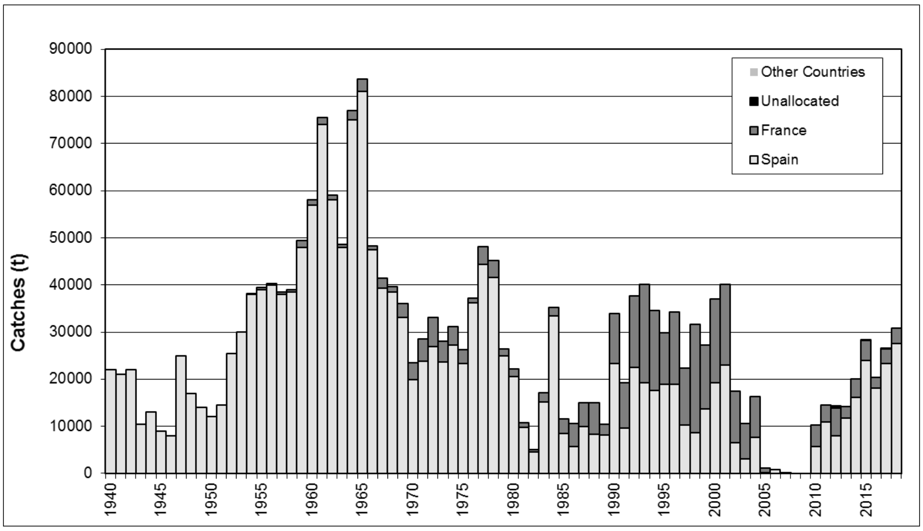


Figure 3.2.2.1. Bay of Biscay anchovy: Historical evolution of catches in Division 8 by countries.

3.3 Fishery-independent data

3.3.1 BIOMAN DEPM survey 2019

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 2019 is attached as a working document in ICES WGACEGG 2019 (Annex 3) (**Santos. M *et al.* BIOMAN 2019).**

3.3.1.1 Survey description

The 2019 anchovy DEPM survey was carried out in the Bay of Biscay from 9th to the 31st 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. Some specifications of the sampling are given in **Table 3.3.1.1.1.**

Total number of PairoVET samples (vertical sampling) obtained was 782. From those, 574 had anchovy eggs (73%) with an average of 540 eggs m^{-2} per station in the positive stations, and a maximum of 6590 eggs m^{-2} in a station. A total of 30 882 anchovy eggs were encountered and classified in the PairoVET stations. The number of CUFES samples (horizontal sampling) obtained was 1883. Frome those 1251 (66%) stations had anchovy eggs with an average of 23 eggs m^{-3} per station and a maximum of 332 eggs m^{-3} in a station.

This year 18% of the anchovy eggs were found in the Cantabrian Coast, in this coast the survey arrived until 6ºW. There were eggs all over the French platform, until 200 m depth, up to 46ºN and from there to 47º37’N, from the coast to 100 m depth, were the limit was found. There were some anchovy eggs at the limit of the 8abd at 48ºN but inside the 8abd so those were considered for the biomass estimation. (**Figure 3.3.1.1.1**). The total area covered was 117 111 km^2 and the spawning area was 79 735 km^2.

In relation with the adult samples, 45 pelagic trawls were performed, from which 42 provide anchovy and 40 were selected for the analysis. This year, three additional anchovy adult samples were obtained from the Basque purse seines. In total, there were 43 adult anchovy samples to estimate the adult parameters. The spatial distribution of the samples and their species composition is shown in **Figure 3.3.1.1.2**. This year, as the last, the biggest anchovy were found in the Cantabric coast, mean size anchovy were encountered on the south and north French coast, and the smallest, as usually, around the Gironde estuary. Spatial distribution of mean length and mean weight and size distribution by haul (males and females) for anchovy is shown in **Figure 3.3.1.1.3**. The most abundant species in the trawls ware: anchovy, mackerel, sardine and horse mackerel. Anchovy adults were found in the same places where the anchovy eggs were found.

This year the mean SST of the survey, 14.8 was loewer than last year (15.2ºC), the minimum was 10.2ºC and the maximum16.8ºC. The mean SSS (35) was higher than last year (34.41) with a minimum of 27.7 and a maximum of 39.5. The weather conditions during the survey were good in general.

Figure 3.3.1.1.4 shows the maps of sea surface salinity and temperature found during the survey.

3.3.1.2 Total daily egg production estimate

The estimates of daily egg production(P_0), daily egg mortality rates (z) and total egg production (P_{tot}) 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 2019 was estimated at 1.36 E+13 with a CV of 0.0890, lower than last year and the second highest of the historical series since 1987.**Figure 3.3.1.2.2** shows the historical series of P_0, z, A+ and P_{tot}

3.3.1.3 Daily fecundity and total biomass

To estimate the total Biomass following the DEPM a daily fecundity (*DF*) estimate is necessary. To estimate the *DF* the sex ratio (*R*), the female mean weight (W_f), the batch fecundity (*F*) and the spawning fraction (*S*) estimates are required. The anchovy adults from the survey were used to estimate those parameters. This year there were no problems in estimating those parameters. The results of all those parameters are showed in table (**Table 3.3.1.3.1**) and the historical series of those in **Figure 3.3.1.3.1**. The final **total biomass** obtained was **223 210 t with a CV of 0.1155.**

3.3.1.4 Population-at-age

In order to estimate the numbers-at-age, the age readings based on 2789 otoliths from 40 samples, well distributed over the spawning area, were available. Six strata were defined based on the egg abundance, the adult distribution and the size and age of adult anchovy: Cantabric (Ca), Coastal South (CS), Coastal North (CN), Garonne (G), North (N) and West(W). (**Figure 3.3.1.4.1**). 63% of the anchovy in numbers were estimate as individuals of age 1 (53% in mass), 34% of the individuals in numbers were of age 2 (42% in mass) and 3% of the individuals in numbers were of age 3 (4% in mass) (**Table 3.3.1.4.1**). This was a medium year recruitment. The anchovy age composition by haul 2019 is shown in **Figure 3.3.1.4.2**. The time-series of the numbers-at-age is shown in **Figure 3.3.1.4.3.** The historical series of the total biomass at age (1, 2 and 3) and weight-at-age 1, 2 and 3 that is downwards is showed in **Figure 3.3.1.4.4.**

Table 3.3.1.1.1. Bay of Biscay anchovy: Details of the DEPM survey BIOMAN 2019.

Parameters	Anchovy DEPM survey
Surveyed area	(43º19' to 48º08'N & 7º 09' to 1º13' W)
RV	Ramón Margalef and Emma Bardán
Date	9–31/05/2019
Eggs	**RV RAMON MARGALEF**
Total egg stations	782
% st with anchovy eggs	73%
Anchovy egg average by st	540 eggs/m^2
Maximum anchovy eggs in a St	6590 eggs/m^2
Total ANE egg collected and staged	30 882 eggs
North spawning limit	47º'37'N
West spawning limit	6º00'W
Total area surveyed	117 111 Km^2
Spawning area	79 735 Km^2
CUFES stations	1883
Adults	**RV EMMA BARDAN and Purse-Seines**
Pelagic trawls	45
With anchovy	42
Selected for analysis	40
Hauls from purse-seines	3
Total adult samples for analysis	43

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 2019.

Parameter	Value	S.e.	CV
P_0	170.33	16.70	0.0980
z	0.19	0.048	0.2540
Ptot	1.36.E+13	1.3.E+12	0.0980

Table 3.3.1.3.1. Bay of Biscay anchovy: estimates of adult parameters for applying the DEPM for anchovy in the Bay of Biscay (ICES 8abcd): batch fecundity (*F*) (eggs/batch/mature female), females mean weight (W_f) (g), sex ratio (*R*) (% of females), spawning fraction (*S*) (% of females spawning per day), daily fecundity (*DF*)(eggs/g/day) and the total biomass (*B*) (tons) with their correspondent standard error (s.e.) and coefficient of variation (CV) for 2019. Total egg production (P_{tot}) estimate is shown as well.

Parameter	estimate	S.e.	CV
P_{tot} (eggs)	1.36E+13	1.33E+12	0.0980
R'(% of females)	0.51	0.0021	0.0040
S (% fem. spawning/day)	0.35	0.0128	0.0362
F (eggs/batch/mature fem.)	6,419	428	0.0667
W_f (g)	18.87	0.75	0.0397
DF (eggs/g/day)	61.09	3.73	0.0610
B (tons)	223 210	25 775	0.1155

Table 3.3.1.4.1. Bay of Biscay anchovy: Anchovy total biomass (*B*), 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 2019.

Parameter	estimate	S.e.	CV
BIOMASS (tons)	223 210	25 775	0.1155
Total mean Weight (g)	16.679	0.74	0.0445
Population (millions)	13 382	1684	0.1258
Percentage-at-age 1	0.63	0.037	0.0589
Percentage-at-age 2	0.34	0.033	0.0969
Percentage-at-age 3+	0.03	0.006	0.2276
Numbers-at-age 1	8438	1330.8	0.1577
Numbers-at-age 2	4602	584.4	0.1270
Numbers-at-age 3+	342	79.0	0.2310
Percentage-at-age 1 in mass	0.530	0.036	0.0680
Percentage-at-age 2 in mass	0.428	0.031	0.0718
Percentage-at-age 3+ in mass	0.042	0.009	0.2245
Biomass-at-age 1 (tons)	118 102	16 198	0.1371
Biomass-at-age 2 (tons)	95 616	12 632	0.1321
Biomass-at-age 3+ (tons)	9492	2393	0.2522
Weight-at-age 1 (g)	14.02	0.61	0.0432
Weight-at-age 2 (g)	20.77	0.58	0.0278
Weight-at-age 3 (g)	27.81	1.51	0.0542
Length-at-age 1 (mm)	131.55	1.79	0.0136
Length-at-age 2 (mm)	148.08	1.26	0.0085
Length-at-age 3 (mm)	162.42	2.10	0.0129

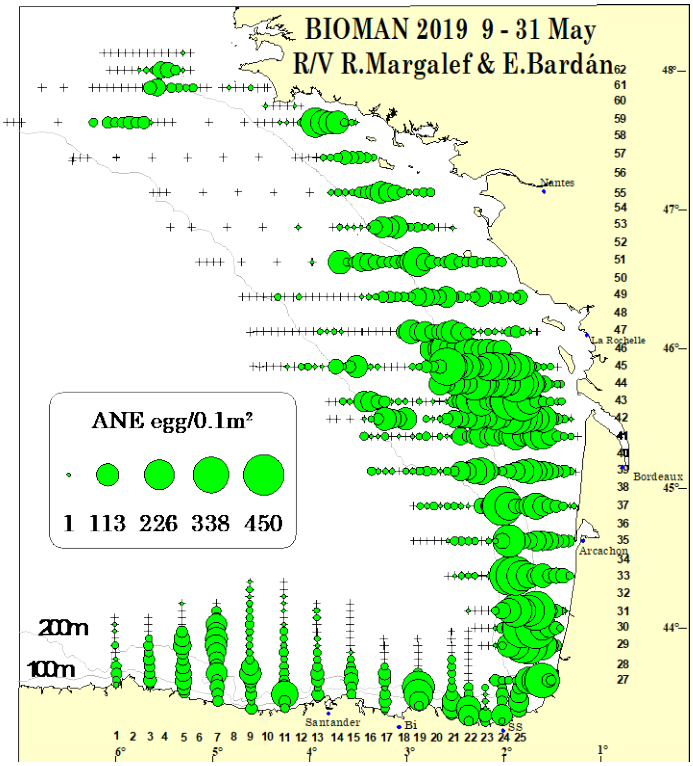


Figure 3.3.1.1.1. Bay of Biscay anchovy: Spatial distribution of anchovy egg abundance (eggs per 0.1 m²) from the DEPM survey BIOMAN2019 obtained with PairoVET (vertical sampling net).

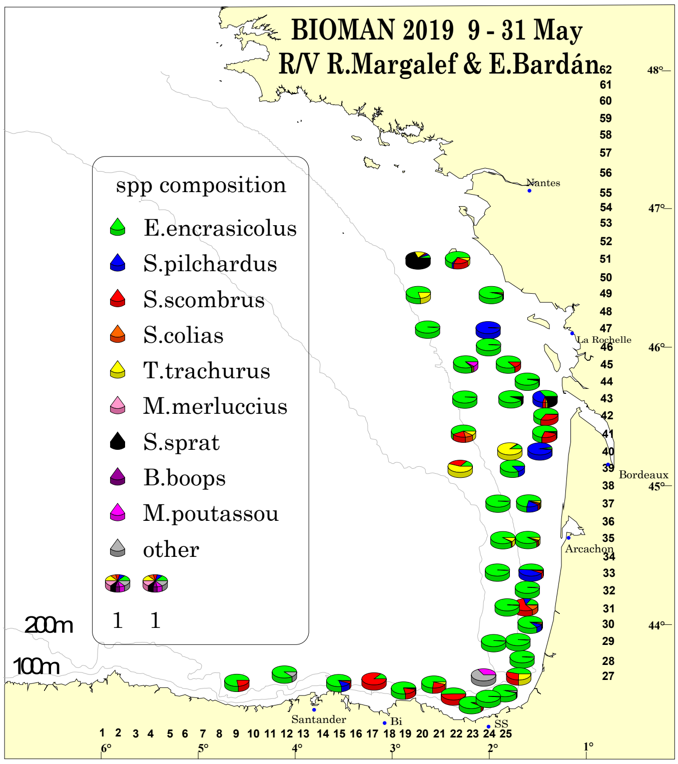
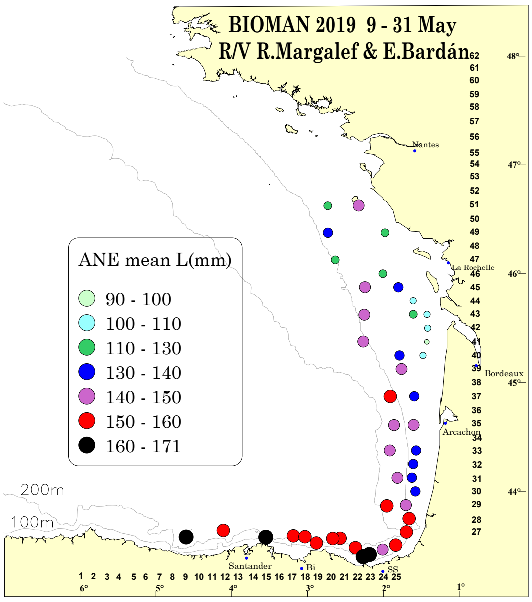
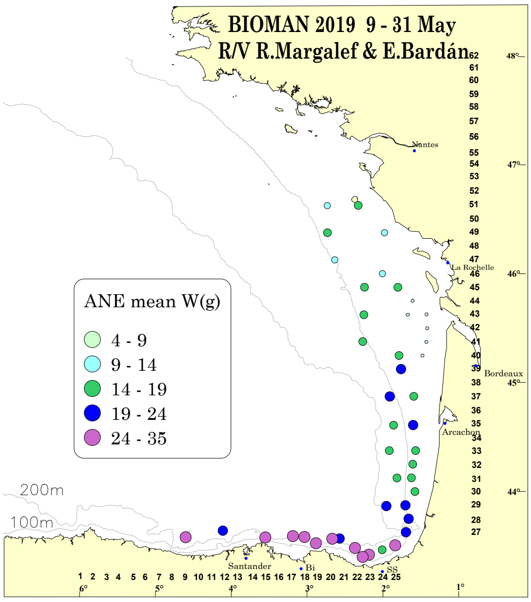


Figure 3.3.1.1.2. Bay of Biscay anchovy: Species composition of the 40 pelagic trawls from the RV Emma Bardán and three hauls from the purse-seines during BIOMAN2019.





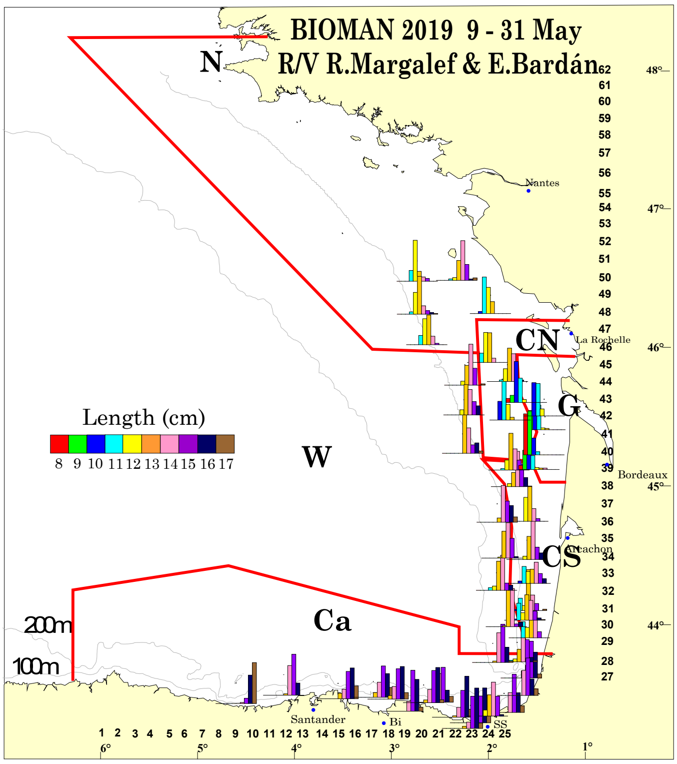


Figure 3.3.1.1.3. Bay of Biscay anchovy: Spatial distribution of anchovy mean length (left), mean weight (right) and size distribution by haul (down) (males and females) during BIOMAN2019.

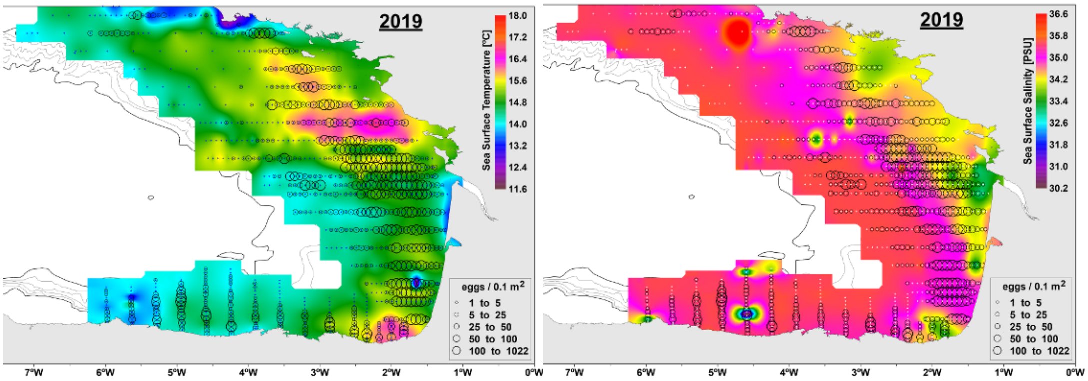


Figure 3.3.1.1.4. Bay of Biscay anchovy: From left to right spatial distribution of SST and SSS in BIOMAN 2019.

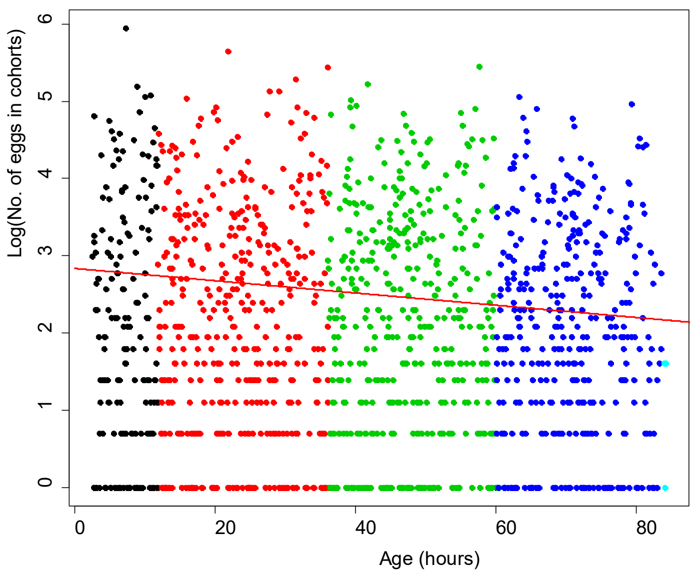


Figure 3.3.1.2.1. Bay of Biscay anchovy: Exponential mortality model in log scale adjusted applying a GLM to the data obtained in the Bayesian egg ageing (spawning peak at 23:00h GMT). The red line is the adjusted line. The coloured dots represent the different cohorts.

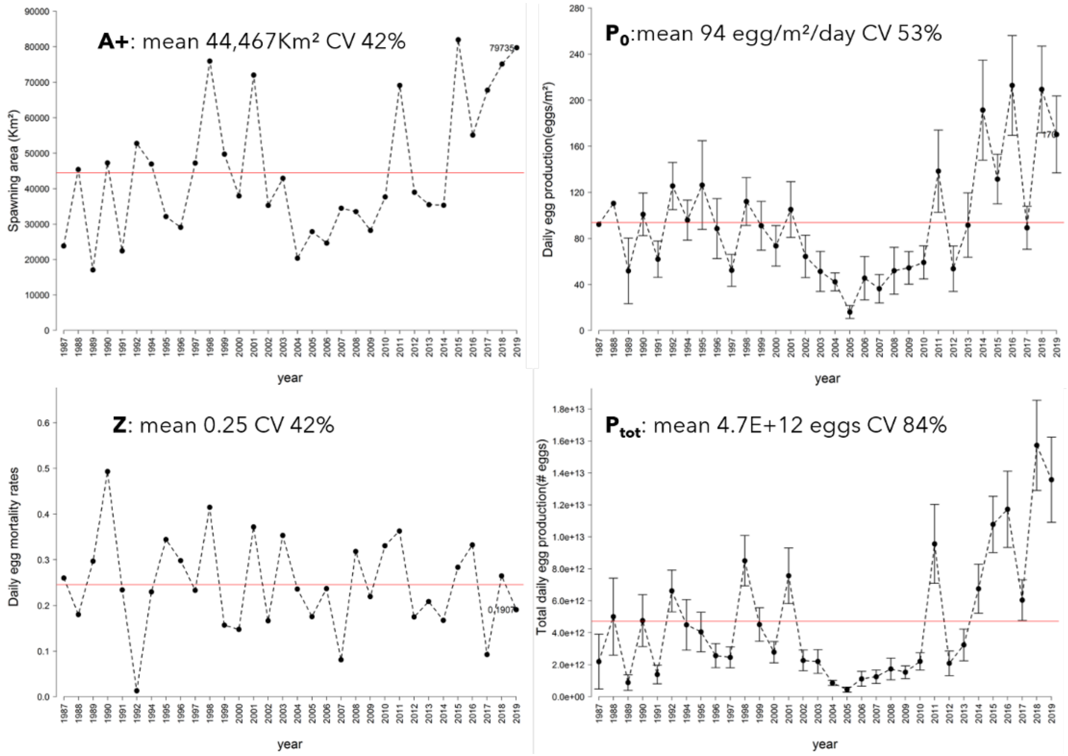


Figure 3.3.1.2.2. Bay of Biscay anchovy: Historical series of daily egg production (*P_0*), daily mortality (*z*), total daily egg production (*P_{tot}*) and spawning area (*A+*).

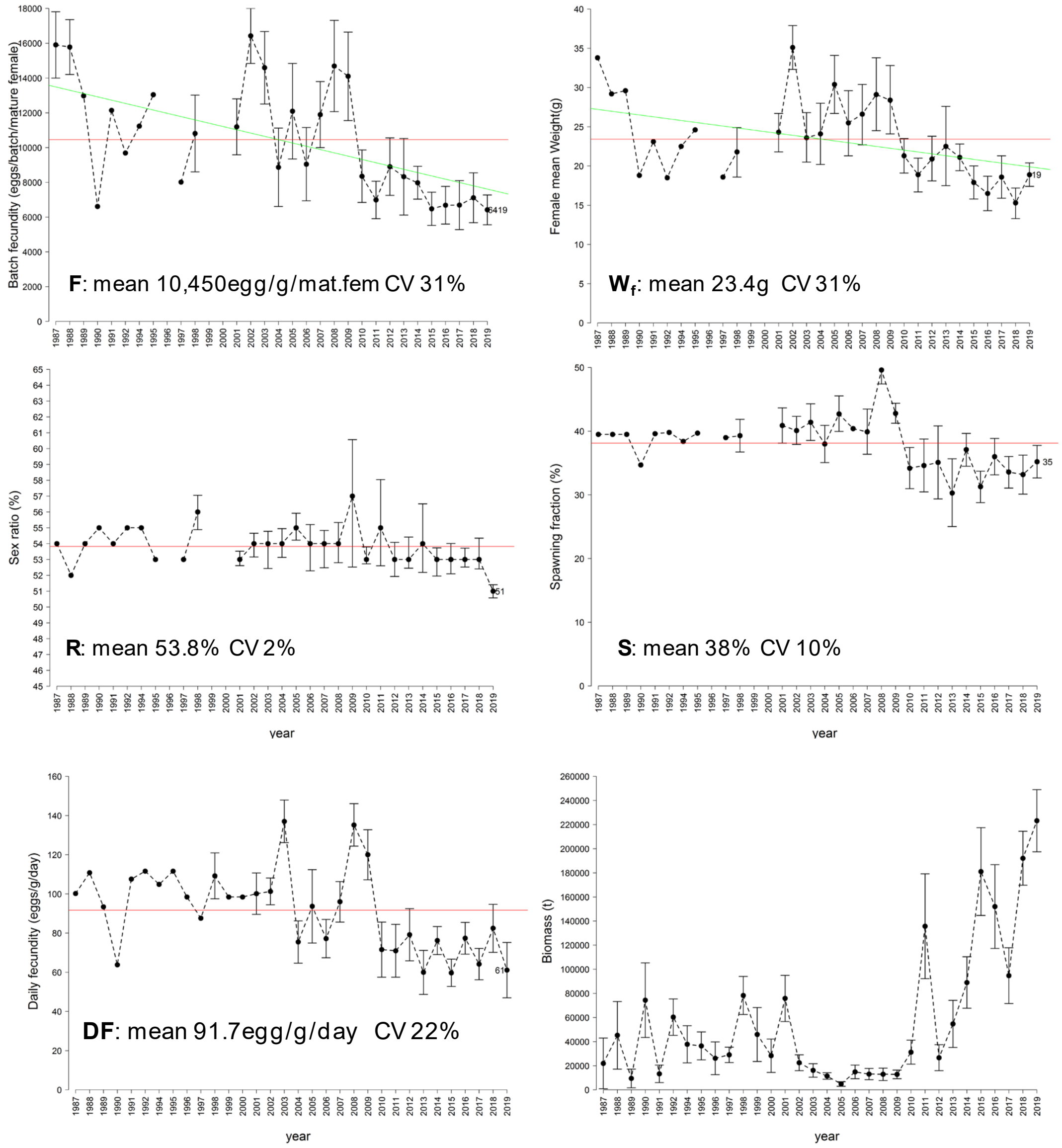


Figure 3.3.1.3.1. Bay of Biscay anchovy: Series of anchovy batch fecundity (*F*), female mean weight (*W_f*), sex ratio (R), spawning fraction (S), daily fecundity (DF) and total biomass estimates (tonnes) obtained from the DEPM. The 2019 estimates are shown.

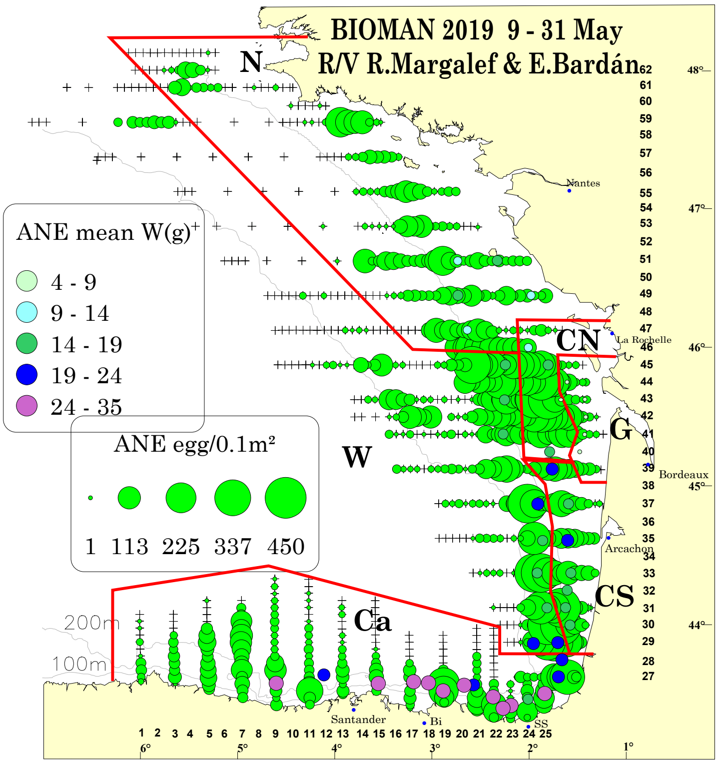


Figure 3.3.1.4.1. Bay of Biscay anchovy: 6 regions defined to weight the adult samples to estimate anchovy numbers-at-age in 2019: Cantabric (Ca), Coastal South (CS), Coastal North (CN), Garonne (G), North (N) and West(W). The red lines represent the border of the regions, the green bubbles the abundance of anchovy eggs (egg/0.1m²) in each station and the small colour bubbles represent the mean weight (g) of individuals within each haul.

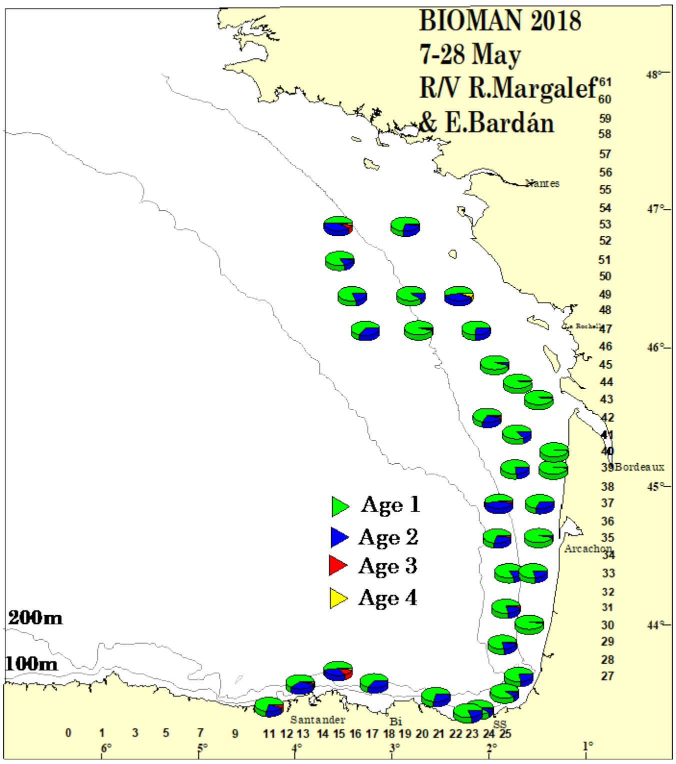


Figure 3.3.1.4.2. Bay of Biscay anchovy: Anchovy age composition by haul in BIOMAN2019.

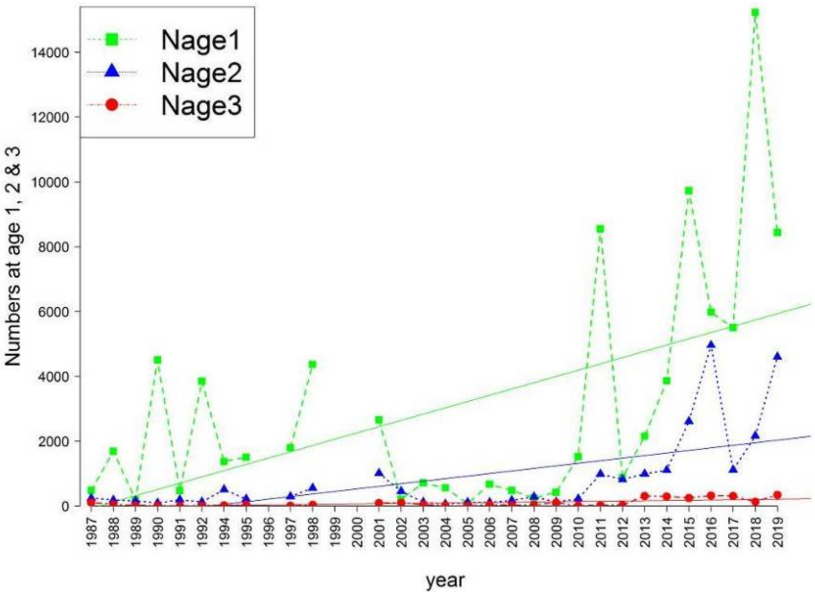
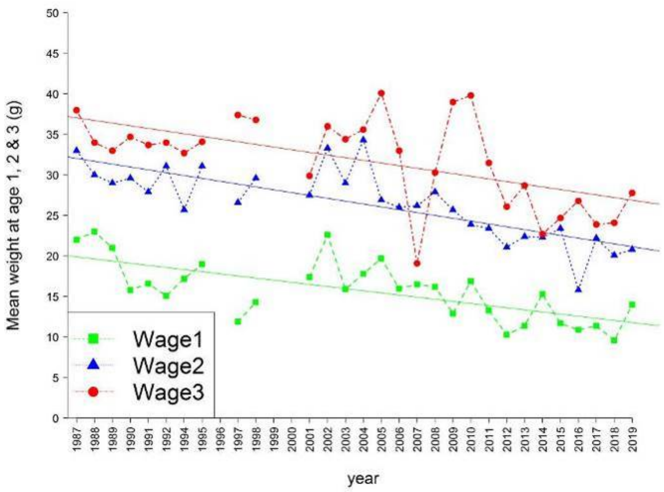


Figure 3.3.1.4.3. Bay of Biscay anchovy: Anchovy historical series of numbers-at-age from 1987 to 2019 from BIOMAN surveys.



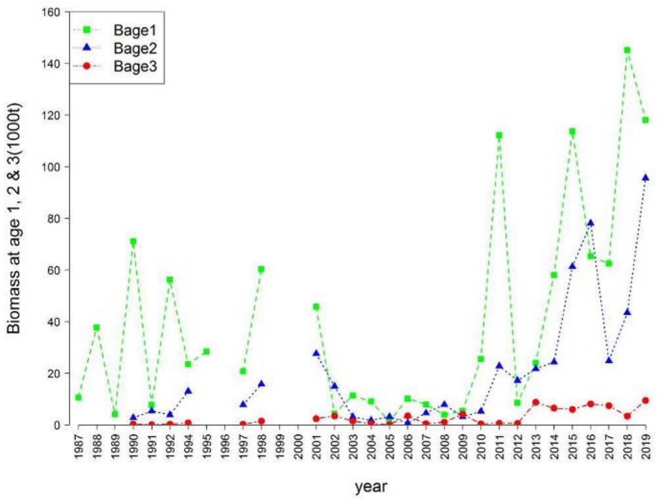


Figure 3.3.1.4.4. Bay of Biscay anchovy: Anchovy historical series (1987–2018) of mean weight-at-age and the tendency and total biomass-at-age.

3.3.2 The PELGAS 19 spring acoustic survey

[For more detail, see WD Duhamel *et al*. (2019) 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 identical to previous surveys (2000 to 2018). 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 1 nautical 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).
- acoustic 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 echo sounder between the surface and 8 m depth.

Acoustic data were collected by RV Thalassa along a total amount of 4855 nautical miles from which 1857 nautical miles on one way transect were used for assessment. A total of 23 442 fish were measured (including 8644 anchovies and 3765 sardines) and 2968 otoliths were collected for age determination (1860 of anchovy and 1108 of sardine).

A consort survey is routinely organised since 2007 with French commercial vessels during 17 days. This approach is in identical to last year's surveys, using the commercial vessel's hauls were for echoes identification and biological parameters to complement hauls made by the RV Thalassa. Catches and biological data were used to complement the sampling made on board the RV Thalassa. A total of 108 hauls (including four not valid) were carried out during the consort survey including 52 hauls by the RV Thalassa and 56 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 more abundant than last year and their abundance was estimated this year at a high level compared to the historical time-series (around 183 000 tonnes). Strong densities were observed in the Gironde area. It must be noticed that anchovy was observed on every transects from the Spanish coast to the northwest of the Bay of Biscay. (Table 3.3.2.1 and Figure 3.3.2.4).

The one-year old anchovies were mostly present front of the Gironde (in terms of energy and, as well, biomass) but they were still well present on the platform, until Brittany along the bathymetric line of 100 m. The average size of one-year old fish was comparable the average size in recent years (two years really differed from the average: 2012 and particularly 2015 where fish were much smaller) but shows a clear decreasing trend, year after year. Bigger (and older) fish appeared close to the surface more offshore.

One-year old anchovies were also present, in lower quantities, mixed with older fish, even off-shore.

Looking at the numbers-at-age since 2000 (Figure 3.3.2.5), the number of 1-year old anchovies this year seems to be equivalent to 2011, 2012 or 2017, far away from the very best recruitment observed in 2015. This huge 2015 age class is not followed in 2016 or in 2017 as well. Once again, it could indicate that an overestimation occurred on the recruitment in 2015. Several investigation have been done to explain, without results for the time being.

Age 1 were present all over the area where anchovy was present. This one-year old anchovy is almost pure front of the Gironde and along the coast of Brittanny, and mixed with older individuals elsewhere. (Figure 3.3.2.6).

The CUFES index, vertically integrated by the vertical model, has been processed for the working group. (Figure 3.3.2.7).

On Figure 3.3.2.8, we can see that globally the spatial distribution of eggs match with the adult's one along the coast. But, more offshore between 45°N and 47°N, eggs were counted in important quantity with low echoes attributed to anchovy. It could be due to the presence of fish completely closed to the surface, in the blind layer of echo sounders.

Table 3.3.2.1. Acoustic biomass index for sardine and anchovy by strata during PELGAS19.

	Classic	Surface	total
Boarfish	5873	8265	14 137
Anchovy	**129 660**	**53 505**	**183 166**
Hake	37 828	654	38 482
blue whiting	12 287		12 287
Sardine	**309 418**	**19 324**	**328 741**
chub mackerel	15 514	240	15 754
Mackerel	629 952	16 537	646 488
Sprat	108 663	3288	111 951
Med horse mackerel	2509	68 283	70 792
horse mackerel	45 643	6458	52 101

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	2017	2018	2019
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**	**134 500**	**185 524**	**183 166**
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*	0.073551	0.13	0.154339	0.0699	0.0533063
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**	**465 022**	**265 504**	**328 741**
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*	0.102315	0.08	0.060653	0.0620727	0.05383762
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**	**15 778**	**16 321**	**111 951**
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*	0.19534	0.44	0.52701	0.5879399	0.1181859
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**	**61 919**	**93 728**	**52 101**
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*	0.15498	0.3	0.288318	0.1443578	0.18583827
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**	**23 944**	**3 585**	**12 287**
CV BW	-	-	*0.386*	*0.131*	*0.202*	*0.593*	*0.210*	*0.147*	*0.253*	*0.219*	*0.074*			*0.1542*	*0.337606*	*0.223479*	*0.15*	*0.147063*	*0.30485*	*0.28011046*

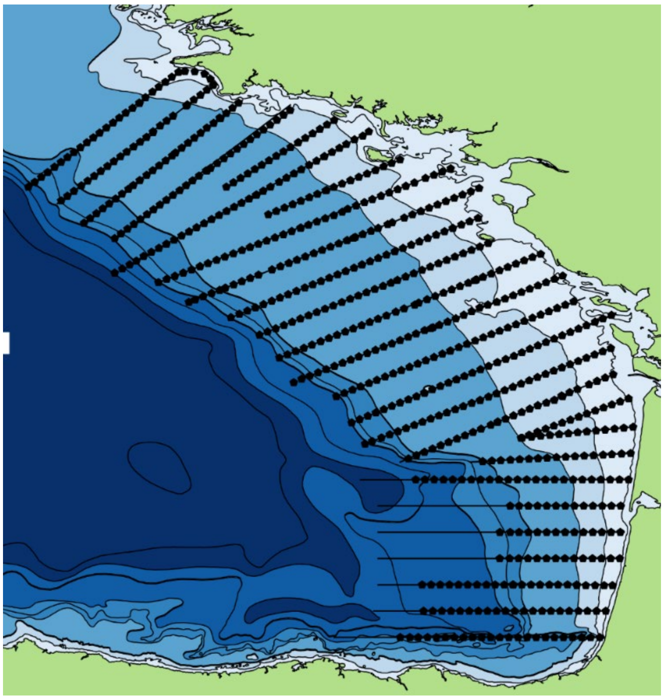
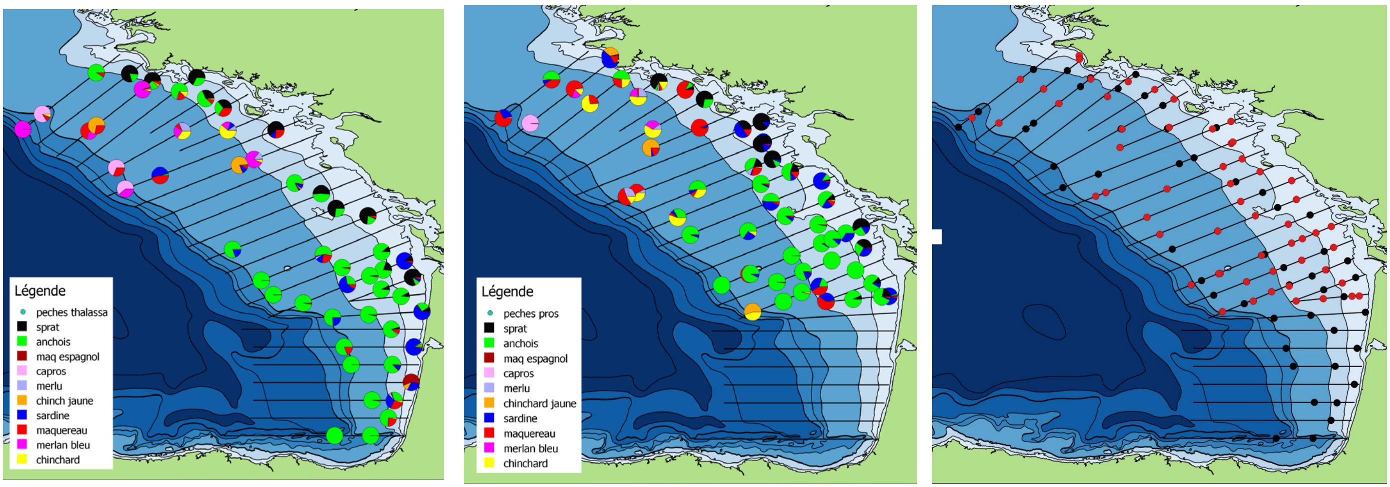


Figure 3.3.2.1. Acoustic transects network during PELGAS19 survey.

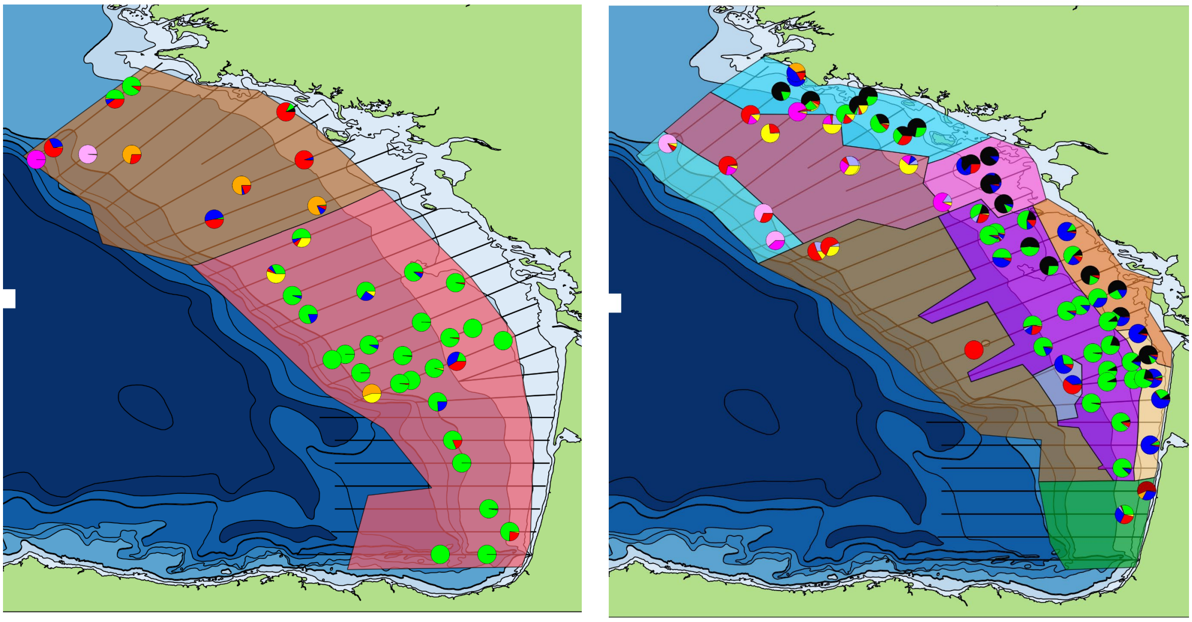


a) Thalassa (nb :52)

b) Commercial vessels (nb : 56)

c) all fishing hauls (nb :108) Thalassa in black and commercial in red

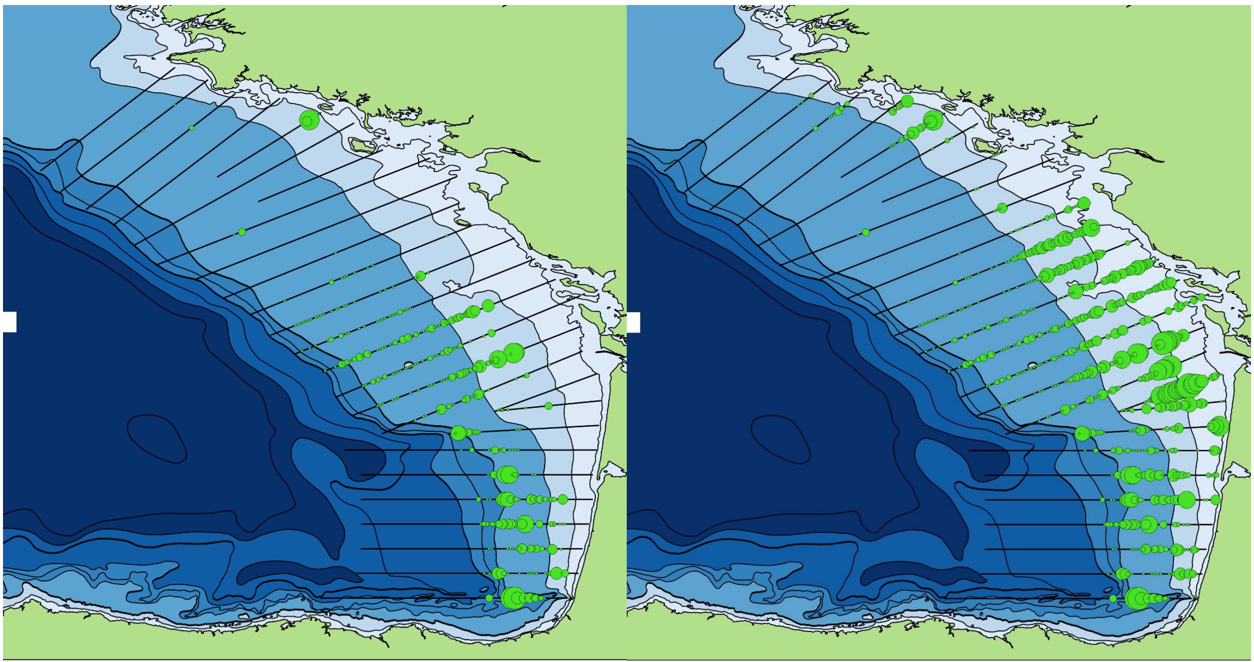
Figure 3.3.2.2. Fishing operations carried out by Thalassa and commercial vessels during consort survey PELGAS19.



Coherent surface strata

Coherent classic strata

Figure 3.3.2.3. Coherent strata (for classic and surface echo traces) according to species distributions for abundance indices estimates.



Surface distribution

Total distribution

Figure 3.3.2.4. Anchovy distribution according to PELGAS19 survey.

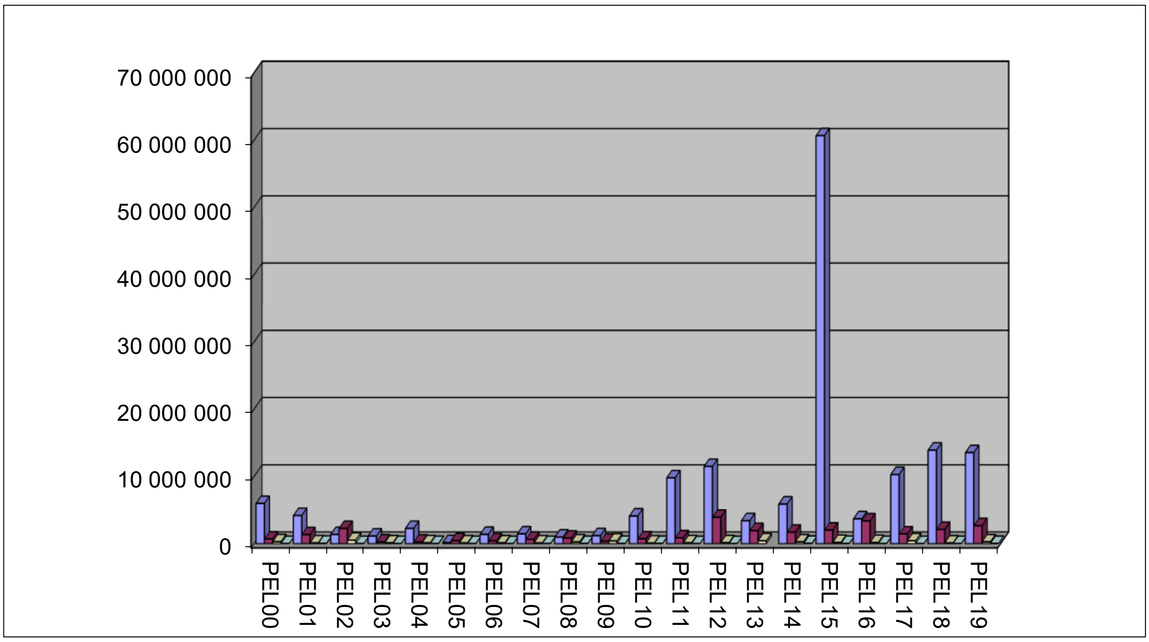


Figure 3.3.2.5. Age distribution of anchovy along PELGAS series.

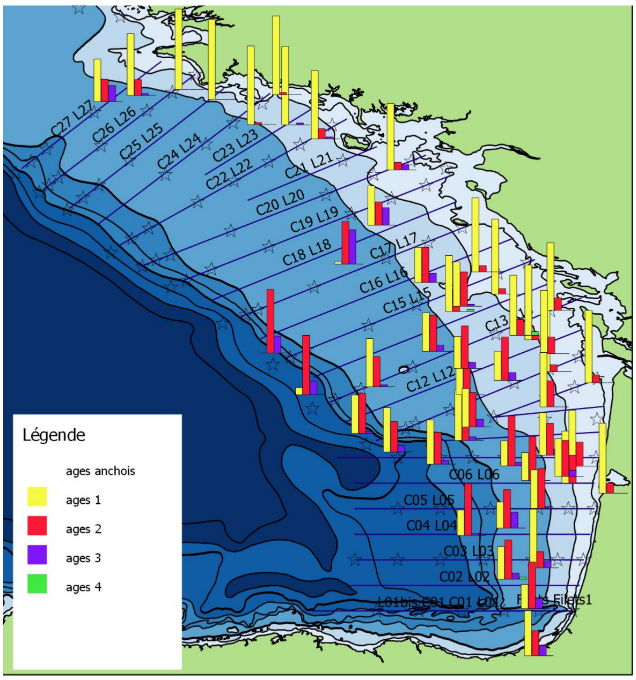


Figure 3.3.2.6. Anchovy proportion-at-age in each haul as observed during PELGAS19 survey (yellow = age 1, red = age 2).

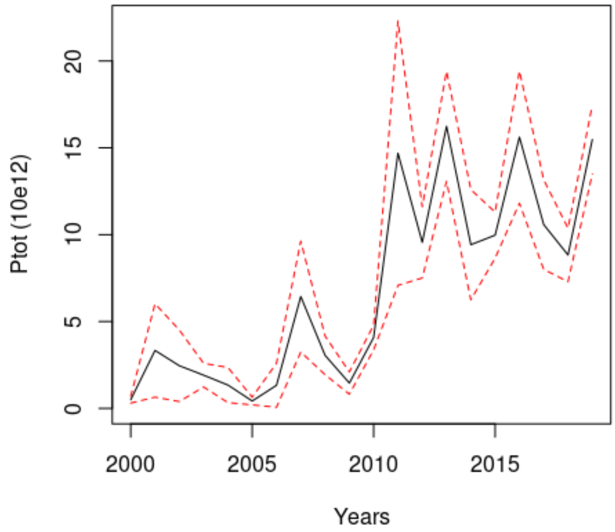


Figure 3.3.2.7. CUFES index, with number of eggs corrected by the vertical model.

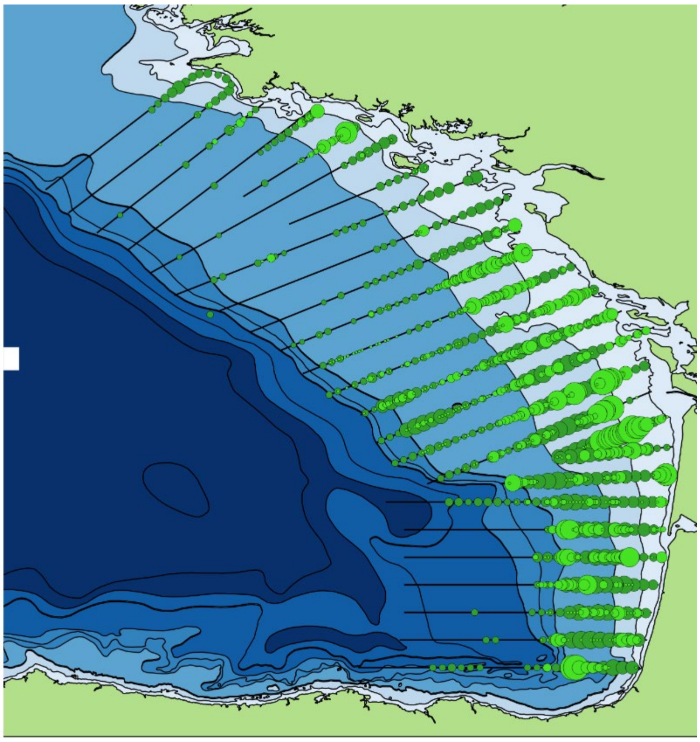


Figure 3.3.2.8. Coherence between spatial distribution of adults and eggs. light green = biomass of adults per ESDU, dark green = eggs.

3.3.3 Autumn juvenile acoustic survey 2019 (JUVENA 2019)

The methodology of the autumn juvenile acoustic survey JUVENA is described in detail in the stock annex - Bay of Biscay Anchovy (Subarea 8). The results of the last survey in autumn 2019 were reported and discussed in autumn 2019 in WGACEGG meeting (Boyra *et al*., 2019, WD WGACEGG2019 (ICES, 2019)). Description of the survey and the estimates of anchovy juvenile abundance produced by this 2019 survey was already reported and discussed in WGACEGG report (ICES, 2019) therefore here below it follows just a short summary, highlighting some issues of relevance for this input of the assessment.

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 2019, as in previous years, the survey was coordinated by AZTI and IEO. AZTI led the assessment studies whereas IEO led the ecological studies. The survey JUVENA 2019 took place between the 31st of August and 3rd of October on board the chartered RV Ramon Margalef and the RV Emma Bardán, both equipped with scientific echo sounders. (Boyra *et al*., 2019; WD to WGACEGG). The sampling area intended to cover the waters of the Bay of Biscay between 8º00′ W and 48º00′ N., following the standard transect design and acoustic methods as in previous years. However due to bad weather, the northern limit was not reached and the actual coverage went from 7º00′ W and 46º40′ N. A total of 64 hauls were done during the survey to identify the species detected by the acoustic equipment, 43 of which were positive of anchovy (**Figure 3.3.3.1**). As usual, most of the biomass of juveniles was located off-the-shelf or in the outer part of the shelf in the first layers of the water column (**Figure 3.3.3.2**). The area of distribution of juvenile anchovy this year was among the highest in the temporal series, being the juveniles spread from the continental shelf to bathymetries of 4000 m up to the 45º15 N, but the scarcity, small size and low density of the juvenile schools provided a rather low abundance (**Figure 3.3.3.3**). The mean size of anchovy was 6.1 cm long, less than the average.

The biomass of juveniles estimated for this year was 114 000 tonnes (**Table 3.3.3.1**). This value represents a medium low value, well below the average in the temporal series. In order to have an idea of the potential underestimation caused by the limited coverage of the northern area of the Bay of Biscay, an estimate of the potential missing biomass of juveniles (corresponding to such uncovered area) was estimated by Boyra *et al*. (2019 WD to WGACEGG): The result was that the fraction of the biomass of juvenile anchovy in the North is ~10% (+-8%).

The team of WGHANSA has decided not to apply such a correction factor to the estimates produced by JUVENA survey in 2019, because a) for other Juvena surveys (particularly at the beginning of the series) where a similar northern regions of the Bay of Biscay could not be covered, such corrections were not applied, and the uncorrected original estimates of the series were directly used as input for the assessment, and b) the estimated mean underestimate is in any case low, within the CV of the estimates. In any case, the group agreed to make a sensitivity assessment by including the JUVENA 2019 estimate corrected with the factor (1/0.9), to see what implications it has on the series of biomass and recruitment estimates and in the short-term forecast. In addition, the team agreed to include in the list of the benchmark issues the assessment of the convenience of applying this corrections when necessary to the Juvena series for potential underestimates of juveniles.

Table 3.3.3.1. Bay of Biscay anchovy: Summary of the estimates obtained in JUVENA autumn acoustic surveys from 2003 to 2017.

Year	Area+ (nm^2)	Size juveniles (cm)	Biomass juveniles (t)
2003	3476	7.9	98 601
2004	1907	10.6	2406
2005	7790	6.7	134 131
2006	7063	8.1	78 298
2007	5677	5.4	13 121
2008	6895	7.5	20 879
2009	12 984	9.1	178 028
2010	21 110	8.3	599 990
2011	21 063	6	207 625
2012	14 271	6.4	142 083
2013	18 189	7.4	105 271
2014	37 169	5.9	723 946
2015	21 867	6.8	462 340
2016	16 933	7.3	371 563
2017	19 808	6.6	725 403
2018	26 787	6.3	489 708
2019	20 298	6.1	114 072

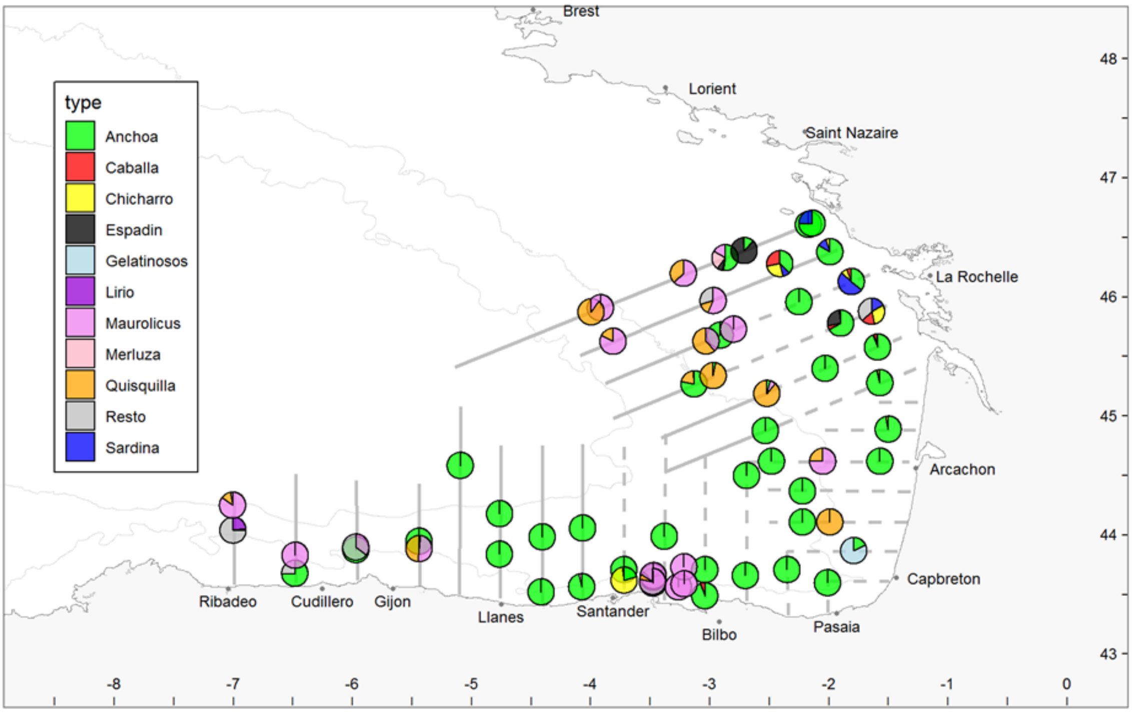


Figure 3.3.3.1. Bay of Biscay anchovy. Surveying transects and spatial distribution and species composition of the pelagic hauls in JUVENA 2019.

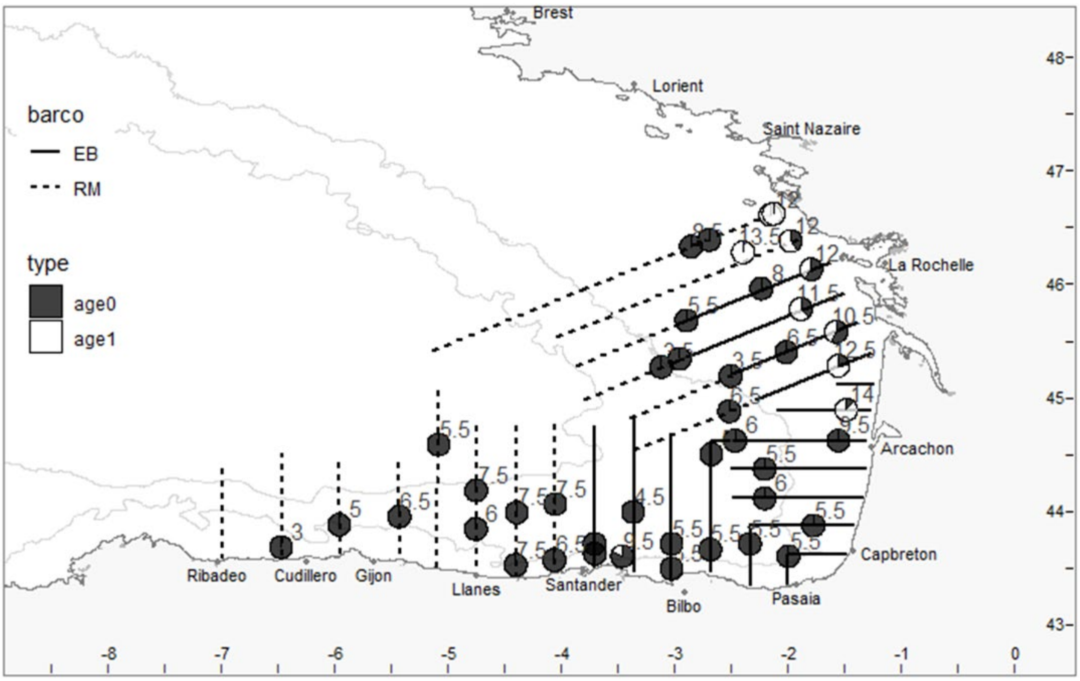


Figure 3.3.3.2. Bay of Biscay anchovy. Positive area of anchovy in JUVENA 2017. The pie charts show the percentage of juveniles (white) and adults (black) in the fishing hauls.

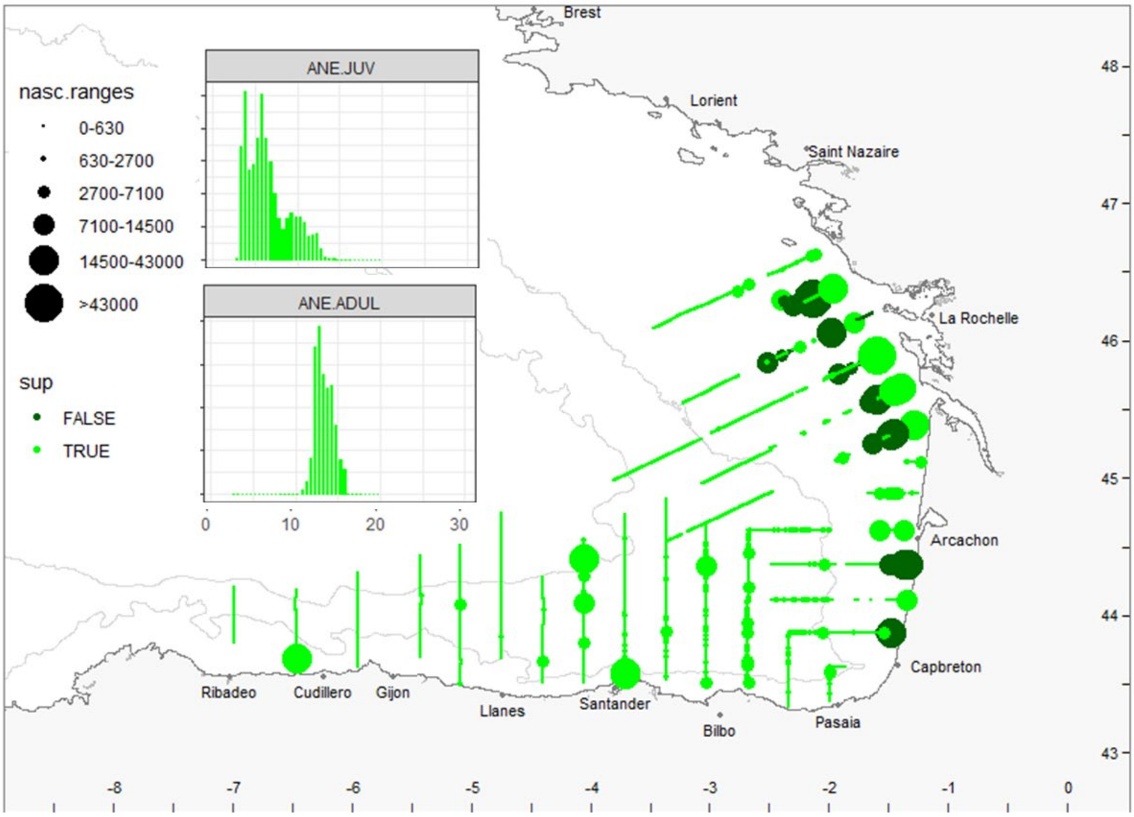


Figure 3.3.3.3. Bay of Biscay anchovy. Bubble maps representing acoustic backscattering by ESDU of 0.1 nm.

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 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 G1 and G2+ 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, the assessment of the Bay of Biscay anchovy can be conducted in June or November. The management plan applied in the last years is based on the November assessment. This year the final assessment of the stock was conducted in November 2019.

3.5.1 Stock assessment

The input data entering into the assessment of the anchovy stock consist of:

- total biomass estimated by DEPM and acoustic surveys (BIOMAN and PELGAS) with their corresponding coefficients of variation;
- proportion of the biomass at-age 1 estimated by the DEPM and acoustic surveys (BIOMAN and PELGAS);
- juvenile abundance index from JUVENA;
- total catch by semester;
- proportion (in mass) of age 1 in the catch by semester (in 2019 only for the first semester);
- growth rates by age estimated from the weights-at-age of the stock.

The historical series of spawning–stock biomass (SSB) from the DEPM and acoustic surveys are shown in Figure 3.5.1.1. The trends in biomass from both surveys are similar. From 2003 to 2018, a parallel trend but with larger biomass estimates from the acoustic surveys is apparent, except in 2016 and 2018 that the DEPM biomass estimate was larger than the acoustic biomass. In 2019, the DEPM SSB estimate (around 223 000 t) was the largest of the historical time-series and was again larger than the acoustic one (around 183 000 t). This resulted in a relative increase in biomass from 2018 for the DEPM, whereas the acoustic biomass decreased slightly. The largest discrepancy between the SSB estimates from the DEPM and acoustic surveys occurred in 1991, 2000, 2002, 2012 and 2015.

The agreement between both surveys is usually higher when estimating the relative age composition of the population. However, in 2019 the acoustic age 1 biomass proportion was around 0.71, which is above the average of the time-series, while the DEPM survey age 1 biomass proportion was around 0.53, slightly below the average of the time-series (Figure 3.5.1.2). These differences might be due to the fact that this year 17% of the biomass of the DEPM survey was in the Cantabrian coast, which is not covered by the acoustic survey, and the majority of the individuals found in that region were aged 2 and older, in contrast to northern areas where most individuals were age 1 (see Section 3.4).

The historical series of the juvenile abundance index from the autumn acoustic survey JUVENA is shown in Figure 3.5.1.3. The 2019 survey index represented a medium-low value, about 57% lower than the average of the temporal series. Due to the bad weather conditions, the survey could not cover the region to the north of 46.6ºN, so the 2019 juvenile abundance index is probably underestimated (see Section 3.4).

Figure 3.5.1.4 shows the historical series of total catches by semester. In general, catches in the first semester are larger than in the second semester. The absence of catches from 2005 to 2009 corresponds to various consecutive fishery closures due to the low level of the population. The fishery was reopened in March 2010. In 2019, the preliminary total catch was around 22 400 t in the first half of the year and 4220 t in the second half. The latter was under the assumption that the November and December catches represent 3.3% of the total catch (according to the average % of November and December catches in 2010–2017). Definitive 2019 catch estimates will be provided in WGHANSA 2020. Regarding the age structure of the catches, age 1 proportion in the catches in the first semester in 2019 was 0.32, which is below the average age 1 proportion in the time-series (Figure 3.5.1.5).

Historical series of intrinsic growth rates by age (computed from the weights-at-age of the stock) suggest a larger growth at-age 1 than at-age 2+ (Figure 3.5.1.6).

The data used for the November assessment are given in Table 3.5.1.1.

Figure 3.5.1.7 compares prior and posterior distribution of some of the parameters estimated. Summary statistics (median and 90% probability intervals) of the posterior distributions of the parameters estimated are given in Tables 3.5.1.2 and 3.5.1.3. Recruitment (age 1 in mass at the beginning of the year), SSB (at spawning time which is assumed to be 15th May), fishing mortality by semester and harvest rates (catch/biomass) from the final assessment are shown in Figure 3.5.1.8. The estimated level of SSB in 2019 is 144 800 t, which is the highest in the time-series, and the 90% probability interval is around 103 000 t and 201 900 t. This probability interval is amongst the widest in the time-series, accounting for the discrepancies observed in the surveys of the last years. The posterior median of recruitment in 2020 is around 33 700 t and the 90% probability interval is between 17 300 t and 64 200 t. The posterior distribution of recruitment is wider than the posterior distribution of previous recruitments because only the JUVENA 2019 survey provides direct information about 2019 recruitment. Assuming no fishing takes place in 2020, the SSB in 2020 is estimated at 100 700 t with a 90% probability interval around 72 200 t and 143 000 t (Figure 3.5.1.9).

Overall, the Pearson residuals for all the observations used in the assessment are within -2 and 2, showing no major discrepancies between the observed and modelled quantities (Figure 11) and indicating that the model estimates are a compromise between all surveys inputs and catch estimates and all along the time-series. Since 2013, the time-series of biomass from the DEPM has positive residuals, which should be further investigated in next years.

The final estimates are compared with last year's December assessment (ICES, WGHANSA 2018) in Figure 3.5.1.11. In general, the results from both assessments are similar except to small changes in the perception of the last three years. Recruitment in 2019 has been revised upwards, whereas recruitment in 2018 is smaller in this assessment than in last year's assessment. Fishing mortality in the first semester of 2018 is slightly larger than in last year's assessment. As a result, biomass in 2018 is slightly smaller than in last year's assessment. Fishing mortality in the second semester after the fishery closure (2010–2017) are almost the same as estimated in last year's assessment. However, fishing mortality in the second semester before the fishery closure is revised slightly upwards in the current assessment.

3.5.2 Retrospective pattern

A five-year retrospective analysis of SSB, recruitment, fishing mortality by semester and harvest rate was conducted. For each run, assessment was conducted using DEPM and acoustic surveys data until the terminal year and recruitment survey data until the intermediate year. Catch data for the intermediate year were assumed to be zero, so that SSB and fishing mortality by semester for the intermediate year were not considered reliable, i.e. only estimates of recruitment in the intermediate year were analysed.

The trends for SSB, recruitment and fishing mortality by semester in the retrospective analysis are similar. Furthermore, the estimates from the retrospective analysis are in general within the 90% probability interval of last year's assessment (Figure 3.5.2.1).

Retrospective bias was measured in terms of the Mohn's rho (Mohn, 1999) using the function mohn() in the R package icesAdvice (https://CRAN.R-project.org/package=icesAdvice). The relative bias for recruitment in the intermediate year was positive and high in 2018, and negative and smaller in the other years (Figure 3.5.2.2). It ranged between -0.15 and 0.48 and the Mohn's rho was calculated at -0.016. The relative bias for SSB in the terminal year was negative in the first year and positive in the rest (Figure 3.5.2.2). The relative bias for SSB ranged between -0.25 and 0.13, and the Mohn's rho was -0.001. Mohn's rho for the fishing mortality by semester and annual harvest rate was 0.012, -0.045 and 0.021 respectively. The relative bias for the three time-series followed the same trends, being positive in the first year and negative afterwards (Figure 3.5.2.2).

3.5.3 Sensitivity analysis

In order to study the sensitivity of the current assessment to the potential underestimation of the juvenile abundance index from JUVENA in 2019, the stock assessment was repeated, but using a juvenile abundance index revised upwards to account for the juvenile biomass not covered by the survey. From past survey results, the juvenile anchovy biomass above 46.6ºN was estimated around 10% of the overall biomass. Therefore, the juvenile abundance index in 2019 (114 072 t) was assumed to represent 90% of the overall biomass. The juvenile abundance index after accounting for underestimation was equal to 126 747 t.

The stock assessment with the juvenile abundance index corrected for underestimation was basically the same as with the current juvenile abundance index (Figure 3.5.3.1). Only minor differences were found in the last year. Recruitment in 2020 was estimated at 35 375 t, around 5% larger than with the uncorrected index. SSB in 2020 (without fishing) was estimated at 102 218 t, 1% larger than with the uncorrected index."

3.5.4 Reliability of the assessment

Compared to commonly used assessment methods in ICES, the Bayesian two-stage biomass-based model (CBBM) entails changes in both the methodology used for projecting the population forward and establishing catch options and in the terminology in which the assessment and consequent advice is given. The state of the stock is given in terms of spawning biomass, recruitment is understood as biomass at-age 1 at the beginning of the year and management options may be given in terms of catches. Due to the Bayesian framework, all the results are given in stochastic terms and deterministic point estimates are replaced by summary statistics of the posterior distributions of the parameters, such as medians and percentiles.

The Pearson residuals for all the observations used in the assessment show no major discrepancies between the observed and modelled quantities (residuals within -2 and 2). However, the residuals of the age 1 proportion (in mass) in the catch of the first semester have been negative from 2010 (fishery reopening) to 2015, and the residuals of biomass from the DEPM have been positive since 2013. The former can be related to changes in the selection pattern of the fishery, while the later can be related to interannual changes in the percentage of biomass in the Cantabrian coast, which is not covered by the acoustic survey. All these patterns should be further investigated in next years.

The juvenile abundance index from JUVENA 2019 is probably underestimated. The sensitivity analysis of the assessment to the potential underestimation of the juvenile abundance index from JUVENA in 2019 indicated that correcting for this level of underestimation will result in 5% larger recruitment and 1% larger SSB in 2020 (without fishing). Given that the 2020 recruitment distribution forms the basis for the short-term projections, underestimation of the latest juvenile abundance index could lead to more conservative catch options.

The catch data for 2019 are preliminary and the definite data will be available for WGHANSA 2020. As a result, the fishing mortality estimates in 2019 must also be considered as preliminary.

In 2015, the WG tested the sensitivity of the assessment to the reallocation of the French catches near the border of Subarea 8, and it was demonstrated that the influence was low. In 2018, no anchovy were caught in Subarea 7, and no sensitivity analysis was done. This should be further investigated in the next coming years, especially if the reallocated catches exceed the limits of the historical series.

The assessment scale is given by the survey catchability estimates. It therefore must be emphasized and admitted explicitly that the assessment should always be examined in relative terms, exploring the trends in biomass or harvest rates.

Table 3.5.1.1. Bay of Biscay anchovy: Input data for CBBM.

	BIOMAN			PELGAS			JUVENA	CATCH				GROWTH	
	DEPM survey			Acoustic survey			Acoustic	Semester1		Semester2		G1	G2+
Year	Age1	Total	cv	Age1	Total	cv	Age0 previous year	Age1	Total	Age1	Total	Age1	Age2+
1987	10637	21943	0.480	NA	NA	NA	NA	4561	11719	2219	2666	0.405	0.141
1988	37813	45230	0.310	NA	NA	NA	NA	6739	10002	4018	4404	0.266	0.125
1989	4128	9477	0.410	6476	15500	NA	NA	3026	7153	643	1086	0.323	0.129
1990	71142	74371	0.208	NA	NA	NA	NA	17337	19386	12080	14347	0.566	0.130
1991	7821	13295	0.271	28322	64000	NA	NA	6150	15025	2743	3087	0.626	0.198
1992	56202	60332	0.125	84439	89000	NA	NA	19737	26381	9939	10829	NA	NA
1993	NA	NA	NA	NA	NA	NA	NA	12152	24058	12589	15255	NA	NA
1994	23739	37777	0.204	NA	35000	NA	NA	8236	23214	8849	10408	0.594	0.283
1995	28416	36432	0.159	NA	NA	NA	NA	11600	23479	4961	5629	NA	NA
1996	NA	26148	0.260	NA	NA	NA	NA	13007	21024	10397	11864	NA	NA
1997	21098	29022	0.110	38498	63000	NA	NA	6730	10600	8675	9852	0.911	0.324
1998	68015	78277	0.101	NA	57000	NA	NA	9620	12918	14811	18481	NA	NA
1999	NA	45932	0.244	NA	NA	NA	NA	3681	15381	6136	10617	NA	NA
2000	NA	28321	0.245	89363	113120	0.064	NA	12036	22536	11463	14354	NA	NA
2001	45779	75826	0.126	67110	105801	0.141	NA	10379	23095	13828	17043	0.649	0.266
2002	4330	22462	0.147	27642	110566	0.113	NA	2585	11089	3720	6405	0.249	0.032
2003	11401	16109	0.173	18687	30632	0.132	NA	1055	4074	3376	6405	0.769	0.206
2004	9042	11496	0.117	33995	45965	0.167	98601	5467	9183	6285	7004	0.410	0.157
2005	1441	4832	0.202	2467	14643	0.171	2406	146	1127	0	0	0.277	0.205
2006	10085	15113	0.238	18282	30877	0.136	134131	982	1659	69	95	0.493	-0.307
2007	7946	13060	0.178	26230	40876	0.1	78298	42	141	0	0	0.524	0.146

	BIOMAN			PELGAS			JUVENA	CATCH				GROWTH	
	DEPM survey			Acoustic survey			Acoustic	Semester1		Semester2		G1	G2+
Year	**Age1**	**Total**	**cv**	**Age1**	**Total**	**cv**	**Age0 previous year**	**Age1**	**Total**	**Age1**	**Total**	**Age1**	**Age2+**
2008	3940	12898	0.200	10400	37574	0.162	13121	0	0	0	0	0.458	0.333
2009	5460	12832	0.140	11429	34855	0.112	20879	0	0	0	0	0.618	0.439
2010	25543	31277	0.159	64564	86355	0.147	178028	3099	6111	3544	3971	0.325	0.276
2011	112202	135732	0.160	115379	142601	0.077	599990	3701	10913	3256	3576	0.465	-0.123
2012	8936	26663	0.202	73843	186865	0.046	207625	948	8600	3869	5753	0.777	0.307
2013	24090	54686	0.179	42508	93854	0.128	142083	1759	10928	1722	3144	0.670	0.013
2014	59283	91299	0.125	86670	125427	0.063	105271	4188	14274	4752	5278	0.427	0.101
2015	113677	181063	0.101	313249	372916	0.074	723946	9524	19416	4976	8838	0.257	0.143
2016	65312	152049	0.114	35604	89727	0.130	462340	5024	15380	2501	3991	0.765	0.456
2017	62488	94759	0.122	83713	134500	0.154	371563	9316	22763	1705	3248	0.567	0.079
2018	145159	192088	0.116	136397	185524	0.070	725403	14138	25499	4095	5236	0.773	0.325
2019	118102	223210	0.115	129269	183166	0.053	489708	7084	22403	NA	4219	NA	NA
2020	NA	NA	NA	NA	NA	NA	114072	0	0	0	0	NA	NA

Table 3.5.1.2. Bay of Biscay anchovy: Median and 90% probability intervals for some of the parameters estimated in the CBBM.

	5.00%	Median	95.00%	Meaning of parameter
qdepm	0.620	0.750	0.902	Catchability of the DEPM B index
qac	1.139	1.361	1.632	Catchability of the Acoustic B index
qrobs	0.006	0.075	1.038	Parameter of the observation equation for the juvenile index
krobs	1.119	1.369	1.609	Parameter of the observation equation for the juvenile index
psidepm	2.858	4.964	8.866	Precision (inverse of variance) of the observation equation of DEPM B index
psiac	4.647	8.278	14.222	Precision (inverse of variance) of the observation equation of Acoustic B index
psirobs	1.703	3.516	7.015	Precision (inverse of variance) of the observation equation of juvenile index
xidepm	3.257	3.906	4.625	Variance-related parameter for the observation equation of DEPM age 1 proportion
xiac	2.865	3.484	4.079	Variance-related parameter for the observation equation of Acoustic age 1 proportion
xicatch	2.331	2.697	3.043	Variance-related parameter for the observation equation of age 1 proportion in the catch
B0	15903	20984	27283	Initial biomass
mur	10.245	10.526	10.796	Median (in log scale) of the recruitment process
psir	0.774	1.187	1.752	Precision (in log scale) of the recruitment process
sage1sem1	0.389	0.459	0.543	Age 1 selectivity during the 1st semester
sage1sem2	0.875	1.080	1.310	Age 1 selectivity during the 2nd semester
G1	0.500	0.561	0.624	Intrinsic growth at age 1
G2	0.171	0.227	0.288	Intrinsic growth at age 2+
psig	19.364	27.798	38.512	Precision of the observation equations for intrinsic growth at ages 1 and 2+

Table 3.5.1.3. Bay of Biscay anchovy: Median and 90% probability intervals for recruitment, spawning–stock biomass, fishing mortalities by semester and harvest rates (Catch/SSB) as resulted from CBBM.

	R (tonnes)			**SSB (tonnes)**			**fsem1**			**fsem2**			**Harvest rate**		
Year	5.00%	Median	95.00%	5.00%	Median	95.00%	5.00%	Median	95.00%	5.00%	Median	95.00%	5.00%	Median	95.00%
1987	12045	16055	21452	16032	21047	27458	0.954	1.245	1.629	0.253	0.356	0.509	0.897	0.683	0.524
1988	25730	30900	38056	23808	29048	36312	0.809	1.042	1.309	0.284	0.384	0.520	0.605	0.496	0.397
1989	6586	9192	12951	11171	15762	22053	0.693	0.957	1.306	0.129	0.189	0.286	0.738	0.523	0.374
1990	58629	67208	78549	46060	53542	63866	1.003	1.249	1.531	0.541	0.722	0.953	0.732	0.630	0.528
1991	17468	22898	30450	22732	30041	39911	0.872	1.149	1.492	0.198	0.280	0.398	0.797	0.603	0.454
1992	68761	86754	109965	54683	72089	93511	0.910	1.211	1.613	0.258	0.374	0.552	0.680	0.516	0.398
1993	50315	63569	78532	60794	72865	87773	0.694	0.878	1.111	0.437	0.577	0.770	0.647	0.540	0.448
1994	32907	41035	50989	38533	47655	59360	0.944	1.184	1.486	0.463	0.632	0.867	0.873	0.706	0.566
1995	34237	45327	59494	29190	40797	55908	1.150	1.563	2.146	0.243	0.368	0.577	0.997	0.713	0.521
1996	39860	49943	61865	38770	47179	58336	0.969	1.259	1.611	0.517	0.710	0.971	0.848	0.697	0.564
1997	30510	39442	51428	34698	45007	58792	0.497	0.662	0.869	0.411	0.588	0.849	0.589	0.454	0.348
1998	70367	90893	118123	70156	90773	117921	0.351	0.472	0.624	0.350	0.504	0.739	0.448	0.346	0.266
1999	29839	43812	62030	51921	68202	88184	0.407	0.543	0.725	0.304	0.424	0.602	0.501	0.381	0.295
2000	72228	89002	108560	75477	91606	110418	0.588	0.737	0.923	0.297	0.393	0.522	0.489	0.403	0.334
2001	61603	73425	87331	77956	89961	104638	0.558	0.677	0.820	0.399	0.508	0.635	0.515	0.446	0.384
2002	9444	13132	18484	32105	38870	47598	0.450	0.553	0.677	0.388	0.503	0.644	0.545	0.450	0.368
2003	15288	19343	24513	22341	27489	33915	0.304	0.385	0.484	0.484	0.645	0.866	0.469	0.381	0.309
2004	24340	29925	37376	24487	30549	38532	0.676	0.877	1.125	0.443	0.618	0.854	0.661	0.530	0.420
2005	2547	3896	5773	10295	14169	19323	0.115	0.159	0.222	0.000	0.000	0.000	0.109	0.080	0.058
2006	12417	16970	23196	15310	20474	27156	0.179	0.242	0.325	0.008	0.011	0.015	0.115	0.086	0.065
2007	16014	21859	29840	23544	30782	40186	0.010	0.013	0.017	0.000	0.000	0.000	0.006	0.005	0.004
2008	6338	8968	12785	18955	24378	31387	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

	R (tonnes)			SSB (tonnes)			fsem1			fsem2			Harvest rate		
Year	5.00%	Median	95.00%	5.00%	Median	95.00%	5.00%	Median	95.00%	5.00%	Median	95.00%	5.00%	Median	95.00%
2009	7156	10076	14035	15753	20308	25878	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2010	36127	46760	60717	37511	48206	61767	0.319	0.413	0.531	0.138	0.190	0.266	0.269	0.209	0.163
2011	86888	109175	138430	93556	116057	145317	0.241	0.306	0.389	0.051	0.069	0.093	0.155	0.125	0.100
2012	34810	45263	59040	79259	96790	119491	0.159	0.200	0.249	0.120	0.154	0.198	0.181	0.148	0.120
2013	28605	37695	49665	54511	68386	85833	0.291	0.368	0.465	0.089	0.117	0.154	0.258	0.206	0.164
2014	51949	68844	89393	64028	83421	105626	0.374	0.479	0.619	0.112	0.152	0.210	0.305	0.234	0.185
2015	91943	116494	149669	106993	132856	166825	0.341	0.432	0.552	0.117	0.157	0.209	0.264	0.213	0.169
2016	42830	56581	75543	83155	105794	135311	0.260	0.335	0.430	0.072	0.095	0.127	0.233	0.183	0.143
2017	54959	71719	94252	74865	96808	125701	0.457	0.599	0.777	0.060	0.082	0.112	0.347	0.269	0.207
2018	93135	123661	164542	105442	141030	185370	0.395	0.526	0.701	0.062	0.087	0.123	0.291	0.218	0.166
2019	68320	98195	142412	103047	144834	201916	0.283	0.392	0.549	0.049	0.071	0.105	0.258	0.184	0.132
2020	17342	33706	64193	72174	100725	142951	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

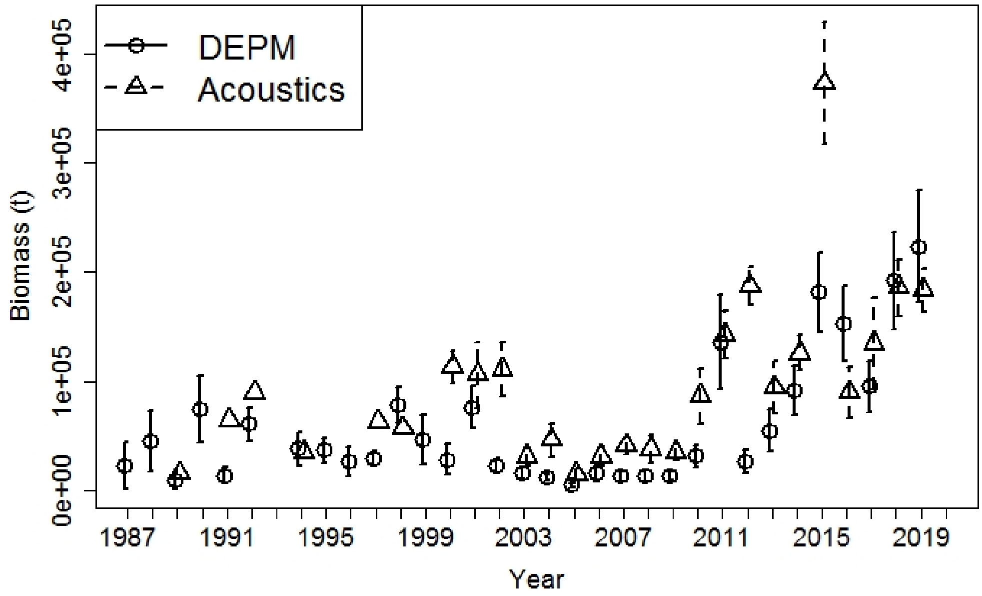


Figure 3.5.1.1. Bay of Biscay anchovy: Historical series of spawning–stock biomass estimates and the corresponding confidence intervals from DEPM (solid line and circles) and acoustics (dashed line and triangles).

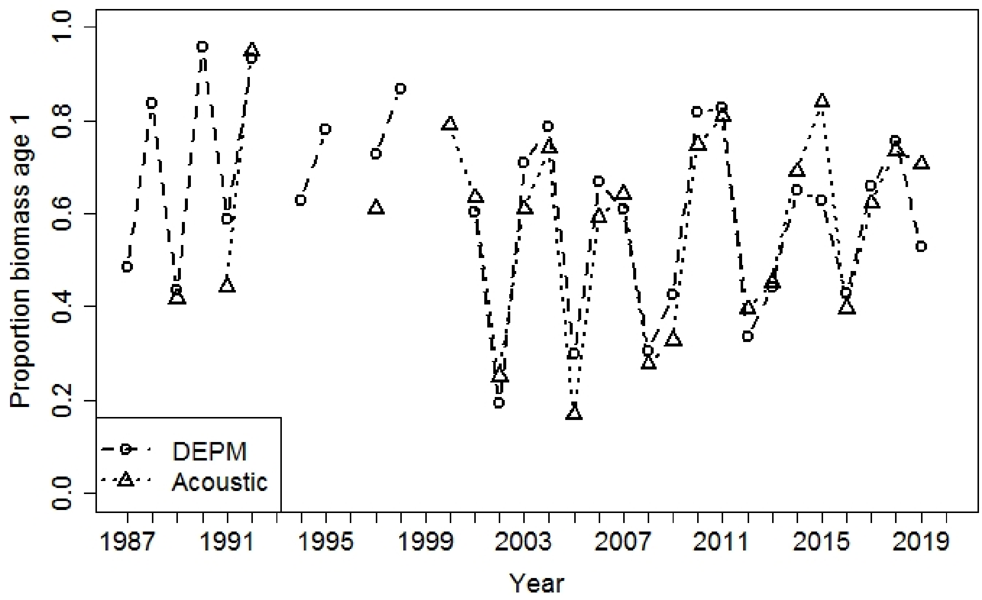


Figure 3.5.1.2. Bay of Biscay anchovy: Bay of Biscay anchovy: Historical series of age 1 biomass proportion estimates from DEPM (dashed line and circles) and acoustics (dotted line and triangles).

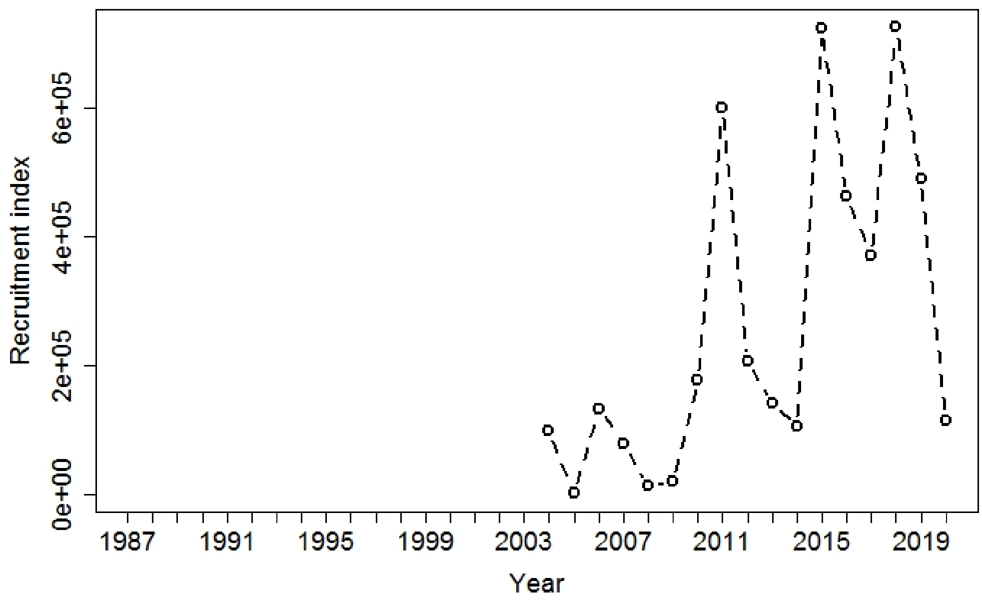


Figure 3.5.1.3. Bay of Biscay anchovy: Historical series of the juvenile abundance index from the autumn acoustic survey JUVENA that is related to recruitment (age 1) next year.

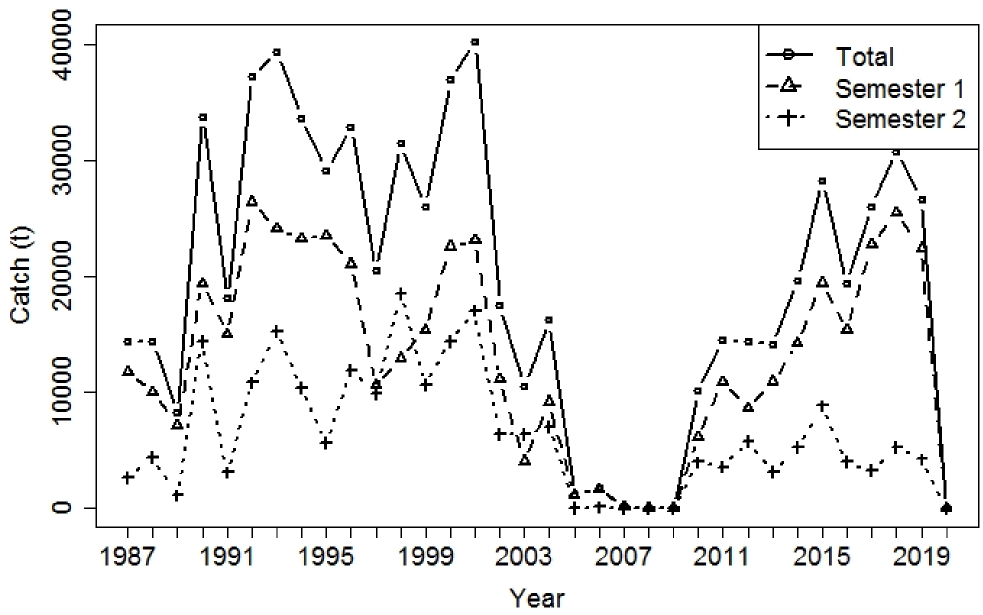


Figure 3.5.1.4. Bay of Biscay anchovy: Historical series of total catch (solid line) and catch by semesters (dashed and dotted lines for the first and second semester respectively). Note that the catch in 2019 is provisional and the catch in 2020 is set at zero.

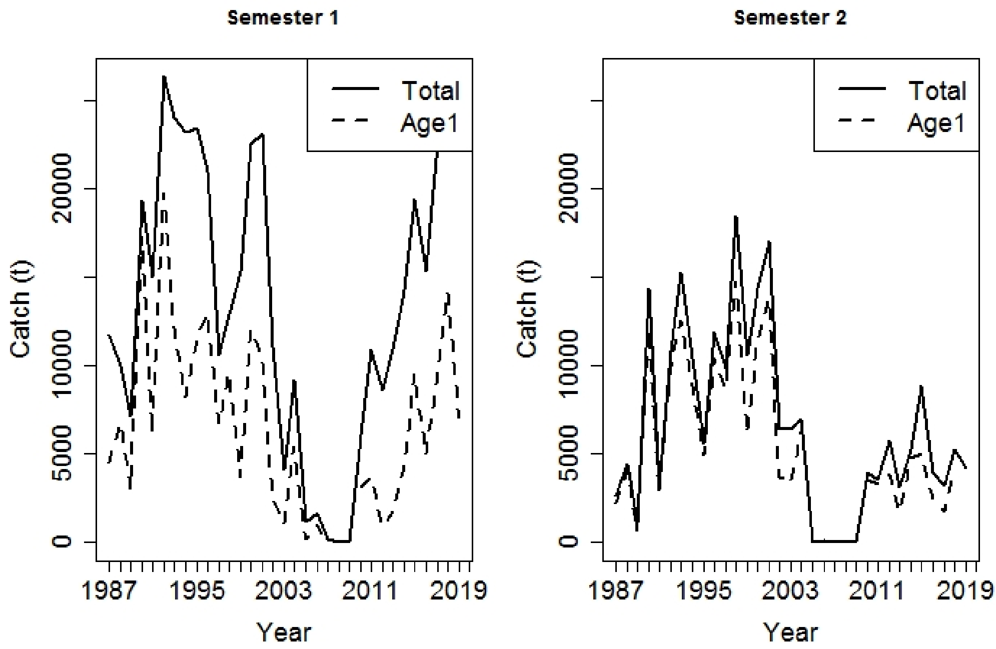


Figure 3.5.1.5. Bay of Biscay anchovy: Historical series of total (solid line) and age 1 (dashed line) catch (in tonnes). The left panel corresponds to the first semester and the right panel to the second semester. Note that the catch in 2019 is provisional.

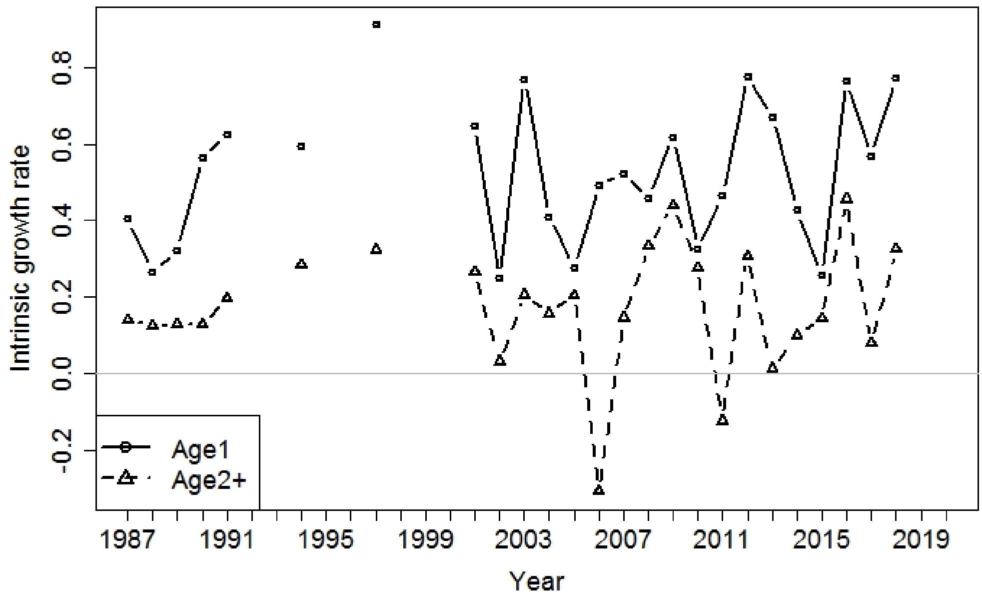


Figure 3.5.1.6. Bay of Biscay anchovy: Historical series of intrinsic growth rates by age as estimated from the mean weights-at-age of the stock.

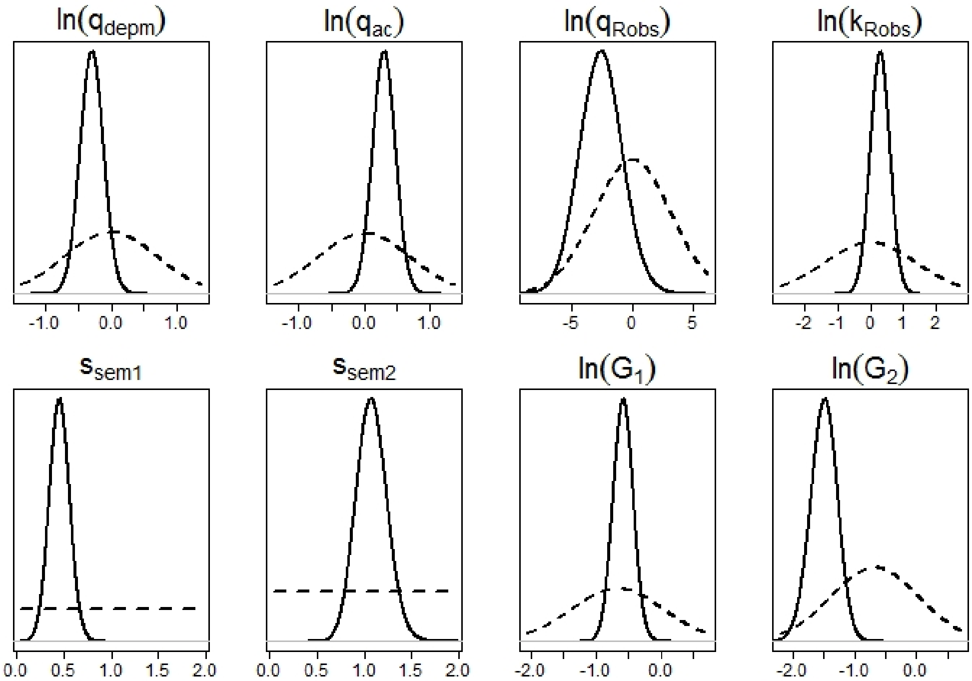
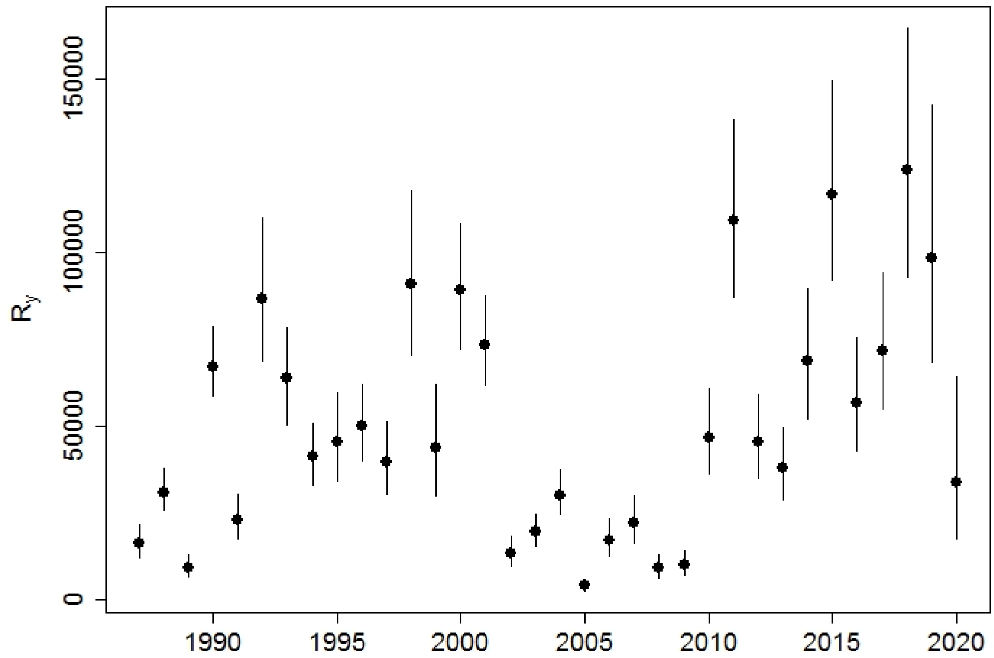
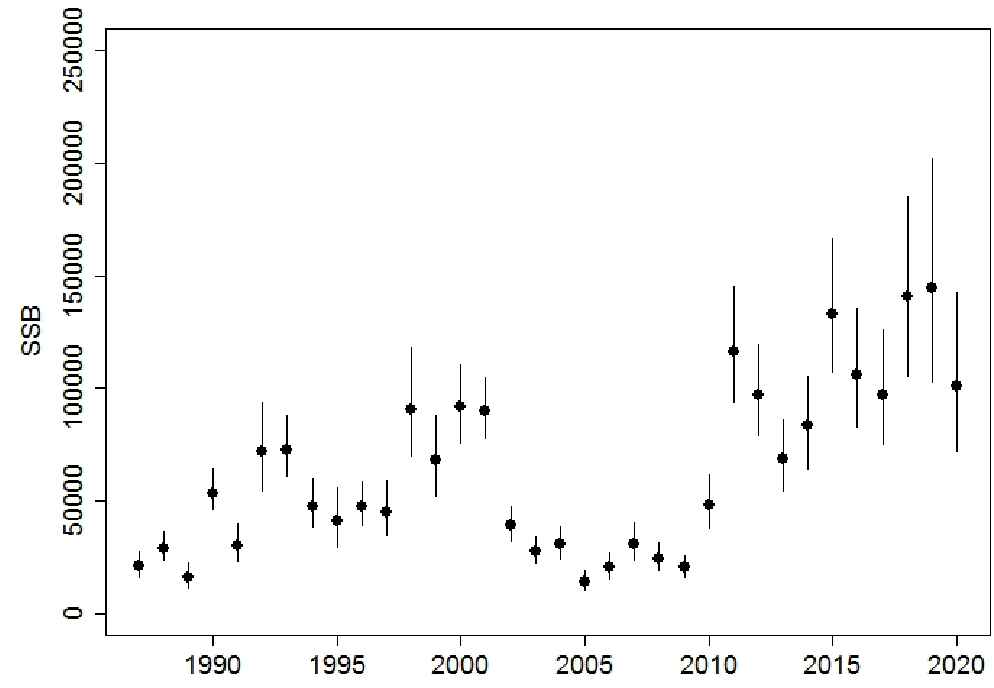
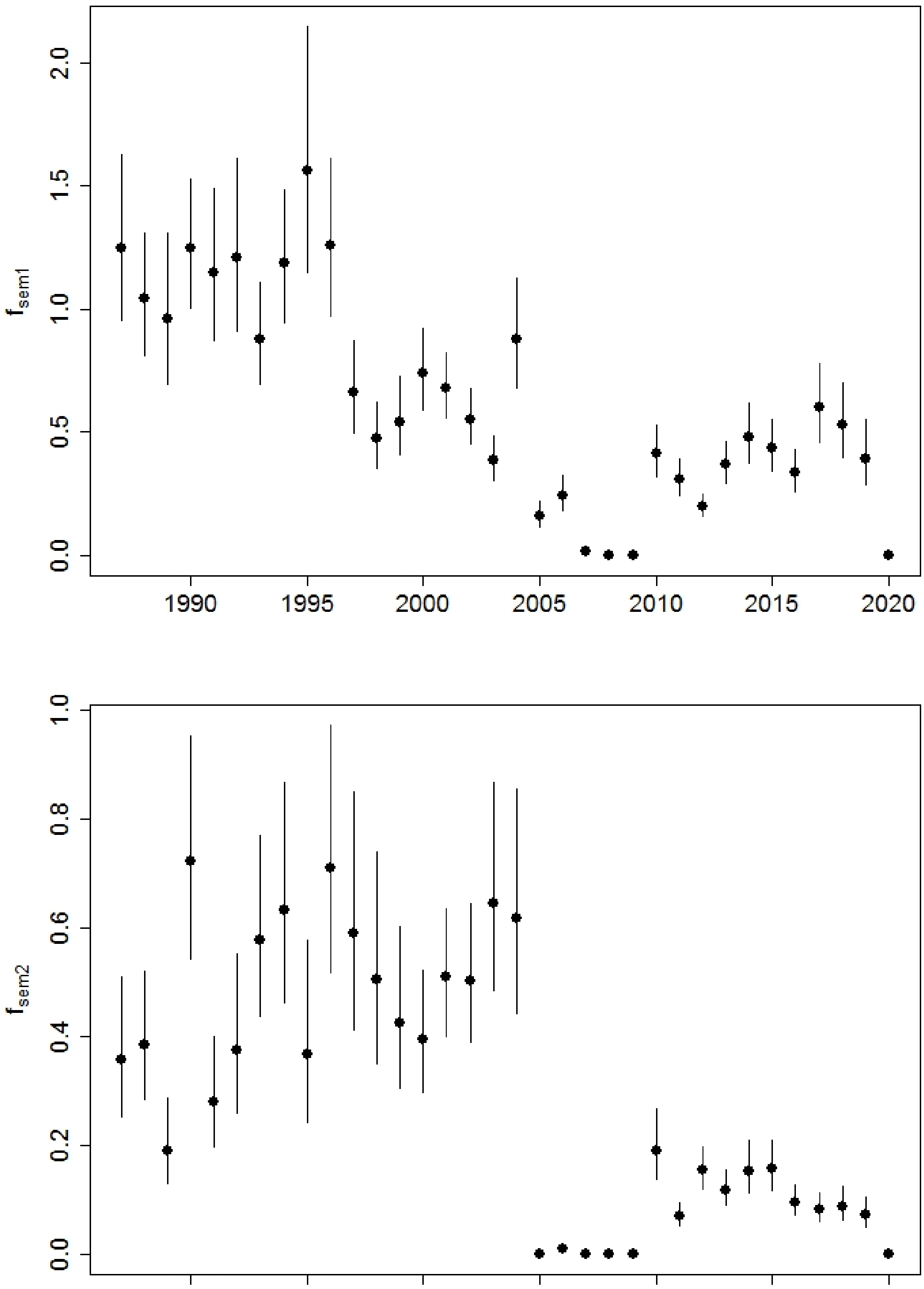


Figure 3.5.1.7. Bay of Biscay anchovy: Comparison between the prior (dotted line) and posterior distribution (solid line) for some of the parameters of CBBM.


R_y
0
50000
100000
150000
1990
1995
2000
2005
2010
2015
2020


SSB
0
50000
100000
150000
200000
250000
1990
1995
2000
2005
2010
2015
2020



f_sem1
0.0
0.5
1.0
1.5
2.0
1990
1995
2000
2005
2010
2015
2020
f_sem2
0.0
0.2
0.4
0.6
0.8
1.0
1990
1995
2000
2005
2010
2015
2020

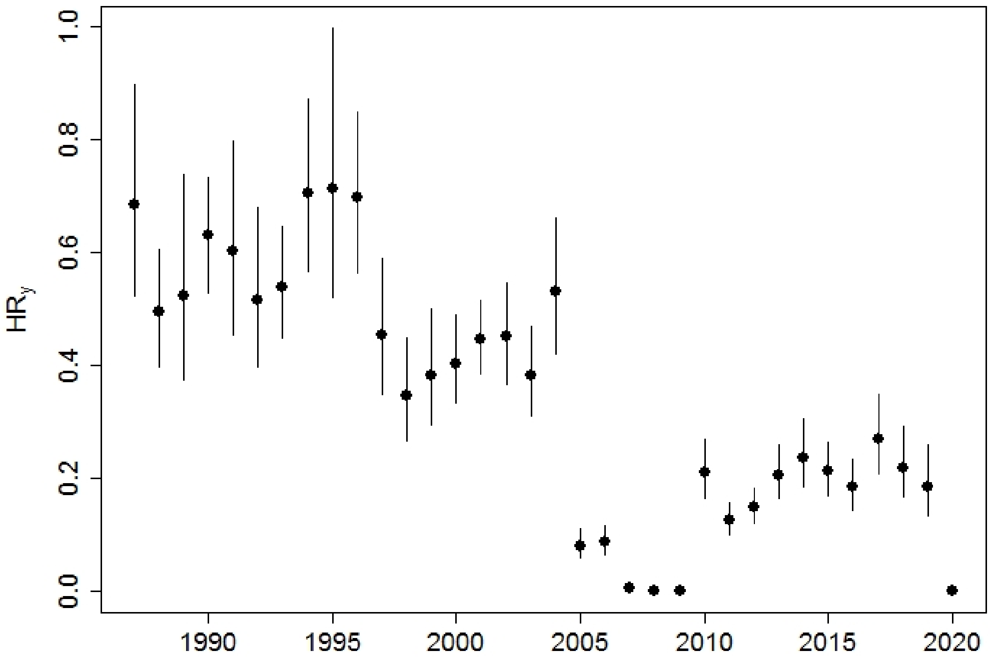


Figure 3.5.1.8. Bay of Biscay anchovy: Posterior median (bullet points) and 90% probability intervals (solid lines) for the recruitment (age 1 in mass in January), the spawning–stock biomass, the fishing mortality for the first and second semesters and the harvest rates (catch/biomass) from the CBBM. It must be taken into account that the fishing mortalities in 2020 are fixed at zero and SSB in 2020 results from no fishing in 2020.

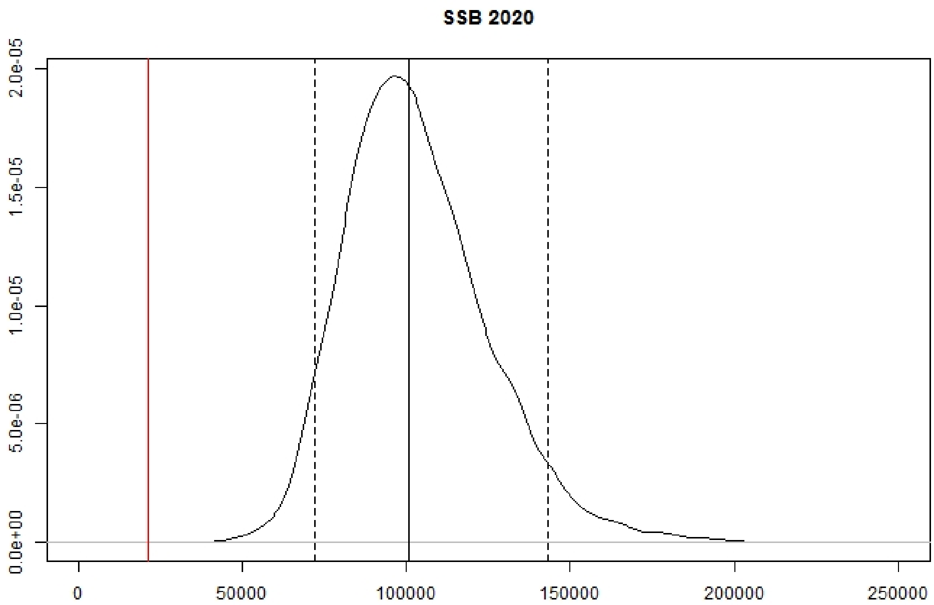


Figure 9. Bay of Biscay anchovy: Posterior distribution of SSB in 2020, under the assumption of no fishing during 2020. The red vertical line represents B_{lim} at 21 000 tonnes.

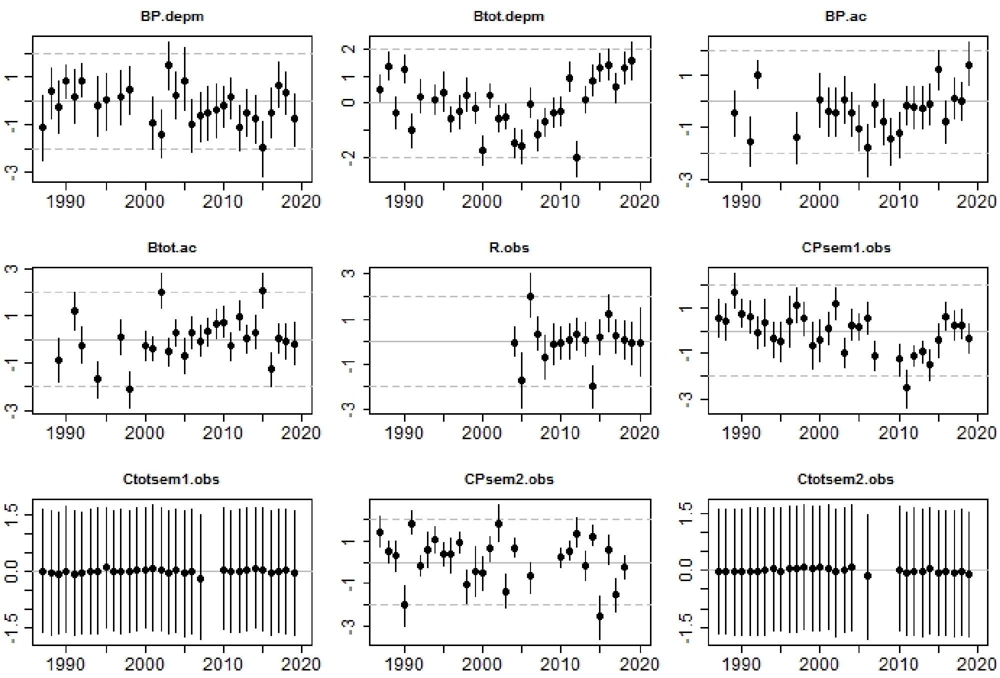
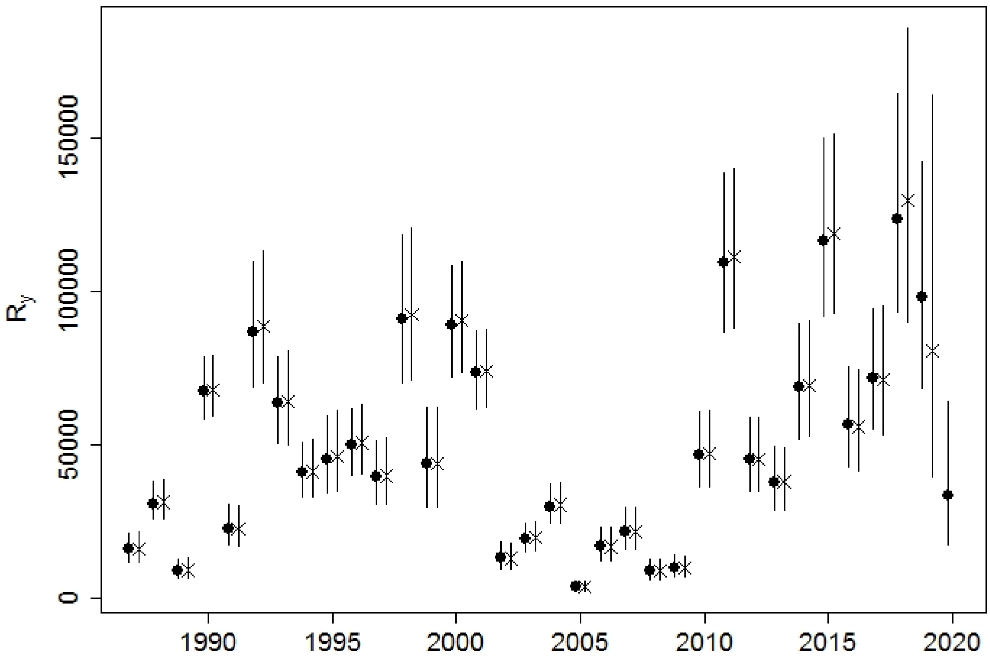
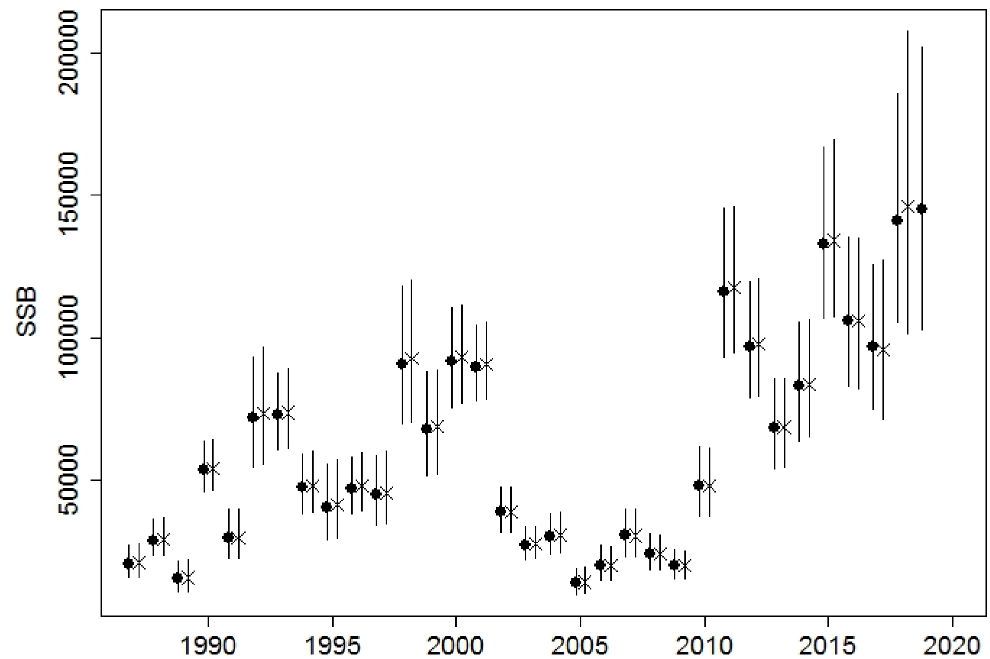


Figure 3.5.1.10. Bay of Biscay anchovy: Pearson residual medians and 90% probability intervals to the survey and catch observations used in the CBBM. From top to bottom and from left to right, residuals of the age 1 biomass proportion from the DEPM, total biomass from the DEPM, age 1 biomass proportion from the acoustic, total biomass from the acoustic, recruitment index, age 1 proportion in mass in the 1st semester catch, total catch in the 1st semester, age 1 proportion in mass in the 2nd semester catch and total catch in the 2nd semester.



R_y
0
50000
100000
150000
1990
1995
2000
2005
2010
2015
2020



SSB
50000
100000
150000
200000
1990
1995
2000
2005
2010
2015
2020

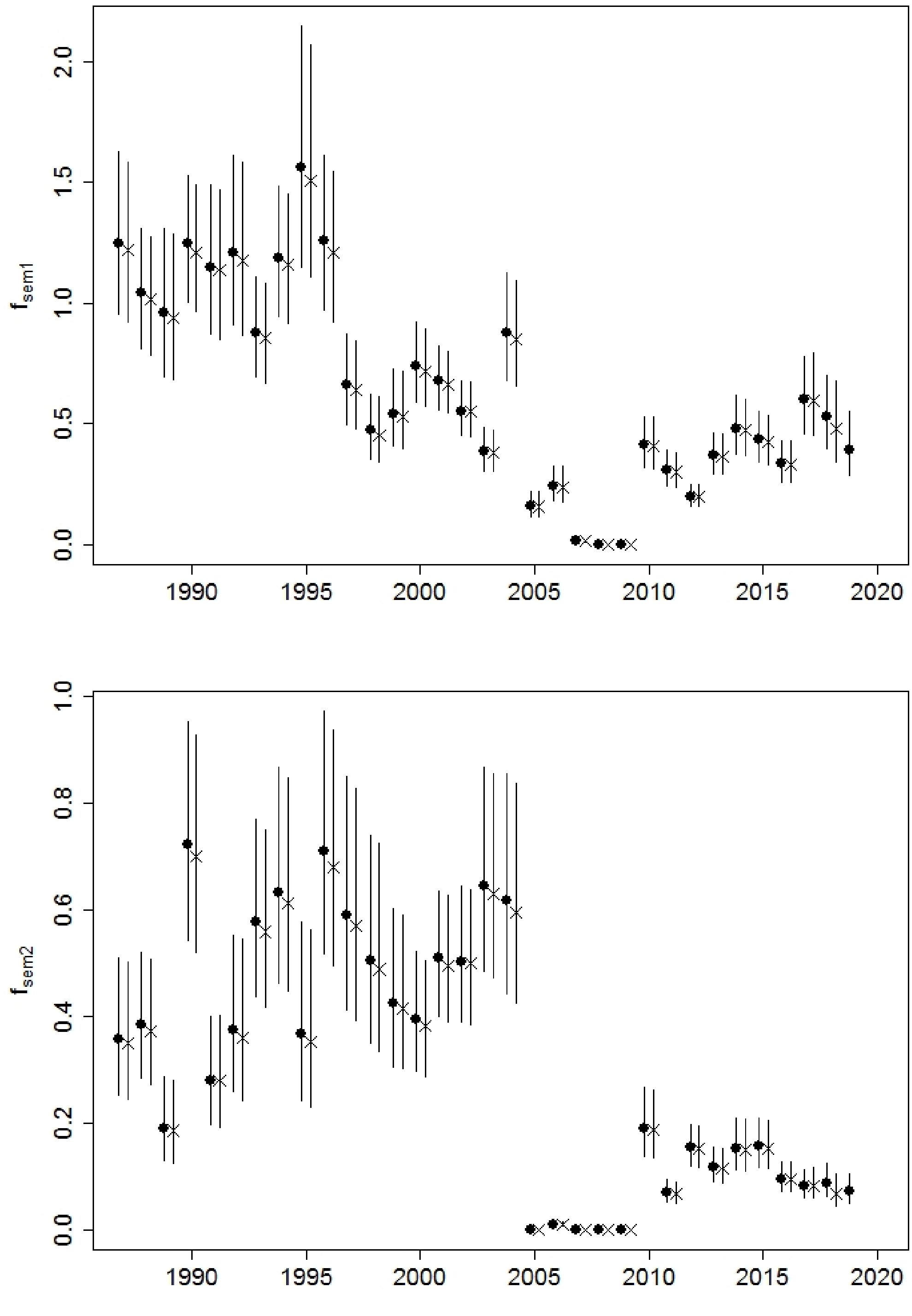
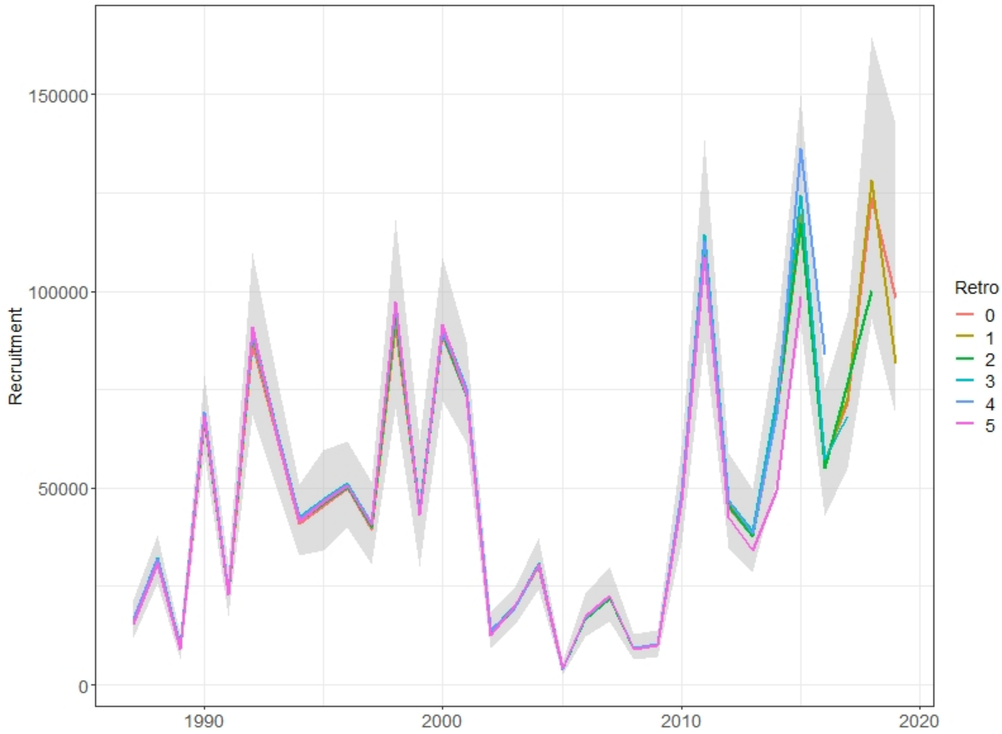
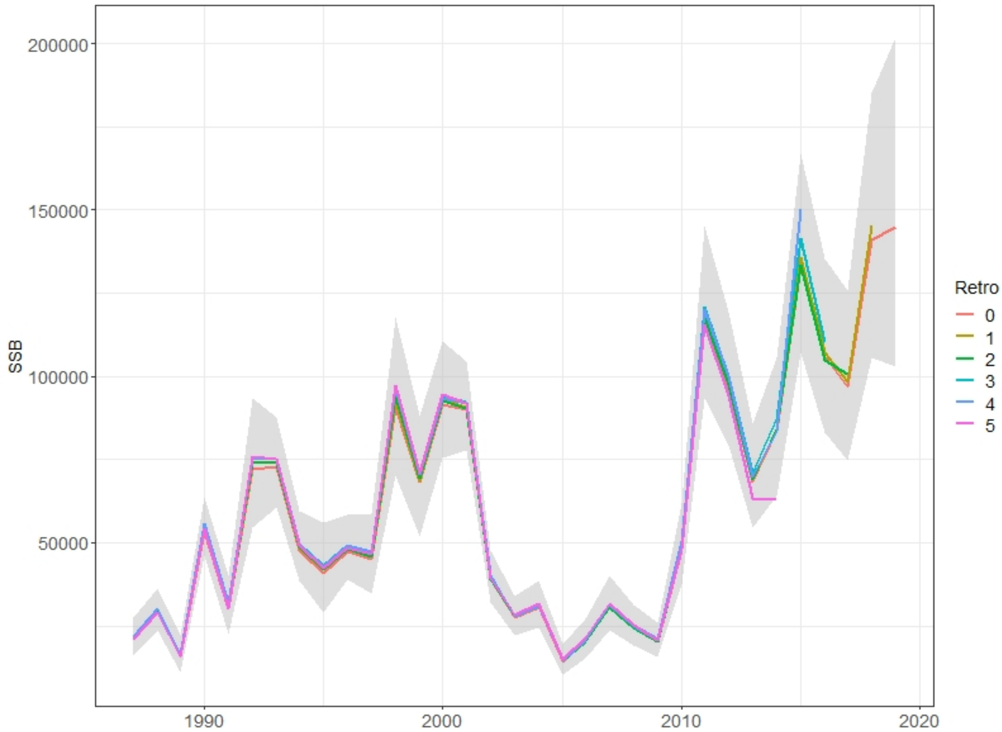
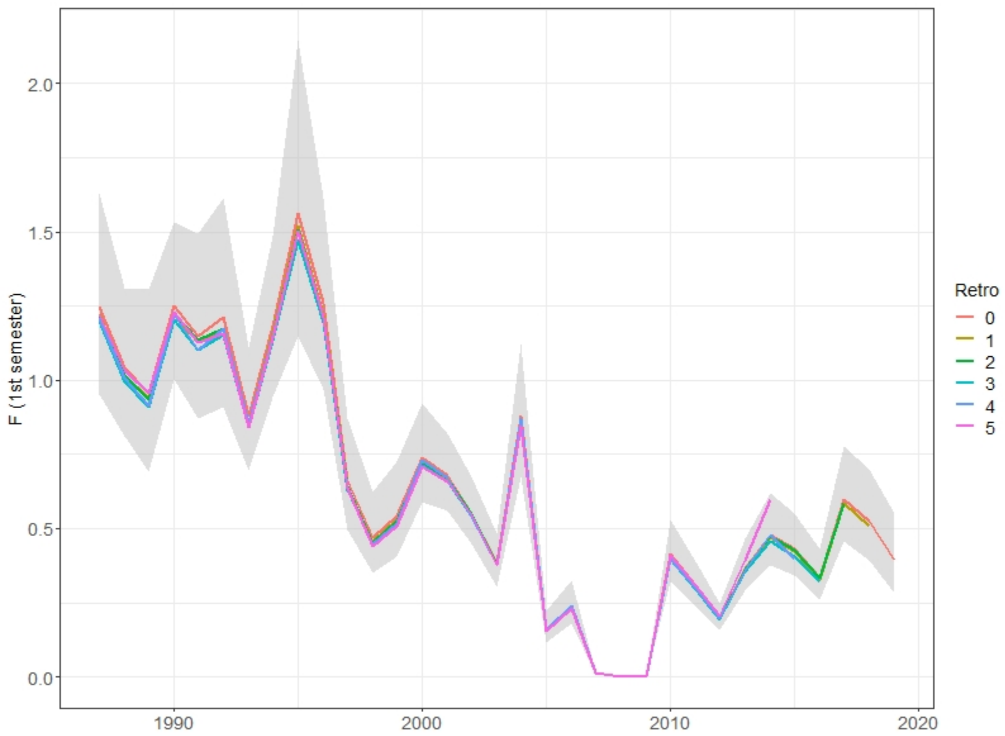
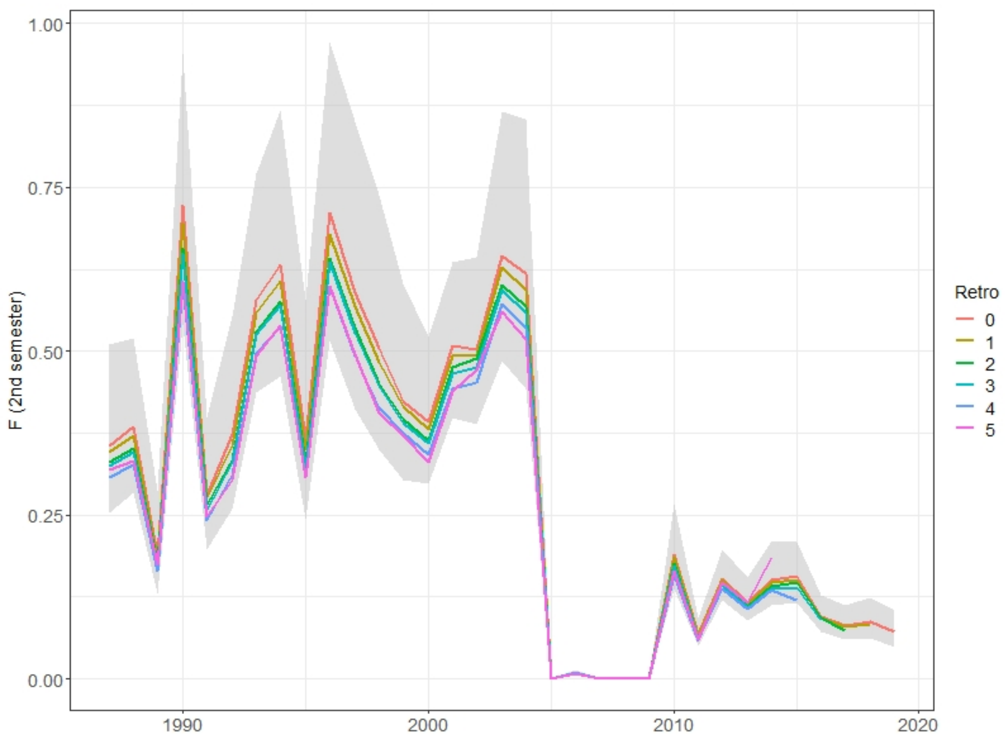


Figure 3.5.1.11. Bay of Biscay anchovy: From top to bottom comparison of the posterior median (points) and 90% probability intervals (solid lines) of the recruitment (age 1 in mass in January), the spawning–stock biomass and the fishing mortality in the first and in the second semester assessed in WGHANSA 2018 (cross) and in November WGHANSA 2019 (bullet).


Recruitment
150000
100000
50000
0
1990
2000
2010
2020
Retro
0
1
2
3
4
5


SSB
200000
150000
100000
50000
1990
2000
2010
2020
Retro
0
1
2
3
4
5


F (1st semester)
Retro
0
1
2
3
4
5
0.0
0.5
1.0
1.5
2.0
1990
2000
2010
2020


F (2nd semester)
Retro
0
1
2
3
4
5
0.00
0.25
0.50
0.75
1.00
1990
2000
2010
2020

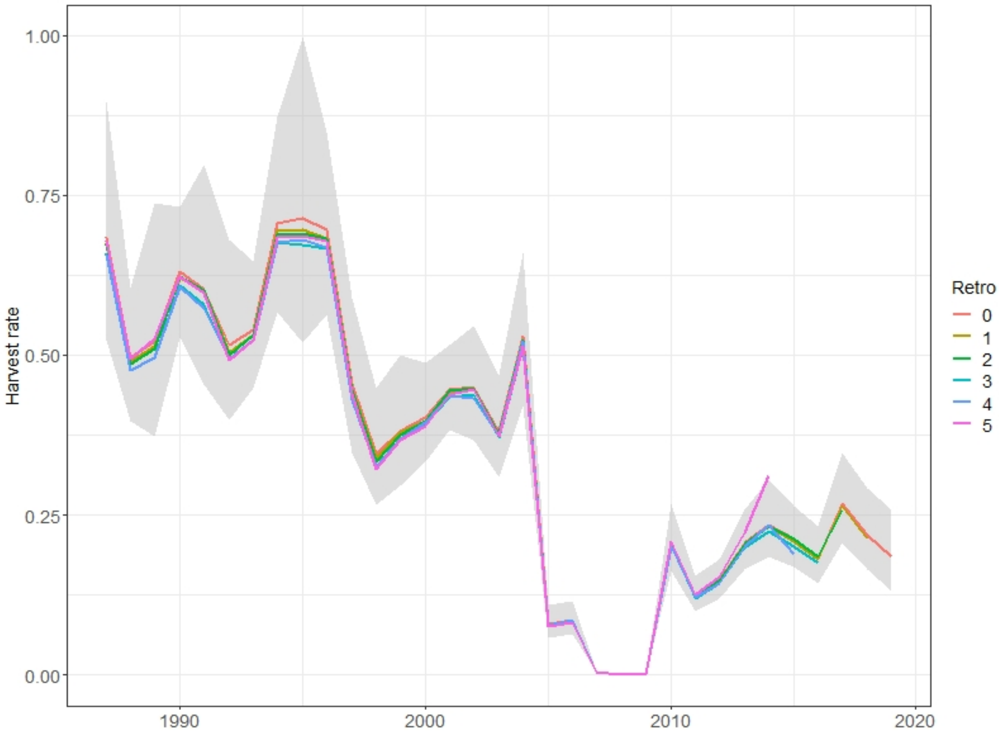
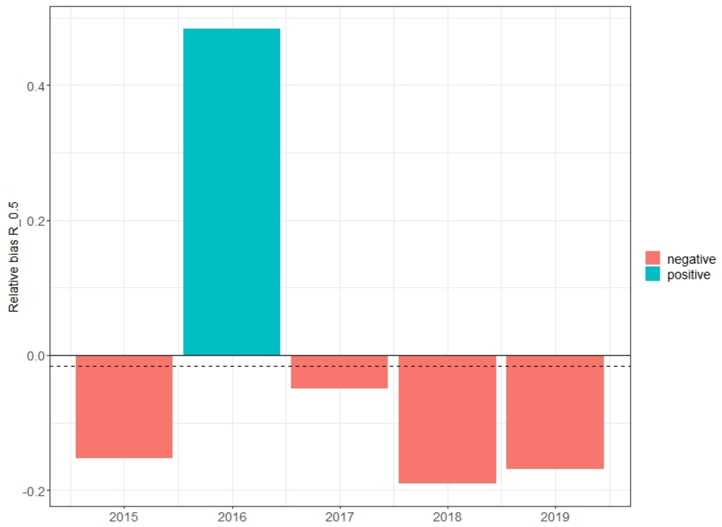
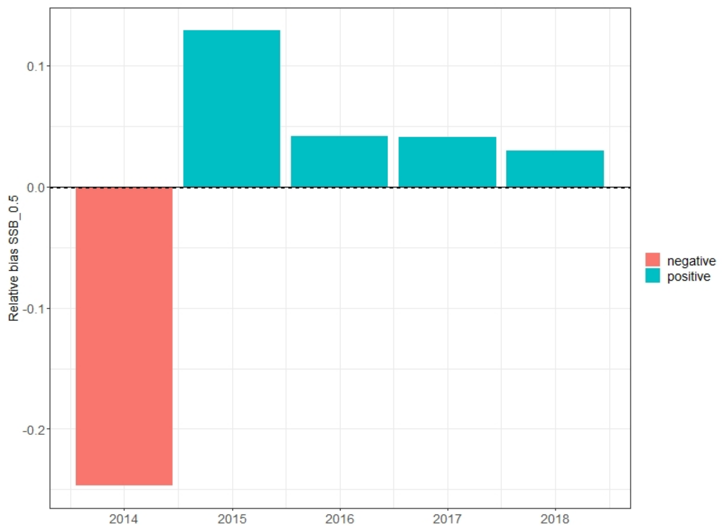
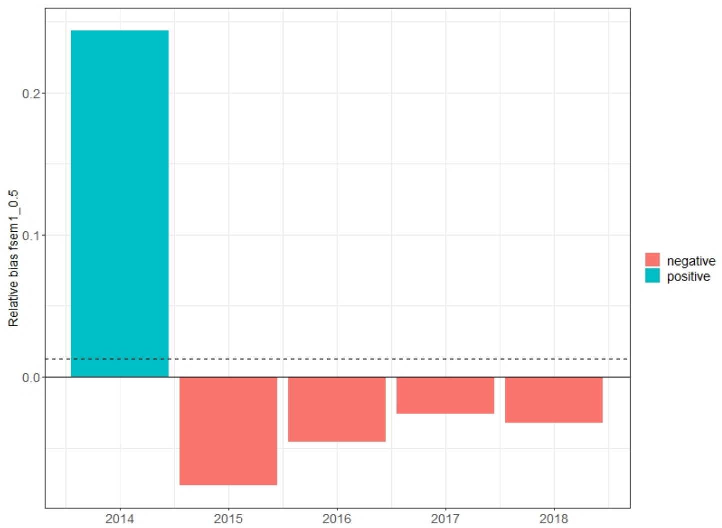


Figure 3.5.2.1. From top to bottom retrospective pattern of recruitment (age 1 in tonnes on 1st January), SSB, fishing mortality on 1st and 2nd semesters and harvest rate. The shaded are represents the 90% probability intervals from this year's assessment.


0.4
0.2
0.0
-0.2
Relative bias R_0.5
2015
2016
2017
2018
2019
negative
positive


0.1
0.0
-0.1
-0.2
Relative bias SSB_0.5
2014
2015
2016
2017
2018
negative
positive


0.2
0.1
0.0
Relative bias fsem1_0.5
2014
2015
2016
2017
2018
negative
positive

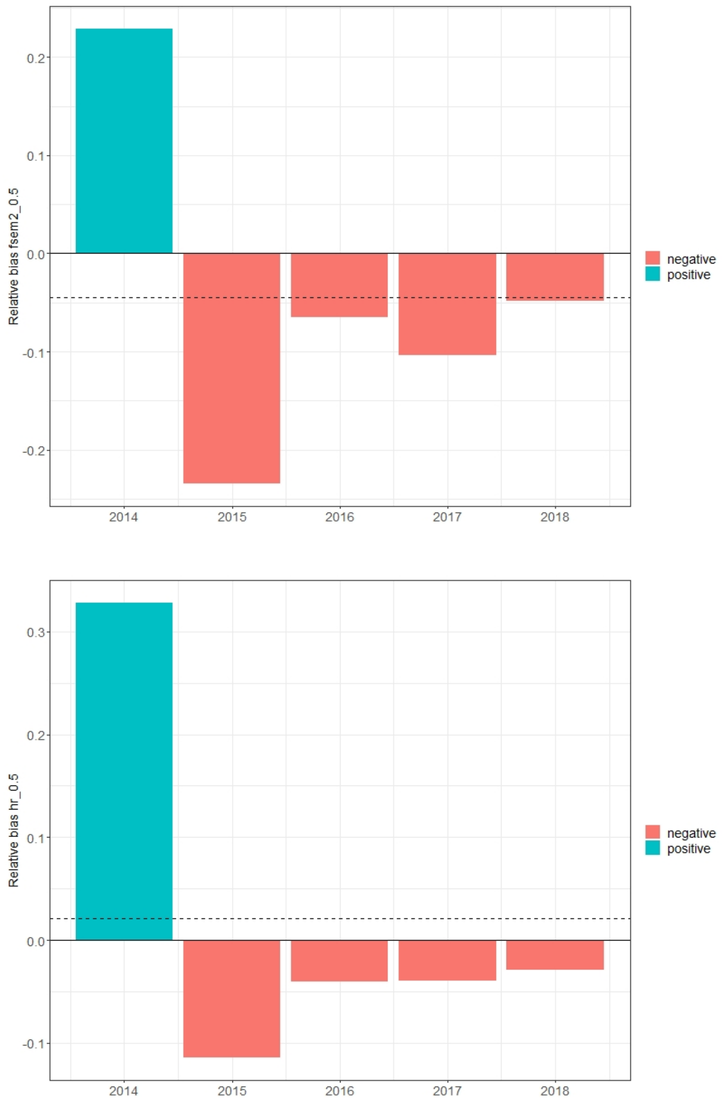
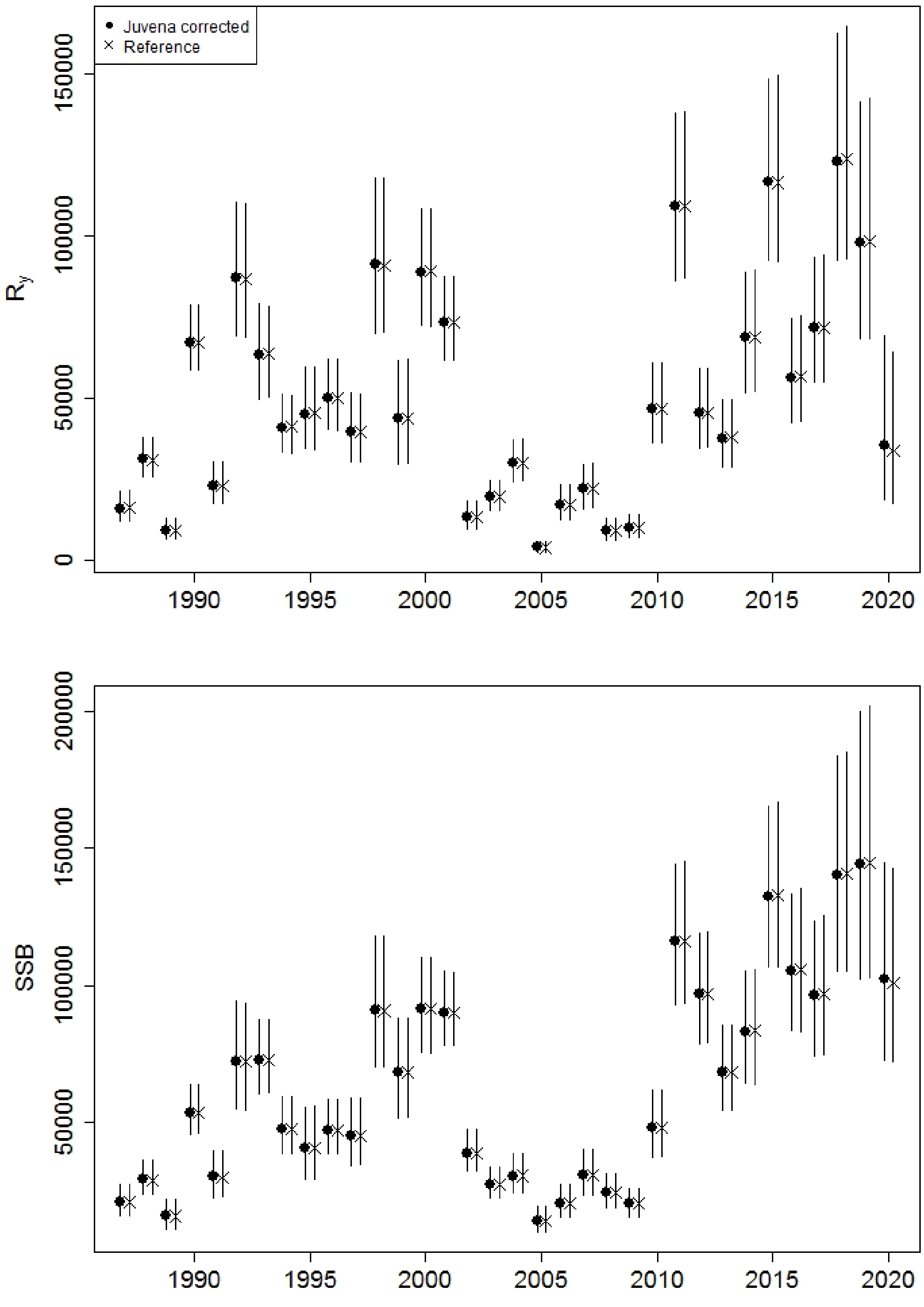


Figure 3.5.2.2. From top to bottom relative bias of recruitment (age 1 in tonnes on 1st January), SSB, fishing mortality on 1st and 2nd semesters and harvest rate. The horizontal dashed lines represent the Mohn's rho statistic for each time-series.



Juvena corrected
Reference
Ry
0
50000
100000
150000
1990
1995
2000
2005
2010
2015
2020
SSB
50000
100000
150000
200000
1990
1995
2000
2005
2010
2015
2020

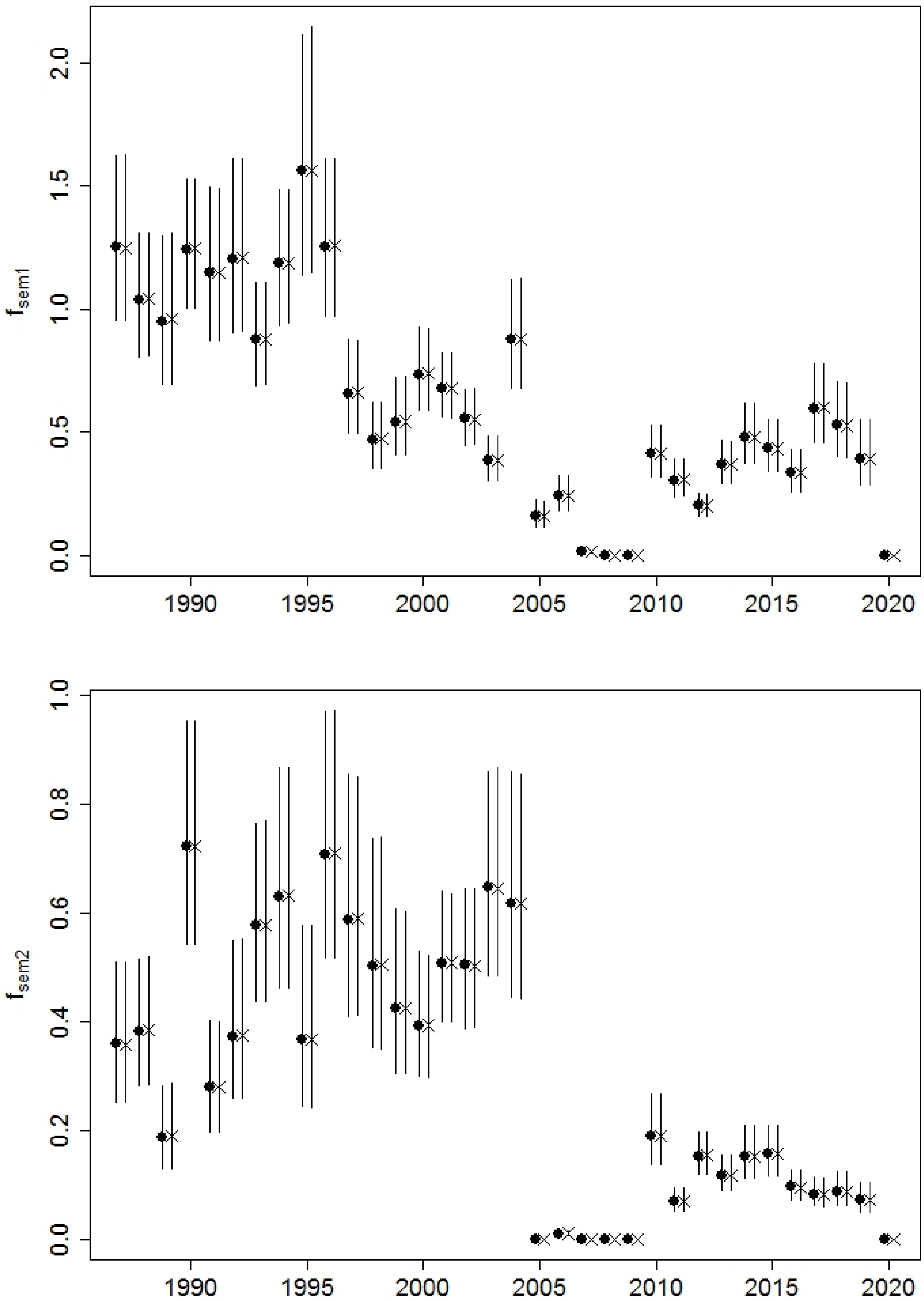


Figure 3.5.3.1. Bay of Biscay anchovy: From top to bottom comparison of the posterior median (points) and 90% probability intervals (solid lines) of the recruitment (age 1 in mass in January), the spawning–stock biomass and the fishing mortality in the first and in the second semester without (cross) and with (bullet) the potential underestimation of the juvenile abundance index of JUVENA 2019 corrected.

3.6 Short-term predictions

As the assessment, the short-term forecast for this stock can be conducted in June or in November. In June, there is no indication on next year recruitment, so the forecast has usually been based on an assumed undetermined recruitment scenario in which all the past recruitments were equally likely. In November, the forecast can be based on the next year recruitment distribution derived from the November assessment. The short-term prediction presented here, is based on the results from the final assessment conducted in November described in the previous section.

Recruitment in 2020 is estimated in the assessment and it is mainly informed by the latest JUVENA juvenile abundance index and the parameters of the JUVENA observation equations. Figure 3.6.1 shows the posterior distribution of recruitment in 2020 from the assessment in November. The median recruitment (age 1 biomass on 1st January) in 2020 for the November projections is around 33 700 t.

The method for the short-term projections based on the November assessment is described in the stock annex approved in October 2013.

The European Commission requested ICES to provide advice based on the harvest control rule (HCR) named G3 with a harvest rate of 0.4 (STECF, 2013; 2014).

The full formulation of this HCR is as follows:

$$TAC_{Jan_y-Dec_y} = \begin{cases} 0 & if\ \widehat{SSB_y} \leq 24000 \\ -2600 + 0.4\,\widehat{SSB_y} & if\ 24000 < \widehat{SSB_y} \leq 89000 \\ 33000 & if\ \widehat{SSB_y} > 89000 \end{cases}$$

where $\widehat{SSB_y}$ is the expected spawning–stock biomass in year y. See also Figure 3.6.2 for a graphical representation.

In this rule, the TAC from January to December is based on the spawning biomass $\widehat{SSB_y}$ 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 inter-dependent and vary together. This leads to seek the value of fishing mortality during the first semester solving the system for the median values of recruitment 2020, biomass at-age 2+ at the beginning of 2020, 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 was assumed to be 60% following STECF (2013; 2014). The simulations done by STECF for similar HCR suggested that the performance of the HCR was not dependent on the assumed split of the catches by semesters.

According to HCR G3 with harvest rate of 0.4, the TAC for the fishing season running from 1 January to 31 December 2020 should be established at 31 892 t, slightly below the maximum of 33 000 t. Under the assumption that 60% of the annual catches are taken in the first semester, the median SSB in 2020 is around 87 700 t with a 90% probability interval between 59 100 t and 129 900 t (Figure 3.6.3). The probability of SSB in 2019 being below B_{lim} is below 0.001.

Starting from the posterior distribution of recruitment (age 1 biomass) and biomass at-age 2+ on the 1st January 2020, the population was projected forward for one year. Total allowable catch during 2020 were explored from 0 (fishery closure) to 70 000 tonnes with a step of 5000 tonnes for a range of percentages of catches being taken in the first semester from 0 to 1 with a step of 0.1. Probability distributions of SSB in 2020 were derived for each of the catch options. For all cases, the probability of SSB in 2020 being below B_{lim} is below 0.06 (Table 3.6.1 and Figure 3.6.4) and the corresponding median SSB values in 2020 are above 50 300 t (Table 3.6.2 and Figure 3.6.4). Under the assumption that 60% of the annual catches are taken in the first semester, the probability of SSB in 2020 being below B_{lim} is lower than 0.05 for total catches up to 115 000 t (Table 3.6.1 and Figure 3.6.5). The harvest rate in 2019 was equal to 0.184. The same harvest rate in 2020 would lead to catches around 17 200 t and SSB around 93 700 t, with probability of SSB being below B_{lim} lower than 0.001.

Table 3.6.1. Bay of Biscay anchovy: Probability of SSB in 2020 of being below B_{lim} under different catch options for 2020 and alternative catch allocation by semesters.

$P(SSB<B_{lim})$		% CATCHES IN THE 1st SEMESTER 2020										
		0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
R estimated	TOTAL CATCH 2020											
	0	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	5000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	10000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	15000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	20000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	25000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00018
	30000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00018	0.00018	0.00018
	35000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00018	0.00018	0.00018	0.00036
	40000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00018	0.00018	0.00018	0.00055	0.00109
	45000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00018	0.00018	0.00055	0.00127	0.00273
	50000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00018	0.00018	0.00036	0.00109	0.00273	0.00400
	55000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00018	0.00018	0.00109	0.00236	0.00400	0.00982
	60000	0.00000	0.00000	0.00000	0.00000	0.00018	0.00018	0.00055	0.00182	0.00346	0.00818	0.01528
	65000	0.00000	0.00000	0.00000	0.00000	0.00018	0.00018	0.00109	0.00291	0.00727	0.01309	0.03023
	70000	0.00000	0.00000	0.00000	0.00000	0.00018	0.00036	0.00182	0.00364	0.01037	0.02329	0.05689

Table 3.6.2. Bay of Biscay anchovy: Median SSB in 2019 under different catch options for 2019 and alternative catch allocation by semesters.

SSB			% CATCHES IN THE 1st SEMESTER 2020										
			0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
R estimated	TOTAL CATCH 2020	0	100725	100725	100725	100725	100725	100725	100725	100725	100725	100725	100725
		5000	100725	100394	100060	99724	99387	99052	98714	98379	98043	97708	97372
		10000	100725	100060	99387	98714	98043	97372	96696	96018	95335	94652	93969
		15000	100725	99724	98714	97708	96696	95677	94652	93627	92599	91576	90549
		20000	100725	99387	98043	96696	95335	93969	92599	91234	89859	88484	87094
		25000	100725	99052	97372	95677	93969	92258	90549	88828	87094	85340	83597
		30000	100725	98714	96696	94652	92599	90549	88484	86393	84296	82197	80083
		35000	100725	98379	96018	93627	91234	88828	86393	83947	81489	79028	76540
		40000	100725	98043	95335	92599	89859	87094	84296	81489	78674	75824	72937
		45000	100725	97708	94652	91576	88484	85340	82197	79028	75824	72573	69273
		50000	100725	97372	93969	90549	87094	83597	80083	76540	72937	69273	65574
		55000	100725	97035	93284	89514	85690	81843	77964	74027	70011	65944	61835
		60000	100725	96696	92599	88484	84296	80083	75824	71480	67054	62580	58025
		65000	100725	96358	91917	87444	82898	78319	73662	68905	64080	59177	54226
		70000	100725	96018	91234	86393	81489	76540	71480	66313	61079	55736	50358

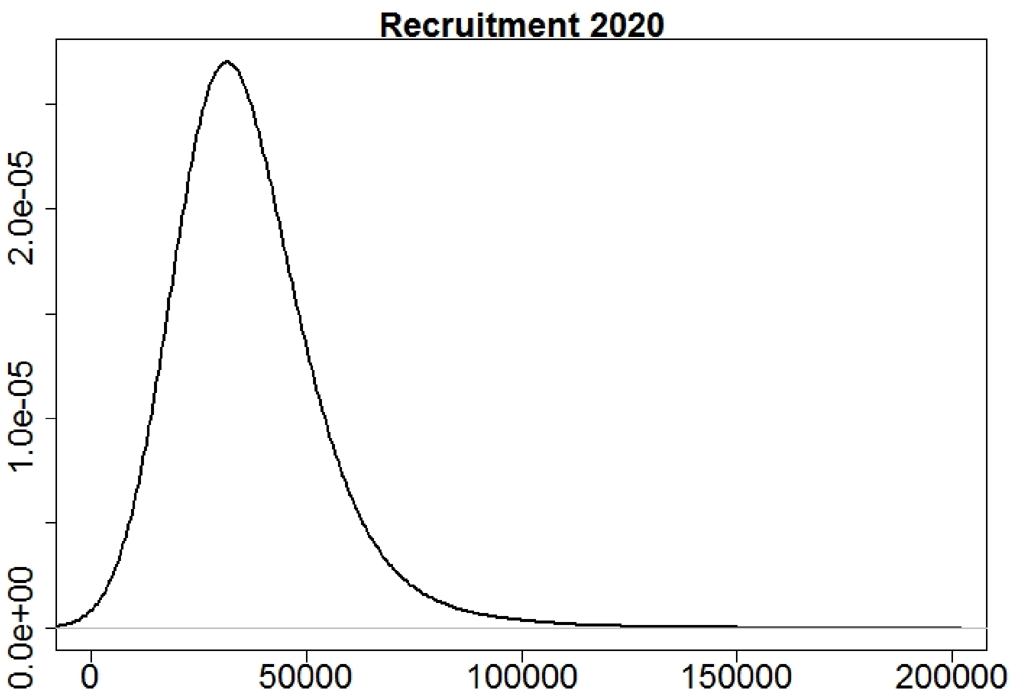


Figure 3.6.1. Bay of Biscay anchovy: Posterior distribution of recruitment (age 1 biomass at the beginning of the year) in 2020.

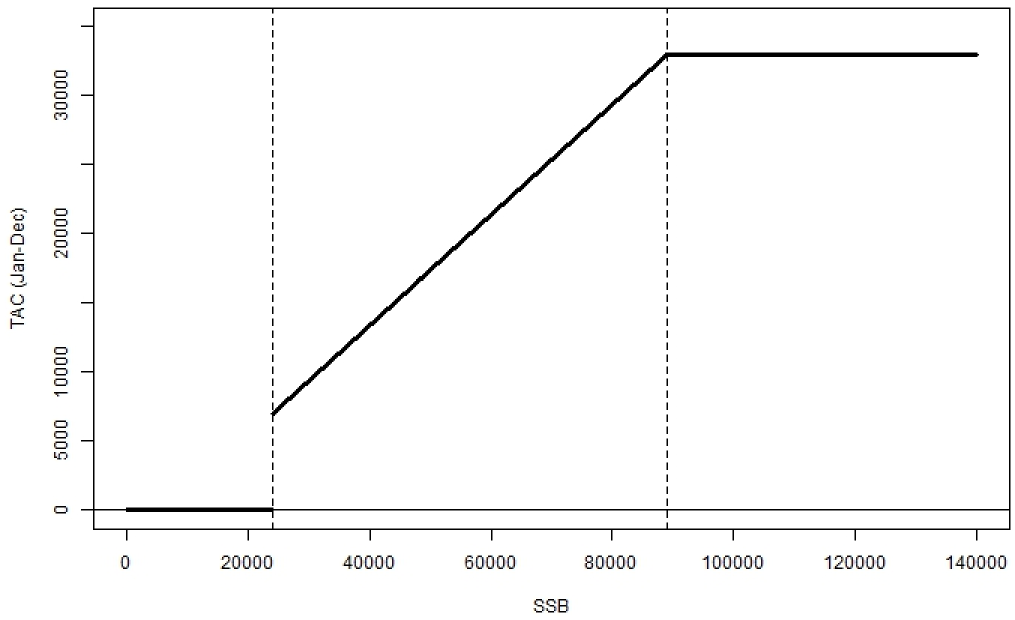


Figure 3.6.2. Bay of Biscay anchovy: Harvest control rule G3 with harvest rate of 0.4 according to which the TAC from January to December is set as a function of the expected spawning–stock biomass (on 15th May) in the management year.

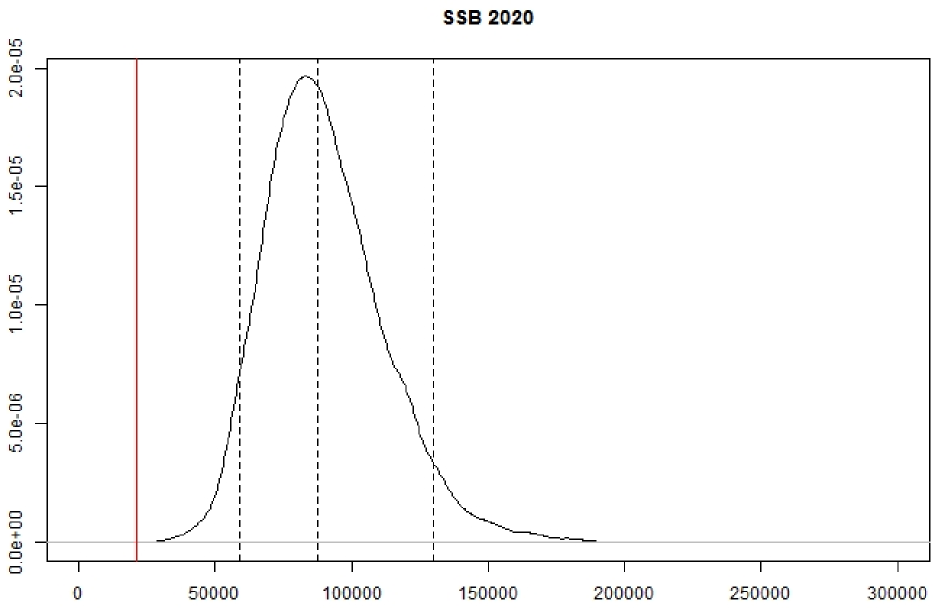


Figure 3.6.3. Bay of Biscay anchovy: Posterior distribution of SSB in 2020 if the annual catch is set according to the LTMP at 33 000 t and 60% of the catch is taken during the first semester. Vertical black dashed lines represent the 5, 50 and 95 posterior quantiles, whereas the red vertical line is B_{lim} (21 000 t).

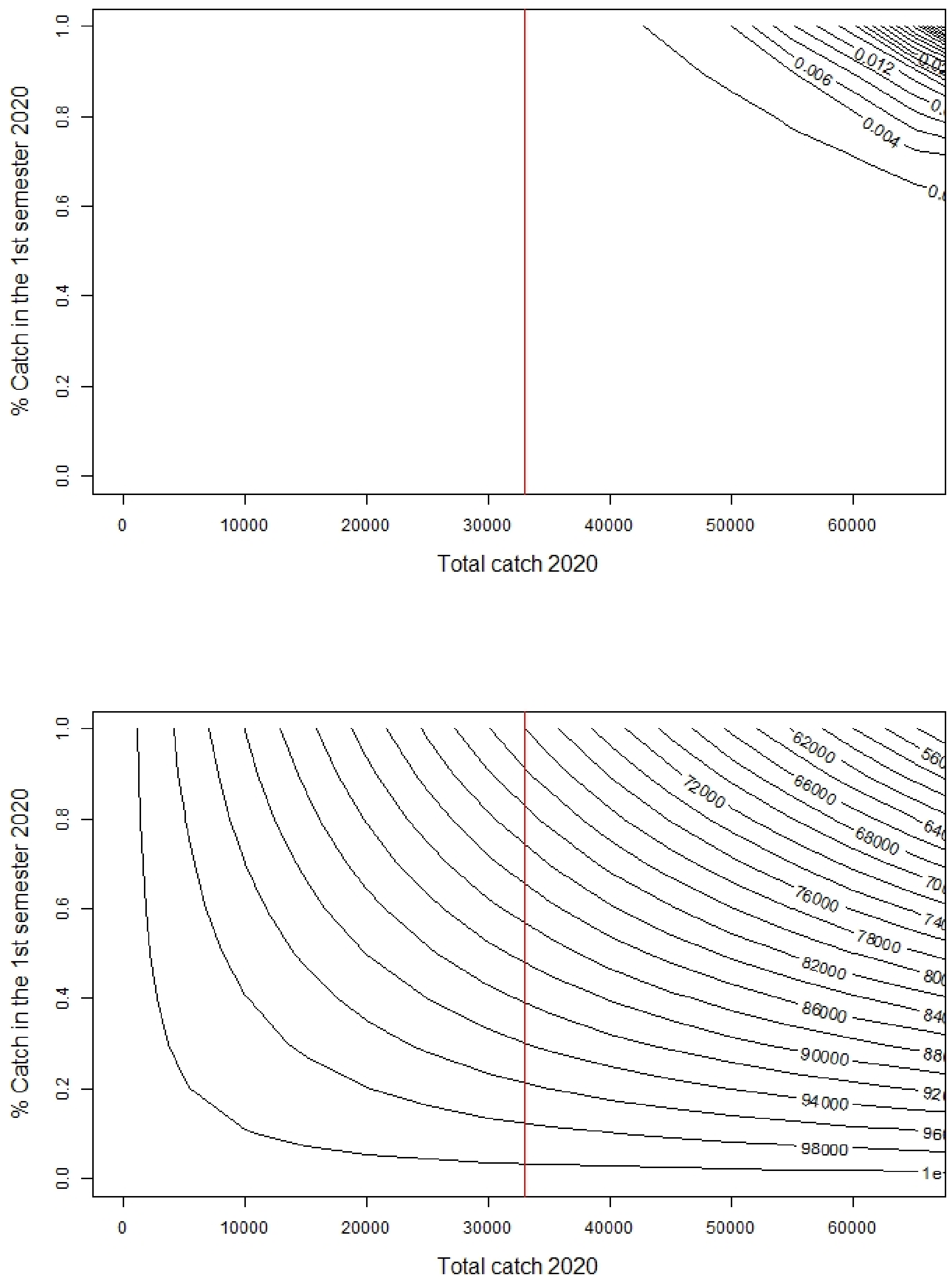


Figure 3.6.4. Bay of Biscay anchovy: Contour plots of probability of SSB in 2020 being below B_{lim} (on the top) and median SSB in 2020 (on the bottom) depending on the total catch in 2020 (x-axis) and the % of the catch in the first semester (y-axis). The vertical red line is set at 33 000 t.

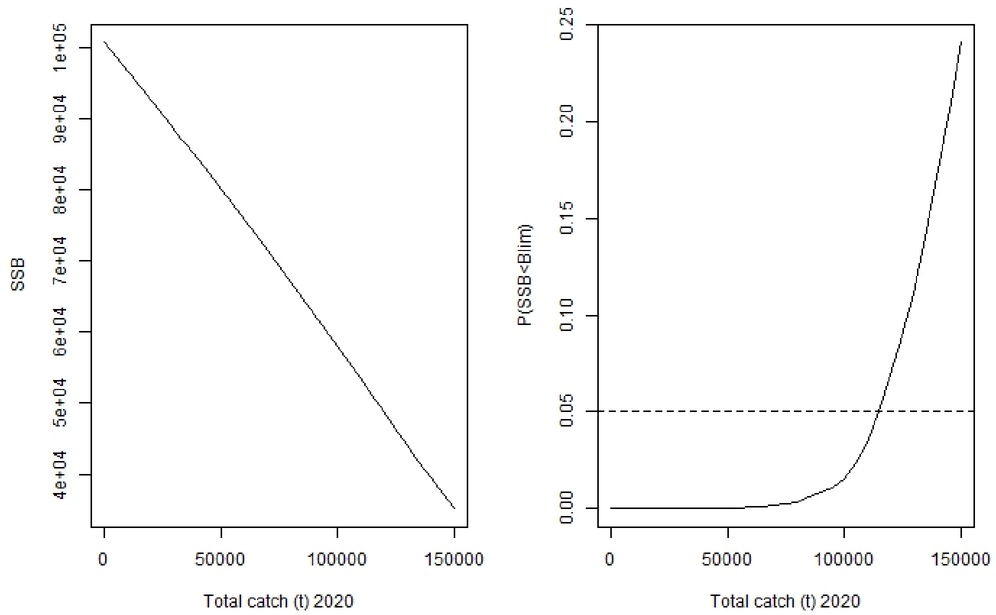


Figure 3.6.5. Bay of Biscay anchovy: SSB in 2020 (on the left) and probability of SSB in 2020 been below B_{lim} (on the right) depending on the total catch taken in 2020 when 60% of the catch is taken during the first semester.

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.

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}. B_{lim} is set at 21 000 tonnes. 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 precautionary approach (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 2018, 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. In addition, fishing mortality is not allowed to be higher than F_{cap}, a limit fishing mortality that constraints the exploitation rate when biomass is high. 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. ICES advice for this stock is based on a management plan and MSY $B_{escapement}$ and F_{cap} have 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 November 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 November 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 latter, 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 compared with 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 2015 was 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 (Figure 3.7.3.1). According to this rule, the TAC for the management period from January to December is set as:

$$TAC_{Jan_y-Dec_y} = \begin{cases} 0 & if\ \widehat{SSB_y} \le 24000 \\ -3800 + 0.45\,\widehat{SSB_y} & if\ 24000 < \widehat{SSB_y} \le 64000 \\ 25000 & if\ \widehat{SSB_y} > 64000 \end{cases}$$

where is the expected spawning–stock biomass in year. 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 recommended 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 3.7.3.1), which sets the TAC for the management period from January to December as:

$$TAC_{Jan_y-Dec_y} = \begin{cases} 0 & if\ \widehat{SSB_y} \le 24000 \\ -2600 + 0.4\,\widehat{SSB_y} & if\ 24000 < \widehat{SSB_y} \le 89000 \\ 33000 & if\ \widehat{SSB_y} > 89000 \end{cases}$$

This rule complies with the probability of risk of 5% as evaluated by STECF (2014) and has been assessed to conform to the ICES criteria for management plans (ICES, 2016, Annex 9). The SWWAC recommended an immediate application of this HCR and in June 2016 the European Commission increased the fishing opportunities for 2016 from 25 000 to 33 000 tonnes. The European Commission requested that this rule was used as the basis of the ICES advice from 2017 onwards.

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. However, their prediction capacity is still being tested.

3.7.5 Ecosystem effects of fisheries

These effects are not quantified.

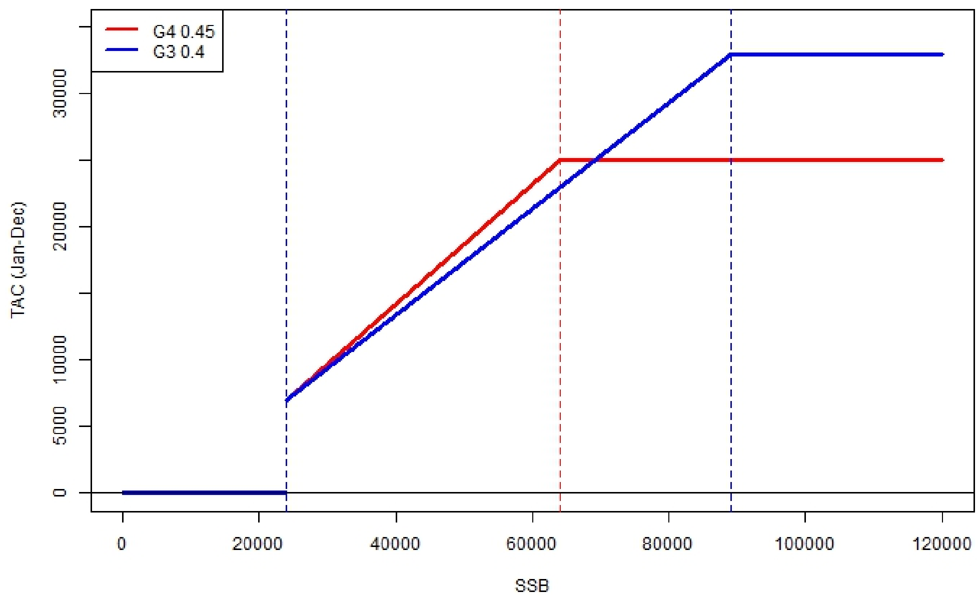


Figure 3.7.3.1. Bay of Biscay anchovy: Harvest control rules G4 with harvest rate of 0.45 (in red) and G3 with harvest rate of 0.4 (in blue) according to which the TAC from January to December is set as a function of the expected spawning–stock biomass (on 15th May) in the management year.

4 Anchovy in Division 9.a

4.1 ACOM Advice Applicable to the management period July 2018–June 2019

ICES could not give catch advice for 2018 under a management calendar based on calendar years. This is due to 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). ICES notes, however, that the historical fisheries along the division seem to have been sustainable.

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 of the stock and the need for a reliable index of recruitment strength.

The stock was benchmarked in February 2018 (WKPELA 2018 ICES, 2018a). WKPELA 2018 supported the proposal of considering two different components of the stock (western and southern component) due to the different dynamics of their fisheries and populations. However, until the stock structure along the division is properly identified, the provision of advice will still be given for the whole stock, but with separate catch advice for each stock component. Furthermore, the management calendar for the application of the advice has been agreed to be the one from 1st July of year *y* to 30th June of year *y+1* since 2018 onwards.

Official anchovy landings in the division in 2018 were of 13 640 t. Estimated total catches were 13 732 t. The agreed TAC for the management calendar July 2018–June 2019 is 17 068 t (western component: 13 308 t; southern component: 3760 t). Provisional official landings for this management calendar are 15 391 t (western component: 12 521 t; southern component: 2870 t).

4.2 Population structure and stock identity

A review of the anchovy substock structure in the Iberian Atlantic waters (Ramos, 2015) was submitted in 2015 to the ICES Stock Identification Methods Working Group SIMWG; ICES, 2015). At that time, SIMWG considered that there was evidence to support a self-sustained population of anchovy located in the Gulf of Cadiz (GoC, ICES Subdivision 9a South), but there was a lack of information regarding the origin of European anchovy in the western subdivisions (comprising subdivisions 9a North, 9a Central-North and 9a Central-South; **Figure 4.2.1**).

This stock was benchmarked at WKPELA in 2018 by ICES (ICES, 2018a) and an updated review of this issue was provided to this workshop, which included new available information of the origin of the populations of the 9a West subdivisions (Garrido *et al*., 2018a). Anchovy spatial distribution in Division 9a provided by surveys shows a persistent discontinuity between the western and southern components of the stock for several life stages (eggs, juveniles and adults) and during different seasons of the year. Landings also show this discontinuity, with e.g. more than 90% of Portuguese landings occurring in Subdivision 9a C-N in 2017. Moreover, no correlation was found of anchovy catches between the West and South components (Garrido *et al*., 2018a), further suggesting independent dynamics. The hypothesis that the western population(s) might come from migration from the southern component is not supported by the current data, since there was no correlation between anchovy abundance or landings in the western Iberia with anchovy abundance in the southern Iberia in the previous year (Garrido *et al*., 2018a). On the contrary, anchovy landings in the western coast were significantly related to the abundance of the species in that area, demonstrating the independent dynamics of anchovy fishery for the two components. A review of studies conducted in Portuguese estuaries have also shown the persistent presence of recruits in numerous estuaries, mainly in the Subdivision 9a C-N, which, agreeing with the concentration of eggs in this subdivision, points to the presence of a self-sustained population in this area. Morphometric and genetic studies indicate a differentiation of the western and Cantabrian populations, as well as a separation with those from the GoC, while the separation of the population from the GoC and the Alboran Sea (Spanish SW Mediterranean) is still unclear (Garrido *et al*., 2018a).

The evidence summarized above have led WKPELA to support the proposal of considering two different components of the stock (western and southern components; **Figure 4.2.1**) for which the advice should be given separately, but evidences were not consensually considered sufficient to modify the current stock structure. New studies on genetics and otolith microchemistry, aimed at elucidating the identity and structure of anchovy populations in the western component, are still in progress. WKPELA suggested to present both the available evidences and the resulting new evidences from these undergoing studies to the ICES Stock Identification Methods Working Group for future consideration.

The western component comprises the subdivisions 9a North, 9a Central-North and 9a Central-South. The southern component includes the Portuguese and Spanish waters of the Subdivision 9a South.

4.3 The fishery in 2018

4.3.1 Fishing fleets

Anchovy harvesting throughout the Division 9.a was carried out in 2018 by the following fleets in each stock component:

Western component

- 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 miscellaneous fleet (artisanal métiers accidentally fishing anchovy) (MIS_MIS_0_0_0_HC).
- Spanish artisanal trammel and gillnets (GTR_DEF_40-59_0_0, GNS_DEF_60-79_0_0 accidental anchovy landings).
- Spanish bottom otter trawl directed to demersal and pelagic fish (OTB_DEF_>=55_0_0 and OTB_MPD_>=55_0_0 anchovy discards).

Southern component

- Portuguese purse-seine fleet (PS_SPF_0_0_0).
- Portuguese trawl fleet for demersal fish species (OTB_DEF_>=55_0_0).
- Spanish purse-seine fleet (PS_SPF_0_0_0).
- Spanish miscellaneous fleet (artisanal métiers accidentally fishing anchovy) (MIS_MIS_0_0_0_HC).
- Spanish bottom otter trawl directed to demersal fish in 9.a South (OTB_DEF_>=55_0_0 anchovy discards).

The Spanish fleet fishing anchovy in the Western component was composed in 2018 by a total of 80 vessels. From this total, 75 vessels (93.8%) were purse-seiners (**Table 4.3.1.1**). The Portuguese fleet targeting anchovy and operating in the Western component in 2018 was composed by a total of 113 vessels in the Subdivision 9.a Central North and 52 vessels in the Subdivision 9.a Central South (**Table 4.3.1.2**).

Number and technical characteristics of the purse-seine vessels operated by Spain targeting anchovy in their national waters off GoC (Southern component) are also summarised in **Table 4.3.1.1**. In 2018, GoC anchovy fishing was practised by 74 purse-seiners. Details of the dynamics of this fleet in terms of number of operative vessels over time in recent years are given in ICES (2008a; WGANC 2008 report) and subsequent reports. The Portuguese fleet targeting anchovy and operating in the Southern component in 2018 was composed of a total of 22 vessels (**Table 4.3.1.2**).

4.3.2 Catches by stock component and division

4.3.2.1 Catches in Division 9.a

Anchovy total catch in 2018 was estimated at 13 732 t, which represented a 7% decrease on the catches landed in the previous year (14 705 t), and the second consecutive historic maximum in the recent fishery (since 1989; **Table 4.3.2.1.1**, **Figure 4.3.2.1.1**). The above estimate is the result from adding up 13 640 t of official landings and 92 t of discards (see **Section 4.3.3**).

As usual, the anchovy fishery in 2018 was almost exclusively harvested by purse-seine fleets (99.3% of total catches). However, unlike the Spanish fleet fishing in the GoC, 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 2014–2018.

Provisional official landings during the first semester in 2019 amounted to 7305 t. Provisional catches during the current management period (July 2018–June 2019), as the result of summing up total catches from the second semester in 2018 and provisional official landings from the first semester in 2019, amounted to 15 391 t.

The contribution of each stock component to this total catch is described in the following sections.

4.3.2.2 Catches by stock component

The updated historical series of anchovy catches by subdivision are shown in **Table 4.3.2.1.1** (see also **Figure 4.3.2.1.1**). **Table 4.3.2.2.1** shows the contribution of each fleet in the total annual catches by subdivision. The seasonal distribution of 2018 catches by subdivision is shown in **Table 4.3.2.2.2**.

Western component

The total catch in 2018 for this stock component was estimated at 9233 t, which accounted for 9% decrease on the 2017 catch (10 094 t) and represented 67% of the total catch in the division. This

2018 estimate is the third historic high since the one recorded in 1995. The fractions composing this total catch in 2018 were: 9233 t of official landings and 0.6 t of discards.

Provisional official landings during the first semester in 2019 amounted to 6280 t.

Provisional catches during the current management period (July 2018–June 2019) amounted to 12 521 t.

The distribution of these catches by subdivision is as follows:

Subdivision 9a North

In this Spanish subdivision a total of 992 t was caught in 2018, which represented a 7% decrease in relation to the catches estimated the previous year (1069 t, i.e. the second historical maximum). These catches accounted for 9.7% of the total catch estimated for the Western component and 7.2% for the whole division. This estimated catch is the result of adding up 992 t of official landings and 0.6 t of discards. Purse seiners were the main responsible for the fishery (99.9% of total catch in the subdivision). The fishery was concentrated in the second semester.

Provisional official landings during the first semester in 2019 amounted to 281 t (up to 27th May 2019). Those ones corresponding to the current management calendar amounted to 909 t.

Subdivision 9a Central-North

This subdivision concentrated majority a great part of the anchovy fishery in 2018, both in relation to the whole division and to the Western component: a total catch of 7871 t was estimated (with all of these catches corresponding to official landings; neither unallocated nor discarded catches were reported). These catches represented an 11% decrease on the catches estimated the previous year (8854 t) and became the second historical maximum for this subdivision. They accounted for 85.2% of catches in the Western component and 57.3% of catches in the whole division. Purse-seiners practically harvested the whole fishery, mainly during the second semester in the year.

Provisional official landings during the first semester in 2019 amounted to 5974 t. Official landings during the current management calendar were 11 487 t.

Subdivision 9a Central-South

Anchovy catches from this subdivision were 370 t (all of them official landings), accounting for a strong 117.5% increase in relation to the catches in 2017 (170 t) and reaching its historical maximum. Notwithstanding the above, such catches accounted only for 4.0% of the total catch in the subdivision and 2.7% on the total catch in the division. The fishery was mainly harvested by purse-seiners, mostly during the first quarter.

Provisional official landings during the first semester in 2019 in this subdivision amounted to 24 t and to 125 t for the current management calendar.

Southern component

Subdivision 9a South

The total catch in 2018 of this stock component was estimated at 4499 t, which accounted for a 2% decrease with respect to the 2017 catch (4611 t) and represented 33% of the total catch in the division. The fractions composing this total catch in 2018 were: 4408 t of official landings (Portugal: 65 t, Spain: 4342 t) and 91 t of (Spanish) discards. Ninety eight percent (98.0%) of the total catch was captured by the purse-seine fleet. The fishery was concentrated during the second and third quarters in the year, mainly the second one.

Provisional official landings during the first semester in 2019 amounted to 1026 t (0 t from the Portuguese fishery, 1026 t from the Spanish one).

4.3.3 Discards

See the stock annex for previous available information on discards in the division.

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

Western component

Subdivision 9a North

A total of only 0.6 t of anchovy discards from the bottom-trawl fishery were estimated for the Spanish fishery in this component (in 9a N). Discards were recorded in the three first quarters in the year (**Tables 4.3.5.1.5**, **4.3.5.1.6** and **4.3.5.1.7**). The overall annual discard ratio for the Spanish fishery in this stock component in 2018 was 0.0006 (0.06%) and may be considered as negligible.

Subdivisions 9a Central-North and Central-south

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

Southern component

Subdivision 9a South

No anchovy discards have been reported from the Portuguese fishery.

Quarterly and annual estimates of discarded catches by size class and gear are shown in **Tables 4.3.5.1.12**, **4.3.5.1.14** and **4.3.5.1.16** (purse-seine, bottom trawl and total discards in 9.a South, respectively). The overall annual discard ratio for the Spanish fishery in 9.a South, was 0.020 (2.0%). Therefore, anchovy discards for the Spanish fishery in 2018 may also be considered as negligible.

4.3.4 Effort and landings per unit of effort

Western component

Cpue indices are not considered for this stock component.

Southern component

Annual standardised lpue series for the whole Spanish purse-seine fleet fishing GoC anchovy (Subdivision 9.a-South) are routinely provided to this WG. An update of the available series (1988–2018) has been provided this year to this WG (**Table 4.3.4.1** and **Figure 4.3.4.1**). Details of data availability and the standardisation process are commented in the stock annex. At present, the series of commercial lpue indices is only used for interpreting the Spanish purse-seine fleets' dynamics in Subdivision 9a S. The recent dynamics of fishing effort and lpue for this fleet has been described in previous WG reports. Fishing effort has experienced a strong decrease in 2017 and 2018, which was coupled to a parallel decrease in catches. Such trends resulted in a relative stable trend in the lpue series during the most recent years (at around 1 t/fishing day). However, a probable overestimation of the annual estimates computed so far was suggested in previous WG reports 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.

4.3.5 Catches by length and catches-at-age by stock component

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 GoC (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 since 2014 have led to a circumstantial exploitation of the species by the fleets operating in those areas. The respective national sampling programmes accounted for this event those years but in an accidental way. In 2018 and 2019, a higher a sampling effort has been made in the port of Matosinhos (9a. Central-North) to have monthly biological data of anchovy in that area that represents the bulk of catches in the western component.

Quarterly LFDs in 2018 have 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 the ones from the anchovy purse-seine fishery in Subdivision 9.a Central-North, given that only 4% of the catches occurred in the 9.a Central-South division.

Catch-at-age data in 2018 have been provided only for the Spanish fishery in the Subdivision 9.a North and South and from the Portuguese fishery in Subdivision 9 .a Central North.

No age structure is available for 2018 Portuguese anchovy catches in subdivisions 9.a Central South and 9 a. South (Algarve), related to the low catches observed in those areas.

4.3.5.1 Length distributions

Western component

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 2018 are shown in **Tables 4.3.5.1.1** to **4.3.5.1.8**. Size range in catches from the whole fishery was comprised between 11.0 and 21.0 cm size classes (mode at 15.0 cm size class), with an annual mean size and weight in catches being estimated at 14.5 cm and 23.5 g, respectively.

Subdivision 9.a Central–North

The available size compositions of 2018 anchovy catches from the Subdivision 9.a Central-North are shown in **Tables 4.3.5.1.9** and **4.3.5.1.10**. These length–frequency distributions (LFDs) correspond to catches landed by purse-seiners from all quarters and bottom-trawl and polyvalent fleets but not for all the quarters with catches, hence the raising and further pooling processes applied in order to obtain overall LFDs by quarters for the whole fishery were done using the data from purse-seine fishery, that accounts for 95% of all catches. Anchovy size composition in purse-seine catches (i.e. the main fishery) ranged between 10.5 and 18.0 cm size classes (mode at 15.0 cm size class), with an annual mean size and weight in catches being estimated at 15.0 cm and 23.5 g, respectively.

Subdivision 9.a Central–South

No length composition is available from the Portuguese fishery in this subdivision since the catches were very scarce.

Southern component

Subdivision 9.a South

Quarterly LFDs from the Spanish catches in 2018 by métier/fraction and for the whole fishery are shown in **Tables 4.3.5.1.12** to **4.3.5.1.17**. Size range of the exploited stock (landings plus discards) in the whole fishery was comprised between 5.0 and 20.5 cm size classes, with the modal class at 12.0 cm size class. Anchovy mean length and weight in the Spanish 2018 annual catch (12.1 cm and 11.7 g) were higher than in previous years and they used to be the smallest anchovies in the division.

No length composition is available from the Portuguese fishery in this subdivision since the catches were very scarce.

4.3.5.2 Catch numbers-at-age

Western component

Subdivision 9.a North

Estimates from the fishery in this subdivision in 2018 have been provided to the WG (**Table 4.3.5.2.1**). These estimates are shown together with the age composition of catches in previous years with available data in **Table 4.3.5.2.2** and **Figure 4.3.5.2.1**.

The estimated total catch in numbers in 2018 was of 42.2 million fish, composed by ages 1, 2 and 3 anchovies, with age- 1 and 2 olds accounting for 79% and 20% of the total catch, respectively.

Subdivision 9.a Central–North

Estimates from the fishery in this subdivision in 2018 have been provided to the WG (**Table 4.3.5.2.3**, **Figure 4.3.5.2.2**).

The estimated total catch in numbers in 2018 was of 334 million fish, composed by 1, 2 and 3 years old anchovies, which accounted for 74%, 21%, and 5% of the total catch, respectively.

Subdivision 9.a Central–South

No estimate from this subdivision in 2018 has been provided to this WG since the catches were very scarce.

Southern component

Subdivision 9.a South

Table 4.3.5.2.4 shows the quarterly and annual anchovy catches-at-age in the Spanish fishery in 2018. Total catches in the Spanish fishery in 2018 were estimated at 362 million fish, which accounted for a 31% decrease in relation to the 525 million caught during the previous year. Such a decrease was mainly caused by the 67% and 21% decreases of ages 0 and 1 respectively, which were not compensated by the 49% increase experienced 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 is shown in **Table 4.3.5.2.5** and **Figure 4.3.5.2.3**. Description of annual trends of landings-at-age data from the Spanish fishery through the available dataseries is given in previous WG reports.

No data are available from the Portuguese fishery in this subdivision since the catches were very scarce.

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

Western component

Subdivision 9.a North

The available estimates for the fishery in 2018 are shown in **Tables 4.3.6.1** and **4.3.6.2**. The available series of estimates are shown in **Figure 4.3.6.1** and indicate that anchovies by age group from this subdivision are usually larger and heavier than those harvested in the southernmost areas. In 2018, all the age groups but age 3 fish experienced a small decrease in the mean length and weight in catches, a trend also exhibited by the overall mean estimates for the whole exploited population.

Subdivision 9.a Central–North

The available estimates for the fishery in 2018 are shown in **Tables 4.3.6.3** and **4.3.6.4**. A series of regular estimates is not available for the previous years in this subdivision. Anchovy mean length and weight in the catches of northwestern Portugal were 15.3 cm and 24.0 g (**Figure 4.3.6.2**).

Subdivision 9.a Central–South

No estimate from this subdivision is available.

Southern component

Subdivision 9.a South

The 2018 estimates of the mean length and weight-at-age of Gulf of Cadiz anchovy Spanish catches are shown in **Tables 4.3.6.5** and **4.3.6.6. Figure 4.3.6.3** shows the recent history of the evolution of such estimates. Anchovy mean length and weight in the Spanish 2018 annual catches were estimated at 12.1 cm and 11.7 g respectively, somewhat higher estimates than in previous years.

4.4 Fishery-independent Information

Table 4.4.1 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.

4.4.1 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 stock 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 2017.

The time-series of mean estimates and their associated variances for the egg and adult parameters, and the SSB are shown in **Table 4.4.1.1** and **Figure 4.4.1.1**.

The next survey will be conducted in July 2020.

4.4.2 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). Survey's methodologies deployed by the respective national Institutes (IPMA and IEO) are also thoroughly described in ICES (2008 b, 2009 b) and Massé *et al*. (2018).

A summary list of the available acoustic and DEPM surveys providing direct estimates for anchovy in Division 9.a is given in **Table 4.4.1**. Detailed information in the present section will be provided for those surveys carried out during the elapsed time between 2018 and 2019 WGHANSA meetings.

PELACUS series

The Spanish *PELACUS* acoustic trawl time-series started in 1984. Since 1998, survey strategies and methodologies, together with the Portuguese *PELAGO*, are standardized with the French one *PELGAS*. Moreover, since 2000 the three time-series are using CUFES to collect sub-surface sardine and anchovy eggs. *PELACUS* was carried out on board R/V *Thalassa* from 1997 to 2012 and since then is routinely conducted on board the Spanish R/V *Miguel Oliver*. An inter-calibration survey was done in April 2014 off Garonne mouth (e.g. at the spawning season and area of both sardine and anchovy). No significant changes in both fish availability (acoustic) nor in fish accessibility, catchability or selectivity (trawl) were detected, and therefore similar performance for both vessels was assumed.

PELACUS 0319

PELACUS 0319 was conducted between 25th March to 18th April 2019 on board the R/V *Miguel Oliver*. As in 2018, the surveyed area was prospected westwards (e.g. from the Spanish French border to the Spanish–Portuguese one), reaching in April at 9aN. But contrary to the situation found in the previous year, in spring 2019 only few anchovy schools (and eggs) were detected in this division. **Figure 4.4.2.1** shows the species contribution (% in number) in each of the valid hauls performed in 9aN. A total of 5.2 mt were caught, corresponding to 57 437 specimens, of those 4597 were measured (505 kg of fish). Sardine, with a presence in 54% of the fishing hauls accounted for the 63% of the total catch in number, yet most of them came from the same fishing station. Anchovy was also caught in the same percentage of the trawl hauls, but the presence was negligible, with only a 0.85% in number (**Table 4.4.2.1**). On overall mean length in the catch was 15.92 cm. **Figure 4.4.2.2** shows the distribution area and density derived from the NASC values attributed to this fish species. Few schools were found and thus the estimated density (mt/nmi^2) was very low. In the same way, egg density, as collected by CUFES, was scarce, but matching well with the distribution obtained from acoustic (**Figure 4.4.2.3**).

Only 192.50 mt, corresponding to 6.9 million fish were estimated (**Table 4.4.2.2**), a 98% lower than that estimated in 2018 (10 660 mt corresponding to 771 million fish). The bulk of the biomass belonged to age group 2 (72%, 64.7% in number), evidencing the lack of a good strength in the 2018 year class. This result agreed with population structure estimated during the *IBERAS 1118* survey where only the 8% of the total estimation in number belonged to 0-group. **Figure 4.4.2.4** shows the estimated abundance and biomass by length class while in **Figure 4.4.2.5**, is shown by age group. In **Figure 4.4.2.6** the time-series (1996–2019) of anchovy biomass estimates from *PELACUS* is shown.

PELAGO series

PELAGO 19

The *PELAGO 19* survey was conducted this year between 12th April and 19st May on board R/V *Noruega*. Seventy-one (71) transects were acoustically sampled between Caminha and Cape Trafalgar. A total of 36 pelagic and 23 bottom trawl hauls were carried out by the research vessel. The distribution and species composition of all of these hauls are shown in **Figure 4.4.2.7**.

Regarding the mapping of acoustic energy, anchovy was only detected in Subdivisions 9.a Central-North (mainly between Póvoa de Varzim and Nazaré), a few in front of Cascais, and in the Bay of Cadiz, in Spanish waters (**Figure 4.4.2.8**).

Anchovy acoustic estimates for the whole surveyed area were 3634 million fish and 33 813 t.

In 9a Central-North were estimated a total of 229 million fish and 3814 t, an estimate which return to the usual low levels recorded before 2016. The estimated population in this subdivision ranged between 9.5 and 17.5 cm size classes, with a main mode at 14.5 cm size class (**Figure 4.4.2.9**). The assessed population from this subdivision was structured by Age-1, Age-2 and Age-3 fish, with the Age-2 olds being the dominant age (60%), followed by Age-1 fish (39%) and an incidental occurrence of Age-3 fish (**Figure 4.4.2.10**).

Anchovy population in 9a Central-South was supported by only 7 million fish and 123 t, showing a size range between 9.5 and 17.0 size classes, without a neat modal size, and with the only occurrence of one and two year olds, which showed a relatively similar contribution to the population structure (**Figures 4.4.2.9** and **4.4.2.10**).

In the Subdivision 9.a South, with values of 3398 million fish and 29 876 t (**Table 4.4.2.3**), the Spanish waters concentrated all the population The estimated population in this subdivision ranged between 6.5 and 15.5 cm size classes, with a main mode at 11.5 cm size class (**Figure 4.4.2.9**). The population was exclusively composed by 1 and 2 year olds, with the younger anchovies being the dominant age (91%), (**Figure 4.4.2.10**).

Table 4.4.2.3 and **Figure 4.4.2.11** track the historical series of anchovy acoustic estimates from *PELAGO* surveys in the Division 9.a. Anchovy experienced a huge outburst in 9.a Central-North in 2018, after the decreased biomass recorded in 2017, and reaching population levels even higher than the previous historical peaks recorded in the 2011 and 2016 outbursts. However, the population has drastically dropped again in 2019 up to the usually low levels recorded before 2016. Anchovy in 9.a Central-South is still maintaining around the usually low or even null levels recorded in the last years. Biomass levels in the subdivision 9.a South are, however, still experiencing the increasing trend restarted in 2018, at a level above the historical average (about 26 kt).

Figure 4.4.2.12 shows the age structure of the population estimates in the western component. Age 1 anchovies constitute the bulk of the population in spring, followed by age 2, and 3 are also present. Strong incoming recruitments seem to be inferred in 2014, 2016 and 2017, as evidenced by the increased levels of age 1 anchovies in those years. In 2019, the major percentage of the anchovies were age 2, for the first time in the time-series, followed by age 1 and a very low percentage of age 3. This dominance of age 2 over age 1 suggests decreased levels of recruitment.

Size composition and age structure of the population estimated in the southern component through the time-series was described in previous reports. In **Figure 4.4.2.13** we revisit the trends observed in the age structure of the population as estimated by the *PELAGO* and *ECOCADIZ* survey series. 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 population age structure in 2010, as estimated by the Portuguese survey, evidenced a strong decrease in 1-year-old anchovies, but especially in two year old fish, suggesting a weak population structure sustaining a very low biomass level.

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. These reasons led to the WG to consider the 2011 acoustic estimate with caution. The population age structure in 2013 suggests a failed recruitment, which, however, seems to show clear signs of progressive recovery in the three following years, especially in 2016. The decreased population levels in 2017 pointed again to a failed incoming recruitment. The situation in 2018 and 2019 seems to be quite similar to the one occurring in 2015–2016.

ECOCADIZ series

ECOCADIZ 2018–07

The *ECOCADIZ 2018-07* survey was conducted by IEO between 31th July and 13rd August 2018 in the Portuguese and Spanish shelf waters (20–200 m isobaths) off the Gulf of Cadiz on board the Spanish R/V *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 25 valid fishing hauls (between 41–185 m depth) for echotrace ground-truthing purposes were carried out (**Figure 4.4.2.14**). CUFES sampling (151 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 161 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. Twenty two (22) *Manta trawl* hauls were also carried out to characterize the distribution pattern of micro-plastics over the shelf. Results from this survey were not presented in the last ICES WGACEGG meeting (ICES, 2018b). A detailed description of the *ECOCADIZ 2018-07* survey methods and results are given in Ramos *et al*. (WD 2019a).

Chub mackerel (*Scomber colias*) was the most frequent species in the fishing hauls, followed by sardine, anchovy, mackerel (*S. scombrus*) and bogue (*Boops boops*). *Trachurus* spp. showed a medium relative frequency of occurrence. Pearlside (*Maurolicus muelleri*), snipefish (*Macrorhamphosus scolopax*) and boarfish (*Capros aper*) only occurred in hauls conducted in the deepest limit of the surveyed area. Anchovy was the most abundant species in these hauls, followed by pearlside, sardine and chub mackerel, with the remaining species showing negligible relative contributions (**Figure 4.4.2.14**).

The estimate of total NASC allocated to the "pelagic fish species assemblage" has been the highest one ever recorded within the time-series, denoting a high fish density during the survey. By species, sardine (49%), chub mackerel (22%) and anchovy (18%) were the most important species in terms of their contributions to the total back-scattering energy. Anchovy was widely distributed over the surveyed area, although showing the highest densities in the Spanish shelf waters between El Rompido (transect RA10) and Bay of Cadiz (RA03), and in a secondary nucleus located over the Portuguese shelf, between Alfanzina (RA18) and Cape of Santa Maria (RA15). This distribution pattern differed from the exhibited one during the *PELAGO* spring survey, when anchovy was restricted to a zone comprised between Vila Real de Santo Antonio (easternmost Portuguese waters) and the Bay of Cadiz. (**Figure 4.4.2.14**).

Overall acoustic estimates in summer 2018 were of 3063 million fish and 34 908 tonnes. By geographical strata, the Spanish waters yielded 93% (2839 million) and 88% (30 683 t) of the total estimated abundance and biomass in the Gulf, confirming the importance of these waters in the species' distribution. The estimates for the Portuguese waters were 224 million and 4225 t.

The size class range of the assessed population varied between the 9.0 and 17.0 cm size classes, with one main modal class at 12.0 cm. The spatial pattern of anchovy sizes confirms the usual pattern exhibited by the species in the area during the spawning season, with the largest (and oldest) fish being distributed both in the westernmost and easternmost waters and the smallest (and youngest) ones concentrated in the surroundings of the Guadalquivir river mouth and adjacent shallow waters, including those ones in front of the Bay of Cadiz (**Figures 4.4.2.15** and **4.4.2.16**). The population was composed by fishes not older than two years. As it has been happening in the last years, during the 2018 survey some recruitment (age 0 fish) has also been recorded, probably as a consequence of the delayed survey dates. In fact, age 0 fish accounted for 46 and 35% of the total estimated abundance and biomass, respectively. Age 1 fish represented 53% and 62% of the total abundance and biomass (**Figure 4.4.2.16**).

The summer 2018 biomass estimate (34 908 t) becomes in the second historical maximum within the time-series (2006: 35 539 t; 2016: 34 184 t; see **Figure 4.4.2.17**). The *PELAGO 18* spring Portuguese survey previously estimated for this same area 23 473 t (2157 million): 4328 t (300 million) in Portuguese waters and 19 145 t (1857 million) in Spanish waters.

The summer 2018 biomass estimate becomes in the second historical maximum within the time-series (2006: 35 539 t; 2016: 34 184 t; **Figure 4.4.2.17**) and denotes a strong increase in relation to the previous year, up to levels well above the historical average (ca. 22 kt), but without showing any clear recent trend. Although the spring *PELAGO 18* survey also estimated increased population levels (i.e. 23 473 t (2157 million): 4328 t (300 million) in Portuguese waters and 19 145 t (1857 million) in Spanish waters), such increase was not so pronounced as the estimated by its summer counterpart.

4.4.3 Recruitment surveys

SAR and 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 4.4.1**). **Table 4.4.3.1** shows the historical series of anchovy acoustic estimates derived from this survey series in the Division 9.a available so far. The *JUVESAR* autumn survey series, an acoustic surveys restricted to the Subdivision 9.a Central-North, the main recruitment area of sardine in Portuguese waters, started in 2013. The scarce presence and abundance of anchovy in the 2013 and 2014 surveys prevented the provision of acoustic estimate for the species. The last survey in this series, was conducted in 2017 (*JUVESAR 17*), because in 2018 the *JUVESAR* acoustic sampling area was incorporated into the new *IBERAS* survey series, described below. Point estimates of anchovy abundance of the *JUVESAR/IBERAS* series are at present scarce for these autumn survey series, which is currently not directly used in the qualitative trend-based assessment (but see **Figure 4.4.3.7** for estimates in 9.a South).

IBERAS is a new acoustic-trawl time-series aiming at to get a synoptic coverage of the Atlantic waters of the Iberian Peninsula and the Bay of Biscay targeting on Young of the Year (YoY) of sardine and anchovy. Since 2017, both the Bay of Biscay (*JUVENA*) and the Gulf of Cadiz (*ECO-CADIZ-RECLUTAS*) were routinely prospected by R/V *Ramón Margalef* and the Northwest coast of Portugal (*JUVESAR*) by R/V *Noruega* since 2013. The idea is to fill the gap between both *JU-VENA* and *ECOCADIZ-RECLUTAS* surveys and incorporate the *JUVESAR* series, following the same radials in Subdivision 9a. Central-North. This new time-series will be conducted in the vessel R/V *Ángeles Alvariño*, twin of R/V *Ramón Margalef*. Both vessels have similar shape, with slight changes in the main engine but using the same equipment (acoustic and trawling devices). Together with this synoptic coverage, using similar vessel equipment will limit both the vessel and trawling effects on the overall precision and accuracy of the estimates. In 2018, due to the lack of available vessel time in September, the survey was delayed until November, but in 2019 the survey has been planned in September, at the same time of *JUVENA* and previous to *ECO-CADIZ-RECLUTAS* one.

The rational of this new time-series is to track and assess early juveniles for predicting the strength of the recruitment previously to the incoming fishing season (e.g. next year) as this will heavily depend on the incoming year class. This strategy is of special interest to manage the fisheries for short-lived species because of the short time between spawning and the exploitation of subsequent emerging recruits. Due to the actual situation of the sardine stock, with the bio-mass at the lowest productivity ever recorded and with a continuous period since 2004 of bad recruitment as compared with previous periods, any recovery of the biomass will likely be trig-gered by the strength of the recruitment.

IBERAS 1118

IBERAS 1118 was carried out on board R/V *Ramón Margalef* from 31st October to 19th November. Further details are shown in Carrera *et al*. (2018). The survey covered from Cape São Vicente (south Portugal, ICES Subdivision 9aCS) to Cape Fisterra (43ºN, 9aN). Due to bad weather con-ditions, the survey stopped from 7th until 11th November. Consequently, some of the tracks were steamed during night hours and the two northernmost ones were not covered.

The survey area (from 20 to 100 m isobath) was covered using a systematic grid with random start and track evenly distributed each 8 nmi on those areas out of the main expected recruitment areas and each 4 nmi on the main ones (**Figure 4.4.3.1**).

A total of 25 pelagic fishing were done as shown in **Figure 4.4.3.1**. Anchovy was mainly found in 9aCN, between Figueira da Foz and Matosinhos. Of a total of 17 mt caught, 33% belonged to anchovy which was present at the 39% of the fishing stations. Horse mackerel was caught at the 85% of the fishing stations.

The method used to scrutinize the echograms was the school processing; all echotraces recorded were identified and main morphometric and energetic variables, included echo integration re-ferred to ESDU (1 nmi) were extracted, accounting 7652 echotraces with a total NASC (s_A) of 476 837.09 m^2 nmi^{-2}. The bulk of the schools were found at 32 m depth, although in terms of backscattering energy the center was located at 22 m. This shift was mainly due to a mega-school of anchovy located near Tocha beach. This single school accounted for more than 57% of the total backscattering energy (**Figures 4.4.3.2** and **4.4.3.3**), being almost pure anchovy of 14.6 cm as a mean length. Due to this school, the center of gravity of anchovy was found at 17.5 m depth and close to Figueira da Foz.

A total of 200 thousand tonnes were estimated, corresponding to 9 billion fish, with almost all concentrated in 9aCN. In 9aCS only 0.4 mt were assessed and a similar quantity in 9aN. Young of the year (YoY) only represented a 7% in number, even less than the amount of older fish (2+). Age group 1 accounted for 82%. As most of this assessment was driven by the mega-school, the length distribution obtained at the fishing station performed on this had also a big impact in the overall estimates. Given the low contribution of 9aCS and 9aN in the total estimates (<0.001%), results are shown for the whole area, but referring almost exclusively to 9aCN (**Table 4.4.3.2**; **Figures 4.4.3.4** and **4.4.3.5**). WGHANSA-1 recommends that the impact of this mega-school in the precision of this estimate is further discussed in the next WGACEGG meeting.

ECOCADIZ–RECLUTAS survey series

ECOCADIZ–RECLUTAS 2018–10

ECOCADIZ-RECLUTAS 2018-10 survey was conducted by IEO between 10th and 29th October 2018 in the Portuguese and Spanish shelf waters (20–200 m isobaths) off the Gulf of Cadiz on board the R/V *Ramón Margalef*. Subsurface sea temperature, salinity and *in vivo* fluorescence were continuously collected with a thermosalinograph-fluorometer. Vertical profiles of hydrographical variables were also recorded by night from 150 $CTDO_2$ casts. Neither CUFES sampling nor census of top predators were carried out during the survey. Results from this survey have been reported to this WG by Ramos *et al*. (WD 2019b).

The 21 foreseen acoustic transects were sampled. A total of 25 valid fishing hauls were carried out for echotrace ground-truthing purposes. Chub mackerel was the most frequent species in those hauls, followed by sardine, anchovy, horse mackerel (*Trachurus trachurus*), mackerel, bogue and Mediterranean horse mackerel (*T. mediterraneus*), (**Figure 4.4.3.6**).

Acoustic sampling was carried out with a recently installed *Simrad*™ *EK80* echosounder working in multi-frequency and in CW mode. A misconfiguration of the range of the acoustic active layer entailed to slow down the ping rate (1.5–2.0 seconds) in relation to the standard values (at about 0.3 seconds), resulting an acoustic sampling rate much lower than it should be and hence the results from this acoustic sampling and the resulting estimates from this survey should be considered with caution. For these reasons, WGHANSA-1 recommends that the implications of this problem in the estimated population levels by this survey should also be discussed in the next WGACEGG meeting.

Sardine accounted for 36% of the total back-scattered energy attributed to fishes, followed by anchovy (25%), chub mackerel (19%), pearlside (11%), and the remaining species with relative contributions of acoustic energies lower than 5%.

Anchovy avoid in autumn 2018 the easternmost waters of the Gulf. Something similar also happened in the shallower waters of the western Algarve. The spatial pattern of distribution of the acoustic density was further characterised by a concentration of a great part of the population in a relatively restricted area comprising the shelf waters between Cape Santa Maria and the Guadiana river mouth. The remaining population was widely distributed between this last landmark and the Bay of Cadiz (**Figure 4.4.3.6**). The size composition of anchovy catches indicates that smallest recruits occurred mainly in those last Spanish coastal waters.

Gulf of Cadiz anchovy abundance and biomass in autumn 2018 were of 953 million fish and 10 493 t. Spanish waters concentrated 58% (548 million) and 40% (4234 t) of the total estimated abundance and biomass respectively. Portuguese estimates amounted to 405 million and 6259 t (**Table 4.4.3.3**; **Figure 4.4.3.7**).

The size range recorded for the estimated population was comprised between 7.5 and 18.5 cm size classes, with two marked modes at the 9.0 (the dominant one) and 14.0 cm size classes. Both modes were also present in the size composition of the estimated biomass, but showing in this case a reversed importance (**Table 4.4.3.3**; **Figure 4.4.3.7**).

The age-0 population fraction was estimated at 543 million fish and 3834 t, 57% and 36% of the total population abundance and biomass respectively. Juveniles were widely distributed in the coastal-inner shelf waters between the Guadiana river mouth and Bay of Cadiz, with the Matalascañas-Bay of Cadiz area being the area where the highest densities of anchovy juveniles were recorded (**Table 4.4.3.3**; **Figure 4.4.3.8**).

The survey estimates time-series is shown in **Figure 4.4.3.9**. **Figure 4.4.3.10** shows the 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. Some positive relationship seems to be suggested when the most recent *ECOCADIZ-RECLUTAS* and *PELAGO* surveys estimates are compared.

Bottom–trawl surveys

Data on the occurrence of anchovy in the time-series of demersal trawl surveys since 1990 until 2018, were analysed in order to investigate a different source of the abundance of anchovy in subdivisions 9a. Central-North and 9a. Central-South of the western component during fall. The surveys follow a fixed grid of 97 sampling stations, spread throughout the shelf between 36 and 710 m. The time-series of data (1990–2018) collected by 44 surveys conducted in the fall (27 surveys), summer (ten surveys), spring and winter (five and one survey, respectively). The fishing gear used is a bottom trawl (type Norwegian Campell Trawl 1800/96 NCT) with a 20 mm codend mesh size. The target duration of each tow was 60 min and further details on the methodology of the surveys can be found in Cardador *et al*. (1997).

Most of fish caught in the Portuguese demersal trawl surveys are distributed in the Subarea 9aCN, particularly near Aveiro–Figueira da Foz and in the Algarve. The occurrence of anchovy in Subarea 9a-CS is almost limited to the area around Lisbon, which is a similar trend to that found in the spring acoustic survey series.

The correlation between the abundance of anchovy in the demersal trawl in year *y* and the PELAGO + PELACUS surveys in the spring of the following year (*y+1*) for the time period 1999–2019 is very high (Pearson r = 0.87, p=0.0005), suggesting this can be a potential series to evaluate the trend of abundance of this species.

4.5 Biological data

4.5.1 Weight-at-age in the stock

Western component

A first attempt of estimating mean weights-at-age in this stock component from *PELACUS* and *PELAGO* spring acoustic surveys was presented in WKPELA 2018. Given the assessment and provision of advice for this stock component is a surveys trend-based one no weights-at-age estimates have been provided to the present WG, although the collections of otoliths of the Portuguese surveys are being analysed by IPMA to be able to reconstruct a time-series of weights-at-age for this stock component to present.

A calibration exercise was done between experienced age readers of IEO (Santander) and IPMA (Algés) using all the otoliths of the individuals collected during the IBERAS1118 survey. Main results of this inter-calibration were a very high agreement, low CV, and no biases between the three readers, which have applied well the current age determination criteria updated in the last workshop of the anchovy age (ICES, WKARA2, 2016). The results of this inter-calibration are presented in the WD Villamor *et al*. (2019).

Southern component

Weights-at-age in the stock are shown in **Table 4.5.1.1**. See the stock annex for comments on their computation.

4.5.2 Maturity-at-Age

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 c).

See the stock annex for comments on computation of the maturity ogives in both stock components.

Due to some inconsistencies in the maturity ogives of anchovy in the southern component, not noticed during WKPELA 2018, we assume that all individuals with age 1 or higher (B1+), are mature for assessment purposes.

The macroscopic maturity scale used by IPMA (Soares *et al*., 2009) has been validated with histology (microscopic identification of macroscopic maturity stages). Results show that only histology allows the correct identification of mature and immature individuals macroscopically identified as stage 1 (Immature or Resting); therefore, the maturity ogive of this species must be obtained during the spawning season with histology.

4.5.3 Natural mortality

Western component

Natural mortality, M, is unknown for this stock component. It has been suggested in WKPELA 2018 to follow the M pattern at-age used for the anchovy in the Bay of Biscay, which is 1.2 for age 0, 0.8 for age 1 and 1.2 for older ages, for further modelling exercises.

Southern component

M is also unknown for this stock component. The following estimates for M at-age were finally adopted in WKPELA 2018: M0=2.21; M1=1.30; M2+=1.30 (similar at any older age; see ICES, 2018a). A description of the rationale and whole process for deriving the above estimates is shown in the stock annex.

4.6 Stock Assessment

Both components of the stock are assessed using an interim trend-based procedure according to ICES data-limited stock approaches (by analogy with the current method 3.2, DLS: ICES CM 2012/ACOM 68) and following the ICES WKLIFE VIII REPORT 2018 (ICES CM 2018/ACOM:40), as follows:

$$C_y = \begin{cases} 0.2C_{y-1} & if \ \dfrac{I_y}{(I_{y-1}+I_{y-2})/2} < 0.2 \\ C_{y-1}\dfrac{I_y}{(I_{y-1}+I_{y-2})/2} & if \ 0.2 \le \dfrac{I_y}{(I_{y-1}+I_{y-2})/2} \le 1.8 \\ 1.8C_{y-1} & if \ \dfrac{I_y}{(I_{y-1}+I_{y-2})/2} > 1.8 \end{cases},$$

where C_y and C_{y-1} represent the catch advice corresponding to the current (*y*) and previous (*y-1*) years, respectively, and I_y, I_{y-1} and I_{y-2} represent the biomass indicators corresponding to the current (*y*) and two previous years (*y-1* and *y-2*), respectively. Note that the first and third cases correspond to the application of an uncertainty cap of 0.2 and 1.8, respectively. For the Western component the biomass indicator input has been taken from the results of the acoustic spring surveys covering this area (by adding *PELAGO* and *PELACUS* estimates), while for the Southern component the biomass indicator input has been obtained from the results of SSB estimates from the Gadget assessment model, using those as a relative index. The basis of this procedure for both components was approved in the last benchmark for this stock (WKPELA 2018; ICES, 2018), when it was also decided that instead of providing advice for calendar years, advice would be given in-year for the period from 1st July to 30th June next year, after obtaining the results of the spring acoustic surveys. The uncertainty cap for this year is different to the one used in 2018 as a consequence of the conclusions obtained in ICES WKLIFE 8.

4.6.1 Western component

The stock assessment procedure for this component is described in the stock annex.

4.6.1.1 Biomass survey trend as base of the advice

The anchovy biomass indicator for the Western component is computed as the sum of *PELACUS* (9a N) and *PELAGO* (9a C-N and 9a C-S) acoustic estimates of biomass. Advised catches for the period July 2018 to June 2019 of the western sub-divisions were also used as the initial reference capture to apply the trend-based method.

4.6.2 Southern component

4.6.2.1 Model used as basis of the advice

The model used to provide the estimates of the SSB indicator is a Gadget model. Gadget is an age–length-structured model that integrates different sources of information in order to produce a diagnosis of the stock dynamics. It works making forward simulations and minimizing an objective (negative log-likelihood) function that measures the difference between the model and data. General model specifications are described in the Stock Annex while details on data input, implementation and results up to 2019 are described in Rincón *et al.* (WD 2019).

There are two remarkable model issues that were found this year regarding 2018 implementation. The first is that *PELAGO* Age–length key for 2017 were available for the time of the assessment in 2018 (only for Spanish samples, no Portuguese information available) but it was not included in that assessment, even when the model specifications in the previous report were specifying that. For this year it has been included and also a sensitivity analysis was conducted to see the consequences of this missing data in 2018 assessment (see Model comparison at the end of Rincón *et al.*, WD 2019). Results of this analysis show that these missing data did not have remarkable consequences in stock estimations for 2018.

The second issue is that according to Gadget order of calculations, recruits enter to the Age-0 population at the end of quarters 2, 3 and 4 (but this is equivalent to have recruitment one quarter later, *i.e.* in the beginning of quarters 3, 4 and 1 of the next year) of all years except the last year, because at the end of June there are no recruits (Age-0 group individuals). Then, biomass and abundance estimates at the end of the second quarter need to be corrected removing Age-0 individuals in all these previous years. This also implies that the value for recommended catches for year 2018 needed to be recalculated removing Age-0 individuals from the estimated biomass by the assessment model of 2018.

The re-calculation of advised catches for 2018 results in 4476 tons. Details of the procedure following the Stock Annex indications are described in Rincón *et al*. (WD 2019).

4.6.2.1.1 Data input

Data input for optimization routines is summarized in **Table 4.6.2.1.1.1**. It corresponds to all the information of the fishery available until the end of June of 2019, together with data from *ECOCADIZ* and *PELAGO* survey series up to 2018 and 2019, respectively.

Catches from Spain and Portugal were not used for optimization. They were used in the first part of the model where population dynamics are simulated. They are assumed to be removed from the population by only one fleet from 1989 to the second quarter of 2019. For the first two quarters of year 2019, provisional catches estimations of Spanish (until May 27th) purse-seine fleet were used and catches for June were estimated as the 37% of January to May catches based on historical records from 2009 to 2018. There were not any catches for Portuguese purse-seine in these two quarters.

4.6.2.1.2 Model fit

A summary of the goodness of fit of model estimations compared with data is shown in **Figures 4.6.2.1.2.1**, **4.6.2.1.2.2**, **4.6.2.1.2.3** (length distributions), **4.6.2.1.2.5**, **4.6.2.1.2.6** and **4.6.2.1.2.7** (age distributions). These figures show that length and age frequency distributions of catches and surveys match reasonably well with available data. Goodness of fit for length distribution of catches (**Figure 4.6.2.1.2.1**) is better in the last 19 years compared to the first years, in coherence with the assumption of two different selectivity periods. The model seems to not capture well enough the bimodal length distribution or the highly non differentiable pattern of some years of the surveys, like 2010, 2013 and 2015 for the *ECOCADIZ* (**Figure 4.6.2.1.2.2**) survey and 2001, 2002, 2006, 2009 and 2015 for *PELAGO* (**Figure 4.6.2.1.2.3**). Age distributions present a very good fit in almost all of the cases (**Figures 4.6.2.1.2.5**, **4.6.2.1.2.6** and **4.6.2.1.2.7**), except for some mismatch in year 2014 for *PELAGO* survey (**Figure 4.6.2.1.2.7**). There are no remarkable differences compared with the fit of the 2018 model implementation.

Figure 4.6.2.1.2.4 shows the model residuals from the fit to the catch-at-length composition and the acoustic survey length composition, while **Figure 4.6.2.1.2.8** shows the model residuals from the fit to the catch-at-age composition and the acoustic survey age composition. In both cases the residuals from the present assessment are very similar to those in the benchmarked model implementation.

Figure 4.6.2.1.2.9 presents the comparison between observed and estimated survey indices. It can be observed that the model assimilates the trend of survey indices in most of the years.

4.6.2.1.3 Model estimates

Parameter estimates after optimization are presented in **Table 4.6.2.1.3.1**, while **Figure 4.6.2.1.3.1** presents model annual estimates for abundance (removing Age-0 individuals to be accurate with the time of the assessment), recruitment, fishing mortality and catches at the end of the second quarter of each year. **Figure 4.6.2.1.3.2** shows annual estimates for biomass of individuals of Age-

1+ at the end of the second quarter of each year. Due to some inconsistencies in the maturity ogives not noticed during WKPELA 2018, we assume that all individuals with Age 1 or older (B_{1+}) are mature, *i.e.* these biomass estimates result equivalent to spawning stock biomass estimates. The SSB estimates used for 2019 advice are those corresponding to years 2017, 2018 and 2019, with values of 2074, 5715 and 5470 t, respectively (**Figure 4.6.2.1.3.2**).

4.7 Reference points

4.7.1 Western component

Reference points were not calculated for this area.

4.7.2 Southern component

A B_{lim} of 1730 t (corresponding to a relative B_{lim} equal to 0.3) and a B_{pa} of 2837 t were calculated with updated values of SSB following the procedure agreed at the most recent benchmark (**Figure 4.7.2.1**). B_{pa} is defined as the upper 95% of the distribution of the estimated SSB if the true SSB equals B_{lim} based on a terminal SSB coefficient of variation assumed as 0.3 as recommended by ICES (ICES, 2017b) for short-lived species.

4.8 State of the Stock

4.8.1 Western component

The stock size indicator (a combined index from *PELAGO* and *PELACUS* estimates) shows a sharp decrease this year (93.6%) after a period of increase since 2014 (**Figure 4.8.1.1**). In addition, the harvest rate in 2018 was below the mean of the historical time-series (**Figure 4.8.1.1**).

4.8.2 Southern component

The SSB has been fluctuating without a trend over the time-series showing a small variability in the last four years and F has been fluctuating with no clear trend (**Figures 4.6.2.1.3.1** and **4.6.2.1.3.2**).

4.9 Catch scenarios

4.9.1 Western component

The ICES framework for category 3 stocks was applied (ICES, 2012). The advice is based on the ratio between the last index value corresponding to 2019 (4129 t) and the average of the two preceding values of 2016 and 2017 (42 072 t), and the Advised Catch (July 2018 to June 2019, 13 308 t). The index is estimated to have decreased by 90% and thus the 80% uncertainty cap was applied. The Western component of the stock has decreased significantly, as the application of the "1 versus 2" advice rule gave an indicator ratio of 0.1. For this reason, the precautionary buffer was applied. The resulting advice for this stock component is 13 308 t*0.8*0.2=2129 t.

4.9.2 Southern component

The ICES framework for category 3 stocks was applied (ICES, 2012). The SSB estimated by the assessment model was used as the index of stock size development. The advice is based on the ratio between the last index value (5470 t) and the average of the two preceding values (5592.5 t), multiplied by the recent advised catches for 2018 (July 2018 to June 2019, 4476 t). Following the ICES WKLIFE VIII REPORT 2018 (ICES CM 2018/ACOM:40) an uncertainty cap of 80% was applied. The index ratio is estimated to have increased 41%, i.e. less than 80% and thus the uncertainty cap was not applied. Stock size has been above B_{pa} for the last nine years and without any trend. This was considered as sufficient evidence to not apply a precautionary buffer. Fishing mortality was not used to consider the application of this buffer because fishing mortality reference points are not considered relevant for short lived species.

4.10 Short-term projections

Short-term projections were not calculated in the two components.

4.11 Quality of the assessment

4.11.1 Western Component

In the last benchmark it was decided that this stock component would be assessed using a biomass survey trend as basis of the advice. This decision was made taking into account that there is no time-series of regular information of the composition by length and age of the catches available. This data gap corresponds to a very low abundance index and low catches in the first half of the time-series.

Advised catches were calculated according to the Guidance on the applications of the advisory rules for category 3 short lived stocks drafted by WKLIFE 8 in its Annex 8 (ICES, 2018, page 167), whereby the one over two rules is constrained by an uncertainty cap of +/- 80% of the former catch advice. This approach differs from the former standard suggestions of adopting a 20% uncertainty cap as it is more responsive to the highly variable nature of short-lived species, requiring a more flexible accommodation of the TAC advices to their large interannual fluctuations (ICES, 2018).

In addition, a precautionary buffer of a 20% additional reduction was adopted as suggested in the basis of ICES advice (Published 13 July 2018) for category 3–6 stocks, because this was not applied before (as judged unnecessary) and to take into account the serious reduction of the stock (by 91%) occurred the last year.

After the observed decrease of the index this year, advised catches following the current rule will increase to 3832 t even if the stock increases to the maximum historical value of 65 097 t next year, which would result in an HR=0.06. A Workshop (ICES WKDLSSLS) is planned for September 2019 to address this issue.

4.11.2 Southern Component

The biomass estimates provided by the Gadget model are assumed as relative because during the last benchmark it was observed that although the model provided a good model fit, it presented some instability (as shown by the occurrence of a certain retrospective pattern) and also the estimated catchability do not seem to be credible. These issues need to be further investigated.

4.12 Management considerations

ICES has agreed with the clients that the catch advice will be framed in a management calendar set from 1st July (*y*) to the following 30th June (*y+1*), instead of calendar years.

Other management considerations and the current management situation are described in the stock annex.

4.12.1 Ecosystem considerations

Ecosystem considerations are described in the stock annex and there have not been remarkable changes in the last year.

4.13 References

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Table 4.3.1.1. Anchovy in Division 9.a. Composition of the Spanish fleets operating in Southern Galician waters (Western component, subdivision 9.a North) and in the Gulf of Cadiz (Southern component, Subdivision 9.a-South) targeting anchovy in 2018. The categories include both single purpose purse-seiners, artisanal 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 one fishing day). Similar tables for yearly data since 1999 are shown for the Gulf of Cadiz Spanish fleet in previous WG reports.

Subdivision 9.a North						
2018	Vessels targeting anchovy					
	Engine (HP)					
Length (m)	0–50	51–100	101–200	201-500	>500	Total
≤10	4					4
11–15	5	16	12			33
16–20			6	9		15
>20			2	25	1	28
Total	9	16	20	34	1	80

Subdivision 9.a South						
2018	Vessels targeting anchovy					
	Engine (HP)					
Length (m)	0–50	51–100	101–200	201-500	>500	Total
≤10						
11–15	2	8	2	1		13
16–20		6	32	9		47
>20			2	11	1	14
Total	2	14	36	21	1	74

Table 4.3.1.2. Anchovy in Division 9.a. Composition of the Portuguese fleets operating in the Western Iberian waters (Western component, subdivisions 9.a Central North and 9.a Central South) and in the Algarve (Southern component, Subdivision 9.a-South) targeting anchovy in 2018. 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). Some vessels land in more than one of these three subdivisions.

Subdivision 9.a Central North						
2018	Vessels targeting anchovy					
	Engine (HP)					
Length (m)	0-50	51-100	101-200	201-500	>500	Total
≤10	27	8	1			36
11-15	6	13	4			23
16-20			4	6		10
>20				39	5	44
Total	33	21	9	45	5	113
Subdivision 9.a Central South						
2018	Vessels targeting anchovy					
	Engine (HP)					
Length (m)	0-50	51-100	101-200	201-500	>500	Total
≤10	6	3				9
11-15	1	7	3			11
16-20			3	3		9
>20				24	2	26
Total	7	10	6	27	2	52
Subdivision 9.a South						
2018	Vessels targeting anchovy					
	Engine (HP)					
Length (m)	0-50	51-100	101-200	201-500	>500	Total
≤10						0
11-15		1	3			4
16-20			6	1		7
>20			1	7	3	11
Total		1	10	8	3	22

Table 4.3.2.1.1. Anchovy in Division 9.a. Recent historical series of annual catches (t) by subdivision, stock component and total division 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, 1996 and WGMHSA, WGANC, WGANSA and WGHANSA members). The rest of the historical series of catches is shown 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. Notwithstanding the above, the estimates for the Spanish fishery include estimates of discarded (and unallocated) catches since 2014 on. (*) Provisional official landings data for the 2019 first semester updated until 27–31 May depending on the subdivision.

Year	9.a N	9.a C-N	9.a C-S	West. Comp.	9.a S (PT)	9.a S (ES)	South. Comp.	Total Division
1989	118	646	141	905	36	5330	5365	6270
1990	220	431	4	655	110	5726	5836	6491
1991	15	187	3	205	22	5697	5718	5924
1992	33	136	1	170	2	2995	2997	3167
1993	1	22	1	24	0	1960	1960	1984
1994	117	236	8	361	0	3035	3035	3397
1995	5329	2521	9	7859	0	571	571	8430
1996	44	2711	13	2768	51	1780	1831	4599
1997	63	610	8	682	14	4600	4614	5296
1998	371	894	153	1419	610	8977	9587	11006
1999	413	957	96	1466	355	5587	5942	7409
2000	10	71	61	142	178	2182	2360	2502
2001	27	397	19	444	439	8216	8655	9098
2002	21	433	90	543	393	7870	8262	8806
2003	23	211	67	301	200	4768	4968	5269
2004	4	83	139	226	434	5183	5617	5844
2005	4	82	6	92	38	4385	4423	4515
2006	15	79	15	110	14	4368	4381	4491
2007	4	833	7	844	34	5576	5610	6454
2008	5	211	87	303	37	3168	3204	3508
2009	19	35	5	59	32	2922	2954	3013
2010	179	100	2	281	28	2901	2929	3210
2011	541	3239	1	3782	78	6216	6294	10076
2012	39	521	220	779	56	4754	4810	5589
2013	69	192	131	392	67	5172	5240	5632
2014	581	678	21	1281	118	8933	9051	10332
2015	173	2533	10	2717	2	6878	6880	9597
2016	222	6908	10	7140	19	6581	6599	13740
2017	1069	8854	170	10094	26	4585	4611	14705
2018	992	7871	370	9233	65	4433	4499	13732
2019*	282	5974	24	6280	0	1026	1026	7306

Table 4.3.2.2.1. Anchovy in Division 9.a. Catches (t) by gear and subdivision in 1989–2018. 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. Notwithstanding the above, the estimates for the Spanish fishery include estimates of discarded catches by gear since 2014 on. 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	2016	2017	2018
9.a N	Demersal trawl	0	0	0	0	0	0.2	0	7	0.6
	Artisanal	4	0	1	6	0	21	6	6	0.4
	Purse-seine	175	541	37	63	581	152	217	1057	991
9.a C-N	Demersal Trawl	5	4	1	0.5	2	3	2	2	0,3
	P. seine polyvalent	45	1116	177	17	9	150	294	332	403
	Purse-seine	50	2119	342	175	668	2381	6613	8521	7468
9.a C-S	Demersal Trawl	1	1	0.4	1	3	2	1	0.2	1
	P. seine polyvalent	0	0.1	17	4	1	0.4	4	13	14
	Purse-seine	1	0.4	202	127	18	8	5	157	355
9.a S (PT)	Demersal Trawl	8	13	16	2	5	1	3	6	1
	P. seine polyvalent	4	33	0.1	2	0.04	0.02	0.04	0	0
	Purse-seine	17	33	41	63	113	1	16	20	65
9.a S (ES)	Demersal Trawl	0	0	2	0	99	33	118	204	90
	Artisanal	0	0	0	0	0	0.1	0.1	0.01	0
	Purse-seine	2901	6216	4752	5172	8835	6845	6463	4381	4343

Table 4.3.2.2.2. Anchovy in Division 9.a. Quarterly anchovy catches (t) by subdivision in 2018.

SUBDIVISION/ COMPONENT	QUARTER 1		QUARTER 2		QUARTER 3		QUARTER 4		ANNUAL (2018)	
	C(t)	%	C(t)	%	C(t)	%	C(t)	%	C (t)	%
9.a North	193	19,4	171	17,3	392	39,5	236	23,8	992	7,2
9.a Central North	2304	29,3	53	0,7	3073	39,0	2441	31,0	7871	57,3
9.a Central South	245	66,3	24	6,6	96	25,8	5	1,3	370	2,7
Western Comp.	2742	29,7	249	2,7	3560	38,6	2682	29,0	9233	67,2
9.a South (PT)	1	2,2	12	18,0	52	79,6	0,1	0,1	65	0,5
9.a South (ES)	234	5,3	2379	53,7	1362	30,7	458	10,3	4433	32,3
Southern Comp.	236	5,2	2391	53,2	1414	31,4	458	10,2	4499	32,8
TOTAL	2978	21,7	2640	19,2	4974	36,2	3140	22,9	13732	100,0

Table 4.3.4.1. 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 (1988–2018). Increasing colour intensities denote increasing problems in sampling coverage of fishing effort.

Year	Landings	Effort	LPUE
1988	4263	4545	0,933
1989	5330	5713	0,922
1990	5726	6203	0,913
1991	5697	7642	0,737
1992	2995	5594	0,540
1993	1629	2996	0,478
1994	2883	3616	0,713
1995	495	1704	0,156
1996	1556	5583	0,224
1997	4376	4354	0,926
1998	7824	4963	1,472
1999	4594	6002	0,765
2000	2078	5923	0,351
2001	8180	6737	1,214
2002	7847	7539	1,041
2003	4754	6412	0,741
2004	5177	7100	0,728
2005	4386	5598	0,784
2006	4367	7253	0,602
2007	5575	6873	0,811
2008	3168	4542	0,697
2009	2922	4655	0,628
2010	2901	4341	0,668
2011	6196	6189	1,001
2012	4754	4750	1,001
2013	5172	6261	0,826
2014	6340	6358	0,997
2015	6701	5035	1,331
2016	6424	6013	1,068
2017	3636	3356	1,076
2018	4342	3508	1,210

Table 4.3.5.1.1. Anchovy in Division 9.a. Western component. Subdivision 9.a North. Spanish purse-seine fishery (métier PS_SPF_0_0_0). Seasonal and annual length distributions ('000) of anchovy landings in 2018.

2018	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	29	0	0	0	29
11.5	58	1052	157	0	1267
12	222	2572	313	0	3107
12.5	247	2221	1252	0	3721
13	277	351	1931	0	2558
13.5	892	0	2609	0	3501
14	1681	163	2194	0	4038
14.5	1707	0	2459	389	4554
15	1543	599	2028	563	4734
15.5	1452	0	1302	820	3574
16	575	1360	1111	1087	4134
16.5	302	0	833	880	2015
17	218	980	412	666	2276
17.5	0	0	252	381	633
18	0	327	55	425	806
18.5	0	0	18	220	239
19	0	0	0	231	231
19.5	0	0	0	207	207
20	0	0	0	297	297
20.5	0	0	0	200	200
21	0	0	0	82	82
21.5	0	0	0	0	0
Total N	9204	9628	16940	6449	42220
Catch (T)	193	171	391	236	991
L avg (cm)	14,8	13,8	14,6	14,6	14,5
W avg (g)	20,9	17,8	23,1	36,7	23,5

Table 4.3.5.1.2. Anchovy in Division 9.a. Western component. Subdivision 9.a North. Spanish artisanal fishery (métier MIS_MIS_0_0_0_HC). Seasonal and annual length distributions ('000) of anchovy landings in 2018. Length–frequency distributions were 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.

2018	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	0,4	0,1	0	0,5
12	0	1	0,2	0	1
12.5	0	1	1	0	2
13	0	0,1	1	0	1
13.5	0	0	2	0	2
14	0	0,1	2	0	2
14.5	0	0	2	0	2
15	0	0,2	1	0	2
15.5	0	0	1	0	1
16	0	0,5	1	0	1
16.5	0	0	1	0	1
17	0	0,3	0,3	0	1
17.5	0	0	0,2	0	0,2
18	0	0,1	0,04	0	0,2
18.5	0	0	0,01	0	0,01
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
21	0	0	0	0	0
21.5	0	0	0	0	0
Total N	0	3	12	0	15
Catch (T)	0	0,1	0,3	0	0,3
L avg (cm)	-	13,8	14,6	-	14,3
W avg (g)	-	17,8	23,1	-	21,2

Table 4.3.5.1.3. Anchovy in Division 9.a. Western component. Subdivision 9.a North. Spanish artisanal fishery (métier GNS_DEF_60-79_0_0). Seasonal and annual length distributions ('000) of anchovy landings in 2018. Length–frequency distributions were 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.

2018	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	0,1	0,01	0	0,1
12	0	0,2	0,02	0	0,2
12.5	0	0,1	0,1	0	0,2
13	0	0,02	0,1	0	0,2
13.5	0	0	0,2	0	0,2
14	0	0,01	0,2	0	0,2
14.5	0	0	0,2	0	0,2
15	0	0,03	0,2	0	0,2
15.5	0	0	0,1	0	0,1
16	0	0,1	0,1	0	0,2
16.5	0	0,0	0,1	0	0,1
17	0	0,1	0,03	0	0,1
17.5	0	0	0,02	0	0,02
18	0	0,02	0.004	0	0,02
18.5	0	0	0.001	0	0.001
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
21	0	0	0	0	0
21.5	0	0	0	0	0
Total N	0	1	1	0	2
Catch (T)	0	0,01	0,03	0	0,04
L avg (cm)	-	13,8	14,6	-	14,3
W avg (g)	-	17,8	23,1	-	21,2

Table 4.3.5.1.4. Anchovy in Division 9.a. Western component. Subdivision 9.a North. Spanish artisanal fishery (métier GTR_DEF_60-79_0_0). Seasonal and annual length distributions ('000) of anchovy landings in 2018. Length–frequency distributions were 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.

2018	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	0	0	0
13.5	0	0	0	0	0
14	0	0	0	0	0
14.5	0	0	0	0,02	0,02
15	0	0	0	0,02	0,02
15.5	0	0	0	0,03	0,03
16	0	0	0	0,05	0,05
16.5	0	0	0	0,04	0,04
17	0	0	0	0,03	0,03
17.5	0	0	0	0,02	0,02
18	0	0	0	0,02	0,02
18.5	0	0	0	0,01	0,01
19	0	0	0	0,01	0,01
19.5	0	0	0	0,01	0,01
20	0	0	0	0,01	0,01
20.5	0	0	0	0,01	0,01
21	0	0	0	0,003	0,003
21.5	0	0	0	0	0
Total N	0	0	0	0,3	0,3
Catch (T)	0	0	0	0,01	0,01
L avg (cm)	-	-	-	14.6	14.6
W avg (g)	-	-	-	36.7	36.7

Table 4.3.5.1.5. Anchovy in Division 9.a. Western component. Subdivision 9.a North. Spanish bottom-trawl fishery (métier OTB_DEF_>=55_0_0). Seasonal and annual length distributions ('000) of anchovy discards in 2018. Note that the raw LFDs were measured to the lower 1 cm size class.

2018	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	0	0	0
13.5	0	0	0	0	0
14	0	0	0	0	0
14.5	0	0	0	0	0
15	0	0	0	0	0
15.5	0	0	0	0	0
16	0	0	0	0	0
16.5	0	0	0	0	0
17	0	0	0,3	0	0,3
17.5	0	0	0	0	0
18	0	0	0	0	0
18.5	0	0	0	0	0
19	0	0	2	0	2
19.5	0	0	0	0	0
20	0	0	0	0	0
20.5	0	0	0	0	0
21	0	0	0	0	0
21.5	0	0	0	0	0
Total N	0	0	2	0	2
Catch (T)	0	0	0,1	0	0,1
L avg (cm)	-	-	18.0	-	18.0
W avg (g)	-	-	41.4	-	41.4

Table 4.3.5.1.6. Anchovy in Division 9.a. Western component. Subdivision 9.a North. Spanish bottom-trawl fishery (métier OTB_MPD_>=55_0_0). Seasonal and annual length distributions ('000) of anchovy discards in 2018. Note that the raw LFDs were measured to the lower 1 cm size class.

2018	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	1	0	0	0	1
11.5	0	0	0	0	0
12	0,3	0	0	0	0,3
12.5	0	0	0	0	0
13	0,3	0	0	0	0,3
13.5	0	0	0	0	0
14	1	0	0	0	1
14.5	0	0	0	0	0
15	0,3	0	6	0	6
15.5	0	0	0	0	0
16	0,3	0,04	4	0	4
16.5	0	0	0	0	0
17	0	0	6	0	6
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
21	0	0	0	0	0
21.5	0	0	0	0	0
Total N	3	0,04	16	0	19
Catch (T)	0,05	0,001	0,5	0	1
L avg (cm)	13,1	16,3	16,2	-	15,7
W avg (g)	14,3	27,9	31,0	-	28,4

Table 4.3.5.1.7. Anchovy in Division 9.a. Western Component. Subdivision 9.a North. Spanish fishery (all fleets). Seasonal and annual length distributions ('000) of anchovy landings and discards in 2018. Note that the raw LFDs of discards were measured to the lower 1 cm size class.

2018	Q1		Q2		Q3		Q4		TOTAL	
Length (cm)	9.a N (ES)		9.a N (ES)		9.a N (ES)		9.a N (ES)		9.a N (ES)	
Frac-tion	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	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	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0
10.5	0	0	0	0	0	0	0	0	0	0
11	29	1	0	0	0	0	0	0	29	1
11.5	58	0	1053	0	157	0	0	0	1268	0
12	222	0,3	2573	0	313	0	0	0	3108	0,3
12.5	247	0	2222	0	1253	0	0	0	3723	0
13	277	0,3	351	0	1932	0	0	0	2560	0,3
13.5	892	0	0	0	2611	0	0	0	3503	0
14	1681	1	163	0	2195	0	0	0	4040	1
14.5	1707	0	0	0	2461	0	389	0	4556	0
15	1543	0,3	599	0	2030	6	563	0	4735	6
15.5	1452	0	0	0	1303	0	820	0	3575	0
16	575	0,3	1361	0,04	1112	4	1087	0	4136	5
16.5	302	0	0	0	833	0	880	0	2016	0
17	218	0	980	0	413	6	666	0	2277	6
17.5	0	0	0	0	252	0	381	0	633	0

2018	Q1		Q2		Q3		Q4		TOTAL	
Length (cm)	9.a N (ES)		9.a N (ES)		9.a N (ES)		9.a N (ES)		9.a N (ES)	
Frac-tion	Landings	Discards	Landings	Discards	Landings	Discards	Landings	Discards	Landings	Discards
18	0	0	327	0	55	2	425	0	807	2
18.5	0	0	0	0	18	0	220	0	239	0
19	0	0	0	0	0	0	231	0	231	0
19.5	0	0	0	0	0	0	207	0	207	0
20	0	0	0	0	0	0	297	0	297	0
20.5	0	0	0	0	0	0	200	0	200	0
21	0	0	0	0	0	0	82	0	82	0
21.5	0	0	0	0	0	0	0	0	0	0
Total N	9204	3	9628	0,04	16940	18	6449	0	42220	21
Catch (T)	193	0,05	171	0,001	391	1	236	0	992	1
L avg (cm)	14,8	14,1	13,8	16,3	14,6	16,4	14,6	-	14,5	16,1
W avg (g)	20,9	18,2	17,8	27,9	23,1	32,2	36,7	-	23,5	30,2

Table 4.3.5.1.8. Anchovy in Division 9.a. Western Component. Subdivision 9.a North. Spanish fishery (all fleets). Seasonal and annual length distributions ('000) of anchovy catches in 2018.

2018	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	30	0	0	0	30
11.5	58	1053	157	0	1268
12	222	2573	313	0	3109
12.5	247	2222	1253	0	3723
13	277	351	1932	0	2560
13.5	892	0	2611	0	3503
14	1682	163	2195	0	4041
14.5	1707	0	2461	389	4556
15	1543	599	2036	563	4742
15.5	1452	0	1303	820	3575
16	575	1361	1117	1087	4140
16.5	302	0	833	880	2016
17	218	980	418	666	2282
17.5	0	0	252	381	633
18	0	327	57	425	808
18.5	0	0	18	220	239
19	0	0	0	231	231
19.5	0	0	0	207	207
20	0	0	0	297	297
20.5	0	0	0	200	200
21	0	0	0	82	82
21.5	0	0	0	0	0
Total N	9207	9628	16957	6449	42241
Catch (T)	193	171	392	236	992
L avg (cm)	14,8	13,8	14,6	14,6	14,5
W avg (g)	20,9	17,8	23,1	36,7	23,5

Table 4.3.5.1.9. Anchovy in Division 9.a. Western Component. 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 2018. Discards are null, hence landings correspond to catches.

2018	Q1	Q2	Q3	Q4	TOTAL
Length (cm)	9.a C-N	9.a C-N	9.a C-N	9.a C-N	9.a C-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	72	0	71	0	144
11	0	100	93	0	194
11.5	118	117	115	0	349
12	141	141	137	0	419
12.5	136	168	164	0	468
13	167	197	200	189	754
13.5	200	233	232	218	883
14	232	281	284	254	1050
14.5	271	319	325	281	1196
15	318	373	370	339	1399
15.5	363	420	433	381	1597
16	407	0	474	451	1332
16.5	464	0	545	503	1512
17	518	0	611	582	1712
17.5	595	0	661	620	1876
18	655	0	744	711	2110
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	4656	2350	5459	4529	16994
Catch (T)	2245	51	2863	2310	7468
L avg (cm)	15.6	13.1	15.0	15.6	15.0
W avg (g)	22.7	14.9	23.6	24.7	23.5

Table 4.3.5.1.10. Anchovy in Division 9.a. Western Component. Subdivision 9.a Central North. Portuguese fishery (all fleets). Seasonal and annual length distributions ('000) of anchovy catches in 2018. Discards are null, hence landings correspond to catches. Length frequency distributions were not available for other métiers. They have been estimated by raising total catches to the respective quarterly LFDs from the métier PS_SPF_0_0_0, that represents >93% of catches from all quarters.

2018	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	356	0	294	0	650
11	0	59	2353	0	2412
11.5	356	503	3824	0	4683
12	356	592	7647	0	8595
12.5	2490	592	6765	0	9846
13	6046	592	8235	9607	24481
13.5	8180	474	7941	9607	26202
14	8180	355	15294	9607	33437
14.5	11025	296	12941	8646	32909
15	11737	59	14706	9607	36109
15.5	11025	59	9412	9607	30103
16	11381	0	10882	9607	31871
16.5	7824	0	9412	9607	26843
17	11381	0	9412	8646	29439
17.5	6046	0	6471	9607	22124
18	5335	0	4412	4804	14550
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
21	0	0	0	0	0
21.5	0	0	0	0	0
Total N	101717	3582	130001	98954	334254
Catch (T)	2304	53	3073	2441	7871
L avg (cm)	15.6	13.1	15.0	15.6	15.0
W avg (g)	22.7	14.9	23.6	24.7	23.5

Table 4.3.5.1.11. Anchovy in Division 9.a. Southern component. 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 2018. Length–frequency distribution from Q4 landings was not available but it has been estimated by raising Q4 landings to the LFD from Q3.

2018	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)	
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	0	0	0	0	0	0	0
7.5	0	0	0	0	0	0	0	0	0	0
8	0	0	32	3	0	0	0	0	32	3
8.5	100	0	901	5	0	0	0	0	1001	5
9	562	0	3125	3	0	0	0	0	3687	3
9.5	587	0	7768	21	462	0	154	0	8972	21
10	2964	0	13479	13	2355	0	784	0	19583	13
10.5	3600	0	20378	14	2816	4	937	0	27730	18
11	3942	0	29859	0	4663	3	1552	0	40017	4
11.5	4564	0	32873	4	8020	5	2670	0	48127	9
12	3955	0	38075	2	16855	9	5612	0	64497	11
12.5	1064	0	27746	2	17344	4	5775	0	51928	6
13	93	0	14779	2	17007	1	5662	0	37541	4
13.5	359	0	6818	1	9578	3	3189	0	19943	4
14	0	0	4165	1	7969	0	2653	0	14787	1
14.5	1	0	1796	0	4061	1	1352	0	7211	1
15	0	0	186	0	2664	0	887	0	3737	0
15.5	0	0	74	0	484	0	161	0	719	0
16	0	0	0	0	391	0	130	0	521	0
16.5	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	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	0	0	0	0	0	0	0	0
20.5	0	0	0	0	0	0	0	0	0	0
Total N	21791	0	202052	71	94670	30	31520	0	350033	101
Catch (T)	201	0	2349	1	1344	0,4	448	0	4342	1
L avg (cm)	11,3	-	11,8	10,4	12,9	12,2	12,9	-	12,2	11,0
W avg (g)	9,2	-	11,6	8,0	14,2	11,8	12,4	-	12,2	9,1

Table 4.3.5.1.12. Anchovy in Division 9.a. Southern component. 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 2018. Length–frequency distribution from Q4 landings was not available but it has been estimated by raising Q4 landings to the LFD from Q3.

2018	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	0	0	0	0
7.5	0	0	0	0	0
8	0	34	0	0	34
8.5	100	906	0	0	1006
9	562	3128	0	0	3690
9.5	587	7789	462	154	8993
10	2964	13492	2355	784	19596
10.5	3600	20392	2819	937	27748
11	3942	29860	4666	1552	40021
11.5	4564	32877	8025	2670	48136
12	3955	38077	16864	5612	64508
12.5	1064	27747	17348	5775	51934
13	93	14781	17008	5662	37545
13.5	359	6819	9581	3189	19947
14	0	4166	7969	2653	14789
14.5	1	1796	4062	1352	7212
15	0	186	2664	887	3737
15.5	0	74	484	161	719
16	0	0	391	130	521
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	21791	202124	94700	31520	350135
Catch (T)	201	2350	1345	448	4343
L avg (cm)	11,3	11,8	12,9	12,9	12,2
W avg (g)	9,2	11,6	14,2	12,4	12,2

Table 4.3.5.1.13. Anchovy in Division 9.a. Southern component. Subdivision 9.a South (ES). Spanish bottom-trawl fishery (métier OTB_MCD_>=55_0_0). Seasonal and annual length distributions ('000) of anchovy landings and discards in 2018. Length–frequency distributions of landings were not available. They have been estimated by raising landings from this métier to the respective quarterly LFDs from the métier PS_SPF_0_0_0.

2018	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)	
Fraction	Landings	Discards	Landings	Discards	Landings	Discards	Landings	Discards	Landings	Dis-
5	0	5	0	0	0	0	0	0	0	5
5.5	0	6	0	106	0	0	0	10	0	122
6	0	78	0	45	0	15	0	32	0	171
6.5	0	386	0	31	0	0	0	91	0	508
7	0	451	0	23	0	0	0	84	0	558
7.5	0	411	0	47	0	15	0	150	0	623
8	0	551	0	118	0	61	0	208	0	939
8.5	0,005	588	0	362	0	42	0	308	0,005	1300
9	0,03	870	0	579	0	46	0	160	0,03	1656
9.5	0,03	495	0	543	0,003	157	0	169	0,03	1364
10	0,1	156	0	576	0,02	116	0	144	0,2	991
10.5	0,2	107	0	304	0,02	266	0	82	0,2	759
11	0,2	244	0	200	0,03	161	0	31	0,2	637
11.5	0,2	104	0	379	0,1	205	0	14	0,3	703
12	0,2	130	0	143	0,1	171	0	12	0,3	455
12.5	0,1	208	0	81	0,1	104	0	9	0,2	402
13	0,005	224	0	84	0,1	69	0	9	0,1	386
13.5	0,02	134	0	92	0,1	35	0	7	0,1	267
14	0	98	0	45	0,1	0	0	4	0,1	147
14.5	0	43	0	49	0,03	14	0	4	0,03	109
15	0	27	0	0	0,02	6	0	3	0,02	36
15.5	0	13	0	0	0,004	6	0	2	0,004	22
16	0	7	0	0	0,003	5	0	12	0,003	24
16.5	0	5	0	0	0	0	0	27	0	32
17	0	0	0	0	0	49	0	10	0	58
17.5	0	0	0	0	0	49	0	8	0	57
18	0	1	0	0	0	0	0	10	0	11
18.5	0	0	0	0	0	0	0	4	0	4
19	0	0	0	0	0	0	0	10	0	10
19.5	0	0	0	0	0	0	0	10	0	10
20	0	1	0	0	0	0	0	2	0	3
20.5	0	0	0	0	0	0	0	8	0	8
Total N	1	5346	0	3805	1	1592	0	1633	2	12376
Catch (T)	0,01	33	0	30	0,01	17	0	10	0,02	90
L avg (cm)	11,3	9,5	-	10,2	12,9	11,5	-	9,3	11,9	9,9
W avg (g)	9,3	6,2	-	7,8	14,2	10,8	-	6,2	11,2	7,3

Table 4.3.5.1.14. Anchovy in Division 9.a. Southern component. Subdivision 9.a South (ES). Spanish bottom-trawl fishery (métier OTB_MCD_>=55_0_0). Seasonal and annual length distributions ('000) of anchovy catches in 2018. Length–frequency distributions of landings were not available. They have been estimated by raising landings from this métier to the respective quarterly LFDs from the métier PS_SPF_0_0_0.

2018	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)
5	5	0	0	0	5
5,5	6	106	0	10	122
6	78	45	15	32	171
6.5	386	31	0	91	508
7	451	23	0	84	558
7.5	411	47	15	150	623
8	551	118	61	208	939
8.5	588	362	42	308	1300
9	870	579	46	160	1656
9.5	495	543	157	169	1364
10	156	576	116	144	991
10.5	108	304	266	82	759
11	244	200	162	31	637
11.5	105	379	205	14	703
12	130	143	171	12	456
12.5	208	81	104	9	402
13	224	84	69	9	386
13.5	134	92	35	7	268
14	98	45	0	4	147
14.5	43	49	14	4	109
15	27	0	6	3	37
15.5	13	0	6	2	22
16	7	0	5	12	24
16.5	5	0	0	27	32
17	0	0	49	10	58
17.5	0	0	49	8	57
18	1	0	0	10	11
18.5	0	0	0	4	4
19	0	0	0	10	10
19.5	0	0	0	10	10
20	1	0	0	2	3
20.5	0	0	0	8	8
Total N	5347	3805	1593	1633	12378
Catch (T)	33	30	17	10	90
L avg (cm)	9,5	10,2	11,5	9,3	9,9
W avg (g)	6,2	7,8	10,8	6,2	7,3

Table 4.3.5.1.15. Anchovy in Division 9.a. Southern component. Subdivision 9.a South (ES). Spanish fishery (all fleets). Seasonal and annual length distributions ('000) of anchovy landings and discards in 2018.

2018	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)	
Fraction	Landings	Discards	Landings	Discards	Landings	Discards	Landings	Discards	Landings	Discards
5	0	5	0	0	0	0	0	0	0	5
5.5	0	6	0	106	0	0	0	10	0	122
6	0	78	0	45	0	15	0	32	0	171
6.5	0	386	0	31	0	0	0	91	0	508
7	0	451	0	23	0	0	0	84	0	558
7.5	0	411	0	47	0	15	0	150	0	623
8	0	551	32	120	0	61	0	208	32	941
8.5	100	588	901	367	0	42	0	308	1001	1305
9	562	870	3125	582	0	46	0	160	3687	1658
9.5	587	495	7768	564	462	157	154	169	8972	1385
10	2964	156	13479	589	2355	116	784	144	19583	1005
10.5	3600	107	20378	318	2816	269	937	82	27730	776
11	3943	244	29859	201	4663	165	1552	31	40017	640
11.5	4564	104	32873	383	8020	210	2670	14	48127	712
12	3955	130	38075	145	16855	179	5612	12	64497	466
12.5	1064	208	27746	82	17344	108	5775	9	51928	408
13	93	224	14779	86	17007	70	5662	9	37541	389
13.5	359	134	6818	93	9578	37	3189	7	19943	272
14	0	98	4165	46	7969	0	2653	4	14788	148
14.5	1	43	1796	49	4061	15	1352	4	7211	110
15	0	27	186	0	2664	6	887	3	3737	36
15.5	0	13	74	0	484	6	161	2	719	22
16	0	7	0	0	391	5	130	12	521	24
16.5	0	5	0	0	0	0	0	27	0	32
17	0	0	0	0	0	49	0	10	0	58
17.5	0	0	0	0	0	49	0	8	0	57
18	0	1	0	0	0	0	0	10	0	11
18.5	0	0	0	0	0	0	0	4	0	4
19	0	0	0	0	0	0	0	10	0	10
19.5	0	0	0	0	0	0	0	10	0	10
20	0	1	0	0	0	0	0	2	0	3
20.5	0	0	0	0	0	0	0	8	0	8
Total N	21792	5346	202052	3877	94670	1622	31520	1633	350035	12477
Catch (T)	201	33	2349	30	1344	18	448	10	4342	91
L avg (cm)	11,3	9,5	11,8	10,2	12,9	11,5	12,9	9,3	12,2	10,0
W avg (g)	9,2	6,2	11,6	7,8	14,2	10,8	12,4	6,2	12,2	7,3

Table 4.3.5.1.16. Anchovy in Division 9.a. Southern component. Subdivision 9.a South (ES). Spanish fishery (all fleets). Seasonal and annual length distributions ('000) of anchovy catches in 2018.

2018	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)
5	5	0	0	0	5
5,5	6	106	0	10	122
6	78	45	15	32	171
6.5	386	31	0	91	508
7	451	23	0	84	558
7.5	411	47	15	150	623
8	551	152	61	208	973
8.5	688	1268	42	308	2306
9	1432	3707	46	160	5346
9.5	1082	8333	620	323	10357
10	3121	14068	2472	928	20587
10.5	3707	20695	3085	1019	28507
11	4186	30060	4828	1584	40657
11.5	4669	33256	8230	2685	48839
12	4085	38220	17035	5624	64963
12.5	1272	27828	17452	5784	52336
13	317	14865	17077	5671	37930
13.5	493	6911	9615	3196	20215
14	98	4210	7969	2657	14935
14.5	44	1845	4076	1356	7321
15	27	186	2670	891	3774
15.5	13	74	490	163	741
16	7	0	396	142	545
16.5	5	0	0	27	32
17	0	0	49	10	58
17.5	0	0	49	8	57
18	1	0	0	10	11
18.5	0	0	0	4	4
19	0	0	0	10	10
19.5	0	0	0	10	10
20	1	0	0	2	3
20.5	0	0	0	8	8
Total N	27139	205929	96292	33153	362513
Catch (T)	234	2379	1362	458	4433
L avg (cm)	11,0	11,8	12,9	12,7	12,1
W avg (g)	8,3	11,1	13,9	12,1	11,7

Table 4.3.5.2.1. Anchovy in Division 9.a. Western component. Subdivision 9.a North. Spanish catches (all fleets) in numbers-('000) at-age of Galician anchovy in 2018 on a quarterly (Q), half-year (HY) and annual basis.

2018	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	0	0	0	0	0
	1	6666	7375	15915	3381	14041	19296	33336
	2	2431	2008	1042	3068	4440	4111	8551
	3	109	245	0	0	354	0	354
	Total (n)	9207	9628	16957	6449	18835	23406	42241
	Catch (t)	193	171	392	236	364	628	992
	SOP	193	171	392	236	364	628	992
	VAR.%	99,9	100,1	100,0	100,0	100,0	100,0	100,0

Table 4.3.5.2.2. Anchovy in Division 9.a. Western component. Subdivision 9.a North. Spanish annual catches of anchovy in numbers ('000) at-age (only data for 2011–2012 and 2015–2018).

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
2016	4677	9206	881	1
2017	14116	21150	10310	184
2018	0	33336	8551	354

Table 4.3.5.2.3. Anchovy in Division 9.a. Western component. Subdivision 9.a Central-North. Portuguese catches (all fleets) of anchovy in numbers ('000) at-age in 2018 on a quarterly (Q), half-year (HY) and annual basis.

2018	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	0	0	0	0	0
	1	54517	3582	114896	75896	56543	77983	248078
	2	34561	0	13455	23057	33325	16433	69036
	3	11571	0	1648	0	11493	1965	17140
	Total (n)	100649	3582	130001	98954	101361	96381	334254
	Catch (t)	2304	53	3073	2441	2357	5514	7871
	SOP	2304	53	3072	2440	2357	5513	7871
	VAR.%	98.7	108	102	94	101	98	1.01

Table 4.3.5.2.4. Anchovy in Division 9.a. Southern component. Subdivision 9.a South. Spanish catches (all fleets) in numbers ('000) at-age of Gulf of Cadiz anchovy in 2018 on a quarterly (Q), half-year (HY) and annual basis.

2018	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	23188	16279	0	39467	39467
	1	25771	202818	71329	16418	228589	87747	316336
	2	1367	2852	1775	456	4219	2231	6450
	3	0	0	0	0	0	0	0
	Total (n)	27139	205669	96292	33153	232808	129445	362253
	Catch (t)	234	2379	1362	458	2613	1820	4433
	SOP	234	2373	1362	400	2503	1741	4245
	VAR.%	100,0	100,3	100,0	114,4	104,4	104,5	104,4

Table 4.3.5.2.5. Anchovy in Division 9.a. Southern component. Subdivision 9.a South. Spanish annual catches (all fleets) in numbers ('000) at-age of Gulf of Cadiz anchovy (1995–2018).

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
2016	87979	460201	19758	0
2017	118554	402410	4339	8
2018	39467	316336	6450	0

Table 4.3.6.1. Anchovy in Division 9.a. Western component. Subdivision 9.a North. Mean length (TL, in cm) at-age in the Spanish catches of Galician anchovy (all fleets) in 2018 on a quarterly (Q), half-year (HY) and annual basis.

2018	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	0	0	0	0	0
	1	14,4	12,9	14,5	16,2	13,6	14,8	14,3
	2	15,8	16,8	16,6	12,8	16,3	13,8	15,1
	3	17,3	17,3	0	0	17,3	0	17,3
	Total	14,8	13,8	14,6	14,6	14,3	14,6	14,5

Table 4.3.6.2. Anchovy in Division 9.a. Western component. Subdivision 9.a North. Mean weight (in kg) at-age in the Spanish catches of Galician anchovy (all fleets) in 2018 on a quarterly (Q), half-year (HY) and annual basis.

2018	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	0	0	0	0	0
	1	0,019	0,013	0,022	0,031	0,016	0,024	0,021
	2	0,026	0,032	0,033	0,043	0,028	0,040	0,034
	3	0,034	0,034	0	0	0,034	0	0,034
	Total	0,021	0,018	0,023	0,037	0,019	0,027	0,023

Table 4.3.6.3. Anchovy in Division 9.a. Western component. Subdivision 9.a Central-North. Mean length (TL, in cm) at-age in the Portuguese catches of Northwestern anchovy (all fleets) in 2018 on a quarterly (Q), half-year (HY) and annual basis.

2018	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	0	0	0	0	0
	1	14.7	13.1	14.7	15.6	14.7	15.2	14.8
	2	16.6	0	16.7	15.6	16.7	16.2	16.5
	3	17.0	0	17.8	0	17.0	17.2	17.1
	Total	15.6	13.1	15.0	15.6	15.6	15.4	15.3

Table 4.3.6.4. Anchovy in Division 9.a. Western component. Subdivision 9.a Central-North. Mean weight (in kg) at-age in the Portuguese catches of Northwestern anchovy (all fleets) in 2018 on a quarterly (Q), half-year (HY) and annual basis.

2018	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	0	0	0	0	0
	1	0.020	0.014	0.024	0.028	0.020	0.023	0.022
	2	0.031	0	0.034	0.028	0.031	0.029	0.031
	3	0.033	0	0.040	0	0.033	0.034	0.033
	Total	0.025	0.014	0.025	0.028	0.025	0.024	0.024

Table 4.3.6.5. Anchovy in Division 9.a. Southern component. Subdivision 9.a South. Mean length (TL, in cm) at-age in the Spanish catches of Gulf of Cadiz anchovy (all fleets) in 2018 on a quarterly (Q), half-year (HY) and annual basis.

2018	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	11,7	11,8	0	11,7	11,7
	1	10,9	11,8	13,2	13,5	11,7	13,3	12,1
	2	12,6	13,5	14,4	14,6	13,2	14,4	13,6
	3	0	0	0	0	0	0	0
	Total	11,0	11,8	12,8	12,7	11,7	12,8	12,1

Table 4.3.6.6. Anchovy in Division 9.a. Southern component. Subdivision 9.a South. Mean weight (in kg) at-age in the Spanish catches of Gulf of Cadiz anchovy (all fleets) in 2018 on a quarterly (Q), half-year (HY) and annual basis.

2018	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	0,010	0,010	0	0,010	0,010
	1	0,008	0,011	0,015	0,014	0,011	0,015	0,012
	2	0,013	0,017	0,021	0,021	0,016	0,021	0,018
	3	0	0	0	0	0	0	0
	Total	0,009	0,012	0,014	0,012	0,011	0,013	0,012

Table 4.4.1. 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 Cadiz) (see Section 4.5.1); (2): surveys analysed since 2008 in the trends-based qualitative assessment; (3): *ECOCADIZ-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	IBERAS	ECOCADIZ		ECOCADIZ-RECLUTAS	BOCADEVA	
Institute (Country)	IEO (ES)	IPMA (PT)		IPMA (PT)	IPMA (PT)	IPMA-IEO (PT-ES)	IEO (ES)		IEO (ES	IEO (ES)	
Subareas	9.a N	9.a CN-9.a S		9.a CN-9.a S	9.a CN	9.a N-9.a CS	9.a S		9.a S	9.a S	
Year/Quarter	Q2	Q1	Q2	Q4	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)			

Method	**Acoustics**									**DEPM**	
Survey	PELACUS 04	PELAGO		SAR	JUVESAR	IBERAS	ECOCADIZ		ECOCADIZ-RECLUTAS	BOCADEVA	
Institute (Country)	IEO (ES)	IPMA (PT)		IPMA (PT)	IPMA (PT)	IPMA-IEO (PT-ES)	IEO (ES)		IEO (ES	IEO (ES)	
Subareas	9.a N	9.a CN-9.a S		9.a CN-9.a S	9.a CN	9.a N-9.a CS	9.a S		9.a S	9.a S	
Year/Quarter	Q2	Q1	Q2	Q4	Q4	Q4	Q2	Q3	Q4	Q2	Q3
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)		Dec			Jul(2)	Oct		
2017	Mar(2)		Apr(2)		Dec			Jul(2)	Oct		Jul(2)
2018	Mar(2)		Apr(2)			Nov		Jul(2)	Oct		
2019	Mar(2)		Apr.(2)								

Table 4.4.1.1. Anchovy in Division 9.a. *BOCADEVA* survey series (summer Spanish anchovy DEPM survey in Subdivision 9.a South). Historical series of eggs, adult and SSB estimates in Subdivision 9.a South.

Year	2005	2008	2011	2014	2017
P0 (eggs/m^2/day)	50.8 / 224.5	184 / 348	276	314	146
Z (day^{-1}) (CV)	-0.039	-1,43	-0.29	-0.33	-0,16
Ptotal (eggs/day) (x10^{12})	1,13	2,11	1,87	1,95	0,74
Surveyed area (km^2)	11982	13029	13107	14595	15556
Positive area (km^2)	6139	6863	6770	6214	5080
Female Weight (g)	25.2 / 16.7	23,7	15,2	18,2	16,1
Batch Fecundity	13820/ 11160	13778	7486	7502	7502
Sex Ratio	0.53 / 0.54	0,53	0,53	0,54	0,53
Spawning Fraction	0.26 / 0.21	0,218	0,276	0,276	0,234
Spawning Biomass (tons)	14673	31527	32757	31569	12392

Table 4.4.2.1. Anchovy in Division 9.a. *PELACUS* survey series (spring Spanish acoustic survey in Subdivision 9.a North and Subarea 8.c). Summary of the fishing stations performed during *PELACUS 0319* in 9aN.

	TOTAL CAP (Kg)	No ind.	No Fishing st	Sample weight (kg)	Measured fish	Mean length	%PRES	% Catch_W	% Catch_No
WHB	382	5929	4	36	523	22.02	30.77	7.42	10.32
MAC	152	922	7	115	651	27.83	53.85	2.96	1.61
HKE	53	553	13	53	553	23.44	100.00	1.03	0.96
HOM	1315	12242	10	84	767	23.27	76.92	25.52	21.31
PIL	3065	36428	7	78	999	20.34	53.85	59.49	63.42
NOO	0	3	1	0	3	10	7.69	0.00	0.01
BOG	152	804	5	107	545	26.48	38.46	2.94	1.40
VMA	3	19	6	3	19	25.08	46.15	0.06	0.03
SEAB	16	48	3	16	48	27.46	23.08	0.31	0.08
ANE	14	489	7	14	489	15.92	53.85	0.27	0.85
Total	5153	57437	13	505	4597				

Table 4.4.2.2. 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
April 2008	N	10
	B	306
April 2009	N	0.7
	B	26
April 2010	N	0.03
	B	90
April 2011	N	73
	B	1650
April 2012	N	1
	B	45
March 2013	N	-
	B	-
March 2014	N	-
	B	-
March 2015	N	-
	B	-
March 2016	N	8
	B	205
March 2017	N	124
	B	3566
March 2018	N	771
	B	10660
March 2019	N	7
	B	192

Table 4.4.2.3. 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).

Survey	Estimate	Portugal				Spain	S(Total)	TOTAL
		C-N	C-S	S(A)	Total	S(C)		
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	-	-	-	-	-	-	-

***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 echo-traces attributable to the species were detected in this area, however, the loss of pelagic gear samplers prevented from confirming directly this.**

Table 4.4.2.3. Anchovy in Division 9.a. *PELAGO* survey series (spring Portuguese acoustic survey in Subdivisions 9.a Central-North to 9.a South). Cont'd.

Survey	Estimate	Portugal				Spain	S(Total)	TOTAL
		C-N	C-S	S(A)	Total	S(C)		
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
May 17	N	1015	0	137	1152	1718	1855	2870
	B	15481	0	1208	16689	12589	13797	29278
Apr. 18	N	4845	0	300	5145	1857	2157	7001
	B	54437	0	4328	58765	19145	23473	77910
Apr. 19	N	229	7	0	236	3398	3398	3634
	B	3814	123	0	3937	29876	29876	33813

Table 4.4.2.4. 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).

Survey	Estimate	Portugal	Spain	TOTAL
		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
Jul. 16	N	346	3341	3686
	B	5250	29051	34301
Jul. 17	N	151	1354	1504
	B	2666	9563	12229
Jul. 18	N	224	2839	3063
	B	4224	30683	34908

*****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 4.4.3.1. 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 and Central-South - *JUVESAR* -). Historical series of overall and regional acoustic estimates of anchovy abundance (N, millions) and biomass (B, tonnes). Juvenile fish (< 10.0 cm) estimates between parentheses.

Survey	Estimate	Portugal				Spain	S (Total)	TOTAL
		C-N	C-S	S (PT)	Total	S (ES)		
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	3870 (3835)	-	-	-	-	-	-
	B	30000 (29000)	-	-	-	-	-	-
Dec. 16	N	2836 (2835)	-	-	-	-	-	-
	B	14397 (14367)	-	-	-	-	-	-
Dec 17	N	2145 (570)		-	-	-	-	-
	B	38000 (4700)		-	-	-	-	-

*** 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 4.4.3.2. Anchovy in Division 9.a. *IBERAS* survey series (autumn Spanish-Portuguese acoustic survey in subdivisions 9.a North to Central-South). Historical series of overall and regional acoustic estimates of anchovy abundance (N, millions) and biomass (B, tonnes). Age 0 fish estimates between parentheses.

Survey	Estimate	Spain	Portugal			TOTAL
		N	C-N	C-S	Total	
Nov. 18	N	0.04 (0.03)	8836 (592)	0.02 (0.001)	8836 (592)	8836 (592)
	B	0.4 (0)	181576 (5894)	0.4 (0)	181577 (5894)	181577 (5894)

Table 4.4.3.3. 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.

Survey	Estimate	Portugal	Spain	TOTAL
		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)
Oct. 16	N	177 (42)	3490 (3404)	3667 (3445)
	B	3054 (463)	16807 (15506)	19861 (15969)
Oct. 17**	N	-	1492 (1433)	-
	B	-	7641 (7290)	-
Oct. 18	N	405 (96)	548 (447)	952 (543)
	B	6259 (1005)	4234 (2830)	10493 (3834)

*** Partial estimate: only the Spanish waters were acoustically surveyed. ** Partial estimate only 70% of the Spanish waters was acoustically surveyed.**

Table 4.5.1.1. Anchovy in Division 9.a. Southern component. Subdivision 9.a South. Mean weight-at-age in the stock (in g).

Year	Age 0	Age 1	Age 2	Age 3
1995	7,0	10,7	22,6	
1996	1,1	6,3	20,0	
1997	2,6	11,1	20,9	
1998	2,6	7,4	20,4	
1999	3,2	12,8	20,0	
2000	3,1	10,0	23,8	
2001	6,2	13,3	31,8	
2002	3,3	10,5	26,3	
2003	6,0	10,6	26,8	
2004	6,6	12,0	21,9	
2005	4,9	9,2	22,6	
2006	3,6	8,2	21,0	
2007	5,4	9,4	20,4	
2008	7,2	14,9	21,8	23,1
2009	4,1	12,2	20,3	24,2
2010	6,9	11,3	19,1	23,0
2011	8,2	10,3	22,7	
2012	8,3	14,3	22,5	
2013	6,4	11,9	21,8	
2014	6,6	10,9	19,0	
2015	7,7	10,5	20,7	
2016	8,7	12,9	18,2	
2017	6,7	9,1	19,9	
2018	10,2	12,4	18,6	

Table 4.6.2.1.1.1. Anchovy in Division 9.a. Southern component. Overview of the data used in the assessment model for optimization routines.

Data source	Type	Timespan
Commercial landings	Length distribution	All quarters, 1989–2018
	Age–length key	All quarters, 1989–2018
ECOCADIZ acoustic survey	Biomass survey indexes	Second quarter 2004, 2006 third quarter 2007, 2009, 2010, 2013–2018
	Length distribution	Second quarter 2004, 2006 third quarter 2007, 2009, 2010, 2013–2018
	Age–length key	Second quarter 2004, 2006 third quarter 2007, 2009, 2010, 2013–2018
PELAGO acoustic survey	Biomass survey indexes	First quarter 1999, 2001–2003 second quarter 2005–2010 and 2013–2019
	Length distribution	First quarter 1999, 2001–2003 second quarter 2000, 2005–2010, 2013–2019
	Age–length key	second quarter 2014–2019

Table 4.6.2.1.3.1. Anchovy in Division 9.a. Southern component. Summary of parameters estimated by the assessment model.

Symbol	Meaning and estimated value
l_∞	Asymptotic length, l_∞=28.92 cm
k	Annual growth rate, k =0.05590558
β	Beta-binomial parameter, β = 2.461572
ν_a	Age factor, ν_1 = 1.000051e-06, ν_2 = 1.000027e-06, ν_3 = 0.019059
μ	Recruitment mean length, μ = 3.082296cm
σ_t	Recruitment length standard deviation by quarter, σ_2 = 3.082296, σ_3 = 1.813474, σ_4 = 3.802042
$l_{50,T}$	Length with a 50% probability of predation during period T, seine: $l_{50,1}$= 11.77cm, $l_{50,2}$ = 11.01 cm, *ECOCADIZ* survey: l_{50}= 13.67 cm, *PELAGO* survey: l_{50}= 13.3 cm
α_T	Shape of selectivity function, purse-seine: α_1 = 0.402, α_2 = 0.993, *ECOCADIZ* survey: α_3 = 1.007, *PELAGO* survey: α_3 = 0.651

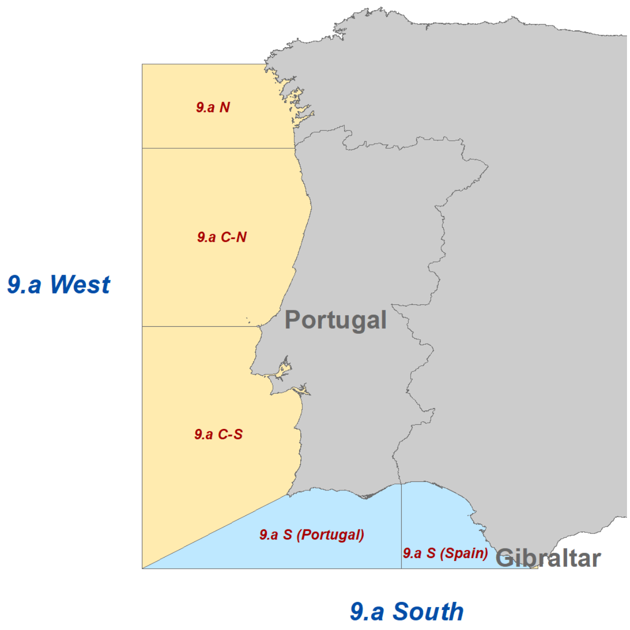


Figure 4.2.1. Anchovy in Division 9.a.Map showing the split of Division 9a into the stock components 9a South and 9a West. Note that, in turn, the stock component 9a South is divided into Portuguese and Spanish waters, whereas stock component 9a West is divided into the subdivisions 9a North, 9a Central–North, and 9a Central–South.

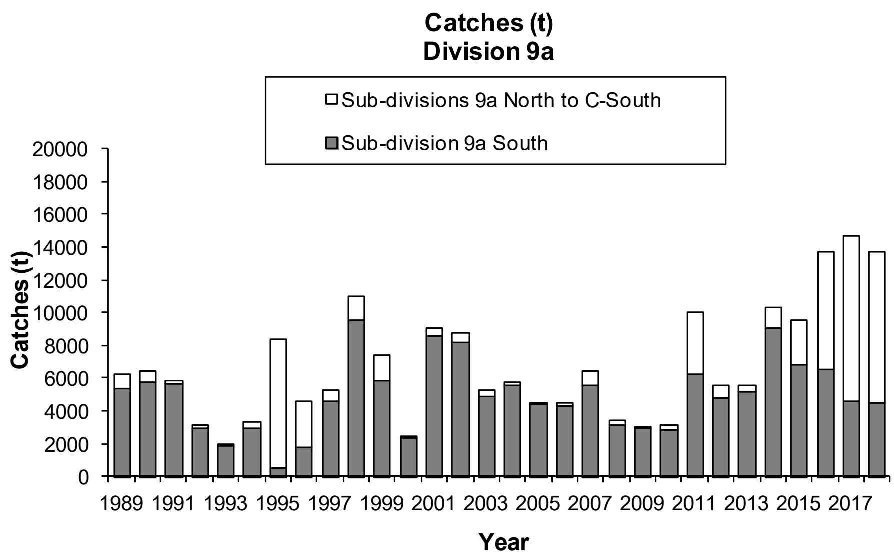


Figure 4.3.2.1.1. Anchovy in Division 9.a. Recent series of anchovy catches in Division 9.a (ICES estimates for 1989–2018, the period with data for all the subdivisions, all metiers are considered). Subdivisions are pooled in order to differentiate the anchovy fishery harvested throughout the Atlantic façade of the Iberian Peninsula (Western component: ICES subdivisions 9.a North, Central-North and Central-South) from the fishery in the Gulf of Cadiz (Southern component: Subdivision 9.a South), where both the stock and the fishery were mainly located during a great part of the time-series. Discards are considered as negligible all over the division, but since 2014 on estimates include the available discarded catches (see Section 4.3.3).

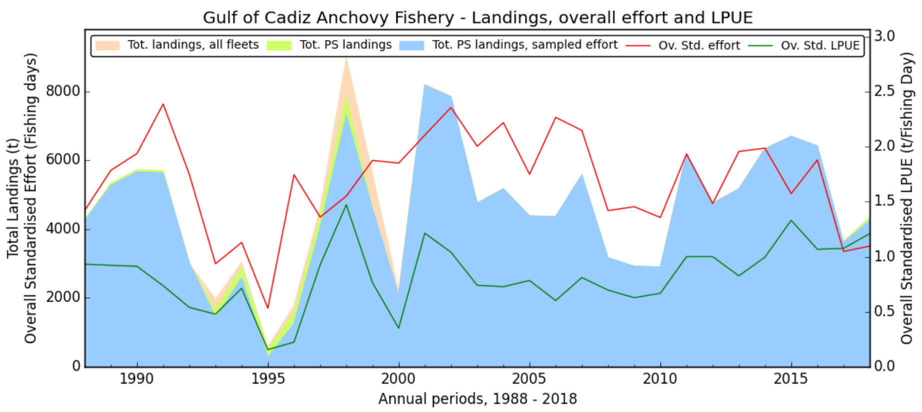


Figure 4.3.4.1. Anchovy in Division 9.a. Southern component. Subdivision 9.a South. Spanish purse-seine fishery (métier PS_SPF_0_0_0). Trends in Gulf of Cadiz anchovy annual landings, and purse-seine fleets' standardised overall effort and lpue (1988–2018).

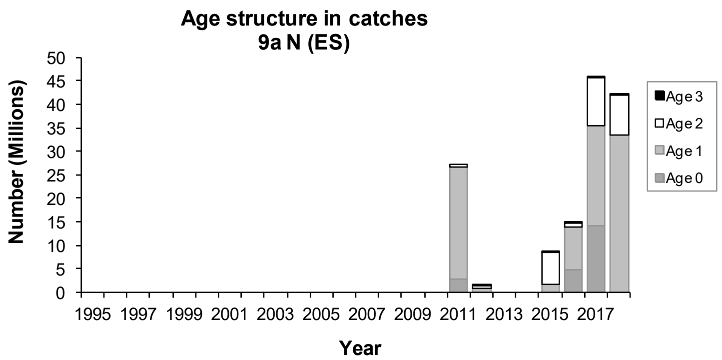


Figure 4.3.5.2.1. Anchovy in Division 9.a. Western component. Subdivision 9.a North. Spanish fishery (all métiers). Age composition in Spanish catches of SW Galician anchovy (available data provided to the WG). Although discards are still considered as negligible (hence landings are assumed as equal to catches), data since 2014 include discards estimates (see Section 4.3.3).

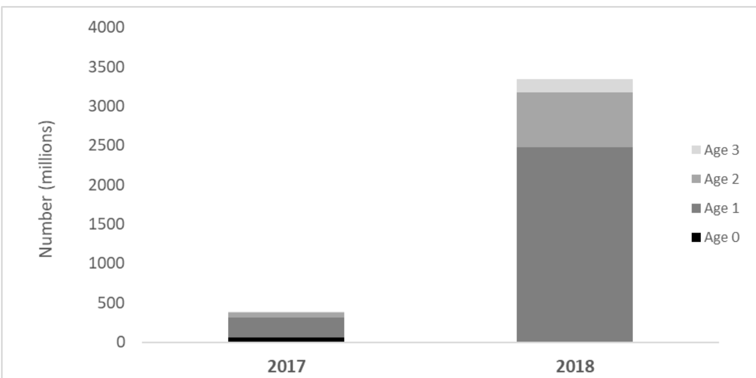


Figure 4.3.5.2.2. Anchovy in Division 9.a. Western component. Subdivision 9.a Central-North. Portuguese fishery (all métiers). Age composition in Portuguese anchovy catches (available data provided to the WG). Discards are negligible (hence landings are assumed as equal to catches).

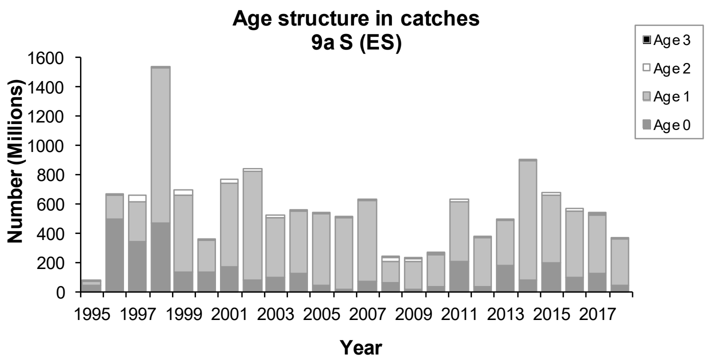
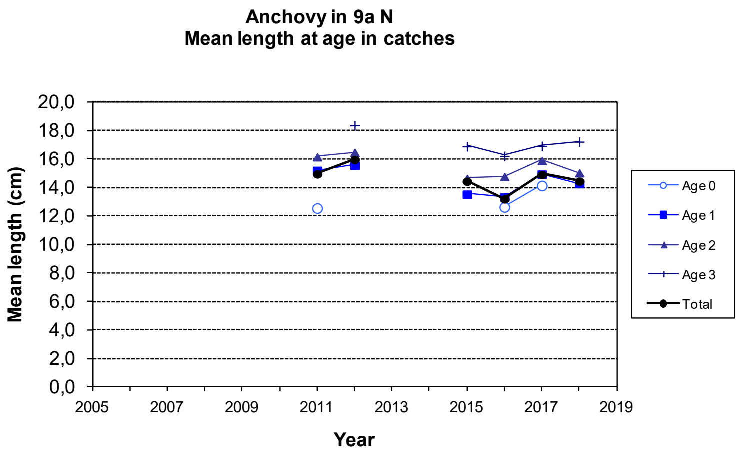


Figure 4.3.5.2.3. Anchovy in Division 9.a. Southern component. Subdivision 9.a-South. Spanish fishery (all métiers). Age composition in Spanish catches of Gulf of Cadiz anchovy (1995–2018). Discards are considered as negligible in this fishery, but since 2014 on estimates include the available discarded catches (see Section 4.3.3).



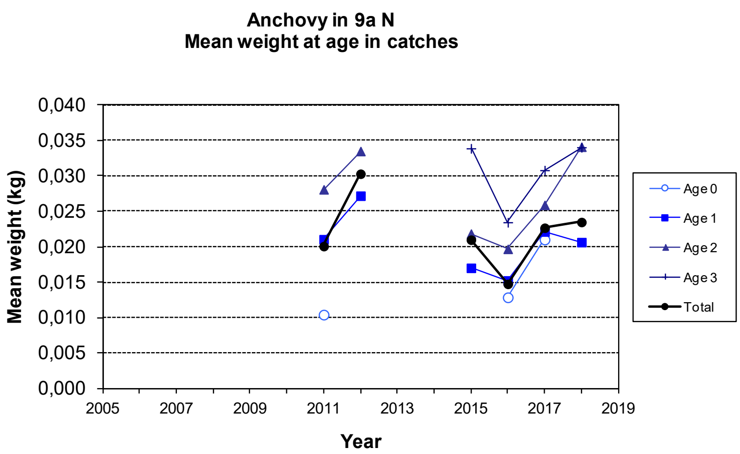


Figure 4.3.6.1. Anchovy in Division 9.a. Western component. Subdivision 9.a North. Spanish fishery (all métiers). Annual mean length (TL, in cm) and weight (kg) at-age in the Spanish catches of Western Galicia anchovy (2011–2018).

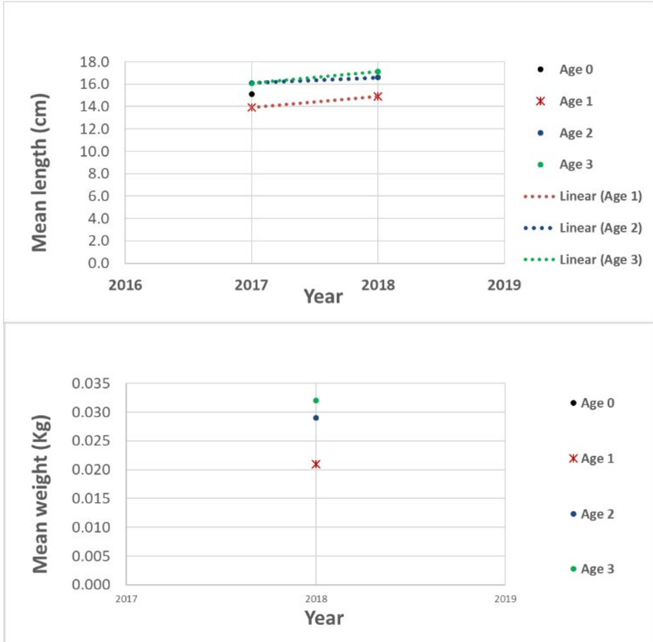


Figure 4.3.6.2. Anchovy in Division 9.a. Western component. Subdivision 9.a Central North. Spanish fishery (all métiers). Annual mean length (TL, in cm) and weight (kg) at-age in the Portuguese catches of North Western Portugal anchovy (2017 and 2018).

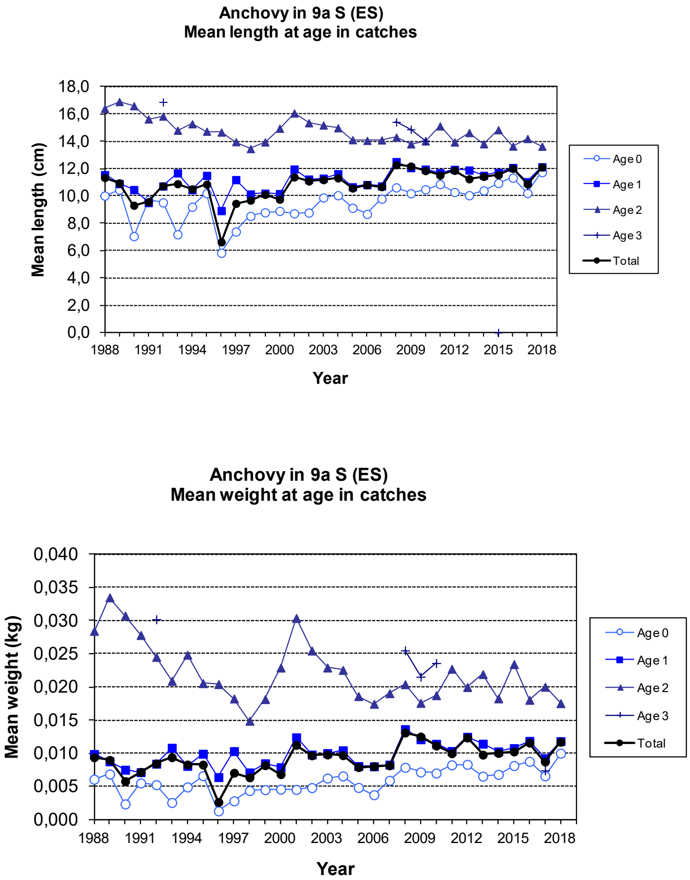


Figure 4.3.6.3. Anchovy in Division 9.a. Southern component. Subdivision 9.a-South. Spanish fishery (all métiers). Annual mean length (TL, in cm) and weight (kg) at-age in the Spanish catches of Gulf of Cadiz anchovy (1988–2018).

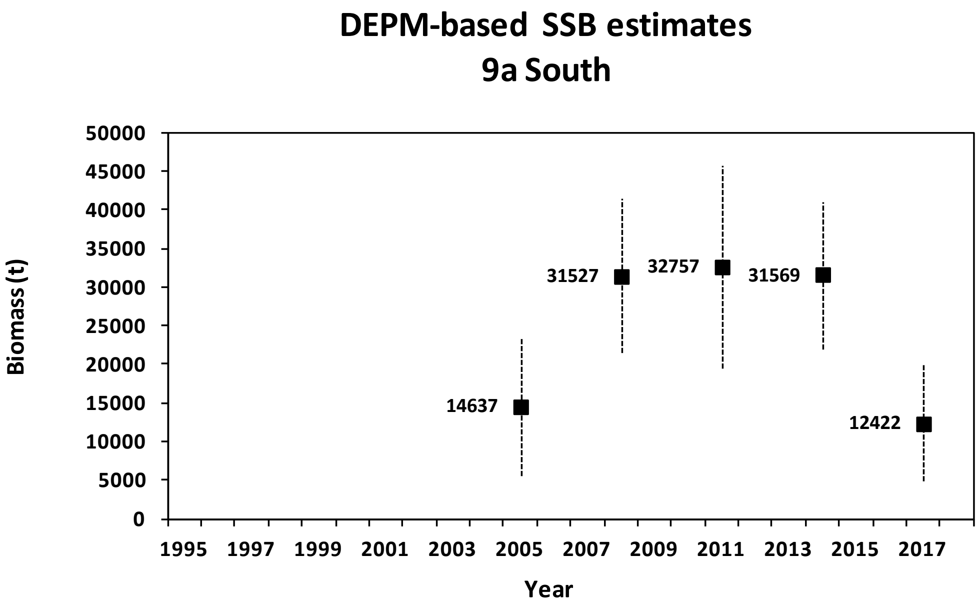


Figure 4.4.1.1. Anchovy in Division 9.a. Southern component. Subdivision 9.a South. *BOCADEVA* survey series (summer Spanish DEPM survey in Subdivision 9.a South). Series of SSB estimates (±SD) obtained from the survey series.

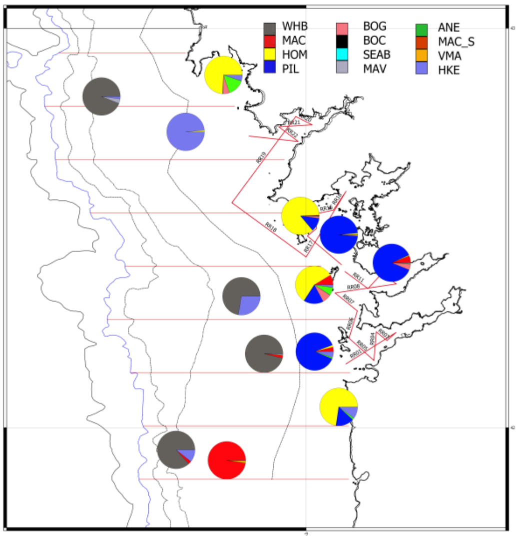


Figure 4.4.2.1. Anchovy in Division 9.a. Western component. Subdivision 9.a North. *PELACUS 0319* survey (spring Spanish acoustic survey in Subdivision 9.a North and Subarea 8c in 2019). Distribution of pelagic hauls for echotraces identification in 9.a North, with indication of the species composition.

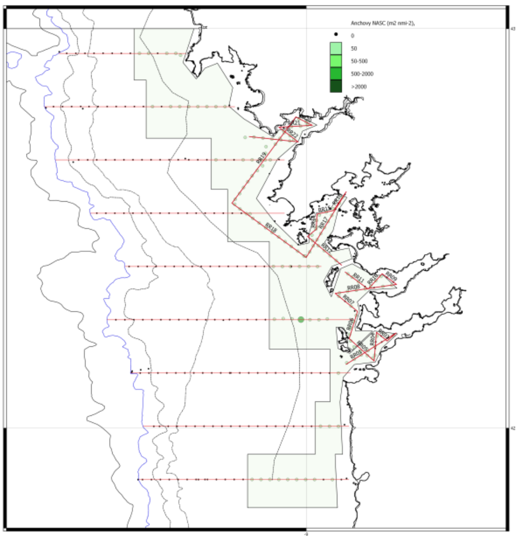


Figure 4.4.2.2. Anchovy in Division 9.a. Western component. Subdivision 9.a North. *PELACUS 0319* survey (spring Spanish acoustic survey in Subdivision 9.a North and Subarea 8c in 2019). Spatial distribution of energy allocated to anchovy in 9.a North (NASC coefficients in m^2/mn^2). Polygons are drawn to encompass the observed echoes, and polygon colour indicates density in mt/nm^2 within each polygon.

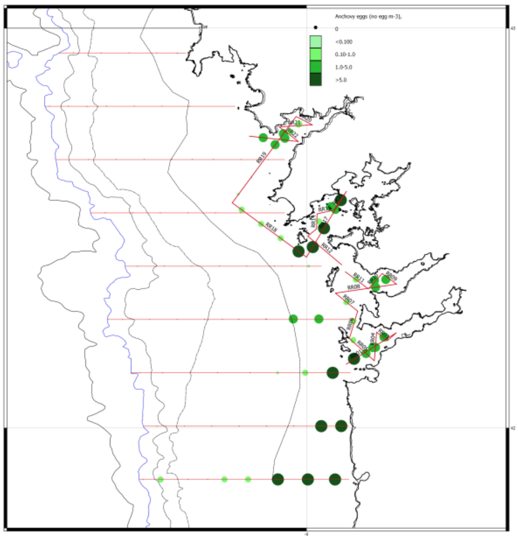


Figure 4.4.2.3. Anchovy in Division 9.a. Western component. Subdivision 9.a North. *PELACUS 0319* survey (spring Spanish acoustic survey in Subdivision 9.a North and Subarea 8c in 2019). Anchovy egg distribution as sampled by CUFES.

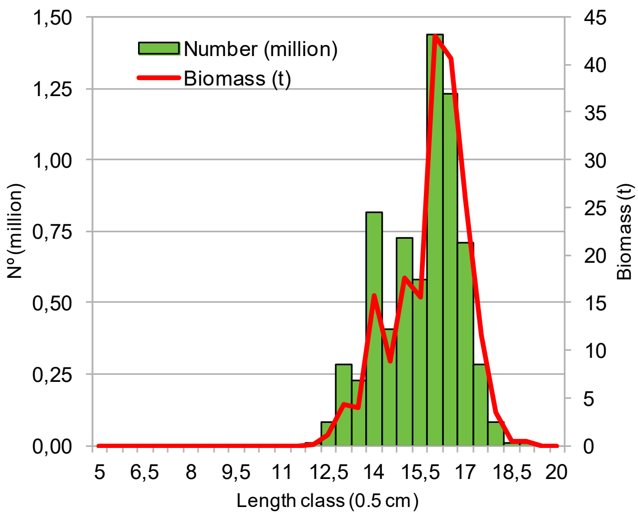
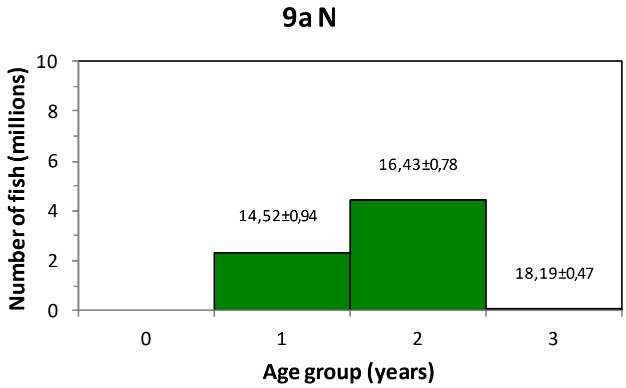


Figure 4.4.2.4. Anchovy in Division 9.a. Western component. Subdivision 9.a North. *PELACUS 0319* survey (spring Spanish acoustic survey in Subdivision 9.a North and Subarea 8c in 2019.Estimated abundance and biomass (number of fish in millions and tonnes, respectively) in Subdivision 9.a North by size class.



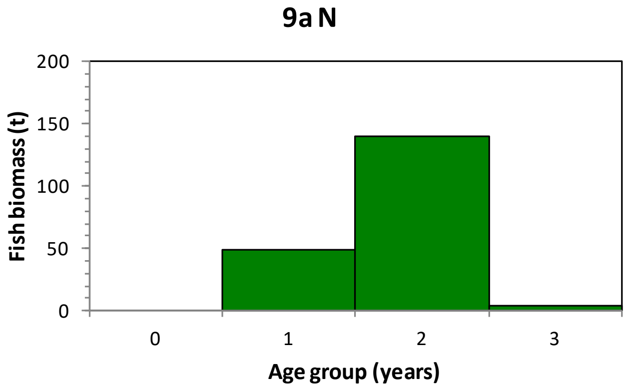


Figure 4.4.2.5. Anchovy in Division 9.a. Western component. Subdivision 9.a North. *PELACUS 0318* survey (spring Spanish acoustic survey in Subdivision 9.a North and Subarea 8c in 2019. Cont'd. Estimated abundance and biomass (number of fish in millions and tonnes, respectively) in Subdivision 9.a North by age group, with indication of the mean size by age.

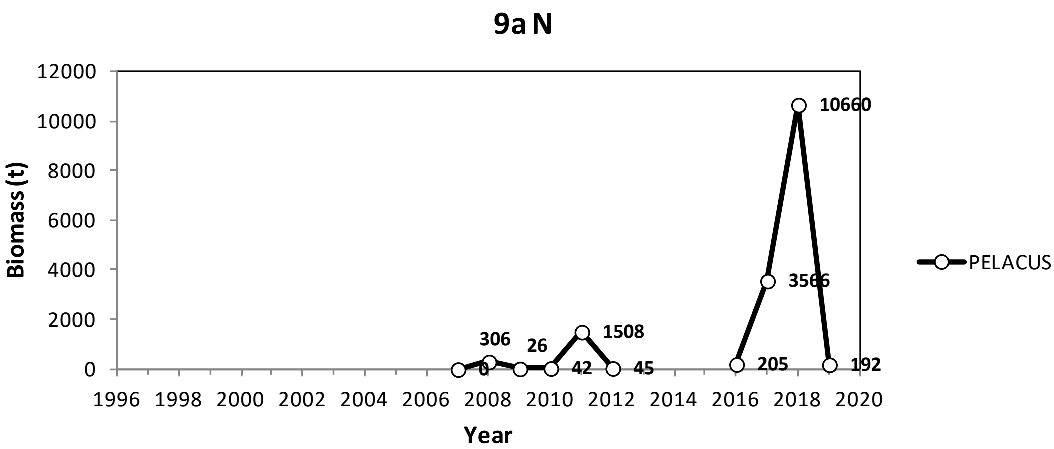


Figure 4.4.2.6. Anchovy in Division 9.a. Western component. Subdivision 9.a North. *PELACUS* survey series (spring Spanish acoustic survey in Subdivision 9.a North and Subarea 8c). Historical series of acoustic estimates of anchovy biomass (t) for the Subdivision 9.a North.

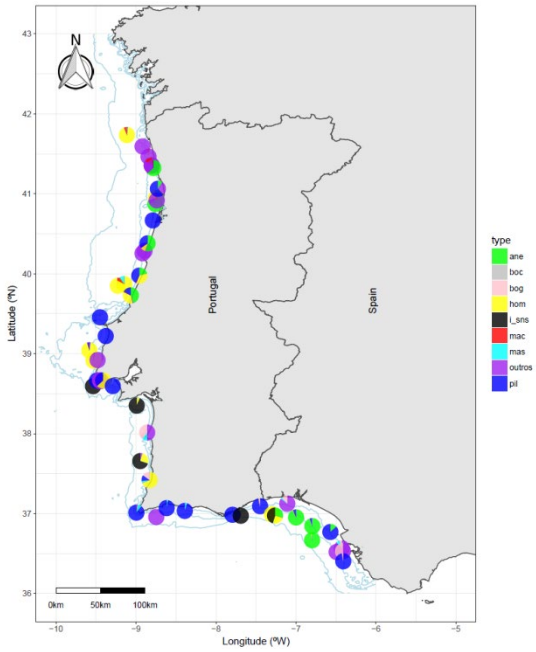


Figure 4.4.2.7. Anchovy in Division 9.a. Western and Southern components. Subdivisions 9.a Central-North to 9.a South. *PELAGO* survey series (spring Portuguese acoustic survey in Subdivisions 9.a Central-North to 9.a South). *PELAGO 19* survey. Location of valid fishing stations with indication of their species composition (percentages in number).

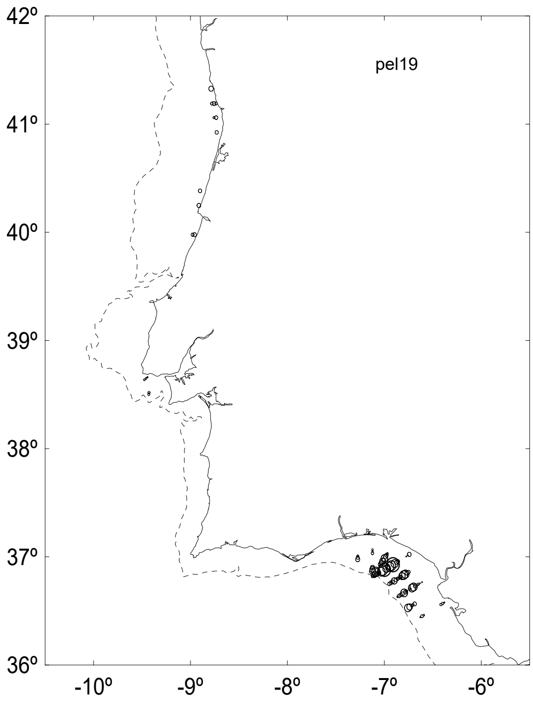


Figure 4.4.2.8. Anchovy in Division 9.a. Western and Southern components. Subdivisions 9.a Central-North to 9.a South. *PELAGO* survey series (spring Portuguese acoustic survey in Sub-divisions 9.a Central-North to 9.a South). *PELAGO 19* survey. Distribution of the NASC coefficients (m^2/mn^2) attributed to anchovy.

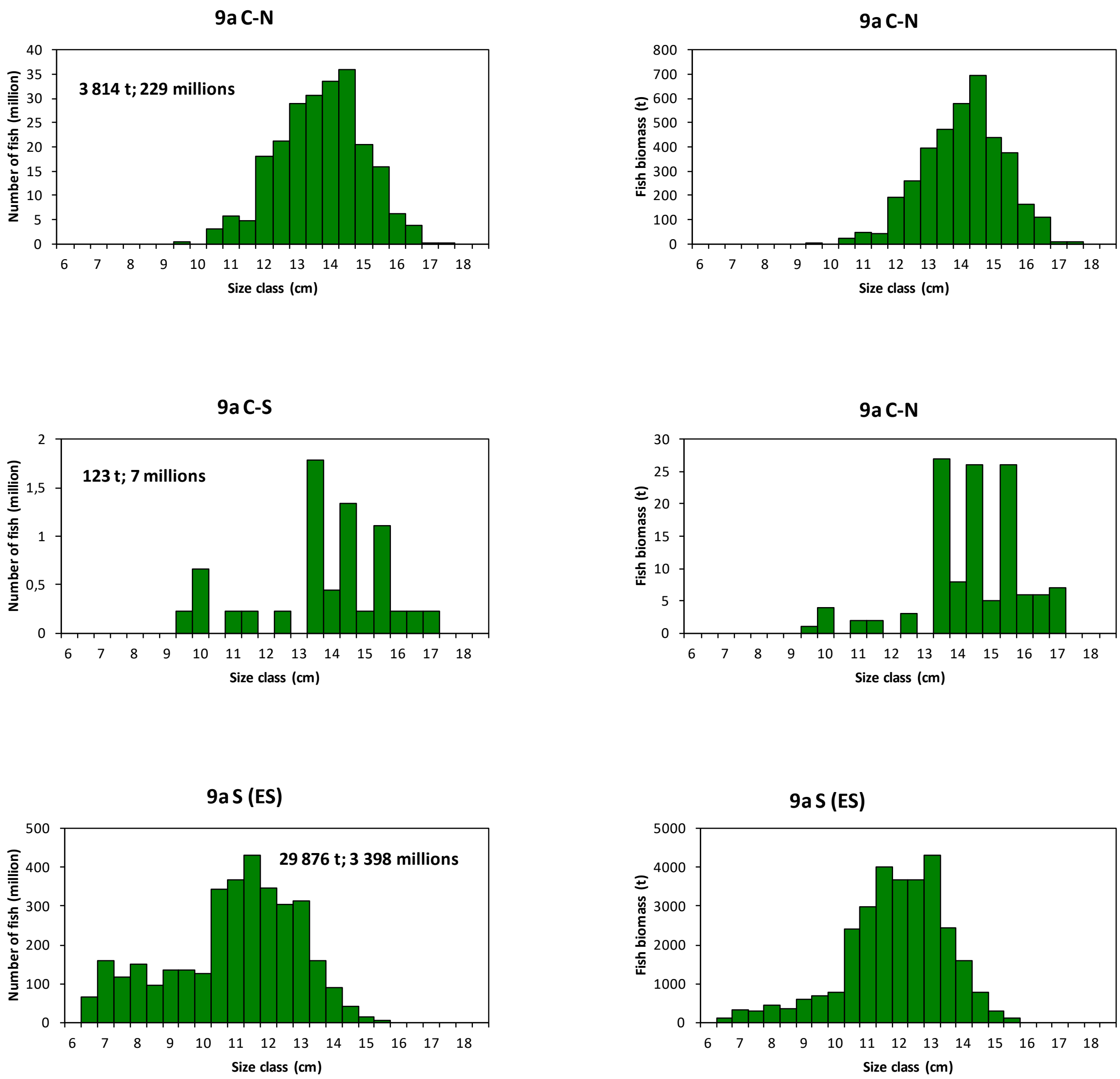


Figure 4.4.2.9. Anchovy in Division 9.a. Western and Southern components. Subdivisions 9.a Central-North to 9.a South. *PELAGO* survey series (spring Portuguese acoustic survey in Subdivisions 9.a Central-North to 9.a South). *PELAGO 19* survey. Estimated abundances and biomasses (number of fish in millions and tonnes, respectively) for the surveyed area by length class (cm).Note the different scales in the y-axis.

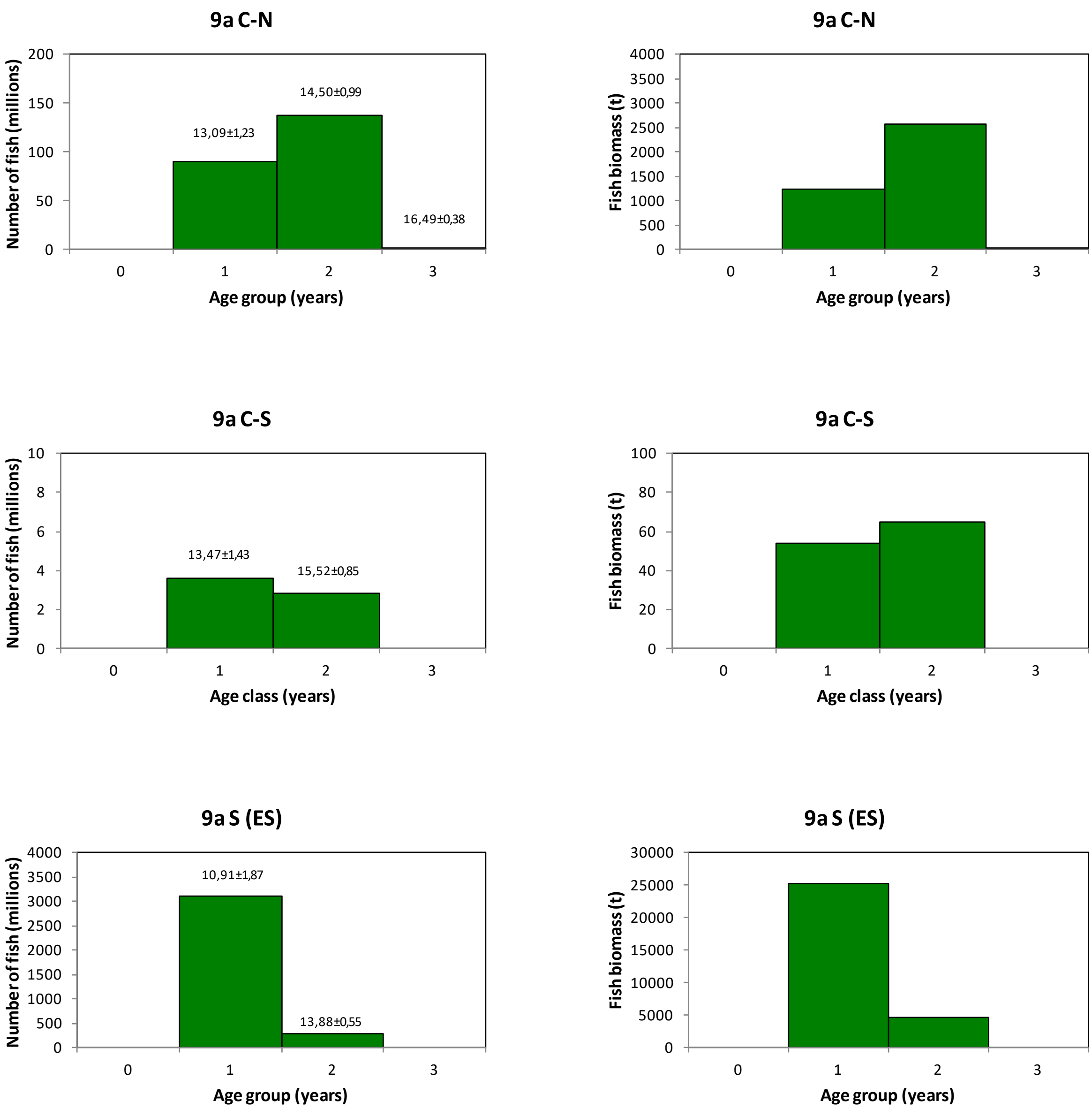


Figure 4.4.2.10. Anchovy in Division 9.a. Western and Southern components. Subdivisions 9.a Central-North to 9.a South. *PELAGO* survey series (spring Portuguese acoustic survey in Subdivisions 9.a Central-North to 9.a South). *PELAGO 19* survey. Estimated abundances and biomasses (number of fish in 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.

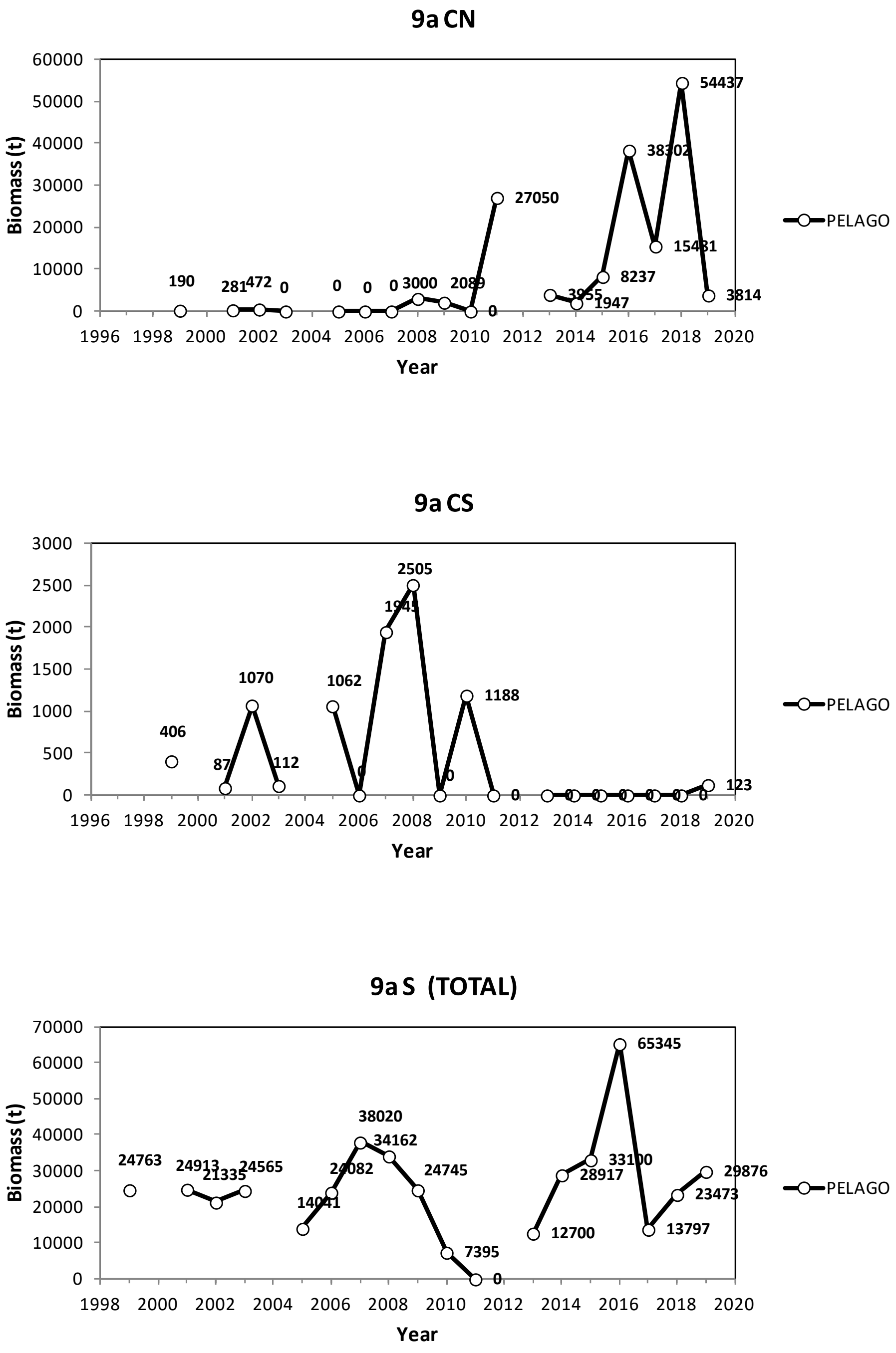
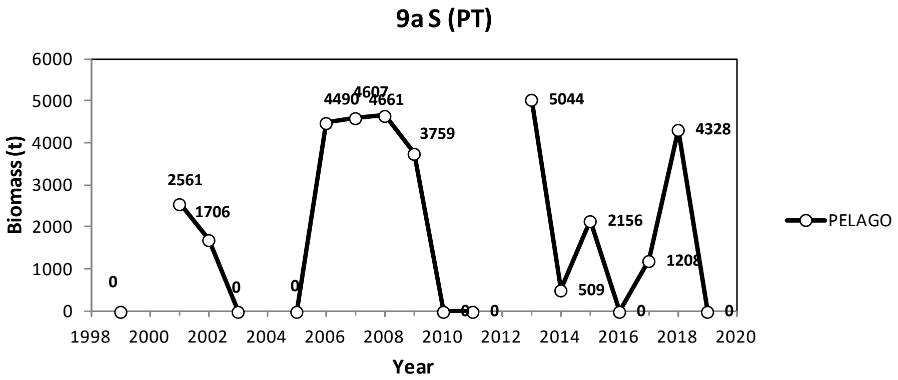


Figure 4.4.2.11. Anchovy in Division 9.a. Western and Southern components. Subdivisions 9.a Central-North to 9.a South. *PELAGO* survey series (spring Portuguese acoustic survey in Subdivisions 9.a Central-North to 9.a South). Historical series of regional acoustic estimates of anchovy biomass (t). Note the different scale of the y-axis.



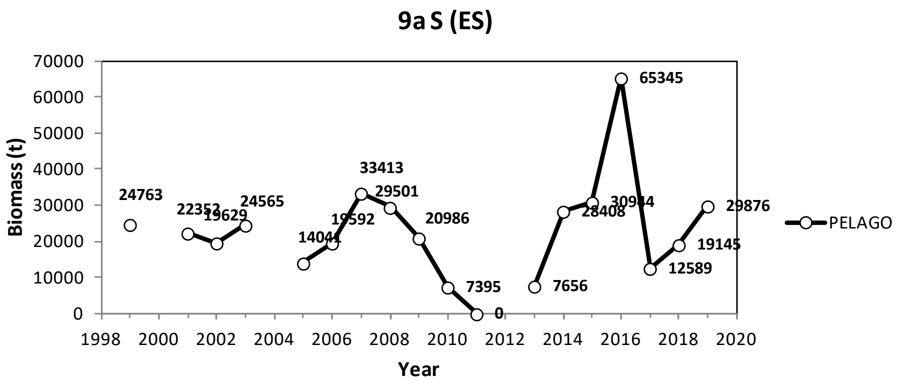


Figure 4.4.2.11. Continued. Acoustic estimates in the 9.a South differentiated by Portuguese (PT) and Spanish waters of the Gulf of Cadiz (ES). Note the different scale of the y-axis. Although estimates from Subdivision 9.a-South in 2010 and 2014 were not separately provided for Algarve and Cadiz to 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.

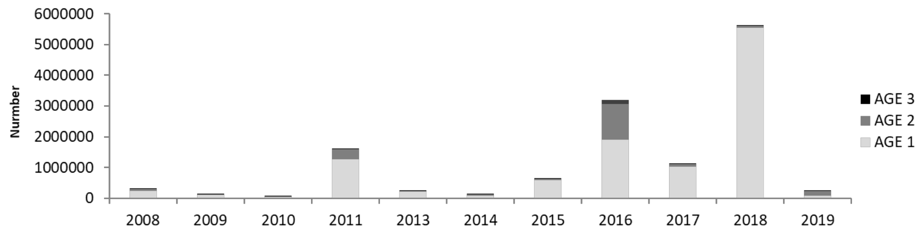
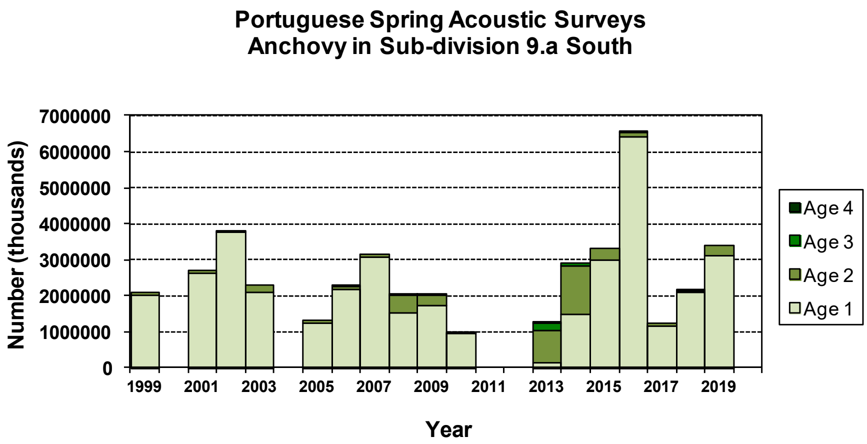


Figure 4.4.2.12. Anchovy in Division 9.a. Western component. Subdivisions 9.a North to Central-South. Annual trends of the estimated population by age class from the *PELACUS* (9a North)+*PELAGO* (9a Central-North and Central-South) Spring acoustic surveys.



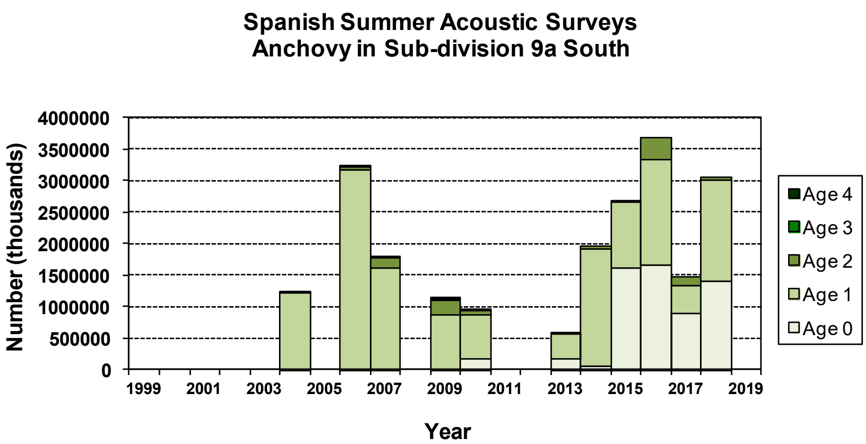


Figure 4.4.2.13. Anchovy in Division 9.a. Southern component. Subdivision 9.a-South. Annual trends of the estimated population by age class from the Algarve + Gulf of Cadiz areas by the Portuguese Spring (upper plot) and Spanish summer (lower plot) acoustic surveys. Portuguese estimates until 2012 have been age-structured using Spanish ALKs from the commercial fishery in the second quarter in the year.

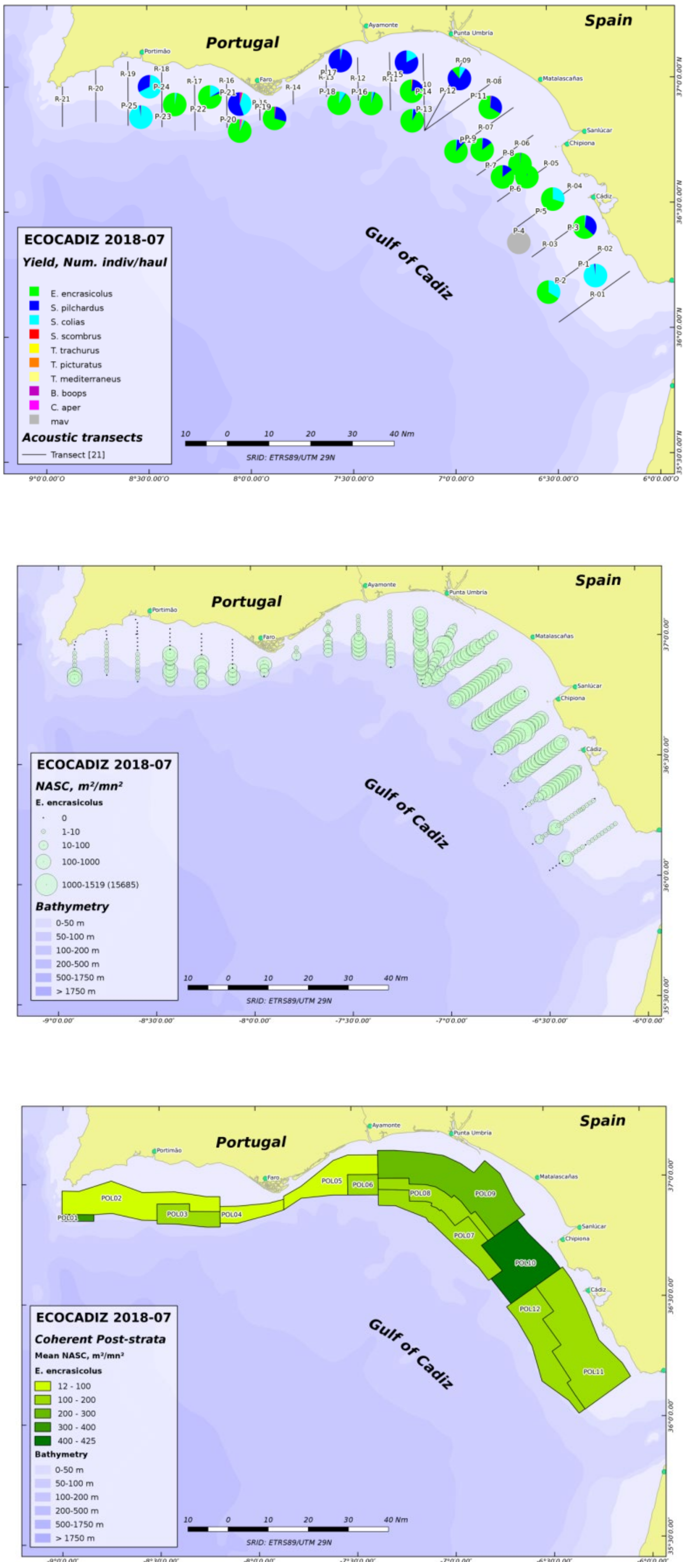


Figure 4.4.2.14. Anchovy in Division 9.a. Southern component. Subdivision 9.a South. *ECOCADIZ 2018-07* survey (summer Spanish acoustic survey in Subdivision 9.a South).Top: Location of valid fishing stations with indication of their species composition (percentages in number).Middle: Distribution of 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.

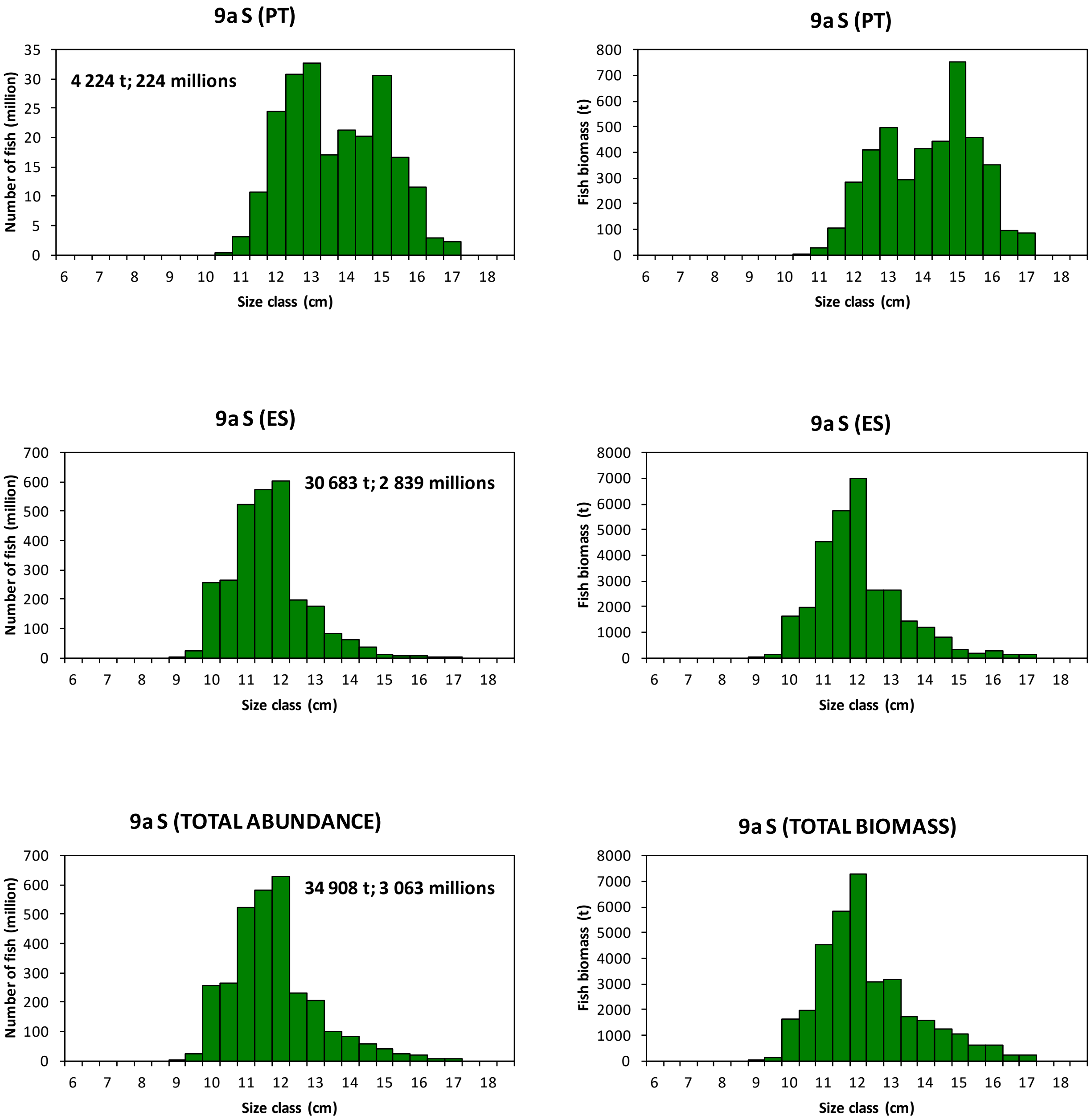


Figure 4.4.2.15. Anchovy in Division 9.a. Southern component. Sub-division 9.a South. *ECOCADIZ 2018-07* survey (summer Spanish acoustic survey in Subdivision 9.a South). Estimated abundances and biomasses (number of fish in millions and tonnes, respectively) for the surveyed area by length class (cm).Note the different scales in the y-axis.

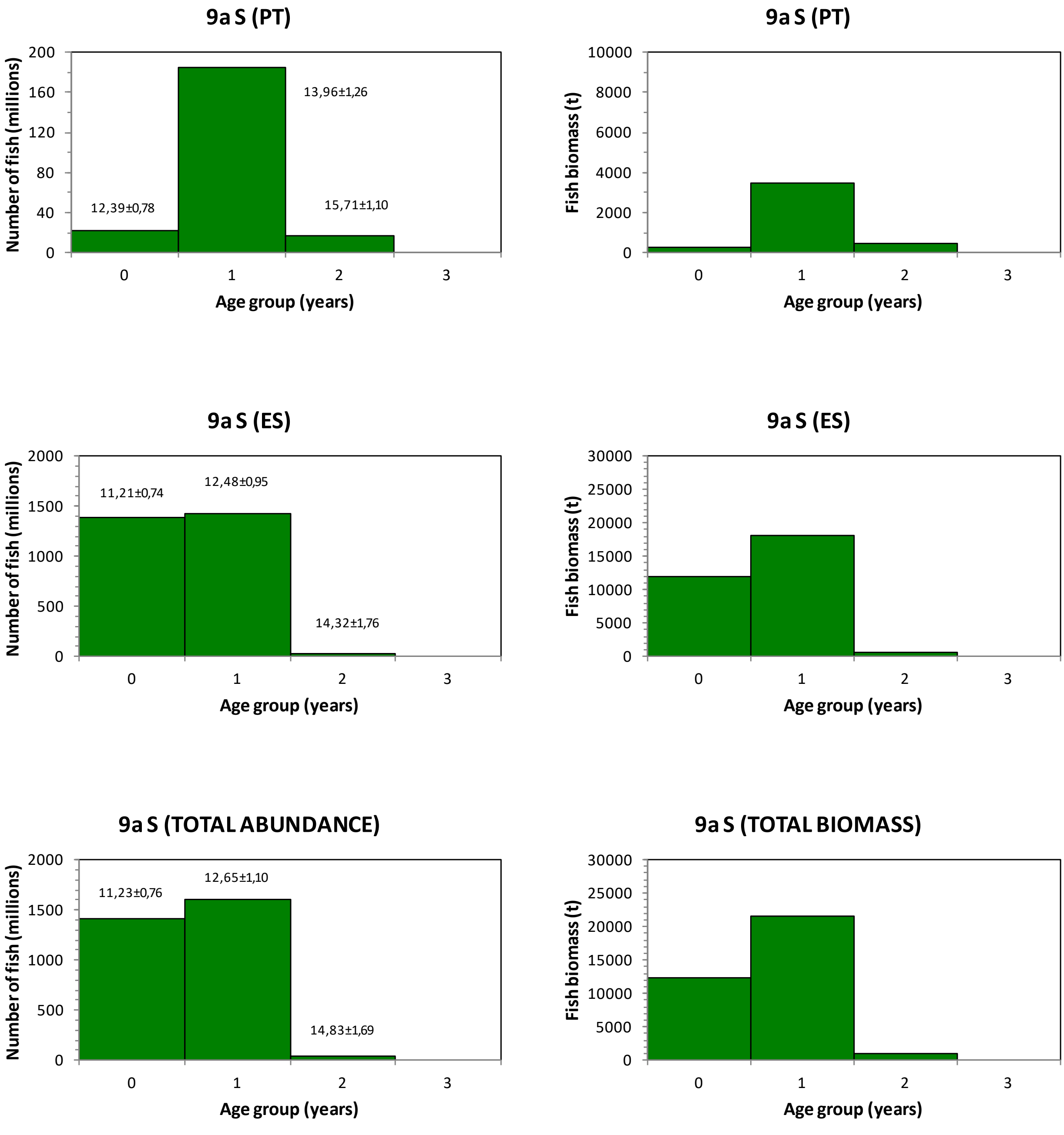
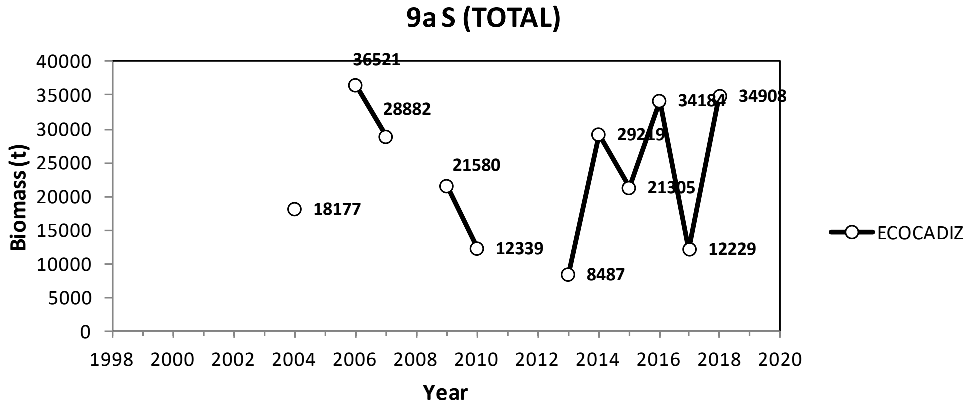
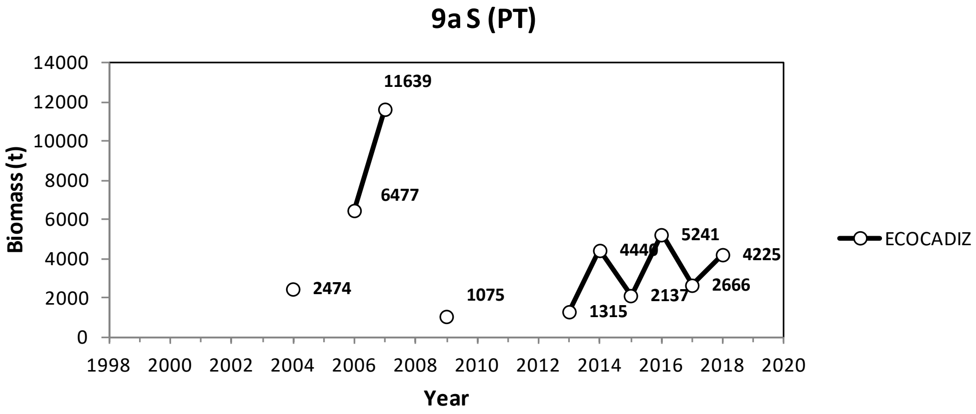


Figure 4.4.2.16. Anchovy in Division 9.a. Southern component. Subdivision 9.a South. *ECOCADIZ 2018-07* survey (summer Spanish acoustic survey in Subdivision 9.a South). Estimated abundances and biomasses (number of fish in millions and tonnes, respectively) for the surveyed area by age group, with indication of the mean size by age. Note the different scales in the y-axis.





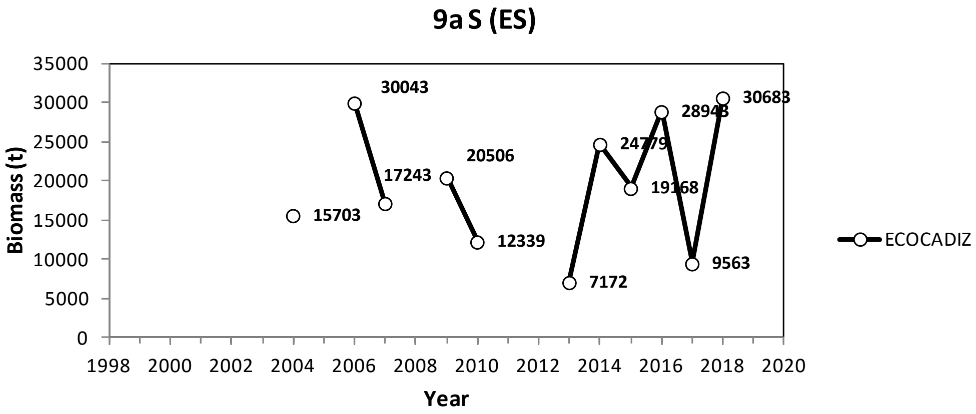


Figure 4.4.2.17. Anchovy in Division 9.a. Southern component. Subdivision 9.a South. *ECOCADIZ* survey series (summer Spanish acoustic survey in Subdivision 9.a South). Historical series of overall and regional (Portuguese, PT, and Spanish waters of the Gulf of Cadiz, ES) acoustic estimates of anchovy biomass (t). Note the different scale of the y-axis.

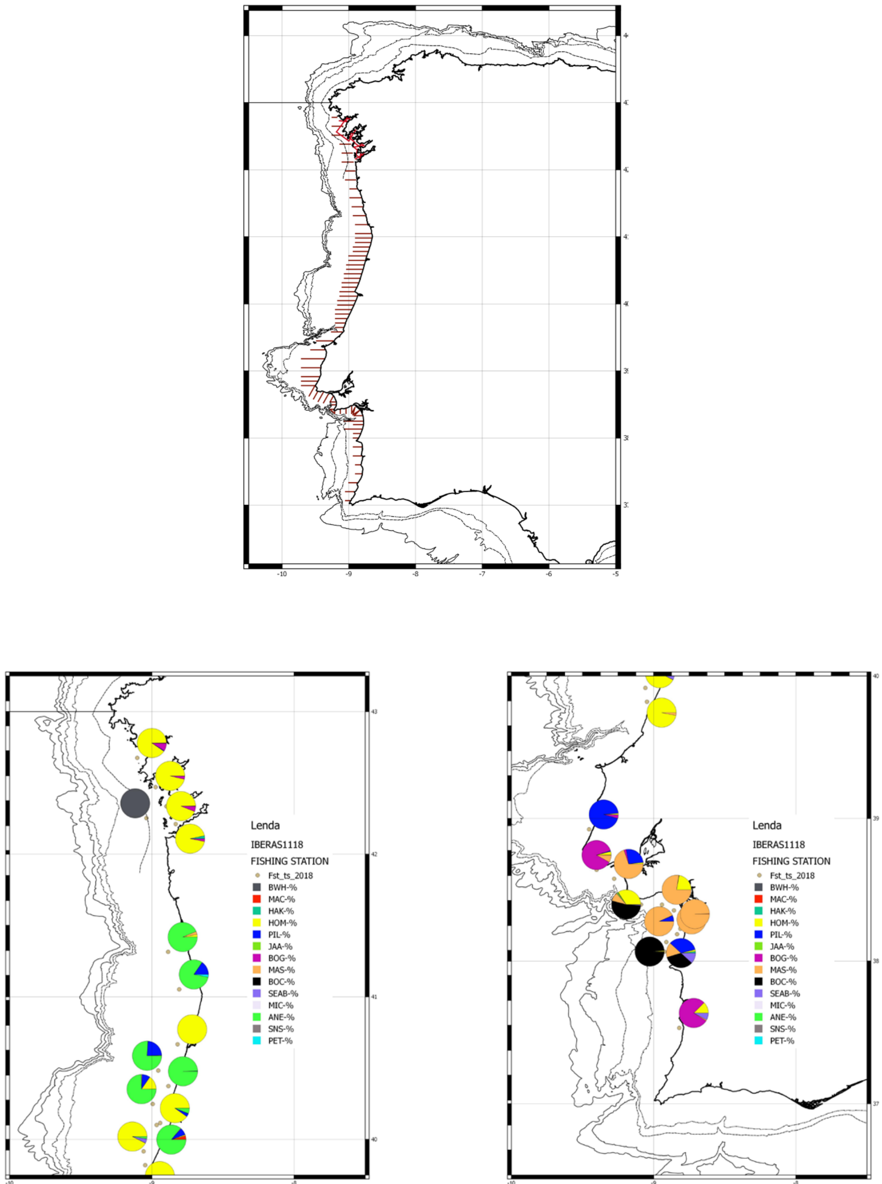


Figure 4.4.3.1. Anchovy in Division 9.a. Western component. Subdivisions 9.aNorth, 9.a Central-North and 9.a Central-South. *IBERAS 1118* survey (autumn Spanish-Portuguese acoustic survey in Subdivisions 9.aNorth to Central-South). Top: sampling grid. Bottom: location of valid fishing stations with indication of their species composition (percentages in number).Bottom: distribution of the backscattering energy (Nautical area scattering coefficient, NASC, in m^2 nmi^{-2}) attributed to the species and of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of fish density (in t nmi^{-2}) in each stratum.

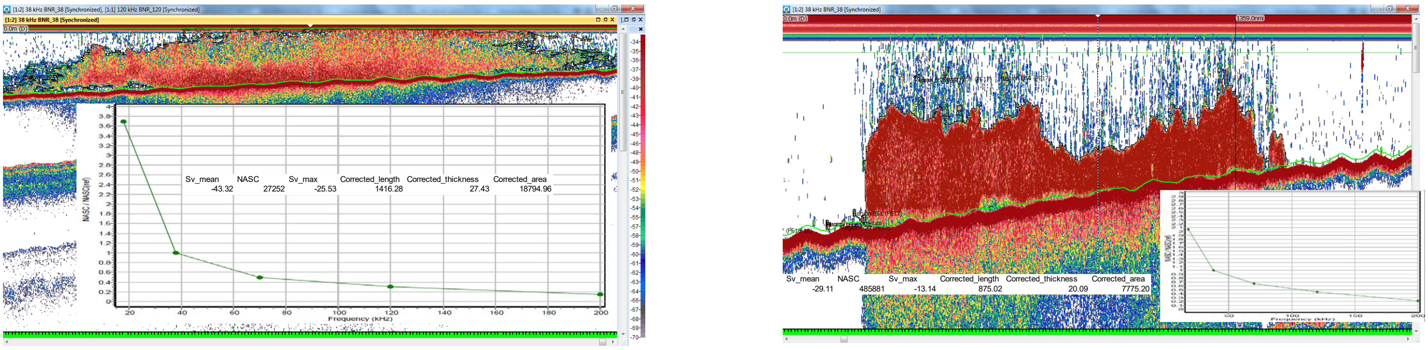


Figure 4.4.3.2. Anchovy in Division 9.a. Western component. Subdivisions 9.aNorth, 9.a Central-North and 9.a Central-South. *IBERAS 1118* survey (autumn Spanish-Portuguese acoustic survey in Subdivisions 9.aNorth to Central-South). Anchovy mega-school of about 1x4 nmi and 17 m height.

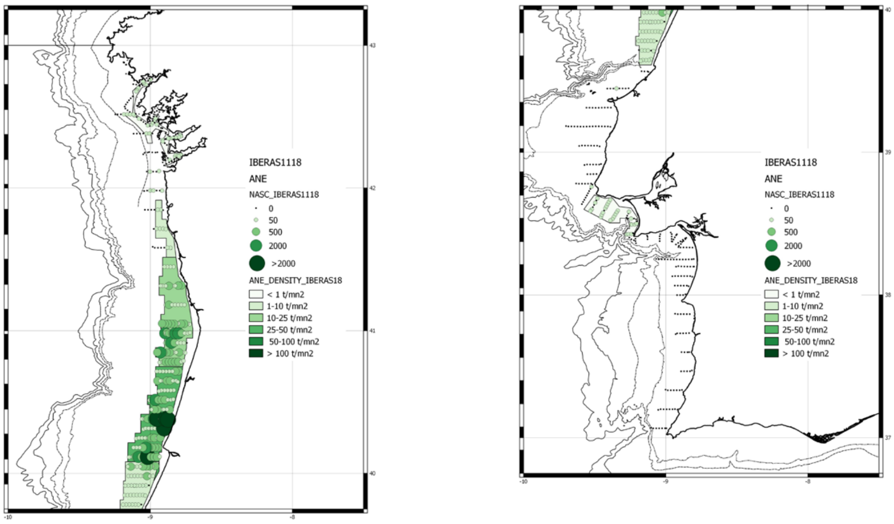


Figure 4.4.3.3. Anchovy in Division 9.a. Western component. Subdivisions 9.aNorth, 9.a Central-North and 9.a Central-South. *IBERAS 1118* survey (autumn Spanish-Portuguese acoustic survey in Subdivisions9.a North to Central-South). Distribution of the backscattering energy (Nautical area scattering coefficient, NASC, in m² nmi⁻²) attributed to the species and of the homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of fish density (in t nmi⁻²) in each stratum.

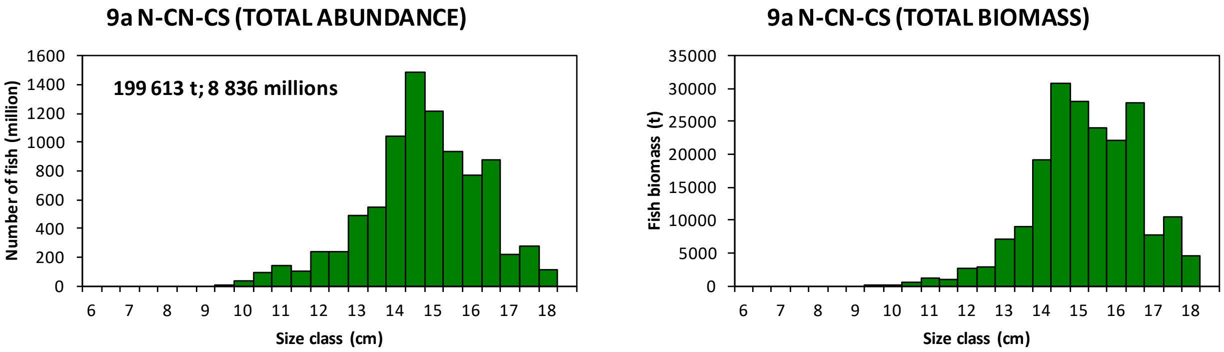


Figure 4.4.3.4. Anchovy in Division 9.a. Western component. Subdivisions 9.aNorth, 9.a Central-North and 9.a Central-South. *IBERAS1118* survey (autumn Spanish-Portuguese acoustic survey in Subdivisions9.a North to Central-South). Estimated abundances and biomasses (number of fish in millions and tonnes, respectively) for the surveyed area by length class (cm).Note the different scales in the y-axis.

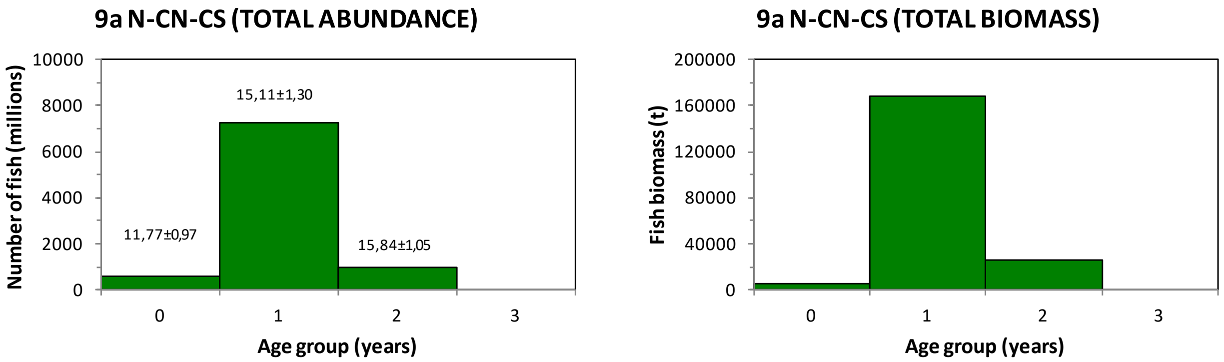


Figure 4.4.3.5. Anchovy in Division 9.a. Western component. Subdivisions 9.a North, 9.a Central-North and 9.a Central-South. *IBERAS1118* survey (autumn Spanish-Portuguese acoustic survey in Subdivisions 9.a North to Central-South). Estimated abundances and biomasses (number of fish in millions and tonnes, respectively) for the surveyed area by age group, with indication of the mean size by age. Note the different scales in the y-axis.

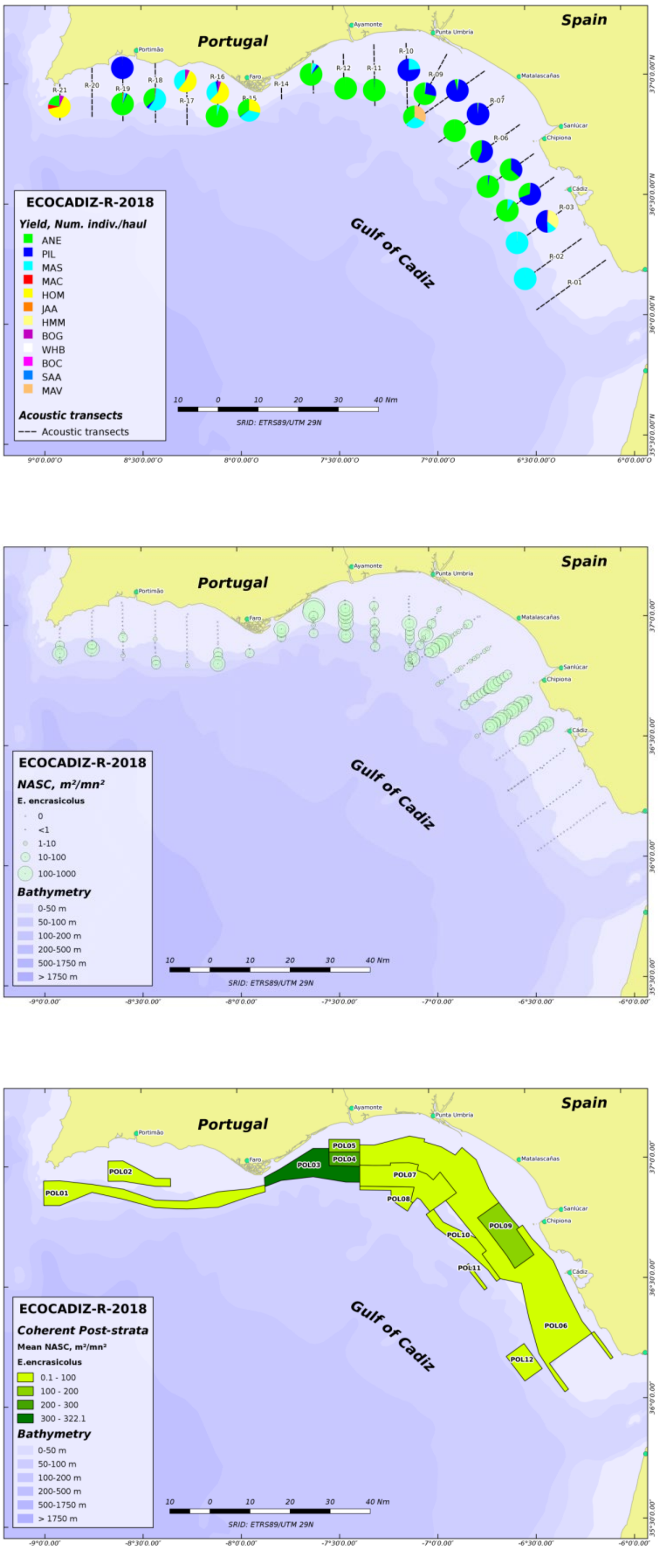


Figure 4.4.3.6. Anchovy in Division 9.a. Southern component. Subdivision 9.a South. *ECOCADIZ-RECLUTAS 2018-10* survey (autumn Spanish acoustic survey in Subdivision 9.a South). Top: Location of valid fishing stations with indication of their species composition (percentages in number).Middle: Distribution 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.

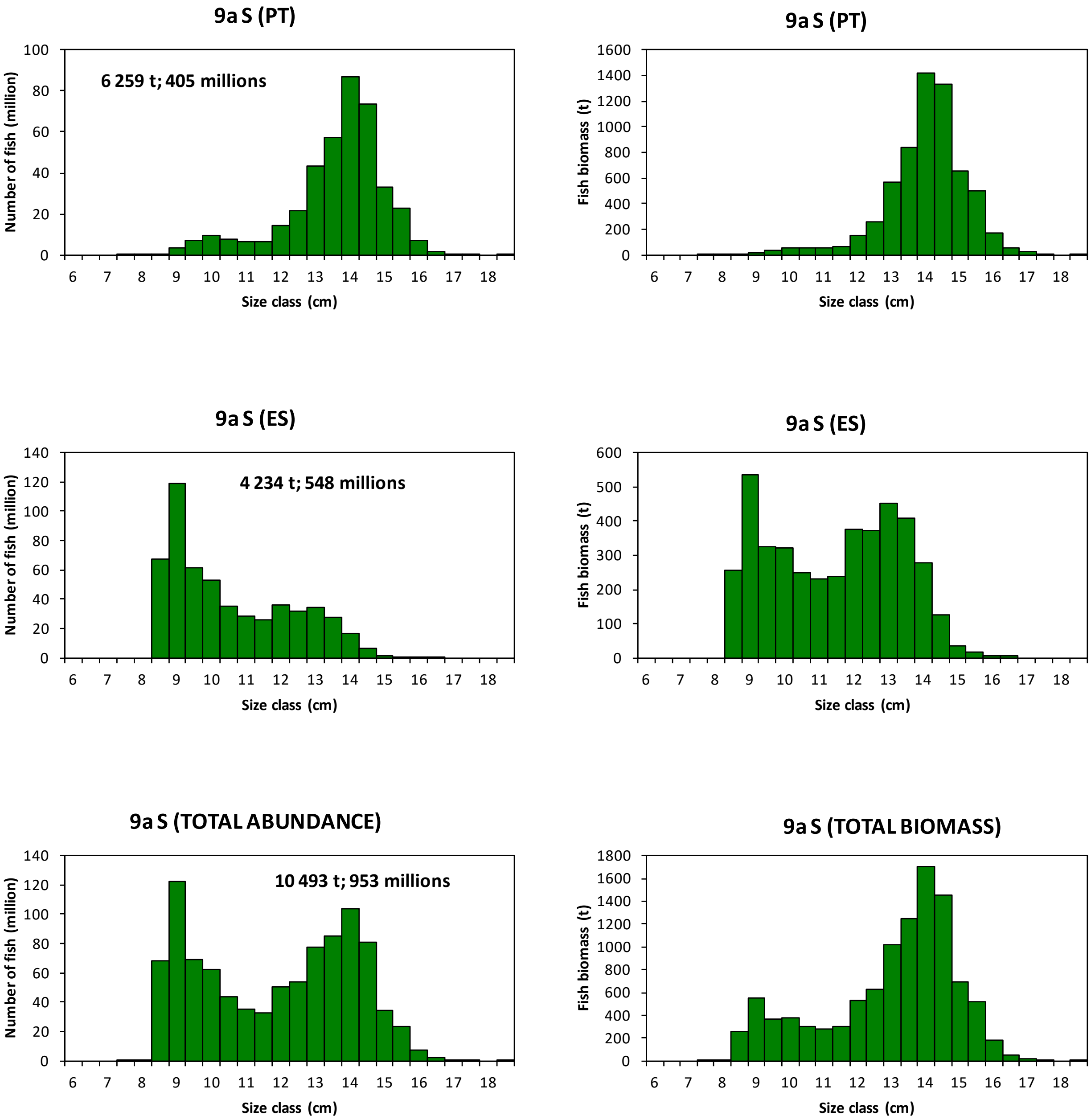


Figure 4.4.3.7. Anchovy in Division 9.a. Southern component. Subdivision 9.a South. *ECOCADIZ-RECLUTAS 2018-10* survey (autumn Spanish acoustic survey in Subdivision 9.a South). Estimated abundances and biomasses (number of fish in millions and tonnes, respectively) for the surveyed area by length class (cm).Note the different scales in the y-axis.

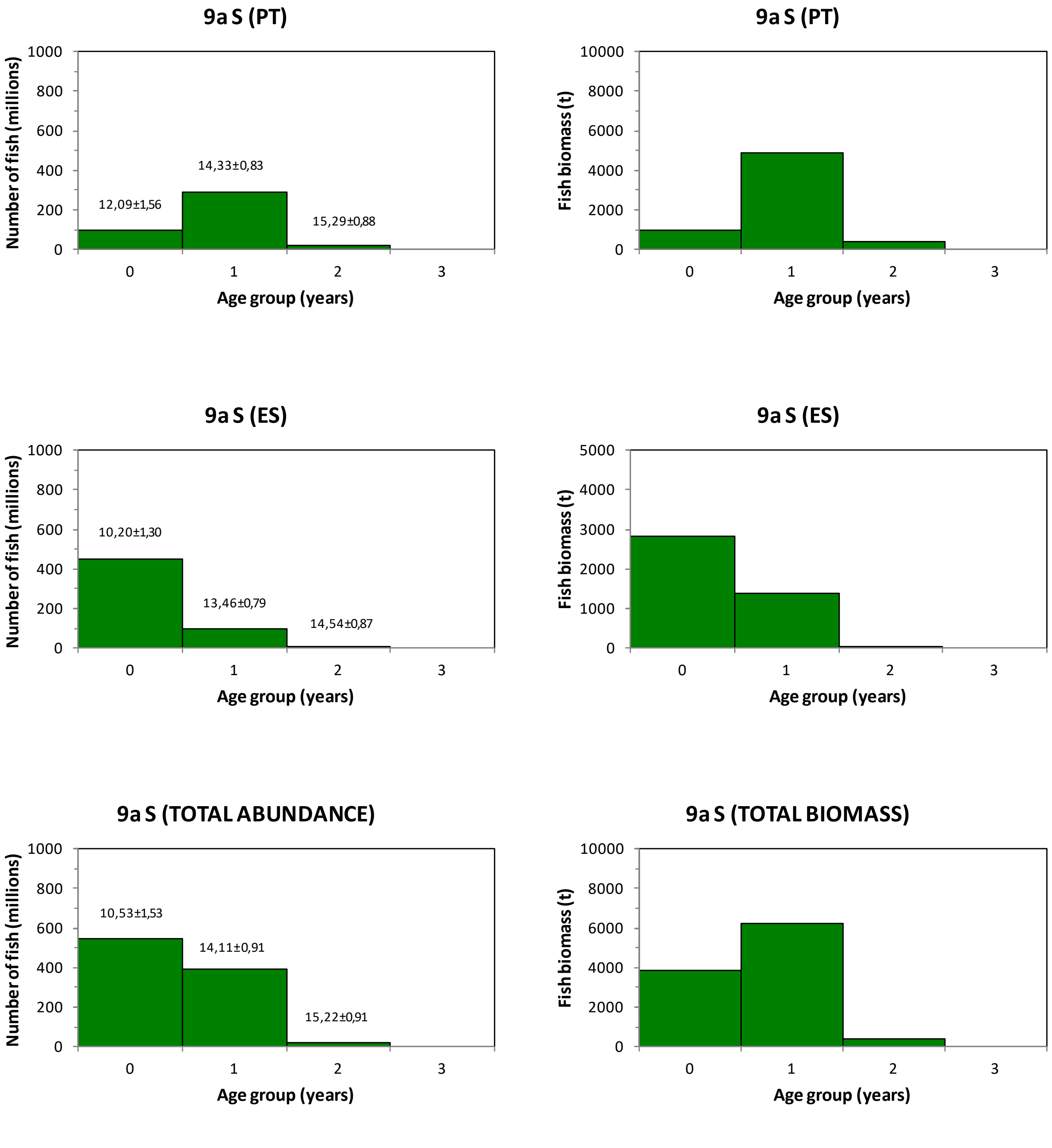


Figure 4.4.3.8. Anchovy in Division 9.a. Southern component. Subdivision 9.a South. *ECOCADIZ-RECLUTAS 2018-10* survey (autumn Spanish acoustic survey in Subdivision 9.a South). Estimated abundances and biomasses (number of fish in millions and tonnes, respectively) for the surveyed area by age group, with indication of the mean size by age. Note the different scales in the y-axis.

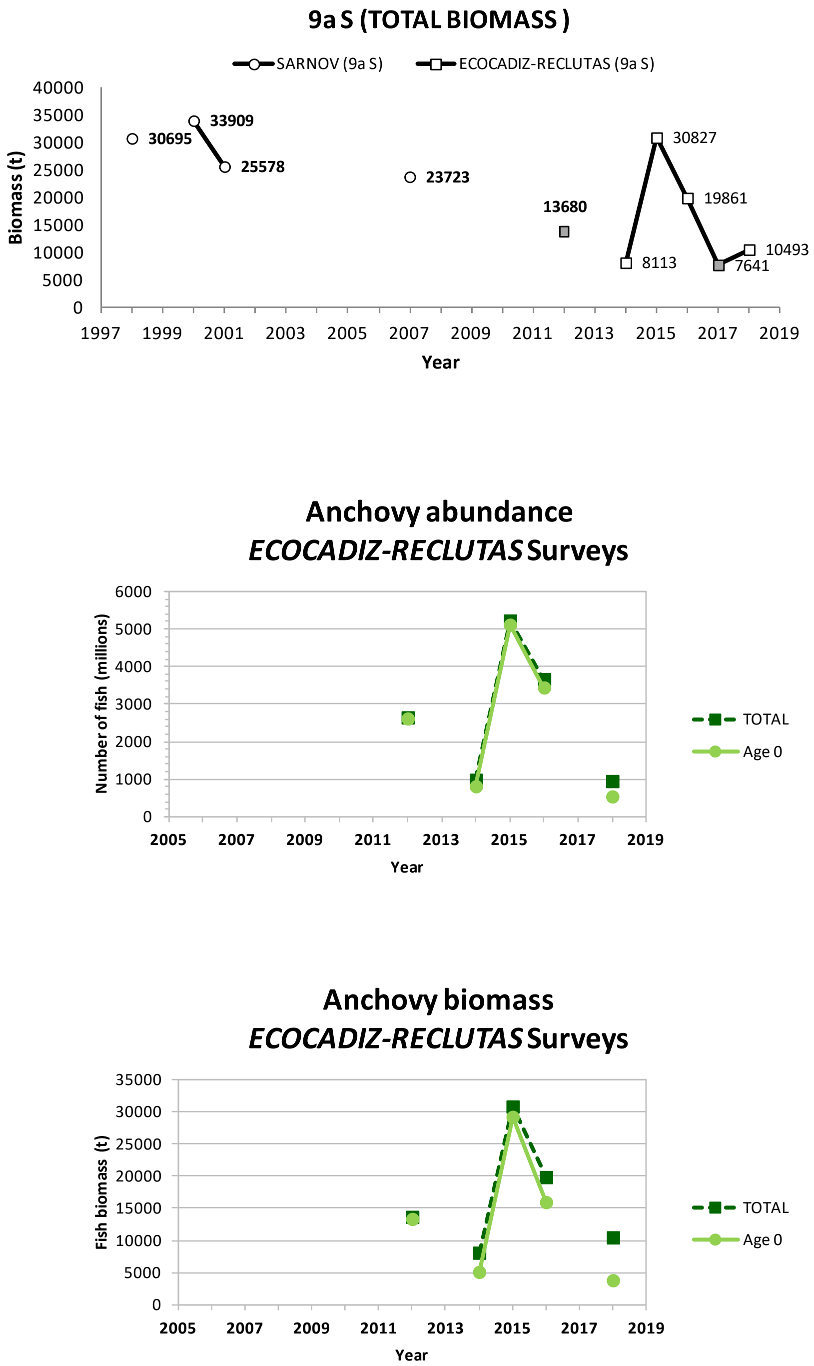


Figure 4.4.3.9. Anchovy in Division 9.a. Southern component. Subdivision 9.a South. *ECOCADIZ-RECLUTAS* survey series (autumn Spanish acoustic survey in Subdivision 9.a South). Top: historical series of overall acoustic estimates of anchovy biomass (t), (squares). The estimates from the older Portuguese *SARNOV* survey series are also included for comparison of trends (circles). The 2012 and 2017 estimates (in dark grey) are partial ones, since the surveys either covered the Spanish waters (2012) or the seven easternmost transects (2017). Middle and bottom: time-series estimates of abundance and biomass of the total population and Age 0 fish. In this case, the 2017 has not been included. The 2012 estimate is retained because the recruitment area was almost covered.

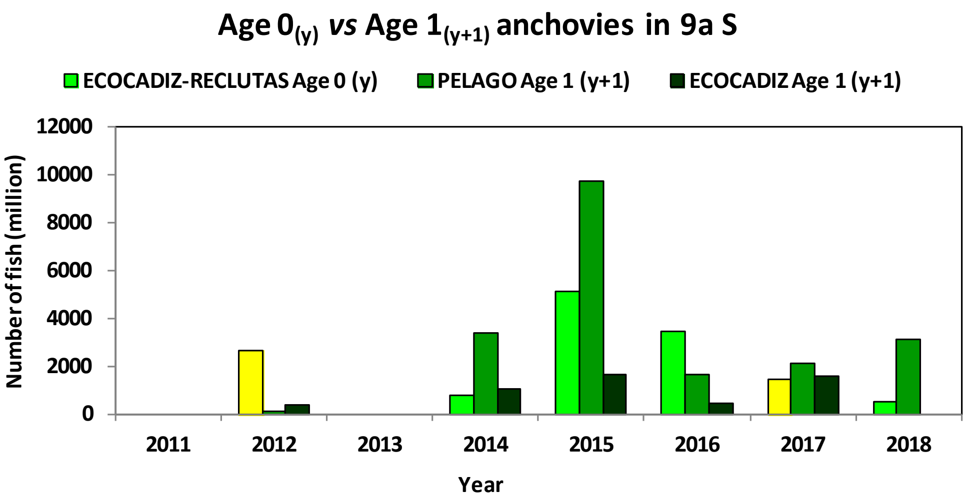


Figure 4.4.3.10. Anchovy in Division 9.a. Southern component. Subdivision 9.a South. *ECOCADIZ-RECLUTAS* survey series (autumn Spanish acoustic survey in Subdivision 9.a South). Correspondence between acoustic estimates of abundance of Age 0 anchovies from *ECOCADIZ-RECLUTAS* surveys in the autumn of 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). The *ECOCADIZ-RECLUTAS* 2012 and 2017 estimates are partial ones since the 2012 survey only covered the Spanish waters and the 2017 survey the seven easternmost transects. *ECOCADIZ* 2019 will be conducted after the WG.

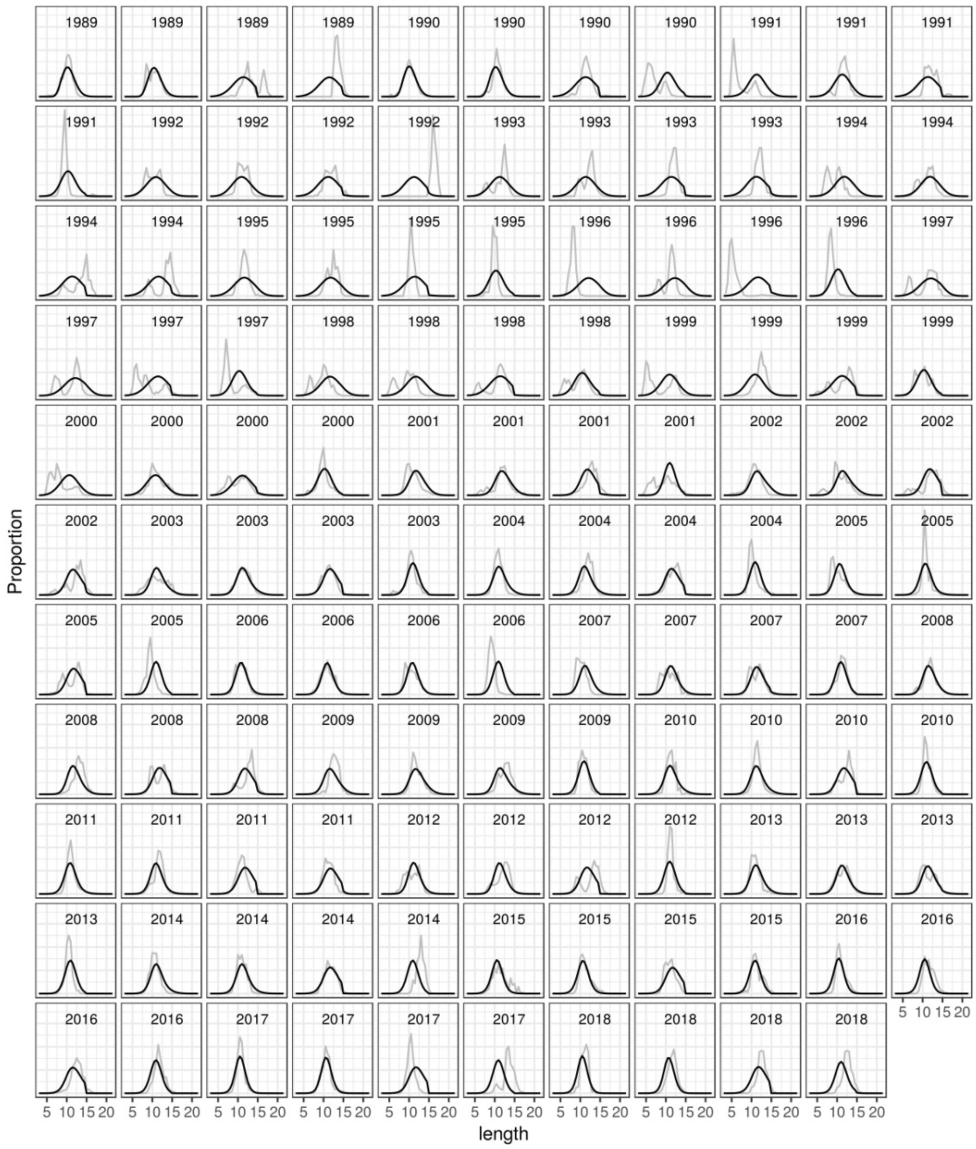


Figure 4.6.2.1.2.1. Anchovy in Division 9.a. Southern component. Comparison between observed and estimated catches length distribution by quarters from 1989 to 2018. Black lines represent estimated data while gray lines represent observed data.

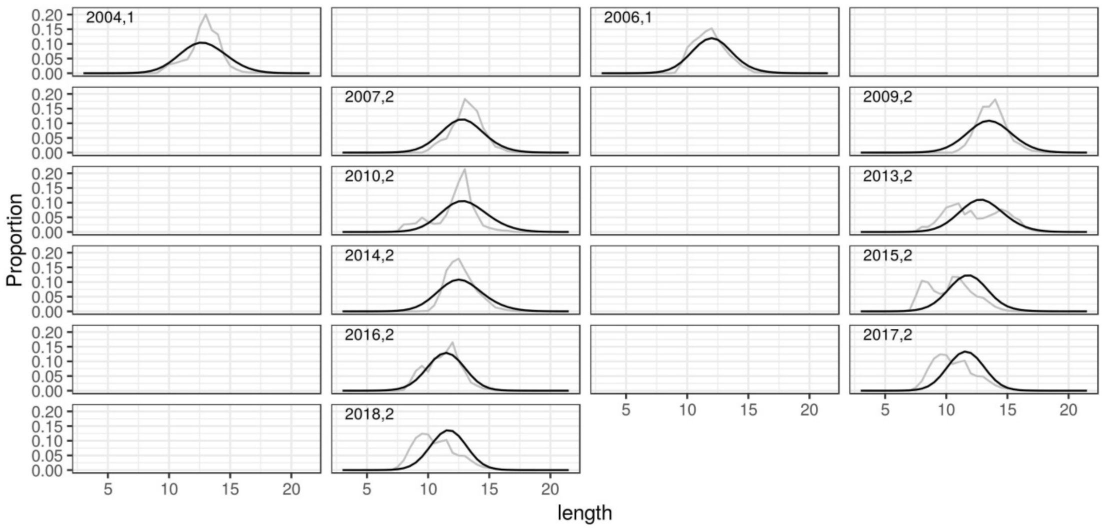


Figure 4.6.2.1.2.2. Anchovy in Division 9.a. Southern component. Comparison between observed and estimated catches length distribution for *ECOCADIZ* survey from 2004 to 2018. Black lines represent estimated data while gray lines represent observed data. The number next to the year indicates the quarter. Note that the time of the survey in the model is assumed to be one quarter before it really happens; this assumption follows from the order of calculations in the model.

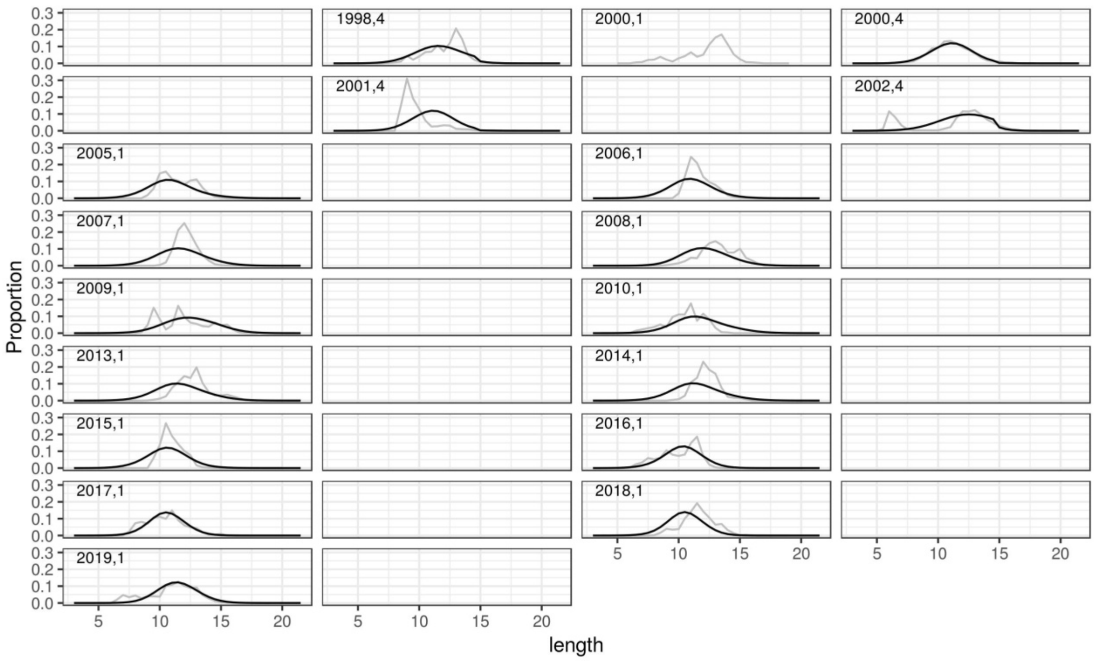


Figure 4.6.2.1.2.3. Anchovy in Division 9.a. Southern component. Comparison between observed and estimated catches length distribution for *PELAGO* survey from 1998 to 2019. Black lines represent estimated data while gray lines represent observed data. The number next to the year indicates the quarter. Note that the time of the survey in the model is assumed to be one quarter before it really happens; this assumption follows from the order of calculations in the model.

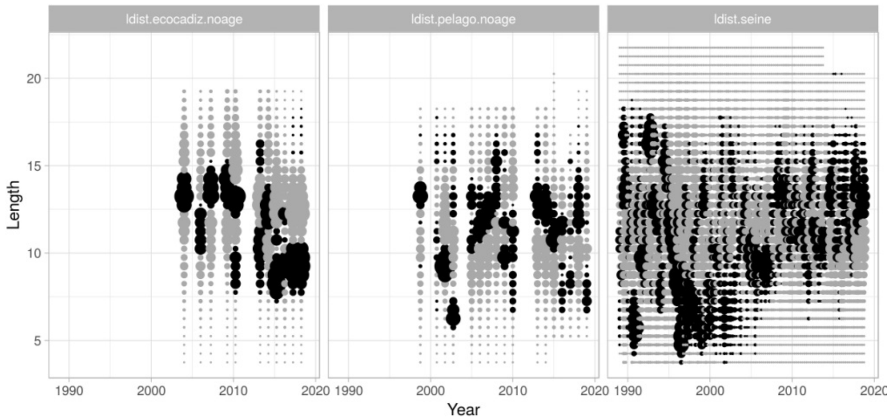


Figure 4.6.2.1.2.4. Anchovy in Division 9.a. Southern component. Standardised residual plots for the fitted length distribution from the *ECOCADIZ* survey, *PELAGO* survey and commercial fleet. Black points denote a model underestimate and gray points an overestimate. The size of the points denotes the scale of the standardised residual.

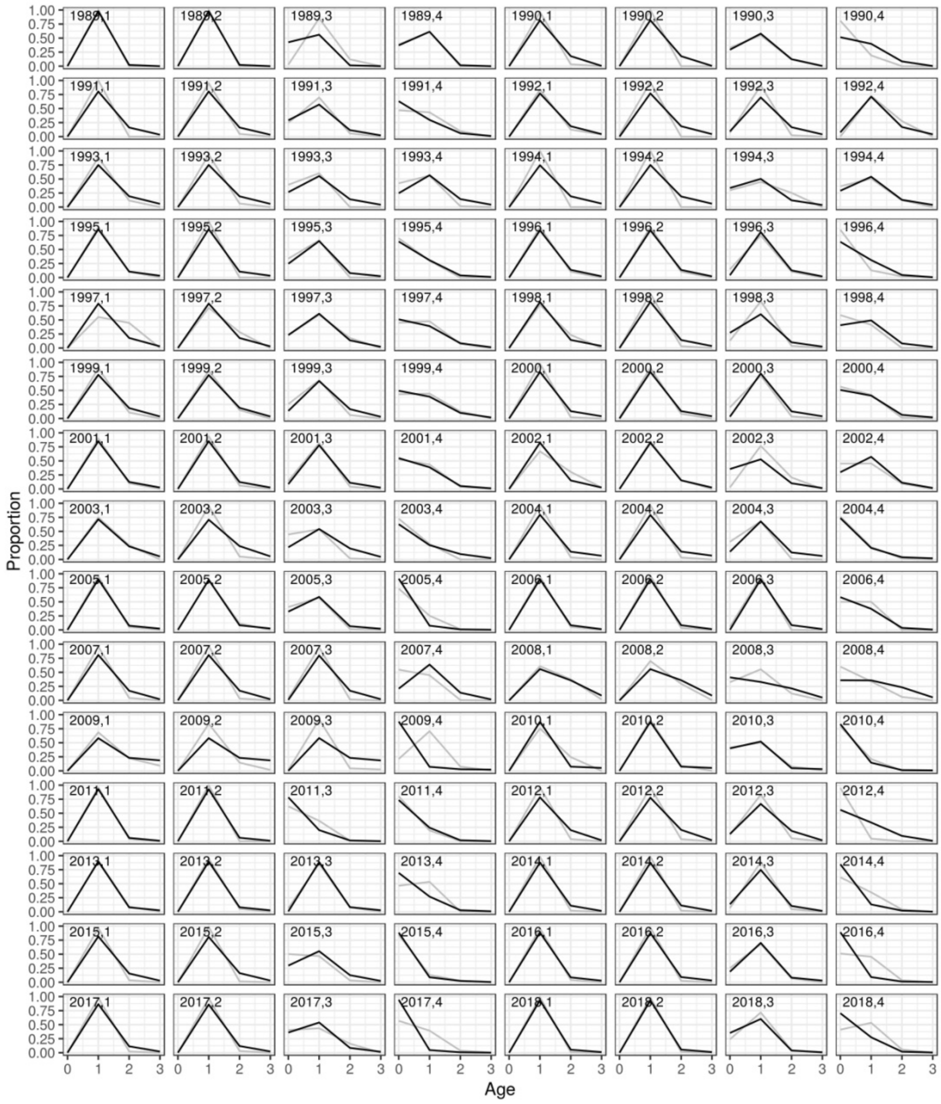


Figure 4.6.2.1.2.5. Anchovy in Division 9.a. Southern component. Comparison between observed and estimated quarterly catches age distribution from 1989 to 2018. Black lines represent estimated data while gray lines represent observed data. The number next to the year indicates the quarter.

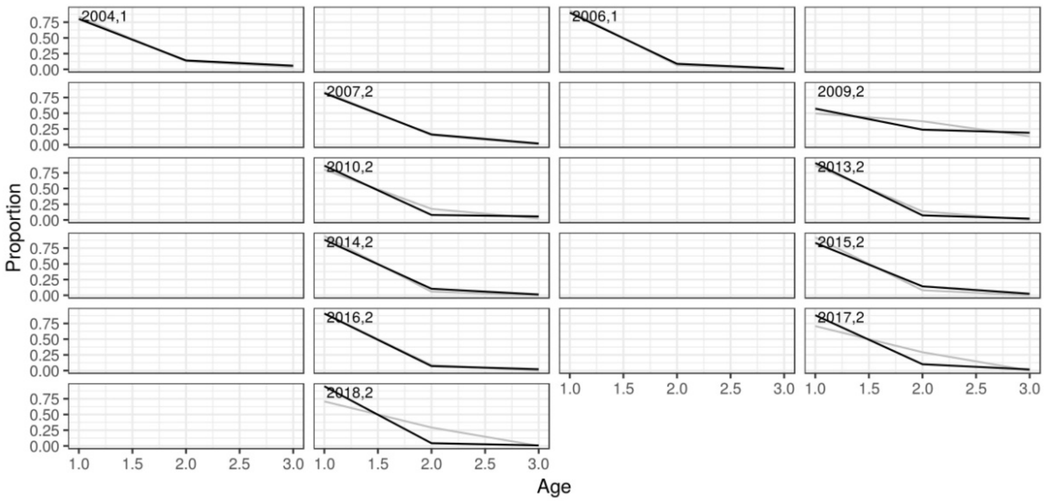


Figure 4.6.2.1.2.6. Anchovy in Division 9.a. Southern component. Comparison between observed and estimated *ECOCADIZ* survey age distribution from 2004 to 2018. Black lines represent estimated data while gray lines represent observed data. The number next to the year indicates the quarter. Note that the time of the survey in the model is assumed to be one quarter before it really happens; this assumption follows from the order of calculations in the model.

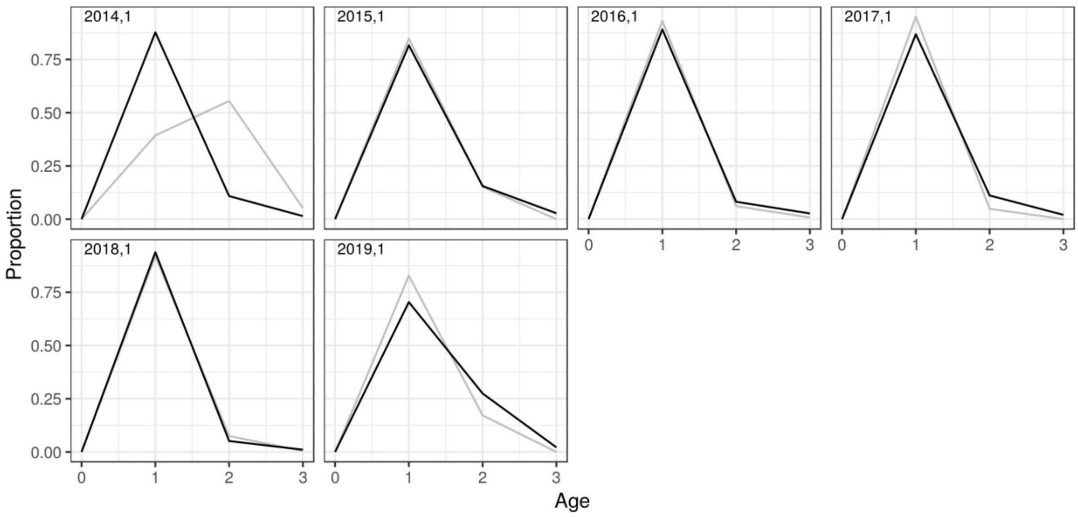


Figure 4.6.2.1.2.7. Anchovy in Division 9.a. Southern component. Comparison between observed and estimated *PELAGO* survey age distribution from 2014 to 2019. Black lines represent estimated data while gray lines represent observed data. The number next to the year indicates the quarter. Note that the time of the survey in the model is assumed to be one quarter before it really happens; this assumption follows from the order of calculations in the model.

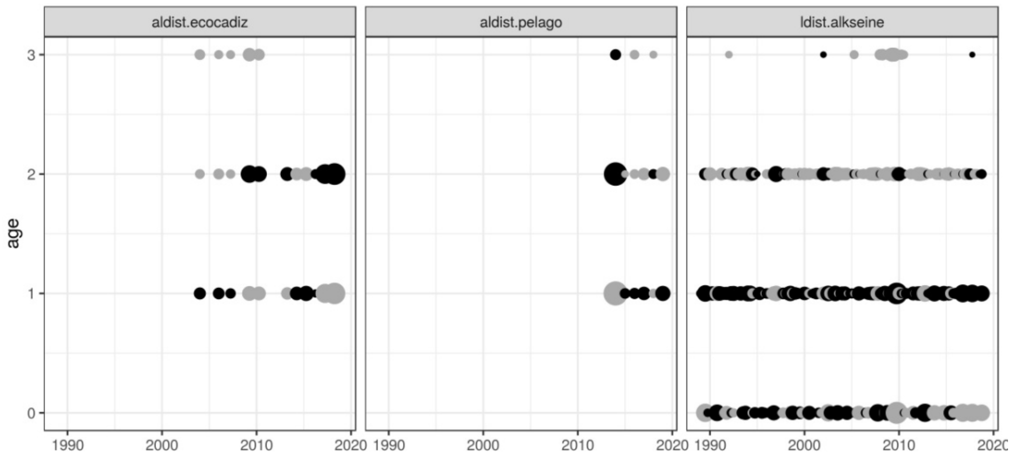


Figure 4.6.2.1.2.8. Anchovy in Division 9.a. Southern component. Standardised residual plots for the fitted age distribution from the *ECOCADIZ* survey, *PELAGO* survey and commercial fleet. Black points denote a model underestimate and gray points an overestimate. The size of the points denotes the scale of the standardised residual.

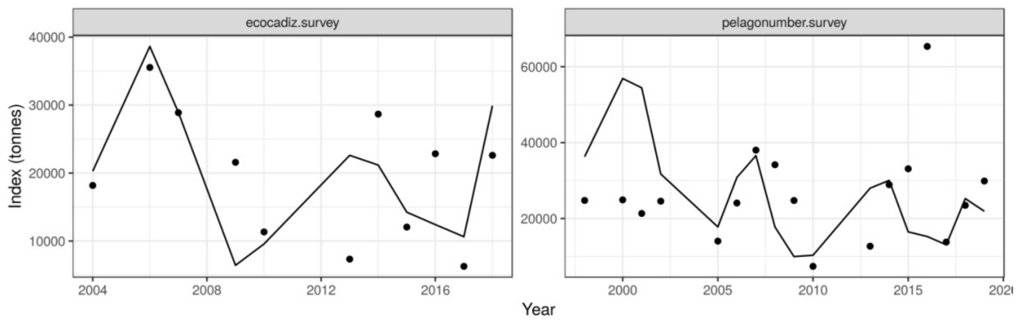


Figure 4.6.2.1.2.9. Anchovy in Division 9.a. Southern component. Comparison between observed and estimated survey biomass indices. Black points represent observed data while black line represents estimated data.

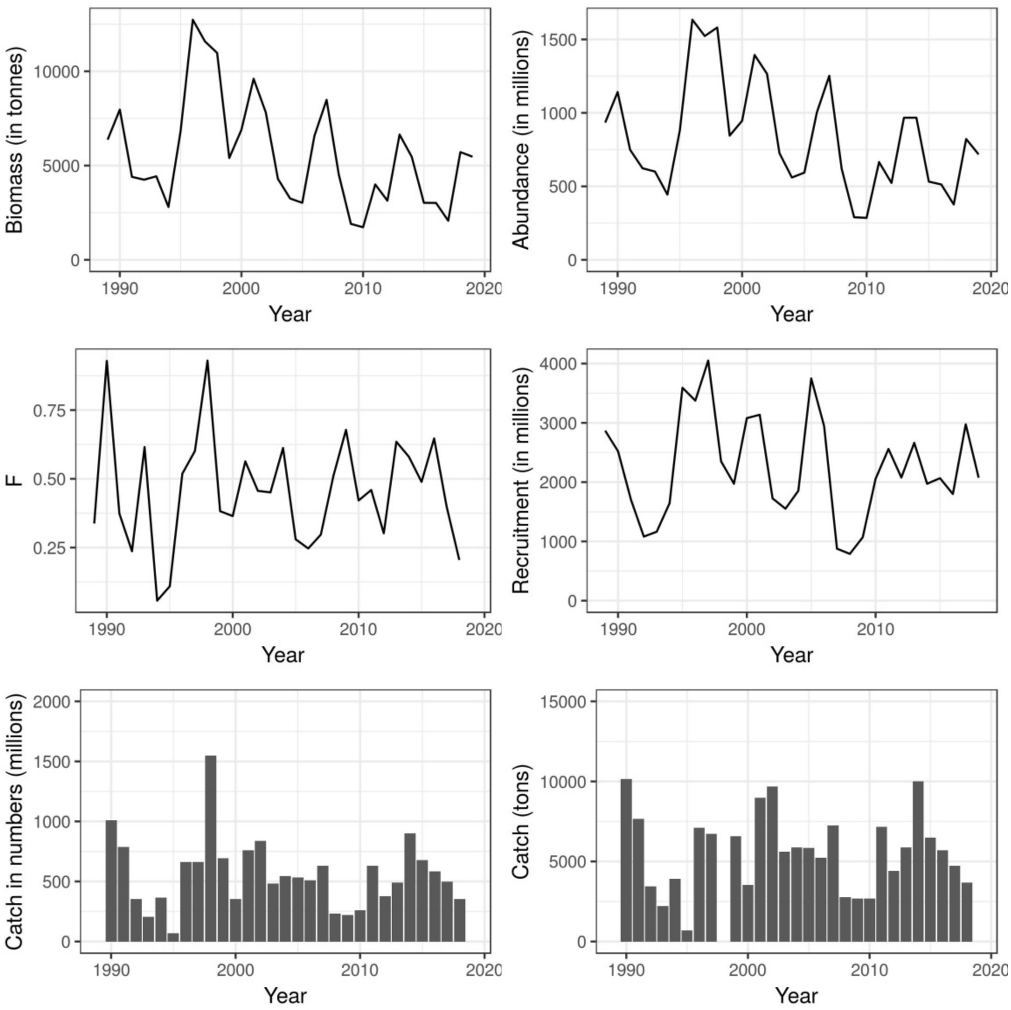


Figure 4.6.2.1.3.1. Anchovy in Division 9.a. Southern component. Annual model estimates for abundance (in numbers and biomass), recruitment and fishing mortality compared with annual catch time-series (in numbers and biomass). Measures were summarised at the end of June each year, assuming that a year starts in July and ends in June of the next year.

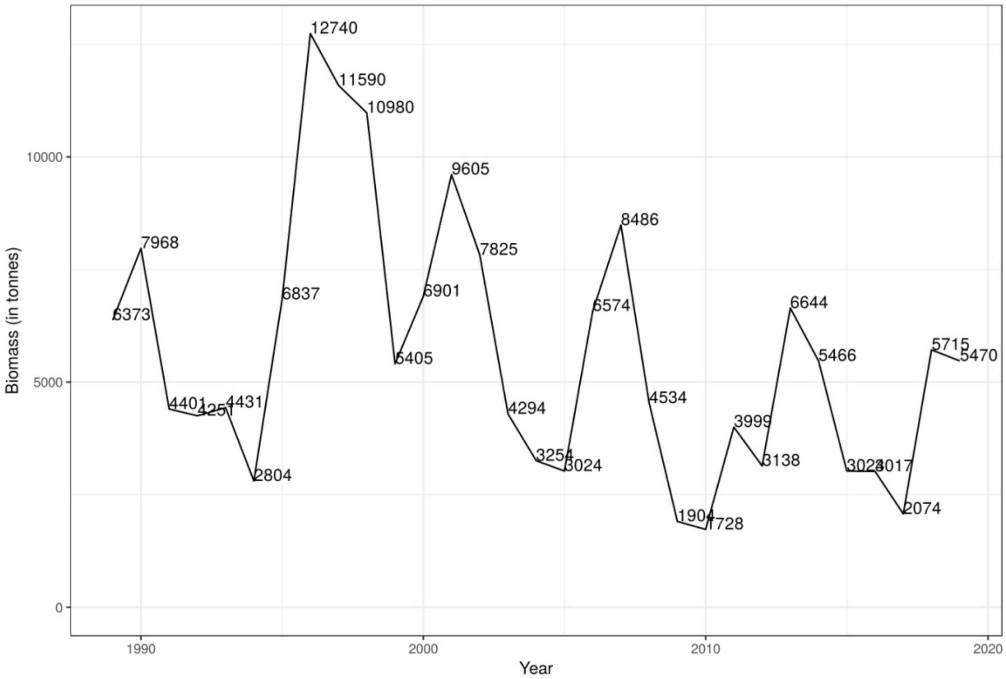


Figure 4.6.2.1.3.2. Anchovy in Division 9.a. Southern component. Time-series of estimated biomass at the end of June each year, assuming that a year starts in July and ends in June of the next year. For this stock, it is assumed that there are no individuals of age 0 at that time of the year, then this abundance estimates corresponds to individuals of age 1+. These biomass estimates are equivalent to spawning–stock biomass estimates since it is assumed that all individuals with age 1 or higher are mature.

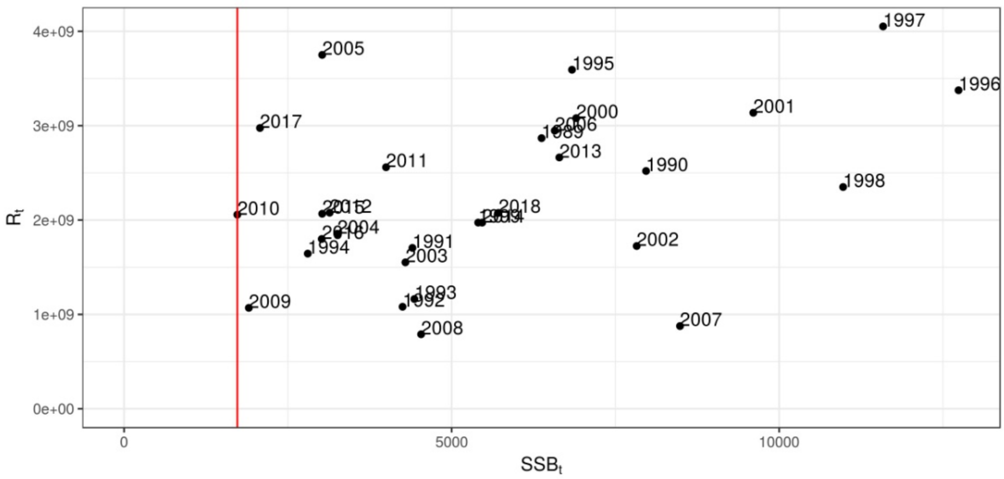


Figure 4.7.2.1. Anchovy in Division 9.a. Southern component. Estimated Stock Spawning biomass vs. Recruitment plot. Red line indicates the Blim value (Blim=Bloss=SSB2010=1730 t).

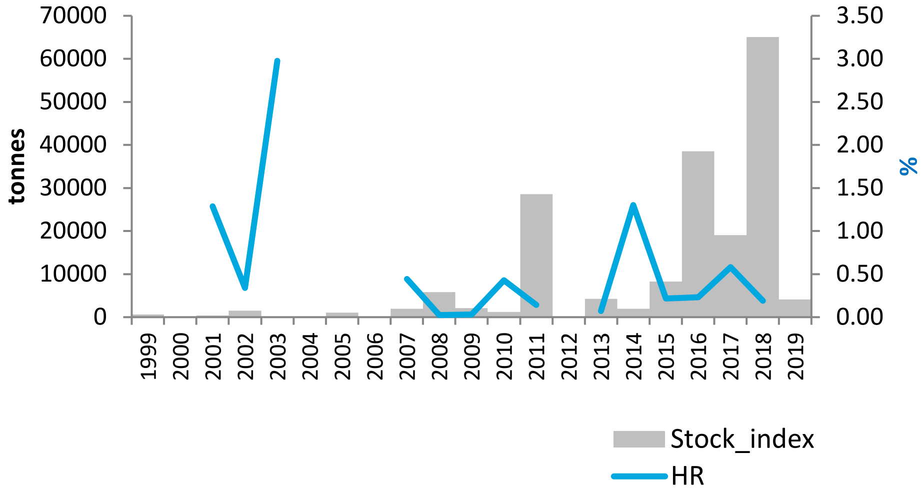


Figure 4.8.1.1. Anchovy in Division 9.a. Western Component. Stock biomass survey index and harvest rates. Harvest rates were estimated with the biomass of the surveys of a given year and the catches of the management period, i.e. 1989 corresponds to the period 07/1989 to 06/1990.

5 Sardine general

This stock section hasn't been updated.

6 Sardine in divisions 8a, b, d

6.1 Population structure and stock identity

Sardine in Celtic Seas (7a, b, c, f, g, j, k), English Channel (7d, 7e, 7h) and in Bay of Biscay (8a, b, d) are considered to belong to the same stock from a genetic point of view.

Therefore, it has been previously considered that the sardine stock in 8a, b, d and 7.as a single-stock unit. The assessment of this stock as a single unit has assumed that the trends derived from the observations made in the Bay of Biscay through the scientific surveys (PELGAS, BIOMAN) could be extended to the area 7.

Information from the ICES WKSAR workshop (ICES, 2016) suggests higher growth rates for the populations of the English Channel and Celtic sea than for the Bay of Biscay but it is unknown if this results from different oceanographic conditions or from population characteristics. Furthermore, there is no information on connectivity between the Bay of Biscay and English Channel/Celtic Sea. Bordering catches in Subarea 7 (statistical rectangles 25E4, 25E5) to the Bay of Biscay are generally considered to be taken from sardine populations in the Bay of Biscay. The recent PELTIC surveys (abundance of eggs, larvae, recruits and adults in the Channel) and results from the calorimetry/growth analysis suggest that Channel/Celtic Sea can be a self-sustained population. In fact, there are historical (Wallace and Pleasants, 1972) and recent evidence (Coombs *et al*., 2009) that a significant spawning takes place regularly in Subarea 7 and in a recent acoustic survey series in this area (PELTIC surveys) relevant concentrations of all life stages (eggs, juveniles and adults) have been found as well (van der Kooij *et al*. Presentation to WKSAR report ICES CM 2016/ACOM:41). Furthermore, the Cornish fisheries has been operating there for more than a century.

In terms of stock assessment, the availability of data strongly differs between the northern (Celtic Seas, English Channel) and the southern areas (Bay of Biscay). Additionally, each area presents different historical exploitation patterns. Therefore, analysis and management advice between the areas may differ.

The workshop concluded that in the absence of evidences of connectivity between the Bay of Biscay and Subarea 7 sardine populations, and taking into account the indications of shelf-sustained populations in each area (whereby all stages are found in substantial amounts in both regions) it would be preferable to deal with the Bay of Biscay and Subarea 7 separately.

6.2 Input data in 8a, b, d

6.2.1 Catch data in divisions 8a, b, d

Official landings per country are given in Table 6.2.1.1. Most of the landings correspond to France and Spain. As part of the inter-benchmark process in 2019, French landings have been revised from 2013 to 2017 (ICES, 2019).

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

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 and other regions of the north of Spain, which operate mostly in Division 8b (Spanish landings averaged around 4000 tonnes in the late 1990s early 2000s with peaks in 1998 and 1999 at almost 8 thousand tonnes. Catches have then decreased until 2010 to below 1 thousand tonnes. Since 2011, catches have raised again, reaching 16 237 tonnes in 2014. Landings in 2018 were 7094 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 an increasing trend which stopped in 2013 with 20 066 tonnes landed, which is close to the time-series maximum. In 2018, landings reached a new maximum with 25 195 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 usually taken in summer, even if sometimes catches can be important during winter. Almost all the catches are taken in southwest Brittany.

Table 6.2.1.1. Official landings reported to ICES (1989–2018).

	8 a,b,d									
year	France	Spain	Netherlands	Ireland	United Kingdom	Denmark	Germany	Lithuania	Belgium	Total
1989	8811	0	0	0	0	0	0	0	0	8811
1990	8543	0	0	0	0	0	0	0	0	8543
1991	12482	35	0	0	0	0	0	0	0	12517
1992	8847	43	0	0	0	0	0	0	0	8890
1993	8805	45	0	0	0	308	0	0	0	9158
1994	8604	0	0	0	0	0	0	0	0	8604
1995	9877	0	24	0	0	0	0	0	0	9901
1996	8604	0	0	0	0	0	0	0	0	8604
1997	10706	0	26	0	0	0	0	0	0	10732
1998	9778	873	0	0	0	0	68	0	0	10719
1999	0	2384	0	0	0	124	11	0	0	2519
2000	10615	3158	34	0	0	0	38	0	0	12505
2001	10004	3720	333	0	0	0	135	0	0	10589
2002	11977	4428	23	19	276	0	4	0	0	15519
2003	9809	1113	68	1750	68	0	0	0	0	14925
2004	11155	342	6	1401	0	0	0	0	0	13231
2005	10975	898	1	974	0	0	54	0	0	17694
2006	10884	825	2	49	0	12	78	5	0	16986

	8 a,b,d									
year	France	Spain	Netherlands	Ireland	United Kingdom	Denmark	Germany	Lithuania	Belgium	Total
2007	13231	1263	0	0	0	48	0	0	0	16814
2008	18071	717	0	0	1	39	0	0	0	23133
2009	15847	228	0	0	0	0	0	0	0	21229
2010	12877	642	0	0	0	0	0	0	0	22432
2011	12469	5283	5	0	0	0	0	0	0	25155
2012	10854	14948	0	0	0	0	0	0	0	33100
2013	13614*	12423	445	0	252	0	0	0	0	37291
2014	14730*	16237	0	0	0	0	0	0	0	39829
2015	13132*	13055	0	25	7	0	1	0	0	31574
2016	14320*	6824	65	0	0	0	0	0	0	30122
2017	17265*	6380	0	0	0	0	0	0	0	30249
2018	18161*	7094	0	0	0	0	0	0	0	32289

Table 6.2.1.2. Sardine landings by France (1983–2018) and Spain (1996–2018) in ICES divisions 8a,b,d as estimated by the WG.

Year	France	Spain	total
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	13965	n/a	
1992	10231	n/a	
1993	9837	n/a	
1994	9724	n/a	
1995	11258	n/a	
1996	9554	2053	11607
1997	12088	1608	13696
1998	10772	7749	18521
1999	14361	7864	22225
2000	11939	3158	15097
2001	11285	372	11657
2002	13849	4428	18277
2003	15494	1113	16607
2004	13855	342	14197
2005	15462	898	16360
2006	15916	825	16741
2007	16060	1263	17323
2008	21104	717	21821
2009	20627	228	20855
2010	19485	642	20127
2011	17925	5283	23208
2012	15952	14948	30900
2013	20515	12423	32938
2014	19467	16237	35704
2015	15701	13055	28756
2016	2293	6824	29754
2017	24055	6380	30435
2018	25195	7104	32299

6.2.2 Surveys in divisions 8abd

6.2.2.1 DEPM surveys in Divisions 8abd

The DEPM survey BIOMAN takes place annually in spring in the Bay of Biscay with the main objective of estimate 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 estimate since 2011. The survey took place from the 9th to the 31st of May. All the methodology for the survey and the estimates performance, are described in detail in Annex A.5_stock annex - Bay of Biscay Anchovy (Subarea 8). A detailed report of the survey and results 2019 is attached as a working document in ICES, WGACEGG 2019 in Annex 3 (Santos M. *et al*. BIOMAN 2019).

Total egg abundance for sardine was estimate as the sum of the numbers of eggs in each station multiplied by the area each station represents. This year sardine egg abundance estimate was 7.59E+12 eggs, considered the whole area surveyed. Considering the 8abd the estimate was 6.86E+12 and removing part of the North for assessment propose, to be consistent with the historical series, the total egg abundance was 4.49E+12 eggs, below the time-series average (5.85E+12) (Figure 6.2.2.1.1, Table 6.2.2.1.1). Sardine eggs were encountered all along the Cantabric coast, from the coast to 200 m depth, between 2º and 6º00’W; the west spawning limit was not found in the Cantabric coast, although few eggs were encountered in the last transect completed to the west. In the French platform, sardine eggs were encountered along the isobath of 100 m depth until 46ºN. And from there to 48ºN between coast and 100 m depth. In 48ºN at 100 m depth a patch of sardine eggs was encountered as last year and as well as happened for anchovy, those were taken into account for the estimation of the egg abundance. (Figure 6.2.2.1.2).

In the sampling with the PairoVET net (vertical sampling) from 782 stations a total of 300 (38%) had sardine eggs with an average of 200 eggs/m^2 per station in the positive stations, a maximum of 2840 egg m^2 in a station and a total number of eggs sorted of 59 770 eggs/m^2. In the sampling with CUFES (horizontal sampling) a total of 727 stations (38%) had sardine from 1883 stations. To cover the spawning area of sardine in the 8abd the survey was extended to the North until 48ºN and to the West in the French platform, until the west limit of the sardine spawning area was delimited. But for the propose to be an input for the assessment of sardine in the 8abd, stations from the Northwest were removed to maintain the same coverage of the area of the time-series (Figure 6.2.2.1.2).

This year the total sardine egg production for 2019 and 2018 was as well estimate trying to obtain it for all the historical series. The following years will be estimate for the previous years to complete the series and to have this more formal estimate for all the series in 8abd. For the time being, this estimate (P_{tot}) is available for years 2002, 2008, 2011, 2014, 2017, 2018, 2019.

Table 6.2.2.1.1. Time-series for sardine, total egg abundances (Σ(egg_St*area_st)) in numbers of eggs, without the North-west, the one adopted as an input for the assessment of sardine in 8abd.

Year	TotAb_8abd_without N
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	5.47E+12
2014	8.21E+12
2015	5.52E+12
2016	8.56E+12
2017	5.99E+12
2018	4.67E+12
2019	4.49E+12
Mean	**5.85.E+12**
Std Dev	**3.E+12**
CV	**46.0%**

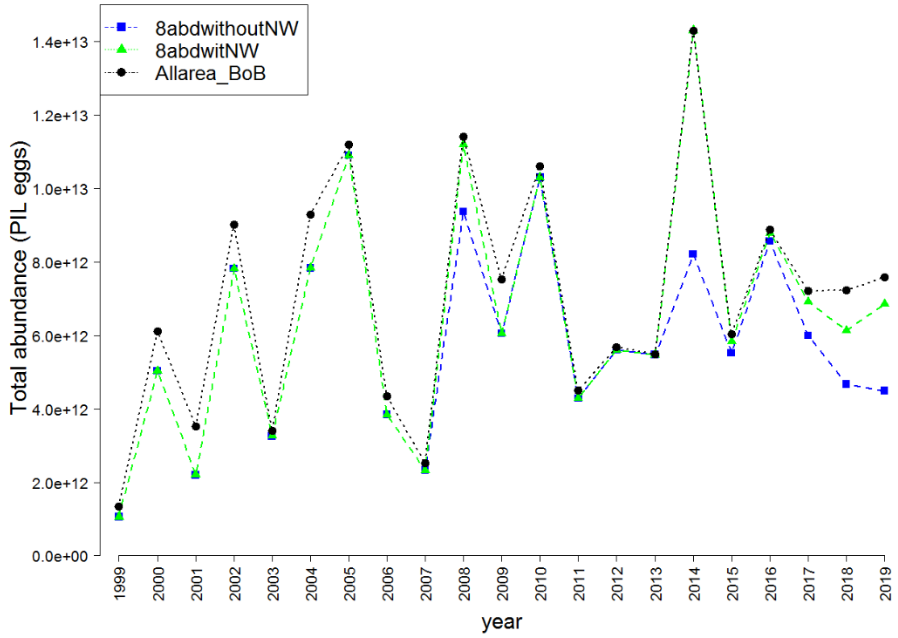


Figure 6.2.2.1.1. Historical series for sardine egg abundances in all the area surveyed (black line), in all 8abd (green line) and 8abd without Northwest stations (blue line) including 2019.

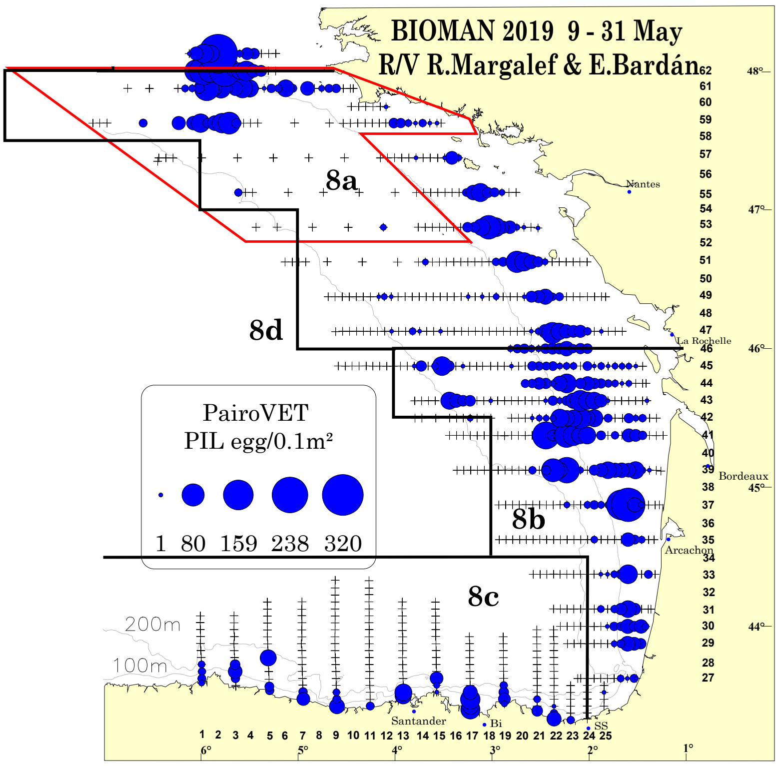


Figure 6.2.2.1.2. Distribution of sardine egg abundances (eggs per 0.1 m²) from the DEPM survey BIOMAN2019 obtained with PairoVET. The red line represents the stations removed for assessment propose in 8abd. Black lines represent the limits of 8abcd.

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 2019, PELGAS took place from the 23rd April to 25th of May and detailed objectives, methodology and sampling strategy are described in the WD- *Duhamel et al.* (2019) 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 PELGAS18 is 328 741 tons (Table 3.3.2.1), which constitutes an increase from last year, the biomass reaching a medium level of the PELGAS series. It must be noticed that the sardine abundance index is very variable, and it could be explained that this survey doesn't 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. It is also possible that sometimes, a small fraction of the population could be present in very coastal waters, when the RV Thalassa is unable to operate in those waters.

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.ab) sardine population.

Sardine was distributed (Figure 6.2.2.2.1) all along the French coast of the bay of Biscay, from the south to the north. The small sardine was present this year, pure along the Lande's coast sometimes mixed with other species (sprat and anchovy this year) along the coast. Sardine appeared also sometimes present close to the surface in the middle of the platform in the northern part of the Bay of Biscay (on the great mud bank) which is not his regular habitat. Offshore, close to the surface, along the shelf break, sardine was totally absent this year.

Sardine length distribution is shown in Figure 6.2.2.2.2. The strong fist mode, about 14 cm corresponds to age 1 and suggest again that a good recruitment occurred.

PELGAS19 sardine length–weight and age–length keys are presented in Figure 6.2.2.2.3 and Table 6.2.2.2.1, respectively.

Sardine proportions-at-age are presented in Figure 6.2.2.2.4. The population is still very young, with an age distribution largely dominated age 1 and 2 groups (sum about 92% in numbers).

Series of sardine abundances-at-age (2000–2019) is shown in Figure 6.2.2.2.5. Cohorts can be visually tracked on the graph particularly in the past : 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. This is less true in recent years, with the good recruitment in 2013, which doesn't profit to incoming years, or the 2017 year class which seems to be the best recruitment ever and who seems to contribute not that much to the total abundance of sardine in 2018 in the Bay of Biscay. The year 2019 seems to have the best recruitment ever and the population is becoming younger and younger (81% of the fish are 1 year olds).

The PELGAS sardine mean weights-at-age series (Figure 6.2.2.2.6) shows a clear decreasing trend, whose biological determinant is still poorly understood. It must be noticed that there is no real evolution since 2011 concerning ages 1 and 2, but older ages (4 and 5) continue to show a decreasing weight-at-age.

Further work must be conducted to explore the causes of the fluctuation of mean weights-at-ages.

The spatial pattern of sardine eggs overlaps with the one of anchovy, without any distribution along the shelf break this year. For sardine, egg abundances are at a low level with regards to the whole Pelgas time-series. The cufes index has been processed this year, with the egg abundance corrected by the vertical model, and the trend is the same as the egg count. It is also possible to have a look at the estimate fecundity dividing the egg count corrected by the vertical model by the acoustic biomass (Figures 6.2.2.2.7). The fecundity appears low this year, corroborated by the youth of the sardine population (age 1 starting their maturation).

Table 6.2.2.2.1. Sardine age–length key from PELGAS19 samples (based on 1108 otoliths).

Nombre de Age	Age								
Taille	1	2	3	4	5	6	7	8	Total général
10	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
10.5	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
11	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
11.5	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
12	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
12.5	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
13	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
13.5	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
14	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
14.5	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
15	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
15.5	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
16	92.31%	5.13%	2.56%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
16.5	61.29%	38.71%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
17	15.52%	77.59%	5.17%	1.72%	0.00%	0.00%	0.00%	0.00%	100.00%
17.5	2.99%	82.09%	13.43%	0.00%	1.49%	0.00%	0.00%	0.00%	100.00%
18	0.00%	70.13%	24.68%	3.90%	1.30%	0.00%	0.00%	0.00%	100.00%
18.5	0.00%	28.21%	69.23%	1.28%	1.28%	0.00%	0.00%	0.00%	100.00%
19	0.00%	24.42%	60.47%	9.30%	5.81%	0.00%	0.00%	0.00%	100.00%
19.5	0.00%	8.75%	70.00%	8.75%	11.25%	1.25%	0.00%	0.00%	100.00%
20	0.00%	4.23%	52.11%	11.27%	25.35%	4.23%	2.82%	0.00%	100.00%
20.5	0.00%	1.54%	43.08%	15.38%	26.15%	10.77%	3.08%	0.00%	100.00%
21	0.00%	2.38%	14.29%	19.05%	35.71%	23.81%	2.38%	2.38%	100.00%
21.5	0.00%	0.00%	2.70%	16.22%	45.95%	24.32%	10.81%	0.00%	100.00%
22	0.00%	0.00%	0.00%	8.33%	16.67%	66.67%	0.00%	8.33%	100.00%
22.5	0.00%	0.00%	0.00%	14.29%	28.57%	57.14%	0.00%	0.00%	100.00%
23	0.00%	0.00%	0.00%	0.00%	20.00%	0.00%	80.00%	0.00%	100.00%
23.5	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	100.00%
Total général	36.11%	20.65%	24.63%	5.00%	8.33%	3.89%	1.20%	0.19%	100.00%

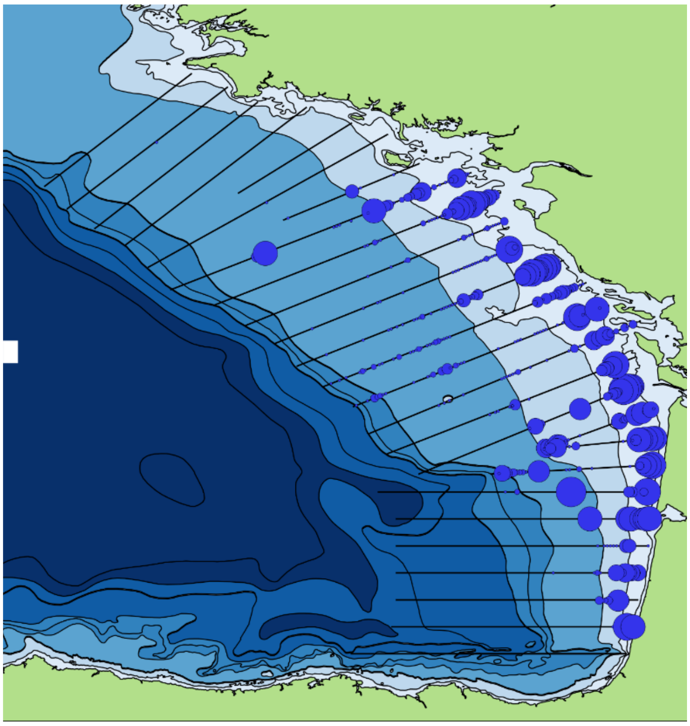


Figure 6.2.2.2.1. Sardine distribution during PELGAS19 survey.

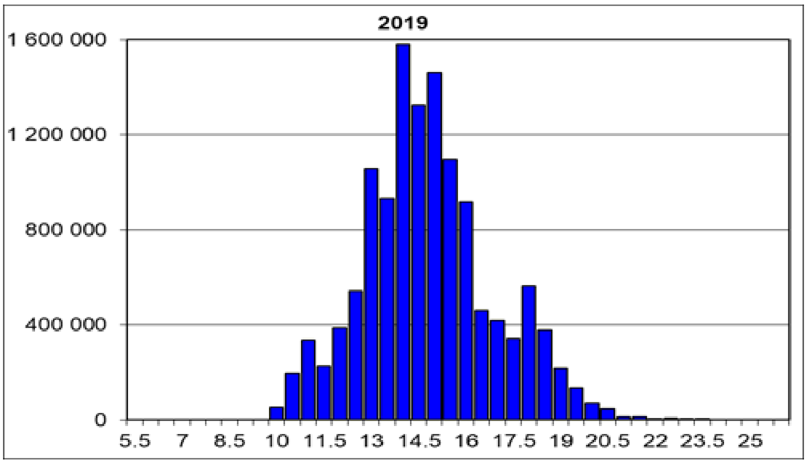


Figure 6.2.2.2.2. Length distribution of sardine as observed during PELGAS19.

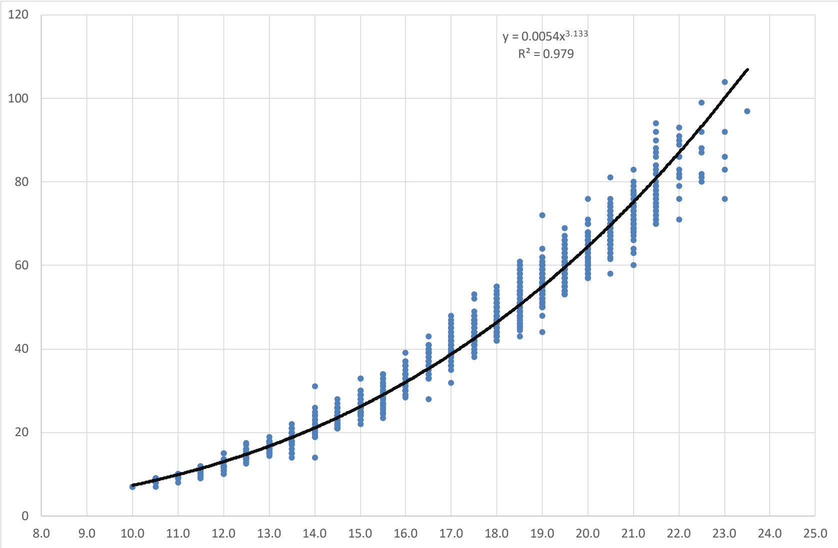


Figure 6.2.2.3. Weight–length key of sardine established during PELGAS19.

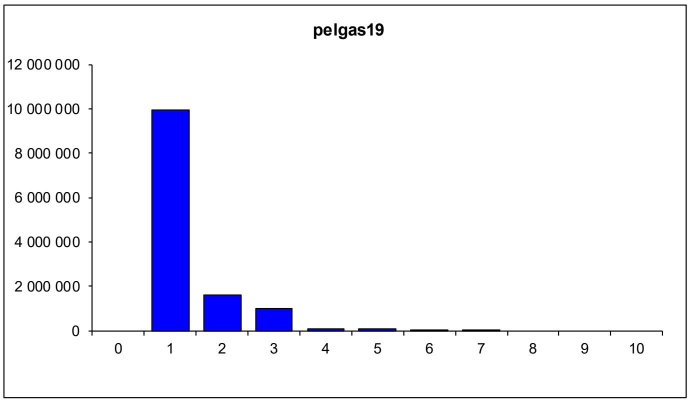


Figure 6.2.2.2.4. Global age composition (nb) of sardine as observed during PELGAS 19.

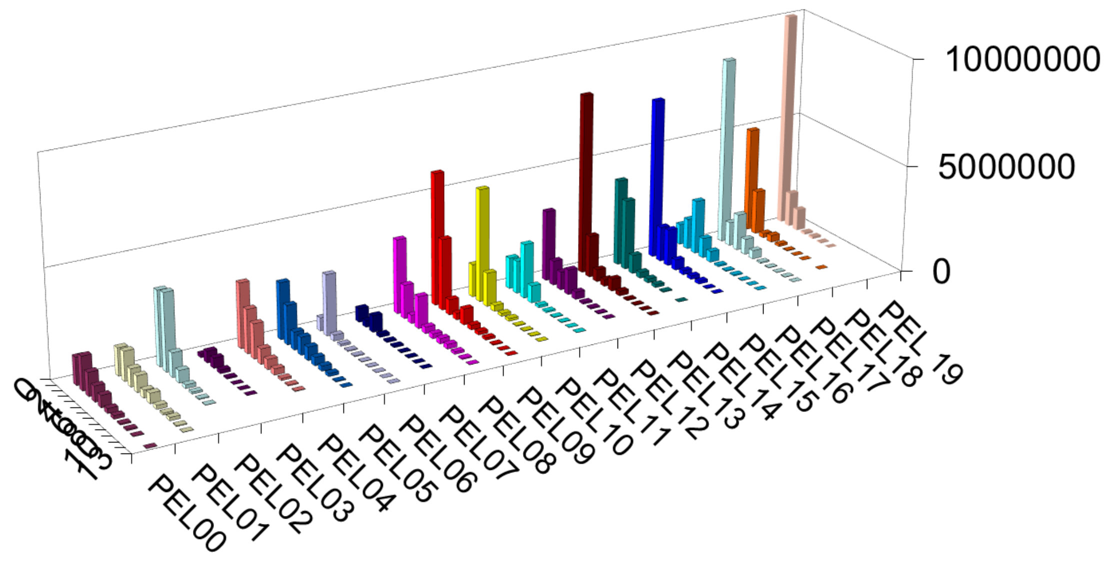


Figure 6.2.2.2.5. Age composition of sardine as estimated by acoustics since 2000.

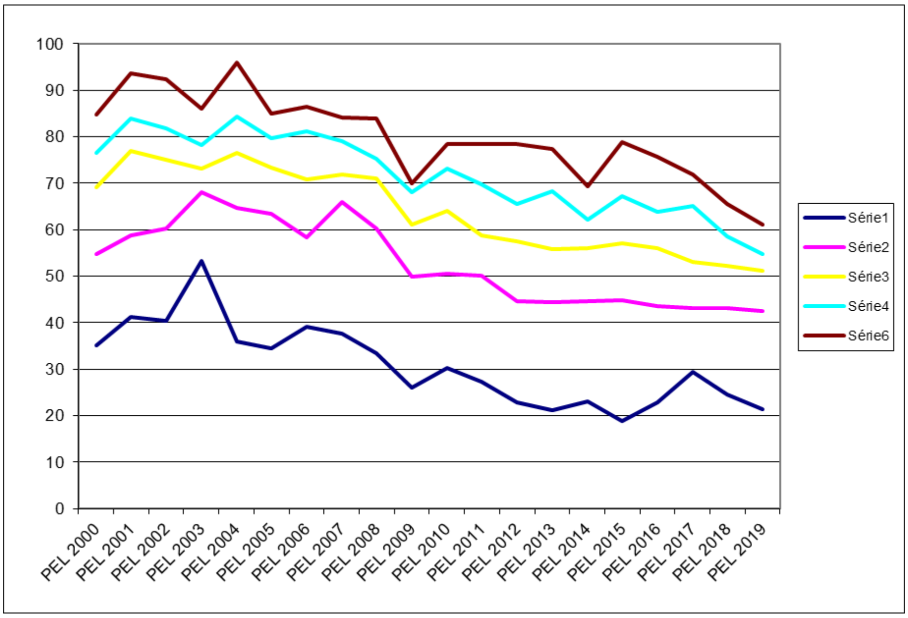
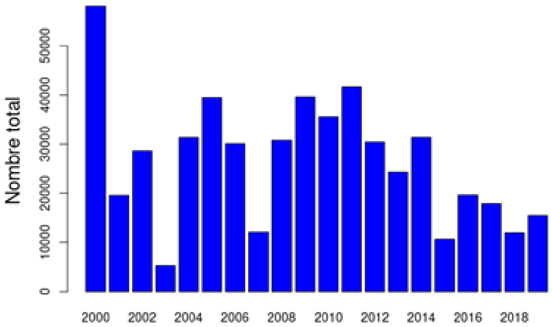


Figure 6.2.2.2.6. Sardine mean Weight-at-age along pelgas series (since 2000).



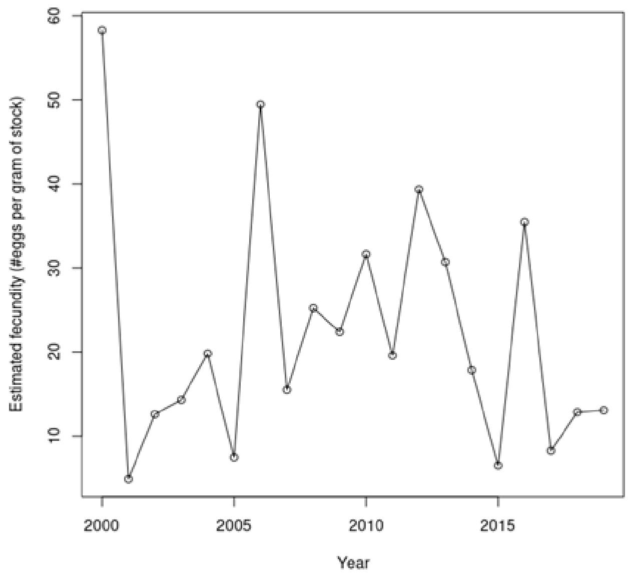


Figure 6.2.2.2.7. Number of eggs observed during PELGAS surveys from 2000 to 2019 counted in the CUFES system (left) and estimated fecundity acoustic biomass vs number of eggs corrected by the vertical model (Right).

6.2.3 Biological data

6.2.3.1 Catch numbers-at-length and age

Catches were sampled, and numbers by length class for divisions 8a, b, d by quarter are shown in Tables 6.2.3.1.1 and 6.2.3.1.2, for France and Spain, respectively. Sardine caught in area 8a, b, d ranges from 10 to 25 cm. In 2018, a peak is observed in the catch-at size distributions around 18 cm length.

Tables 6.2.3.1.3 and Table 6.2.3.1.4 shows the catch-at-age in numbers for each quarter of 2017 for Spanish and French landings respectively. Even if France and Spain are not fishing at the same place and at the same period, fish of age 1 dominated the fishery for both countries.

6.2.3.2 Mean length and mean weight-at-age

Mean length and mean weight-at-age by quarter in 2017 for France are shown in Tables 6.2.3.2.1 and 6.2.3.2.2.

The Spanish mean length and mean weight-at-age are shown in Tables 6.2.3.2.3 and 6.2.3.2.4.

Table 6.2.3.1.1. French Sardine catch at length composition (thousands) in ICES divisions 8a,b in 2018.

Length * (half cm)	**Length (cm)**	**Quarter 1**	**Quarter 2**	**Quarter 3**	**Quarter 4**	**All year**
3.5	5					
4	6					
4.5	7					
5	8					
5.5	9					
6	10					
6.5	11					
7	12					
7.5	13					
8	14					
8.5	15					
9	16					
9.5	17					
10	18	18				18
10.5	19	9				9
11	20					
11.5	21					
12	22			379		379
12.5	23	9		285	143	437
13	24	53				53
13.5	25	9				9
14	26	332	224	1 303	143	2 001
14.5	27	81	402	1 488		1 971
15	28	855	4 046	6 473	1 030	12 404
15.5	29	822	8 122	9 773	1 195	19 912
16	30	890	14 360	13 515	4 968	33 732
16.5	31	1 916	18 392	21 409	1 741	43 458
17	32	6 775	29 842	36 031	7 585	80 232
17.5	33	6 229	23 068	34 978	6 268	70 542
18	34	5 434	19 161	33 653	19 383	77 630
18.5	35	3 084	9 125	19 822	16 819	48 850
19	36	3 199	3 861	17 387	22 881	47 328
19.5	37	3 154	2 872	11 327	14 037	31 390
20	38	4 723	749	7 367	14 432	27 270
20.5	39	2 008	1 187	2 217	8 972	14 384
21	40	1 536	499	1 137	6 772	9 944
21.5	41	636	256		991	1 883

Length * (half cm)	Length (cm)	Quarter 1	Quarter 2	Quarter 3	Quarter 4	All year
22	42	495	207		368	1 070
22.5	43	85	120			205
23	44	130	81		1	212
23.5	45					
24	46					
24.5	47					
25	48				205	205
25.5	49					
26	50					
26.5	51					
27	52					
27.5	53					
28	54					
28.5	55					
29	56					
29.5	57					
30	58					
30.5	59					
31	60					
	TOTAL numbers	42 482	136 572	218 545	127 931	525 529
	Official Catch (t)	2 251	5 320	10 247	7 378	25 195

Table 6.2.3.1.2. Spanish sardine catch-at-length composition (thousands) in ICES Division 8b in 2018.

Length * (half cm)	Length (cm)	Quarter 1	Quarter 2	Quarter 3	Quarter 4	All year
3.5	5					
4	6					
4.5	7					
5	8					
5.5	9					
6	10					
6.5	11					
7	12					
7.5	13					
8	14					
8.5	15					
9	16					
9.5	17					
10	18					
10.5	19	21				21
11	20	11	1	1	1	14
11.5	21	33				33
12	22	226	5	8	4	243
12.5	23	398		17		415
13	24	884	3	40	2	928
13.5	25	1 616		61		1 677
14	26	1 100	1	75		1 176
14.5	27	908		52		960
15	28	229	1	22		252
15.5	29	105	1	11	9	126
16	30	69	31	7	88	195
16.5	31	83	81	2	711	877
17	32	292	161	25	3 909	4 387
17.5	33	659	406	29	9 250	10 344
18	34	685	585	46	17 818	19 135
18.5	35	299	281	54	20 186	20 820
19	36	501	135	79	20 424	21 139
19.5	37	89	154	82	15 749	16 074
20	38	126	82	60	11 861	12 129
20.5	39	70	29	35	7 953	8 087
21	40	19	4	32	4 916	4 970
21.5	41	10	26	29	2 396	2 462

Length * (half cm)	Length (cm)	Quarter 1	Quarter 2	Quarter 3	Quarter 4	All year
22	42	4	1	18	1 087	1 110
22.5	43	1		11	263	276
23	44	1	1	6	104	112
23.5	45				35	35
24	46				17	17
24.5	47					
25	48					
25.5	49					
26	50					
26.5	51					
27	52					
27.5	53					
28	54					
28.5	55					
29	56					
29.5	57					
30	58					
30.5	59					
31	60					
	TOTAL numbers	8 441	1 990	801	116 783	128 015
	Official Catch (t)	254	98	43	6 709	7 104

Table 6.2.3.1.3. Spanish 2018 landings in ICES Division 8ab: Catch in numbers (thousands) -at-age.

Age	First Quarter	Second Quarter	Third quarter	Fourth Quarter	Whole Year
0	0	0	252.219	6.09157	258.311
1	5339.74	33.0321	84.8594	10982.5	16440.1
2	2314.25	1419.34	244.414	69453.8	73431.8
3	254.576	179.181	77.9024	16392.2	16903.9
4	392.673	264.165	85.432	15588.7	16331
5	112.436	74.5292	38.6593	2963.26	3188.88
6	22.8714	17.2866	12.9443	1189.29	1242.39
7	2.44732	1.66977	2.61931	168.692	175.428
8	1.49122	0.61048	0	0	2.1017
9	0.12686	0.03239	1.64229	37.6411	39.4427

Table 6.2.3.1.4. French 2018 landings in ICES Division 8b: Catch in numbers (thousands) -at-age.

Age	First Quarter	Second Quarter	Third quarter	Fourth Quarter	Whole Year
0			2609.38	349.013	2958.39
1	6153.74	46306.6	152774	51800.4	257034
2	21086	76023.2	52396.7	49592.8	199099
3	3433.85	6248.18	9311.41	18408.4	37401.9
4	7423.06	5856.36	724.739	5208	19212.2
5	3405.11	1669.95	728.912	2572.22	8376.19
6	817.81	386.488			1204.3
7	103.238	48.469			151.707
8	56.0037	30.3953			86.399
9					0
10	2.92686	1.9499			4.87676

Table 6.2.3.2.1. French 2018 landings in divisions 8a,b: Mean length (cm) -at-age.

	First Quarter	Second Quarter	Third quarter	Fourth Quarter	Whole Year
0			13.9612	13.8183	13.9443
1	16.0443	16.1227	17.0884	17.7597	17.0247
2	17.8029	17.5062	18.5341	19.0716	18.1981
3	18.9691	18.2415	19.6432	20.008	19.5267
4	19.8605	19.1471	20.814	21.224	20.0486
5	20.5783	20.3515	20.2931	20.5829	20.5097
6	20.7831	20.6967			20.7554
7	20.9033	20.8889			20.8987
8	20.329	19.9146			20.1832
9					
10	22.7547	22.7742			22.7625

Table 6.2.3.2.2. French 2018 landings in divisions 8a,b: Mean weight (kg) -at-age.

Age	First Quarter	Second Quarter	Third quarter	Fourth Quarter	Whole Year
0			0.02218	0.02155	0.0221
1	0.03288	0.03312	0.04179	0.04728	0.04112
2	0.04509	0.04272	0.05392	0.05893	0.04995
3	0.055	0.04863	0.06464	0.06851	0.06298
4	0.06326	0.05666	0.07747	0.08287	0.0671
5	0.07065	0.0686	0.07157	0.07484	0.07161
6	0.07288	0.07226			0.07268
7	0.07421	0.07434			0.07425
8	0.068	0.06411			0.06663
9					
10	0.09602	0.09624			0.09611

Table 6.2.3.2.3. Spanish 2018 landings in ICES Division 8,b: mean length (cm) -at-age.

Age	First Quarter	Second Quarter	Third quarter	Fourth Quarter	Whole Year
0	0	0	13.915	12.635	13.8849
1	13.8565	15.7448	16.9708	18.3115	16.8524
2	17.7262	18.0479	19.0107	18.8687	18.8173
3	18.8728	18.8575	20.1379	19.9621	19.9348
4	19.4598	19.456	20.6063	20.2767	20.2455
5	20.0986	20.2246	22.1321	21.5753	21.4984
6	20.0079	20.1682	21.7376	21.1513	21.1227
7	20.8866	20.9798	22.1392	22.1079	22.0806
8	20.75	20.75	0	0	20.75
9	22.75	22.75	22.75	22.75	22.75
10					

Table 6.2.3.2.4. Sardine general: Spanish 2018 landings in ICES Division 8b: mean weight (kg) -at-age.

	First Quarter	Second Quarter	Third quarter	Fourth Quarter	Whole Year
0	0	0	0.02005	0.01469	0.01993
1	0.01989	0.03168	0.03897	0.04885	0.03935
2	0.04405	0.04618	0.05465	0.05331	0.05288
3	0.05336	0.05322	0.06573	0.06395	0.06368
4	0.05899	0.05899	0.07093	0.06733	0.06701
5	0.06544	0.06685	0.08893	0.08195	0.0811
6	0.06476	0.0666	0.08409	0.07713	0.07682
7	0.07386	0.07489	0.08868	0.08829	0.08796
8	0.07197	0.07197	0	0	0.07197
9	0.09677	0.09677	0.09677	0.09677	0.09677
10					

6.3 Historical stock development

Model used: SS3

This is the third year this stock is assessed using SS3. The procedure is described in the stock annex following the WKPELA benchmark (2018). It was updated in 2019 following the IBSardine inter-benchmark (ICES, 2019). The inter-benchmark took place in 2018 and was tasked with evaluating the stock assessment focusing on retrospective bias, data revisions and updating reference points. Standard model diagnostics were used to evaluate a series of interventions designed to evaluate the models and to determine causes of and corrections for the retrospective bias.

The retrospective bias could be corrected by several straightforward interventions. First, fixing selectivity at asymptotic improved model fit and reduced bias. Second, invoking a very weak stock–recruitment relationship (steepness=0.99) and commensurate bias correction ramping on recruitment deviations coupled with not estimating terminal year recruitment, further reduced the bias. Such a treatment of terminal year recruitment and penalizing poorly informed recruitment deviations is common assessment practice.

Additional concerns were raised by the estimated catchability coefficients above one for the PELGAS and BIOMAN surveys. There are a number of reasons why these surveys could estimate higher abundance than the assessment model. These include mismatch of timing given the rapid population dynamics, overestimation of acoustic biomass, mismatch of assumed selectivity of the survey as well as many other common issues that support the standard practice of treating most surveys as relative rather than absolute. Once the decision to use these indices as relative inputs, the absolute value of catchability is meaningless as the index could simply be scaled to a mean of one with the same impact in the model.

Given the substantial reduction in retrospective bias achieved through straightforward model interventions and the solid diagnostic performance of the WG-preferred model, it was recommended the assessment be upgraded from category 2 to category 1.

Nonetheless, the model cannot estimate MSY-based reference points and this requires proxies. Based on considerations of life history, the WG recommends a proxy of SPR35%. Recommendations for future work include explicitly modelling variability in growth reflecting the declines in mean weight-at-age, incorporating length composition and considering a management procedure approach as the majority of catch comes from ages 1 and 2 which are very poorly informed in catch projection due to the time-lag between the assessment and the provision of management advice.

This assessment is the first one following the inter-benchmark in 2019. No deviations were made to the new procedure.

6.3.1 State of the stock

Summary of the assessment is shown in Table 6.3.1 and in Figures 6.3.1–6.3.3.

The spawning–stock biomass (SSB) is above MSY $B_{trigger}$. SSB has decreased from 2010 to 2012 to the lower value of the series and has been since then stable until 2016. Then it has been increasing in 2017. The decrease after 2012 is not clearly related to the increase in fishing mortality in recent years, as F went up above F_{MSY} just after the drop in biomass assessed for January 2012. Landings were above 30 kt between 2012 and 2014, dropping for two years and then raising up again to 32 kt in 2018 for four consecutive years. Fishing mortality has been above 0.4 and above F_{MSY} since 2012 and below F_{pa}. Recruitment has been variable over time. Recruitment in 2018 is well above the time-series average.

Table 6.3.1. Summary of the sardine 8abd stock assessment.

Year	Recruitment (thousand)	SSB (tonnes)	Total Catch (tonnes)	F(2–5)
2000	4346.64	138508	15097	0.140
2001	5295.82	156794	15005	0.145
2002	3505.66	169851	18277	0.170
2003	3878.27	178598	16607	0.137
2004	7164.24	149344	14197	0.131
2005	2313.01	177620	16360	0.128
2006	3591.33	156019	16741	0.139
2007	7030.33	139733	17323	0.149
2008	8588.75	160469	21821	0.212
2009	3483.51	137301	20855	0.169
2010	2639.79	153462	20127	0.167
2011	4373.03	123340	23208	0.222
2012	7682.36	90518.1	30900	0.397
2013	5392.27	97236.4	32938	0.431
2014	7296.34	101812	35704	0.526
2015	2823.17	92725.9	28756	0.442
2016	6977.28	86702.1	29754	0.516
2017	6505.96	112621	30435	0.491
2018	7992.04	109462	32299	0.476
2019*	4933.77*	102910		

***Geometric mean (2002–2018).**

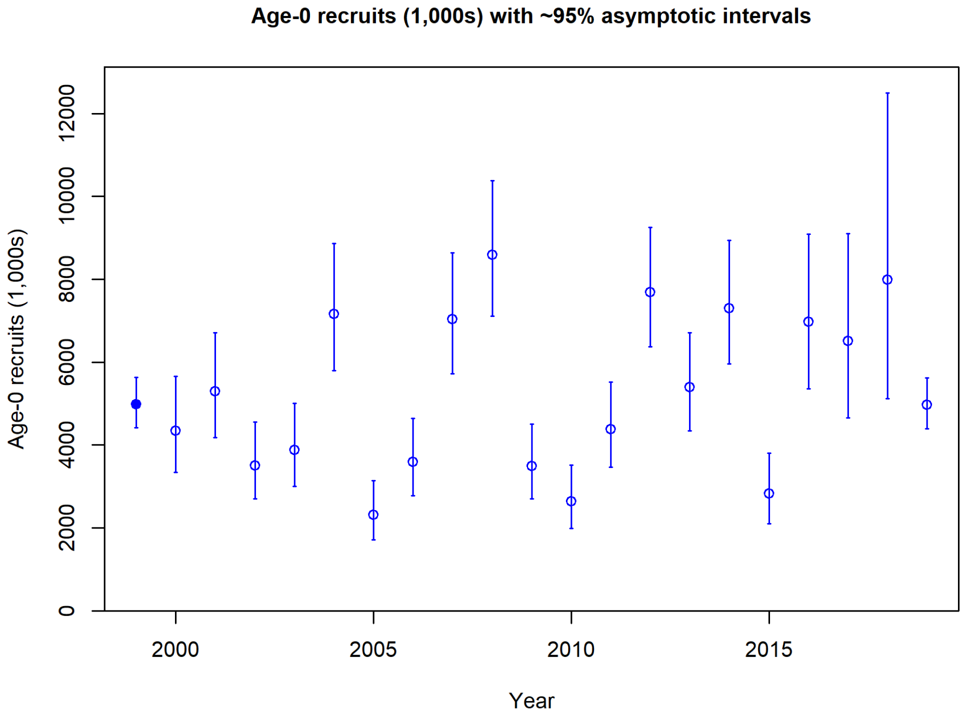


Figure 6.3.1. Recruitment estimates from SS3 outputs for sardine 8abd. Last year's value is estimated from the model.

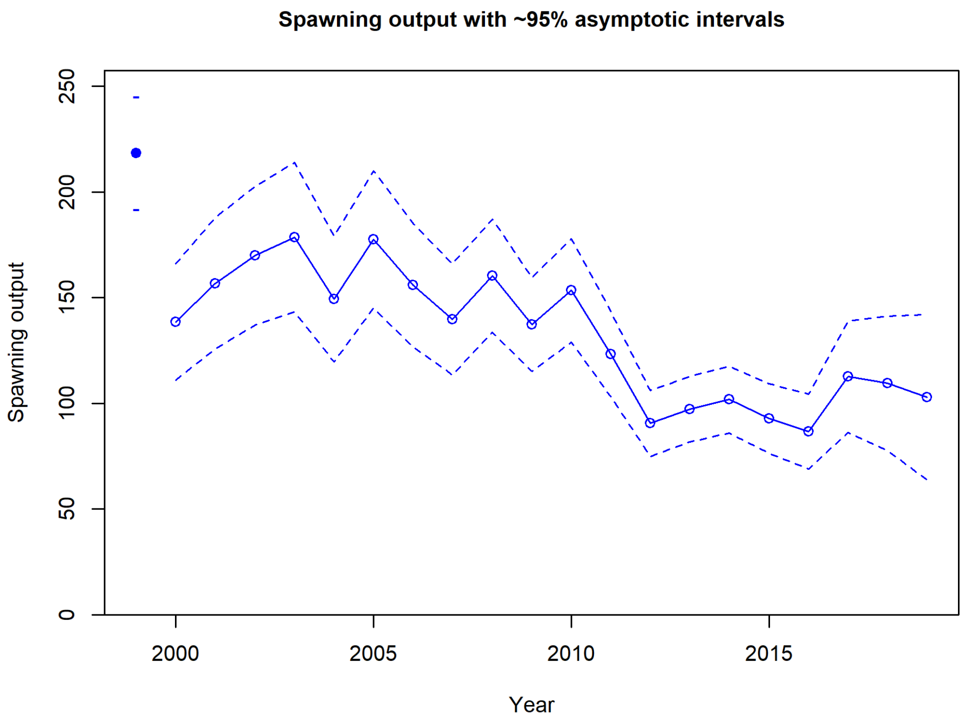


Figure 6.3.2. Spawning–stock biomass from SS3 outputs for sardine 8abd. Last year's value is estimated from the model.

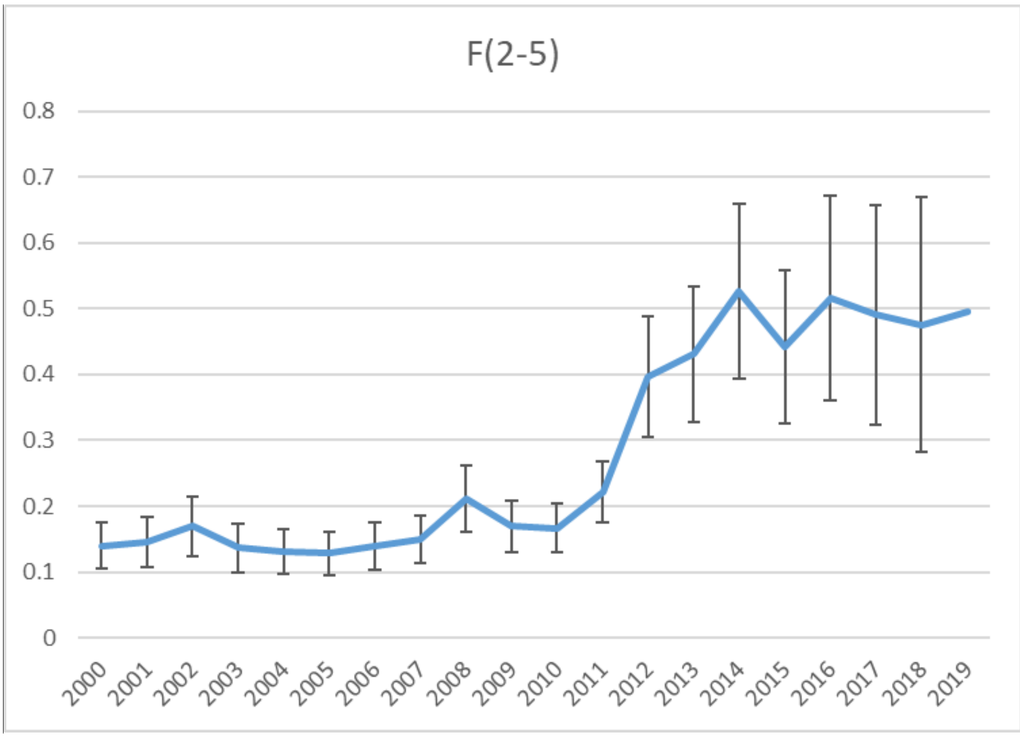


Figure 6.3.3. Fishing mortality for ages 2 to 5 derived from SS3 outputs for sardine 8abd. Last year's point is an estimate of F *status quo* from the average fishing mortality of the three years before (2015–2017).

6.3.2 Diagnostics

Residuals (Figures 6.3.4–6.3.5) and diagnostics do not highlight any problem regarding the input data and model fit. Some cohorts lead to some model over or underestimations. This phenomenon appears on some years for the Pelgas survey. For Pelgas, age 1 has positive residuals since 2011 and negative in earlier years.

For the commercial vessels, the cohort effect is less visible, but some years appears to have more residuals than other (e.g. 2009). The model fit to the survey indices is within the confidence intervals of those indices. There is no clear trend in recruitment estimates (Figure 6.3.6).

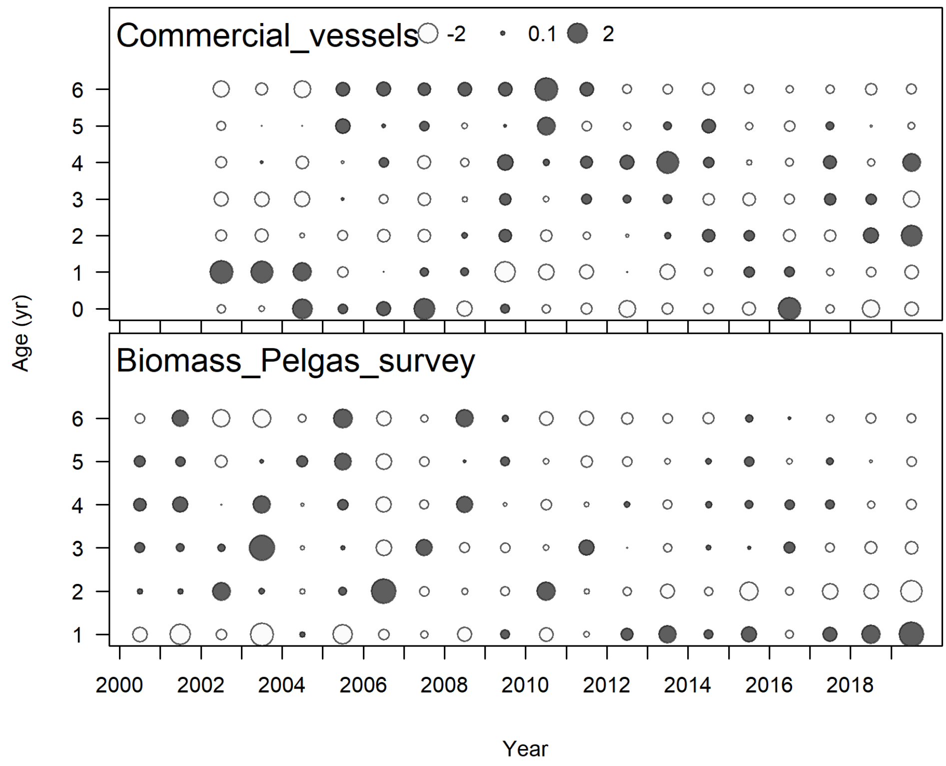
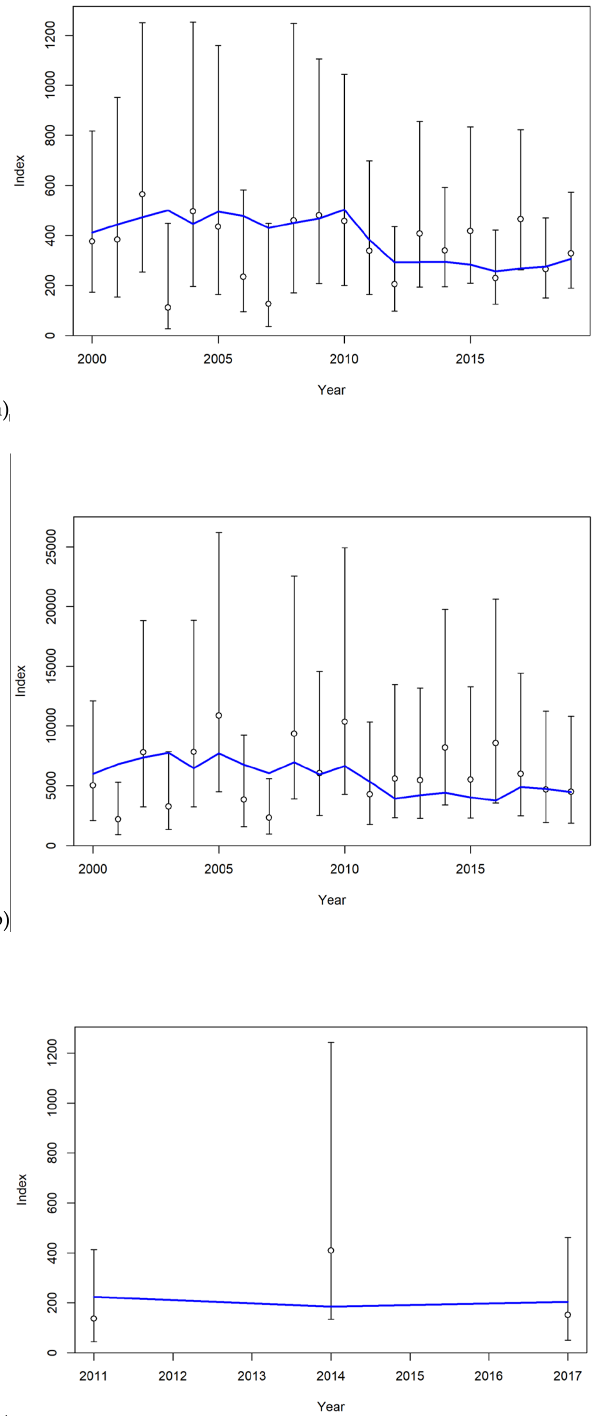


Figure 6.3.4. Fit between model and age composition from the Pelgas survey and commercial vessels.



a)

b)

c)

Figure 6.3.5. Fit between model and survey indices: a - Acoustic (Pelgas), b - egg count (Bioman), c - DEPM.

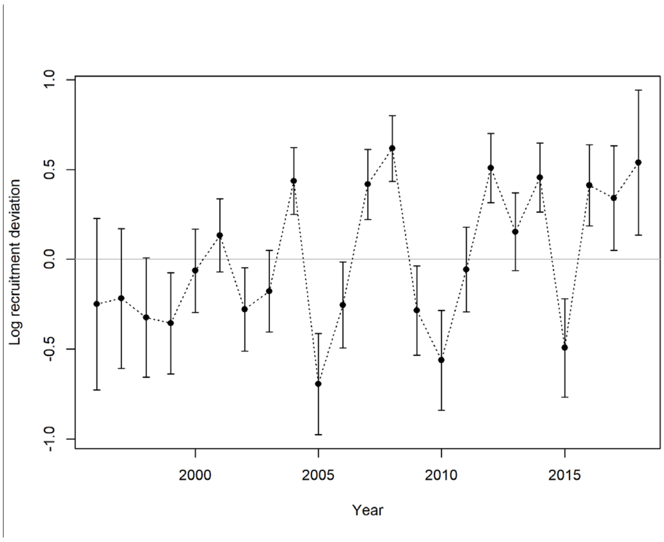


Figure 6.3.6. Log recruitment deviation from the SS3 output.

6.3.3 Retrospective pattern

Retrospective patterns were considered in last year's assessment a problem because strong bias over the time-series including some scaling effects. This required to recalculate biological reference points every year. The inter-benchmark that took place in 2019 aimed at reducing retrospective patterns by revisiting data and changing some of the model assumptions.

Retrospective patterns for SSB, F_{bar}(2–5), apical F and recruitment were computed for years 2014–2019 (Figure 6.3.7) using the r4ss *do_retro()* function and Mohn's rho estimates were calculated using the same approach carried out during the inter-benchmark and therefore values can be compared to the work made during the inter-benchmark. For each run, assessment was performed including survey data until the last retrospective year and catch data until previous year, as done in the current assessment (2019).

Overall, SSB tends to be overestimated while F is underestimated. There is no clear patterns regarding recruits.

Absolute values of Mohn's rho estimates have increased in comparison to previous assessment:

- Mohn's rho for SSB is 0.231 (previously 0.147).
- Mohn's rho for R is 0.264 (previously -0.133).
- Mohn's rho for F is -0.152 (previously -0.132).

Considering the assessment methodology this year has just been benchmarked, it is impossible to establish if the increase of retro bias is related to the added year of data or if this is a trend that will continue over the upcoming years. In both cases, this should be followed every year. On the other hand, it is worth noting that, previously, the SSB estimates were scaled down over the full time-series, meaning that the average SSB levels for each run was getting lower and lower when a year of data was added. With the current settings, while there are variations in the last years of the assessment, all retro runs tend to originate from the same levels at the beginning of the various time-series.

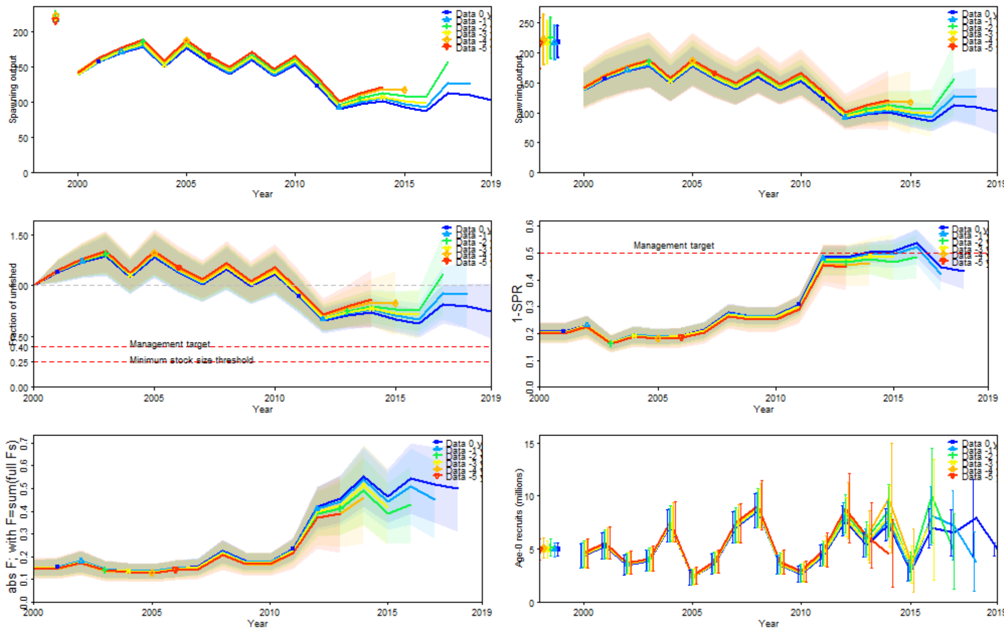


Figure 6.3.7. Summary of retrospective plots.

6.3.4 Comparison with previous assessment

The comparison is done with the run carried out during the Inter-benchmark (Figures 6.3.8–6.3.10). The included time-series, although revised, are similar in terms of length to those used during WGHANSA last year.

Uncertainties are higher for the last two years because the available data of the assessment year are limited to an assumption on preliminary catches and survey data. The data of the previous year are fully consolidated in terms of number and weight-at-age for the commercial fleets. The catches are also final rather than assumed.

Considering the confidence intervals, levels in 2018 of both SSB and F are similar. The mean levels however suggest, as for the retrospective patterns, that SSB is overestimated leading this year to a downward revision of the 2018 value. The opposite is observed for the fishing mortality. There is no clear pattern for recruits.

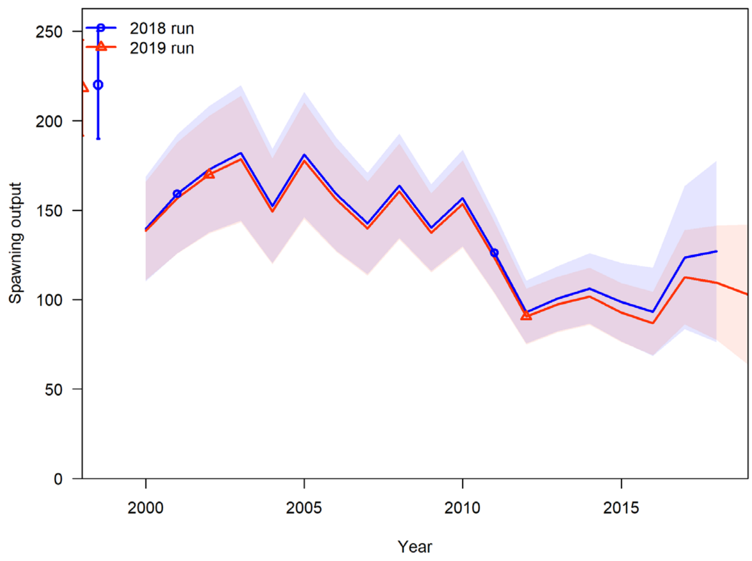


Figure 6.3.8. Comparison of SSB estimates between this year and last year's runs.

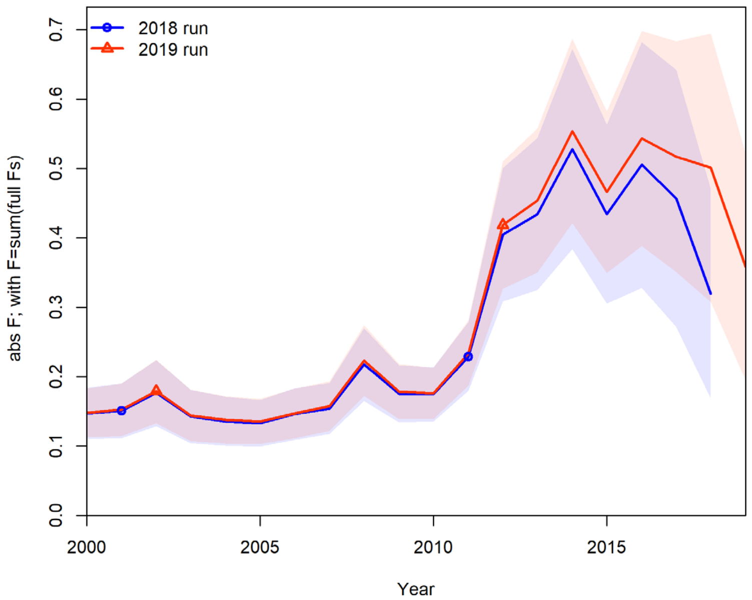


Figure 6.3.9. Comparison of F estimates between this year and last year's runs.

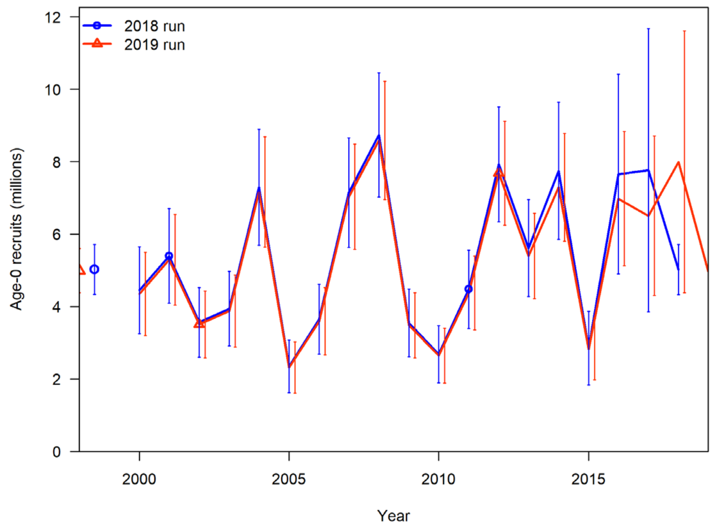


Figure 6.3.10. Comparison of Recruitment estimates between this year's and last year's runs.

6.4 Short-term projections

The recruitment of sardine for the intermediate year is assumed to be the geometric mean of the time-series of recruitment. Short-term projections were performed using FLR libraries using the *fwd* function.

The initial stock size corresponds to the assessment estimates for ages 1–6+ at the final year of the assessment. The maturity ogive is provided during the interim year by the PELGAS survey. F and M before spawning are zero, which correspond to the beginning of the year when the SSB is estimated by the model. Weights-at-age in the stock are provided during the interim year by the PELGAS survey. Weights-at-age in the catch are calculated as the arithmetic mean value of the last three years of the assessment. The exploitation pattern is equal to the last year of the assessment.

Preliminary catches are estimated and used as assumption for the interim year. The fwd function is set to use the preliminary catch estimates (instead of F estimates as done in previous years). Preliminary catch were available for quarter 1 to 3. Quarter 4 catches were estimated from the average proportion of Q4 catches over total catches for the last three previous years of the assessment.

Recruitment in the interim year and forecast year is set equal to the geometric mean of the time-series.

Recruitment for 2019 was assumed to be 4933 thousand individuals. Assumption for the intermediate year are presented in Table 6.4.1. The catch assumption was also included as preliminary catches in the stock assessment model this year. Input data for the short-term forecast are provided in Table 6.4.2. Table 6.4.3 provides the management options.

Table 6.4.1. Assumptions for the intermediate year.

Variable	Value	Notes
F ages 2–5 (2019)	0.49	Based on estimated catches for 2019
SSB (2020)	123 110 tonnes	Short term forecast
$R_{age\ 0}$ (2019/2020)	4934 million	Geometric mean (2000–2018)
Total catch (2019)	27 130 tonnes	Preliminary value based on reported catches for the first 3 quarters and predicted catches for quarter 4 assuming that they correspond to 44% of the annual catches (average percentage in 2016–2018).
Discards (2019)	0 tonnes	Negligible

Table 6.4.2. Input data for the short-term forecast.

Year	Age	stock.n	stock.wt	catch.wt	mat	M	F
2019	0	4933.775	0.001	0.0243	0	1.071	0.01
	1	2719.202	0.0257	0.0386	0.7580	0.6912	0.19
	2	887.258	0.0433	0.0466	0.9977	0.5463	0.29
	3	367.001	0.0537	0.0569	0.9976	0.4752	0.41
	4	54.652	0.0624	0.0629	1.0000	0.4356	0.41
	5	55.148	0.0710	0.0725	0.9986	0.4122	0.41
	6+	29.952	0.0840	0.0778	1.0000	0.3978	0.41
2020	0		0.0003	0.0257	0	1.071	0.01
	1		0.0266	0.0386	0.8461	0.6912	0.19
	2		0.0432	0.0475	0.9985	0.5463	0.30
	3		0.0530	0.0572	0.9979	0.4752	0.42
	4		0.0620	0.0620	1.0000	0.4356	0.42
	5		0.0695	0.0709	0.9981	0.4122	0.42
	6+		0.0806	0.0746	1.0000	0.3978	0.42
2021	0		0.0003	0.0257	0	1.071	0.01
	1		0.0266	0.0386	0.8461	0.6912	0.19
	2		0.0432	0.0475	0.9985	0.5463	0.30
	3		0.0530	0.0572	0.9979	0.4752	0.42
	4		0.0620	0.0620	1.0000	0.4356	0.42
	5		0.0695	0.0709	0.9981	0.4122	0.42
	6+		0.0806	0.0746	1.0000	0.3978	0.42

Table 6.4.3. Management option table.

Basis	Catch (2020)	F (2020)	SSB (2021)	% SSB change *	% Catch change **	% Advice change ***
ICES advice basis						
MSY approach: F_{MSY}	34 647	0.453	107 290	-13	7	55
Other scenarios						
F = 0	0	0	135 412	10	-100	-100
$F = F_{pa}$	40 050	0.54	103 018	-16	24	79
$F = F_{lim}$	52 385	0.76	93 409	-24	62	134
$SSB_{2021} = B_{lim}$	104 332	2.32	56 300	-54	223	366
$SSB_{2021} = B_{pa} =$ MSY $_{Btrigger}$	71 907	1.19	78 700	-36	123	221
$F = F_{2019}$	37 245	0.49	105 231	-15	15	66

*** SSB 2021 relative to SSB 2020.**

**** Catch in 2020 relative to catch in 2018 (32 299 t).**

*****Advised catch for 2020 relative to advised catch for 2019.**

Based on the GM recruitment and *catch assumption* in 2019, for all catch options except for the SSB target of B_{lim} in 2021, the SSB will remain well above $B_{trigger}$. In all cases except no fishing, SSB in 2021 is expected to decrease compared with the one of 2020.

6.5 Medium-term projection

No medium-term projections were carried out.

6.6 MSY and Biological reference points

Up to 2018 Sardine in 8abd was a category 3 stock, for which Biological Reference Points (BRPs) were annually assessed and revised. Furthermore, the assessment and BRPs were taken in relative terms, relative to the mean of the assessment series. The BRPs were defined according to the ICES guidelines for a scatterplot of Stock and recruitment estimates which could be considered either of type 4 (stocks with a wide dynamic range of SSB, and evidence that recruitment increases as SSB decreases) or type 6 (stocks with a narrow dynamic range of SSB and showing no evidence of past or present impaired recruitment). In any of the two cases, B_{loss} (the lowest observed biomass in the time-series) was taken as B_{pa}. This corresponded to 88 000 tonnes in year 2012. Then, a proxy for B_{lim} was calculated from the inverse relationship between B_{lim} and B_{pa} as follows: $B_{lim} = B_{pa} \times \exp(-1.645\ \sigma)$, where σ is the standard deviation of ln(SSB) in the final assessment year (taken as default at 0. Thus, B_{lim} was set at 63 328 tonnes. Next, Fishing reference points were deduced applying ICES standard procedures with EqSim software.

As a result of the Inter-benchmark carried out in October 2019, the assessment of this sardine has been upgraded to category 1 and a set of new Biological reference points have been defined. In particular, B_{lim} has been proposed at 35%SBR (ICES 2019), based on considerations of life history and precautionary reference points (Myers *et al*., 1999; Mace, 1994; Mace and Sissenwine, 1993) and proxies for F_{MSY} based on natural mortality rate (Zhou *et al*., 2012).

The Inter-benchmark preferred this approach because for this stock 18 pairs of stock and recruitment estimates (2000–2017), covering a narrow range of biomass-es (Min/Max=51%) and with no clear indications of impaired recruitment (Figure 6.6.1), setting B_{pa}=B_{loss} led to infer B_{lim} (63 328 t) and afterwards F_{MSY} (0.27) which seemed to be respectively a bit high and low value respectively. On the one hand, such B_{lim} would be above the expected biomass at $F_{0.1}$ (as calculated for this stock in the deterministic yield per recruit) and on the other hand F_{MSY} at 0.27 resuls in a 61%SBR, which is well below the typical F_{MSY} proxies at %SBR of 40% or 50% (Mace, 1994; Horbowy and Luzenczyk, 2012), below $F_{0.1}$, and also below the alternative F_{MSY} proxy of 0.87*M (= 0.44). For these reasons, an alternative definition of B_{lim} from which derived F_{MSY} was looked for, based on %SPR.

Mace (1994) and Mace and Sissenwine (1993) pointed out that for stocks of unknown resilience a more prudent approach would be using F30%B0. Furthermore, in their analysis Mace and Sissenwine (1993) found that pelagic species that reach relatively small maximum size and/or mature at small size, seem to have high replacement %SPR, and the analysis by taxonomic groups suggested a mean replacement %SPR for cupleoids of about 37.5% higher than for other taxonomic groups. Myers *et al*. (1999) also found that the median steepness of cupleoids and engraulidae were intermediate (not in the upper range of values). Therefore, it can be deduced or presumed from a precautionary approach that small pelagic fish may have relatively lower resilience to fishing (Mace and Sinsenwine, 1993). This led the IBP group to set B_{lim} at 35%B0, which was equal to 56 300 t.

Following the ICES guidelines for stocks in Category 1 and 2, the remaining reference points were derived from the former value of B_{lim} (= 56 300 t). B_{pa} was derived as B_{pa} = B_{lim} x exp(1.645 σB), where σB is the standard deviation of ln(SSB) in the terminal year (2018) (σB = 0.204 rounded to 0.2). Thus, B_{pa} was set at 78 700 tonnes. As unconstrained F_{MSY} in Eqsim resulted in a value (0.621) conditioned to a hockey stick S–R relationship with inflection point at B_{lim} (Figure 6.6.2). Because this F_{MSY} value was higher than F_{pa} (0.539) and higher than $F_{p0.05}$ (0.453) the F_{MSY} value was reduced to $F_{p0.05}$. The final estimate of F_{MSY} (over ages 2–5) (= 0.453) has the property of being consistent with the ideas of Zhou *et al*. (2012) of setting F_{MSY} equal to 0.87·Natural Mortality (=0.44 for this sardine stock).

The updated biological and MSY reference points in absolute terms are:

Table 6.6.1. Biological Reference Points for sardine in 8abd as estimated in ICES 2019.

Framework	Reference point	Absolute value	Technical basis
MSY approach	MSY $B_{trigger}$	78 700	B_{pa}
	F_{MSY}	0.453	$F_{MSY} = F_{p.05}$, i.e. the F that leads to SSB $>B_{lim}$ with probability 0.95 when including the ICES MSY advice rule
Precautionary approach	B_{lim}	56 300	35%SPR, i.e. equilibrium biomass at F that leads to 35% of spawner of recruit without fishing
	B_{pa}	78 700	$B_{pa} = B_{lim} \times \exp(+1.645 \times \text{sigma})$, where sigma=0.2
	F_{lim}	0.757	F that results in 50% probability that SSB is above B_{lim} in the long term, using segmented regression with B_{lim} (EqSim)
	F_{pa}	0.539	$F_{pa} = F_{lim} \times \exp(-1.645 \times \text{sigma})$, where sigma=0.207
Management plan	SSB_{MGT}	Not applicable	
	F_{MGT}	Not applicable	

All details of the calculations are described in the Inter-benchmark report (ICES 2019) and in the stock annex. These values are expected to be updated every benchmark or after relevant changes in the selectivity of the fishery are detected.

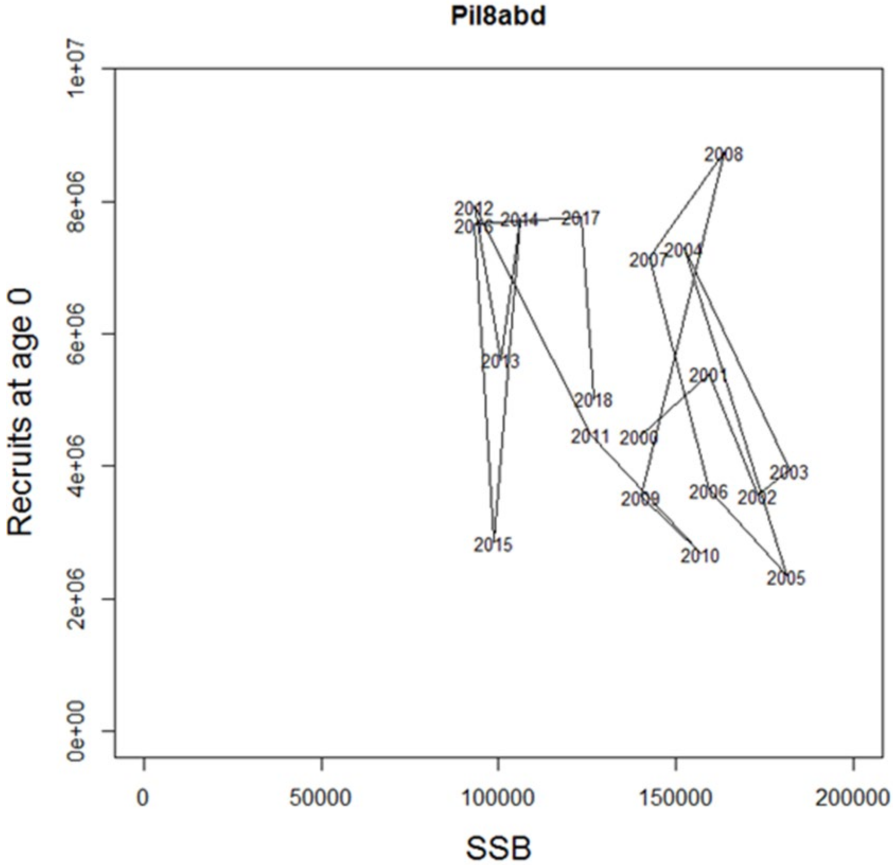


Figure 6.6.1. Stock–recruitment relationship for sardine in 8abd.

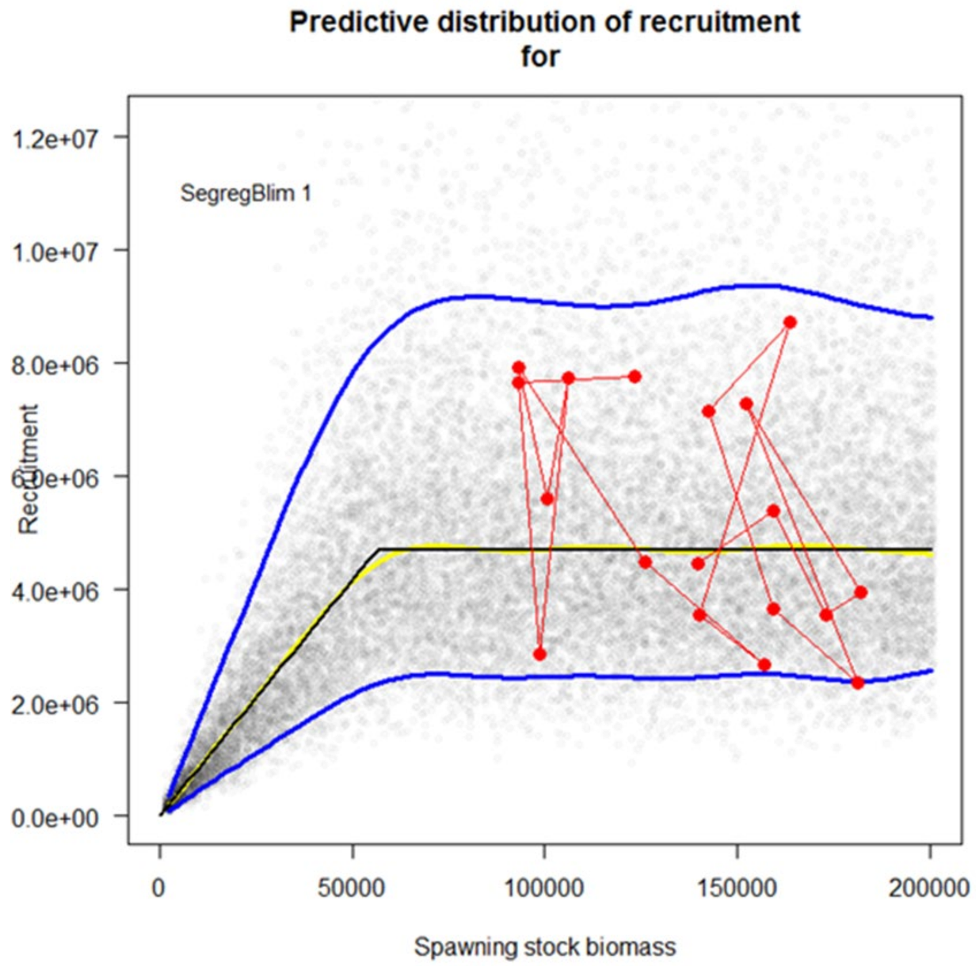


Figure 6.6.2. Segmented regression model with the breakpoint fixed at B_{lim} for sardine in 8abd.

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6.7 Management plan

There are no specific management objectives or a management plan for this stock at the moment. There is ongoing discussion about a management plan or TAC through the SWWRAC for this stock but the plan has not been formalised yet.

6.8 Uncertainties and bias in assessment and forecast

Uncertainties in the assessment relate to the retrospective pattern and relative changes in the perception of the most recent years.

Most of the uncertainties in the forecast comes from the assumption in the intermediate year although the fishery is not expected to increase over the next years.

6.9 Management considerations

No TAC is currently set for this stock.

6.10 References

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7 Sardine in Subarea 7

7.1 Population structure and stock identity

Sardine stock in Subarea 7 has historically being assessed together with the Southern population in the Bay of Biscay (divisions 8.a,b and d). However, during the WKPELA benchmark (ICES, 2017), it was decided that the two should be assessed independently, claiming a different growth rate, the existence of separate spawning grounds and the presence of all stages in substantial amounts in both areas, as well as the limited availability of data from the northern stock unit compared to the data rich stock in division 8. Consequently, the stock in area 7 was classified as category 5, and the advice was purely based on trends in landings.

Despite the limited evidence supporting the decision of treating the population in area 7 as a separate stock, the degree of mixing occurring with the Bay of Biscay is still debated.

Results obtained in 2017 as part of a spatially extended PELTIC survey into the French waters of Division 7e, suggest that a part of the stock inhabits those waters (~30%), increasing the possibility of mixing with the southern population. In addition, little is known about the extension of the stock in the Eastern Channel. Until new insights are put forward, modelling the two populations separately appears to be the most appropriate option.

7.2 The Fishery

7.2.1 Landings

Sardine landings are highly variable (Table 7.2.1.1 and Figure 7.2.1.1) between years, from around 2000 tons in 1984 to more than 25 000 tons in 2001. Overall, catches increased from the 1970s to the 2000s, followed by a decreasing trend until 2011. In the following years the catches remained lower than 10 000 t, but in 2016 catch reached almost 20 000 tons due to a higher contribution from all countries (4700 tons for Netherlands, 9400 for United Kingdom and around 2000 tons each for Denmark and Germany). Since 2017, catches dropped due to a lower contribution of Germany, Netherlands and Denmark, whereas UK catches remained stable. Danish catches were high during the eighties and nineties, contributing on average to more than 50% of the total catches in the area and up to 86% in 1994. Almost no catches from the Danish fleet in area 7 have been recorded since then, until the last two years: the reliability of these values have to be further investigated.

Catches from Cornish ringnetters (UK) represents on average (2010–2018) about 56% of the total landings. Discarding by this fleet is low, as well as the activity of slipping. French sardine landings have been corrected for notorious misallocations between 7e,h and 8a; traditionally a substantial part of French catches from divisions 7.h and 7.e are misallocated to Division 8.a due to localised fishing effort straddling the borders between 8.a, 7.h and 7.e. French sardine landings declared in 25E5 and 25E4 have hence been reallocated to 8a.

It must be noted that in a part of the Eastern Channel, the Seine bay, sardine catches are totally forbidden for human consumption since 2010, due to PCB contamination.

7.2.2 Discard

Discards for sardine in area 7 are considered to be negligible.

7.3 Biological composition of the catch

Historically, biological sampling of sardine from commercial catches has been almost non-existent. Dutch pelagic freezer trawlers operating in the English Channel provided length distribution in 1994, 1996 and annually from 2000; despite these vessels capturing substantial amounts of sardine, they don't have it as their main target, they fish sardine only sporadically and are structurally different compared to the fishing vessels from the other main countries (United Kingdom, France): the length structures may therefore not be representative for the population. Other countries have not provided length or age information regularly due to the lack of national biological sampling scheme and no DCF requirement regarding that species in 7.

In 2017, UK has started a self-sampling programme involving the Cornish ringnet fleet, whose catches contribute to more than half of the total landings. Since fishing season 2017–2018, these vessels have been recording fishing trip information (haul locations, total catches, bycatch, discard and effort) on dedicated logbooks. In addition, they were each asked to collect individual lengths of a subsample approximately four times per month. In parallel, the main processors were asked to provide biological information (length and weight) for every catch. Peak catches occurred in October–November (Figure 7.3.1.1). The average size of sardines caught was around 20 cm and was fairly stable across vessels and time of the year (Figures 7.3.1.2.a–d).

Some discrepancies were found in the length/weight data provided by the processors, which requires further scrutiny. However, this self-sampling initiative was considered a success by both scientists and industry and will be continued in future.

7.4 Fishery-independent information

7.4.1 The PELTIC survey in Division 7

A pelagic survey was undertaken in autumn in the western English Channel and Eastern Celtic Sea to acoustically asses the biomass of the small pelagic fish community within this area (divisions 7.e–g). This survey, conducted from the RV Cefas Endeavour, is divided into three geographically separated regions: the western English Channel, the Isles of Scilly and the Bristol Channel. Since 2017, the survey was expanded to cover also the French part of Division 7e. In 2018 only, the survey coverage expanded to Eastern English Channel.

The PELTIC survey (ICES, 2015) has been carried out annually since 2013 in October. The survey follows a systematic parallel transect design with 10 nautical miles spaced transects running perpendicular to the coastline or bathymetry. In 2017, a higher resolution of 5 nmi between parallel transects was used in Lyme Bay (7.e) (Figure 7.4.1.1).

Acoustic data are collected using a Simrad EK60 scientific echosounder, at a ping rate of 0.6 s-1 and pulse duration of 0.512 µs. Split-beam transducers are mounted on the vessel's drop keel and lowered to the working depth of 3.2 m below the vessel's hull or 8.2 m subsurface. Three operating frequencies are used during the survey (38, 120 and 200 kHz) for trace recognition purposes, with 38 kHz data used to generate the abundance estimate for clupeids (and other fish with swimbladder) and 200 kHz for mackerel. All frequencies are calibrated at the start of the survey. Regular trawls are conducted to collect biological data and ground-truth acoustic marks for species and size information.

To distinguish between organisms with different acoustic properties (echotypes) a multifrequency algorithm was developed, principally based on a threshold applied to the summed backscatter of the three frequencies, eventually resulting in separate echograms for each of the echotypes.

The acoustic data were then processed using StoX's software. The global area has been split into several strata. For each strata, energies were converted into biomass by applying catch ratio and then weighted by abundance of fish in the haul surrounded area.

In order to provide a wider-scale picture of sardine distribution, PELTIC density data were combined with those from the JUVENA survey (Figure 7.4.1.2). JUVENA is an AZTI (Spain) run acoustic survey, designed to quantify juvenile anchovy in the Bay of Biscay in September but also provides information on sardine using the same methods as PELTIC. The combined map shows that in the autumn, the English Channel is the most important area for sardine in the NE Atlantic. It also shows that the new expanded survey coverage is crucial in capturing the distribution of the entire sardine population; with earlier gaps now filled.

The extension of the survey in French waters of the 7e from 2017 showed a significant percentage of sardine stock extending in this area (~30%).

The time-series of biomass estimated from the PELTIC (without the French part of Division 7.e, Core Area) shows a continuous increase since 2016. The 2019 value is equal to 174 424 tonnes with a CV of 21% (Figure 7.4.1.3a). When observing the time-series of biomass estimated for the Total Area (including French side of Division 7.e, Figure 7.4.1.3b), a slight drop in 2018 is followed by an increase in 2019, being the value equal to 239 478 tonnes with a CV of 19%.

Biological information from trawl catches carried out during the PELTIC acoustic survey, identified age classes from 0 to 9. In 2019, only six age classes were recorded. The numbers-at-age as measured in the fish samples considering both coverages (core area and total area) are shown in Figure 7.4.1.4ab.

7.5 Stock assessment

This stock is considered as a category 5 stock (catch only), and the stock status is therefore evaluated based on trends in landings only. However, analysis of newly available data, including a fisheries-independent time-series, will be used to reassess the categorization of this stock; pending the results, it may potentially be moved to a category 3.

Overall landings in Subarea 7 have decreased since 2004, especially since 2010 (Figure 7.2.1.1). This is mainly due to a decrease in French landings only partly compensated by an increase in landings by the UK. It is worth noting that since 2004, this subarea almost evolved 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.

It must be noted that the catches strongly increased in 2016 and decreased again since 2017, although they remained higher than the average of the preceding ten years.

7.6 Short-term projections

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

7.7 Reference points

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

7.8 Management consideration

There are no management objectives for these fisheries and there is no international TAC. Although currently the data available for the stocks are still limited, the data collected during 2017–2018 fishing season from the commercial fleet, together with the results from the PELTIC acoustic survey, suggest a sustainable exploitation of the sardine stock in area 7. The size structure of the catches relies on the ringnet or purse-seine fleet only, but this represents the most important fleet in terms of landed quantities.

The extension of the PELTIC survey in 2017 suggests a good coverage of the stock distribution, as well as an extensive coverage of the area where the majority of the fishery happens, and it might be considered a reliable indicator of the biomass present in the area.

The harvest rate is on the low side and, from the starting of the PELTIC time-series, has never exceed the 20%, which is usually consider a safe level of exploitation.

7.9 References

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Table 7.2.1.1. Official landings (tonnes) by country reported to ICES (1970–2018) in ICES Subarea 7.

	France	United Kingdom	Netherlands	Ireland	Germany	Denmark	Lithuania	Belgium	Spain
1970	1014	890	38	0	2112	0	0	0	0
1971	1350	1242	108	0	3362	0	0	0	0
1972	1297	2190	54	0	1553	0	0	0	0
1973	1603	2375	17	0	2577	0	0	0	0
1974	833	1280	15	0	1826	0	0	0	0
1975	678	6	561	0	4043	0	0	0	0
1976	1284	3	127	0	2346	0	0	0	0
1977	3544	10778	623	0	183	0	0	0	0
1978	2773	549	1523	0	1463	0	0	0	0
1979	3247	46	1321	0	1188	0	0	0	0
1980	3573	753	1131	0	79	0	0	0	0
1981	1125	35	553	0	0	4471	0	0	0
1982	908	141	928	0	0	1311	0	0	0
1983	802	6	795	0	19	4743	0	0	0
1984	817	1	0	0	0	1210	0	0	0
1985	2089	20	0	0	0	3111	0	0	0
1986	2570	30	0	0	0	3602	0	0	0
1987	965	124	0	0	0	1573	0	0	0
1988	2586	0	0	0	0	3234	0	0	0
1989	1219	1660	11	0	0	4667	0	0	0
1990	1128	2078	6	0	107	6113	0	0	0
1991	1963	2952	0	0	8	4462	0	0	0
1992	1777	4493	41	0	4	17843	0	0	0
1993	1135	4917	109	0	0	13395	0	0	0
1994	1285	2081	20	0	2	20804	0	0	0
1995	1282	7133	107	0	66	9603	0	0	0

	France	United Kingdom	Netherlands	Ireland	Germany	Denmark	Lithuania	Belgium	Spain
1996	1563	7304	48	0	0	1396	0	0	0
1997	3346	7280	411	0	13	1124	0	0	0
1998	1974	6873	1647	192	100	14316	0	0	0
1999	119	4815	5166	2375	146	3490	0	0	8
2000	4074	4353	6586	354	436	1682	0	0	0
2001	8589	10375	6609	1060	454	0	0	0	0
2002	5324	7858	1905	2652	224	0	0	0	10
2003	6594	4358	6897	2580	25	0	0	0	0
2004	6681	2681	2187	6195	109	742	0	0	0
2005	11113	3631	2231	2083	274	0	0	0	5
2006	12965	1925	2287	698	481	0	17	0	2
2007	8865	2654	1106	14	0	4	0	0	0
2008	8665	3470	2073	875	42	54	0	0	0
2009	4135	2541	3406	33	0	0	0	0	0
2010	850	2521	6645	25	106	13	0	0	0
2011	507	3604	513	983	22	3	0	0	0
2012	444	4423	1439	8	0	0	0	0	0
2013	1768	3722	1804	236	214	40	0	0	0
2014	1202	3889	249	0	18	953	0	0	0
2015	1040	4293	1137	380	1551	1011	1	0	0
2016	863	9389	4697	232	1941	2286	0	1	0
2017	726	7623	1349	140	1095	2459	0	0	0
2018	663	8141	0	44	490	263	0	0	0

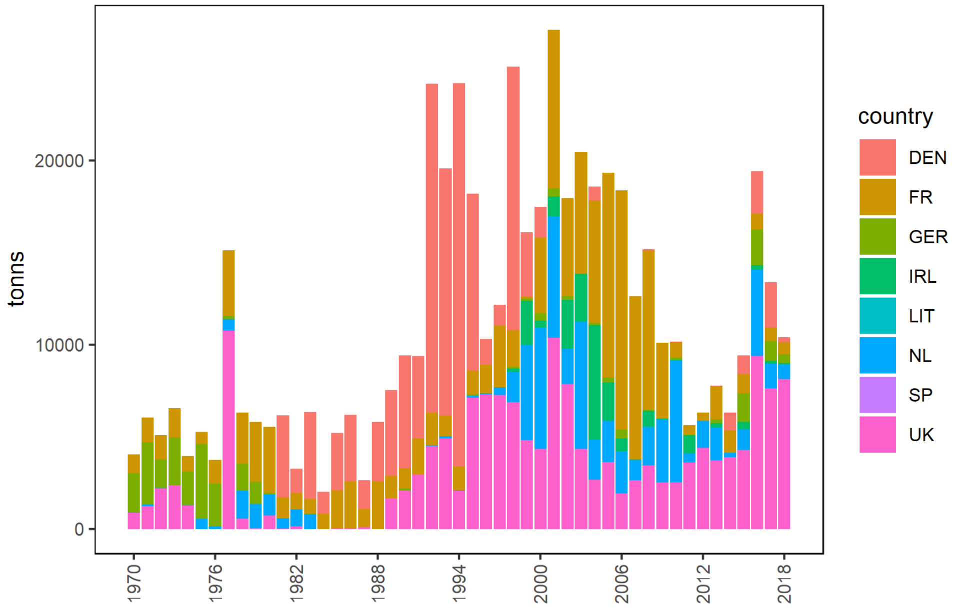

Figure 7.2.1.1. Official landings (tonnes) by country reported (1970–2018) in Subarea 7.

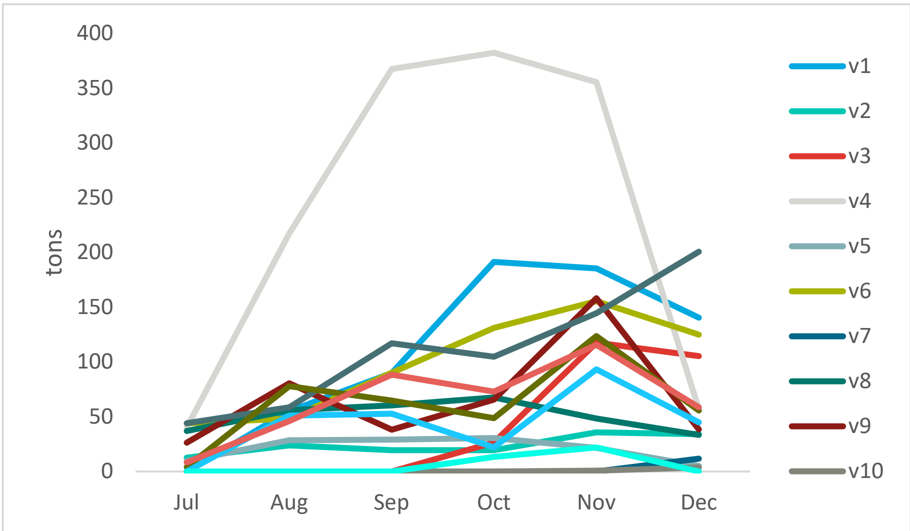

Figure 7.3.1.1. Monthly catches for the Cornish ringnetters as self-reported during the fishing season 2018–2019.

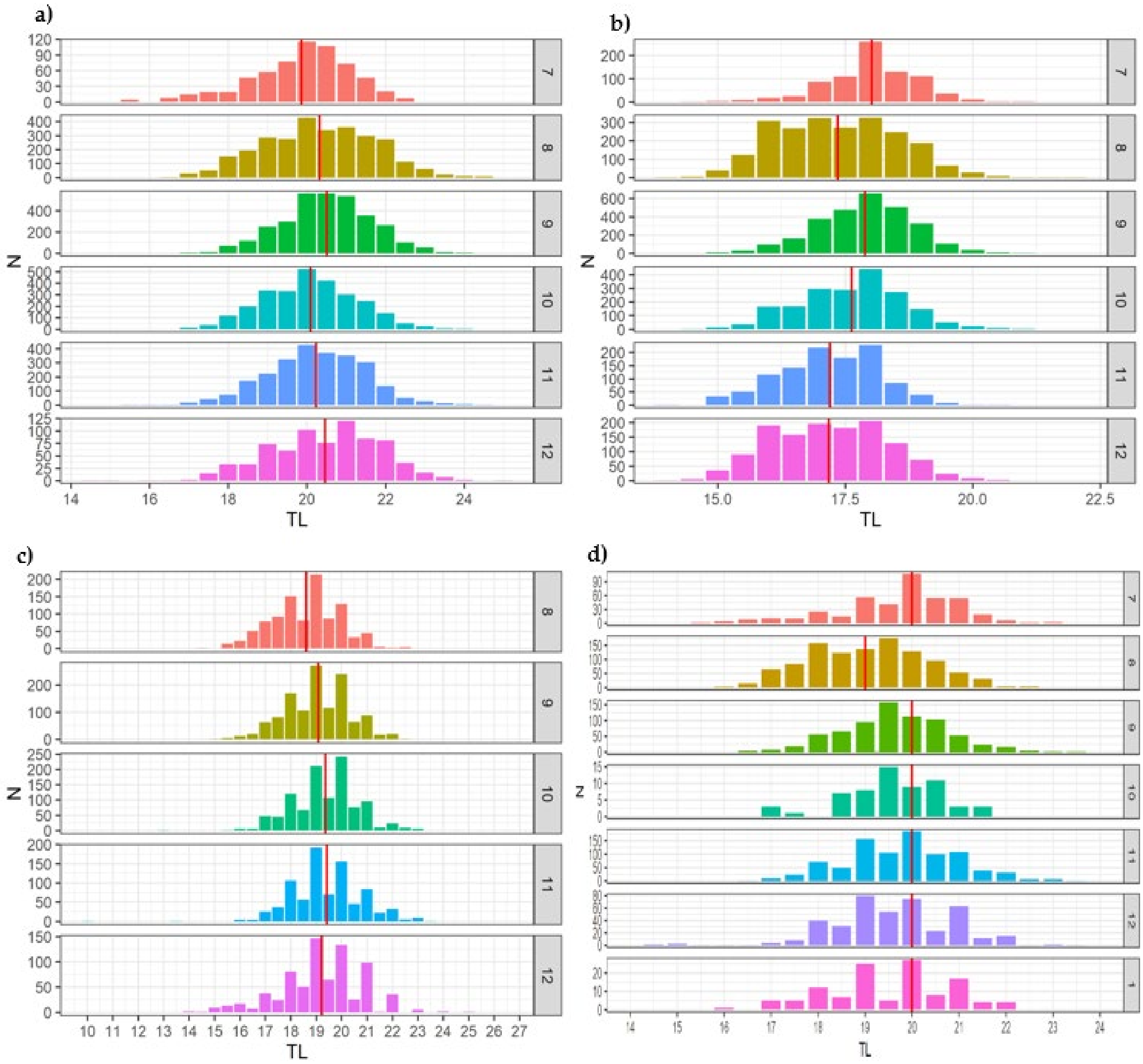

Figure 7.3.1.2. Monthly length–frequency distribution from the Cornish ringnetters for the fishing season 2018–2019: a) fishers; b), c) and d) processors.

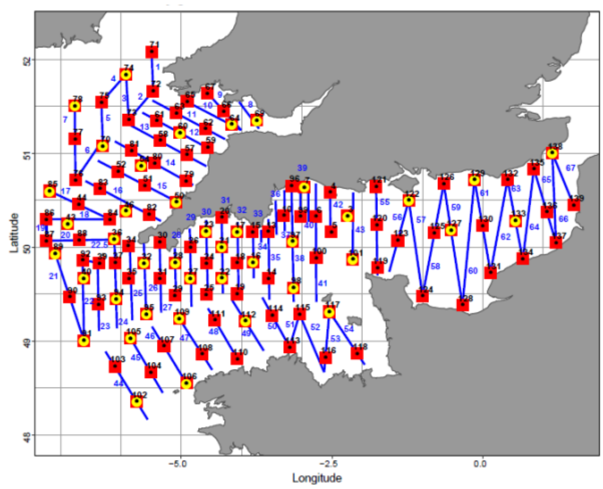

Figure 7.4.1.1. Overview of the survey area (PELTIC), with the acoustic transect (blue lines), plankton stations (red squares) and hydrographic stations (Yellow circles). The Eastern Channel area was covered only in 2018.

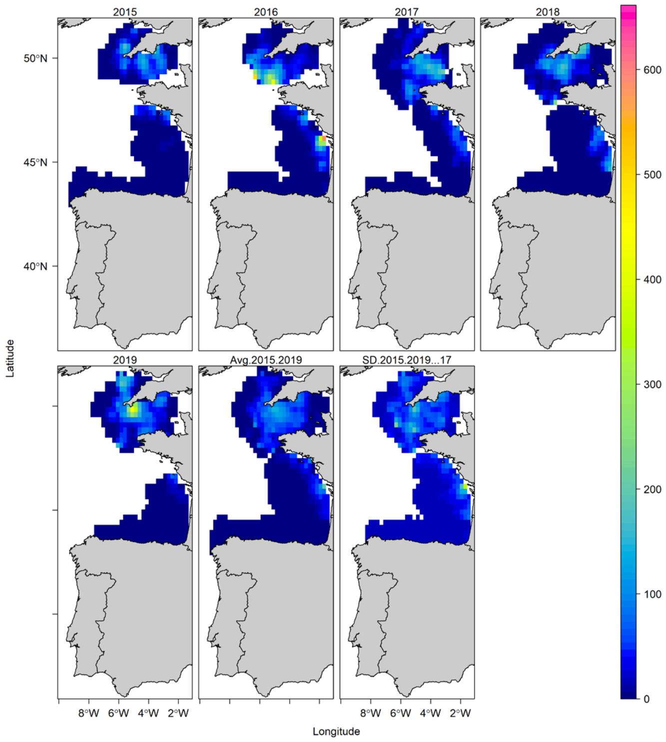

Figure 7.4.1.2. Annual autumn acoustically derived sardine distribution in the Northeast Atlantic Ocean, shown separately for the years 2015–2019, and for all years averaged (including the standard deviation). Note that in 2015 and 2016 spatial coverage of the combined PELTIC and JUVENA surveys was incomplete, leaving a gap off Brittany; a key issue that has been addressed since 2017.

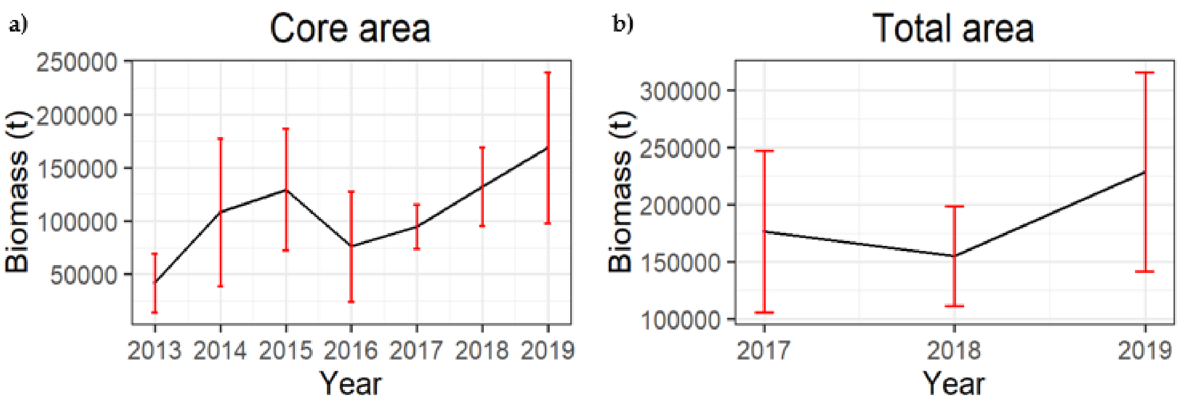

Figure 7.4.1.3. Sardine biomass along with CI from PELTIC survey: a) Core area covered Division 7.f and English waters of 7.e; b) Total area covered Division 7.f and 7.e (also French side).

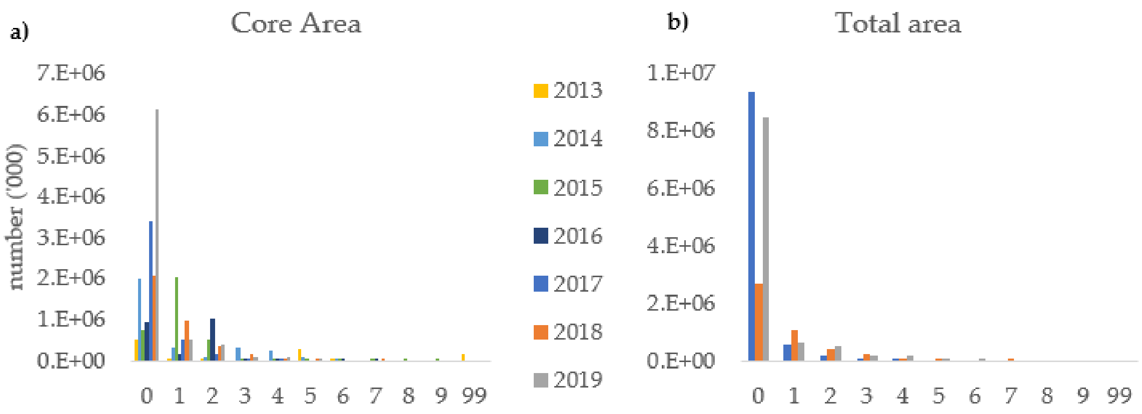

Figure 7.4.1.4. Numbers-at-age measured in the fish samples collected during the PELTIC survey: a) Core area covered Division 7.f and English waters of 7.e; b) Total area covered Division 7.f and 7.e (also French side).

8 Sardine in 8c and 9a

8.1 ACOM Advice Applicable to 2019, STECF advice and Political decisions

ICES advises that when the MSY approach is applied, there should be zero catches in 2019.

In Portugal, sardine catches were not allowed with any fishing gear from the 28th of September 2018 to the 2nd of June 2019 (Despacho n.º 9193-B/2018, Diário da República, 2.ª série - N.º 188 - 28 de setembro de 2018; Despacho n.º 4859-A/2019, Diário da República, 2.ª série - N.º 92 - 14 de maio de 2019). From the 3rd of June to the 31st of July, a catch limit of 5000 tonnes, daily landing limits by vessel, limit of fishing days per week, restrictions to the catch of small sardine (spatial and landing limit), were regulated for the purse-seine fleet (Despacho n.º 4859-A/2019, Diário da República, 2.ª série - N.º 92 - 14 de maio de 2019). From the 1st of August onwards, a catch limit of 4000 tonnes were regulated for the purse-seine fleet (Despacho n.º 7712-A/2019, Diário da República, 2.ª série - N.º 166 - 30 de agosto de 2019). Sardine catches reached the established limit in October and sardine catches were not allowed with any fishing gear from the 12th of October (Despacho n.º 9004-A/2019, Diário da República, 2.ª série - N.º 193 - 08 de outubro de 2019). During the period between 31st of July and the 12th of October changes on the daily landing limits and landing limits of small sardines were regulated as well as a fishing ban on Wednesdays (Despacho n.º 6683-A/2019 Diário da República, 2.ª série - N.º 141 - 25 de julho de 2019; Despacho 37/DG/2019 de 13 de setembro de 2019).

Under the bilateral agreement with Portugal, of the 10 799 tonnes agreed for both countries, 3618 tons were allocated to the Spanish fleet. The fishery remained closed from 2nd September 2018 until 1st May 2019, date on which it was provisionally opened until 31th August, with maximum allowable catches of 2532.4 tonnes. For the second period of the year, the authorized catches were 1085.3 t, with a closure of the fishery set for October 31, 2019 (BOE-A-2019-6960, BOE-A-2019-7755, BOE-A-2019-10799, BOE-A-2019-10957).

8.2 The fishery in 2018

8.2.1 Fishing fleets in 2018

Sardine is taken in purse-seine throughout the stock area and the fleet has remained relatively constant in recent years. In Spain (Gulf of Cadiz and northern waters), data from 2018 indicate that the number of purse-seiners taking sardine were 295, with mean power of 208 Kw.

In Portuguese waters, fleet data indicate that 178 vessels landed sardine with mean vessel tonnage of 40.8 GT and engine power category of 213 Kw.

8.2.2 Catches by fleet and area

The WG estimates of landings and catches are shown in Tables 8.2.2.1 and 8.2.2.2.

Total sardine landings in 2018 are shown in Tables 8.2.2.1, 8.2.2.2 and Figure 8.2.2.1. Total 2018 landings in divisions 8c and 9a were of 15 062 t, which represents a decrease by 31% with respect to 2017 landings (21 911 tonnes). The bulk of the landings (99%) were made by purse-seiners.

In Spain, sardine landings, 5324 tonnes, represent a 26% decrease in relation to values from 2017 (7217 tonnes). All ICES subdivisions, except 8c (where catches increased by 23%) showed a significant decrease in catches (by 61% in 9aN and by 38% in 9aS-Cadiz).

In Portugal, sardine landings showed a global decrease of 34% (9738 tonnes in 2018 vs 14 694 tonnes in 2017). By subdivisions, the larger decrease, of 51%, was observed in the 9aS-Algarve subdivision. In the western areas 9aCN and 9aCS, the reduction was of 31% and 29%, respectively.

Table 8.2.2.1 summarises the quarterly landings and their relative distribution by ICES subdivision. In 2018, due to management regulations implemented in Spain and Portugal, the sardine fishery opened later in the year, the 1st of May in Spain (BOE-A-2018-5879) and the 21st of May in Portugal (Despacho nº532-A/2018). In addition, the agreed catch for both countries, 14 600 t (Orden APM/605/2018, de 1 de junio, BOE 136, Section III. Pág. 58155, Martes 5 de junio de 2018) was lower than in previous years and therefore the fishery also closed earlier (2nd September in Spain - Resolución de la Secretaria General de Pesca del 31 de Agosto de 2018- and 28th of September in Portugal - Despacho n.º 9193-B/2018, Diário da República, 2.ª série - N.º 188 - 28 de setembro de 2018). For that reason, the sum of the second and third quarter landings represent more than 93% of the annual catches. The relative contribution of the different areas for the total catch are similar in relation with 2017 with area 9aS-Algarve loosing importance and area 8cW gaining importance in relative contribution to total catches when compared with last year.

Figure 8.2.2.2 shows the historical relative contribution of the different subareas to the total catches.

Data from Portugal and Spanish regular DCF monitoring in 2018 show that discards can be considered negligible and do not constitute a major issue for this fishery.

8.2.3 Effort and catch per unit of effort

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

8.2.4 Catches by length and catches-at-age

Tables 8.2.4.1b,c,d,e show the quarterly length distributions of landings from each subdivision. Annual length distributions (Table 8.2.4.1a) were unimodal in Spain in 8c subdivision (with modes at 19 cm and 21 cm in 8cE and 8cW respectively). In 9a, distributions were bimodals, with a smaller mode at 13 and 13.5 cm in 9aN and 9aS-Cádiz, and another at 21 cm and 17 cm respectively. As usual, smaller individuals were caught in 9aS-Cádiz subdivision.

For Portugal, sardine annual length distributions were unimodal in 9aS-Algarve, with a mode at 17.5 cm. For 9aCN and 9aCS, length distributions present several modes at 13, 16.5 and 19.5, and 14, 18 and 22.5 cm, respectively.

Table 8.2.4.2 shows the catch-at-age in numbers for each quarter and subdivision for the year 2018, while Table 8.2.4.3 shows the historical catch-at-age data. In Table 8.2.4.4 and Figure 8.2.4.1, the relative contribution of each age group in each subdivision is shown as well as their relative contribution to the catches. Age 2 had the higher contribution, with a 36% to the total biomass in catches, followed by age 1, with 20% of the catches. Age 0 was mainly caught in 9aS-Cadiz (54%), followed by 9aCN (23%), the two main recruitment areas for this stock. These areas also show no percentage or low percentage of age-3 and older. We can also observe the dominance of age 2 (2016 year class) individuals in all areas except Cádiz, where age 0 and age 1 represent 73% of catches.

8.2.5 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 8.2.5.1 and 8.2.5.2.

8.3 Fishery-independent information

Figures 8.3.1 and 8.3.2 show the time-series of fishery-independent information for the sardine stock.

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

As part of the Iberian DEPM survey, surveys are carried out every three years by Portugal (IPMA) and Spain (IEO). As described in the Stock Annex, the total spawning biomass from the two surveys is used in the assessment (see Annex 3).

The DEPM survey is planned and discussed within WGACEG (e.g. WGACEGG 2019), where final results were presented and fully discussed (ICES, 2019a).

In 2017, the IEO campaign was conducted in March/April. IPMA's survey took place in March–May, later than planned, with several interruptions and partially concurrent to the acoustic survey, consequently with a reduction in the number of the plankton stations. Moreover, during the 2017 surveys, on the Portuguese NW coast the availability of sardine for fishing was low and therefore adult samples for the DEPM were scarce. Also, the late period of the survey, in relation to the sardine spawning season, mainly in the SW coast of Portugal, likely explain that for this area a large fraction of the females sampled were already inactive. These constrains caused that it was not possible to estimate the spawning fraction for the western stratum from the samples available. The estimation of the spawning fraction was obtained (by bootstrap) using historic values.

The main conclusions from the Iberian DEPM survey are:

- Results obtained for the South coast (stratum 1) do not show *a priori* reasons for not considering the real estimates obtained from the surveying/sampling in that area: Total egg production (Ptot) increased in relation to 2014; number of eggs spawned per mature females per batch (F) decreased likely related to the lower mean female weight observed in the South (as relative fecundity was similar to the one obtained in 2014); the spawning fraction (S) estimated was lower but within the values obtained in the past and calculated based on most of the females sampled being reproductively active (~80%).
- In all strata, though the P_{tot} estimates for 2017 are among the lowest of the historical series, they are within the range of values obtained previously; moreover, on the West coast (stratum 2), the nearly absence of eggs and reproductive activity of the fish in most of the SW area, and the results obtained in the PELAGO survey (higher sardine biomass in the SW area), suggest that in stratum 2 "potential" total egg production, and subsequent spawning–stock biomass (SSB), have possibly been underestimated due to the late timing of the survey and/or an insufficient number of samples was obtained.
- Though relative batch fecundity is known to vary seasonally, the estimate obtained for the West (stratum 2) is similar to what was obtained in previous years, and therefore there is *a priori* no reason for not considering the F estimated for that stratum.
- In view of the above, WGACEGG recommended the adoption of the estimates presented in Table 8.3.1.1 for the 2017 sardine DEPM survey. All parameters were calculated from the real data obtained during the survey and following the same DEPM standard methodology used in previous years, except for the spawning fraction (S) of the West coast

(stratum 2) which corresponds to a historical average (Table 8.3.1.1 and Figure 8.3.1.1). The detailed re-analyses of the data uncover the fact that the NW Portuguese coast (41–42 ºN) had a higher contribution to the final biomass estimates. Nevertheless, final results calculated with further spatial stratification are potentially more realistic and to be considered for future. The life history parameters (weight and maturity-at-age) used in the assessment of the Atlantic Iberian Sardine stock, originated from the DEPM surveys, are based on the estimations presented in the WGACEGG report (ICES, 2019a).

8.3.2 Iberian acoustic survey (PELACUS-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 subdivisions 8c and 9a. The Iberian acoustic survey is planned and discussed within WGACEGG (e.g. WGACEGG, 2019). As described in the Stock Annex (see Annex 3), 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 9a and 8c using acoustic methods. The Portuguese survey (PELAGO19) took place on board the RV "Noruega" while the Spanish survey (PELACUS0319) 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.

8.3.2.1 Portuguese spring acoustic survey

PELAGO19 survey was carried out on board RV "Noruega" from 12th April to 19th May 2019, with similar design to that of the previous years.

During PELAGO19, 59 fishing hauls were undertaken, of which 36 pelagic trawls and 23 bottom trawls. Figure 8.3.2.1.1 shows the acoustic transect along the surveyed area.

Figure 8.3.2.1.2 shows the position of the fishing operations that occurred during the acoustic survey and the proportion of species in each fishing stations. During PELAGO19, in the 9aCN subdivision there was a predominance of anchovy, sardine, mackerel and horse mackerel, while the most abundant species in the 9aCS were sardine, horse mackerel and snipe fish. In the southern areas surveyed, sardine was the most abundant species, together with anchovy in the Gulf of Cadiz.

In general terms, low acoustic energy was observed, with the exception of the 9aS-Cadiz subdivision.

In relation to 2018, total abundance of sardine (number of individuals) in the survey PELAGO showed a decrease of 52%. This fact was due to the unusual presence of juveniles in the 2018 survey (72% of total number of individuals), which was carried out later than planned. However, if we consider only the age groups from the acoustic survey that are included in the assessment model, individuals of age-1 and older, the acoustic spring survey of 2019 showed an increase of sardine biomass of 23% and an increase of number of individuals of 55% compared to the PELAGO18 acoustic survey. In the 2019 acoustic survey, the most abundant year class detected was age 1 (2018 cohort, 49.5% of total number of individuals) (Table 8.3.2.1.1 and Figures 8.3.2.1.3 and 8.3.2.1.4). The sardine B1+ was estimated in 152217 tonnes for the whole area and an increase in B1+ was verified in areas 9aCN, 9aS-Algarve and 9aS-Cadiz. In 9aCS, a decrease in B1+ was verified.

During PELAGO19, lower sardine egg density was recorded in relation with the 2018 survey. Higher egg densities were found around Douro-Minho Rivers, river Mira - Arrifana and east Algarve.

8.3.2.2 Spanish spring acoustic survey

The Spanish survey PELACUS 0319 was carried out from 27th March to 19th April in the RV "Miguel Oliver". Sampling design and methodology was similar to that of the previous surveys. Due to the participation in the International Blue Whiting Spawning Stock Survey, from 2017 the area is covered anti clockwise, i.e. from the eastern part (Spanish–French border) to the southwestern part (Spanish–Portuguese border). Figure 8.3.2.2.1 shows the acoustic tracks carried out along the sampling area.

As expected in this time of the year, bad weather conditions had an impact on the survey and some of the foreseen tracks (25–27, 31 to 33 and 37 to 41) were partially covered (e.g. outer part). Fish were mainly located close to the coast, avoiding the areas of rough weather conditions. This, together with the lack of available time decreased the total number of fishing stations and only 46 valid hauls were done. Figure 8.3.2.2.2 shows the location and the catch composition of these hauls.

Mackerel, was present in 80% of the fishing stations, representing 83% in weight and 52% in number. Sardine catches distribution is rather similar to that found last year, mainly concentrated in the outer parts of the surveyed areas (e.g. inner part Bay of Biscay and 9a).

The bulk of the sardine acoustic energy distribution was recorded in the western area (i.e. Atlantic waters). The amount of backscattering energy allocated to sardine shows an increasing trend since 2013, when the minimum was observed. Furthermore, as the number of fish is increasing, the center of gravity is moving towards the western area (Galician area), and consistently moving to shallower waters (Figure 8.3.2.2.3).

A total of 71 thousand tonnes, corresponding to 713 million fish were estimated, most of them, as expected, in the western part (8cW and 9aN). Although this represents a significant increase in biomass in relation to that estimated in 2018, age group 1 only accounted for less than 1% of the total biomass (Table 8.3.2.2.1, Figures 8.3.2.2.4 and 8.3.2.2.5). It is also noticeable that the increase in biomass is only due to a vegetative increase (e.g. individual growth) and not for an increase in number. In fact, the number of fish decreased. Age group 3 was dominant in the whole survey area, and accounted for 48% of the total biomass and number.

Sardine egg distribution collected by CUFES is similar to that recorded from the acoustic survey (Figure 8.3.2.2.6), with most of the egg being concentrated in the western part, and only few eggs just at the inner part of the Bay of Biscay were adult occurrence was also negligible. 367 samples were collected. Of those, only 121 (33%) were positive for sardine, lower than in previous year, although the number of eggs was slightly higher accounted 2930, with an average density over the positive stations of 2.17 eggs/m^3.

8.3.3 Other regional indices

Although not included as an input in the sardine assessment, ECOCADIZ survey (fully described in Section 4, Anchovy in 9a division), provides sardine abundance and biomass estimates in the Gulf of Cadiz and Algarve (9aS subdivision) in the summer, which can be compared with the results obtained by the spring Portuguese acoustic survey in the same area. For both surveys, trends in abundance (and biomass) are broadly similar, although they have interannual differences.

In addition, during autumn, ECOCADIZ-reclutas gives (since 2012) an estimation of sardine recruitment in the Gulf of Cadiz, one of the main recruitment areas for the stock.

For the major recruitment area in Portugal, in the recent period (from 2013), JUVESAR juvenile surveys were carried out from Lisbon to the Portuguese–Spanish border, to assess the abundance of recruits in that particular area.

Since 2018, as a result of a collaboration between IPMA and IEO, the survey IBERAS estimates a recruitment index in Atlantic waters of the Iberian Peninsula, aiming to improve the estimation of the strength of the recruitment for both Ibero-Atlantic sardine and the western component of the south anchovy population (for further details see IBERAS1118 and IBERAS0919 WDs). In 2018, the survey was carried out in November and in 2019, the date was advanced to September. Figure 8.3.3.1 shows the area prospected during IBERAS. Comparing with JUVESAR time-series, the number of sardine juveniles in 2018 was higher than those estimated in 2017 (525 million fish in 2018 and 472 million fish in 2017), although the biomass was higher in 2017 (1 kt more). In 2019, in general terms, the change from November to September improved the survey strategies and the assessment itself. The number of lost days due to bad weather conditions considerably decreased and the bulk of the recruitment is available. IBERAS showed a significant increase in the strength of the estimated recruitment (5.45 10^9 individuals). All the recruits were found in Portugal, and the bulk of the distribution was found in 9aCN. The strength of this recruitment should, therefore, be confirmed with the estimates of age 1 provided by the next spring surveys PELACUS and PELAGO.

During WGHANSA, survey consistency and trends of juvenile abundance and biomass in both recruitment surveys and spring acoustic surveys used in the assessment were discussed and results are presented in Section 11.

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

Mean weight-at-age in the catch are shown in Table 8.3.4.1a.

According to the stock annex, mean weights-at-age in the stock (Table 8.3.4.1b) come from the DEPM surveys. See Annex 3.

- For years with no DEPM survey, a linear interpolation of the data from two consecutive surveys is carried out to obtain the estimates of mean weight-at-age.
- For the period 1978–1998 (before the DEPM series started) it was decided to consider the two closest DEPM surveys, and assume for that period the average between 1999 and 2002 estimates.
- For the years after the last DEPM survey, the estimates of the last DEPM survey (2017) are assumed.

8.3.5 Maturity-at-age

Following the stock annex, maturity ogive from the stock comes from the DEPM surveys.

- For years with no DEPM survey, a linear interpolation of the data between two consecutive surveys is carried out to obtain the estimates of maturity-at-age.
- For the period 1978–1998 (years before starting the DEPM series), constant proportions of maturity-at-age were assumed, based on the average of the estimates obtained from the six DEPM surveys of the 1999–2014 period, thus including both years of strong year classes and years of low recruitment.
- For the years after the last DEPM survey, the estimates of the last DEPM survey (2017) are assumed.

8.3.6 Natural mortality

Following the stock annex, natural mortality is:

M, year^{-1}	
Age 0	0.98
Age 1	0.61
Age 2	0.47
Age 3	0.40
Age 4	0.36
Age 5	0.35
Age 6	0.32

8.3.7 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 8.3.7.1 and 8.3.7.2.

8.4 Assessment Data of the state of the stock

8.4.1 Stock assessment

The table below presents an overview of the model settings. Additional details can be found in the stock annex. (See Annex 3)

Input data	WGHANSA 2019
Catch	Catch biomass 1978–2018 (tonnes)
	Catch-at-age 1978–2018 (thousands of individuals)
Acoustic survey (Joint SP+PT)	Total numbers 1996–2019 (thousands of individuals)
	Numbers-at-age 1996–2019 (thousands of individuals)
DEPM survey (Joint SP+PT)	SSB 1997, 1999, 2002, 2005, 2008, 2011, 2014, 2017 (tonnes)
Weight-at-age in the catch	Yearly averages 1978–2018 (constant up to 1989), kg
Weight-at-age in the stock	From DEPM surveys in DEPM years, linear interpolation for years in-between (constant 1978–1998, 2017–2018), kg
Maturity-at-age	From DEPM surveys in DEPM years, linear interpolation for years in-between (constant 1978–1998, 2017–2018), proportions

Input data	WGHANSA 2019
Model structure and assumptions:	
M	M-at-age 0=0.98, M-at-age 1=0.61, M-at-age 2=0.47, M-at-age 3=0.40, M-at-age 4=0.36, M-at-age 5=0.35, M-at-age 6+=0.32
Recruitment	Density-dependent R model; annual recruitments are parameters, defined as lognormal deviations from Beverton–Holt stock–recruitment model, penalized by a sigma of 0.70, and an input steepness of 0.71.
Initial population	N-at-age in the first year are parameters derived from an input initial equilibrium catch of 135 000 tons, equilibrium recruitment and selectivity in the first year and adjusted by recruitment deviations estimated from the data on the first years of the assessment. Equilibrium assumed to take place in 1972.
Fishery selectivity-at-age	S-at age are parameters, each estimated as a random walk from the previous age; S-at-age 0 used as the reference; S-at-ages 4 and 5 assumed to be equal to S-at-age 3.
Fishery selectivity over time	Three periods: 1978–1987, 1988–2005 and 2006–2018. Selectivity-at-age is estimated for each period and within each period assumed to be fixed over time.
Survey selectivity-at-age	Selectivity assumed to be equal at all ages.
Fishery catchability	Scaling factor, median unbiased
Acoustic survey catchability	Parameter, mean unbiased
DEPM catchability	Parameter, mean unbiased
Log-likelihood function:	
Weights of components	All components have equal weight
Data weights	Sample size of age compositions by year (50 in 1978-1990 and 75 in 1991-onwards for the fishery, 25 for the acoustic survey; Acoustic and DEPM abundance observations with equal weight = CV=25%; age reading uncertainty; user input sample sizes and survey CV are used as inverse weights of likelihood components.

Table 8.5.1.1 shows the parameters estimated by the assessment model. Fishing mortality-at-age and numbers-at-age are presented in Tables 8.5.1.2 and 8.5.1.3. Parameters estimated in the 2019 assessment are also comparable to those from the 2018 assessment, virgin recruitment ($R_{0,2019}$ = 14 619 000 vs $R_{0,2018}$ = 14 548 800, CV = 3%) and the initial F ($initF_{2019}$ = 0.76 year-1 versus initF = 0.78 year-1, CV = 16.4%). Catchability parameters are close to 1 for both the acoustic (Q = 1.28, RMSE = 0.25) and the DEPM (Q=1.18, RMSE=0.32) surveys. Correlations between the assessment parameters range from -0.87 to 0.44 although the majority are very close to zero. Negative correlations below -0.5 are observed between R_0 and $Q_{acoustic\ survey}$ and between selectivity parameters from the first period (five cases).

The assumed standard error for both surveys, all years = 0.25, are consistent with the residual mean square errors estimated by the model, 0.25 for the acoustic index and 0.32 for the DEPM index. The harmonic mean of the fishery age composition sample size, 82, suggests that the data are slightly more precise than assumed (mean initial sample size = 67 for the whole period). In the case of the survey, the sample size of 25 is consistent with the precision indicated by the model (the harmonic mean for the acoustic survey is estimated to be 21).

Figures 8.5.1.1 and 8.5.1.2 show the fit of the model to the acoustic survey and DEPM indices of abundance that are very similar to the fit of the 2018 assessment model. However, the model fit to the acoustic estimate in 2018 is lower. The same pattern was found in last year’s assessment. With the inclusion of the DEPM survey index in this year’s assessment the model fits better to the two DEPM surveys prior 2017, i.e. to the DEPM of 2011 and 2014.

Figure 8.5.1.3 shows the model residuals from the fit to the catch-at-age composition (top panel) and the acoustic survey age composition (bottom panel). In both cases the residuals from the present assessment are very similar to the previous assessment model, suggesting the current assumptions about survey and catch selectivity are more consistent with the age composition data than prior to the benchmark. In particular, catch-at-age residuals show a more random distribution in recent years. The acoustic survey residuals show some clustering with positive residuals in the 1990s at ages 2–5 and negative residuals thereafter.

The fishery selectivity patterns estimated in the present assessment show less abrupt changes over time and through ages (particularly at the age-6+ group) and therefore seem to be more realistic than the patterns estimated in assessment models prior to the benchmark (Figure 8.5.1.4). The patterns over age are dome-shaped in the three periods with the early (1978–1987) and recent periods (2006–2017) showing higher selectivity at ages 1–2 than the middle period (1988–2005), in agreement with the higher fraction of the catches coming from recruitment areas in those periods. The increase of age 0 selectivity estimated in the most recent period is consistent with large catches of this age group in a period that recruitment is at a very low level.

The summary of the 2019 assessment results is shown in Table 8.5.1.4 and Figure 8.5.1.5 (in the Figure compared the 2018 assessment model results). The estimate of B1+ in 2019 assumes stock weights are equal to the mean in the last six years, the same assumption taken in the short term forecast, and in accordance to the stock annex. 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), respectively.

B1+ in 2019 is predicted to be 179 410 t (CV = 15.2%), assuming that the stock weights are equal to the mean of the last six years. This represents an increase of 12% when compared with B1+ in 2018 = 160 898 t (CV = 14.1%). B1+ is below B_{lim} = 196 334 t of the current low productivity regime of the stock (see Section 8.7) since 2011. $F_{bar\ 2–5}$ in 2018 is estimated to be 0.086 year-1 (CV = 15.4%) and is the lowest $F_{bar\ 2–5}$ observed in the historical series. In fact, $F_{bar\ 2–5}$ is decreasing continuously since 2012.

The series of historical recruitments 1978–2018 shows a marked downward trend until 2006 and since then, fluctuates around historically low values (geometric mean 2014–2018 = 4 820 903 thousand individuals). The 2017 recruitment estimate constitutes the lowest value of the time-series and was supported by the low juvenile estimates of ECOCADIZ-RECLUTAS 2017, JUVESAR 2017 juvenile surveys and of the 2018 and 2019 acoustic surveys PELAGO (Section 8.3.3).

8.4.2 Reliability of the assessment

The model used in the current assessment shows a better fit to the data available and provides more precise estimates of biomass, recruitment and fishing mortality in comparison with assessment models prior to the benchmark. The assumptions of survey selectivity and fishery selectivity in the current model are parsimonious.

The 2017 DEPM survey index was included in the present assessment for the first time after revision of the preliminary results presented in 2018 (ICES, 2018; Angélico *et al*., 2017). The use of the 2017 DEPM survey index slightly improves the model fitting. The assessment model is consistent.

Catches for the interim year (2019) are preliminary Portuguese and Spanish official catch data. Assumptions on the interim year catches have a small impact on the assessment estimates and they are always revised in the following year.

8.5 Retrospective pattern

Retrospective patterns for Biomass 1+, $F_{ages2\text{-}5}$ and recruitment were computed for years 2013–2019. For each run, assessment was performed including survey data until the terminal year and catch data until the previous year, as done in the current assessment (2019). This range of runs include runs prior and after the benchmark (2017). The potential retrospective bias in the assessment was quantified using an approach based on the Mohn's rho (Mohn, 1999), following ICES guidelines, and was computed using the function mohn() available in the R package called icesAdvice.

Results are shown in absolute terms (Figure 8.6.1). The model slightly underestimates Biomass 1+ (Mohn's rho of -0.063) and recruitment (Mohn's rho of -0.109) while it overestimates $F_{ages2–5}$ (Mohn's rho of 0.104). Differences in the estimation of these parameters between runs are more pronounced for $F_{ages2–5}$ and, in all cases, in the last portion of the time-series. Most probably, changes in the most recent years are a consequence of the model fit to the most recent data. However, trends do not change between runs. Finally, the retrospective plots indicate that the model is robust.

8.6 Short-term predictions

Catch predictions were carried out following the stock annex, Annex 3. Recruitment in the interim year (2019) and forecast year (2020) were set to the geometric mean of the last five years (2014–2018), $R_{2019–2020}$ = 4 820 903 thousand individuals. This changes the population number-at-age structure and it is therefore necessary to adjust fishing mortality in the interim year (2019). Fishing mortality in the interim year is the fishing mortality that corresponds to a catch constrain based on the catch assumption made for the interim year in the assessment model. In this year's assessment, catch assumption for 2019 was assumed to be 13 316 tonnes based on preliminary official data provided by both Spain and Portugal. With the structure of the population used for the short-term forecast, this corresponds to a $F_{ages2–5,\ 2019}$ = 0.078.

For 2020, predictions were carried out with an $F_{multiplier}$ assuming an F_{sq}= 0.135, the average estimate of the last three years in the assessment (i.e. $F_{ages2-5}$ mean 2016−2018), as indicated in the Stock Annex.

Table 8.7.1 shows input data of the short-term forecast.

Table 8.7.2 shows the results of the short-term forecast. The complete set of results for fine steps of $F_{multiplier}$ scenarios is stored in file pil8c9a_STF2019_scenarios.xls in the WGHANSA SharePoint.

8.7 Reference points

Biological Reference Points (BRPs) for this stock were re-evaluated this year during the Workshop on the Iberian Sardine Management and Recovery Plan (WKSARMP; ICES, 2019b).

ICES adopted new reference points for the stock based on data from the period 2006–2017, which are considered representative of the low productivity state of the stock (ICES, 2019c). The updated BRPs include B_{lim} = 196 334 tonnes and F_{MSY} = 0.032; these values are significantly different from the previous ones.

ICES is not able to predict the persistence of the current state of low productivity and therefore recommended that the state of productivity for this stock is monitored regularly to determine if the BRPs and the resulting harvest control rules associated with low productivity remain valid.

The methodology used for the estimation of the BRPs followed the framework proposed in ICES (2017a) guidelines for fisheries management reference points. Simulations analyses were conducted with the package "msy" using the EqSim routines (https://github.com/ices-tools-prod/msy; ICES, 2016), a stochastic equilibrium reference point software that provides MSY reference points based on the equilibrium distribution of stochastic projections. This was the same approach followed for the previous estimated BRPs.

A Hockey-stick stock–recruitment relationship for the period 2006–2017 was adopted for the calculation of reference points. Following ICES (2017a) guidelines, the S–R data of this stock are consistent with a Type 2 pattern given the wide dynamic range of SSB and evidence that recruitment is impaired. In this case, B_{lim} is equal to the change point of a Hockey-stick model fitted to S–R data.

The following Table shows BRPs and technical basis for the estimation.

Biological Reference Points based on the state of low productivity (2006–2017) during WKSARMP (ICES, 2019b).

BRP	Updated	Technical basis
	2006–2017	
B_{lim}	196 334 t	B_{lim} = Hockey-stick change point
B_{pa}	252 523 t	$B_{pa} = B_{lim} * \exp(1.645 * \sigma)$, $\sigma = 0.17$ (ICES, 2017b)
F_{lim}	0.156	Stochastic long-term simulations (50% probability SSB < B_{lim})
F_{pa}	0.118	$F_{pa} = F_{lim} * \exp(-1.645 * \sigma)$, $\sigma = 0.233$ (ICES, 2016) If $F_{pa} < F_{MSY}$ then $F_{MSY} = F_{pa}$
$B_{trigger}$	252 523 t	$B_{trigger} = B_{pa}$
$F_{p0.5}$	0.032	Stochastic long-term simulations with ICES MSY AR (≤ 5% probability SSB < B_{lim}); Constraint to F_{msy} if $F_{p0.5} < F_{msy}$
F_{MSY}	0.224	Median F_{target} which maximizes yield without $B_{trigger}$
Adopted F_{MSY}*	0.032	If $F_{p0.5} < F_{MSY}$ then $F_{MSY} = F_{p0.5}$

*** The F that maximizes long-term yield under the constraint that the long-term probability of SSB < B_{lim} is ≤ 5% when applying the ICES MSY advice rule (ICES, 2018b).**

8.8 Management considerations

A management plan agreed by Portugal and Spain (Sardine Fishery Management Plan 2012–2015) was evaluated in 2017 and found to be not precautionary (ICES, 2017b). A new management and recovery plan for the Iberian sardine stock (divisions 8.c and 9.a) (Multiannual Management and Recovery Plan for the Iberian Sardine 2018–2023) was developed by Spain and Portugal, and ICES was requested to evaluate two harvest control rules (HCR) within that management and recovery plan (ICES, 2019b). The two HCRs, HCR1 and HCR2, had three reference levels for fishing mortality (no fishing, low F, and target F) and three reference levels for the biomass of age 1 and older individuals, B1+ (B_{low}, 80%B_{lim}, and B_{lim}).

On the 29th of May the ICES advice was published (ICES, 2019c). As ICES considers the Iberian sardine stock to be in a state of low productivity since 2006, and therefore recalculated the value of B_{lim} to be 196 334 tonnes and F_{MSY} to be 0.032 (Section 8.7). ICES advised that the harvest control rules HCR3 and HCR4 (Figure 8.9.1), similar to those in the Portuguese and Spanish request to evaluate a management and recovery plan for the Iberian sardine stock, but with trigger points and biological reference points that reflect a persistent low productivity, fulfil the recovery objective in the request by 2022 (80% above B_{lim} with 90% probability), and are consistent with the ICES precautionary approach with no more than 5% probability of the spawning–stock biomass (SSB) falling below B_{lim}. These harvest rules result in annual catches of around 7000 and 18 000 tonnes in the first ten years and in the last ten years, respectively (ICES, 2019b).

In September 2019, ICES received an additional Special Request from the Portuguese and Spanish Administration to follow up the work done during WKSARMP to evaluate alternative catch rules to HCR4. The new request asks ICES to consider F_{tgt} between 0.08 and 0.09 or, in case the catch rules with these higher F_{tgt} do not comply with the 5% precautionary criterion, to seek the highest F_{tgt} (i.e., an F_{tgt} higher than the HCR4 F_{tgt}, of 0.032) that has a maximum risk3 of 5% in the long term, and that will give higher median catches in the short and long term than with HCR4. ICES advice on this request will be published on the 13th of December of the current year.

The recruitment of the stock has been around the lowest historical level for approximately a decade, and 2017 recruitment was estimated as the lowest one. The biomass of the stock is also around the lowest historical level and below the limit biomass (B_{lim}) since 2011.

Measures to protect spawners and recruits should be maintained and possibly reinforced.

8.9 New references

Angélico MM, Nunes C, Henriques E, Riveiro I, Pérez JR, Garabana D, Domínguez R, Carrera P, Diaz P. 2017. Atlantic Iberian Sardine DEPM estimates for 2017 (ICES areas 9a and 8c). Working Document presented at WGACEGG meeting, Cádiz, Spain, 13–17 Nov. 2017.

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Mohn, 1999. The retrospective problem in sequential population analysis; An investigation using cod fishery and simulated data. ICES Journal of Marine Science, 56: 473–488.

Table 8.2.2.1. Sardine in 8c and 9a: Quarterly distribution of sardine landings (tonnes) in 2018 by ICES subdivision. Above absolute values; below, relative numbers.

Sub-Div	1st	2nd	3rd	4th	Total
8cE	93	106	64	948	**1210**
8cW		855	698		**1554**
9aN	0.03	459	396		**856**
9aCN		1202	2377		**3579**
9aCS		1970	2789		**4759**
9aS-Algarve		628	772		**1400**
9aS-Cadiz	0.10	456	1248	0.42	**1704**
Total	**93**	**5675**	**8345**	**949**	**15062**

Sub-Div	1st	2nd	3rd	4th	Total
8cE	0.61	0.70	0.42	6.30	**8.04**
8cW	0.00	5.68	4.64	0.00	**10.31**
9aN	0.00	3.05	2.63	0.00	**5.68**
9aCN	0.00	7.98	15.78	0.00	**23.76**
9aCS	0.00	13.08	18.52	0.00	**31.59**
9aS-Algarve	0.00	4.17	5.13	0.00	**9.30**
9aS-Cadiz	0.00	3.02	8.29	0.00	**11.32**
Total	**0.62**	**37.68**	**55.41**	**6.30**	

Table 8.2.2.2. Sardine in 8c and 9a: Iberian Sardine Landings (tonnes) by subarea and total by country for the period 1940–2018.

Year	8c	9aNorth	9a Central North	9a Central South	9a South Algarve	9a South Cadiz	Portugal	Spain
1940	66816		42132	33275	23724		99131	66816
1941	27801		26599	34423	9391		70413	27801
1942	47208		40969	31957	8739		81665	47208
1943	46348		85692	31362	15871		132925	46348
1944	76147		88643	31135	8450		128228	76147
1945	67998		64313	37289	7426		109028	67998
1946	32280		68787	26430	12237		107454	32280
1947	43459	21855	55407	25003	15667		96077	65314
1948	10945	17320	50288	17060	10674		78022	28265
1949	11519	19504	37868	12077	8952		58897	31023
1950	13201	27121	47388	17025	17963		82376	40322
1951	12713	27959	43906	15056	19269		78231	40672
1952	7765	30485	40938	22687	25331		88956	38250
1953	4969	27569	68145	16969	12051		97165	32538
1954	8836	28816	62467	25736	24084		112287	37652
1955	6851	30804	55618	15191	21150		91959	37655
1956	12074	29614	58128	24069	14475		96672	41688
1957	15624	37170	75896	20231	15010		111137	52794
1958	29743	41143	92790	33937	12554		139281	70886
1959	42005	36055	87845	23754	11680		123279	78060
1960	38244	60713	83331	24384	24062		131777	98957
1961	51212	59570	96105	22872	16528		135505	110782
1962	28891	46381	77701	29643	23528		130872	75272
1963	33796	51979	86859	17595	12397		116851	85775
1964	36390	40897	108065	27636	22035		157736	77287
1965	31732	47036	82354	35003	18797		136154	78768
1966	32196	44154	66929	34153	20855		121937	76350
1967	23480	45595	64210	31576	16635		112421	69075
1968	24690	51828	46215	16671	14993		77879	76518
1969	38254	40732	37782	13852	9350		60984	78986
1970	28934	32306	37608	12989	14257		64854	61240
1971	41691	48637	36728	16917	16534		70179	90328
1972	33800	45275	34889	18007	19200		72096	79075
1973	44768	18523	46984	27688	19570		94242	63291
1974	34536	13894	36339	18717	14244		69300	48430
1975	50260	12236	54819	19295	16714		90828	62496
1976	51901	10140	43435	16548	12538		72521	62041
1977	36149	9782	37064	17496	20745		75305	45931
1978	43522	12915	34246	25974	23333	5619	83553	62056
1979	18271	43876	39651	27532	24111	3800	91294	65947

Year	8c	9aNorth	9a Central North	9a Central South	9a South Algarve	9a South Cadiz	Portugal	Spain
1980	35787	49593	59290	29433	17579	3120	106302	88500
1981	35550	65330	61150	37054	15048	2384	113253	103264
1982	31756	71889	45865	38082	16912	2442	100859	106087
1983	32374	62843	33163	31163	21607	2688	85932	97905
1984	27970	79606	42798	35032	17280	3319	95110	110895
1985	25907	66491	61755	31535	18418	4333	111709	96731
1986	39195	37960	57360	31737	14354	6757	103451	83912
1987	36377	42234	44806	27795	17613	8870	90214	87481
1988	40944	24005	52779	27420	13393	2990	93591	67939
1989	29856	16179	52585	26783	11723	3835	91091	49870
1990	27500	19253	52212	24723	19238	6503	96173	53256
1991	20735	14383	44379	26150	22106	4834	92635	39952
1992	26160	16579	41681	29968	11666	4196	83315	46935
1993	24486	23905	47284	29995	13160	3664	90440	52055
1994	22181	16151	49136	30390	14942	3782	94468	42114
1995	19538	13928	41444	27270	19104	3996	87818	37462
1996	14423	11251	34761	31117	19880	5304	85758	30978
1997	15587	12291	34156	25863	21137	6780	81156	34658
1998	16177	3263	32584	29564	20743	6594	82890	26034
1999	11862	2563	31574	21747	18499	7846	71820	22271
2000	11697	2866	23311	23701	19129	5081	66141	19644
2001	16798	8398	32726	25619	13350	5066	71695	30262
2002	15885	4562	33585	22969	10982	11689	67536	32136
2003	16436	6383	33293	24635	8600	8484	66528	31303
2004	18306	8573	29488	24370	8107	9176	61965	36055
2005	19800	11663	25696	24619	7175	8391	57490	39855
2006	15377	10856	30152	19061	5798	5779	55011	32012
2007	13380	12402	41090	19142	4266	6188	64499	31970
2008	13636	9409	45210	20858	4928	7423	70997	30468
2009	11963	7226	36212	20838	4785	6716	61835	25905
2010	13772	7409	40923	17623	5181	4662	63727	25843
2011	8536	5621	37152	13685	6387	9023	57223	23180
2012	13090	4154	19647	9045	2891	6031	31583	23275
2013	5272	2128	15065	9084	4112	10157	28261	17557
2014	4344	1924	6889	6747	2398	5635	16034	11903
2015	1916	1946	7117	4848	1812	2956	13777	6818
2016	2886	2887	7695	4031	1972	3233	13697	9006
2017	2251	2225	5182	6676	2836	2742	14694	7217
2018	2764	856	3579	4759	1400	1704	9738	5323

Table 8.2.4.1a. Sardine in 8c and 9a: Sardine length composition (thousands), mean length (cm) and catch (tonnes) by ICES subdivision in 2018.

				Total				
Length	**8c E**	**8c W**	**9a N**	**9a CN**	**9a CS**	**9a S**	**9a S (Ca)**	**Total**
6.5								
7								
7.5								
8								
8.5								
9								
9.5			35					35
10			192				35	227
10.5			332				75	407
11			305				118	424
11.5			179	20			661	860
12			184	90			2 190	2 463
12.5			101	189			2 237	2 526
13	3		384	393	117		3 407	4 304
13.5	28		847	293	411		2 995	4 573
14	81		341	261	704	328	2 219	3 935
14.5	80		17	91	528	547	1 275	2 538
15	83		8	102	235	219	4 732	5 379
15.5	65		8	529		170	3 370	4 142
16	99		85	3 549	572	243	9 141	13 690
16.5	280		250	5 007	1 145	2 847	4 284	13 813
17	776	13	309	4 119	1 717	5 231	9 570	21 736
17.5	1 388	4	319	2 966	4 618	7 347	3 278	19 921
18	2 591	135	134	2 041	7 845	6 483	1 138	20 367
18.5	2 903	362	52	4 168	6 937	2 116	160	16 699
19	3 557	876	160	6 424	5 451	219	61	16 748
19.5	3 022	1 458	630	11 214	3 841	109	2	20 277
20	2 464	3 251	1 496	7 626	2 560		1	17 398
20.5	1 509	3 156	1 738	3 785	2 165		10	12 363
21	970	4 114	2 270	2 797	4 382		1	14 534
21.5	416	2 682	1 252	1 022	5 092			10 464
22	285	1 446	624	471	5 552			8 379
22.5	41	420	256	93	5 982			6 791
23	106	299	151	78	3 186			3 820
23.5	4	80	87		1 051			1 222
24		27	18		439			484
24.5		23	5					28
25		14						14
25.5								
26								
26.5								
27								
27.5								
28								
28.5								
29								
Total	20 750	18 360	12 771	57 328	64 533	25 861	50 958	250 560
Mean L	19.3	20.9	18.8	18.9	20.0	17.6	15.6	18.6
sd	1.33	1.00	3.67	1.76	2.20	0.88	1.74	2.54
Catch	**1210**	**1554**	**856**	**3580**	**4759**	**1401**	**1704**	**15063**

Table 8.2.4.1b. Sardine in 8c and 9a: Sardine length composition (thousands), mean length (cm) and catch (tonnes) by ICES subdivision in the first quarter 2018.

First Quarter

Length	8c E	8c W	9a N	9a CN	9a CS	9a S	9a S (Ca)	Total
6.5								
7								
7.5								
8								
8.5								
9								
9.5								
10								
10.5								
11								
11.5								
12								
12.5								
13								
13.5								
14	3							3
14.5	3							3
15	9							9
15.5	28							28
16	79							79
16.5	190							190
17	343							343
17.5	413							413
18	281							281
18.5	216							216
19	174							174
19.5	72							72
20	67							67
20.5	61							61
21	33							33
21.5								
22								
22.5								
23								
23.5								
24								
24.5								
25								
25.5								
26								
26.5								
27								
27.5								
28								
28.5								
29								
Total	1 971							1 971
Mean L	18.1							18.1
sd	1.19							1.19
Catch	**93**							**93**

Table 8.2.4.1c. Sardine in 8c and 9a: Sardine length composition (thousands), mean length (cm) and catch (tonnes) by ICES subdivision in the second quarter 2018.

	Second Quarter							
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			35					35
10			192				35	227
10.5			332				75	407
11			305				98	404
11.5			179				408	587
12			184				991	1 174
12.5			66				775	840
13			26				609	635
13.5	14		4				319	337
14	51						621	672
14.5	42						633	675
15	33						3 279	3 312
15.5	23			212		61	1 937	2 234
16	19			2 361	572	243	2 986	6 181
16.5	60		2	2 726	1 145	2 737	1 097	7 769
17	125		8	1 106	1 717	4 136	805	7 897
17.5	107		23	1 101	4 580	2 859	226	8 897
18	157	131	49	663	7 340	1 338	28	9 705
18.5	174	267	39	1 506	5 858	365	1	8 210
19	162	587	123	2 500	4 588		3	7 962
19.5	180	893	505	3 361	2 455		2	7 396
20	201	1 871	1 153	2 246	1 828		1	7 300
20.5	135	1 894	1 117	1 048	1 255		1	5 450
21	138	2 240	1 168	699	1 020		1	5 266
21.5	67	1 527	646	559	729			3 528
22	47	656	294	199	157			1 354
22.5	18	179	149	33				380
23	17	189	83	55				345
23.5	4	16	62					81
24		1	13					14
24.5		17						17
25		14						14
25.5								
26		17						17
26.5								
27								
27.5								
28								
28.5								
29								
Total	1 773	10 499	6 759	20 376	33 245	11 740	14 929	99 322
Mean L	19.	20.9	19.	18.7	18.8	17.4	15.1	18.3
sd	2.03	1.03	3.94	1.69	1.18	0.56	1.58	2.27
Catch	**106**	**855**	**459**	**1 202**	**1 970**	**628**	**456**	**5 675**

Table 8.2.4.1d. Sardine in 8c and 9a: Sardine length composition (thousands), mean length (cm) and catch (tonnes) by ICES subdivision in the third quarter 2018.

Third Quarter								
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							20	20
11.5				20			253	273
12				90			1 199	1 289
12.5			35	189			1 462	1 686
13	3		357	393	117		2 799	3 669
13.5	14		843	293	411		2 676	4 235
14	27		341	261	704	328	1 598	3 261
14.5	35		17	91	528	547	642	1 860
15	41		8	102	235	219	1 453	2 058
15.5	14		8	317		109	1 432	1 880
16	1		85	1 188			6 155	7 430
16.5	1		248	2 281		109	3 187	5 826
17		13	301	3 014		1 095	8 765	13 188
17.5		4	296	1 864	39	4 488	3 051	9 743
18	30	4	85	1 378	505	5 145	1 110	8 257
18.5	40	95	13	2 662	1 079	1 751	159	5 799
19	150	290	37	3 924	863	219	59	5 541
19.5	160	566	125	7 853	1 386	109		10 200
20	191	1 379	343	5 380	732			8 024
20.5	140	1 262	622	2 737	910		9	5 680
21	60	1 874	1 102	2 098	3 362			8 496
21.5	40	1 155	607	463	4 363			6 627
22	40	790	330	272	5 395			6 827
22.5		240	107	60	5 982			6 389
23	20	109	67	23	3 186			3 406
23.5		64	26		1 051			1 141
24		26	5		439			470
24.5		6	5					11
25								
25.5								
26								
26.5								
27								
27.5								
28								
28.5								
29								
Total	1 009	7 878	6 012	36 951	31 288	14 120	36 029	133 287
Mean L	19.5	21.1	18.6	19.0	21.4	17.8	15.8	18.7
sd	2.10	0.97	3.33	1.80	2.25	1.03	1.75	2.82
Catch	**64**	**698**	**396**	**2 377**	**2 789**	**772**	**1 248**	**8 345**

Table 8.2.4.1e. Sardine in 8c and 9a: Sardine length composition (thousands), mean length (cm) and catch (tonnes) by ICES subdivision in the fourth quarter 2018.

				Fourth Quarter				
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								
10.5								
11								
11.5								
12								
12.5								
13								
13.5								
14								
14.5								
15								
15.5								
16								
16.5	28							28
17	308							308
17.5	868							868
18	2 123							2 123
18.5	2 473							2 473
19	3 072							3 072
19.5	2 610							2 610
20	2 006							2 006
20.5	1 172							1 172
21	740							740
21.5	309							309
22	198							198
22.5	23							23
23	69							69
23.5								
24								
24.5								
25								
25.5								
26								
26.5								
27								
27.5								
28								
28.5								
29								
Total	15 997							15 997
Mean L	19.4							19.4
sd	1.09							1.09
Catch	**948**							**948**

Table 8.2.4.2. Sardine in 8c and 9a: Catch in numbers- (thousands) at-age by quarter and by subdivision in 2018.

							First Quarter	
Age	**8c-E**	**8c-W**	**9a-N**	**9a-CN**	**9a-CS**	**9a-S**	**9a-C**	**Total**
0								
1	50							50
2	1 408							1 408
3	244							244
4	207							207
5	60							60
6	3							3
7								
8								
9								
10								
11								
12								
Total	1 971							1 971
Catch (Tons)	93							

							Second Quarter	
Age	**8c-E**	**8c-W**	**9a-N**	**9a-CN**	**9a-CS**	**9a-S**	**9a-C**	**Total**
0			988	181.5987		1 889		3 058
1	129	65	417	6 404	3 630	3 396	11 365	25 406
2	846	4 701	2 489	8 674	9 687	7 011	3 539	36 946
3	312	3 868	2 084	3 789	3 991	476	21	14 541
4	346	1 213	665	1 328	3 412		2	6 966
5	117	459	115		2 048		2	2 742
6	19	156			2 626			2 801
7	2	12			709			724
8		10			525			535
9		8						8
10		7						7
11								
12								
Total	1 771	10 499	6 759	20 195	26 628	12 771	14 929	93 733
Catch (Tons)	106	855	459	1 202	1 970	628	456	5 675

							Third Quarter	
Age	**8c-E**	**8c-W**	**9a-N**	**9a-CN**	**9a-CS**	**9a-S**	**9a-C**	**Total**
0	119	10	1 846	8 393	1 799	1 870	20 124	34 162
1	42	1 210	1 368	7 074	2 343	4 112	5 973	22 122
2	364	4 732	2 333	11 686	7 336	4 951	9 894	41 297
3	182	1 356	323	8 293	5 415	792	29	16 390
4	168	516	100	1 081	7 677	412	9	9 961
5	98	37	20	171	4 544	505		5 375
6	35	17	20	199	2 989	236		3 497
7				54	781	217		1 052
8			1		125			126
9					204			204
10								
11								
12								
Total	1 009	7 878	6 011	36 951	33 214	13 094	36 029	134 185
Catch (Tons)	64	698	396	2 377	2 789	772	1 248	8 345

							Fourth Quarter	
Age	**8c-E**	**8c-W**	**9a-N**	**9a-CN**	**9a-CS**	**9a-S**	**9a-C**	**Total**
0	2							2
1	1 562							1 562
2	8 759							8 759
3	2 540							2 540
4	2 123							2 123
5	827							827
6	184							184
7								
8								
9								
10								
11								
12								
Total	15 997							15 997
Catch (Tons)	948							948

							Whole Year	
Age	**8c-E**	**8c-W**	**9a-N**	**9a-CN**	**9a-CS**	**9a-S**	**9a-C**	**Total**
0	121	10	2 834	8 575	1 799	3 759	20 124	37 222
1	1 783	1 275	1 785	13 479	5 973	7 508	17 338	49 140
2	11 377	9 433	4 823	20 360	17 022	11 962	13 434	88 410
3	3 278	5 224	2 408	12 081	9 407	1 268	50	33 715
4	2 844	1 729	765	2 409	11 089	412	11	19 257
5	1 102	497	135	171	6 592	505	2	9 003
6	241	172	20	199	5 615	236		6 484
7	2	12		54	1 491	217		1 776
8		10	1		650			661
9		8			204			212
10		7						7
11								
12								
Total	20 748	18 377	12 769	57 328	59 842	25 865	50 958	245 887
Catch (Tons)	1 210	1 554	856	3 579	4 759	1 400	1 704	15 062

Table 8.2.4.3. Sardine 8c and 9a: Historical catch-at-age data.

Year	Age0	Age1	Age2	Age3	Age4	Age5	Age6+
1978	869437	2296650	946698	295360	136661	41744	16468
1979	674489	1535560	956132	431466	189107	93185	36038
1980	856671	2037400	1561970	378785	156922	47302	30006
1981	1025960	1934840	1733730	679001	195304	104545	76466
1982	62000	795000	1869000	709000	353000	131000	129000
1983	1070000	577000	857000	803000	324000	141000	139000
1984	118000	3312000	487000	502000	301000	179000	117000
1985	268000	564000	2371000	469000	294000	201000	103000
1986	304000	755000	1027000	919000	333000	196000	167000
1987	1437000	543000	667000	569000	535000	154000	171000
1988	521000	990000	535000	439000	304000	292000	189000
1989	248000	566000	909000	389000	221000	2.00E+05	245000
1990	258000	602000	517000	707000	295000	151000	248000
1991	1580580	477368	436081	406886	265762	74726	105186
1992	498265	1001860	451367	340313	186234	110932	80579
1993	87808	566221	1081820	521458	257209	113871	120282
1994	120797	60194	542163	1094440	272466	112635	72091
1995	30512	189147	280715	829707	472880	70208	64485
1996	277053	101267	347690	514741	652711	197235	46607
1997	208570	548594	453324	391118	337282	225170	70268
1998	449115	366176	501585	352485	233672	178735	105884
1999	246016	475225	361509	339691	177170	105518	72541
2000	489836	354822	313972	255523	194156	97693	64373
2001	219973	1172300	256133	195897	126389	75145	49547
2002	106882	587354	753897	181381	112166	55650	40219
2003	198412	318695	446285	518289	114035	61276	51172
2004	589910	180522	263521	386715	377848	78396	55312
2005	169229	1005530	266213	206657	191013	116628	46087
2006	18347	250200	777315	128695	108244	121043	81149
2007	199364	82084	313453	535706	80348	82713	120821
2008	298405	219205	182636	370253	411611	65397	108832
2009	378304	353839	195618	125324	251973	197185	83887
2010	278311	516544	263334	136037	82831	129434	182722
2011	341535	452259	383353	122136	87976	40949	110734
2012	220164	193884	168105	122976	94143	48700	52645
2013	280544	232934	155842	87924	48492	26591	27635
2014	63949	189093	109802	54550	35237	19462	21688
2015	68371	98936	84313	47069	20960	13656	11242
2016	172202	215051	58288	40726	15422	9815	8424
2017	35329	198627	126003	39727	15971	8393	10853
2018	37222	49140	88410	33715	19257	9003	9140

Table 8.2.4.4. Sardine 8c and 9a: 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	1%	0%	22%	15%	3%	15%	39%	15%
1	9%	7%	14%	24%	10%	29%	34%	20%
2	55%	51%	38%	36%	28%	46%	26%	36%
3	16%	28%	19%	21%	16%	5%	0%	14%
4	14%	9%	6%	4%	19%	2%	0%	8%
5	5%	3%	1%	0%	11%	2%	0%	4%
6+	1%	1%	0%	0%	13%	2%	0%	4%
	100%	100%	100%	100%	100%	100%	100%	100%
0	0%	0%	8%	23%	5%	10%	54%	100%
1	4%	3%	4%	27%	12%	15%	35%	100%
2	13%	11%	5%	23%	19%	14%	15%	100%
3	10%	15%	7%	36%	28%	4%	0%	100%
4	15%	9%	4%	13%	58%	2%	0%	100%
5	12%	6%	1%	2%	73%	6%	0%	100%
6+	3%	2%	0%	3%	87%	5%	0%	100%

Table 8.2.5.1. Sardine 8c and 9a: Sardine mean length- (cm) at-age by quarter and by subdivision in 2018.

						First Quarter	
Age	**8c-E**	**8c-W**	**9a-N**	**9a-CN**	**9a-CS**	**9a-S**	**9a-S-C**
0							
1	15.7						
2	17.8						
3	18.7						
4	19.3						
5	19.3						
6	20.2						
7							
8							
9							
10							
11							
12							

						Second Quarter	
Age	**8c-E**	**8c-W**	**9a-N**	**9a-CN**	**9a-CS**	**9a-S**	**9a-S-C**
0			10.8	16.25	18.5	14.6	
1	14.7	18.0	12.9	16.9	19.2	16.9	14.6
2	18.5	20.1	20.2	19.1	21.0	17.2	15.6
3	20.0	20.9	20.9	20.3	22.1	17.5	18.1
4	19.9	21.3	21.7	21.2	22.5		20.0
5	20.3	21.3	23.1		22.8		20.3
6	21.5	22.6			22.8		
7	22.5	24.8			22.9		
8		24.9					
9		25.3					
10		26.0					
11							
12							

						Third Quarter	
Age	**8c-E**	**8c-W**	**9a-N**	**9a-CN**	**9a-CS**	**9a-S**	**9a-S-C**
0	14.8	17.2	14.4	16.4	14.5	16.2	14.4
1	17.2	20.3	18.2	18.7	18.6	17.9	17.2
2	19.4	20.8	20.8	19.7	19.3	18.3	17.0
3	20.1	21.0	21.6	20.5	21.6	19.6	18.7
4	20.1	21.4	21.7	20.8	22.2	19.6	20.5
5	21.3	23.3	23.2	21.6	22.4	20.8	
6	22.1	23.8	23.3	21.9	22.8	21.1	
7				22.3	22.8	20.9	
8			24.3		23.8		
9					23.3		
10							
11							
12							

						Fourth Quarter	
Age	**8c-E**	**8c-W**	**9a-N**	**9a-CN**	**9a-CS**	**9a-S**	**9a-S-C**
0	16.8						
1	18.3						
2	19.1						
3	19.9						
4	20.1						
5	21.1						
6	22.0						
7							
8							
9							
10							
11							
12							

						Whole Year	
Age	**8c-E**	**8c-W**	**9a-N**	**9a-CN**	**9a-CS**	**9a-S**	**9a-S-C**
0	14.8	17.2	13.2	16.4	14.5	15.4	14.4
1	18.0	20.2	17.0	17.8	18.5	17.5	15.5
2	18.9	20.4	20.5	19.4	19.2	17.6	16.6
3	19.8	20.9	21.0	20.5	21.3	18.8	18.4
4	20.0	21.4	21.7	21.0	22.2	19.6	20.4
5	21.0	21.4	23.1	21.6	22.4	20.8	20.3
6	22.0	22.7	23.3	21.9	22.8	21.1	
7	22.5	24.8		22.3	22.8	20.9	
8		24.9	24.3		23.0		
9		25.3			23.3		
10		26.0					
11							
12							

Table 8.2.5.2. Sardine 8c and 9a: Sardine mean weight- (kg) at-age by quarter and by subdivision in 2018.

							First Quarter
Age	**8c-E**	**8c-W**	**9a-N**	**9a-CN**	**9a-CS**	**9a-S**	**9a-S-C**
0							
1	0.030						
2	0.045						
3	0.052						
4	0.057						
5	0.058						
6	0.066						
7							
8							
9							
10							
11							
12							

							Second Quarter
Age	**8c-E**	**8c-W**	**9a-N**	**9a-CN**	**9a-CS**	**9a-S**	**9a-S-C**
0			0.0	0.0	0.1	0.0	
1	0.024	0.055	0.025	0.042	0.062	0.050	0.029
2	0.054	0.075	0.075	0.061	0.077	0.052	0.034
3	0.071	0.083	0.083	0.075	0.087	0.054	0.049
4	0.070	0.088	0.092	0.085	0.091		0.063
5	0.073	0.088	0.109		0.094		0.065
6	0.088	0.103			0.094		
7	0.102	0.133			0.095		
8		0.135					
9		0.140					
10		0.151					
11							
12							

							Third Quarter
Age	**8c-E**	**8c-W**	**9a-N**	**9a-CN**	**9a-CS**	**9a-S**	**9a-S-C**
0	0.024	0.050	0.031	0.040	0.031	0.042	0.026
1	0.049	0.082	0.063	0.060	0.060	0.056	0.046
2	0.071	0.088	0.088	0.070	0.066	0.059	0.045
3	0.080	0.090	0.099	0.081	0.090	0.073	0.061
4	0.079	0.096	0.100	0.084	0.097	0.072	0.084
5	0.094	0.124	0.122	0.095	0.099	0.087	
6	0.105	0.131	0.124	0.100	0.104	0.090	
7				0.104	0.104	0.088	
8			0.139		0.116		
9					0.109		
10							
11							
12							

							Fourth Quarter
Age	**8c-E**	**8c-W**	**9a-N**	**9a-CN**	**9a-CS**	**9a-S**	**9a-S-C**
0	0.036						
1	0.049						
2	0.056						
3	0.064						
4	0.066						
5	0.079						
6	0.090						
7							
8							
9							
10							
11							
12							

							Whole Year
Age	**8c-E**	**8c-W**	**9a-N**	**9a-CN**	**9a-CS**	**9a-S**	**9a-S-C**
0	0.025	0.050	0.025	0.040	0.031	0.039	0.026
1	0.046	0.081	0.054	0.051	0.058	0.053	0.035
2	0.055	0.082	0.082	0.066	0.064	0.055	0.042
3	0.065	0.085	0.085	0.079	0.084	0.066	0.056
4	0.066	0.090	0.093	0.085	0.094	0.072	0.080
5	0.078	0.090	0.111	0.095	0.097	0.087	0.065
6	0.092	0.106	0.124	0.100	0.099	0.090	
7	0.102	0.133		0.104	0.099	0.088	
8		0.135	0.139		0.099		
9		0.140			0.109		
10		0.151					
11							
12							

Table 8.3.1.1. DEPM parameters derived from 2017 sardine DEPM surveys with their CV (%) by stratum (9a South, 9a West and 9a North-8c). Mortality (hour-1), Total egg production Ptot (eggs/day) (x10[12]), Females mean weight, W(g), Sex ratio, R (fraction of population that are mature females by weight), Batch fecundity, F (number of eggs spawned per mature females per batch), Spawning fraction, S (fraction of mature females spawning), and SSB (tonnes).

Strata	Mortality		Ptot		W		R		F		S		SSB	
	Estim	C.V	Estim	C.V.	Estim	C.V.	Estim	C.V.	Estim	C.V.	Estim	C.V.	Estim	C.V.
9a South	-0.026	7.3	2.18	0.14	47.22	0.11	0.632	0.06	16546	0.13	0.054	0.18	182486	0.29
9a West	-0.026	6.9	1.11	0.16	56.20	0.09	0.596	0.06	20444	0.07	*0.061*	*0.08*	84099	0.22
9a North+8c	-0.017	9.4	0.38	0.15	50.95	0.06	0.505	0.06	20698	0.07	0.115	0.16	16129	0.25
Total			**3.68**	**0.1**									**282714**	**0.2**

Table 8.3.2.1.1. Sardine in 8c and 9a: sardine abundance in number (thousands of fish) and biomass (tonnes) by age groups and ICES subdivision in PELAGO19. Mean weight in grams and mean length in cm.

AREA 9aCN											
AGE	0	1	2	3	4	5	6	7	8	9	TOTAL
Biomass (t)	2222	17878	13	65	0	0	0	0	0	0	20178
%Biomass	11.0	88.6	0.1	0.3	0	0	0	0	0	0	100
Abundance (N in 10^3)	518590	563051	227	1270	0	0	0	0	0	0	1083139
%Abundance	47.9	52.0	0.0	0.1	0	0	0	0	0	0	100
Mean Weight (gr)	4.3	31.8	57.2	51.3	NA	NA	NA	NA	NA	NA	18.6
Mean Length (cm)	8.3	16.1	19.5	18.8	NA	NA	NA	NA	NA	NA	12.4
AREA 9aCS											
AGE	0	1	2	3	4	5	6	7	8	9	TOTAL
Biomass (t)	401	15975	6964	30495	4806	4396	7366	4042	930	224	75599
%Biomass	0.5	21.1	9.2	40.3	6.4	5.8	9.7	5.3	1.2	0.3	100
Abundance (N in 10^3)	125186	427218	142016	538796	66986	53874	84997	50539	10778	3339	1503730
%Abundance	8.3	28.4	9.4	35.8	4.5	3.6	5.7	3.4	0.7	0.2	100
Mean Weight (gr)	3.2	37.4	49.0	56.6	71.7	81.6	86.7	80.0	86.3	67.2	50.3
Mean Length (cm)	7.7	17.0	18.5	19.4	20.9	21.7	22.2	21.6	22.1	20.5	18.1
AREA 9aS-ALG											
AGE	0	1	2	3	4	5	6	7	8	9	TOTAL
Biomass (t)	0	28724	7029	11832	2685	981	523	655	180	42	52651
%Biomass	-	54.6	13.4	22.5	5.1	1.9	1.0	1.2	0.3	0.1	100
Abundance (N in 10^3)	0	977472	164868	220739	45787	12892	6895	8062	2039	466	1439219
%Abundance	-	67.9	11.5	15.3	3.2	0.9	0.5	0.6	0.1	0.0	100
Mean Weight (gr)	-	29.4	42.6	53.6	58.6	76.1	75.8	81.2	88.5	90.5	36.6
Mean Length (cm)	-	15.7	17.7	19.1	19.6	21.3	21.3	21.8	22.3	22.5	16.7
AREA 9aS-CAD											
AGE	0	1	2	3	4	5	6	7	8	9	TOTAL
Biomass (t)	725	5340	635	407	30	0	0	0	0	0	7137
%Biomass	10.2	74.8	8.9	5.7	0.4	0	0	0	0	0	100
Abundance (N in 10^3)	224876	269565	17343	10357	534	0	0	0	0	0	522675
%Abundance	43.0	51.6	3.3	2.0	0.1	-	-	-	-	-	100
Mean Weight (gr)	3.2	19.8	36.6	39.3	55.2	-	-	-	-	-	13.7
Mean Length (cm)	7.6	13.8	16.9	17.3	19.3	-	-	-	-	-	11.3
AREA PELAGO											
AGE	0	1	2	3	4	5	6	7	8	9	TOTAL
Biomass (t)	3348	67918	14641	42799	7520	5377	7889	4697	1110	267	155565
%Biomass	2.2	43.7	9.4	27.5	4.8	3.5	5.1	3.0	0.7	0.2	100
Abundance (N in 10^3)	868652	2237307	324455	771162	113307	66765	91892	58601	12817	3805	4548763
%Abundance	19.1	49.2	7.1	17.0	2.5	1.5	2.0	1.3	0.3	0.1	100
Mean Weight (gr)	3.9	30.4	45.1	55.5	66.4	80.5	85.8	80.1	86.6	70.1	34.2
Mean Length (cm)	8.0	15.8	18.0	19.3	20.3	21.7	22.1	21.6	22.2	20.7	15.5

Table 8.3.2.2.1. Sardine in 8c and 9a: sardine abundance in number (thousands of fish) and biomass (tonnes) by age groups and ICES subdivision in PELACUS0319. Mean weight in grams and mean length in cm.

AREA 8cE								
AGE	1	2	3	4	5	6	7	TOTAL
Biomass (Tonnes)	114	2207	4895	1597	396	44	7	9260
% Biomass	1.2	23.8	52.9	17.3	4.3	0.5	0.1	100
Abundance (N in '000)	3011	42085	73021	22123	4912	504	68	145725
% Abundance	2.1	28.9	50.1	15.2	3.4	0.3	0.05	100
Medium Weight (gr)	37.7	51.4	66.7	71.8	80.4	88.0	106.1	63.0
Medium Length (cm)	17.1	18.7	20.2	20.7	21.4	22.0	23.3	19.9
AREA 8cW								
AGE	1	2	3	4	5	6	7	TOTAL
Biomass (Tonnes)	6	5142	23975	13058	5242	894	166	48482
% Biomass	0.0	10.6	49.5	26.9	10.8	1.8	0.3	100
Abundance (N in '000)	121	72347	315108	159043	60960	9778	1568	618925
% Abundance	0.0	11.7	50.9	25.7	9.8	1.6	0.3	100
Medium Weight (gr)	47.2	70.6	75.8	81.7	85.8	91.3	106.1	77.7
Medium Length (cm)	18.3	20.6	21.0	21.5	21.8	22.2	23.3	21.2
AREA 9aN								
AGE	1	2	3	4	5	6	7	TOTAL
Biomass (Tonnes)	326	1819	5134	4307	1063	205	728	13581
% Biomass	2.4	13.4	37.8	31.7	7.8	1.5	5.4	100
Abundance (N in '000)	7264	29112	71153	52586	12172	2187.1	7959	182433
% Abundance	4.0	16.0	39.0	28.8	6.7	1.2	4.4	100
Medium Weight (gr)	44.4	62.1	71.9	81.4	86.2	92.6	91.6	70.0
Medium Length (cm)	17.9	19.8	20.7	21.5	21.8	22.3	22.3	20.8
TOTAL SPAIN								
AGE	1	2	3	4	5	6	7	TOTAL
Biomass (Tonnes)	445	9167	34003	18963	6701	1143	901	71324
% Biomass	0.6	12.9	47.7	26.6	9.4	1.6	1.3	100
Abundance (N in '000)	10396	143543	459283	233752	78045	12470	9594	947084
% Abundance	1.1	15.2	48.5	24.7	8.2	1.3	1.0	100
Medium Weight (gr)	42.4	62.8	73.7	80.7	85.5	91.4	94.0	73.9
Medium Length (cm)	17.7	19.9	20.8	21.4	21.8	22.2	22.4	20.9

Table 8.3.4.1a. Sardine in 8c and 9a: Mean weights-at-age (kg) in the catch. Weights-at-age in 1978–1990 are fixed.

Year	Age0	Age1	Age2	Age3	Age4	Age5	Age6+
1990	0.020	0.039	0.054	0.060	0.066	0.073	0.090
1991	0.020	0.030	0.053	0.058	0.070	0.071	0.094
1992	0.018	0.044	0.052	0.061	0.066	0.077	0.089
1993	0.017	0.038	0.053	0.058	0.065	0.070	0.084
1994	0.020	0.036	0.057	0.060	0.067	0.072	0.089
1995	0.025	0.046	0.057	0.064	0.065	0.078	0.093
1996	0.019	0.037	0.048	0.054	0.062	0.070	0.082
1997	0.023	0.031	0.049	0.059	0.064	0.070	0.079
1998	0.024	0.041	0.055	0.061	0.064	0.067	0.073
1999	0.025	0.043	0.056	0.065	0.070	0.073	0.077
2000	0.025	0.037	0.056	0.066	0.071	0.074	0.077
2001	0.023	0.042	0.059	0.067	0.075	0.079	0.085
2002	0.027	0.045	0.057	0.068	0.074	0.079	0.082
2003	0.024	0.044	0.059	0.067	0.079	0.084	0.091
2004	0.020	0.040	0.056	0.066	0.072	0.082	0.089
2005	0.023	0.037	0.055	0.068	0.074	0.075	0.087
2006	0.031	0.042	0.056	0.068	0.073	0.078	0.082
2007	0.028	0.054	0.071	0.074	0.085	0.086	0.089
2008	0.025	0.043	0.066	0.074	0.075	0.083	0.085
2009	0.020	0.041	0.065	0.075	0.079	0.082	0.090
2010	0.026	0.046	0.061	0.075	0.082	0.084	0.081
2011	0.024	0.045	0.064	0.073	0.077	0.077	0.079
2012	0.031	0.056	0.065	0.078	0.083	0.086	0.090
2013	0.025	0.052	0.069	0.077	0.085	0.090	0.094
2014	0.030	0.046	0.061	0.076	0.080	0.089	0.093
2015	0.025	0.049	0.073	0.079	0.089	0.090	0.097
2016	0.018	0.046	0.062	0.074	0.084	0.092	0.098
2017	0.022	0.039	0.058	0.072	0.083	0.086	0.095
2018	0.031	0.047	0.062	0.080	0.088	0.094	0.099

Table 8.5.1.3. Sardine in 8c and 9a: Numbers-at-age, in thousands at the beginning of the year, estimated in the assessment. Estimates of survivors in 2019 are also shown. Age 0 in 2019 is the estimated of recruitment using the S–R model fitted within the assessment.

Year	Age0	Age1	Age2	Age3	Age4	Age5	Age6+
1978	36242500	11368800	3323980	980051	337529	67299	41672
1979	42274700	13116300	5105070	1378320	464727	166584	56151
1980	48279900	15415800	6128470	2305830	702470	246518	121619
1981	29890300	17614200	7221160	2783210	1180600	374348	203063
1982	16091800	10918400	8304020	3325040	1441720	636518	322516
1983	71438800	5883220	5171160	3861810	1736880	783838	539337
1984	21293100	26127300	2791440	2414210	2023880	947408	750121
1985	18624500	7791380	12429100	1310540	1271230	1109190	968870
1986	15839100	6830630	3751470	5988850	705374	712138	1212340
1987	34463800	5778800	3200020	1704140	3067000	375977	1085030
1988	18688200	12520400	2647510	1385480	838067	1569850	801243
1989	17842600	6799120	6066670	1303490	591446	372363	1173270
1990	18683200	6500120	3310640	3017550	567295	267909	863149
1991	54670800	6788310	3134270	1613530	1263680	247265	618302
1992	37220800	19914600	3304020	1557650	701092	571487	477755
1993	16320400	13664200	9975110	1743160	757829	355017	589862
1994	14211900	5995800	6862760	5292260	857103	387828	552766
1995	11149000	5238570	3048500	3735190	2730950	460340	564521
1996	15926700	4109690	2663800	1659600	1928330	1467420	611580
1997	10719600	5834310	2042240	1382320	782555	946379	1102660
1998	13656300	3895240	2814280	996114	579739	341593	1056910
1999	10546300	4943820	1853230	1333860	395701	239697	740037
2000	32530000	3830820	2381430	901320	556368	171787	533278
2001	20159900	11860200	1870780	1191770	396817	254944	396139
2002	11371700	7361060	5823630	946917	536091	185784	358199
2003	8914620	4171090	3675420	3052210	454966	268088	315609
2004	37870300	3277970	2101780	1963350	1520270	235862	339177
2005	13195000	13896300	1639170	1105010	948923	764763	330427
2006	4232770	4842540	6952610	862735	535177	478339	594738
2007	5814750	1542990	2386330	3698340	485308	313335	656868
2008	7488680	2107390	745677	1229160	2008850	274365	580292
2009	8573320	2659930	951917	343572	591432	1006040	459788
2010	4908180	3022380	1171590	420721	158002	283087	731449
2011	4058120	1702430	1260710	473317	175473	68588	483957
2012	4380140	1385160	672897	466003	179222	69154	247230
2013	4803060	1525130	585281	277694	198909	79621	154987
2014	3594570	1678740	652664	246654	121264	90405	115727

Year	Age0	Age1	Age2	Age3	Age4	Age5	Age6+
2015	6213750	1288420	781754	316226	125352	64143	115256
2016	7927150	2266520	636222	417259	178543	73663	110770
2017	2851410	2890720	1118190	339075	235204	104750	113427
2018	5157800	1043590	1443680	608086	195372	141054	136198
2019	11702300	1907880	540098	832651	373515	124904	183142

Table 8.5.1.4. Sardine in 8c and 9a: Summary table of the WGHANSA 2019 assessment. CVs are presented for SSB, recruitment and Apical F (maximum F-at-age by year); biomass and landings in t, recruits in thousands of individuals, F in year^{-1}.

Year	Biomass 1+	SSB	CV SSB	Recruits	CV Recruits	F (2-5)	F Apical	CV F Apical	Landings
1978	518822	470022	0,156	36242500	0,168	0,362	0,410	0,198	145609
1979	673316	615746	0,156	42274700	0,162	0,287	0,325	0,187	157241
1980	846685	778893	0,149	48279900	0,152	0,282	0,319	0,175	194802
1981	1015720	938042	0,141	29890300	0,176	0,270	0,306	0,164	216517
1982	945084	893107	0,143	16091800	0,237	0,261	0,296	0,155	206946
1983	747440	718736	0,153	71438800	0,107	0,258	0,292	0,149	183837
1984	1164110	1056810	0,105	21293100	0,184	0,253	0,286	0,143	206005
1985	988079	944485	0,102	18624500	0,177	0,230	0,260	0,110	208439
1986	798402	767328	0,102	15839100	0,188	0,282	0,319	0,143	187363
1987	644304	617989	0,105	34463800	0,121	0,324	0,367	0,146	177696
1988	709989	657260	0,093	18688200	0,159	0,398	0,451	0,124	161531
1989	628637	595374	0,095	17842600	0,157	0,381	0,432	0,122	140961
1990	566040	536729	0,097	18683200	0,155	0,415	0,470	0,120	149429
1991	520811	490524	0,103	54670800	0,088	0,382	0,434	0,123	132587
1992	856792	773830	0,080	37220800	0,099	0,283	0,320	0,113	130250
1993	968246	903614	0,071	16320400	0,142	0,273	0,310	0,106	142495
1994	816536	785690	0,071	14211900	0,135	0,231	0,262	0,091	136582
1995	677501	653498	0,072	11149000	0,137	0,230	0,261	0,085	125280
1996	543504	524401	0,074	15926700	0,109	0,310	0,352	0,090	116736
1997	482795	457416	0,074	10719600	0,132	0,414	0,469	0,091	115814
1998	391648	373253	0,080	13656300	0,116	0,462	0,523	0,099	108924
1999	376089	364348	0,082	10546300	0,139	0,419	0,474	0,105	94091
2000	322866	305162	0,090	32530000	0,087	0,371	0,420	0,108	85786
2001	484686	411654	0,078	20159900	0,110	0,352	0,399	0,107	101957
2002	498807	434095	0,078	11371700	0,143	0,294	0,333	0,108	99673
2003	474192	437148	0,080	8914620	0,167	0,262	0,297	0,099	97831
2004	414779	386454	0,087	37870300	0,072	0,289	0,327	0,097	98020
2005	554549	441739	0,075	13195000	0,111	0,287	0,325	0,094	97345
2006	649776	597130	0,065	4232770	0,176	0,172	0,175	0,104	87023
2007	512158	500514	0,066	5814750	0,135	0,206	0,210	0,078	96469
2008	396930	389863	0,068	7488680	0,111	0,325	0,332	0,078	101464
2009	298147	291876	0,070	8573320	0,094	0,369	0,377	0,090	87740
2010	250131	247109	0,068	4908180	0,119	0,465	0,474	0,102	89571
2011	179827	178124	0,076	4058120	0,126	0,560	0,571	0,111	80403
2012	133528	132143	0,093	4380140	0,117	0,442	0,451	0,121	54857
2013	123001	121476	0,103	4803060	0,122	0,420	0,429	0,136	45818
2014	126071	126071	0,114	3594570	0,148	0,271	0,277	0,147	27937

Year	Biomass 1+	SSB	CV SSB	Recruits	CV Recruits	F (2-5)	F Apical	CV F Apical	Landings
2015	117929	117148	0,124	6213750	0,140	0,168	0,172	0,149	20595
2016	145603	145603	0,124	7927150	0,146	0,170	0,173	0,148	22704
2017	178627	177509	0,129	2851410	0,221	0,148	0,151	0,153	21911
2018	160898	159454	0,141	5157800	0,236	0,086	0,087	0,154	15062
2019	179410	179410	0,152	NA	NA	NA	NA	NA	13316

Table 8.7.1. Sardine in 8c and 9a: Input data for short-term catch predictions. Number-at-age for 2019 and recruitment for 2020. Input values for stock weight, catch weight, natural mortality (M) and fishing mortality- (F) at-age. Input units are thousands and kg.

2019						
Age	Number	Stock weight	Catch weight	Maturity	M	F
0	4820903	0	0,024	0	0,980	0,012
1	1907880	0,029	0,044	0,994	0,610	0,040
2	540098	0,047	0,061	0,989	0,470	0,066
3	832651	0,062	0,075	1	0,400	0,072
4	373515	0,066	0,085	1	0,360	0,072
5	124904	0,071	0,091	1	0,350	0,072
6	183142	0,074	0,097	1	0,320	0,059
2020						
0	4820903	0	0,024	0	0,980	
1		0,029	0,044	0,994	0,610	
2		0,047	0,061	0,989	0,470	
3		0,062	0,075	1	0,400	
4		0,066	0,085	1	0,360	
5		0,071	0,091	1	0,350	
6		0,074	0,097	1	0,320	

Table 8.7.2. Sardine in 8.c and 9.a: Output data for short-term catch predictions.

B1+ 2019	F2019	Catch 2019	B1+ 2020	F2020	Catch 2020	B1+ 2021	Catch 2021	Change B1+ 2020–2021(%)	Change Catch 2018–2020(%)
179410	0,078	13316	184137	0	0	199487	0	8,3	-100
179410	0,078	13316	184137	0,023	4142	196454	4386	6,7	-73
179410	0,078	13316	184137	0,031	5565	195413	5861	6,1	-63
179410	0,078	13316	184137	0,032	5742	195283	6044	6,1	-62
179410	0,078	13316	184137	0,061	10824	191570	11173	4,0	-28
179410	0,078	13316	184137	0,078	13750	189434	14033	2,9	-9
179410	0,078	13316	184137	0,080	14091	189185	14362	2,7	-6
179410	0,078	13316	184137	0,118	20484	184528	20359	0,2	36
179410	0,078	13316	184137	0,156	26691	180016	25877	-2,2	77
179410	0,078	13316	184137	0,013	2432	197706	2592	7,4	-84
179410	0,078	13316	184137	0,027	4839	195944	5110	6,4	-68
179410	0,078	13316	184137	0,040	7220	194203	7557	5,5	-52
179410	0,078	13316	184137	0,054	9576	192481	9933	4,5	-36
179410	0,078	13316	184137	0,067	11908	190778	12241	3,6	-21
179410	0,078	13316	184137	0,081	14216	189094	14482	2,7	-6
179410	0,078	13316	184137	0,094	16500	187429	16659	1,8	10
179410	0,078	13316	184137	0,108	18760	185783	18773	0,9	25
179410	0,078	13316	184137	0,121	20996	184155	20826	0,0	39
179410	0,078	13316	184137	0,135	23209	182545	22819	-0,9	54
179410	0,078	13316	184137	0,148	25400	180953	24754	-1,7	69
179410	0,078	13316	184137	0,161	27568	179379	26633	-2,6	83
179410	0,078	13316	184137	0,175	29713	177823	28457	-3,4	97
179410	0,078	13316	184137	0,188	31836	176283	30227	-4,3	111
179410	0,078	13316	184137	0,202	33938	174761	31945	-5,1	125
179410	0,078	13316	184137	0,215	36018	173256	33613	-5,9	139
179410	0,078	13316	184137	0,229	38077	171767	35231	-6,7	153
179410	0,078	13316	184137	0,242	40114	170295	36801	-7,5	166
179410	0,078	13316	184137	0,256	42131	168839	38325	-8,3	180
179410	0,078	13316	184137	0,269	44127	167399	39803	-9,1	193
179410	0,078	13316	184137	0,024	4306	196334	NA	6,6	-71

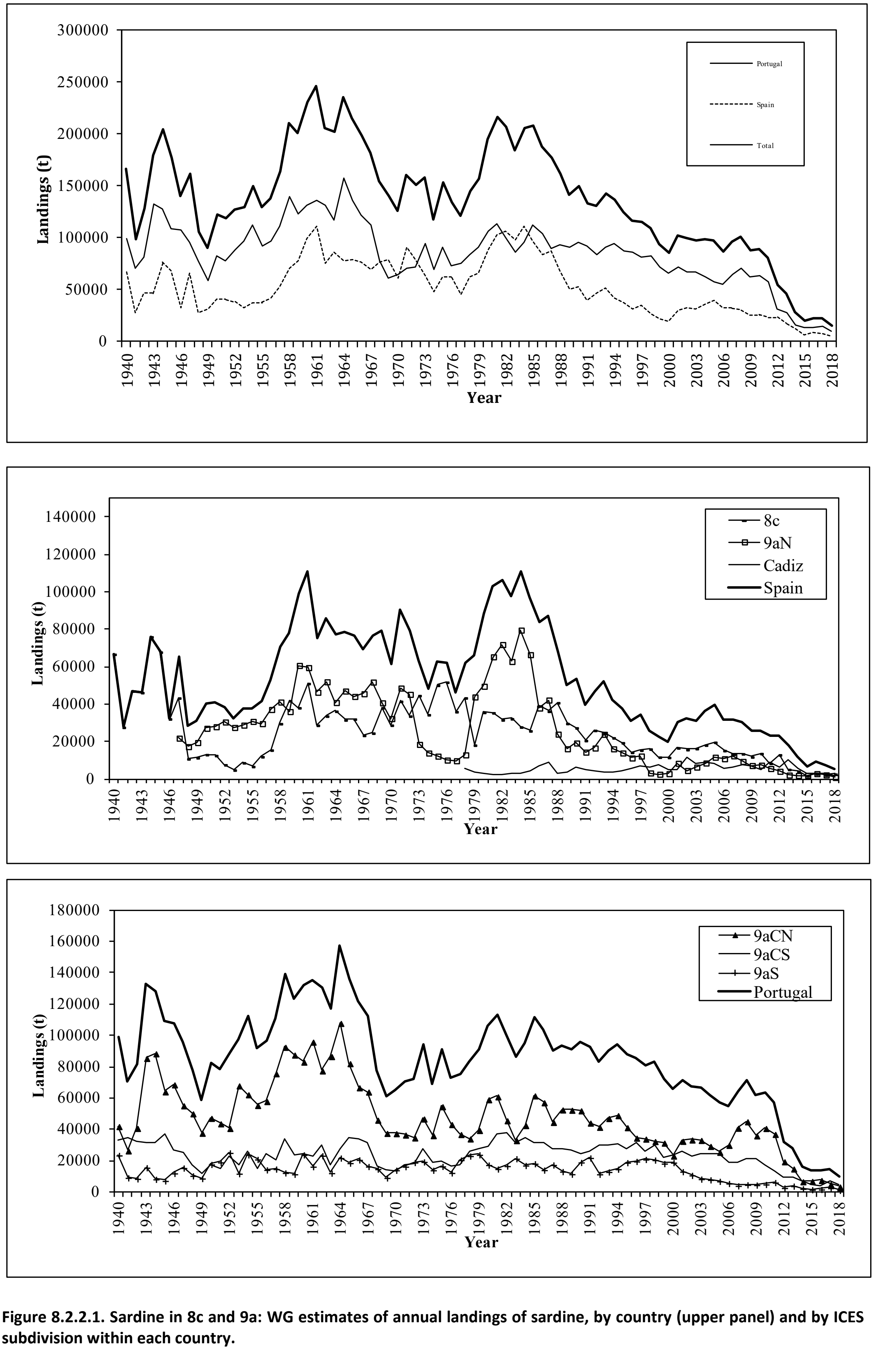


Figure 8.2.2.1. Sardine in 8c and 9a: WG estimates of annual landings of sardine, by country (upper panel) and by ICES subdivision within each country.

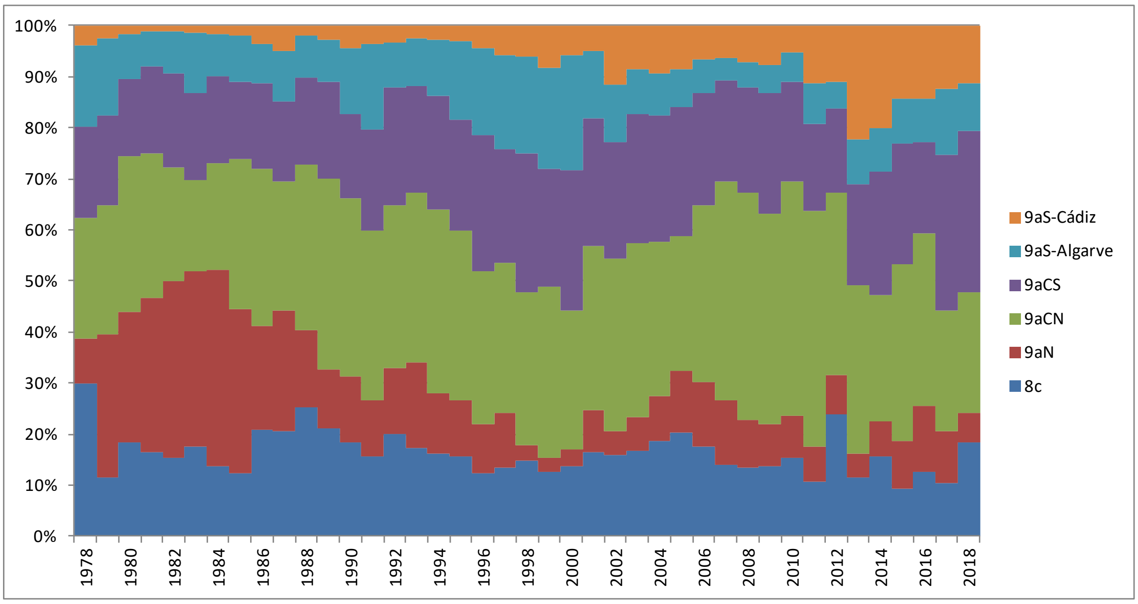


Figure 8.2.2.2. Sardine in 8c and 9a: Historical relative contribution of the different subareas to total catches (1978–2018).

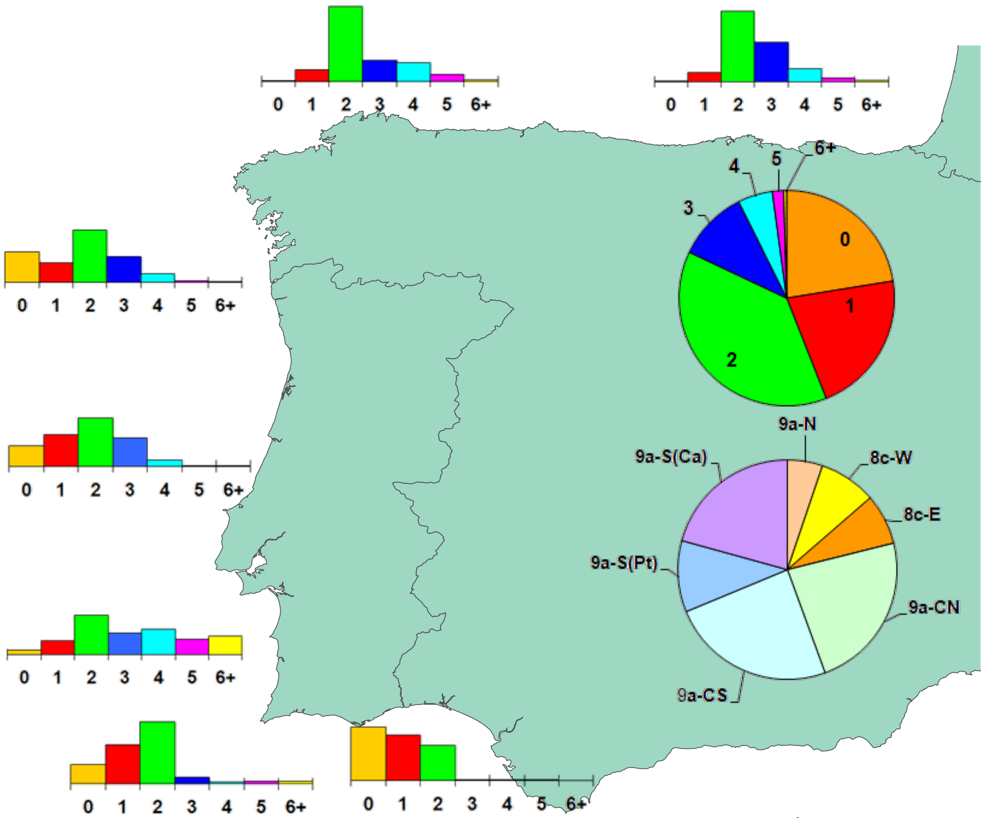


Figure 8.2.4.1. Sardine in 8c and 9a: Relative contribution of each age class by areas as well as their relative contribution to the 2018 catches (pie chart).

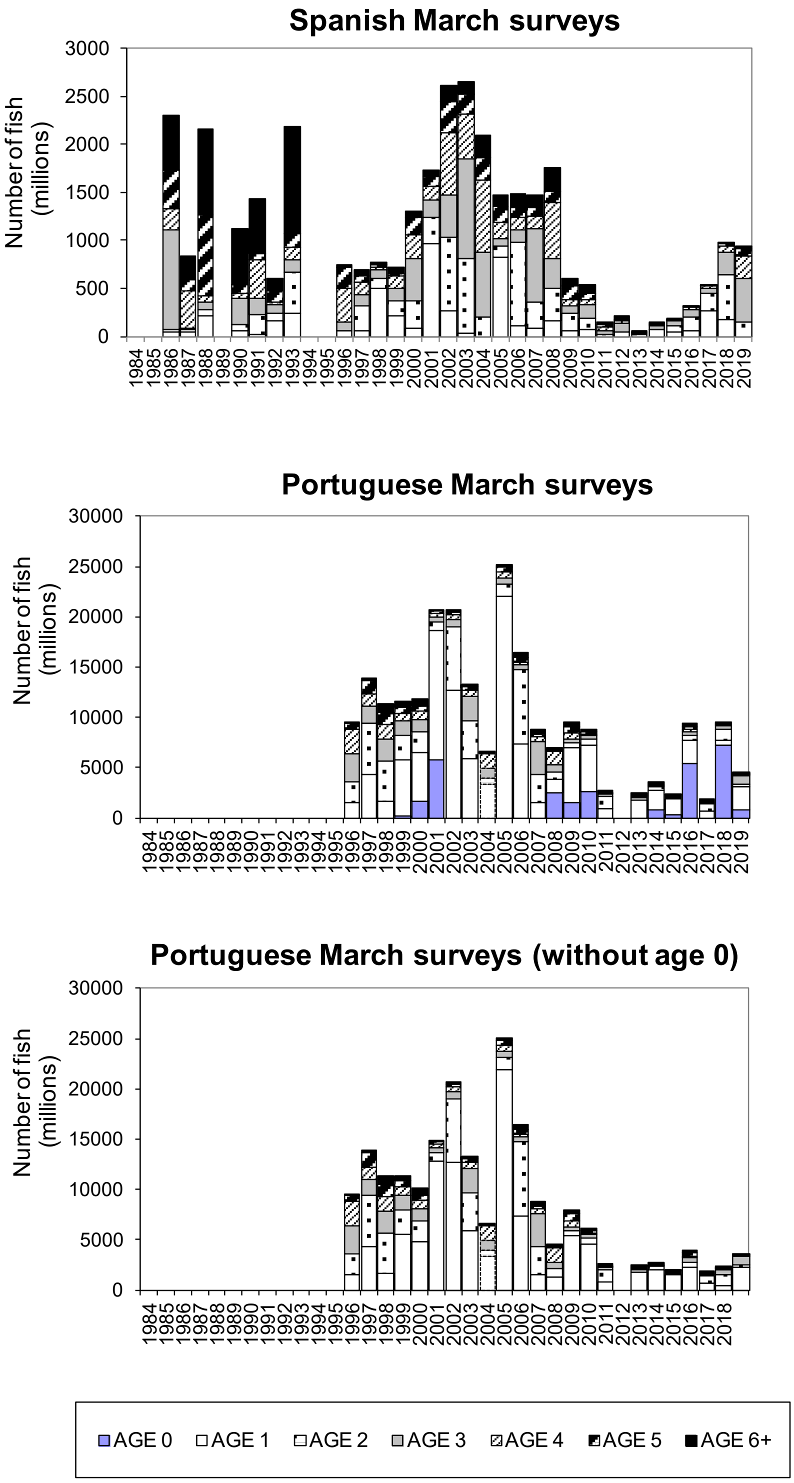


Figure 8.3.1. Sardine in 8c and 9a: Total abundance and age structure (numbers) of sardine estimated in the acoustic surveys. The Spanish March survey series covers area 8c and 9a-N (Galicia) (top panel) and the Portuguese March surveys covers the Portuguese area and the Gulf of Cadiz (subdivisions 9-CN, 9a-CS, 9a-S-Algarve and 9a-S-Cadiz) (middle panel). Portuguese acoustic survey in June 2004 was only considered as an indicator of the population abundance and is not included in the assessment. Estimates from Portuguese acoustic surveys are not available for 2012 (year without survey). Portuguese March survey without age 0 individuals (which are only detected in several years in Portuguese survey, and not considered in the assessment) (bottom panel).

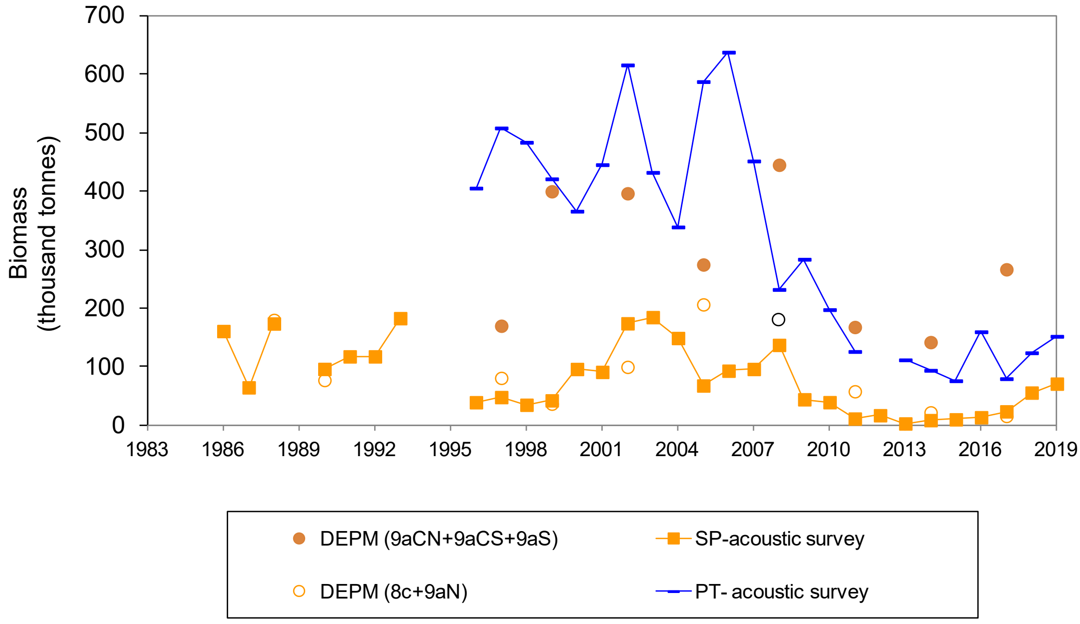


Figure 8.3.2. Sardine in 8c and 9a: Total sardine biomass (thousand tonnes) estimated in the different series of acoustic surveys and SSB estimates from the DEPM series covering the northern area and the west and southern area of the stock.

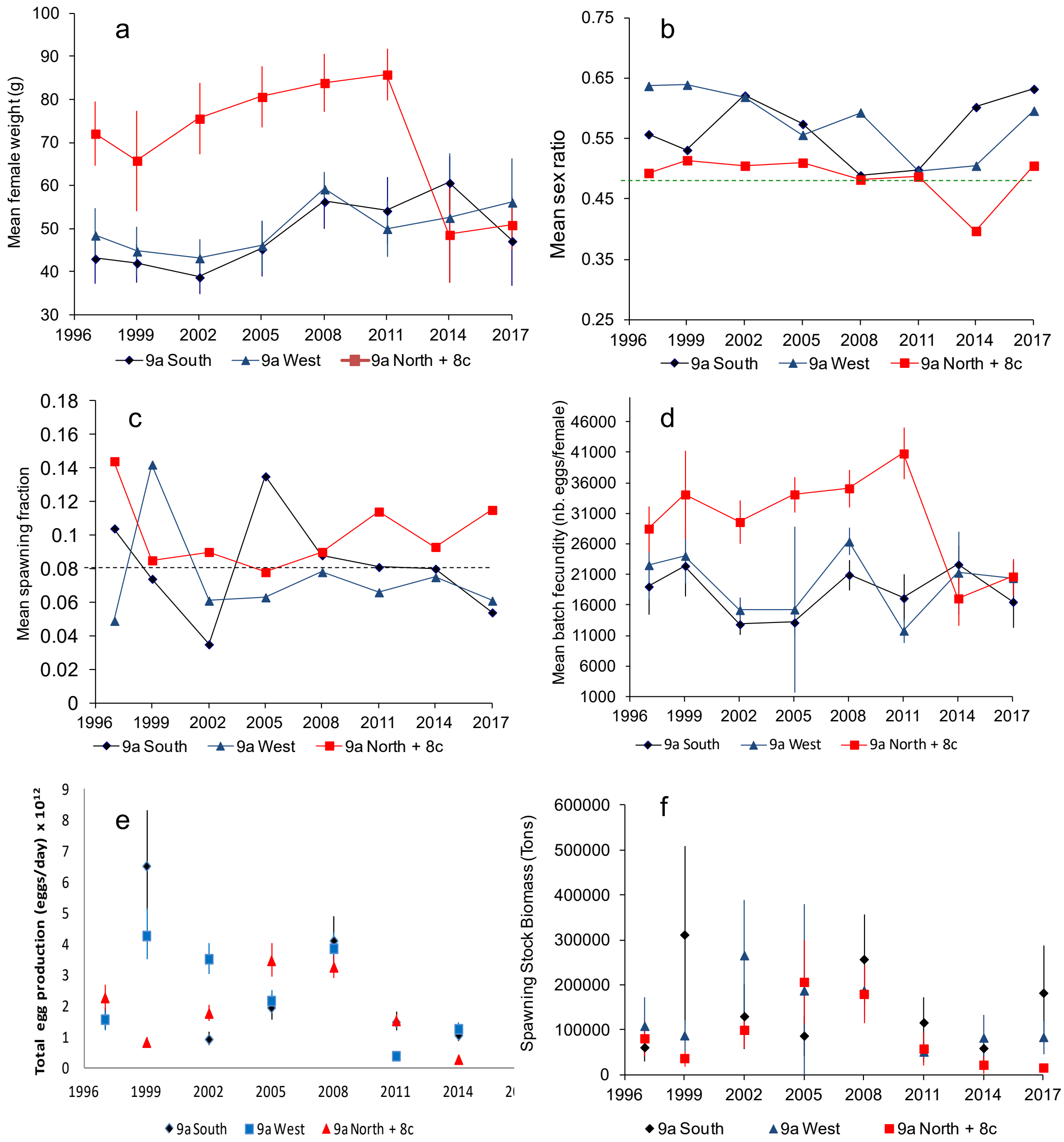


Figure 8.3.1.1. Sardine in 8c and 9a: Historic series (1997–2017) egg and adult parameters. a) Mean females weight (W) (in grams), b) Sex ratio (R), c) Spawning fraction (S), d) Batch fecundity (F) (number eggs/female), e) Total egg production (eggs/day) x10^{12} and f) SSB estimates for the three strata (9a South in black, 9a West in blue and 9a North and 8c in red). Vertical lines indicate approximate 95% confidence intervals (i.e. ± 2 standard-deviations).

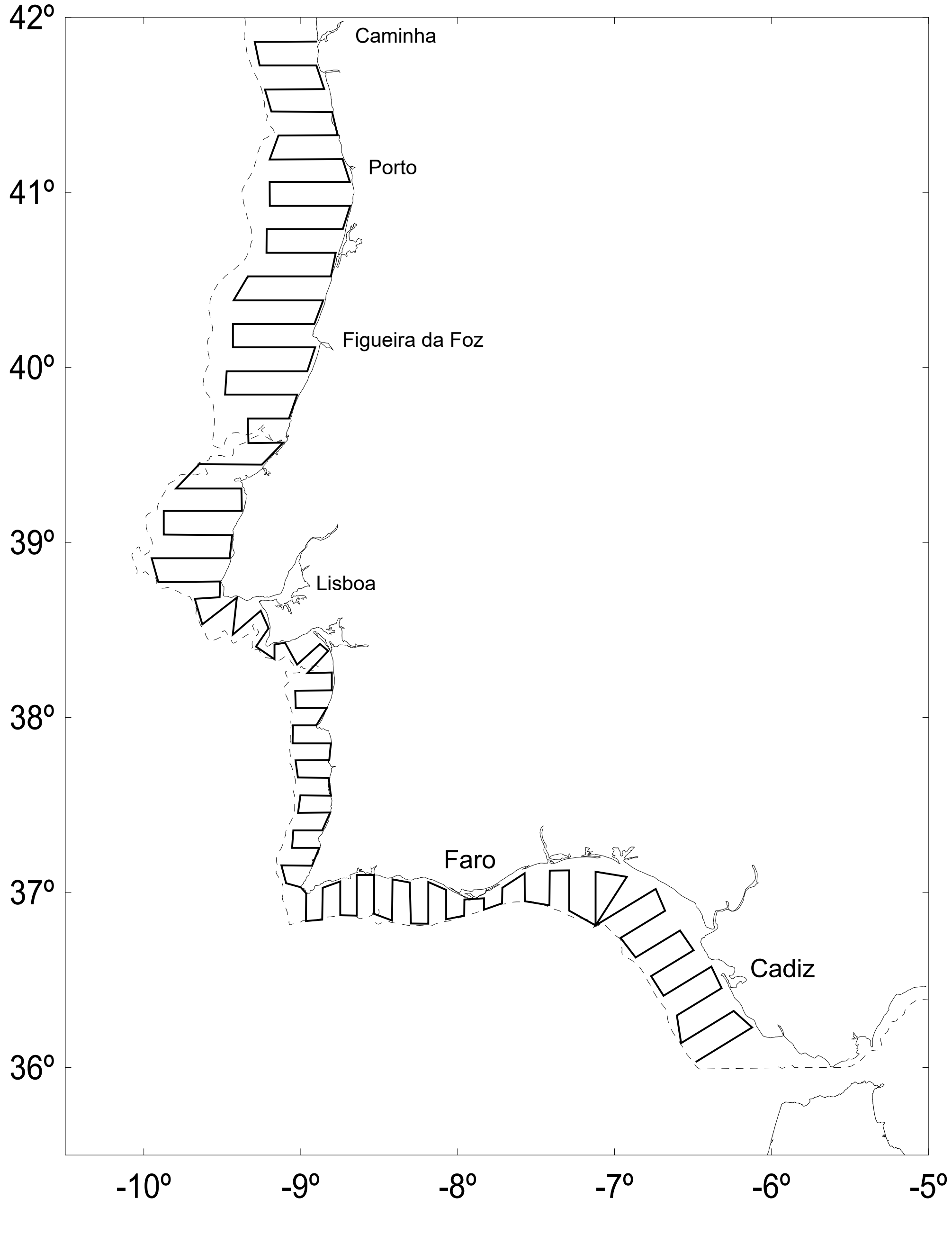


Figure 8.3.2.1.1. Sardine in 8c and 9a: acoustic transect and fishing stations during PELAGO 2019 survey.

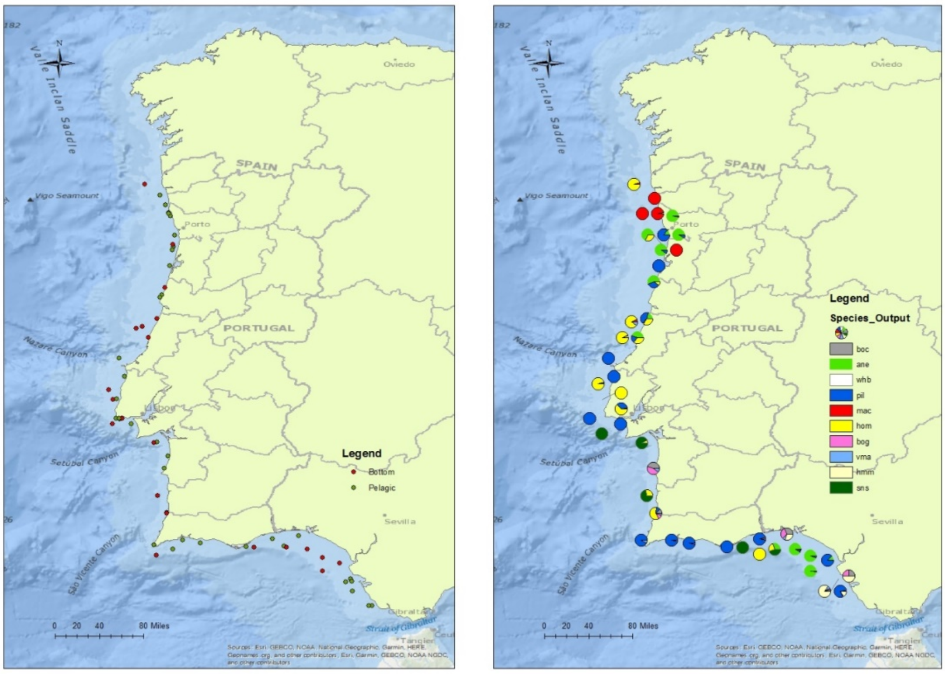


Figure 8.3.2.1.2. Sardine in 8c and 9a: Position (left panel) and proportion of species (right panel) of each fishing haul operation in PELAGO19 acoustic survey.

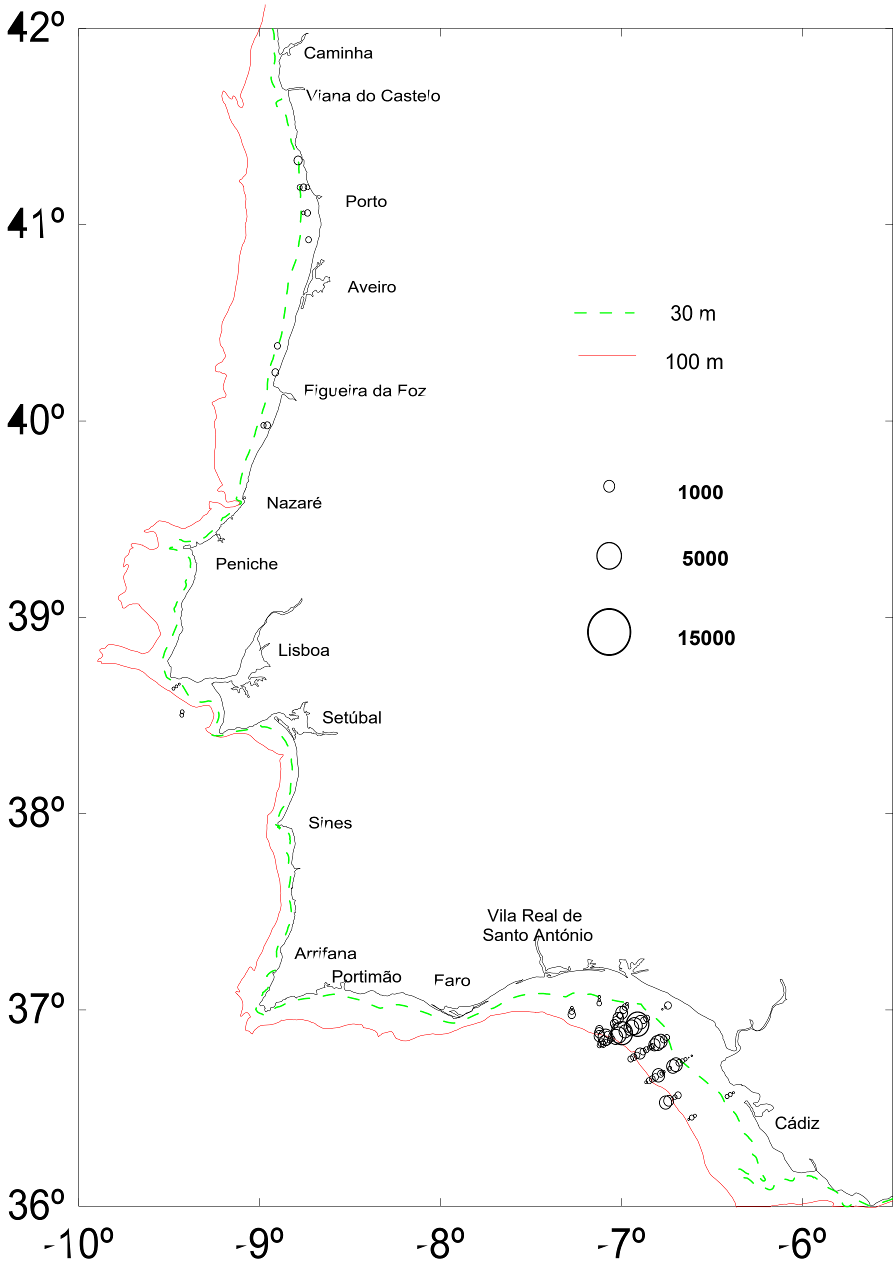


Figure 8.3.2.1.3. Sardine in 8c and 9a: Acoustic energy during PELAGO19.

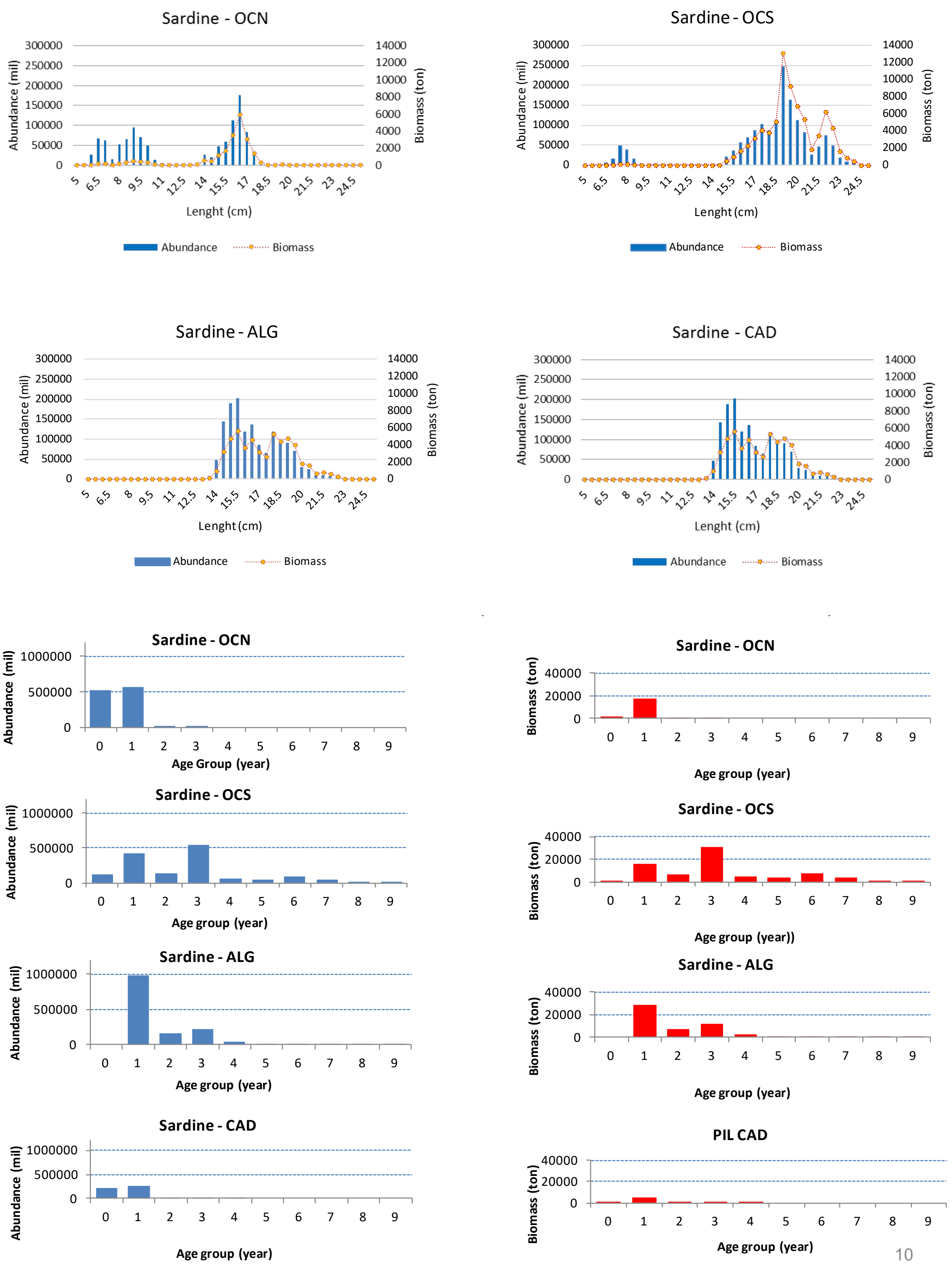


Figure 8.3.2.1.4. Sardine in 8c and 9a: Size (upper panel) and age (bottom panel) composition during PELAGO19.

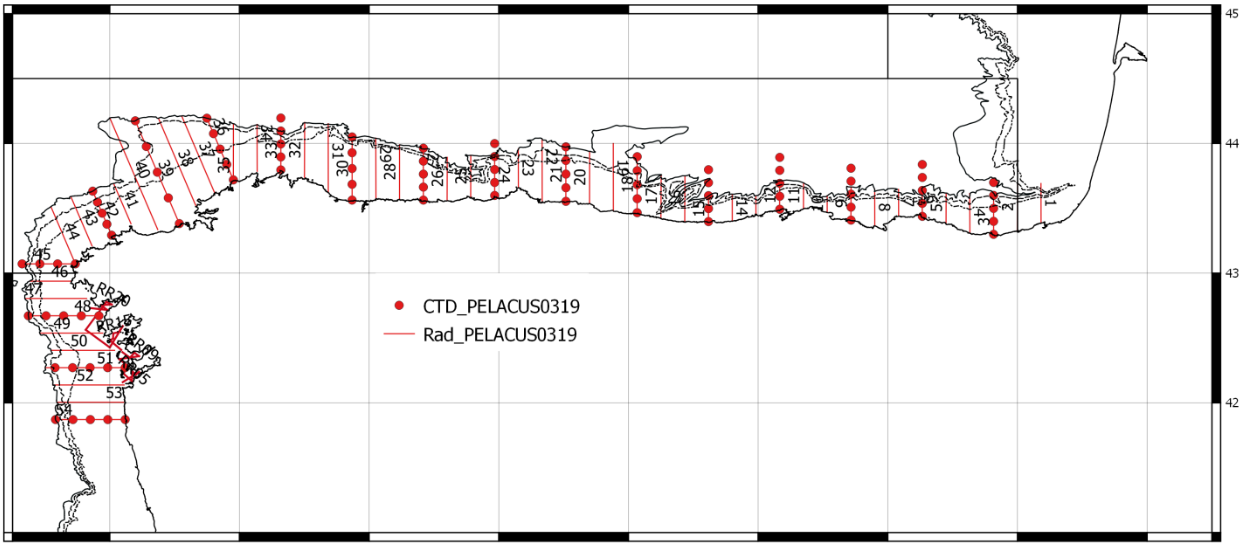


Figure 8.3.2.2.1. Sardine in 8c and 9a: Spanish spring acoustic survey PELACUS0319. 2019 PELACUS survey track.

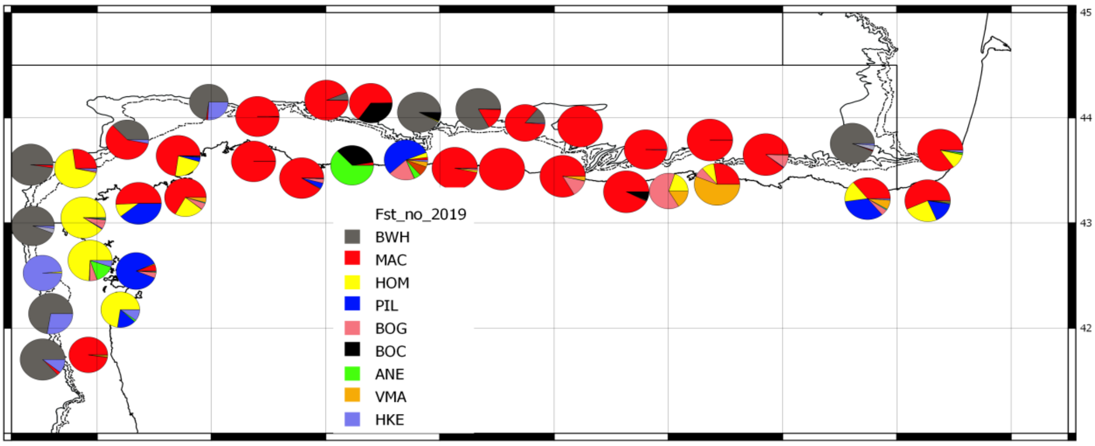
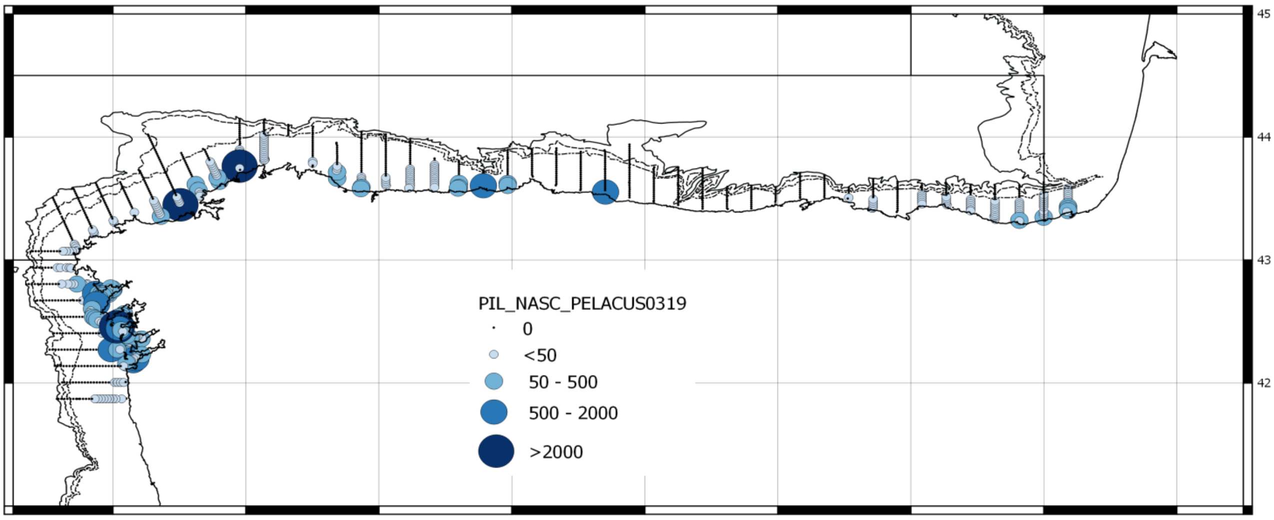


Figure 8.3.2.2.2. Sardine in 8c and 9a: Spanish spring acoustic survey PELACUS0319. Fishing hauls.



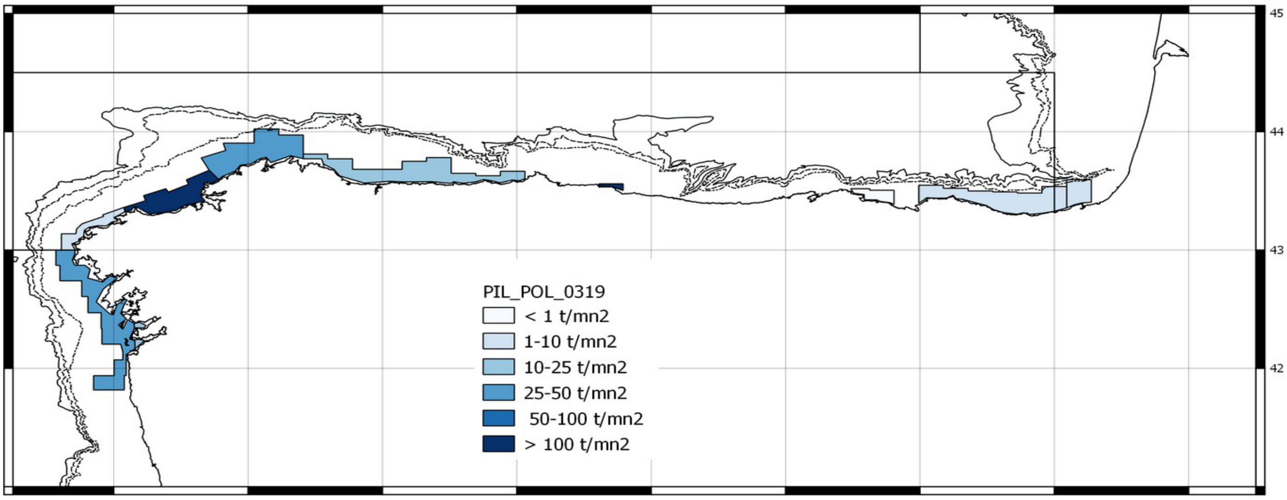


Figure 8.3.2.2.3. Sardine in 8c and 9a: Spanish spring acoustic survey PELACUS0319. Upper figure: Spatial distribution of energy allocated to sardine during the PELACUS0319survey. Bottom figure: Sardine polygons. Polygon colour indicates integrated energy in m^2 within each polygon.

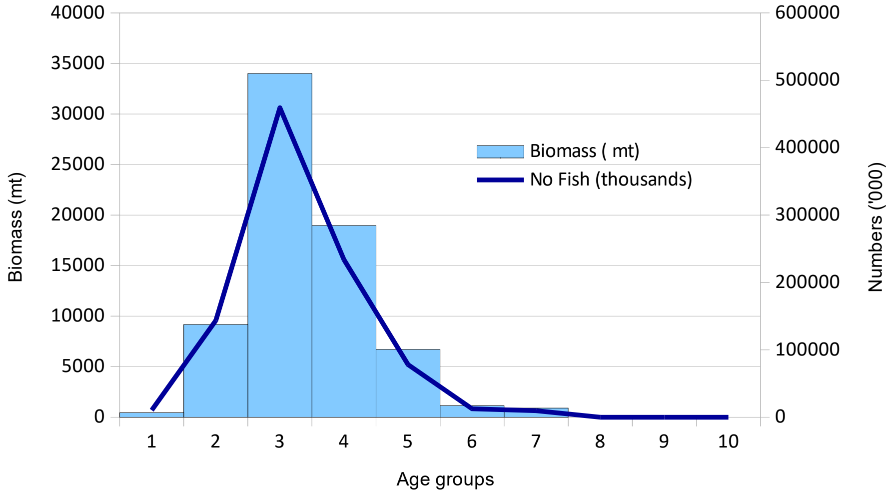


Figure 8.3.2.2.4. Sardine in 8c and 9a: Sardine abundance by age group estimated in PELACUS 0319.

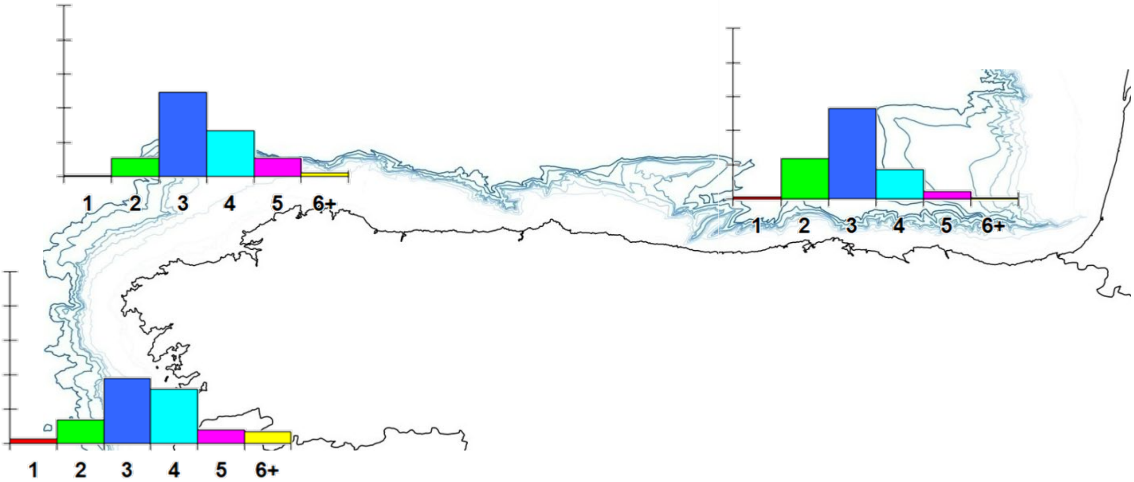


Figure 8.3.2.2.5. Sardine in 8c and 9a: Spanish spring acoustic survey in 2019. Sardine age frequency by area and age and area contribution to the total abundance (charts) in PELACUS 0319.

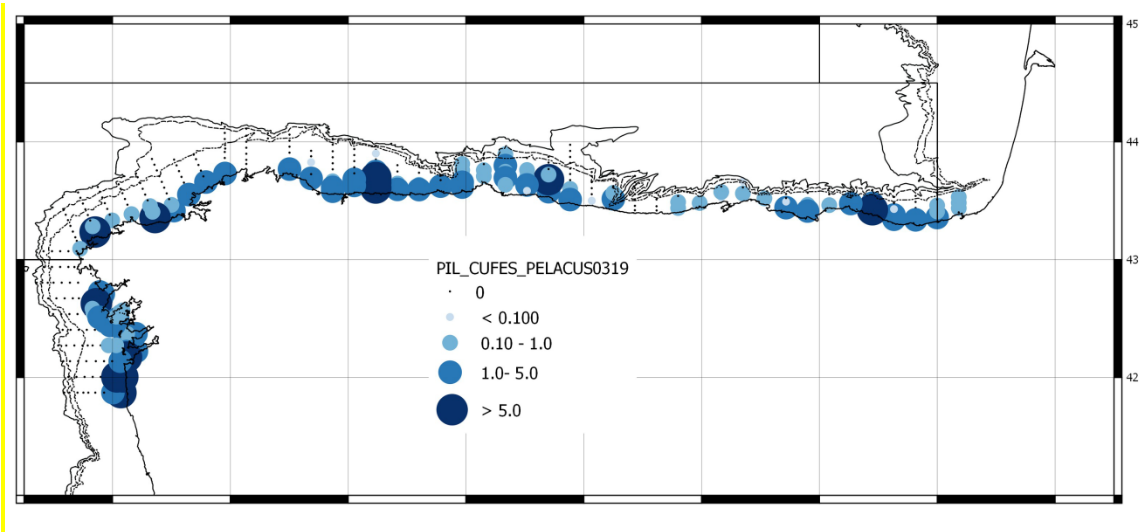


Figure 8.3.2.2.6. Sardine in 8c and 9a: Spanish spring acoustic survey in 2019. PELACUS 0319. Total number of sardine eggs obtained during the survey. Diameter of circles is proportional to egg density.

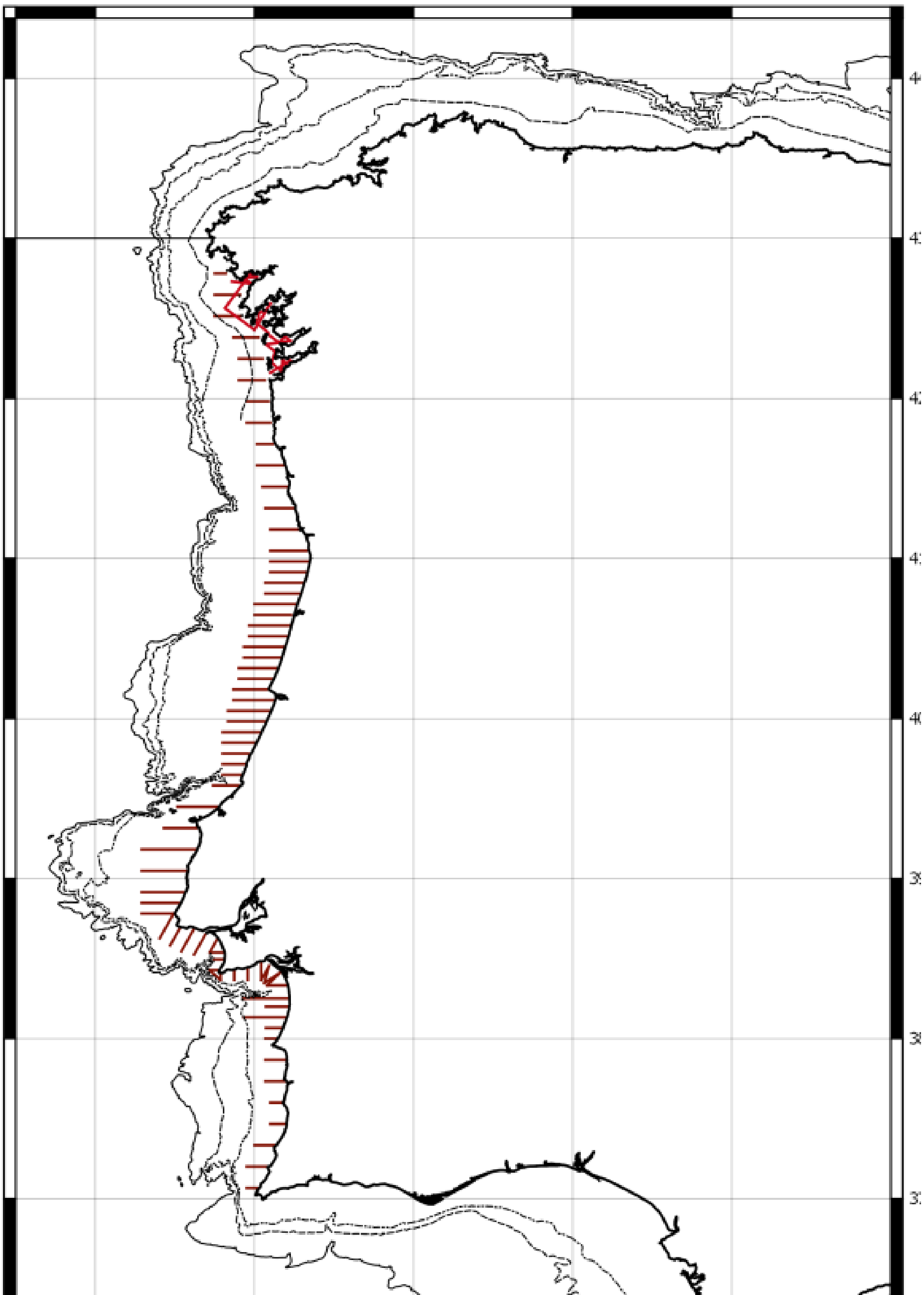


Figure 8.3.3.1. Sardine in 8c and 9a: area prospected during IBERAS.

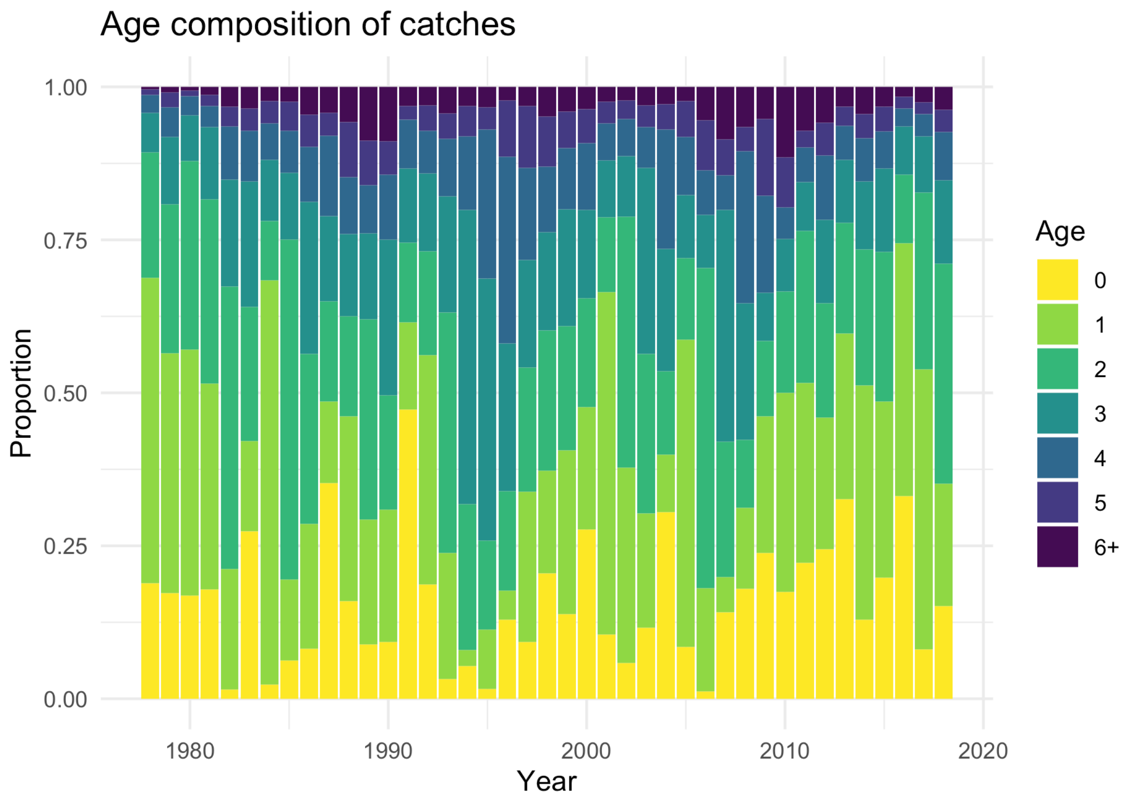


Figure 8.3.7.1. Sardine in 8c and 9a: Catches-at-age for 1978–2018.

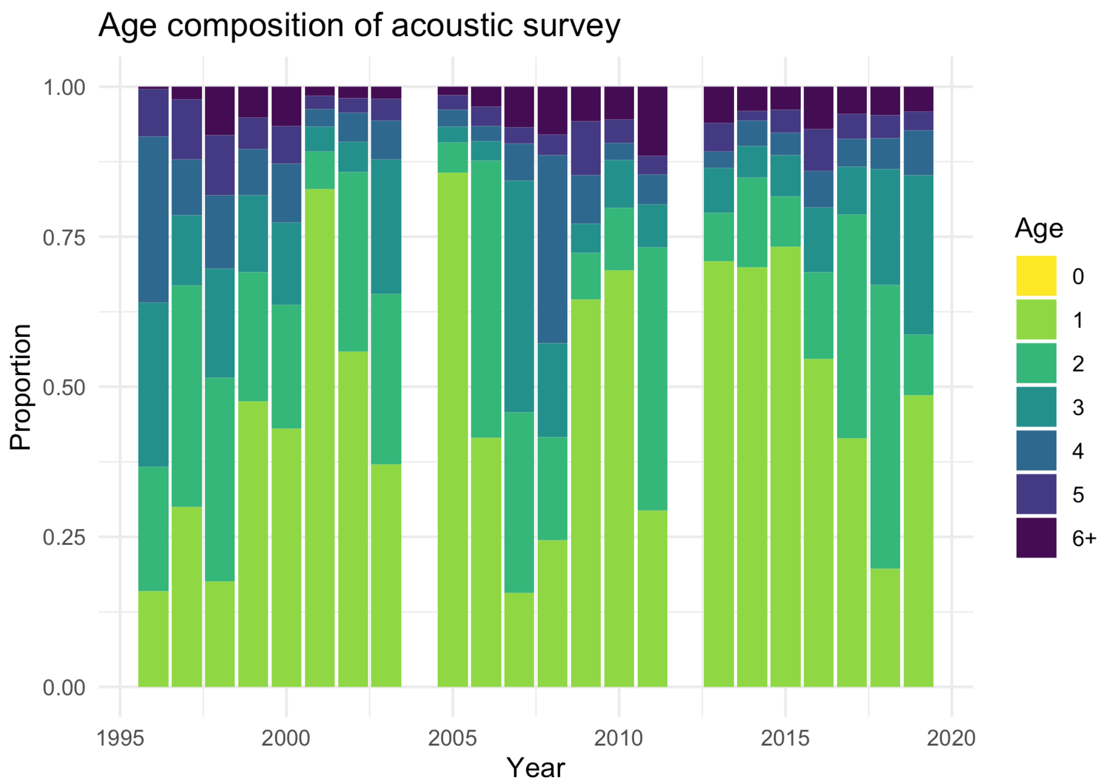


Figure 8.3.7.2. Sardine in 8c and 9a: Abundance-at-age in the joint Spanish-Portuguese spring acoustic survey 1996–2019.

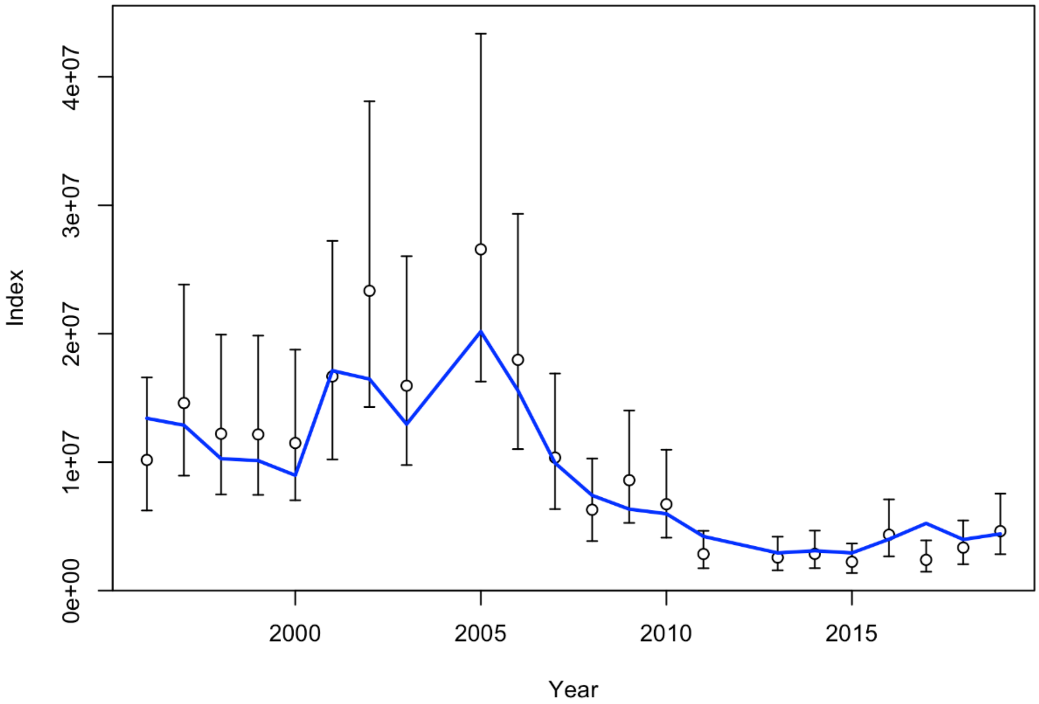


Figure 8.5.1.1. Sardine in 8c and 9a: Model fit to the acoustic survey series. The index is total abundance (in thousands of individuals). Bars are standard errors re-transformed from the log scale.

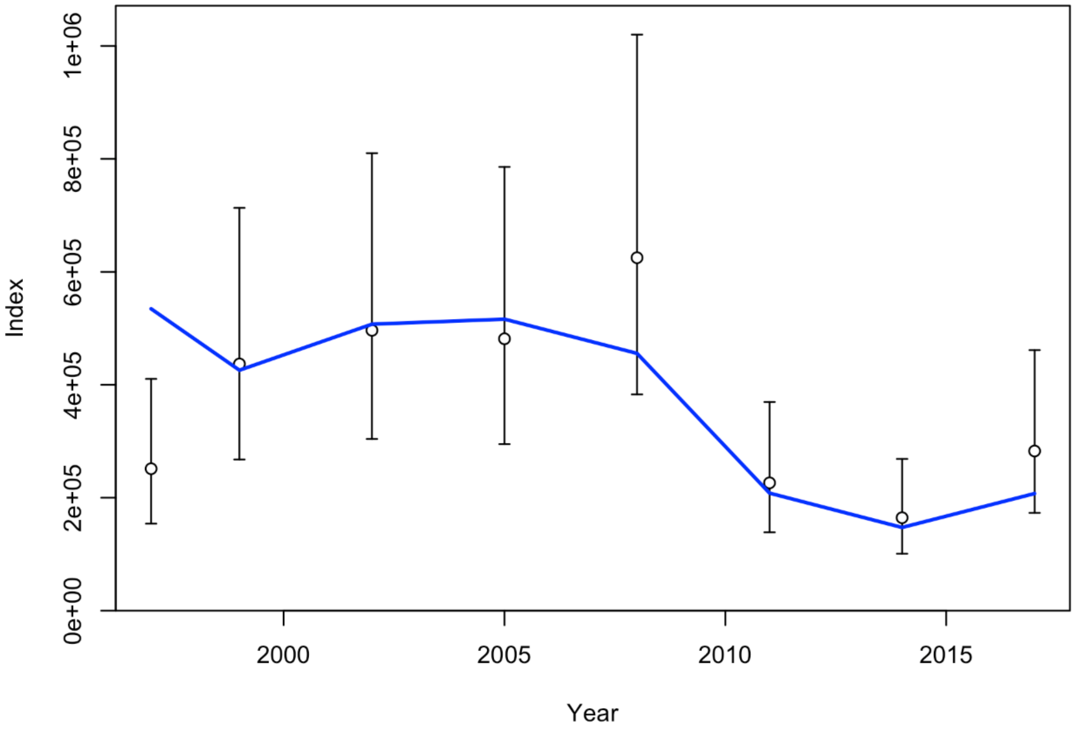
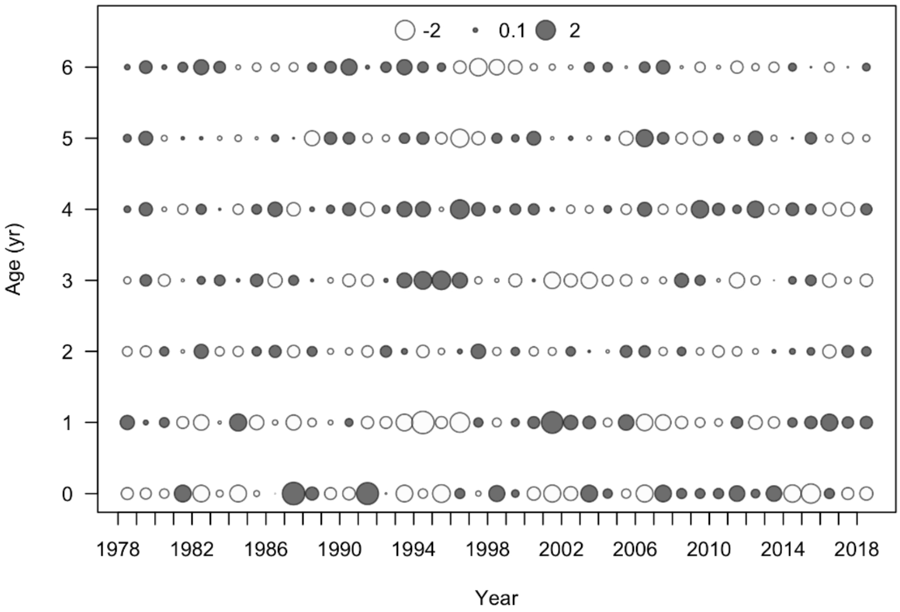


Figure 8.5.1.2. Sardine in 8c and 9a: Model fit to the DEPM survey series. The index is SSB (in thousand tons). Bars are standard errors re-transformed from the log scale.



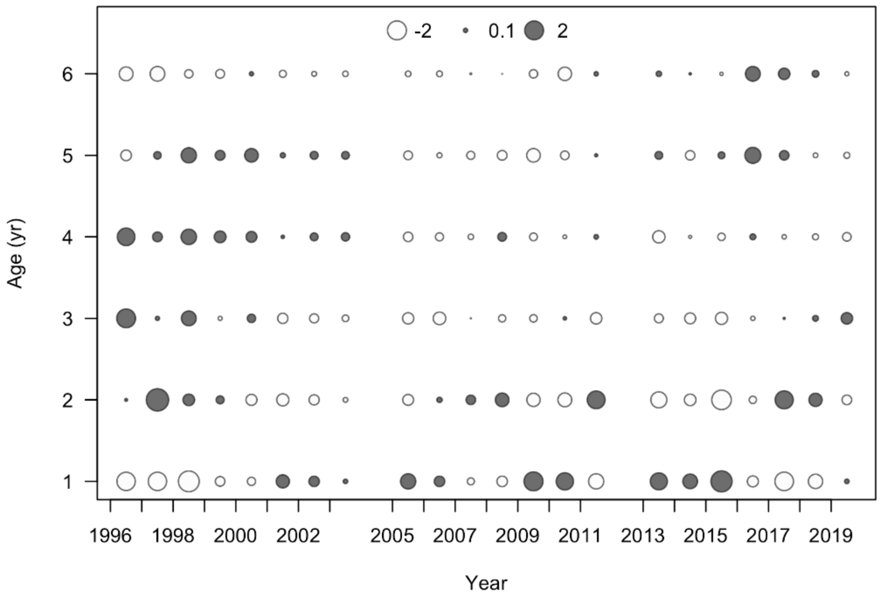


Figure 8.5.1.3. Sardine in 8c and 9a: Model residuals from the fit to the catch-at-age composition (top) and the acoustic survey age composition (bottom).

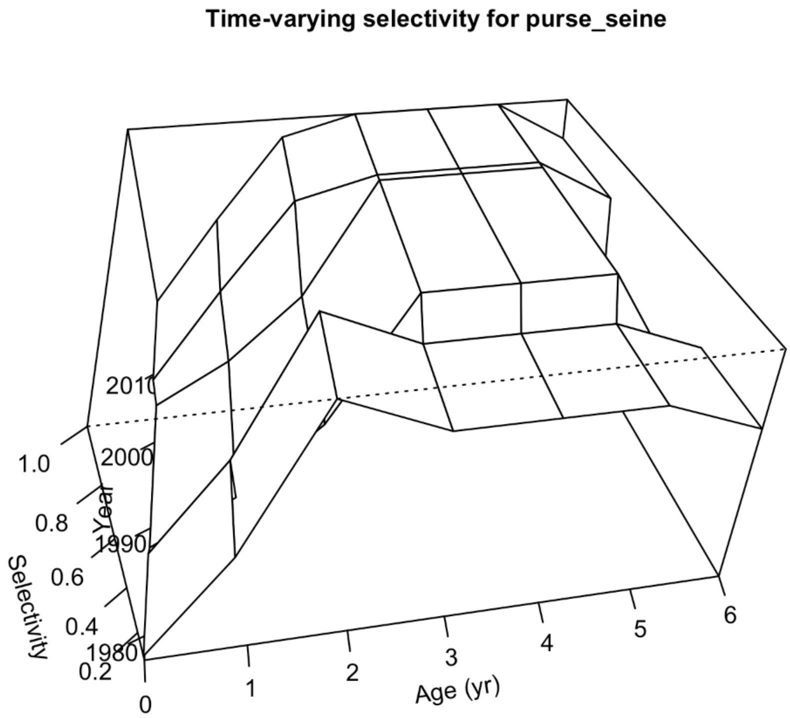


Figure 8.5.1.4. Sardine in 8c and 9a: Selectivity-at-age in the fishery showing the three blocks of fixed selectivity, 1978–1987, 1988–2005 and 2006–2018.

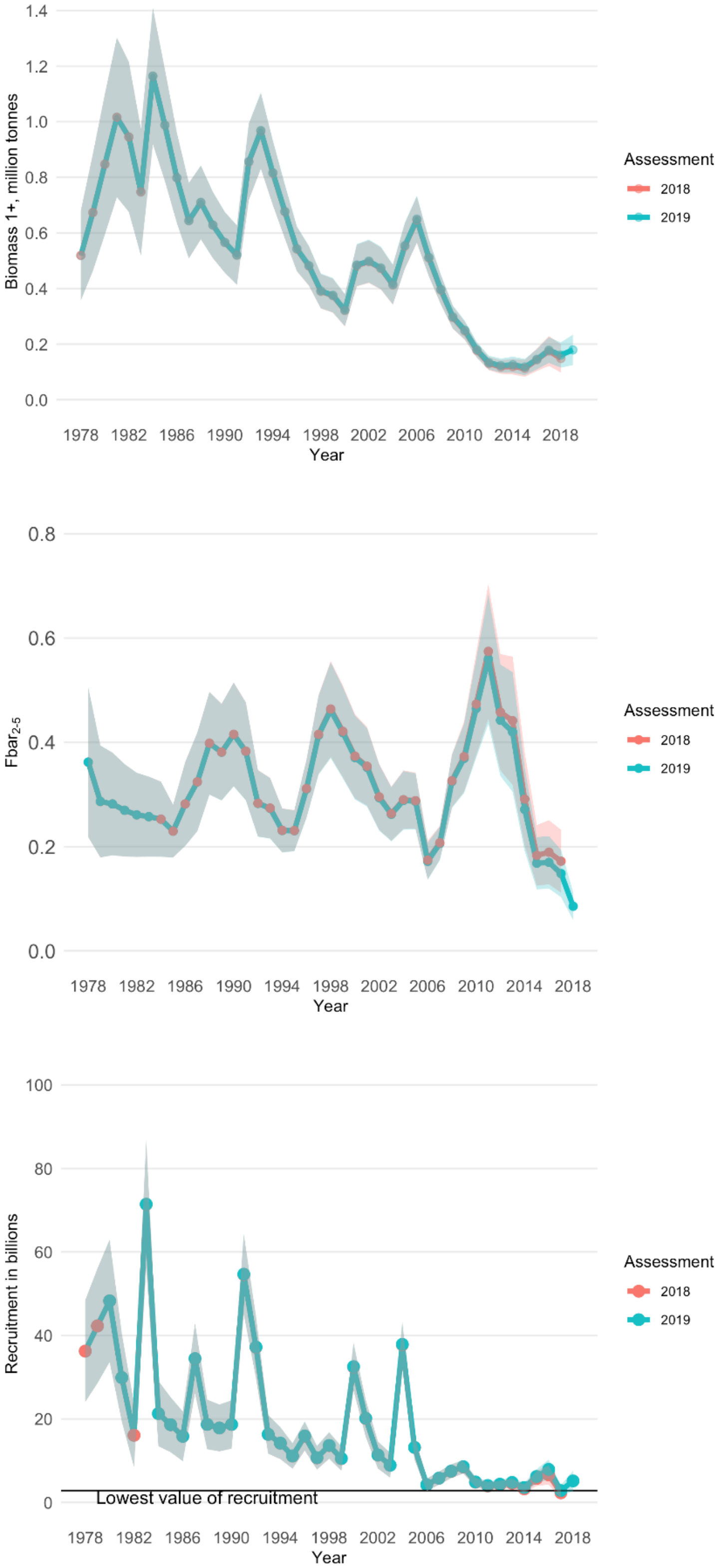


Figure 8.5.1.5. Sardine in 8c and 9a: Historical B1+ (top), $F_{bar(2–5)}$ (middle) and recruitment (bottom) trajectories in the period 1978–2018 (B1+ is estimated up to 2019). The WG 2018 assessment is shown for comparison (red line).

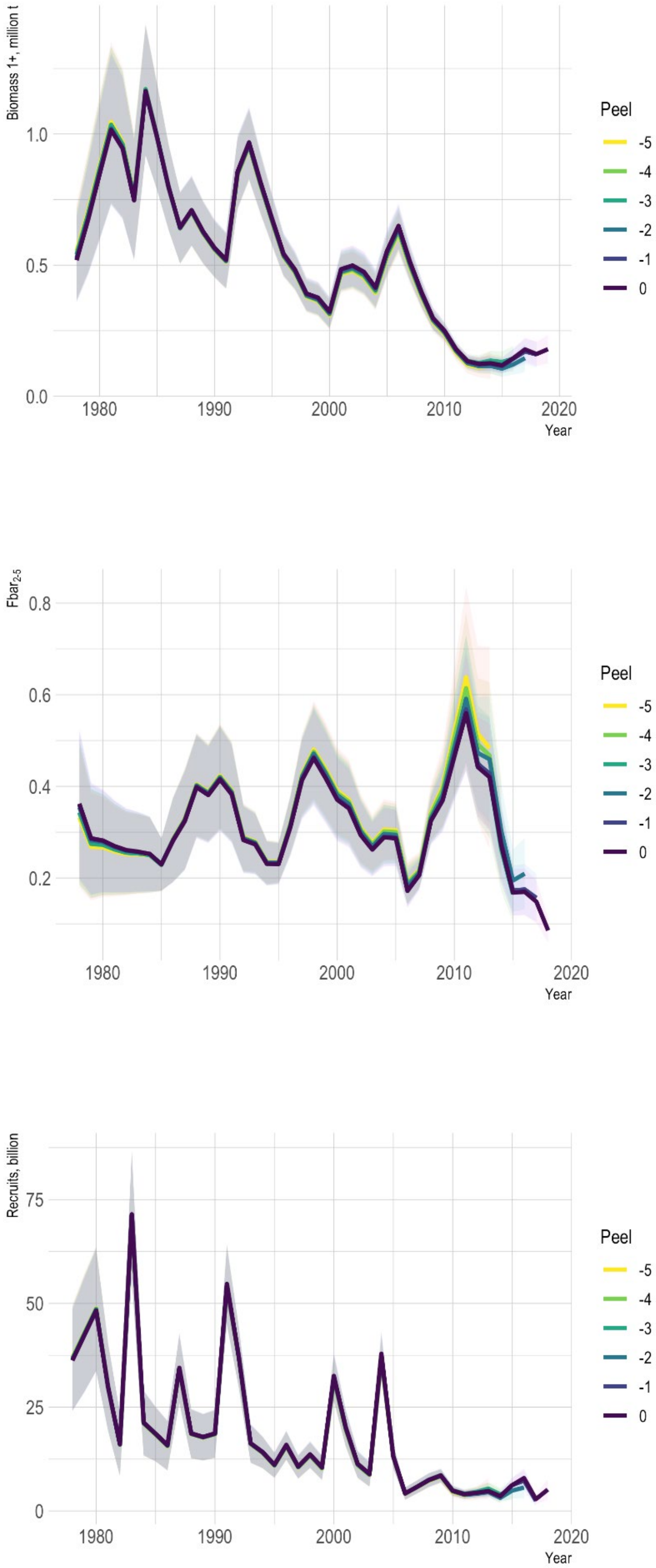
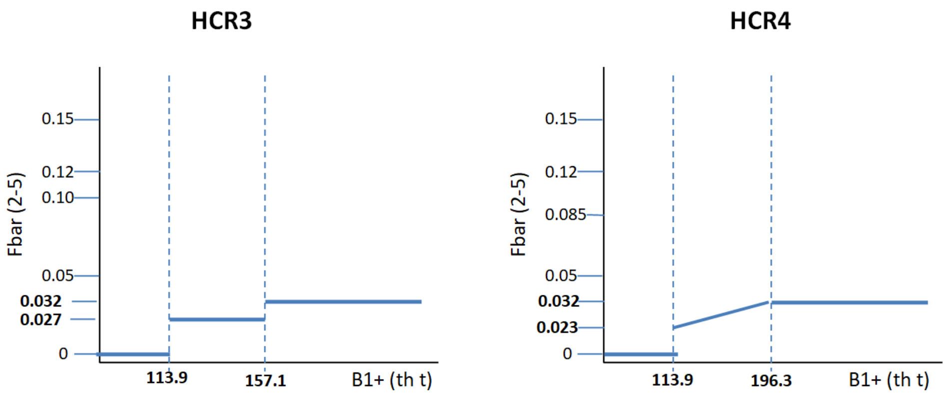


Figure 8.6.1. Sardine in 8c and 9a: Retrospective error for B1+ (top), $F_{bar(2–5)}$ (middle) and recruitment (bottom) in the assessment (B1+ is estimated up to 2019).



HCR3

i) B1+ ≤ 113.9 th t then F=0

ii) 113.9 th t < B1+ ≤ 157.1 th t then F=0.027

ii) In case ii) leads to an inter-annual increase of B1+ below 5%, F should decrease to a level leading to at least 5% inter-annual increase of B1+

iv) B1+ > 157.1 th t then F=0.032

HCR4

i) B1+ ≤ 113.9 th t then F=0

ii) 113.9 th t < B1+ ≤ 196.3 th t, the catch shall be fixed at value consistent with F increasing linearly from F=0.023 to F=0.032

iii) B1+ > 196.3 th t then F=0.032

Figure 8.9.1. Harvest Control Rules HCR3 and HCR4 with fishing mortality and biomass of fish age 1 and older (B1+) reference levels.

9 Southern Horse Mackerel (hom.27.9a)

9.1 ACOM Advice Applicable to 2019, STECF advice and Political decisions

The fishing mortality (F) has been below F_{MSY} over the whole time-series and the spawning–stock biomass (SSB) is above MSY $B_{trigger}$, relatively stable over the entire time-series and with a steep increase in the last three years. Recruitment (R) in 2011–2017 has been above the time-series average. The ICES advice was based on the MSY approach. ICES therefore recommended that catches in 2019 should not exceed 94 017 t. ICES also recommended that the TAC for this stock should only apply to *Trachurus trachurus*. A TAC of 94 017 t in 2019 has been set for *Trachurus* spp.

9.2 The fishery in 2018

9.2.1 Fishing fleets in 2018

The southern horse mackerel fisheries in Division 9.a is targeted by six fleets. These fleets are 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. In the last two years the Spanish purse-seine fleet had a significant increase of individuals from age 1 in the catches. The Portuguese artisanal fleet is mainly composed by small size vessels licensed to operate with several gears (gill and trammelnets, purse-seine and lines). Catches of horse mackerel from the Portuguese artisanal fleet are mainly from trips operating with nets showing the presence of larger/adult fish while the catches from trips operating with purse-seine show the presence of small/juveniles. The Spanish bottom trawl fleet catches mainly adults and a significant decrease in catches (70% decrease) was observed in 2018. The reason behind this large decrease are unclear. Horse mackerel is the main target species in the Portuguese bottom trawl demersal fish fleet, in 2018 accounted for 64% of the Portuguese catches, while in Spain main catches are from the Purse-seine fleet (71%). Spanish artisanal fishery is negligible (4%). In recent years, and due to the lower catch opportunities for the Iberian sardine stock (sar27.8c9a), the relative importance in the annual catches of the purse-seine fleets has increased. Description of the Portuguese and Spanish fleets is available in stock annex.

9.2.2 Catches by fleet and area

The catches of horse mackerel in Division 9.a comprise the following four subdivisions: 9.aNorth (9.a.n: Spain - Galicia), 9.aCentral-North (9.a.c.n: Portugal - Caminha to Figueira da Foz), 9.aCentral-South (9.a.c.s: Portugal - Nazaré to Sines) and 9.aSouth (9.a.s: Portugal - Sagres to V. Real Santo António) and are allocated to the Southern horse mackerel stock (hom.27.9a). 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. In the years before 2004, the catches from Division 8.c were also considered to belong to the southern horse mackerel stock. These catches were removed from previous total catches to obtain the current historical series of stock catches. Previous catch statistics came from areas as the Galician coasts that comprised more than one subdivision, the Subdivision 8.c West and Subdivision 9.a North and that is the reason why the time-series of catch statistics used in the assessment of southern stock is from 1992 onwards. Although Portuguese catches are available since 1927, in the case of Spanish catches the allocation of catches to Subdivision 9.a North and Subdivision 8.c West before 1992, has not yet been possible. Spanish catches from the Gulf of Cádiz (Subdivision 9.a South-Cadiz) are available since 2002 but they are scarce, representing less than the 1% of the total catch. Catches prior to 2014 for *Trachurus trachurus* are less reliable and therefore are not included in the assessment to avoid a possible bias in the assessment results.

The catch time-series used in the assessment (1992–2018) shows a peak in 1998, of 41 564 t, a steady increase since 2011 to 2016 but a slight decrease was observed in 2017 with catches of 36 956 t and 31 661 t in 2018 (Table 9.2.2.1, Figure 9.2.2.1). The minimum catch, of 18 887 t, was observed in 2003. The relative contribution of each gear to the total catch is given in Table 8.2.2.2. Until 2011 the highest contribution to the total catches was, in general, from the trawl fleets. Since 2012, there has been a significant increase in the catches from the purse-seine. The Spanish purse-seine contributions to catches remained high in the last years increasing 9% in 2018 relatively to 2017. Catches from the Spanish bottom trawl decreased 70% from 2017 to 2018 and the catches from the Portuguese bottom trawl decreased 30% from 2017 to 2018. The contribution of the artisanal fleet from both Portugal and Spain is very small, respectively representing 4% and 2% of the total catches in 2018.

Table 9.2.2.1. Time-series of southern horse mackerel historical catches (in tonnes).

Year	Total Catch
1991	34 992
1992	27 858
1993	31 521
1994	28 441[1]
1995	25 147
1996	20 400[1]
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 // (22 575)*
2012	24 868 // (25 316)*
2013	28 993 // (29 382)*
2014	29 017 // (29 205)*
2015	32 723 // (33 178)*
2016	40 741 // (41 081)*
2017	36 946 // (37 088)*
2018	31 661///(31 920)*

(*) In brackets: the Spanish catches from Subdivision 9a South are also included. These catches are only available since 2002 and are not included in the assessment data.

([1]) These figures have been revised in 2008.

Table 9.2.2.2. Southern horse mackerel landings by gear in the period 1992–2018 (in tonnes and in percentage, showing the contribution of each gear to total 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%

Year	Bottom trawl	Purse-seine	Artisanal
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%
2013	9,221	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%
2016	19,172	19,083	2,485
	47.06%	46.84%	6.10%
2017	16,931	18,038	2,120
	45.65%	48.64%	5.72%
2018	9,824	20,187	1,651
	31.03%	63.76%	5.21%

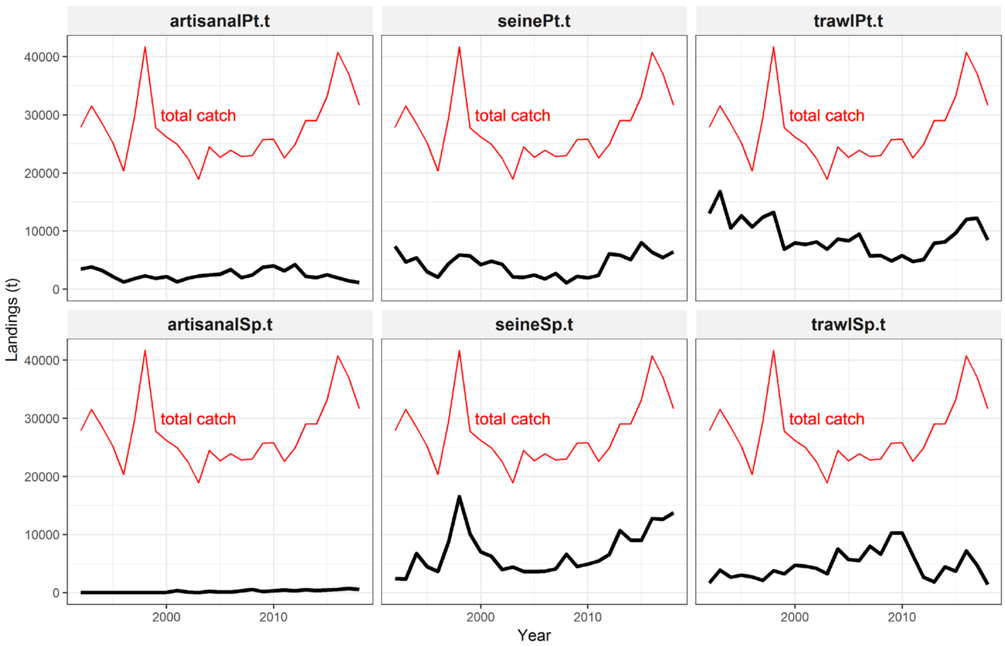


Figure 9.2.2.1. Time-series (1992–2018) of southern horse mackerel catches (in tonnes) by country (Pt – Portugal; Sp – Spain) and gear (artisanal; purse-seine, trawl).

Discards are estimated by both countries (Portugal since 2014, Spain since 2003) from national at-sea sampling (DCF) on board commercial vessels operating in ICES Division 9a. Discards are usually very low and not frequent thus being considered negligible (<0.7% in 2018). The horse mackerel Spanish discards come mainly from the bottom trawl fleet. Spanish discards in 2018 at Subdivision 9a were estimated to be around 204 tonnes, mainly from the trawl fleet (Table 9.2.2.3). The frequency of occurrence of horse mackerel discards from the Portuguese fleets in 2018 were either too low (considered zero discards because such low frequency of occurrence will result in highly biased estimates) or inexistent (Table 9.2.2.3).

Table 9.2.2.3. Discard estimates (tonnes) of southern horse mackerel in 2018 by country (SP – Spain, PT - Portugal), fleet/métier and quarter.

Country	Fleet	Metier	FishingArea	Quarter_1	Quarter_2	Quarter_3	Quarter_4	Total
SP	artisanal	GNS_DEF_80-99_0_0	27.9.a.n	0.3	0.3	0	0.1	0.7
SP	trawl	OTB_DEF_>=55_0_0	27.9.a.n	1.1	4.3	1.7	1.5	8.6
SP	trawl	OTB_MPD_>=55_0_0	27.9.a.n	0.7	1.3	0.6	1	3.6
SP	trawl	PTB_MPD_>=55_0_0	27.9.a.n	1.1	0	0	0	1.1
SP	trawl	OTB_MCD_>=55_0_0	27.9.a.s	10.3	9.1	15	126.1	160.5
SP	purse seine	PS_SPF_0_0_0	27.9.a.s	0	0.6	28.9	0	29.5
PT	trawl	OTB_CRU_>=55_0_0 (Loa >=12m)	27.9.a	0	0	0	0	0
PT	trawl	OTB_DEF_>=55_0_0 (Loa >=24m)	27.9.a	0	0	0	0	0

9.2.3 Effort and catch per unit of effort

No series of catch per unit of effort (cpue) is currently available to be used for stock assessment.

9.2.4 Catches by length and catches-at-age

Sampling method for the catches by length is described in the stock annex. Catch-at-age data have been obtained by applying a semester ALK to each of the catch length distribution estimated by fleet segment (bottom trawl, purse-seine and artisanal) and country from the samples of each subdivision. The catch in numbers-at-age used in the assessment is the total international catch-at-age from 1992–2018 with age range 0–11+.

In general, catches are dominated by juveniles and young adults. Total catches at age-0 showed a sharp increase in 2018 (Table 9.2.4.1, Figure 9.2.4.1).

Table 9.2.4.1. Southern horse mackerel catch-at-age data in the period 1992–2018 (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
2016	15223	116079	122297	49145	28523	31170	14561	15087	11210	5823	7138	20703
2017	25212	192125	75227	48553	31124	12862	7701	9156	10323	4694	4846	19138
2018	71977	182113	69396	52508	26314	12485	11555	6753	6050	3463	2517	4554

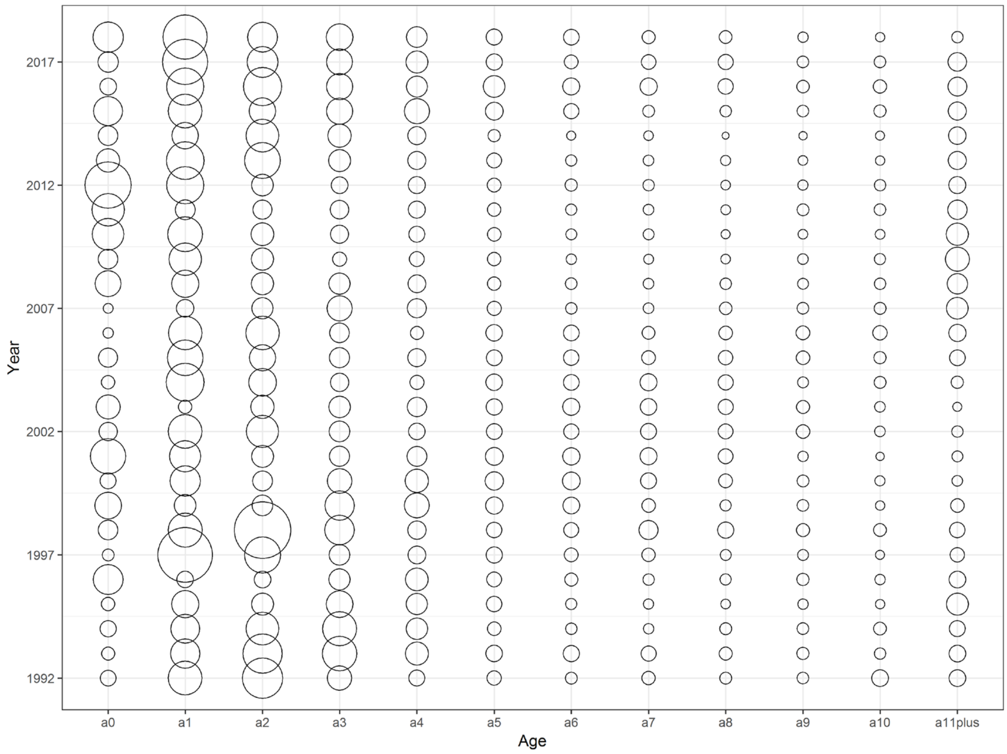


Figure 9.2.4.1. Bubble plot of proportions of southern horse mackerel catch in numbers-at-age in each year (1992–2018).

Table 9.2.4.2 presents the southern horse mackerel catch in numbers-at-age by fishing fleet and Figure 9.2.4.2 shows the proportion of catch-at-age by fleet and country in the period 1992–2018. In 2018, the Portuguese and Spanish purse-seine fleet and the Portuguese trawl and artisanal fleet caught mainly juveniles and young adults. While the Spanish trawl and artisanal fleets catch larger, adult horse mackerel. In the last two years, the Spanish purse-seine fleet showed a high increase in the proportions of catches-at-age-1.

Table 9.2.4.2. Southern horse mackerel catch in numbers-at-age (thousands) by fleet (bottom trawl, purse-seine and artisanal) in the period 1992–2018.

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
2016	2461	26151	47865	29405	9083	11260	6151	5604	4336	4022	6322	16970
2017	2044	15323	21678	22423	15581	6110	3779	5644	6386	3311	3584	14874
2018	2622	23258	19042	20477	8998	4346	5413	3186	3190	1885	1351	2775

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
2016	11898	93528	78720	19246	16407	17104	7090	8488	6186	1451	414	876
2017	18888	172613	50320	23723	13874	6068	3386	2839	3275	1080	880	2560
2018	61071	155490	48838	30137	15822	7290	5295	3079	2427	1288	911	1003

Purse-seine												
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
2016	69	200	520	1265	1511	2037	1391	1164	802	410	453	2431
2017	4280	4189	3229	2407	1669	683	537	673	663	302	382	1704
2018	8284	3365	1516	1894	1495	849	847	488	433	291	255	776

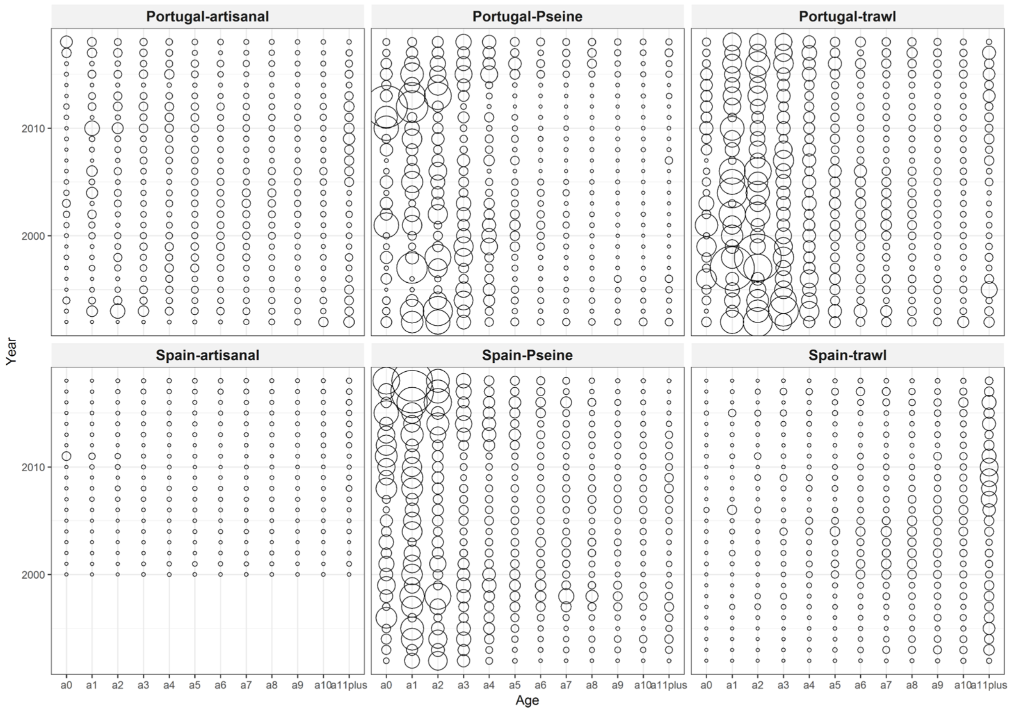


Figure 9.2.4.2. Bubble plot of proportions of southern horse mackerel catch in numbers-at-age by country and fleet in each year (1992–2018).

9.2.5 Mean weight-at-age in the catch

Detailed information on the way to calculate mean weight-at-age and mean length-at-age is provided in the stock annex. Tables 9.2.5.1 and 9.2.5.2 show the mean weight-at-age in the catch and the mean length-at-age in catch, respectively, from 1992 to 2018.

The mean weight-at-age is of a similar magnitude to previous years in ages 0 to 6 but it is noted a significant increase in ages 7 to 11+ (Figure 9.2.5.1) (Table 9.2.5.2). There were no changes in the otolith reading criteria and the same increase was observed in the Age–Length keys that were estimated by Portugal and Spain from independent readers. The increase of weight in older individuals should be further monitored and the impact of this observed pattern in the assessment is further explored in Section 9.4.3 (sensitivity analysis).

Table 9.2.5.1. Southern horse mackerel mean weight-at-age (kg) in the catch (1992–2018).

	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	0.11	0.13	0.15	0.17	0.20	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
2016	0.02	0.04	0.06	0.08	0.11	0.13	0.16	0.18	0.19	0.22	0.26	0.38
2017	0.02	0.04	0.07	0.09	0.12	0.15	0.18	0.20	0.21	0.25	0.28	0.35
2018	0.02	0.04	0.06	0.09	0.12	0.15	0.19	0.24	0.27	0.30	0.34	0.44

Table 9.2.5.2. Southern horse mackerel mean length-at-age (cm) in the catch (age range: 0–15 and older).

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
2016	13.8	16.1	18.7	20.6	23.1	25.0	26.5	28.0	28.5	30.1	31.9	33.7	36.2	36.8	37.1	39.3
2017	13.2	15.8	19.7	21.9	24.4	25.9	28.2	28.9	29.2	30.9	32.3	33.1	34.2	34.8	36.6	40.6
2018	12.9	16.2	19.4	22.1	24.1	25.9	28.4	30.7	31.7	33.0	34.4	37.3	37.9	38.9	38.5	39.2

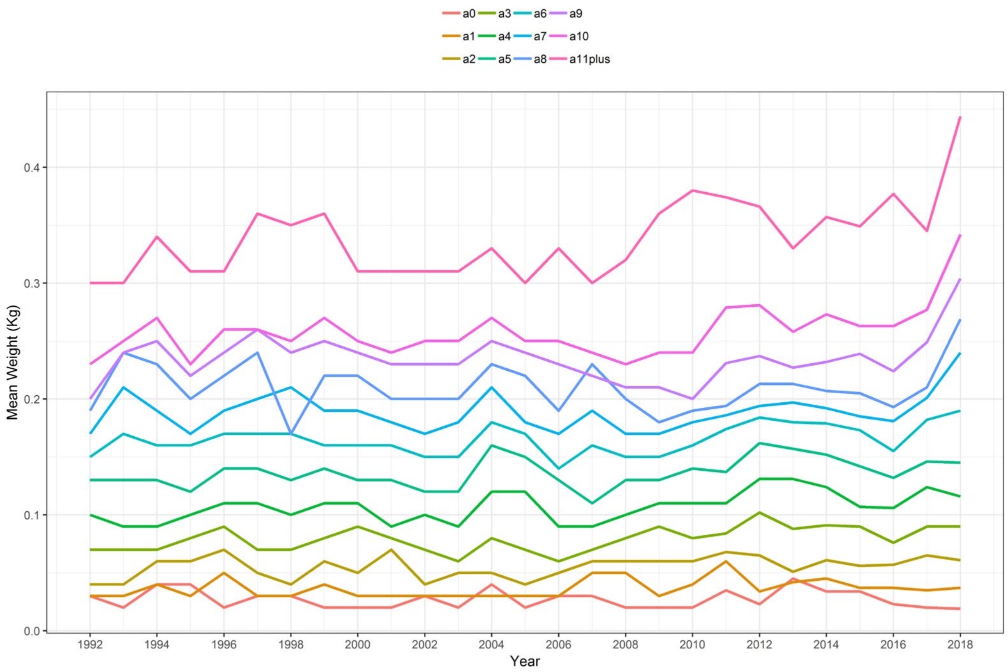


Figure 9.2.5.1. Southern horse mackerel mean weight-at-age (kg) in the catch (age range: 0 to 11+, plus group) (1992–2018).

9.3 Fishery-independent information

The survey datasets currently available for the assessment of southern horse mackerel are those from the bottom-trawl surveys carried out in the 4th quarter (October) by Portugal (Pt-GFS-WIBTS-Q4) and Spain (Sp-GFS-WIBTS-Q4) in ICES Division 9.a. Both IBTS surveys covers the bulk of the geographical distribution of the southern horse mackerel stock at the same time but do not cover the southernmost part of the stock distribution area, corresponding to the Spanish part of the Gulf of Cadiz. In that area another bottom-trawl survey is carried out (Sp-GFS-caut-WIBTS-Q4), usually in November. As explained in the Stock Annex, the survey series is shorter in time (only since 1998) and the raw data were unavailable in time for the WKPELA benchmark (ICES, 2017) to investigate the effect of merging it with the datasets from the other areas.

During the benchmark, horse mackerel estimations from spring acoustic surveys were also analysed to investigate the spatial distribution of juveniles and as a possible indicator of the recruitment strength for this species, which could prove to be useful for short-term forecasts (ICES, 2017). However, the analysis did not reveal any relationship between the estimates of recruitment from the acoustic survey and the stock assessment.

In the current year, a DEPM (Daily Egg Production Method) survey has been performed. SSB estimates from DEPM surveys require further analysis (WGMEGGS 2017) to be used as external auxiliary information according to the stock annex.

9.3.1 Bottom-trawl surveys

IBTS data provide a good sampling of this species with valuable information on horse mackerel distribution, abundance, age–length distributions also providing a good signal of cohort dynamics (ICES, 2017). Several alternative methods for calculating indices of abundance-at-age were explored to improve the precision of the current survey tuning index, the diagnostics of stock assessment model fit, the uncertainty in the estimates of the key parameters fishing mortality, recruitment and spawning–stock biomass, as well as to evaluate the stock trends (ICES, 2017).

Different methods of obtaining an abundance index by age and year were explored. The "standard" stratified mean was an acceptable method to deal with the non-normal abundance distribution and the variability in the survey data. This estimator, described in the stock annex, was found adequate to deal with the data from the current classical stratified survey methodology applied in IBTS surveys and was thus adopted for tuning the assessment.

The abundance indices from both surveys are shown in Table 9.3.1.1. There is a strong variability of age 0 abundance that may be explained by the greater aggregation tendency of these small fish in dense shoals. This feature results in a rather noisy time-series at-age 0.

The historical high cpue index (excluding age 0) observed in 2017 in both Portuguese and Spanish surveys did not persist in 2018. The abundance-at-age from the Portuguese survey index decreased in ages 1 to 4 and the abundance from the Spanish survey was almost null. The combined survey abundance-at-age for tuning the assessment excluding age 0 is presented in Table 9.3.1.2 and Figure 9.3.1.1.

Table 9.3.1.1. Southern horse mackerel. Cpue-at-age (number/hour) by survey, in the period 1992–2018. The Portuguese IBTS (October) survey was not conducted in 2012.

Portuguese October Survey

YEAR	AGES 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1992	452.2	488.2	145.8	26.8	13.2	5.9	4.0	4.3	2.4	2.2	3.0	0.5	0.6	0.2	0.1	0.1
1993	1645.8	183.8	212.2	148.0	32.5	2.0	1.5	0.7	0.5	0.7	0.4	1.0	0.3	0.2	0.0	0.0
1994	3.7	8.0	62.9	36.1	15.2	4.2	2.0	1.7	0.8	0.5	0.3	0.1	0.0	0.0	0.0	0.0
1995	15.8	61.2	89.7	49.7	23.9	6.5	1.4	1.2	0.5	0.2	0.2	0.3	0.3	0.5	0.1	0.1
1996*	1214.1	6.3	8.7	13.5	14.0	3.6	1.7	0.6	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.0
1997	2094.7	97.4	69.0	20.4	45.0	55.4	14.9	10.9	4.5	5.3	1.8	0.1	0.0	0.1	0.1	0.0
1998	86.4	33.2	161.7	17.4	2.2	1.4	0.9	0.9	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1999*	159.5	20.2	31.8	34.8	2.8	1.0	0.5	0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
2000	2.4	13.7	17.1	19.8	11.9	6.6	4.0	1.3	0.7	0.1	0.1	0.1	0.0	0.0	0.0	0.0
2001	1292.7	1.1	8.8	3.9	6.9	13.8	12.2	11.2	6.6	2.5	1.2	0.2	0.1	0.1	0.0	0.0
2002 [1]	21.1	1.5	11.4	10.0	5.5	2.8	1.0	0.7	0.5	0.3	0.6	0.2	0.1	0.1	0.0	0.0
2003*	56.5	9.1	8.2	10.2	8.8	3.3	2.3	1.2	0.7	0.4	0.1	0.0	0.0	0.0	0.0	0.0
2004	58.6	37.1	111.8	38.0	6.7	3.0	1.4	3.5	5.0	0.9	0.2	0.0	0.0	0.0	0.0	0.0
2005	351.9	1188.6	162.2	45.2	21.7	10.4	13.7	14.4	11.7	6.6	4.1	4.6	4.1	0.9	1.0	0.3
2006	65.1	84.6	181.8	46.6	3.4	10.3	7.4	6.6	2.7	1.4	0.4	0.1	0.0	0.0	0.0	0.0
2007	36.2	2.0	22.6	31.5	25.1	9.2	2.5	1.2	0.1	0.4	1.3	1.1	0.5	0.2	0.2	0.4
2008	47.6	28.2	39.7	20.6	26.7	17.3	2.2	0.8	1.2	1.8	1.3	1.0	0.5	0.9	0.5	1.8
2009	1245.2	79.5	147.0	52.4	44.7	11.6	2.8	1.7	1.4	0.9	0.7	0.4	0.7	1.7	0.4	0.8
2010	83.3	36.8	32.8	25.6	38.3	14.1	5.2	7.0	4.7	4.6	1.6	1.8	1.5	1.9	2.1	3.0
2011	132.8	33.1	24.5	16.2	4.7	1.1	0.3	0.4	0.2	0.4	0.5	0.2	0.3	0.4	0.2	0.2
2012	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2013	12.5	363.7	820.0	105.4	18.9	3.0	2.5	2.7	2.2	2.2	1.5	0.8	1.2	0.4	0.3	0.2
2014	53.6	33.3	24.1	69.2	25.6	5.2	1.6	1.5	0.9	1.2	2.2	2.6	3.0	2.5	0.9	0.6
2015	900.2	160.3	112.5	46.6	38.0	4.5	2.3	1.0	0.8	0.9	0.7	0.5	0.4	0.5	0.3	0.5
2016	1.6	17.1	23.1	76.8	53.6	7.6	4.3	6.0	2.4	1.3	1.6	2.0	2.7	1.7	0.2	1.7
2017	68.2	440.0	584.2	263.0	177.1	27.9	3.5	13.5	19.2	2.4	2.1	1.6	1.0	0.9	0.0	0.0
2018	124.5	192.6	177.3	96.7	12.5	14.2	19.9	9.4	10.0	3.5	0.3	0.1	0.1	0.0	0.0	0.0

Spanish October Survey (only Subdivision IXa North)

YEAR	AGES 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1992	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	1.0	0.4	0.5	0.3	0.1	0.6
1993	33.1	0.4	1.2	0.9	0.1	0.0	0.6	2.5	2.6	3.6	2.2	4.2	0.8	0.5	0.1	0.2
1994	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.6	0.0	3.7	3.0	0.3	1.5
1995	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.2	0.6	1.0	2.2	0.6	0.5
1996	8.4	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.7	0.2	0.1	0.5	0.7	0.3	1.1
1997**	0.5	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.3	0.5	0.2	0.1	0.1	0.2	0.3	0.7
1998	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
1999	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.6	0.9	0.7	1.3	0.5	0.4	0.1
2000	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.8	1.0	0.9	0.2	0.2	0.1	0.1	0.1	0.2
2001	3.4	0.8	0.0	0.0	0.0	0.1	0.1	0.7	1.2	1.1	0.9	0.5	0.3	0.3	0.0	0.1
2002	0.2	0.0	0.0	0.0	0.0	0.0	0.2	0.4	2.1	2.0	2.5	2.9	1.0	1.2	0.4	0.6
2003	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.2	0.2	0.1	0.1	0.0	0.0	0.2
2004	24.1	0.3	0.7	4.3	1.4	1.2	0.5	0.4	0.2	0.1	0.2	0.0	0.1	0.0	0.0	0.0
2005	938.1	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.2	0.1	0.1	0.0	0.0
2006	7.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.1
2007	0.4	0.0	0.0	0.0	0.0	0.1	0.3	0.3	0.4	0.2	0.2	0.2	0.0	0.1	0.1	0.0
2008	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.1
2009	23.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.1
2010	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.1	0.2	0.3	0.3
2011	0.4	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.1	0.3	0.3	0.0	0.0	0.0	0.1	0.2
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	0.1	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	0.0	0.0
2014	0.3	7.5	1.2	8.5	8.0	2.6	0.4	0.2	0.2	0.2	0.2	0.1	0.9	0.0	0.0	0.0
2015	6.6	0.0	0.1	1.9	2.8	1.0	0.1	0.2	0.0	0.1	0.2	0.0	0.1	0.0	0.1	0.2
2016	11.9	2.8	20.0	3.2	4.0	11.0	4.6	2.2	0.5	0.3	0.1	0.0	0.0	0.0	0.1	0.1
2017	4.9	27.1	171.7	84.1	48.6	13.4	17.7	0.4	0.7	0.1	0.4	0.1	0.0	0.0	0.0	0.0
2018	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	0.0	0.0

* 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

Table 9.3.1.2. Southern horse mackerel. Stratified mean abundance-at-age (number/hour) in the period 1992–2018. There was no Portuguese survey in 2012 and the combined survey index for 2012 is not estimated. Age 0 is not used in the stock assessment.

	AGES											
YEAR	0	1	2	3	4	5	6	7	8	9	10	11+
1992	454.5	488.2	145.8	26.8	13.2	5.9	4.0	4.4	2.4	2.3	4.0	3.4
1993	1678.9	184.2	213.3	148.8	32.6	2.0	2.1	3.2	3.1	4.3	2.6	7.3
1994	3.8	8.0	63.0	36.1	15.2	4.2	2.0	1.7	0.9	0.8	0.9	8.7
1995	15.8	61.2	89.7	49.7	23.9	6.5	1.4	1.2	0.6	0.3	0.4	6.2
1996	1222.5	6.3	8.7	13.5	14.0	3.6	1.7	0.6	0.4	0.8	0.2	2.8
1997	2095.3	97.4	69.0	20.4	45.0	55.4	15.0	11.2	4.8	5.8	2.1	1.7
1998	86.6	33.2	161.7	17.4	2.2	1.4	1.0	1.2	0.3	0.1	0.0	0.1
1999	159.5	20.2	31.8	34.8	2.8	1.0	0.6	0.2	0.2	0.7	0.9	3.0
2000	2.5	13.7	17.1	19.8	11.9	6.6	4.1	2.1	1.7	1.0	0.3	0.9
2001	1296.1	1.8	8.8	3.9	6.9	13.8	12.3	11.9	7.8	3.7	2.1	1.6
2002	21.2	1.5	11.4	10.0	5.5	2.8	1.2	1.1	2.6	2.3	3.1	6.6
2003	58.9	9.1	8.2	10.2	8.8	3.3	2.4	1.3	0.7	0.6	0.4	0.5
2004	82.7	37.4	112.4	42.4	8.1	4.2	1.9	3.8	5.1	1.0	0.4	0.2
2005	1290.0	1188.6	162.2	45.2	21.8	10.5	13.8	14.5	11.8	6.7	4.1	11.3
2006	72.6	84.6	181.8	46.6	3.4	10.4	7.4	6.7	2.7	1.4	0.5	0.3
2007	36.6	2.0	22.6	31.5	25.1	9.2	2.7	1.6	0.6	0.6	1.4	2.9
2008	52.6	28.2	39.7	20.6	26.8	17.3	2.2	0.8	1.3	1.9	1.4	5.0
2009	1268.3	79.5	147.0	52.4	44.7	11.6	2.8	1.7	1.4	0.9	0.7	4.6
2010	83.4	36.8	32.8	25.6	38.3	14.1	5.2	7.0	4.7	4.6	1.8	11.6
2011	133.2	33.1	24.5	16.2	4.7	1.2	0.4	0.6	0.4	0.7	0.8	1.6
2012	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2013	12.6	363.8	820.0	105.4	18.9	3.0	2.5	2.7	2.2	2.2	1.5	2.9
2014	53.9	40.8	25.4	77.7	33.6	7.8	2.1	1.7	1.2	1.4	2.4	10.5
2015	906.8	160.3	112.6	48.5	40.9	5.5	2.4	1.2	0.9	1.0	0.9	2.6
2016	13.6	19.9	43.1	80.0	57.6	18.6	8.8	8.1	3.0	1.6	1.7	8.6
2017	73.04	467.1	755.9	347.1	225.7	41.3	21.1	13.9	19.9	2.5	2.5	3.7
2018	124.5	192.6	177.3	96.7	12.5	14.2	19.9	9.4	10.0	3.5	0.3	0.1

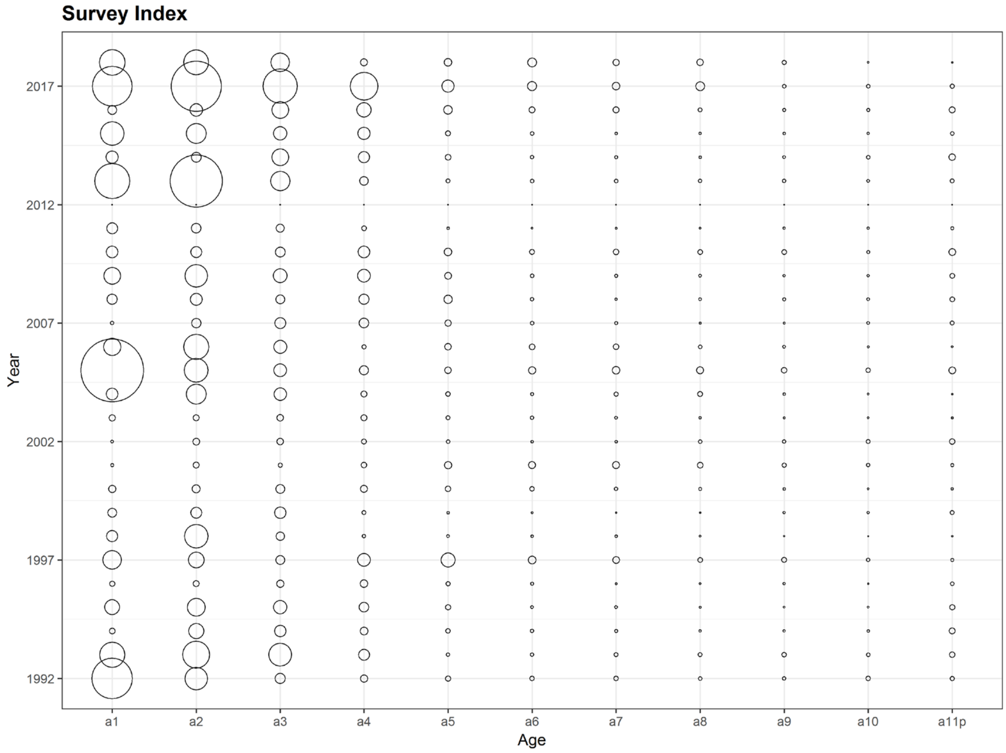


Figure 9.3.1.1. Southern horse mackerel. Bubble plot of proportions of Stratified mean abundance-at-age (number/hour) at the combined survey (1992–2018). There was no Portuguese survey in 2012 and the combined survey index for 2012 was not estimated. Age 0 is not used in the stock assessment.

9.3.2 Mean length and mean weight-at-age in the stock

Taking into consideration that the spawning season is very long, 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.

9.3.3 Maturity-at-age

The maturity ogive corresponds to females. Horse mackerel is a multiple spawner (ICES, 2008) and hence maturity ogives should be based on histological analysis of the gonads which provide a correct and precise means to follow the development of both ovaries and testes (Costa, 2009). Maturity ogive estimation procedures are detailed in Stock Annex. The predicted proportion-at-age is given in the text table below (7+: age 7 and older fish) and was adopted by WKPELA for the assessment period (1992–2015).

Age	0	1	2	3	4	5	6	7+
Proportion mature	0.0	0.0	0.36	0.82	0.95	0.97	0.99	1.0

During the benchmark, it was also agreed to estimate a maturity ogive every three years with the data collected during the triennial DEPM surveys. The maturity ogive will be updated only in the case there is strong evidence that the proportion of fish mature at-age has changed.

9.3.4 Natural mortality

The natural mortality (M) used in the assessment is presented in the text table below (5+: age 5 and older fish).

Age	0	1	2	3	4	5+
M	0.9	0.6	0.4	0.3	0.2	0.15

The procedure in the estimation of natural mortality rate and considerations for adopting the current values are detailed in stock annex.

9.4 Stock assessment

9.4.1 Model assumptions and settings and parameter estimates

The stock assessment has been performed for the period 1992–2017 with the method and settings agreed during the benchmark (ICES, WKPELA 2017) and described in the stock annex. Table 9.4.1.1 presents the input data type, model assumptions and settings adopted by the benchmark.

The assessment was tuned with the stratified mean abundance-at-age estimated for the combined Portuguese and Spanish IBTS survey for the age range 1–11+. The survey series was updated to 2018. In 2012, the Portuguese survey was not carried and, hence, the combined survey index for 2012 could not be estimated. Benchmark discussions also concluded that it was appropriate to adopt only one time-block for the survey selectivity given that the survey characteristics (e.g. survey design, surveyed area, Research vessels and fishing gear) were relatively unchanged along the assessment period.

The three time-blocks for the catch selectivity accommodates the recent changes in the fishery due to the strong year classes of 2011 and 2012, and the increase of horse mackerel catches by purse-seiners, following the Iberian sardine crisis. This pattern is persistent in the recent years being more pronounced in the Spanish purse-seine fleet.

Table 9.4.1.1. Input data type, model assumptions and settings for the assessment of southern horse mackerel with data series 1992–2018.

Name	Year range	Age range	Assumptions/settings
Catch in weight	1992–2018		Variable in time
Catch-at-age	1992–2018	0–11+	Variable by age and time
IBTS (Spanish-Portuguese) mean stratified abundance-at-age	1992–2018	1–11+	Variable by age and time
Mean weight-at-age (catch & stock)	1992–2018	0–11+	Variable by age and time
Proportion of F and M before spawning	1992–2018	0–11+	Fixed at 0.04 (mid-January)
Natural Mortality	1992–2018	0–11+	Age-dependent; time invariant
Catch-at-age selectivity	1992–2018	0–11+	Dome-shaped; constant at age 7+ Three blocks 1992–1997; 1998–2011; 2012–2018
Initial parameter vector		0–11+	0.2,0.7,1,1,0.8,0.5,0.5,0.2,0.2,0.2,0.2,0.2
Survey abundance-at-age selectivity	1992–2011; 2013–2018	1–11+	Dome-shaped; constant at-age 7+ One time-block 1992–2018 (no survey index in 2012)
Initial parameter vector		1–11+	1,1,0.7,0.5,0.4,0.3,0.2,0.2,0.2,0.2,0.2
Proportion-at-age in the catch	1992–2018	0–11+	Multinomial distribution; log-normal with a constant CV of 5%
Proportion-at-age in the survey	1992–2018	1–11+	Multinomial distribution; log-normal with a constant CV of 30%
Effective sample size catch			100
Effective sample size survey			10

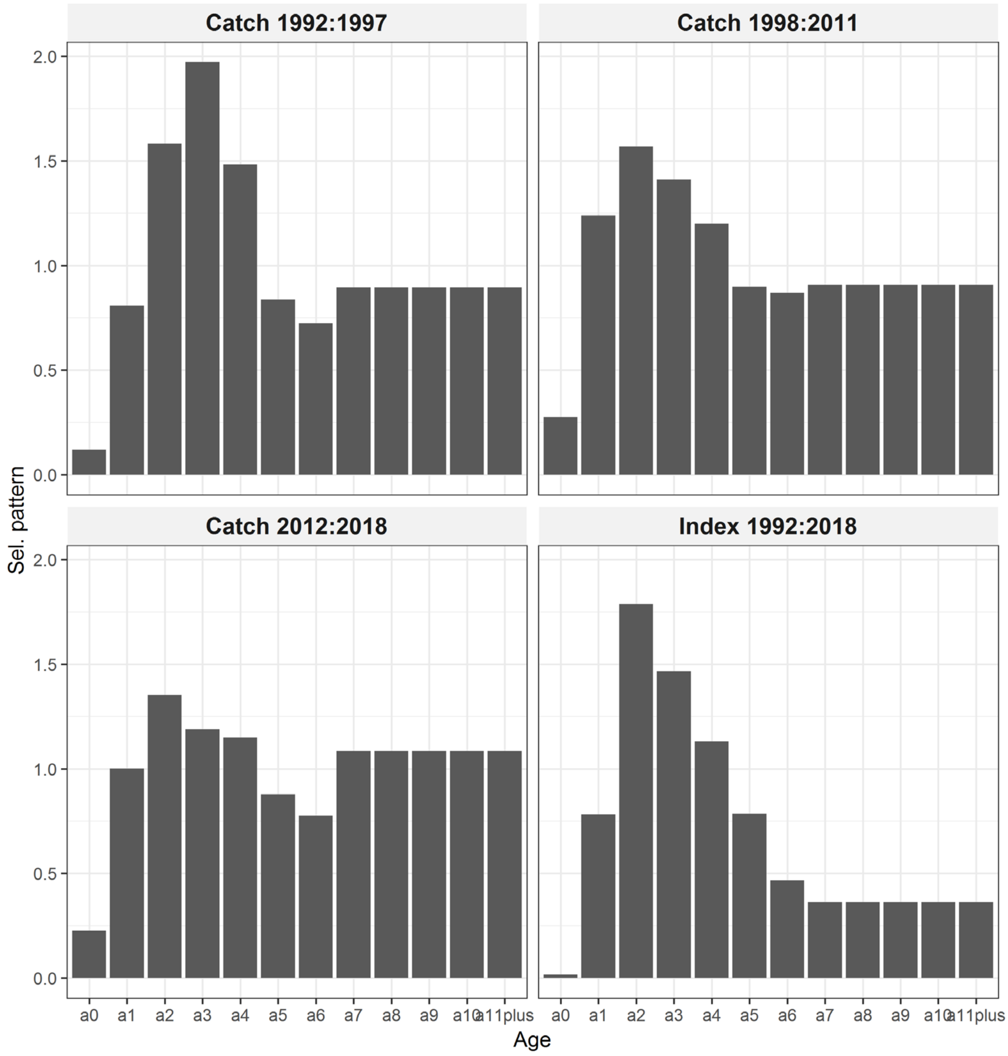


Figure 9.4.1.1. Southern horse mackerel. Estimated selectivity for the catch-at-age (three time blocks) and for the IBTS combined stratified mean abundance-at-age (one time block).

Figure 9.4.1.1 presents the estimated selectivity in the survey (age range 1–11+) and in the catch-at-age (age range 0–11+) for the period 1992–2018.

The summarised results of the stock assessment are shown in Table 9.4.1.2 and Figure 9.4.1.2.

Table 9.4.1.2 Southern horse mackerel final assessment (1992–2018). Stock summary table (SSB at spawning time).

Year	Recruits (10*3)	SD	CV	SSB (t)	SD	CV	mean $F_{2\text{-}10}$	SD	CV	Catch (t)
1992	4341370	844742	0.19	290448	69889	0.24	0.088	0.020	0.23	27858
1993	3039670	624594	0.21	311530	77399	0.25	0.093	0.022	0.24	31521
1994	3001400	623269	0.21	332307	86056	0.26	0.076	0.019	0.25	28441
1995	4113460	829088	0.20	317578	85144	0.27	0.073	0.018	0.25	25147
1996	11072000	2018640	0.18	338222	93386	0.28	0.053	0.013	0.25	20400
1997	3644270	732182	0.20	355798	98467	0.28	0.073	0.018	0.25	29491
1998	2337250	503503	0.22	359916	98405	0.27	0.098	0.025	0.26	41564
1999	3564000	729816	0.20	409961	115316	0.28	0.060	0.016	0.26	27733
2000	3251070	684558	0.21	396407	113979	0.29	0.062	0.017	0.27	26160
2001	3844530	805299	0.21	380541	111931	0.29	0.061	0.016	0.27	24910
2002	2176610	497710	0.23	368150	109747	0.3	0.059	0.016	0.27	22506
2003	4323000	920186	0.21	368634	111105	0.3	0.050	0.013	0.27	18887
2004	4769950	1016120	0.21	418824	127346	0.3	0.054	0.015	0.27	23252
2005	3003100	675702	0.23	383467	117628	0.31	0.055	0.015	0.27	22695
2006	1571490	393807	0.25	371764	114295	0.31	0.061	0.017	0.28	23902
2007	2340330	566606	0.24	375750	117156	0.31	0.058	0.016	0.28	22790
2008	3722960	889463	0.24	370131	117788	0.32	0.060	0.017	0.29	22993
2009	3463290	870345	0.25	370644	120711	0.33	0.068	0.020	0.3	25737
2010	4384510	1128430	0.26	372295	123974	0.33	0.067	0.021	0.31	26556
2011	11195000	2760120	0.25	375522	127511	0.34	0.042	0.013	0.31	21875
2012	13235700	3237580	0.24	399925	135408	0.34	0.044	0.014	0.32	24868
2013	7057550	1843660	0.26	409582	135743	0.33	0.044	0.014	0.32	28993
2014	9391370	2471570	0.26	523347	167024	0.32	0.039	0.012	0.32	29017
2015	10450900	2894450	0.28	579817	181124	0.31	0.043	0.013	0.31	32723
2016	11087100	3314600	0.30	615367	191283	0.31	0.052	0.017	0.32	40741
2017	13087800	4369400	0.33	729278	227312	0.31	0.041	0.013	0.32	36946
2018	4692000*			888422	276054	0.31	0.029	0.009	0.31	31661
Average	5671911	1394055	0.23	422727	127822	0.30	0.059	0.016	0.28	27384
(*)Geometric mean (1992-2017)										

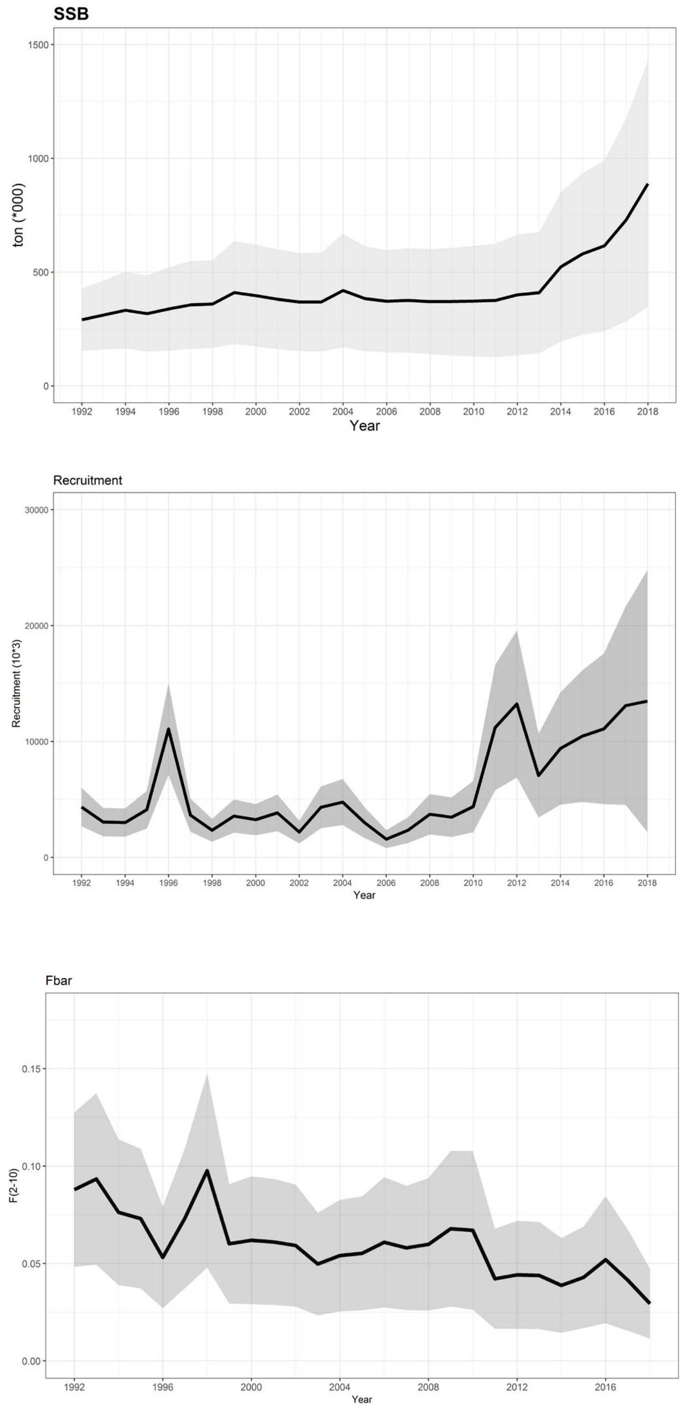


Figure 9.4.1.2 Southern horse mackerel final assessment (1992–2018). Plots of SSB (top), Recruitment (middle) and Fishing mortality (bottom, mean $F_{2–10}$). Grey shaded area shows 95% confidence bounds and average CV is 30% for SSB and 28% for $F_{2–10}$. SSB are in thousand tonnes and recruitment in thousands.

The estimated SSB shows a significant increase from 2013 to 2018 from 410 thousand tonnes to 888 thousand tonnes. Coefficient of variation of SSB is in the range 19–33%. The fishing mortality has been below F_{MSY} over the whole time-series and after the slight increase in 2016, showed a decrease in 2018 to 0.029. Coefficient of variation of F is in the range 23–32%. The stock showed a strong recruitment in 1996 and above average recruitments in the most recent years with the highest values in 2012, 2011 2016 and 2017. The most recent recruitment in 2018 (13 483 million) is estimated to be above average, but the terminal year recruitment is considered not to be reliable and highly uncertain (CV = 43%).

Figure 9.4.1.3 shows the scatterplot of the estimated spawning–stock biomass and recruitment in the period 1992–2018.

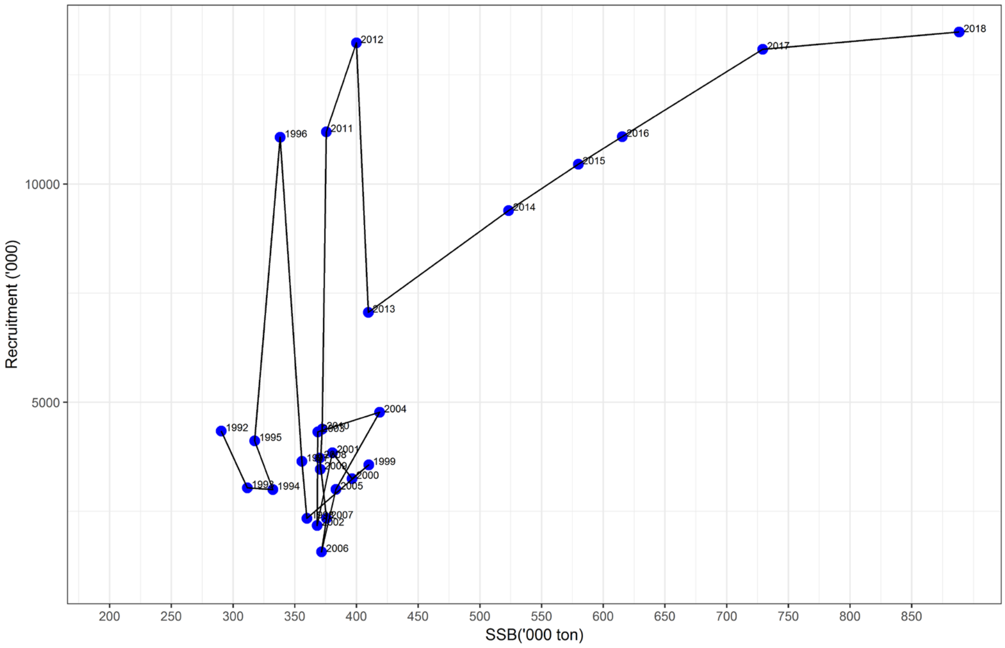


Figure 9.4.1.3. Stock–recruitment data for southern horse mackerel (1992–2017).

9.4.2 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 is given to the dataseries of landings in weight, which was very well fitted by the model (Figure 9.4.2.1). The assessment is also tuned with the stratified mean abundance-at-age estimated for the combined Portuguese and Spanish IBTS surveys. The recent survey indices show values above average and 2017 was the highest in the time-series which resulted in a steady increase of the model fitted survey biomass index from 2013 to 2018, reaching values two times above the average (Figure 9.4.2.1).

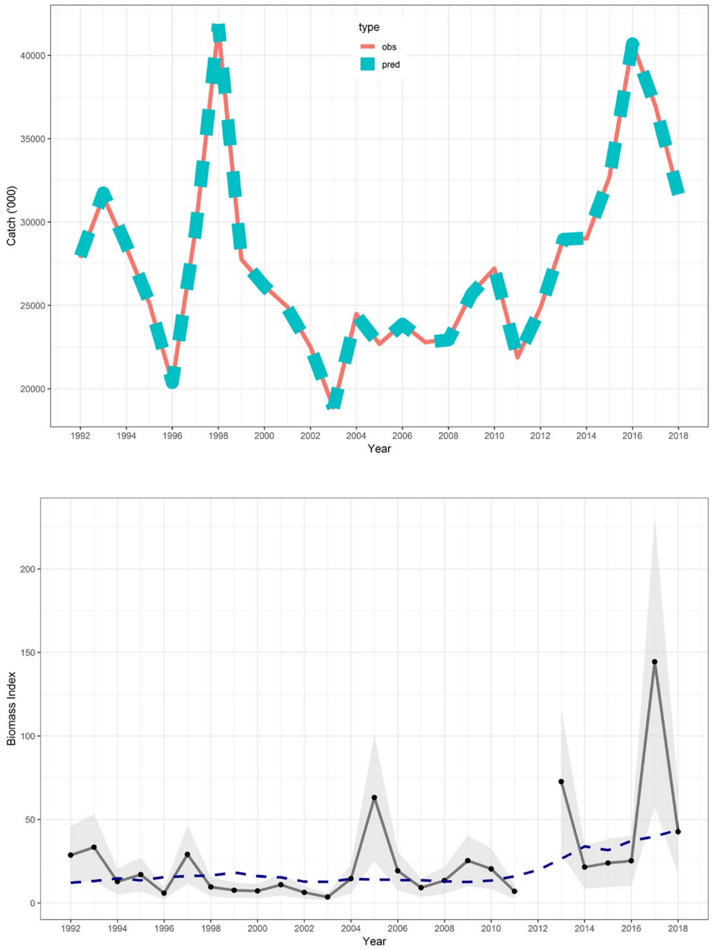


Figure 9.4.2.1. Southern horse mackerel (1992–2018). Catch biomass (top) and survey biomass index (bottom): observed (solid black line) and estimated values (dashed blue line). (grey shaded area shows 95% confidence bounds of survey biomass index).

A good fit was obtained for the proportions-at-age of the catch in numbers (Figure 9.4.2.2) and overall for the abundance indices in number/hour from the IBTS combined survey (Figure 9.4.2.3). The model underestimates the high proportion of catches-at-age -1 observed in the last two years. The bubble plots of the residuals corresponding to the fitting of those data are shown in Figure 9.4.2.4.

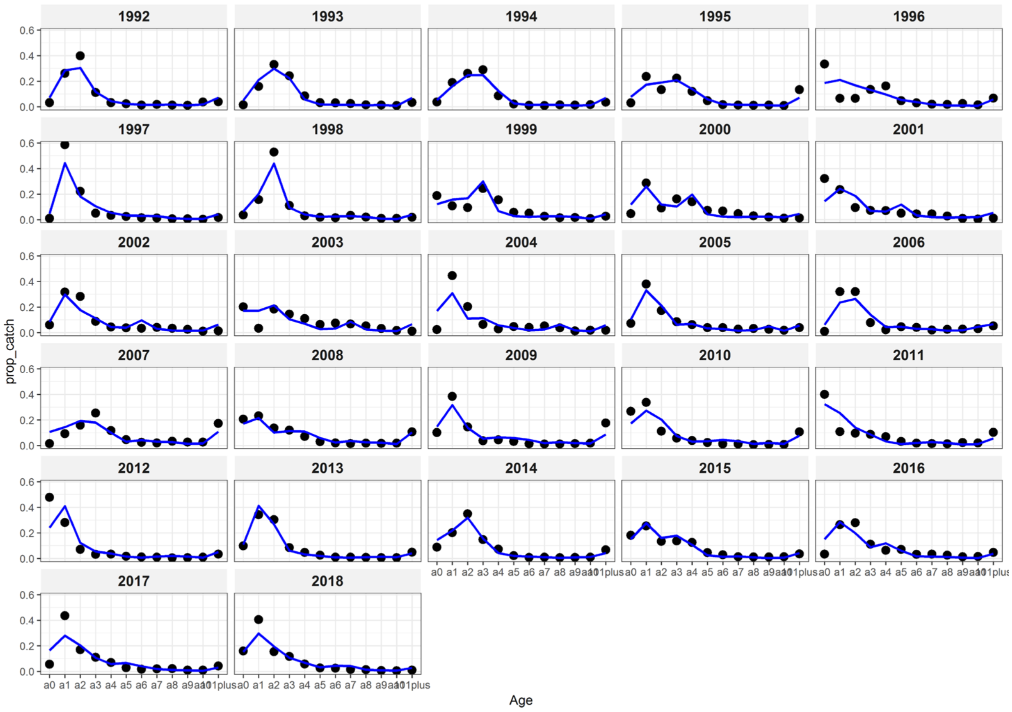


Figure 9.4.2.2. Southern horse mackerel (1992–2018). Comparison of proportions-at-age of the observed and fitted catch data (observed values=dots; fitted values=solid lines).

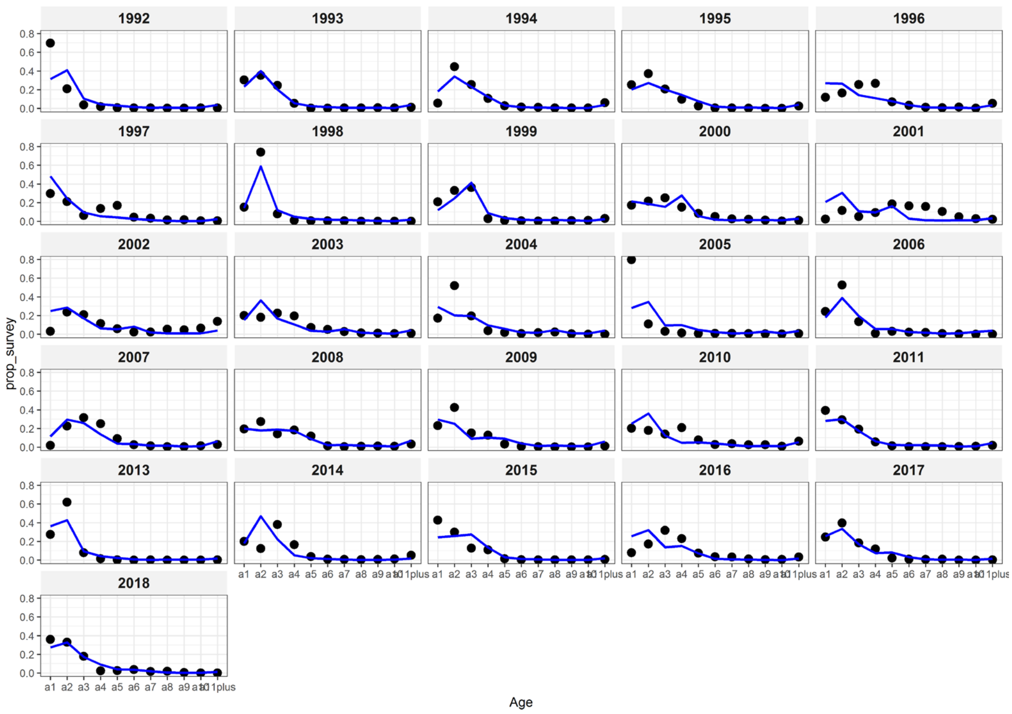


Figure 9.4.2.3. Southern horse mackerel 1992–2018). Comparison of proportions-at-age of the observed and fitted survey data (observed values=dots; fitted values=solid lines).

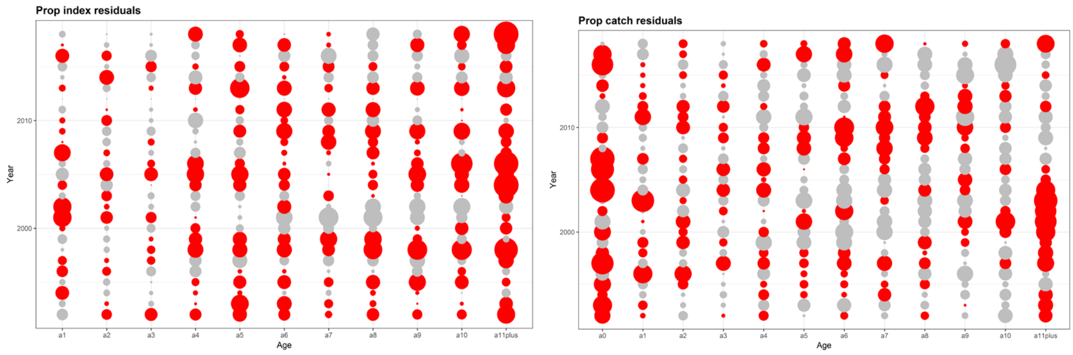


Figure 9.4.2.4. Southern horse mackerel (1992-2018). Bubble plot of catch (left, age range 0–11+) and survey (right, age range: 1–11+) proportion-at-age residuals (negative residuals=red bubbles).

The significant increase in SSB in recent years is reflecting the contribution of the survivors of the above average recruitment in recent years. The uncertainty in SSB in most recent years is around 31% (coefficient of variation). The relatively stables catches observed in 2018 and the continuous increase in stock abundance resulted in a decrease in F_{bar} in 2018. The uncertainty in the estimated F_{bar} is of similar magnitude around 32% (coefficient of variation). The recruitment of 2018 is estimated to be above average (13 483 million). However, there are no survey data at-age 0 in 2018 and age 0 is not entirely available to the fishery and as a result, the most recent recruitment estimate is highly uncertain. This estimate is replaced by the geometric mean recruitment of the period 1992–2017 (4692 million) in the short-term determinist forecast for advice.

The retrospective analysis on SSB, recruitment and F_{bar} (mean F ages 2–10) was performed for a five-year period (current assessment compared to previous 5 assessment), from 1992–2014 to 1992–2018 time-series. The average Mohr´s rho are shown in Figure 9.4.2.5, which indicate an underestimation of the SSB (-0.195) and R estimates (-0.244) and overestimation of F (0.245). Because of the very high uncertainty observed in the last recruitment estimate, the Mohn´s rho for recruitment is calculated without the terminal year (Figure 9.4.2.5).

The Mohn´s rho results are around the critical values (± 2) and the observed retrospectives are mostly inside the confidence bounds of the last assessment estimates.

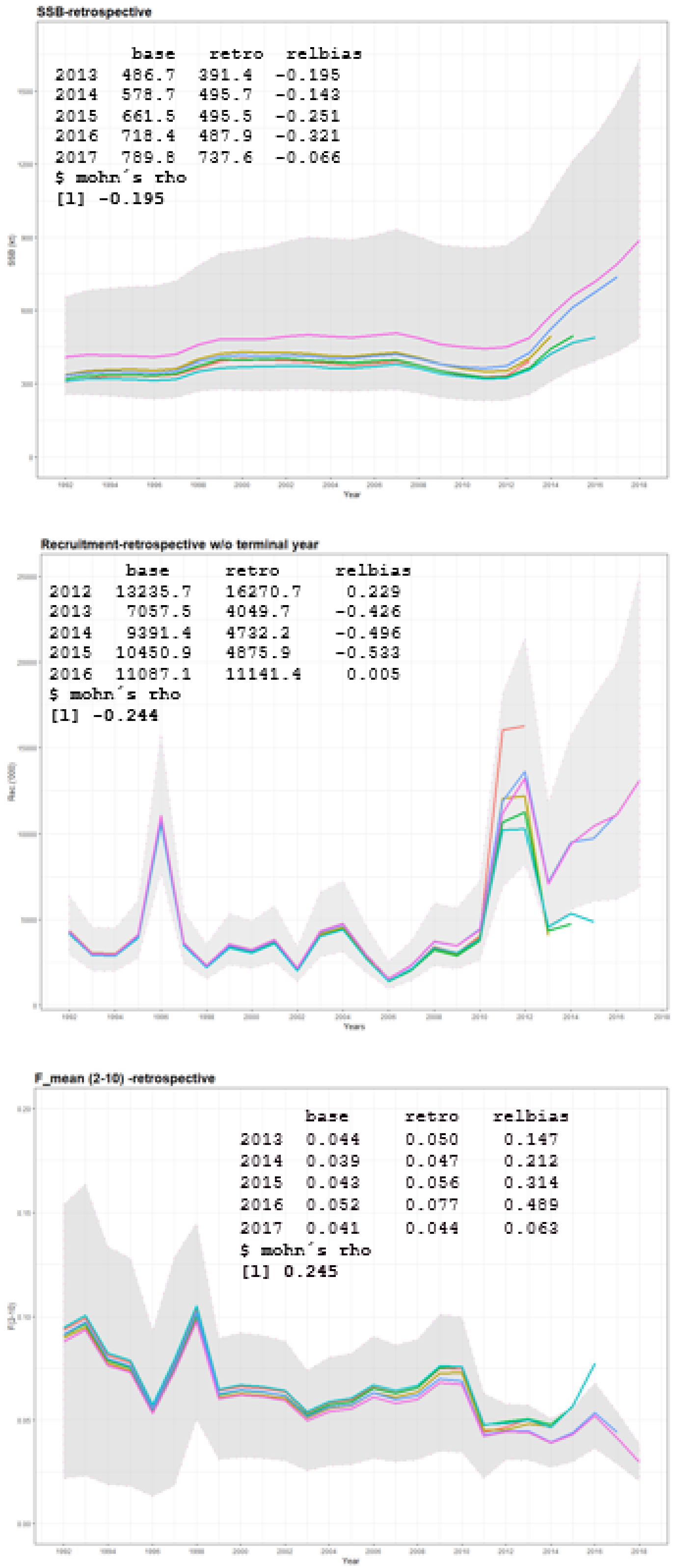


Figure 9.4.2.5. Retrospective analysis results. Trajectories of SSB, Recruitment and F_{bar} (grey=95% confidence intervals for the current assessment). The table in each graph shows the last assessment estimates (*base*) compared to each retrospective assessment (*retro*) and the relative bias in each year (*relbias*). The adopted Monh´s rho is the average of the five last year bias.

9.4.3 Sensitivity analysis

As showed in the previous section, the increasing trend and upward revision of stock abundance contributed for F being revised downward and SSB revised upwards, relatively to previous years. This retrospective pattern could be due to a combination of high proportion of catches in ages 1–2 in recent years (Table 9.3.1.2), above average weight-at-age for older individuals (Figure 9.2.5.1), and the increasing trend observed in the survey index from 2013 (Figure 9.4.2.1).

The 2013 and 2017 survey index were the highest in the time-series, which resulted in a steady and continuous increase of the fitted survey biomass index from 2013 to 2018, from which previous exploratory analysis (WGHANSA 2017) showed the contribution for the SSB retrospective pattern. Additionally, sensitivity analysis revealed that the high weight-at-age observed in older individuals increased the 2018 SSB estimation around 12% when compared to SSB estimates using a three-year average of weight-at-age.

Purse-seine catches in 2018 reached more than twice the catches from the trawl fleet and there was a significant increase in the catch proportion of age-1 in the last two years (Figures 9.2.4.2 and 9.4.2.3). Exploratory assessment trial runs were performed with an extra time block 2017–2018 in the catch selectivity (not shown). This run was evaluated with goodness of fit diagnostics, which showed an improvement in the fit to proportions-at-age. However, the added complexity of the model (number of parameters) resulted in a decrease in the AIC score when compared to the standard assessment run. The large increase of purse-seine catches when compared to the trawl fleet should be further monitored in the following years to assess for potential changes in the selectivity pattern that could accommodate the changes in the catch-at-age composition.

9.5 Short-term predictions

Deterministic short-term forecasts were carried out with R using the Fisheries Library in R (FLR) "FLAssess" and "Flash" (FLCore Version 2.6.0.20170228), following assumptions and settings agreed during the benchmark (ICES, 2017) and described in the stock annex. In short, it is assumed a constant recruitment for 2018 and 2019 corresponding to the geometric mean recruitment of the period 1992–2017 (4.692 million fish), weight-at-age in the catch and in the stock and fishing mortality of the last assessment year. The abundance-at-age-1 in 2019 are the survivors of the geometric mean recruitment assumed for 2018. The input data used for the forecasts are presented in Table 9.5.1.

Table 9.5.2 shows the management options table from the deterministic short-term forecasts. At current fishing mortality (F_{bar} of 0.029), SSB in 2019 is estimated to be 1 001 740 tonnes. Predicted SSB levels for 2020 are 1 078 220 tonnes. Although not implemented, the management options table also include the F based on the management plan (F = MP).

The forecasts are deterministic and, therefore, no estimate of uncertainty is calculated. Sources of uncertainty in the outcomes is the recruitment assumed for 2019 and 2020, the assumptions on a stable mean fishing mortality and the likely changes in the fishery selection pattern in most recent years (see Section 9.4.3).

Table 9.5.1. Southern horse mackerel. Input for the short-term forecast (2019–2018).

2019								
Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	469223	0.90	0	0.04	0.04	0.019	0.010	0.019
1	1895967	0.60	0	0.04	0.04	0.037	0.036	0.037
2	2816876	0.40	0.36	0.04	0.04	0.061	0.531	0.061
3	1521013	0.30	0.82	0.04	0.04	0.09	0.441	0.09
4	1004837	0.20	0.95	0.04	0.04	0.116	0.044	0.116
5	704206	0.15	0.97	0.04	0.04	0.145	0.033	0.145
6	440133	0.15	0.99	0.04	0.04	0.19	0.032	0.19
7	688162	0.15	1	0.04	0.04	0.24	0.048	0.24
8	480824	0.15	1	0.04	0.04	0.269	0.048	0.269
9	152941	0.15	1	0.04	0.04	0.304	0.048	0.304
10	95594	0.15	1	0.04	0.04	0.342	0.048	0.342
11	383932	0.15	1	0.04	0.04	0.444	0.048	0.444
2020								
Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	469223	0.90	0	0.04	0.04	0.019	0.010	0.019
1	.	0.60	0	0.04	0.04	0.037	0.036	0.037
2	.	0.40	0.36	0.04	0.04	0.061	0.531	0.061
3	.	0.30	0.82	0.04	0.04	0.09	0.441	0.09
4	.	0.20	0.95	0.04	0.04	0.116	0.044	0.116
5	.	0.15	0.97	0.04	0.04	0.145	0.033	0.145
6	.	0.15	0.99	0.04	0.04	0.19	0.032	0.19
7	.	0.15	1	0.04	0.04	0.24	0.048	0.24
8	.	0.15	1	0.04	0.04	0.269	0.048	0.269
9	.	0.15	1	0.04	0.04	0.304	0.048	0.304
10	.	0.15	1	0.04	0.04	0.342	0.048	0.342
11	.	0.15	1	0.04	0.04	0.444	0.048	0.444

2021								
Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	469223	0.90	0	0.04	0.04	0.019	0.010	0.019
1	.	0.60	0	0.04	0.04	0.037	0.036	0.037
2	.	0.40	0.36	0.04	0.04	0.061	0.531	0.061
3	.	0.30	0.82	0.04	0.04	0.09	0.441	0.09
4	.	0.20	0.95	0.04	0.04	0.116	0.044	0.116
5	.	0.15	0.97	0.04	0.04	0.145	0.033	0.145
6	.	0.15	0.99	0.04	0.04	0.19	0.032	0.19
7	.	0.15	1	0.04	0.04	0.24	0.048	0.24
8	.	0.15	1	0.04	0.04	0.269	0.048	0.269
9	.	0.15	1	0.04	0.04	0.304	0.048	0.304
10	.	0.15	1	0.04	0.04	0.342	0.048	0.342
11	.	0.15	1	0.04	0.04	0.345	0.048	0.345

N – number of fish; PF and PM- Proportion of F and M before spawning; Sel – Selectivity; SWt and CWt – mean weight in the stock and in the catch (in kg).

Table 9.5.2. Short-term forecast (2019–2021) for southern horse mackerel. Catch and SSB (at spawning time) in tonnes.

			2019			2020			2021
Catch option	fmult	fbar	SSB	Catch		SSB	Catch		SSB
F=0	0.0	0.00				1079518	0		1146911
	0.1	0.00				1079388	3280		1143460
	0.2	0.01				1079258	6550		1140020
	0.3	0.01				1079129	9811		1136590
	0.4	0.01				1078999	13063		1133171
	0.5	0.01				1078869	16305		1129763
	0.6	0.02				1078739	19539		1126365
	0.7	0.02				1078609	22763		1122977
	0.8	0.02				1078479	25979		1119599
	0.9	0.03				1078350	29185		1116232
Fsq	1.0	0.03	1001740	32624		1078220	32383		1112876
	1.1	0.03				1078090	35571		1109529
Fsq*1.2	1.2	0.04				1077960	38750		1106193
	1.3	0.04				1077831	41921		1102867
F = MP	1.5	0.04				1077636	46659		1097896
	1.5	0.04				1077571	48235		1096245
Fsq*1.6	1.6	0.05				1077442	51378		1092949
	1.7	0.05				1077312	54513		1089663
	1.8	0.05				1077182	57639		1086388
	1.9	0.06				1077053	60757		1083122
Fsq*2	2.0	0.06				1076923	63865		1079867
	2.1	0.06				1076793	66965		1076621
	2.2	0.06				1076664	70056		1073385
	2.3	0.07				1076534	73138		1070159
	2.4	0.07				1076405	76212		1066943
	2.5	0.07				1076275	79277		1063737
	2.6	0.08				1076146	82333		1060541
	2.7	0.08				1076016	85381		1057354
	2.8	0.08				1075887	88421		1054177
	2.9	0.09				1075757	91451		1051010
	3.0	0.09				1075628	94474		1047852
	3.1	0.09				1075498	97487		1044704
	3.2	0.09				1075369	100493		1041566
	3.3	0.10				1075240	103489		1038437
	3.4	0.10				1075110	106478		1035318
	3.5	0.10				1074981	109458		1032209
	3.6	0.11				1074851	112430		1029108
	3.7	0.11				1074722	115393		1026018
FMSY	3.8	0.11				1074657	116871		1024476
Fp.05	5.1	0.15				1072913	156017		983726
Flim	6.5	0.19				1071107	195077		943205
SSB (2021) = Blim	81.7	2.40				978471	1071481		103021
SSB (2021) = Bpa = MSY Btrigger	62.3	1.83				1001615	977149		181018

9.6 Biological reference points

Biological Reference Points for southern horse mackerel (B_{lim}, B_{pa}, MSY $B_{trigger}$, F_{lim}, F_{pa} and F_{MSY}) estimated in the 2016 Assessment Working Group (ICES, WGHANSA 2016), were approved by ICES and adopted for the development of the management plan for this stock in the PELAC October 2016 meeting (Table 9.6.1). The biological reference points were re-evaluated during the 2017 benchmark (WKPELA). However, the new estimates resulted in very similar values and it was agreed not to revise the previously accepted BRPs from both ICES and PELAC (ICES, 2017).

Table 9.6.1. Biological Reference points for southern horse mackerel. Values and the technical basis (weights in thousand tonnes).

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$	181	Lower bound (average) of 90% confidence intervals of the SSB time-series in a stock being exploited well below F_{MSY}.	ICES, 2016a
	F_{MSY}	0.11	Constrained by F_{pa} (F_{MSY}=F_{pa}). Stochastic long-term simulations using a segmented regression with breakpoint at MSY $B_{trigger}$.	ICES, 2016a
Precautionary approach	B_{lim}	103	Derived from B_{pa} and assessment uncertainty (B_{lim}= $B_{pa} \times e^{-1.645\sigma}$; σ = 0.34)	ICES, 2016a
	B_{pa}	181	MSY $B_{trigger}$	ICES, 2016a
	F_{lim}	0.19	Equilibrium scenarios with stochastic recruitment: F value corresponding to 50% probability of (SSB < B_{lim}).	ICES, 2016a
	F_{pa}	0.11	Derived from F_{lim} and assessment uncertainty (F_{pa}= $F_{lim} \times e^{-1.645\sigma}$; σ = 0.32)	ICES, 2016a

9.7 Management considerations

There has been a significant increase in purse-seine catches coupled with a steep decrease in the bottom-trawl catches in 2018. 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. Spawning–stock biomass has been above MSY $B_{trigger}$ over the whole time-series with a continuous increase in the last five years and is currently at its highest level. Recruitment since 2011 has been above the time-series average.

The basis for the advice is the same as last year: the MSY approach and gives estimated catches in 2020 of 116 871 tonnes.

ICES was requested by the EU to evaluate a long-term management strategy for this stock (ICES, 2018a). The management plan was considered by ICES to be precautionary and also that when the HCR is applied, the stock is maintained at levels that can lead to catches around MSY. ICES advised that none of the elements of the HCR are in contradiction with ensuring that the stock is fished and maintained, also in the future, at levels that can lead to MSY (ICES, 2018b). However, ICES was requested by the EU to base the advice for 2020 on the ICES MSY approach.

The catch advice for 2020 under the MSY approach represents an increase of 269% in comparison with catches observed in 2018. If the advice would be based on the MP then the increase of catches advised for 2020 in relation to actual catches in 2018 would be of 47%.

TAC for these species was not limiting in the last years due to low market value and opportunities.

10 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 seamounts 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, also bottom longline and handline fisheries catch this species, but not as a target species. 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 anglers 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 and latter limited by local regulations with conditioned daily catch limits. Despite this reduction in the landings, this fishery still has a strong impact on some fishing communities, which directly depends on the income of this fishery.

10.1 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 Macaronesia 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's 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 it is the main pelagic fish species being caught by the local (artisanal) 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.

10.2 ACOM Advice Applicable to 2019

The advice for this stock is biennial and so the 2018 advice is valid for 2019 and 2020: ICES advises that when precautionary approach is applied, catches should be no more than 878 tonnes in each of the years 2019 and 2020.

10.3 The fishery in 2018

Official landings for 2018 includes commercial landings from small purse-seiners (and other surrounding nets), landings from hooks and lines métiers, and not (many times) commercialised withdrawn fish captured with nets and used as bait on longline and handline fisheries.

As 2019 is not an assessment year and many numbers are still being analysed, the figures have not been updated with 2018 numbers. In 2020, in addition to updating the numbers for 2018 and 2019, some observers' sea sampling numbers will be presented (2018, 2019 and the first half of 2020), and all these numbers will be taken into account for next year's assessment.

10.3.1 Fishing fleets

Trachurus picturatus is mostly landed by the artisanal fleet, using purse-seines. In 2018, the fleet landings represented around 90% of total blue jack mackerel landings in the Azores. In 2018, these fleet landings accounted for about 90% of total horse mackerel landings in the 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 40 active vessels in 2018 in the small pelagic fishery. The number of vessels of each size category, for the last years is shown in Figure 1.

10.3.2 Catches

Catches of blue jack mackerel including landings, discards, and tuna bait catches and recreational catches, for the period 1978 to 2018, are presented in Table 1.

Total estimated catches of blue jack mackerel in the Azores, for the considered period in Figure 2 (2002–2017), are around 1600 tonnes; while landings, in same period, are on average 1100 tonnes. In the last three years, the average catches and landings decreased to about 1218 and 700 tonnes, respectively.

An important reduction was observed in the catches in 2016 and 2017, particularly for the fleets targeting the juveniles, such as the artisanal purse-seine fleet and the tuna baitboats fleet. A low recruitment in 2016 is apparently the cause of this reduction. In 2017, increasing catches of age 0 fish, suggesting a strong recruitment. This situation has periodically been observed in the past. In the case of the tuna fleet, catches of bait (*Trachurus picturatus*) are obviously related with tuna occurrence; years with lack of tuna will reflect small catches of bait. Concerning the longliners, the changes in the catches observed in recent years is mostly related to the practice of using the blue jack mackerel for bait, since their market price is too low and the quality as bait is high. These values increased since 2013, although are still be-low the average of the preceding ten years.

10.3.3 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 3. 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 LPUE series were updated for the small purse-seine fleet up to 2017 (Figure 4). The CPUE for the purse-seine catches of blue jack mackerel by tuna baitboat fleet (Figure 5) is available until 2015. Scaled standardized LPUE from small purse-seiners and CPUE from the baitboat tuna fishery are presented in Figure 6.

Landings of blue jack mackerel from the longliners are less representative and a considerable part of the catch is not landed, being used as bait (with negligible discards). Consequently, the LPUE for the adult stock, based on the landed fraction of blue jack mackerel caught as bycatch, was not updated.

10.3.4 Catches by length

Size frequencies for the blue jack mackerel caught in the Azores are available since 1980. In Figures 7 and 8 the size distribution of the landings (catch at size) for the years 2011 to 2017 is presented. The two main fisheries target on different size categories, the surface fleets catches the juvenile fraction of the population while the longliners target the adult stock.

10.3.5 Assessment of the state of the stock

In 2018, stock category of *Trachurus picturatus* in 10.a.2 changed from category 3 to category 5 and a precautionary buffer of 20% was applied. The reasons pointed out were that:

i. different length-based reference points were explored and none worked;

ii. stock-size indicators used (directed fishery from artisanal purse-seiners and bait for tuna fishery) target only on juveniles, thus probably are not reflecting the whole dynamics of the stock;
iii. handliners and longliners were targeting adults although they seem minor compared to purse-seiners; and
iv. no data available from tuna bait, recreational fishery and longline (bait) fisheries from 2016.

2020 will be a year of assessment for this stock and the Working Group discussed different (or complementary) approaches that should be taken into account next year assessment and even as inter-sessional work:

- Continue track of (Catch, effort) CPUE indexes of different fleets (even if they are not good indicators of stock abundance);
- Monitor catch length distributions (for any purpose, including landings or sell as live bait, bait for hooks or discards) of different fleets;
- To assess growth (von Bertalanffy) parameters of blue Jack mackerel;
- Track in time the length distribution series;
- Try length-based methods, but with some changes from what has been done in the past: for example, (i) using the longine length distribution series to verify stability in the length or age distribution; (ii) use any trends in mean length or age composition as an indicator of overall population mortality; (iii) use these series as an indicator of global (medium-term) changes in overall exploitation on the stock;
- Check whether other fisheries may or may not serve as an overall mortality indicator or as an alarm indicator if normal series variability deviates.

10.4 Management considerations

The Azores Administration, put in place in October 2014 a specific management measure (local regulations with daily catch limits) for the purse-seine fleet, mostly for regulate markets. This measure allows only 200 kg or 300 kg per vessel, per day, depending on the island. Also states that fishing and consequent landings shall also be forbidden on weekends and set quantities for withdrawn fish (Portaria n.º 66/2014 de 8 de Outubro de 2014).

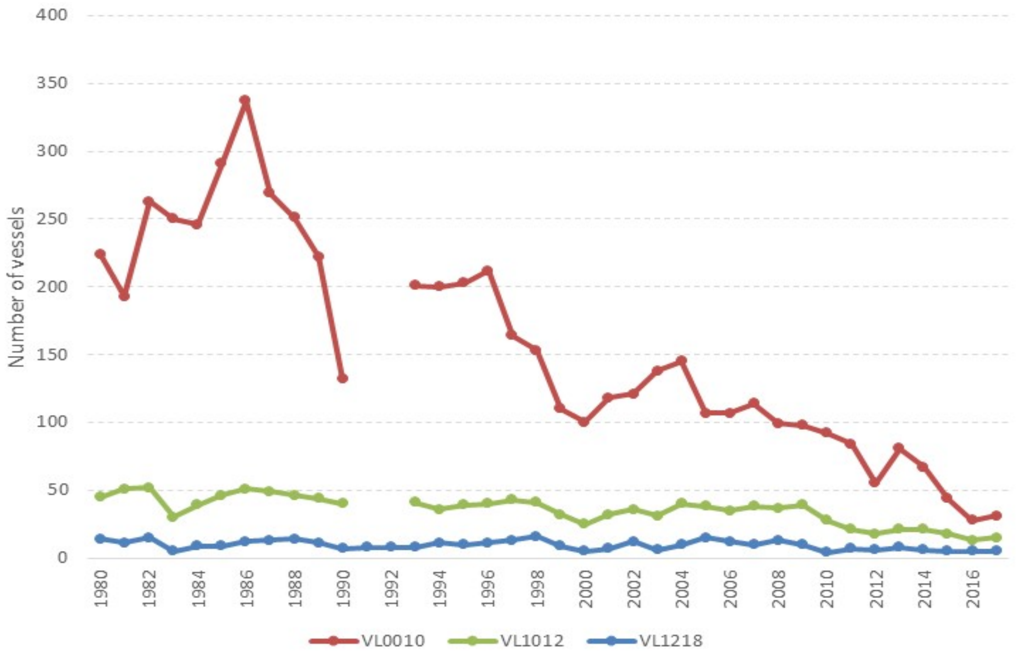


Figure 1. Number of small purse-seine vessels, by length category, of the blue jack mackerel (*T. picturatus*) fishery in the Azores (ICES Subdivision Xa2) from 1980 to 2017.

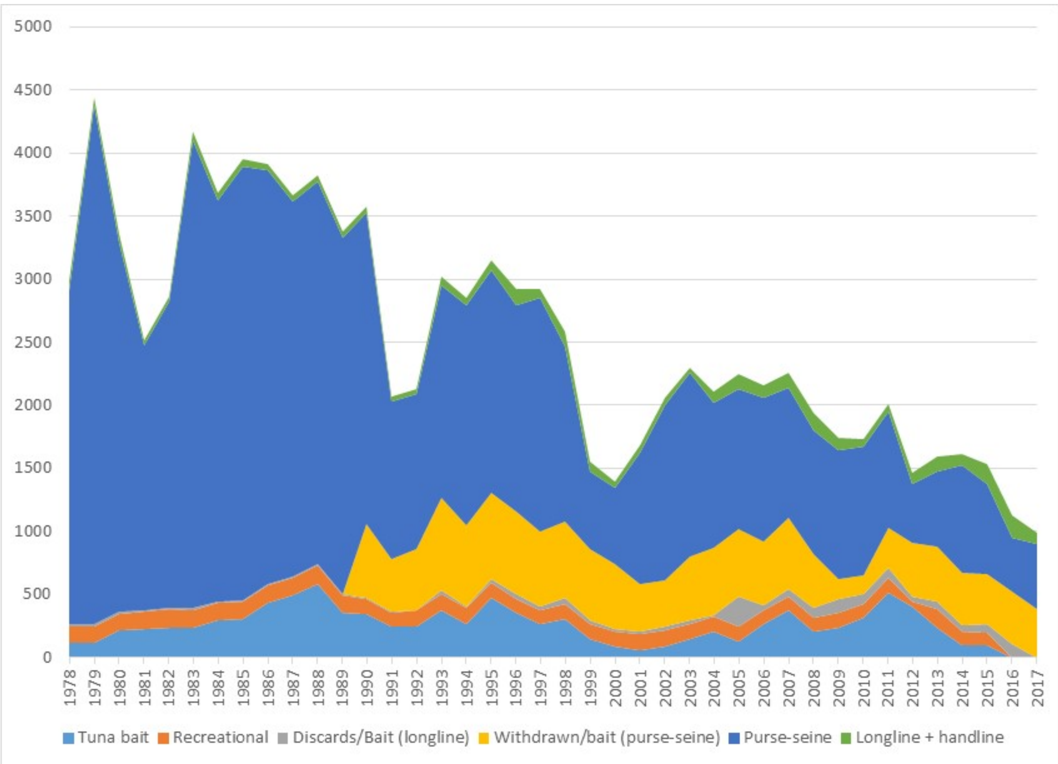


Figure 2. Estimated catches of blue jack mackerel (*T. picturatus*) in the Azores (ICES Subdivision Xa2) from 1978 to 2017.

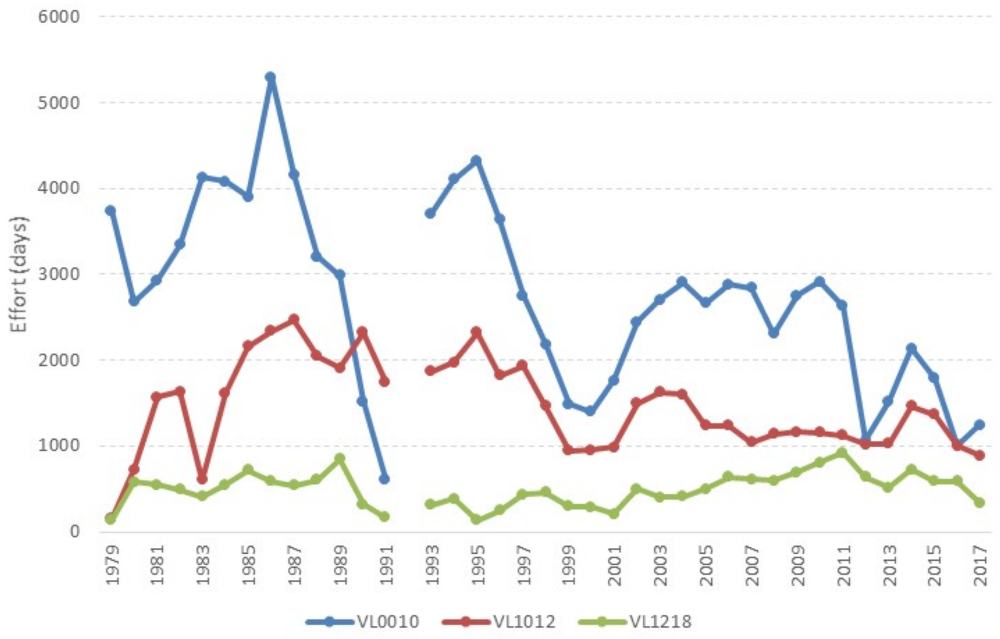


Figure 3. Nominal effort (number of days) of the purse-seine fleet, total and by vessel size category for the period 1978–2017.

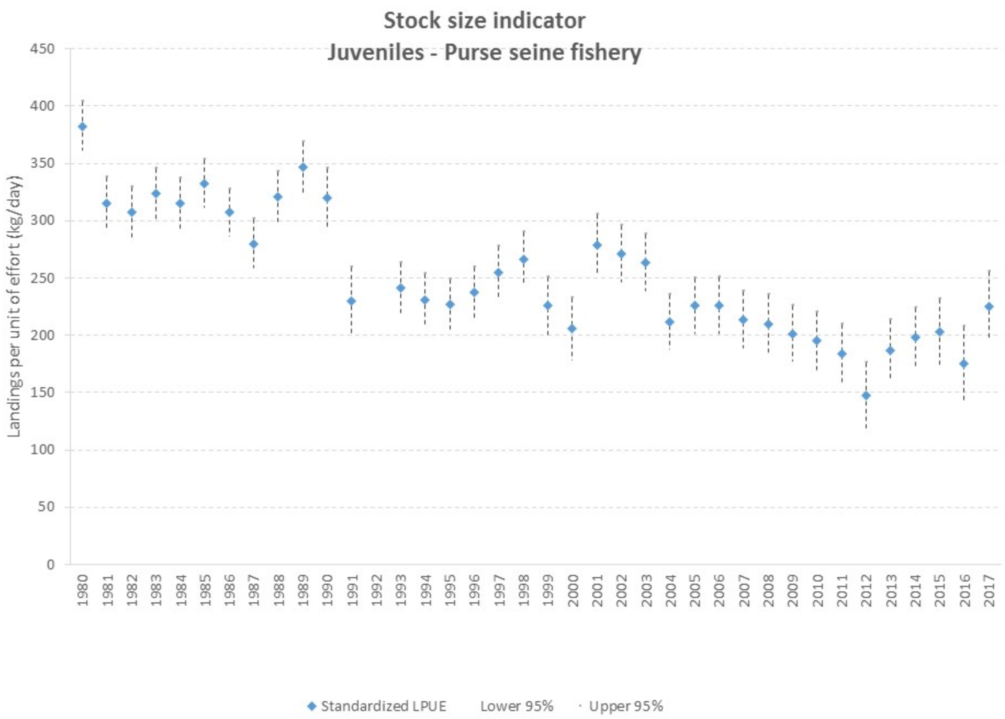


Figure 4. Standardized LPUE for blue jack mackerel from the Azores small purse-seine fishery, for the years 1980–2017. Broken lines indicate 95% confidence intervals.

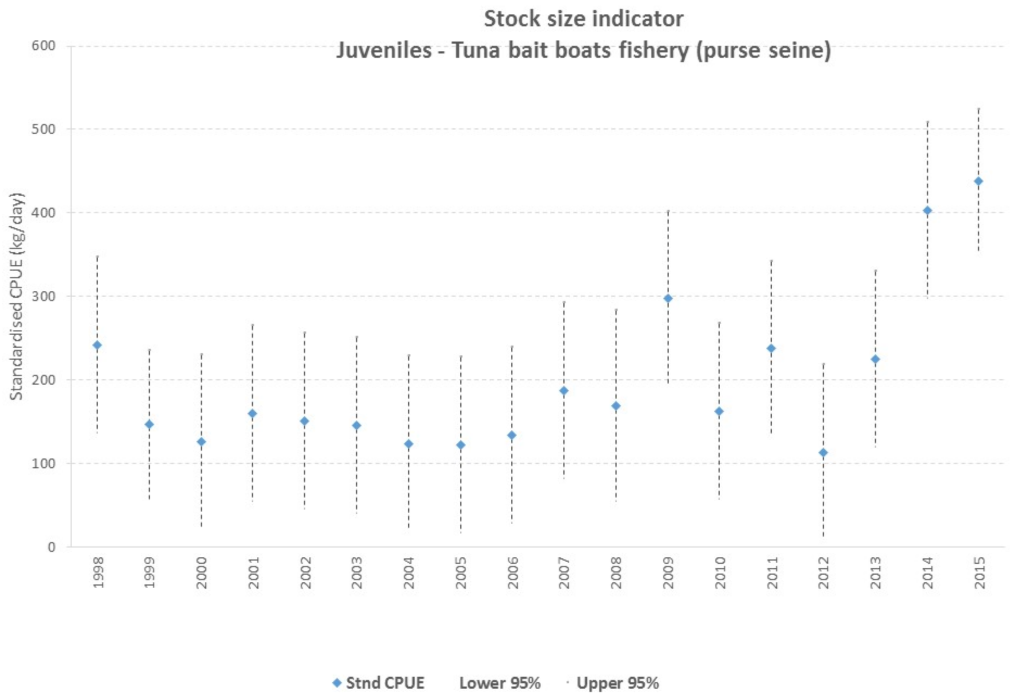


Figure 5. Standardized CPUE for blue jack mackerel from the Azorean baitboat tuna fishery, for the years 1998–2015. Broken lines indicate 95% confidence intervals.

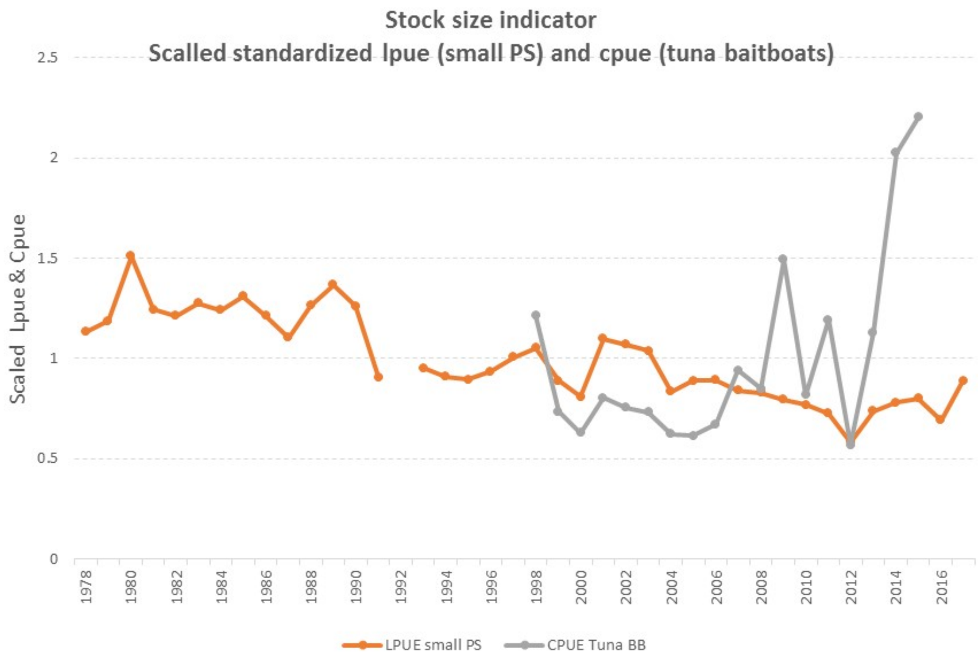


Figure 6. Scaled standardized LPUE from small purse-seiners (1978–2017) and CPUE from the baitboat tuna fishery (1998–2015), for blue jack mackerel in Azores.

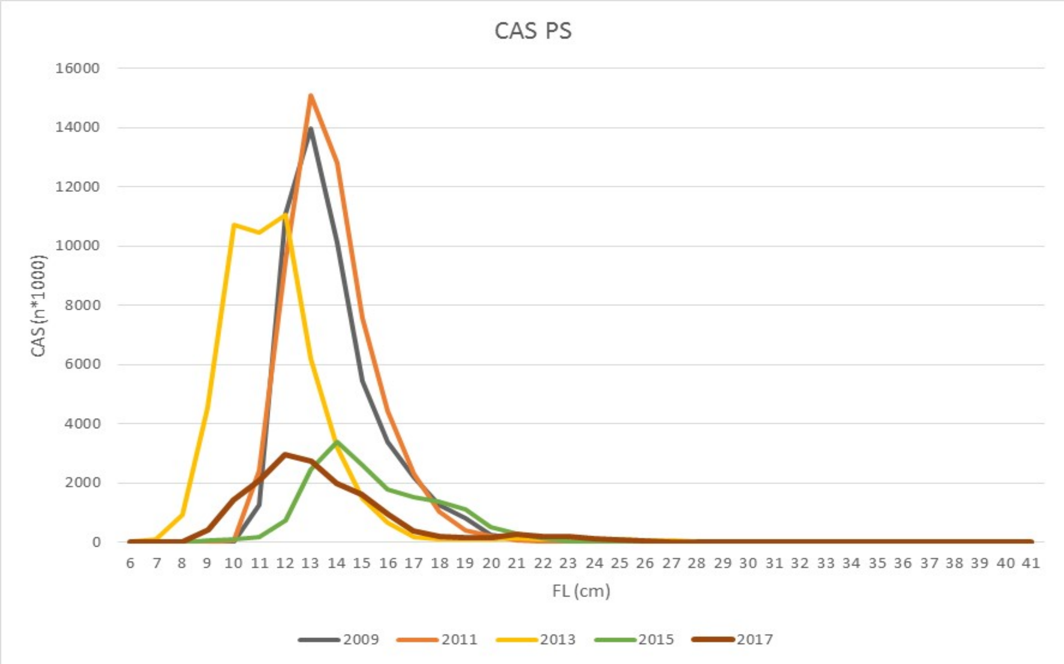


Figure 7. Annual size frequencies of the catches of blue jack mackerel (*T. picturatus*) in the Azores, from 2009 to 2017, from the surface fisheries.

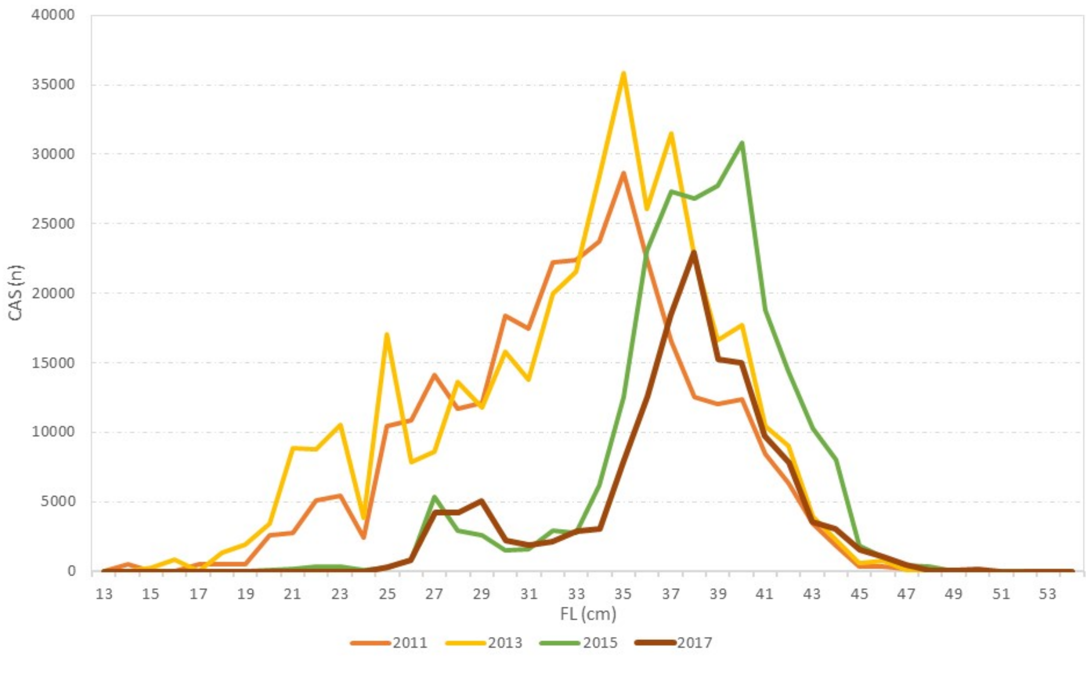


Figure 8. Annual size frequencies of the landings of blue jack mackerel (*T. picturatus*) in the Azores, from 2011 to 2017, from the longline and handline fisheries.

Table 1. Estimated catches of blue jack mackerel (*T. picturatus*) by fishery, in the Azores from 1978 to 2018.

YEAR	OFFICIAL LANDINGS			OTHER CATCH			
	PS	WITHDRAWN (PS)	LL+HAND	RECREATIONAL	RETAINED CATCH [1]	TUNA BAIT	TOTAL
1978	2657	0	78	129	15	115	2995
1979	4114	0	61	130	15	118	4439
1980	2920	0	70	132	22	210	3354
1981	2104	0	39	135	9	229	2516
1982	2429	0	43	142	10	239	2862
1983	3711	0	67	142	21	231	4172
1984	3180	0	62	135	17	295	3689
1985	3442	0	60	136	11	303	3952
1986	3282	0	58	135	9	433	3918
1987	2974	0	53	139	8	491	3666
1988	3032	0	55	143	8	586	3824
1989	2824	0	50	138	9	352	3373
1990	2472	584	48	117	11	345	3577
1991	1247	421	33	115	6	242	2064
1992	1226	486	35	121	6	249	2123
1993	1684	742	70	130	22	375	3023
1994	1745	636	59	125	18	264	2847
1995	1769	688	79	119	24	474	3153
1996	1642	656	123	110	38	351	2920
1997	1849	599	72	110	31	259	2920
1998	1387	606	120	111	52	308	2584
1999	609	565	84	119	37	141	1555
2000	602	521	53	117	23	83	1399
2001	1046	376	55	121	24	59	1681
2002	1387	371	63	132	28	82	2063
2003	1455	510	47	128	21	140	2301
2004	1148	528	98	111	19	208	2112
2005	1111	536	120	120	236	124	2247
2006	1145	501	96	111	40	264	2157
2007	1032	562	122	115	58	370	2259
2008	980	428	139	110	75	205	1937
2009	1023	157	98	119	115	230	1742
2010	1021	152	57	114	75	313	1732
2011	920	319	62	118	79	510	2008
2012	467	422	94	42	41	399	1465

[1] Retained Catch for bait for use on hooks and lines fisheries. Includes negligible discards.

YEAR	OFFICIAL LANDINGS			OTHER CATCH			
	PS	WITHDRAWN (PS)	LL+HAND	RECREATIONAL	RETAINED CATCH [1]	TUNA BAIT	TOTAL
2013	592	441	123	147	54	237	1594
2014	852	410	91	112	49	96	1610
2015	714	402	160	103	67	92	1538
2016	428	421	174	32	61	34	1193
2017	511	385	95	N/A	37	N/A	1028
2018	643	132	77	4[2]	31	N/A	887

[2] Estimation of boat recreational fishing only, anglers not included.

11 ToRs b) and c)

11.1 ToR b) Exploration of juvenile surveys

11.1 *JUVESAR/IBERAS* survey series consistency – Anchovy 9a Western Component

Two methods of examining the *JUVESAR/IBERAS* survey consistency were used for the western component of anchovy in 9a: within-survey consistency and between-survey consistency. These methods mainly follow to those adopted in the 2004 ICES Study Group on Assessment Methods Applicable to Assessment of Norwegian Spring-Spawning Herring and Blue Whiting Stocks (SGAMHBW; ICES, 2004; see also Payne *et al.*, 2009). The main conclusions of these analyses are the following:

- Length of the series: the *JUVESAR* plus one year of *IBERAS* series is still very short, with four consecutive datapoints (2015–2018). The 2018 datapoint should be considered with caution since most of the acoustic energy came from a mega-school found near Figueira da Foz, as described above, which might have overestimated total anchovy abundance. A time-series with at least 6–7 observations will not be available until 2021.
- Geographic range: anchovy recruitment areas seem to have been well covered by the surveys as they are planned, given that most of the stock is located in the 9a Central–North subdivision, the major egg densities of the western component occur in this subdivision and mean length and mean weight of the 9a anchovy stock in spring acoustic surveys is generally lower in the Gulf of Cadiz followed by the 9a Central–North subdivision, which may indicate the presence of two different recruitment areas for this species.
- Bathymetric range: 20–200 m. The distribution of anchovy close to the coast may indicate that some under-sampling of the anchovy juvenile population fraction occurs. However, the vertical echo-sounding of shallower waters than 20 m is problematic (see Gerlotto *et al*., 2000).
- Consistency analyses: the results are conditioned to the low number of datapoints (pairs) as a consequence of the shortness of the series.
  - Within-consistency:
    - No significant correlation between Age 0_y *vs* Age 1_{y+1} (Pearson r = -0.11, p = 0.92) and between Age1_y and Age2_{y+1} (Pearson r = -0.04, p = 0.73), (**Figure 10.1.1**).
  - (*Ad hoc*) Between-survey consistency:
    - Correlations between Age $0_{y,JUVESAR/IBERAS}$ *vs* Age $1_{y+1,PELAGO+PELACUS}$: the *JUVESAR/IBERAS* survey series has a significantly strong but inverse correlation with the *PELAGO+PELACUS* (Pearson r = -0.98, p = <0.0.001) **(Figures 10.1.2** and **10.1.3).**
- The results from these analyses are not yet representative enough to consider the exclusion of this survey series in the western component assessment. As described before, the 2018 estimate of the *IBERAS* survey may be over-estimated, and a time-series with at least six observations will not be available until 2021. Nevertheless, *JUVESAR/IBERAS* should not be currently used in anchovy 9a west stock assessment.

11.2 *ECOCADIZ-RECLUTAS* survey series consistency – Anchovy 9a Southern component

A first assessment of the consistency of this survey series was carried out the last year, during the first benchmark process on the anchovy stock in Division 9a (WKPELA 2018; ICES, 2018a). Two methods of examining *ECOCADIZ-RECLUTAS* survey consistency were used for anchovy in 9a S: within-survey consistency and between-survey consistency. These methods mainly follow to those adopted in the 2004 ICES Study Group on Assessment Methods Applicable to Assessment of Norwegian Spring-Spawning Herring and Blue Whiting Stocks (SGAMHBW; ICES, 2004; see also Payne *et al.*, 2009). An updating of the previous analysis of the consistency of this survey series with the available new data has been provided to this WG and documented in Ramos *et al.* (WD 2019c). The main conclusions of these analyses are the following:

- Length of the series: the series is still very short. There are four non-consecutive datapoints since 2014 (a gap in 2017). The 2018 data point should be considered with caution. A time-series with at least 6–7 observations will not be available until 2021.
- Geographic range: anchovy and sardine recruitment areas are well covered by the surveys as they are planned. Perhaps the recruitment area was almost fully covered in the 2012 survey (Age 0 estimates might be valid), but not covered in 2017.
- Bathymetric range: 20–200 m. The shallowest limit implies to assume some under-sampling of the anchovy and sardine juvenile (and adult) population fraction(s) in the central part of the Gulf. However, the vertical echo-sounding of shallower waters than 20 m is problematic (see Gerlotto *et al.*, 2000). Juveniles are commonly concentrated in coastal waters and close to the bottom with day light (like the adults). This behaviour differs from the one exhibited by Bay of Biscay anchovy juveniles as sampled in *JUVENA* surveys.
- Consistence analyses: the significance of the results is jeopardised by the very low number of datapoints (pairs) as a consequence of the shortness of the series.
    - Within-consistency:
        - High correlations between Age 0_{y} *vs* Age 1_{y+1} (but only 2 datapairs), (**Figure 10.2.1**).
        - Catch curves indicate a relative good cohort tracking (r2 >0.90) of 2012, 2013 and 2014 cohorts, the only ones that could be properly tracked with the (reliable) available data (**Figures 10.2.2** and **10.2.3**).
        - Great interannual variations in the catchability at-age as well as throughout the cohorts (the causes for such a varying *q* should be thoroughly explored).
    - (*Ad hoc*) Between-survey consistency:
        - Correlations between Age $0_{y,ECOCADIZ-R}$ *vs* Age $1_{y+1,PELAGO}$ or Age $1_{y+1,ECOCADIZ}$: some between-survey consistence, higher in the *PELAGO* spring survey series (r = 0.61; more signal of the incoming recruitment), (but only three datapairs), (**Figure 10.2.4**).
        - Correlation between Age $0_{y,ECOCADIZ-R}$ *vs* $R_{y+1,GADGET\ ASSESS}$: correlation between both indices is relatively high (r = 0.67), (but based on only three datapairs), (**Figure 10.2.5**).
- The results from these analyses, although very promising, are not yet representative enough to consider the inclusion of this surveys series in the Gadget model. As described before, there is no complete estimate in 2012 and 2017 and there are some doubts on the reliability of the 2018 estimate, and a time-series with at least six observations will not be available until 2021, when the suitability of this series for its inclusion in the assessment could be re-evaluated. WKPELA 2018 stated that the *ECOCADIZ-RECLUTAS* series

could be used in the future as a good indicator of anchovy recruitment (which is the basis of the fishery) in 9a South once a longer time-series is available.

11.3 Recruitment survey series – Sardine 8c 9a

Several acoustic survey series have been conducted during the fall in part of or the total area off the western Iberian coast. These surveys series are: (i) the SAR survey series, conducted from 1984 to 2008 (with gaps) in the Portuguese coast (9aCN, 9aCS and 9aS-Alg), occasionally including the Spanish waters of Gulf of Cádiz (9a. S-Cad), from the 12m to the 200m bathymetries, (ii) the JUVESAR survey, conducted from 2013 to 2017 in the sub-division 9aCN and part of the 9a.CS (between the 12 and 60m bathymetries) and recently (iii) the IBERAS survey series, conducted from the 20 to the 100m bathymetries in the entire western Iberian coast (9aN, 9aCN and 9aCS). These surveys have methodological differences but all of them were conducted in the main recruitment area of the sardine stock, the 9aCN sub-division. On the other hand, a different survey series has been conducted in the southern Iberian coast (9aS), the ECOCADIZ-RECLUTAS, available since 2012 with a gap in 2017. This area covers a secondary recruitment area for the species but the available data series is still short (**Table 11.3.1**).

Two methods of examining the spring acoustic survey series used in the assessment as an indicator of adult biomass (PELAGO and PELACUS) and the recruitment survey series (SAR/*JUVESAR*/*IBERAS* and ECOCADIZ-RECLUTAS) survey consistency were used for the southern sardine stock in the 8c an 9a areas: within-survey consistency and between-survey consistency. These methods mainly follow those adopted in the 2004 ICES Study Group on Assessment Methods Applicable to Assessment of Norwegian Spring-Spawning Herring and Blue Whiting Stocks (SGAMHBW; ICES, 2004; see also Payne *et al.*, 2009). The main conclusions of these analyses are the following:

◎ Geographic range: The SAR, JUVESAR and IBERAS cover the main recruitment area of the sardine stock, located in the 9aCN sub-division while the ECOCADIZ-RECLUTAS covers a secondary recruitment area which is located in the Gulf of Cadiz (9aS-Cad). The combination of the IBERAS and ECOCADIZ-RECLUTAS surveys conducted during autumn cover the entire recruitment area of the stock.

◎ Bathymetric range: The shallowest limit implies to assume some under-sampling of the sardine juvenile population fraction in the central part of the Gulf of Cadiz and in the northwestern Iberia. However, the vertical echo-sounding of waters shallower than 20 m is problematic (see Gerlotto et al., 2000). Nevertheless, during the IBERAS survey carried out in 2019, specific areas chosen on the core expected distribution area of juveniles (very shallow waters - 15-10 m), were prospected with a portable EK60 mounted on the auxiliary dinghy of the vessel. In the area covered by the dinghy only few schools were recorded. However, this can vary inter-annually, which will be further investigated.

◎ Consistency analyses:

Within-consistency:

◎ Both spring acoustic surveys that estimate sardine biomass of individuals of age 1 and older (PELACUS and PELAGO) have high inter-consistency, high significant correlations of consecutive ages from age 1 to age 7/8 years old (**Figures 11.3.1**). On the other hand, the inter-consistency of the recruitment surveys (SAR, JUVESAR) was low (**Figures 11.3.2**), which is probably explained by the fact that these surveys were designed to target recruits and do not cover the entire habitat of the adults. The survey series IBERAS and ECOCADIZ-RECLUTAS are still very short and the results are hampered by the low number of data points (pairs).

(*Ad hoc*) Between-survey consistency:

- Correlation between Age $0_{y,SAR/JUVESAR/IBERAS}$ in the 9aCN *vs* Age $1_{y+1,PELAGO+PELACUS}$: A significantly strong correlation was found with the *PELAGO+PELACUS* survey series (Pearson r = 0.90, p = <0.001) with the common area surveyed by the three available recruitment survey series, the 9a-CN area **(Figure 10.3.3).**

- Correlation between Age $0_{y,SAR/JUVESAR/IBERAS}$ in the 9aCN *vs* Age 0_y of the assessment model: For the years when acoustic surveys were used in the assessment (from 1996 to present), a significantly strong correlation was found between the recruitment estimated by autumn surveys in the 9aCN and the recruitment estimated by the assessment model for sardine (Pearson r = 0.90, p = <0.001). When considering the whole period of the autumn survey series, from 1982 to present, there was a lower but also significant correlation between recruitment estimates from the autumn surveys and the assessment model (Pearson r = 0.44, p = 0.04) **(Figures 10.3.4 and Figures 10.3.5).**

- The IBERAS and the ECOCADIZ-RECLUTAS survey series are still very short and the results are hampered by the low number of data points (pairs). In the 9aCN area, the SAR, JUVESAR and IBERAS estimates can be considered comparable, particularly the JUVESAR and IBERAS survey that, for that area, follow the same acoustic path. Results from these analyses show that autumn recruitment surveys carried out in the main recruitment area of the stock appear to be promising in estimating recruitment strength of this species, with a very high correlation with Age1 sardines estimated in the spring acoustic surveys carried out in the following year and with the recruit estimates of the assessment model. For this reason, it was decided to study the possibility of incorporating the autumn survey series in the assessment model.

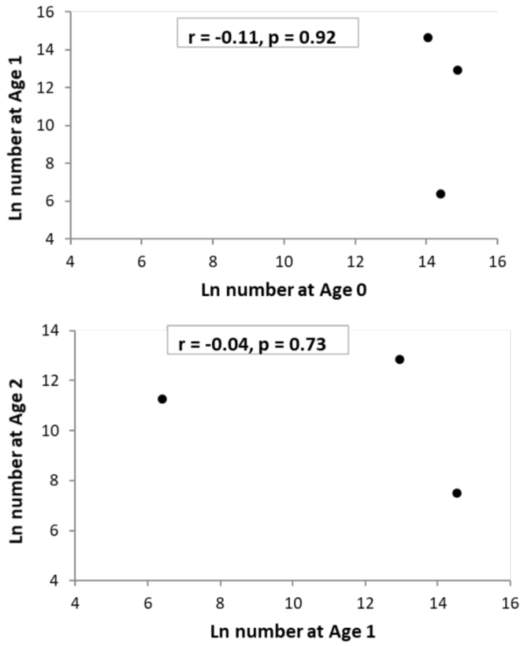


Figure 11.1.1. Anchovy in Division 9.a. Western component. Subdivision 9.a Central North. *JUVESAR* survey series (autumn Portuguese acoustic survey in Subdivision 9.a Central North, *IBERAS/JUVESAR* as from 2018). Correlation within survey. Pearson r correlation coefficient and level of significance are also shown.

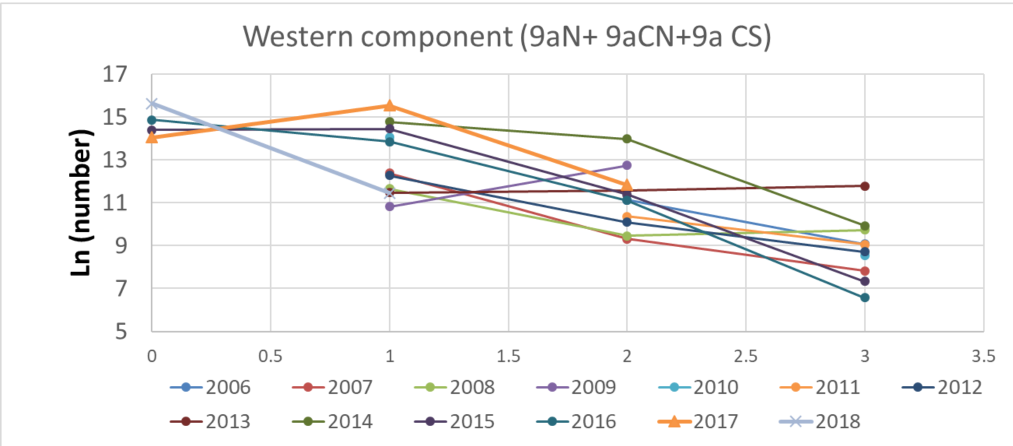


Figure 11.1.2. Anchovy in Division 9.a. Western component. Subdivisions 9.a North, Central North and Central South. *PELAGO* + *PELACUS* survey series (spring Portuguese and Spanish acoustic survey covering Subdivisions 9.a Central North, Central South and North for ages 1+ and *JUVESAR* (year-1) for age 0. Cohorts (ln(N) per age group tracked by the survey series.

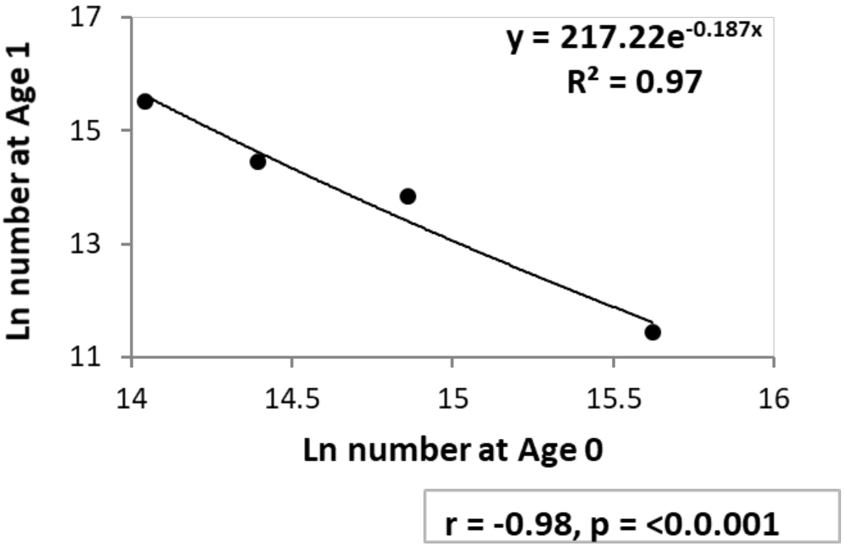


Figure 11.1.3. Anchovy in Division 9.a. Western component. Subdivisions 9.a North, Central North and Central South. *PELAGO + PELACUS* survey series (spring Portuguese and Spanish acoustic survey covering Subdivisions 9.a Central North, Central South and North for ages 1+ and *JUVESAR* (year-1) for age 0. Cohorts (ln(N) per age group tracked by the survey series. The regression coefficient and the fitted linear regression line and model are shown. Pearson r correlation coefficient and level of significance are also shown.

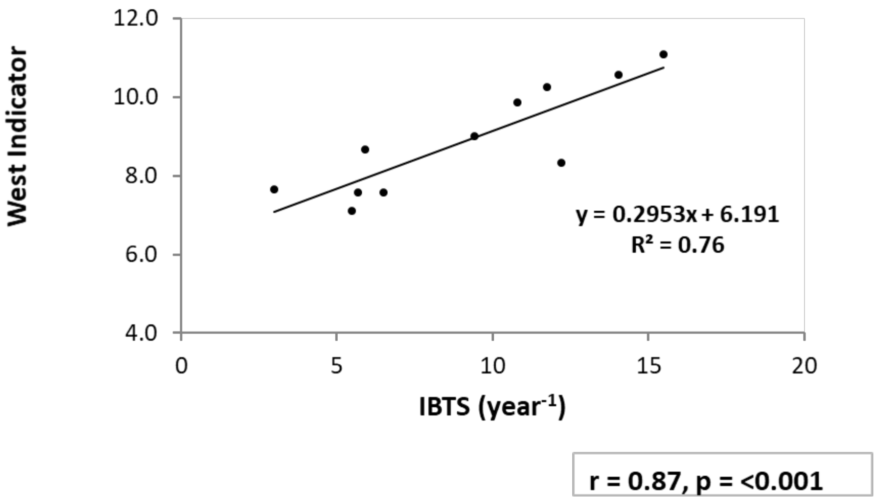


Figure 11.1.4. Anchovy in Division 9.a. Western component. Subdivision 9.a Central North and Central South IBTS survey *vs* Western stock component indicator (*PELAGO + PELACUS* survey series covering Subdivisions 9.a Central North, Central South and North).The regression coefficient and the fitted linear regression line and model are shown. Pearson r correlation coefficient and level of significance are also shown.

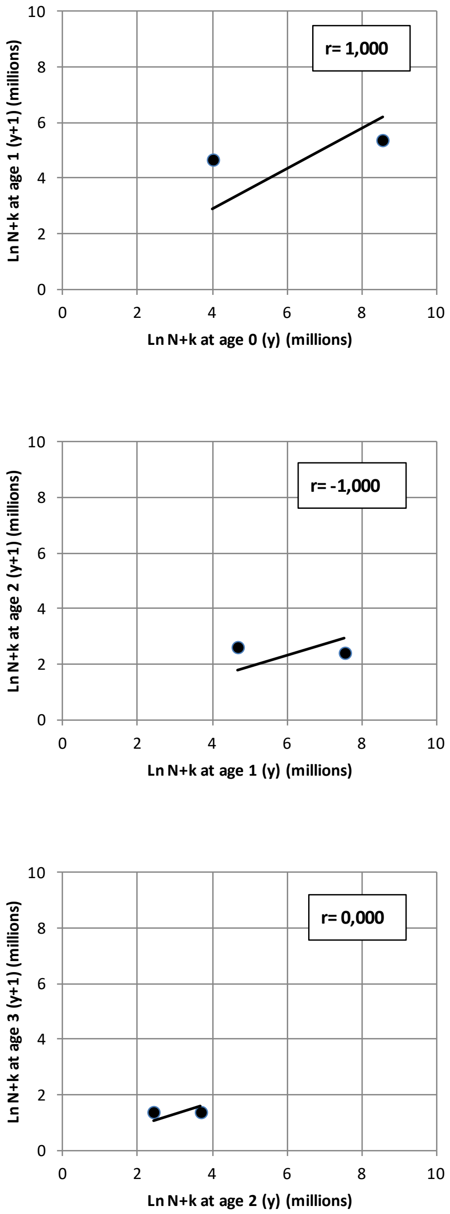


Figure 11.2.1. Anchovy in Division 9.a. Southern component. Subdivision 9.a South. *ECOCADIZ-RECLUTAS* survey series (autumn Spanish acoustic survey in Subdivision 9.a South). Correlation within survey. Pearson correlation coefficient and the fitted linear regression line (forced through the origin) are also shown.

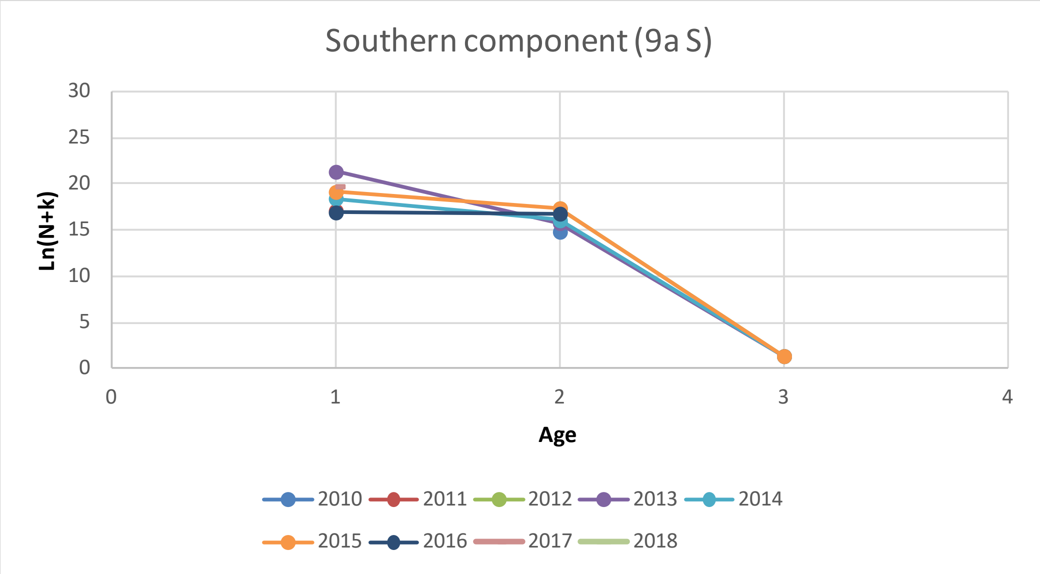


Figure 11.2.2. Anchovy in Division 9.a. Southern component. Subdivision 9.a South. *ECOCADIZ-RECLUTAS* survey series (autumn Spanish acoustic survey in Subdivision 9.a South). Cohorts (ln(N+k) per age group; k = 4 millions) tracked by the survey series.

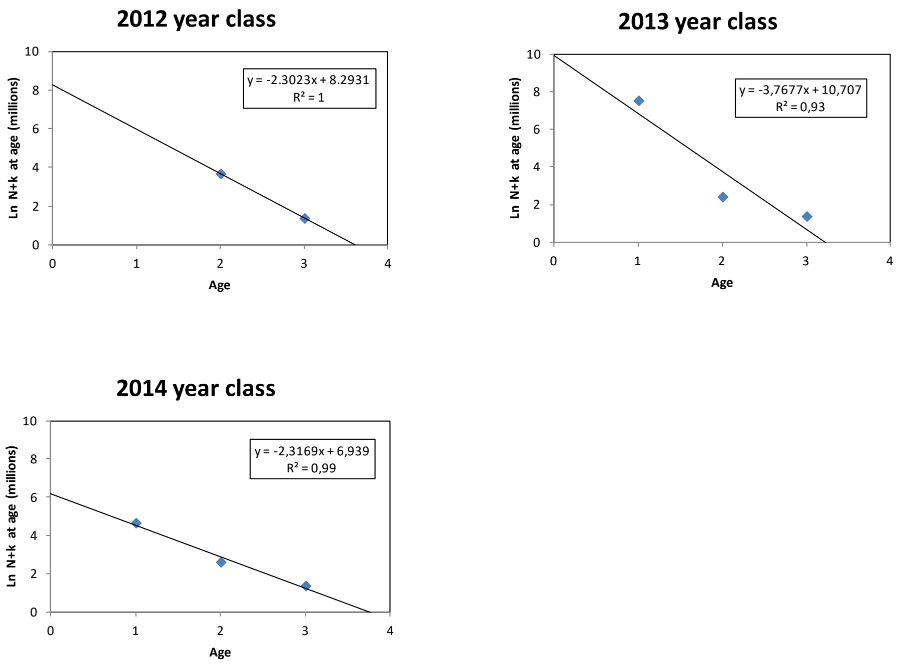
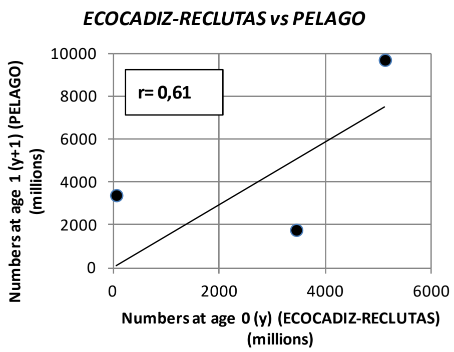


Figure 11.2.3. Anchovy in Division 9.a. Southern component. Subdivision 9.a South. *ECOCADIZ-RECLUTAS* survey series (autumn Spanish acoustic survey in Subdivision 9.a South). Catch curves by year class for anchovy in 9a South. Only those cohorts with reliable age indices are represented. The regression coefficient and the fitted linear regression line and model are also shown. Age 0 anchovies, for simplicity in the linear fitting, have not been fitted in the model and graphs (only the right limb of the catch curve is shown).



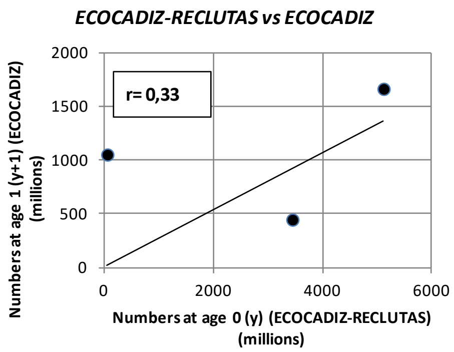


Figure 11.2.4. Anchovy in Division 9.a. Southern component. Subdivision 9.a South. *ECOCADIZ-RECLUTAS* survey series (autumn Spanish acoustic survey in Subdivision 9.a South). Correlation between Age-0 abundance index in year *y* in *ECOCADIZ-RECLUTAS* (autumn-juveniles) surveys and Age-1 abundance index in year *y*+1 in *PELAGO* (spring; top) and *ECOCADIZ* (summer, bottom) surveys. Pearson correlation coefficient and the fitted linear regression line (forced through the origin) are also shown.

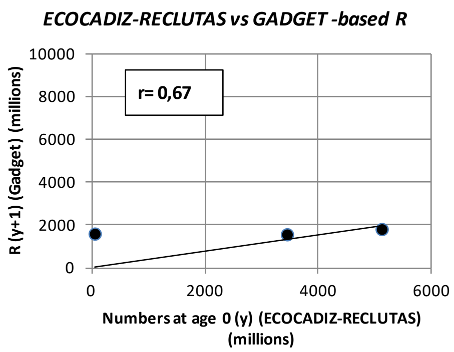


Figure 11.2.5. Anchovy in Division 9.a. Southern component. Subdivision 9.a South. *ECOCADIZ-RECLUTAS* survey series (autumn Spanish acoustic survey in Subdivision 9.a South). Correlation between Age-0 abundance index in year *y* in *ECOCADIZ-RECLUTAS* (autumn-juveniles) surveys and Recruitment in year *y+1* as estimated by the Gadget model in the 2018 assessment. Pearson correlation coefficient and the fitted linear regression line (forced through the origin) are also shown.

Table 11.3.1. Sardine in Division 8c 9a. Data available in the spring acoustic surveys (PELACUS and PELAGO) and in the recruitment surveys carried out in the fall.

years	ADULTS		RECRUITMENT SURVEYS				
	PELACUS	PELAGO	SAR-PT-AUT	SAR-PT-SUM	JUVESAR	IBERAS	ECOCADIZ-REC
1984			X				
1985			X	X			
1986	X	X	X	X			
1987	X		X	X			
1988	X	X		X			
1990	X						
1991	X						
1992	X		X				
1993	X						
1995				X			
1996	X	X		X			
1997	X	X	X				
1998	X	X	X				
1999	X	X	X				
2000	X	X	X				
2001	X	X	X				
2002	X	X					
2003	X	X	X				
2004	X			X			
2005	X	X	X				
2006	X	X	X				
2007	X	X	X				
2008	X	X	X				
2009	X	X					
2010	X	X					
2011	X	X					
2012	X						X
2013	X	X			X		
2014	X	X					X
2015	X	X			X		X
2016	X	X			X		X
2017	X	X			X		X
2018	X	X				X	X
2019	X	X				X	

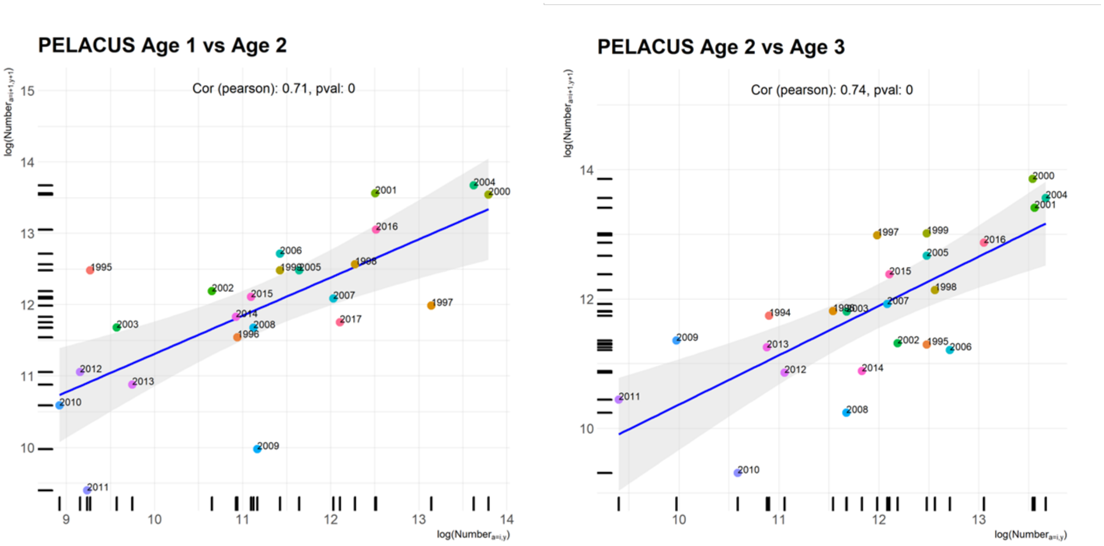


Figure 11.3.1. Sardine in Divisions 8c 9.a. Correlation between Age1 in year *y* and Age2 in year *y+1* (left panel) and Age2 in year *y* and Age3 in year *y+1* (right panel) of sardine abundance index estimated in the PELACUS survey in sub-divisions 8c and 9a. Pearson correlation coefficient and the fitted linear regression line are shown. Correlations were significant between consecutive ages until Age8 (not shown here).

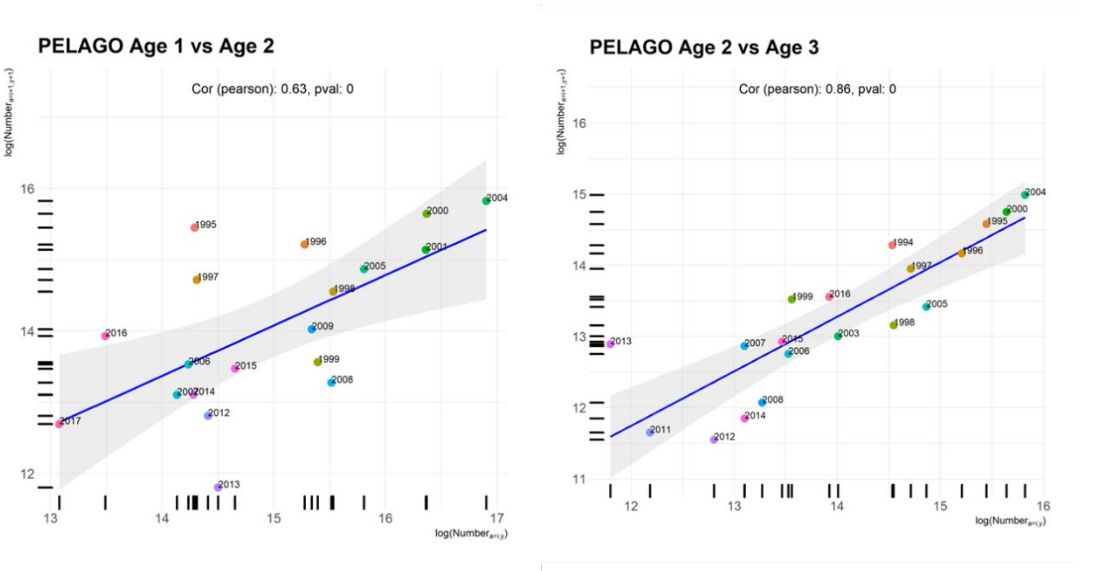


Figure 11.3.2. Sardine in Divisions 8c 9.a. Correlation between Age1 in year *y* and Age2 in year *y+1* (left panel) and Age2 in year *y* and Age3 in year *y+1* (right panel) of sardine abundance index estimated in the PELAGO survey in sub-division 9a CN, 9a CS and 9a S-alg. Pearson correlation coefficient and the fitted linear regression line are shown. Correlations were significant between consecutive ages until Age7 (not shown here).

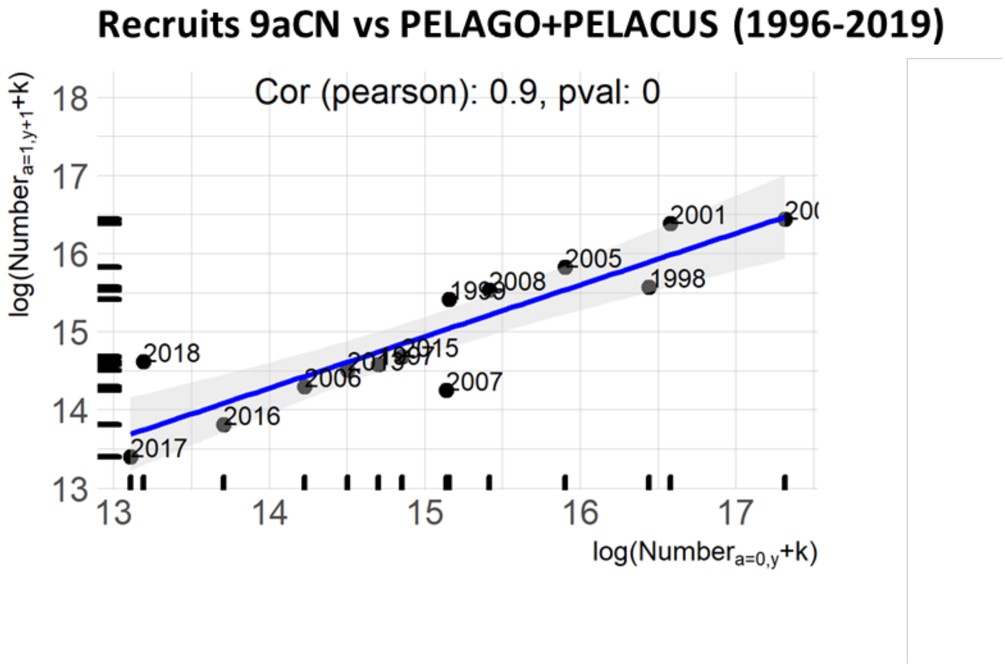


Figure 11.3.3. Sardine in Divisions 8c, 9.a. Correlation between Age-0 abundance index in year *y* in *SAR/JUVESAR/IBERAS* (autumn-juveniles) surveys in the 9a CN and Age-1 in year *y+1* index estimated by the PELACUS+PELAGO surveys. Pearson correlation coefficient and the fitted linear regression line also shown.

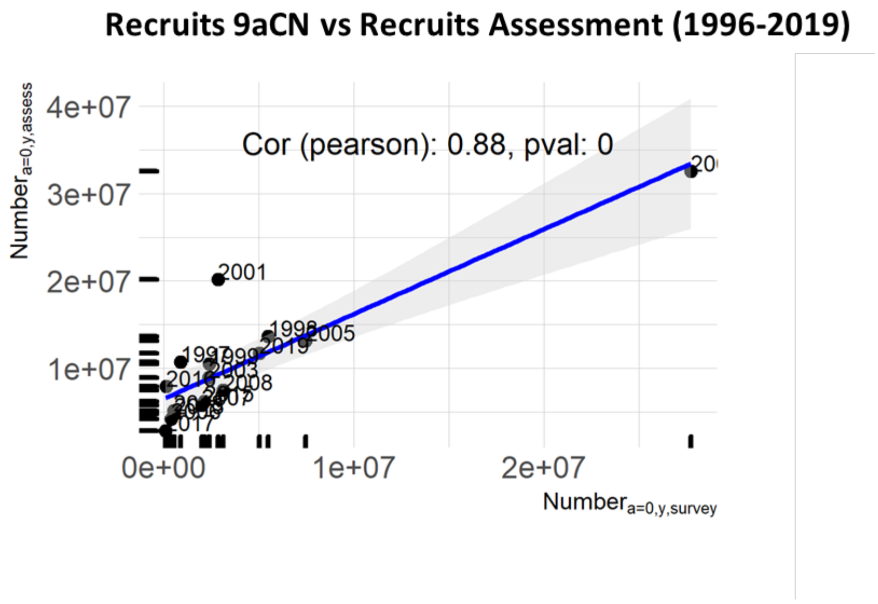


Figure 11.3.4. Sardine in Divisions 8c, 9.a. Correlation between Age-0 abundance index in year *y* in *SAR/JUVESAR/IBERAS* (autumn-juveniles) surveys in the 9a CN and Age-0 in year *y* estimated by the Stock Synthesis assessment model, from 1996 (when acoustic survey indices were incorporated in the assessment model) to present. Pearson correlation coefficient and the fitted linear regression line also shown.

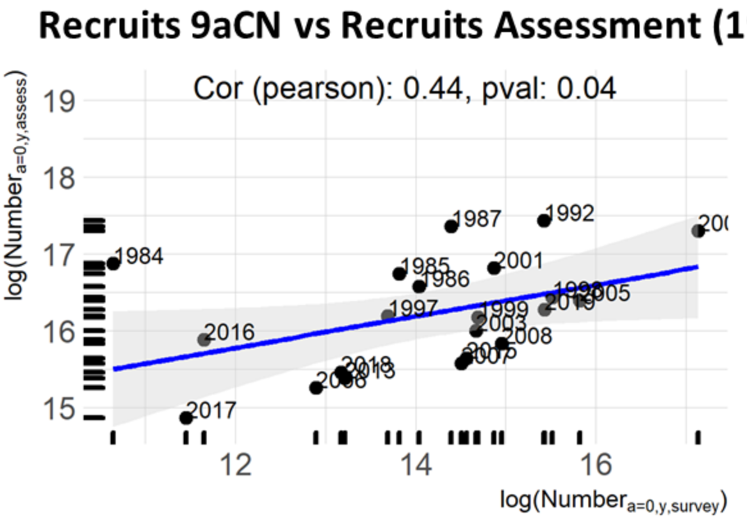


Figure 11.3.5. Sardine in Divisions 8c, 9.a. Correlation between Age-0 abundance index in year *y* in *SAR/JUVESAR/IBERAS* (autumn-juveniles) surveys in the 9a CN and Age-0 in year *y* estimated by the Stock Synthesis assessment model, from 1984 to present. Pearson correlation coefficient and the fitted linear regression line also shown.

12 ToR c) Propose geographical subdivisions within Division 8.c and Division 9.a. WGHANSA to report data and stock biomass trends for sar.27.8c9a and ane.27.9a

In 1992, WGMHSA defined subdivisions within ICES divisions 8c and 9a to report landings, catch- in numbers, mean length and mean weight. The group considered the analysis of data by subdivision as a helpful tool *"… in detecting fish migrations and distribution around the Iberian Peninsula and in understanding how these subdivisions relate to the more northern divisions*." Six subdivisions were defined: VIIIc east: 2º–7.5ºW; VIIIc west: 7.5º–11º W; IXa north: 41.5º–43ºN; IXa central-north: 40º–41.5ºN; IXa central-south: 38º–40ºN; IXa-south: 36º–38ºN.

The initial six subdivisions later became seven when sardine catch data from the Gulf of Cadiz fishery were compiled (Porteiro *et al*., 1996; ICES, 2000) splitting subdivision of IXa south into IXa south-Algarve (off the Portuguese coast) and IXa south-Cadiz (off the Spanish coast, (Figure 1). These subdivisions, with small shifts of some limits (e.g. between IXa-North and IXa-Central North shifted to the Spanish-Portuguese border), have been used since 1991 as geographical strata to report catch biomass and to estimate catch and weight-at-length/age for the assessments. The delimitation is supported by Sousa *et al*. (2015) based on topographic/oceanographic characteristics and demersal assemblages.

Results from acoustic surveys to assess sardine and anchovy stocks were kept on a division/country basis until 1985 (ICES, 1996). In the late 1980s, smaller areas were also defined for acoustic estimation within Subarea 8c and Division 9a based on the patterns of fish distribution and on topographic and environmental continuity. The eastern limit of survey area 8c.west and the southern limit of area 9a.central-south do not match the subdivisions defined for catch data. For the remaining areas, limits of survey and catch areas are the same.

WGHANSA considers it is useful to continue to report catch and survey data by subdivision to track changes in fish and fisheries distribution, biology and connectivity at scales finer than the whole 8c or 9a divisons. The group proposes that ICES recognises two subdivisions with Divison 9a: 9a.west, from the northern limit of Division 9a (latitude 43 00'ºN) to Cape S. Vicente off the Portuguese waters and Subdivision 9a.south, from Cape S. Vicente to the southeastern limit of Division 9a (5º36'W) in the Strait of Gibraltar (Table 12.1; Figure 12.1). These subdivisions are relevant for anchovy 9a advice, for which two stock components were recognised in areas 9a.west and 9a.south. In addition, the group proposes that the following areas are considered within Subarea 8c and Division 9a.

Table 12.1. Coordinates of geographical subdivisions and areas within ICES divisions 8c and 9a.

ICES subdivision	Area	Coordinates of limits
8c	8c.east	2º00' W–7º00' W
	8c.west	7º00´ W–10º00´ W
9a.west	9a.north	42º 00' N–43º 00 ' N
	9a.central-north	39º 30' N–42º 00' N
	9a.central.south	Oblique line from {37º 01.8'N, 9º00´W} to {36º 48.3'N, 9º16.9' W}–39º 30' N
9a.south	9a.south-Portugal	Oblique line from {37º 01.8'N, 9º00´W} to {36º 48.3'N, 9º16.9' W}–7º 23.5' W
	9a.south-Spain	7º 23.5' Wº–5º 36' W

Finally, it is not justifiable to change the limits of survey or fisheries areas in order to have a perfect match as differences are small and comparisons may be made without major bias.

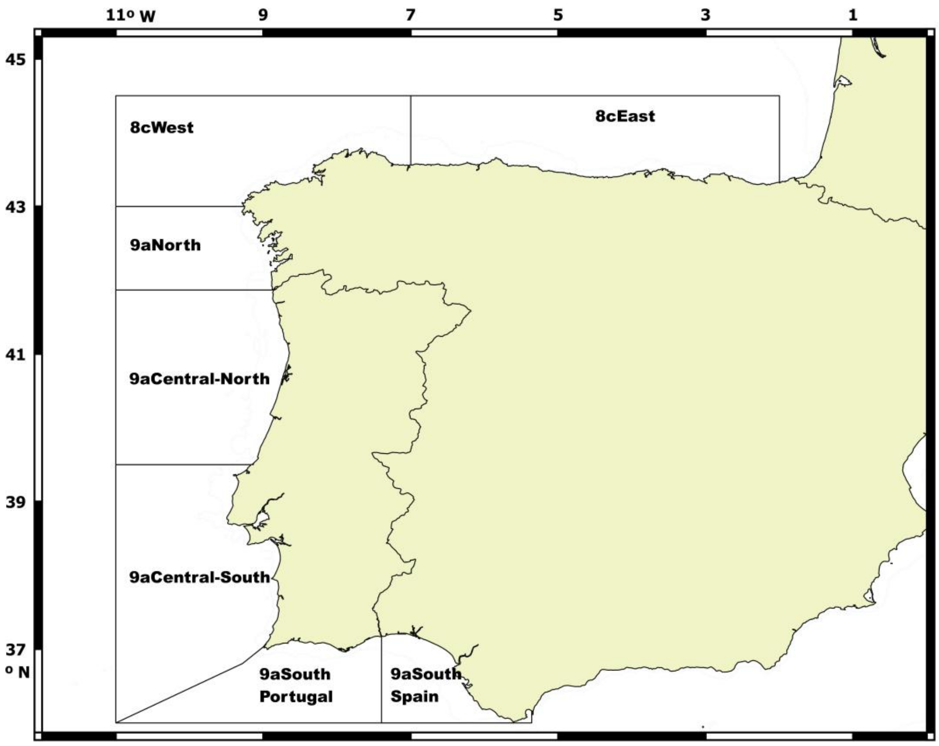


Figure 12.1. Map of geographical subdivisions and areas within ICES divisions 8c and 9a.

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Annex 1: List of participants

Name	Address	Country	E-mail
Gersom Costas	Instituto Español de Oceanografía Centro Oceanográfico de Vigo	Spain	gersom.costas@ieo.es
Ruth Fernandez	International Council for the Exploration of the Seas	Denmark	Ruth.fernandez@ices.dk
Susana Garrido	Portuguese Institute for the Sea and the Atmosphere (IPMA)	Portugal	susana.garrido@ipma.pt
Leire Ibaibarriaga	AZTI Sukarrieta	Spain	libaibarriaga@azti.es
Ursula Krampe Observer	DGMare	Belgium	Ursula.Krampe@ec.europa.eu
Hugo Mendes	Portuguese Institute for the Sea and the Atmosphere-IPMA	Portugal	hmendes@ipma.pt
Rosana Ourens	Centre for Environment, Fisheries and Aquaculture Science	UK	rosana.ourens@cefas.co.uk
Lionel Pawlowski	Ifremer-Lorient Station	France	lionel.pawlowski@ifremer.fr
Fernando Ramos	Instituto Español de Oceanografía-IEO Cádiz	Spain	fernando.ramos@cd.ieo.es
Margarita Rincón Hidalgo	Institut de Ciències del Mar-CSIC	Spain	mmrinconh@gmail.com margarita.rincon@csic.es
Maria Santos	AZTI Tecnalia	Spain	msantos@azti.es
Alexandra (Xana) Silva Chair	Portuguese Institute for the Sea and the Atmosphere-IPMA	Portugal	asilva@ipma.pt
Andrés Uriarte	AZTI Tecnalia	Spain	auriarte@azti.es
Laura Wise	Portuguese Institute for the Sea and the Atmosphere-IPMA	Portugal	lwise@ipma.pt

Annex 2: Working Documents

The following working documents were presented to WGHANSA 2019 and are presented in full in Annex 2:

WD1: Updated Gadget for anchovy 9a South: Model description and results to provide catch advice and reference points (WGHANSA 2018) (Version 2). Margarita María Rincón, Fernando Ramos, Andrés Uriarte, Leire Ibaibarriaga, Susana Garrido, Alexandra Silva.

WD2: On the need of an InterBenchmark for Sardine 8abd: Outlining main issues to be covered and preliminary analysis. Lionel Pawlowski, Andrés Uriarte, Leire Citores, Gael Lavialle, Erwan Duhamel, Leire Ibaibarriaga.

WD3: Updated Gadget for anchovy 9a South: Model description and results to provide catch advice and reference points (WGHANSA-1 2019). Margarita María Rincón, Fernando Ramos, Andrés Uriarte, Leire Ibaibarriaga, Susana Garrido, Alexandra Silva.

WD4: Analysis of the consistency of the *ECOCADIZ-RECLUTAS* survey series. Fernando Ramos, Alexandra Silva, Margarita Rincón, Susana Garrido.

WD5: Acoustic assessment and distribution of the main pelagic fish species in ICES Subdivision 9a South during the *ECOCADIZ 2018-07* Spanish survey (July–August 2018). Fernando Ramos, Jorge Tornero, Paz Jiménez, Paz Díaz, Jesús Gago, Andrés de la Cruz, Ricardo Sánchez-Leal.

WD6: Acoustic assessment and distribution of the main pelagic fish species in ICES Subdivision 9a South during the *ECOCADIZ 2018-10* Spanish survey (October 2017). Fernando Ramos, Pablo Carrera, Jorge Tornero, Pilar Córdoba.

WD7: Report of the Age Calibration Exercise Analysis for Anchovy in Division 9a (IBERAS survey 2018) – IEO-IPMA Readers. Begoña Villamor, Susana Garrido, Pablo Carrera, Ana Antolinez, Clara Dueñas-Liaño, Eduardo Soares.

Updated Gadget for anchovy 9a South: Model description and results to provide catch advice and reference points (WGHANSA 2018) (Version 2)

Margarita María Rincón[a,*], Fernando Ramos[b], Andrés Uriarte[c], Leire Ibaibarriaga[c], Susana Garrido[d], Alexandra Silva[d]

[a]*Department of Coastal Ecology and Management, Instituto de Ciencias Marinas de Andalucía, Consejo Superior de Investigaciones Científicas, Avda República Saharaui 2, 11519 Puerto Real, Cádiz, Spain*
[b]*Instituto Español de Oceanografía, Centro Oceanográfico de Cádiz, Puerto pesquero, Muelle de Levante s/n, Apdo. 2609, 11006 Cádiz, Spain*
[c]*Azti-Tecnalia, Herrera Kaia-Portu aldea z/g, E-20110 Pasaia, Gipuzkoa, Basque Country, Spain*
[d]*Instituto Portugues do Mar e da Atmosfera-IPMA, Av. Brasília, 6, 1449-006 Lisboa, Portugal*

1. Introduction

The model specifications and estimates presented below correspond to the same model implementation used in Rincón el al. WD 2018 to provide catch advice and reference points in 2018 but it differs mainly in the biomass and abundance estimation of individuals of age 1 and older (B_{1+}) (Figures 13 and 14). In the present document, the estimated value of B_{1+} at the time of the advice (the end of the second quarter of each year), is corrected by removing age 0 individuals. These age 0 individuals enters in the model to the population in quarter two due to technical reasons but they really correspond to the next quarter (see section 2.3 below). The sections where something have been modified in comparison with Rincón el al. WD 2018 are listed below and the differences are described in detail:

- Subsection 2.2 **Observation model**: In table 2.2, age-length key of the PELAGO acoustic survey for year 2017 was available but was not included in the model. Then the timespan for this data set should be 2014-2016 instead of 2014-2017.
- Section 3 **Remarkable model assumptions**: An item has been included to explain how recruitment dynamics are assimilated by the model
- Subsection 6.3 **Abundance, recruitment and Fishing mortality**: Figures of this section were modified removing age 0 individuals from biomass and abundance estimates for the end of the second quarter of each year.
- Section 7 **Catch advice for July 2018 to June 2019**: This has been reformulated according to the adjusted biomass values.
- Section 8 **Reference points**: Reference points were calculated using the adjusted biomass values.

*Corresponding author
Email addresses: margarita.rincon@icman.csic.es (Margarita María Rincón), fernando.ramos@cd.ieo.es (Fernando Ramos)

2. Model Description

Gadget is an age-length-structured model that integrates different sources of information in order to produce a diagnose of the stock dynamics. It works making forward simulations and minimizing an objective (negative log-likelihood) function that measures the difference between the model and data, the discrepancy is presented as a likelihood score for each time period and model component.

The general Gadget model description and all the options available can be found in Gadget manual (Begley, 2004) and some specific examples can be found in Taylor et al. (2007), Elvarsson et al. (2014) and WKICEMSE assessment for Ling (Elvarsson, 2017). The latest was used as a guide for this document.

The Gadget model implementation consists in three parts, a simulation of biological dynamics of the population (simulation model), a fitting of the model to observed data using a weighted log-likelihood function (observation model) and the optimization of the parameters using different iterative algorithms.

A list of the symbols used is presented in Table 2 and a graph with the Gadget model structure benchmarked in WKPELA 2018 is available at `http://prezi.com/j8rinhq5kstg/?utm_campaign=share&utm_medium=copy`.

2.1. Simulation model

The model consists of one stock component of anchovy (*Engraulis encrasicolus*) in the ICES subdivision, 9.a South-Atlantic Iberian waters, Gulf of Cádiz. Gadget works by keeping track of the number of individuals, $N_{a,l,y,t}$, at age $a = 0, \ldots, 3$, at length $l = 3, 3.5, 4, 4.5, \ldots, 22$, at year $y = 1989, \ldots, 2018$, and each year divided into quarters $t = 1, \ldots, 4$.. The last time step of a year involves increasing the age by one year, except for the last age group, which its age remains unchanged and the age group next to is added to it, like a 'plus group' including all ages from the oldest age onwards (Taylor et al., 2007).

Growth

The growth function is a simplified version of the Von Bertalanffy growth equation, defined in Begley (2004) as the LengthVBSimple Growth Function (*lengthvbsimple*). Length increase for each length group of the stock is given by the equation below:

$$\Delta l = (l_\infty - l)(1 - e^{k\Delta t}), \tag{1}$$

where Δt is the length of the timestep, $l_\infty = 19\ cm$ (fixed) is the terminal length and k is the growth rate parameter.

The corresponding increase in weight (in Kg) of the stock is given by:

$$\Delta w = a((l + \Delta l)^b - l^b), \tag{2}$$

with $a = 3.128958e^{-6}$ and $b = 3.277667619$ set as fixed and extracted from all the samples available in third and fourth quarters from 2003 to 2017. The growth functions described above calculate the mean growth for the stock within the model. In a second step the growth is translated into a beta-binomial distribution of actual growths around that mean with parameters β and n. The first is fitted by the model as described in Taylor et al. (2007) and the second represents the number of length classes that an individual is allowed to grow in a quarter and it is fixed and equal to 5.

Initial abundance and recruitment

Stock population in numbers at the starting point of the simulation is defined as:

$$N_{a,l,1,1} = 10000\nu_a q_{a,l}, \quad a = 0,\ldots,3, l = 3,\ldots,20$$

Where ν_a is an age factor to be calculated by the model and $q_{a,l}$ is the proportion at lengthgroup l that is determined by a normal density with a specified mean length and standard deviation for each age group. Mean length at age (μ_a) and its standard deviation (σ_a) were extracted from all the data available from 1989 to 2018 including three surveys that are not included in the model: ARSA, ECOCADIZ-RECLUTAS and SAR survey (See table 2). The mean weight at age for this initial population is calculated by multiplying a reference weight corresponding to the length by a relative condition factor assumed as 1. This reference weight at length was calculated using the formula $w = al^b$, with a and b as defined before. In Gadget files this was specified as a normal condition distribution (*Normalcondfile*).

Similarly to the process of calculate the initial abundance described above, the recruitment specifies how the stock will be renewed. Recruits enter to the age 0 population at quarters 2, 3, 4 (because of the Gadget order of calculations for each time step this is equivalent to have recruitment one quarter later, i.e. in quarters 3,4 and 1 of the next year) of all years, respectively, as follows:

$$N_{0,l,y,t} = p_{l,t}R_{y,t}, \quad t = 2,3,4, l = 3,\ldots,15,$$

where $R_{y,t}$ represents recruitment at year y and quarter t, and $p_{l,t}$ the proportion in lengthgroup l that is recruited at quarter t which is sampled from a normal density with mean (μ) and standard deviation (σ_t) calculated by the model. The mean weight for these recruits is calculated by multiplying the reference weight corresponding to the length by a relative condition factor assumed as 1. Reference weight at age was the same used to calculate the initial population mean weight at age explained above. In Gadget files this was specified also as a normal condition distribution (*Normalcondfile*).

Fleet operations

In the model the fleets act as predators. There are three fleets inside the model: two for surveys (ECOCADIZ acoustic survey and PELAGO acoustic survey) and one for commercial landings including all fleets: Spanish purse-seine, trawlers, Portuguese purse-seine, and others. The main fleet is Spanish purse-seine representing more than a 90 % of all the catches from 2001 to 2016 and more than a 80 % from 1989 to 2000. It is also the only fleet with a lenght distribution available, then we decide to include all commercial reported data in the same fleet which is mostly the Spanish purse-seine.

Surveys fleets are assumed to remove 1 Kg in each of the quarters when the surveys take place while the commercial fleet is assumed to remove the reported number of individuals each quarter. This total amount of biomass (for the surveys) or numbers (for the commercial fleet) landed is then split between the length groups according to the equations 3 and 4 respectively, as follows:

$$C_{l,y,t} = \frac{E_{y,t} S_{l,T} N_{l,y,t} W_l}{\sum_l S_{l,T} N_{l,y,t} W_l}, \tag{3}$$

and

$$C_{l,y,t} = \frac{E_{y,t} S_{l,T} N_{l,y,t}}{\sum_l S_{l,T} N_{l,y,t}}, \tag{4}$$

where $E_{y,t}$ represents biomass landed (in Kg) at year y and quarter t in equation 3 and numbers landed in equation 4, W_l corresponds to weight at length and $S_{l,T}$ represents the suitability function that determines the proportion of prey of length l that the fleet is willing to consume during period $T, T = 1, 2, 3$ where $T = 1$ corresponds to the period 1989-2000, $T = 2$ to 2001-2018 and $T = 3$ to 1989-2018.

For this model the suitability function chosen for the fleet and surveys is specified in Gadget manual as an ExponentialL50 function (*expsuitfuncl50*), and it is defined as follows:

$$S_{l,T} = \frac{1}{1 + e^{\alpha_T (l - l_{50,T})}} \tag{5}$$

where $l_{50,T}$ is the length of the prey with a 50% probability of predation during period T and α_T a parameter related to the shape of the function, both parameters are estimated from the data within the Gadget model. The whole model time period (1989-2018) has been splited into two different periods for suitability parameters of the commercial fleet because of changes in size regulation for the fishery around 1995 that become effective around 2001.

2.2. Observation model

Data are assimilated by Gadget using a weighted log-likelihood function. The model uses as likelihood components three biomass survey indices: ECOCADIZ acoustic survey and PELAGO acoustic survey; age - length keys from the commercial fleet (Spanish purse-seine), PELAGO survey and the ECOCADIZ survey; and length distributions for the commercial fleet, PELAGO and ECOCADIZ surveys (see Table 2.2 for a detailed description of the likelihood data used in the model).

Biomass Survey indices

The survey indices are defined as the total biomass of fish caught in a survey. The survey index is compared to the modelled abundance using a log linear regression with slope equal to 1 (*fixedslopeloglinearfit*), as follows:

$$\ell = \sum_t (\log(I_{y,t}) - (\alpha + \log(N_{y,t}))^2 \tag{6}$$

where $I_{y,t}$ is the observed survey index at year y and quarter t and $N_{y,t}$ is the corresponding population abundance calculated within the model. Note that the intercept of the log-linear regression, $\alpha = \log(q)$, with q as the catchability of the fleet (i.e $I_{y,t} = qN_{y,t}$).

Catch distribution

Age-length distributions are compared using l lengthgroup at age a and time-step y, t for both, commercial and survey fleets with a sum of squares likelihood function (*sumofsquares*):

$$\ell = \sum_{y} \sum_{t} \sum_{l} (P_{a,l,y,t} - \pi_{a,l,y,t})^2 \tag{7}$$

where $P_{a,l,t,y}$ is the proportion of the data sample for that time/age/length combination, while $\pi_{a,l,t,y}$ is the proportion of the model sample for the same combination, as follows:

$$P_{a,l,t,y} = \frac{O_{a,l,y,t}}{\sum_{a} \sum_{l} O_{a,l,y,t}} \tag{8}$$

and

$$\pi_{a,l,t,y} = \frac{N_{a,l,y,t}}{\sum_{a} \sum_{l} N_{a,l,y,t}}, \tag{9}$$

where $O_{a,l,y,t}$ corresponds to observed data.

When only length or age distribution is available. It is compared using equation 7 described above but considering all ages or all lengths, respectively.

Understocking

If the total consumption of fish by all the predators (fleets in this case) amounts to more than the biomass of prey available, then the model runs into "understocking". In this case, the consumption by the predators is adjusted so that no more than 95% of the available prey biomass is consumed, and a penalty, given by the equation 10 below, is applied to the likelihood score obtained from the simulation (Stefansson 2005, sec 4.1.)

$$\ell = \sum_{t} U_t^2 \tag{10}$$

where U_t is the understocking that has occurred in the model for that timestep.

Penalties

The BoundLikelihood likelihood component is used to give a penalty weight to parameters that have moved beyond the bounds in the optimisation process. This component does specify the penalty that is to be applied when these bounds are exceeded.

$$\ell_i = \begin{cases} lw_i(val_i - lb_i)^2 & \text{if } val_i < lb_i \\ uw_i(val_i - ub_i)^2 & \text{if } val_i > ub_i \\ 0 & \textit{otherwise} \end{cases}$$

Where $lw_i = 10000$ and $uw_i = 10000$ are the weights applied when the parameter exceeds the lower and upper bounds, respectively, val_i is the value of the parameter and, lb_i and ub_i are the lower and upper bounds defined for the parameter.

2.3. Order of calculations

The order of calulations is as follows:

1. **Printing**: model output at the beginning of the time-step
2. **Consumption**: by the fleets
3. **Natural mortality**
4. **Growth**
5. **Recruitment**: new individuals enter to the population
6. **Likelihood comparison**: Comparison of estimated and observed data, a likelihood score is calculated
7. **Printing**: model output at the end of the time-step
8. **Ageing**: if this is the end of year the age is increased

Because of this order of calculations the time step of indexes, age-length keys and length distributions of the surveys are defined in Gadget a quarter before.

2.4. Implementation, weighting procedure

Input data (Likelihood files) were prepared for Gadget format using the *mfdb* R package (**?**), running and weighting procedures were implemented in R with the gadget.iterative function from *Rgadget* package. This function follows the approach presented in Taylor et al. (2007) and in the appendix of Elvarsson et al. (2014) based on the iterative reweighting scheme of Stefánsson (1998) and Stefansson (2003), which is summarized as follows:

Let $\mathbf{w_r}$ be a vector of length L with the weights of the likelihood components (excluding understocking and penalties) for the run r, and $SS_{i,r}, i = 1, \ldots, L$, the likelihood score of component i after run r. First, a Gadget optimization run is performed to get a likelihood score ($SS_{i,1}$) for each likelihood component assuming that all components have a weight equal to one, i.e., $\mathbf{w_1} = (1, 1, \ldots, 1)$. Then, a separated optimization run for each of the components (L optimization runs) is performed using the following weight vectors:

$$\mathbf{w_{i+1}} = (1/SS_{1,1}, \ldots, (1/SS_{i,1}) * 10000, 1/SS_{i+1,1}, \ldots, 1/SS_{L,1}), i = 1, \ldots, L.$$

Resulting likelihood scores $SS_{i,i+1}$ are then used to calculate the residual variance, $\hat{\sigma}_i^2 = SS_{i,i+1}/df^*$ for each component, that is used to define the final weight vector as

$$\mathbf{w} = (1/\hat{\sigma}_1^2, \ldots, 1/\hat{\sigma}_L^2).$$

Where degrees of freedom df^* are approximated by the number of non-zero data points in the observed data for each component. Finally, the total objective function is the sum of all likelihoods components multiplied by their respective weights according to the vector $\mathbf{w}$.

In order to assign weights to the individual likelihood components (See table 2.2) in the procedure described above, all the survey indices were grouped together.

2.5. Initial parameters and optimization

Initial parameter values with their boundaries and settings for the optimising algorithms can be found in `https://github.com/mmrinconh/gadgetanchovy/blob/master/Anchovybenchmark_allnumbers_2018_2_fv_june25/params.in` and `https://github.com/mmrinconh/gadgetanchovy/blob/master/Anchovybenchmark_allnumbers_2018_2_fv_june25/optfile`. The optimization algorithms converged in individual and weighted runs.

3. Remarkable Model Assumptions

- The model was implemented quarterly from 1989 to the second quarter of 2018.
- All commercial fleets where grouped into only one from 1989 to 2018 second quarter: The Spanish purse-seine. The Spanish purse-seine which represents more than a 90 % of all the catches from 2001 to 2016 and more than a 80 % from 1989 to 2000. It is also the only fleet with a lenght distribution available. For the first two quarters of year 2018, provisional catches estimations of Portuguese (until June 23rd) and Spanish (June 25th) purse-seine were used.
- The parameters for weight-length relationship equation ($w = al^b$,) were assumed fixed and defined as $a = 3.128958e^{-6}$ and $b = 3.277667619$. Those values were calculated from all the samples available in third and fourth quarters from 2003 to 2017.
- Natural mortality at age was also considered fixed with $M_0 = 2.21$ and $M_1, M_2, M_3 = 1.3$,.
- There was a size restriction from 1995, that were only effective until 2001. As a consequence it was neccesary to define different suitability parameters for two different periods. One from 1989 to 2000, and the other from 2001 to 2018.
- Recruits enter to the age 0 population at quarters 2, 3 and 4 (because of the Gadget order of calculations for each time step this is equivalent to have recruitment one quarter later, i.e. in quarters 3,4 and 1 of the next year) of all years except the last year, because at the end of June there are no recruits (zero age individuals). Then, biomass and abundance estimates at the end of the second quarter need to be corrected removing age 0 individuals.

4. Natural mortality selection

Natural mortality selection is justified by the following arguments:

- Natural mortality was preferred to be selected from classical indirect formulations based on life history parameters. For it we used the R package *FSA* to obtain empirical estimates of natural mortality.

- For the estimation of the natural mortality rate, the Von Bertalanffy growth parameters and the maximum age that the species can live were used. Growth parameters of the Von Bertalanffy function were taken from Bellido et al. (2000) ($l_\infty = 18.95, k = 0.89, t_0 = -0.02$), and for the maximum observed age, we explored a range from age 3 to 5, but finally age 4 was considered adequate. A total of 13 estimators were produced using the R package *FSA* and the a value of $M = 1.3$ was undertaken (midway between the median and the mean of the available estimates for Agemax=4).

- Currently is generally accepted that Natural mortality may decrease with age, as far as it presumed to be particularly greater at the juvenile phase. It was agreed to adopt for the adult ages of anchovy (ages 1 to 4) the constant natural mortality estimated before (1.3), but for the juveniles (age 0) a greater one in proportion to the ratio of natural mortality at ages 0 and 1 (M_0/M_1) resulting from the application of the Gislason et al. (2010) method for modelling natural mortality as a function of the growth parameters. For it we used four vectors of length-at-age: derived from the Von Bertalanffy growth function in Bellido et al. (2000) for ages 1-5, from the ECOCADIZ-RECLUTAS survey for ages 0-3, the average of the length-at-age in the catches from 1987 to 2016 and the average of the length-at-age in the catches from 2007 to 2016. There was no major basis to select one or the other, we directly choosed the pattern shown by the ECOCADIZ-RECLUTAS data just because it seemed to be smoothest one (particularly for age 1 onwards as presumed here). The ratio M_0/M_1 is 2.722670/ 1.595922 = 1.7. Therefore $M_0 = 1.3 * 1.7 = 2.21$.

- In summary for anchovy 9a South, the adopted natural mortality by ages are $M_0 = 2.21, M_1 = 1.3$ and $M_2^+ = 1.3$ (similar at any older age).

5. Fit to data

A summary of likelihood scores is presented in Figure 1 while a comparison of estimated versus observed data is summarized in the following Figures:

Length distributions

- Figure 2: Length distribution of the commercial fleet.
- Figure 3: Length distribution of the ECOCADIZ acoustic survey.
- Figure 4: Length distribution of the PELAGO acoustic survey.
- Figure 5: Summary of residuals for length distributions.

Age distributions

- Figure 6: Age distribution of the commercial fleet.
- Figure 7: Age distribution of the ECOCADIZ acoustic survey.
- Figure 8: Age distribution of the PELAGO acoustic survey.

- Figure 9: Summary of residuals for age distributions.

Biomass survey indices fit

- Figure 10: Summary of biomass survey indices fit.

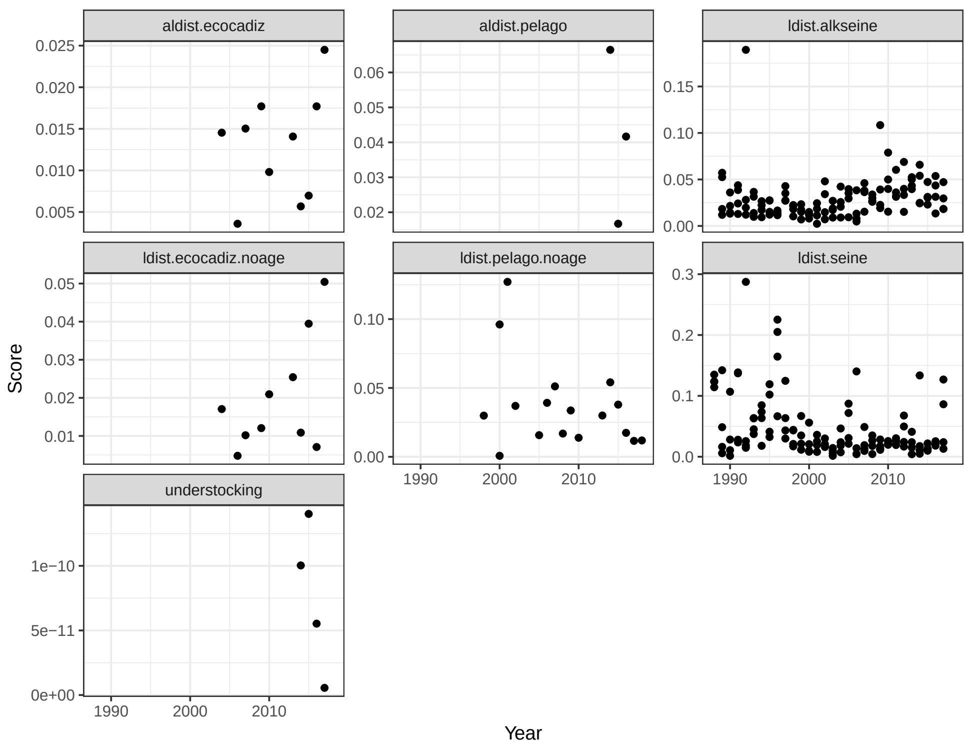

Figure 1: Likelihood scores for age-length key of ECOCADIZ survey, PELAGO survey and commercial landings (Upper panel) and length distribution of ECOCADIZ survey, PELAGO survey and landings. Dots represent the score for each quarter.

Index	
a	Age, $a = 0,\ldots,3$
l	Length, $l = 3,3.5,4,4.5,\ldots,22$
y	Years, $y = 1989,\ldots,2018$
t	Quartely timestep, $t = 1,\ldots,4$
T	$T = 1$ for period 1989-2000, $T = 2$ for period 2001-2018
Parameters	
Fixed	
a	Parameter of weight-length relationship $w = al^b$, $a = 3.128958 \times 10^{-6}$
b	Parameter of weight-length relationship $w = al^b$, $b = 3.277667619$
μ_a	Initial population mean length at age
	$\mu_0 = 9.99, \mu_1 = 12.1, \mu_2 = 15.2, \mu_3 = 16.1$
σ_a	Initial population standard deviation for length at age
	$\sigma_0 = 0.836, \sigma_1 = 0.5, \sigma_2 = 1, \sigma_3 = 1.2$
M_a	Natural mortality, $M_0 = 2.21, M_1 = 1.3, M_2 = 1.3, M_3 = 1.3$
n	Maximum number of length classes that an individual is supposed to grow $n = 5$
Estimated	
l_∞	Asympthotic length, l_∞=30
k	Annual growth rate, $k = 0.0655859$
β	Beta-binomial parameter, $\beta = 21.0543$
ν_a	Age factor, $\nu_0 = 120000, \nu_1 = 149000,$
	$\nu_2 = 0.0654, \nu_3 = 8.73e-07$
μ	Recruitment mean length, $\mu = 10.0741$
σ_t	Recruitment length standard deviation by quarter, $\sigma_2 = 2.87768$, $\sigma_3 = 1.65203$, $\sigma_4 = 3.71785$
$l_{50,T}$	Length with a 50% probability of predation during period T,
	$l_{50,1}^{seine} = 11.5$, $l_{50,2}^{seine} = 11.1$, $l_{50,3}^{ECO} = 14$, $l_{50,3}^{PEL} = 12.9$
α_T	Shape of function, $\alpha_1^{seine} = 0.332$, $\alpha_2^{seine} = 0.778$, $\alpha_3^{ECO} = 0.953$, $\alpha_3^{PEL} = 0.602$
Observed Data	
$E_{y,t}$	Number or biomass landed at year y and quarter t
W_l	Weight at length
$I_{y,t}$	Observed survey index at year y and quarter t
$P_{a,l,y,t}$	Proportion of the data sample over all ages and lengths for timestep/age/length combination
$O_{a,l,y,t}$	Observed data sample for time/age/length combination
$x_{a,y,t}$	Sample mean weight from the data for the timestep/age combination
Others	
Δl	Length increase
Δw	Weight increase
Δt	Length of timestep
$N_{a,l,y,t}$	Number of individuals of age a, length l in the stock at year and quarter y and t, respectively.
$q_{a,l}$	Proportion in lengthgroup l for each age group
$R_{y,t}$	Recruitment at year y and quarter t
$p_{l,t}$	Proportion in lengthgroup l that is recruited at quarter t
$C_{l,y,t}$	Total amount in biomass landed by surveys and in number landed by commercial fleet
$S_{l,T}$	Proportion of prey of length l that the fleet/predator is willing to consume during period T
$\pi_{a,l,y,t}$	Proportion of the model sample over all ages and lengths for that timestep/age/length combination
$\mu_{a,y,t}$	Mean length at age for the timestep/age combination
U_t	Understocking for timestep t
lw_i and uw_i	Weights applied when the parameter exceeds the lower or upper bound
lb_i and ub_i	Lower and upper bound defined for the parameter
val_i	Value of the parameter

Table 1: List of Symbols used in model specification

Data source	type	Timespan	Likelihood function
Commercial landings	Length distribution	All quarters, 1989-2017	See eq. 7
	Age-length key	All quarters, 1989-2017	See eq. 7
ECOCADIZ acoustic survey	Biomass survey indexes	Second quarter 2004, 2006	see eq. 6
		third quarter 2007, 2009, 2010, 2013-2017	
	Length distribution	Second quarter 2004, 2006	see eq. 7
		third quarter 2007, 2009, 2010, 2013-2017	
	Age-length key	Second quarter 2004, 2006	see eq. 7
		third quarter 2007, 2009, 2010, 2013-2017	
PELAGO acoustic survey	Biomass survey indexes	First quarter 1999, 2001-2003	see eq. 6
		second quarter 2005-2010 and 2013-2018	
	length distribution	First quarter 1999, 2001-2003	see eq. 7
		second quarter 2000, 2005-2010, 2013-2018	
	Age-length key	second quarter 2014-2016	see eq. 7

Table 2: Overview of the likelihood data used in the model

Figure 2: Comparison between observed and estimated catches length distribution. Black lines represent estimated data while gray lines represent observed data

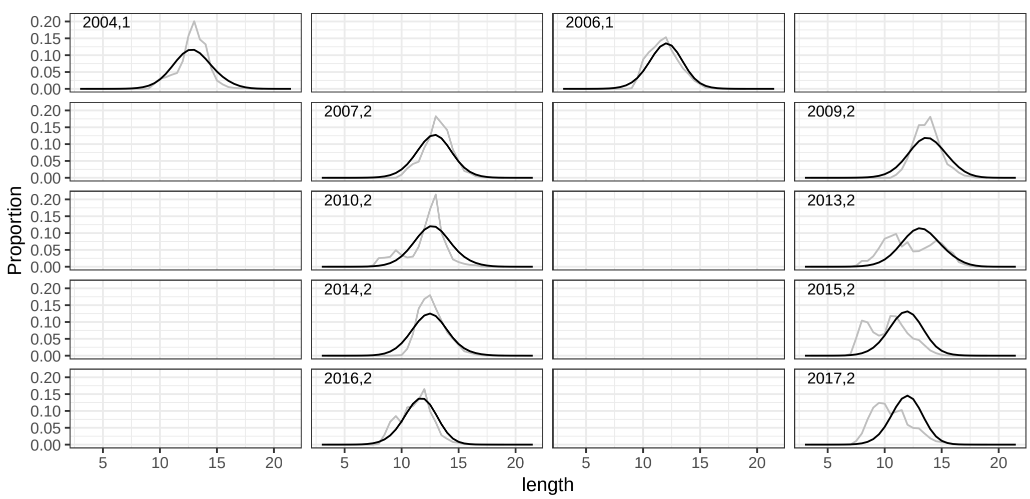

Figure 3: Comparison between observed and estimated catches length distribution for ECOCADIZ survey. Black lines represent estimated data while gray lines represent observed data

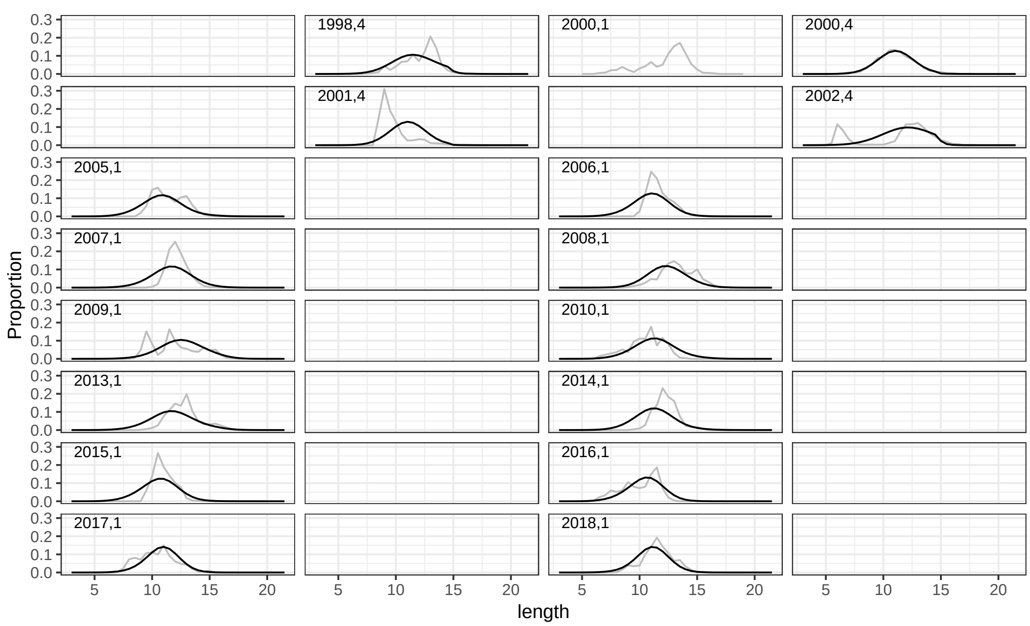

Figure 4: Comparison between observed and estimated catches length distribution for PELAGO survey. Black lines represent estimated data while gray lines represent observed data

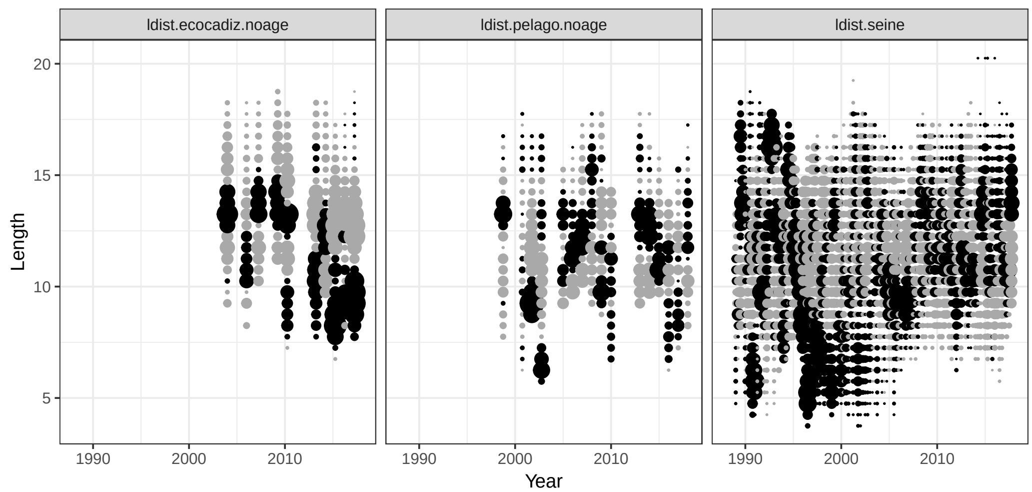

Figure 5: Standardised residual plots for the fitted length distribution from the ECOCADIZ survey, PELAGO survey and commercial landings. Black points denote a model underestimate and gray points an overestimated. The size of the points denote the scale of the standardised residual.

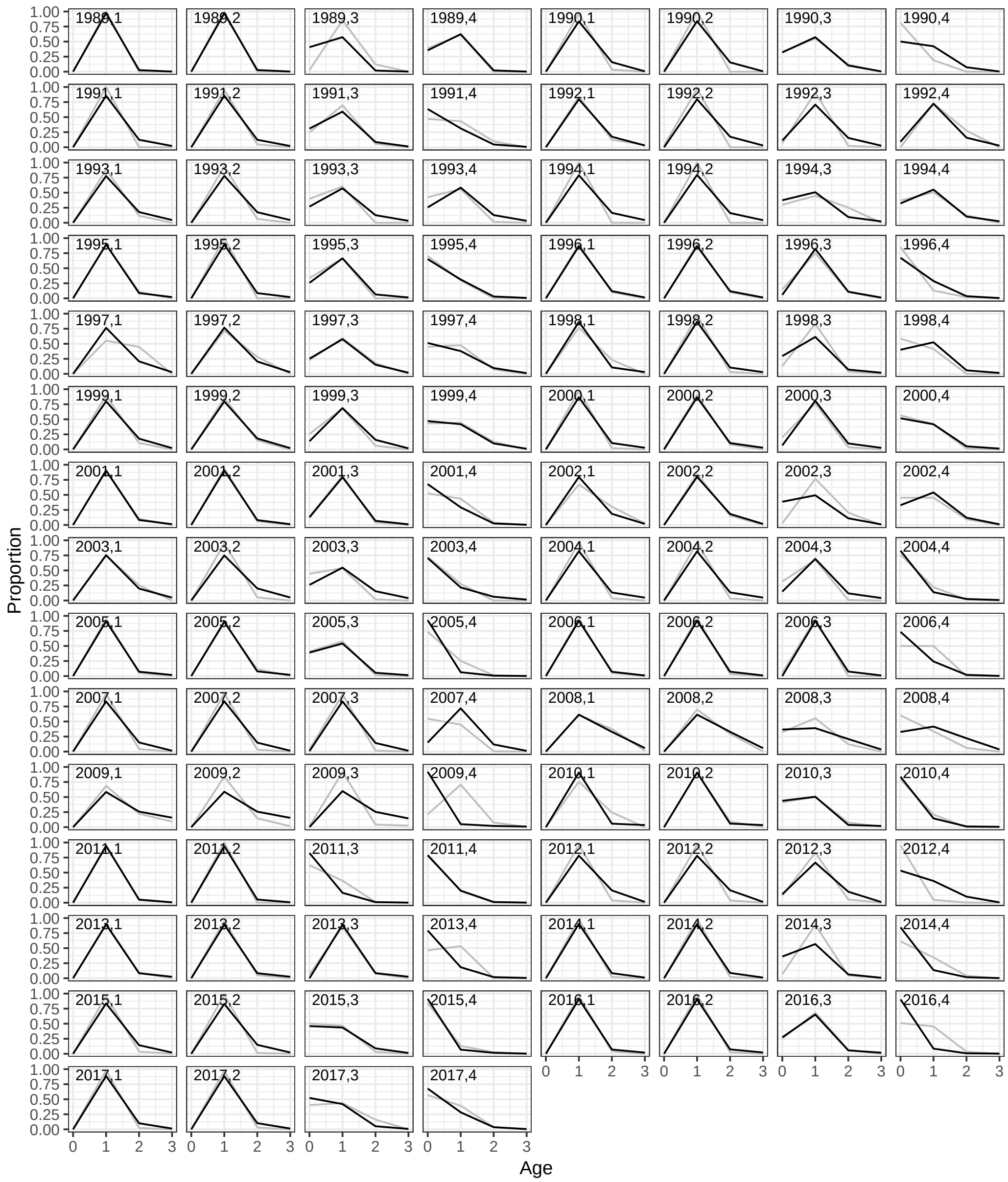

Figure 6: Comparison between observed and estimated catches age distribution. Black lines represent estimated data while gray lines represent observed data.

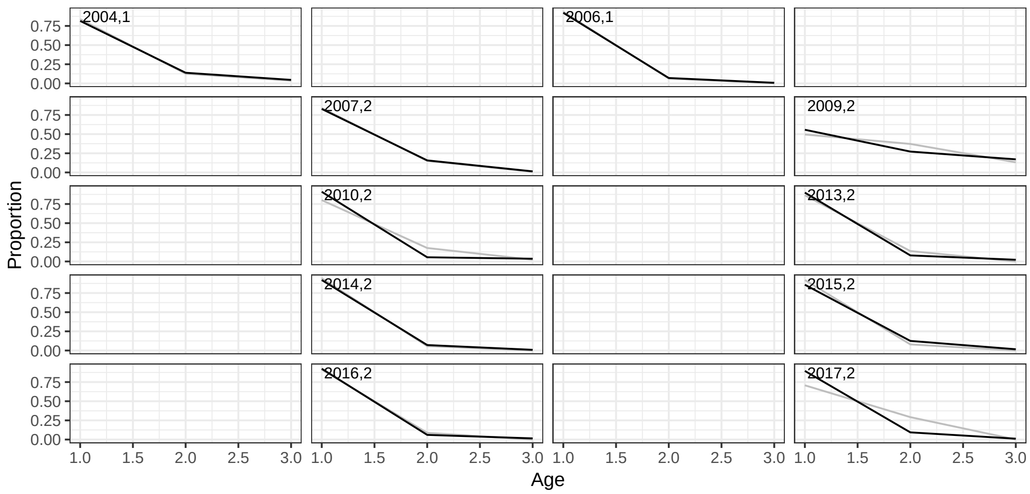

Figure 7: Comparison between observed and estimated ECOCADIZ survey age distribution. Black lines represent estimated data while gray lines represent observed data.

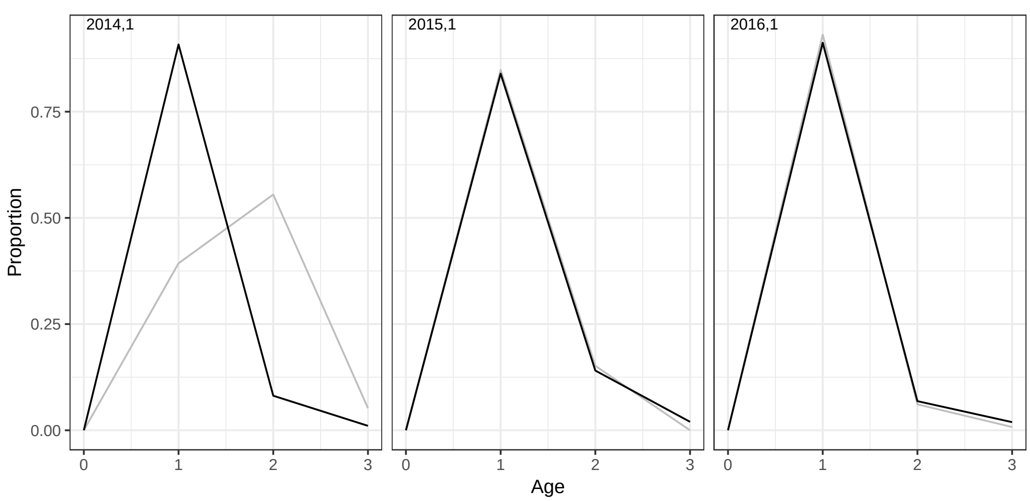

Figure 8: Comparison between observed and estimated PELAGO survey age distribution. Black lines represent estimated data while gray lines represent observed data.

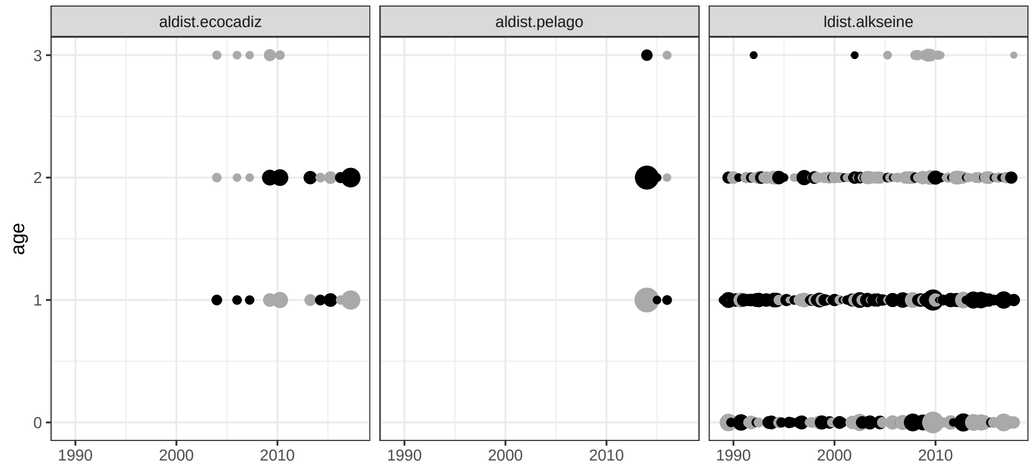

Figure 9: Standardised residual plots for the fitted age distribution from the ECOCADIZ survey, PELAGO survey and commercial fleet. Black points denote a model underestimate and gray points an overestimated. The size of the points denote the scale of the standardised residual.

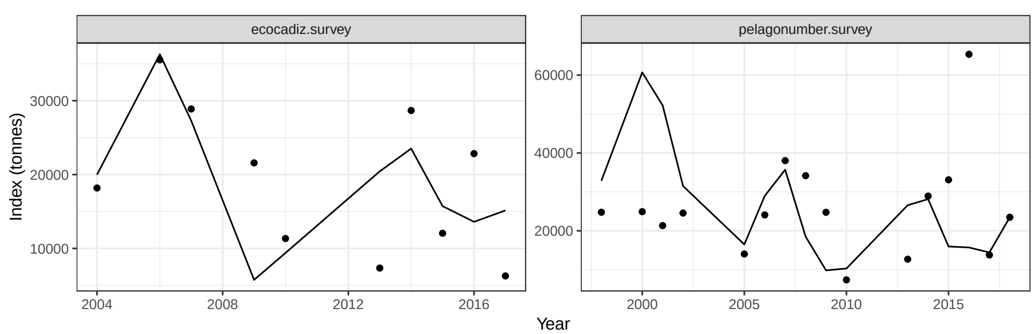

Figure 10: Comparison between observed and estimated survey indices. Black points represent observed data while black line represent estimated data

6. Model estimates

Parameter estimates after optimization are presented in Table 2.

6.1. Catchability

Figure 11 shows the catchability estimated by the model for the different surveys indices

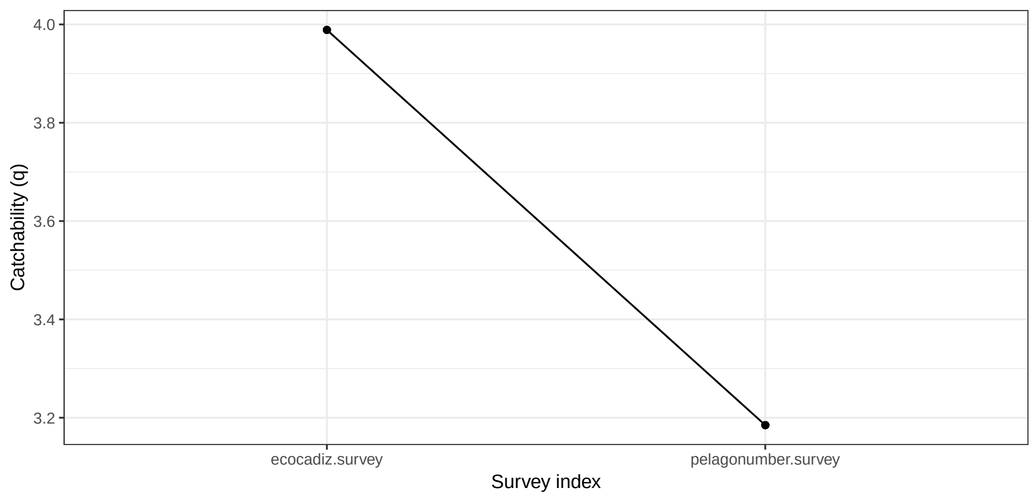

Figure 11: Estimated catchability parameters for the different survey indices

6.2. Suitability

Figure 12 shows the fleet suitability functions estimated by the model for the commercial fleet and different surveys

6.3. Abundance, recruitment and Fishing mortality

Figure 13 presents model annual estimates for biomass, abundance (removing age 0 individuals to be accurate with the time of the assessment, see section 3 above for a more detailed explanation), recruitment, fishing mortality and catches **at the end of the second quarter of each year**. Figure 14 shows annual estimates for biomass of individuals of age 1+ at the end of the second quarter of each year. Due to some inconsistencies in the maturity ogives not noticed during WKPELA 2018, we assume that all individuals with age 1 or higher (B_1+), are mature i.e. these abundance estimates result equivalent to spawning stock biomass estimates.

7. Catch advice for July 2018 to June 2019

The adviced catches for next year according to the formula decided in WKPELA 2018 (ICES, 2018) would be:

$$C_{2018} = 1.2C_{2017} = 1.2 * 3730 = 4476,$$

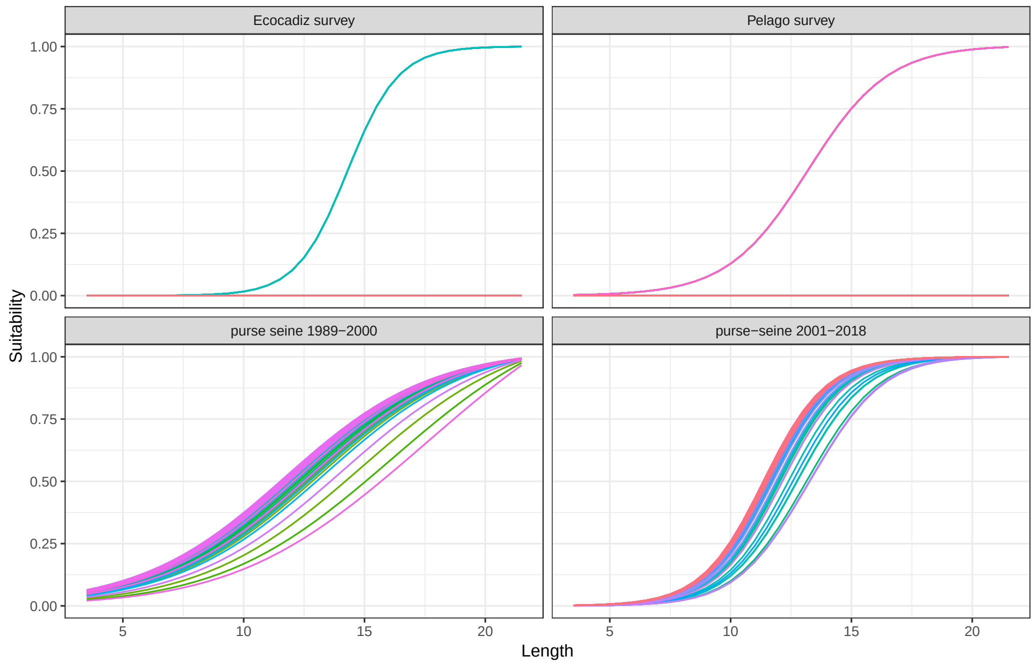

Figure 12: Estimated fleet suitability functions for the commercial fleet and different surveys.

where C_y represents the sum of landings and discards from July of year $y-1$ to June of year y, and the factor 1.2 corresponds to the uncertainty cap because the following ratio value is higher than 1.2:

$$\frac{B_{2018}}{\overline{B_{2017}+B_{2016}}} = \frac{3635}{(1791+2463)/2} = 1.7,$$

where B represents the estimated biomass removing age 0 individuals.

8. Reference points

The methodology applied was the same decided in WKPELA 2018 (page 286 of WKPELA 2018 report (ICES, 2018)) following ICES guidelines for calculation of reference points for category 1 and 2 stocks and the report of the workshop to review the ICES advisory framework for short lived species ICES WKMSYREF5 2017 (ICES, 2017).

According to the above ICES guidelines and the S-R plot characteristics (Figure 15), this stock component can be classified as a "stock type 5" (i.e. stocks showing no evidence of impaired recruitment or with no clear relation between stock and recruitment (no apparent $S-R$ signal)). According to this classification, $Blim$ estimation is possible according to the standard method and it is assumed to be equal to $Bloss$ ($Blim = Bloss$). For 2018 the value of $Bloss$ for the 9a South anchovy corresponds to the estimated SSB in 2010 (1310 t), hence $Blim$ is set at 1310 t and the relative $Blim$ (divided by the mean value of B_1+) results equal to 0.298. Note that due to some inconsistencies in the maturity ogives used in WKPELA2018, age 1+ individuals (B_1+) are assumed as mature i.e. B_1+ class is equivalent to Stock Spawning Biomass (SSB) (see subsection 6.3 above).

ICES recommends to calculate Bpa as follows:

$$Bpa = e^{(1.645\sigma)} Blim,$$

where σ is the estimated standard deviation of $ln(SSB)$ in the last year of the assessment, accounting for the uncertainty in SSB for the terminal year. If σ is unknown and for short living species, as it is in our case, it can be assumed that $\sigma = 0.30$ (see page 34 of ICES WKMSYREF5 2017 report (ICES, 2017)), then $Bpa = e^{(1.645\sigma)} Blim = 1.64Blim$. According to this Bpa is set at 2148.4 t.

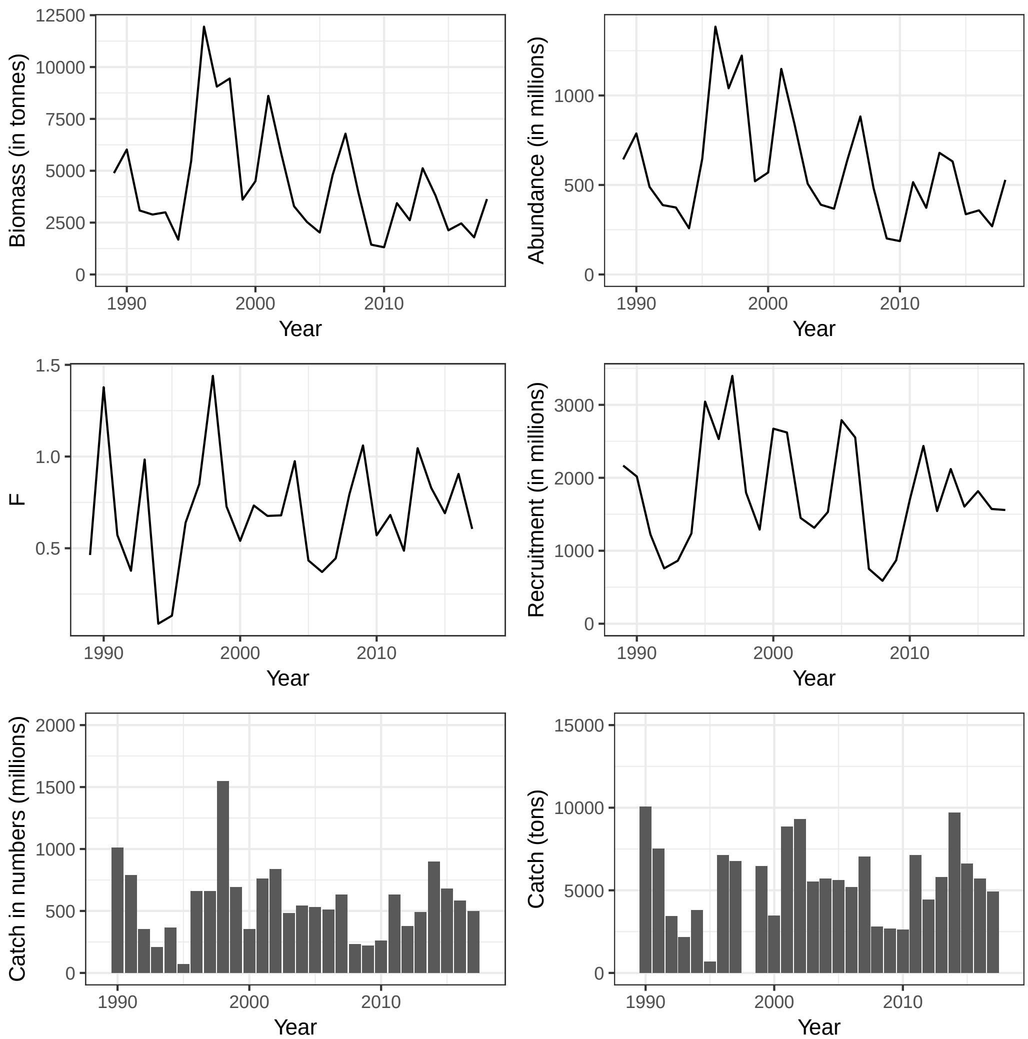

Figure 13: Annual catches time series (in numbers and biomass) compared with annual model estimates for abundance (in numbers and biomass) recruitment and fishing mortality. Measures were summarized at the end of June each year, assuming that a year starts in July and ends in June of the next year.

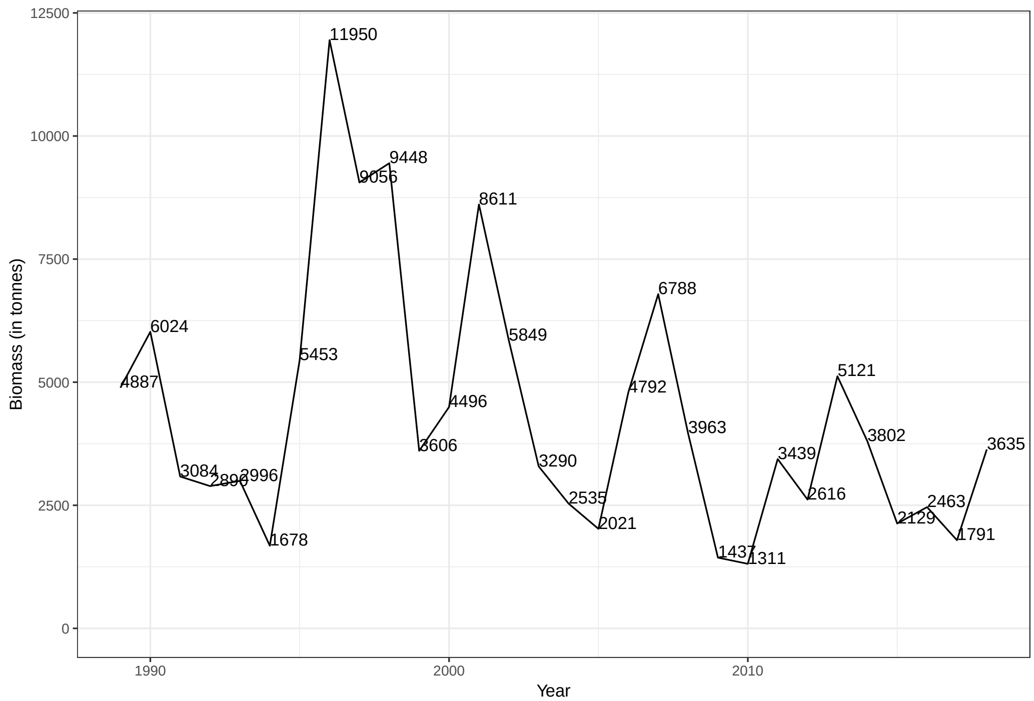

Figure 14: Estimated biomass time series

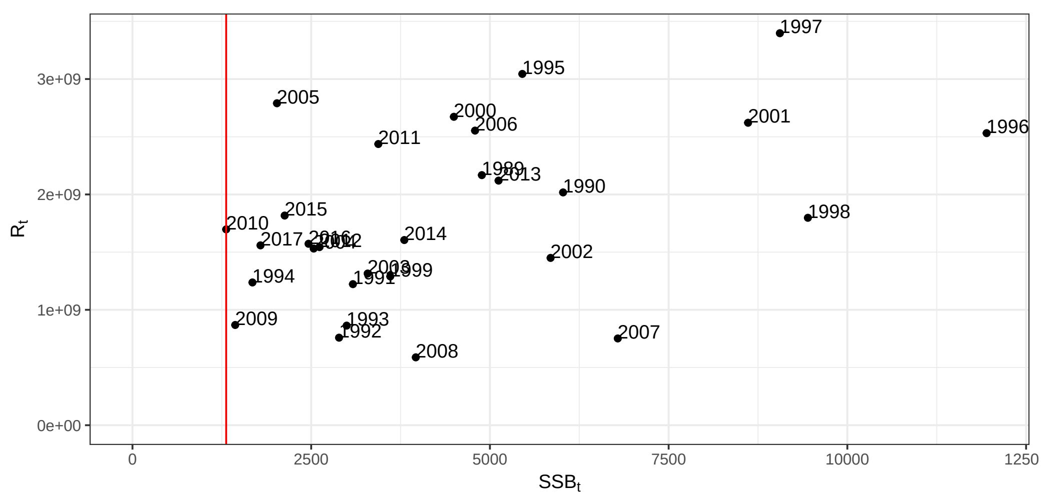

Figure 15: Estimated Stock Spawning biomass (SSB_{t-1}) vs. Recruitment (R_t)

9. Acknowledgements

The research leading to these results has received funding from the European Union Seventh Framework Programme (FP7-KBBE-2013) under the grant agreement 613571/MAREFRAME project and Margarita M. Rincón was funded by P09-RNM-5358 of the Junta de Andalucía. However, the document does not necessarily reflect EC views and in no way anticipates the Commission's future policy in the area. We thank Jamie Lentin from Shuttlethread for the automatization of data input, Bjarki Elvarsson for having an open repository with very useful Gadget data processing routines and to the members of WGHANSA group for their help and support.

We gratefully thank CESGA (Galician Supercomputing Center) for computational time at the FTII Supercomputer and technical assistance.

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WD to ICES WGHANSA

On the need of an InterBenchmark for Sardine 8abd: Outlining main issues to be covered and preliminary analysis.

Lionel Pawlowski (1), Andres Uriarte (2), L. Citores (3), Gael Lavialle (1), Erwan Duhamel (1), Leire Ibaibarriaga (3)

(1) IFREMER - 8 Rue François Toullec, 56100 Lorient, France
(2) AZTI - Herrera Kaia - Portualdea z/g. E-20110 Pasaia, GIPUZKOA, Spain
(3) AZTI – Txatxarramendi Ugartea z/g E-48395 Sukarrieta – BIZKAIA, Spain

1. Introduction

Sardine (*Sardina pilchardus*) in divisions 8.a–b and 8.d (Bay of Biscay) was benckmarked in 2017 (ICES 2017a), but some unsolved issues led to flag the assessment as a category 2 stock (stocks with analytical assessments and forecasts that are only treated qualitatively). One unresolved issue was the low abundance estimates obtained by the model compared to the survey estimates, which led to "unlikely" high estimates of the catchability parameter of the acoustic surveys and DEPM. The estimated catchability for PELGAS (acoustic) (2.4), and for BIOMAN (DEPM) (1.8) biomass indexes were perceived to be too high, because the acoustic and DEPM surveys are designed to estimate absolute biomass and because these catchabilities are quite different from those estimated for the southern sardine stock (ICES 2017a). As pointed out in the quality of the assessment section of the 2018 summary advice for this anchovy (ICES 2018b): "This is partially explained by a lack of signal in the survey time-series compared to the signal in the commercial catch. This makes it difficult for the assessment to reliably estimate the scale of the population in absolute values."

In the assessment of 2018 (ICES 2018a) it was clear that there are two major issues which remain unsolved affecting the current assessment and the provision of advice respectively, as highlighted in the last ADGHANSA minutes (ICES 2018b):

- There is a **retrospective pattern**, whereby assessment tends to overestimate SSB and underestimate Fbar, both in relative and in absolute terms; thus it leads to a downward revision of absolute biomass. This retrospective pattern supports also the allocation of this assessment in category 2. Such category 2 implies that the series of F and SSB in the assessment are taken as relative values and the same affects to the definition of the biological reference points for the management. The relative values of the assessment and of the BRPs have been referred (are relative) so far to the historical mean. ADG questioned the relevance of the model due to this strong retrospective pattern (mostly due to the lack of contrast in the catch data, only available since 2002). ADG felt that an inter-benchmark should be considered.
- **The biological reference points** are affected by this retrospective pattern, and to accommodate for this, biological reference points are updated yearly. Furthermore, the fact that Blim is not within the range of observed biomasses, makes Blim uncertain. Following the guidelines on BRPs for stocks in category 1 and 2, Blim is deduced from Bpa (which is taken from Bloss). Such an indirect estimation of Blim is debatable and very much conditioned by

the sigma (the uncertainty of SSB estimates in the last year of the assessment). The default sigma value (0.2) for all stocks was used but it contrasts with the actual value obtained from the assessment of 0.23 and the suggested one for short-lived species of 0.3 (ICES 2017b). As the definition of Blim affects the estimation of Fmsy, the catch options in the advice are directly affected by the adopted sigma. The use of 0.2, instead of the actual sigma value, leads to overestimate the value of Blim and hence to reduce F0.05 and Fmsy (=F0.05), resulting in more conservative advice than if the actual sigma values would have been used for Blim definition.

In relation to the estimation and definition of BRPs 2018 ADG suggested:

- to compute BRPs relative values to the mean of a fixed period (e.g. for the time-series used in the benchmark) instead of referring to the historical mean by adding every year another (the latest) year.

- to use the right sigma to derive Blim from Bpa (and adjust the F reference points accordingly)

In addition, ADG requested to consider a more precautionary Fmsy proxy (to be in line with the guidance for category 2 stocks which says that reference points for cat 2 stocks should be more precautionary. A candidate for Fmsy proxy is F0.1. This was estimated last yearfor this stock and it was much higher than Fmsy. Therefore, current MSY reference points, were considered technically correct and valid for 2018.

A final issue, which might not require itself an Inter-benchmark to be addressed, is the need of a partial revision of the French catches in recent years (2013-2017). In 2018 there was a change of the official French catches submitted to ICES, which has been questioned both by French fishing organizations and scientists, leading to a posterior revision (after WGHANSA) which can affect slightly the last and future assessments. These revised catches should be incorporated to any new assessment.

This WD aims to launch the Inter benchmark process by introducing elements to the issue list and presenting preliminary analyses on:

a) the implications of adopting the revised French catches of recent years (period 2013-2017).
b) The implications of changing sigma for the estimation of Blim to the actual value obtained.
c) Potential sources of the retrospective pattern in the SSB and F estimates in the assessment.

Further work on better definition of BRPs and on the improvement of the assessment will remain to be done during the Inter Benchmark period.

2. Revision of the catch data (recent French catches and the interim catches) and implications on the 2018 assessment

In ICES WGHANSA 2018, French catches for 2016 were substantially revised downwards. Some investigations were carried out by IFREMER during the summer 2018, based on production data provided by the French fishing organizations. Some inconsistencies in catches were pointed in some harbors on some quarter. It is unknown why the downward revision occurred in the official databases as data in WGHANSA 2017 matched better with production data from the fishing organizations. Production data in 2016 were consistent with the official data used at WGHANSA 2017 therefore it was assumed that the production data were reflecting the actual level of catches and were included in this update assessment with a revision from 2013 to 2016 (table 1).

Due to the changes in the times series of catches, the assessment was re-run using the same setting as used during ICES WGHANSA (ICES, 2018), the major changes being only 1) the revision of the time series from 2013 to 2016, 2) the inclusion of the preliminary catch estimate for 2018 rather than the assumption on catches.

The ICES advice (ICES, 2018b) was drafted based on the assumption that the fishing mortality F in 2018 (the "intermediate year" for the ICES short term forecasts) for age 2-5 would follow the average of estimates of fishing mortality for the period 2015-2017. This "status quo" fishing mortality Fsq was equivalent to an hypothetic catch of 32 776 tonnes of sardine in 2018. With the revision of the catches, the status quo catch would be 32 845 tonnes. But given the preliminary catches are now available for 2018 (in January 2018), it is no longer needed to assume an F value for the interim year in the short-term forecast. Preliminary catches in 2018 were 32 040 tonnes, around 805 tonnes lower than the expected catch under the status quo fishing mortality. The effect of using the preliminary catch data or the status quo fishing mortality assumption was quantified as a separate run.

For the sake of the comparison between previous and new assessment, in order to evaluate the effect of the change in the times series to the model outputs, the outcomes from the assessment are presented in absolute numbers. **It is important to note that the absolute numbers must not be considered, in no way, as absolute estimates of biomass, recruitment or fishing mortality due to this assessment being classified as category 2** ("trend based from analytical assessment"). Those numbers are not considered as good absolutes estimates of biomass and fishing pressure levels.

Table 1. Difference between total catches estimates from ICES WGHANSA and revised catches based. Total catches represent both Spanish and French catches in the Bay of Biscay. Revised catches are the sum of Spanish catches and production data provided by the French fishing industry. For 2018, values were assumed estimates for the ICES short term forecast and preliminary catch information from the Spanish and French industry provided in december 2018.

Year	Total catches (t) ICES WG June 2018	Revised total catches (t) December 2018	Difference (t)
2010	20217	20217	0
2011	23208	23208	0
2012	30900	30900	0
2013	32489	32938	449
2014	33943	35704	1761
2015	27284	28756	1472
2016	25498	29754	4256
2017	30318	30435	117
	Assumed for STF	Preliminary	

2018	(*before revision of time series) 32845 (32776*)	2018 catches 32040	-805

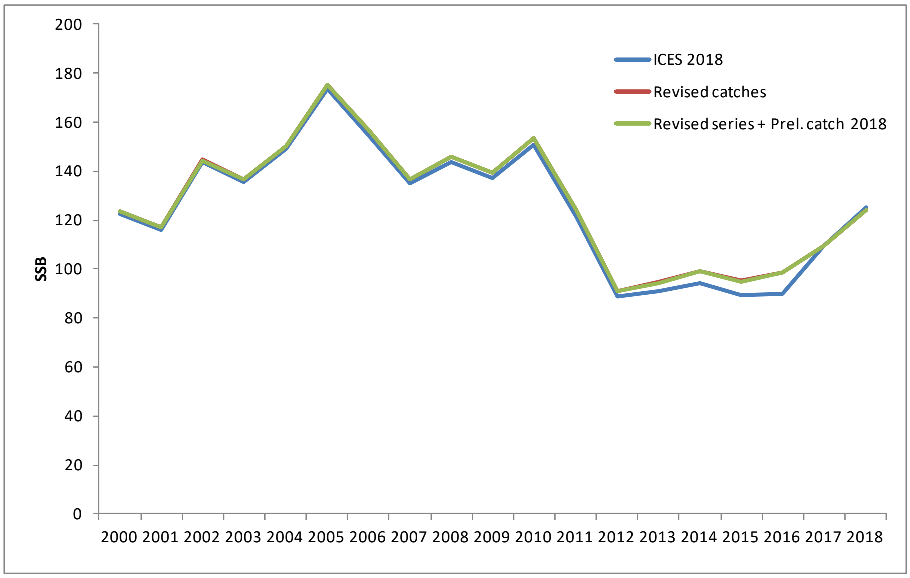


Figure 1: SSB estimates from the different runs (Blue: ICES WGHANSA - reference run, Red: run with revised catches and assumption for 2018, Green: run with revised catches and preliminary catches for 2018).

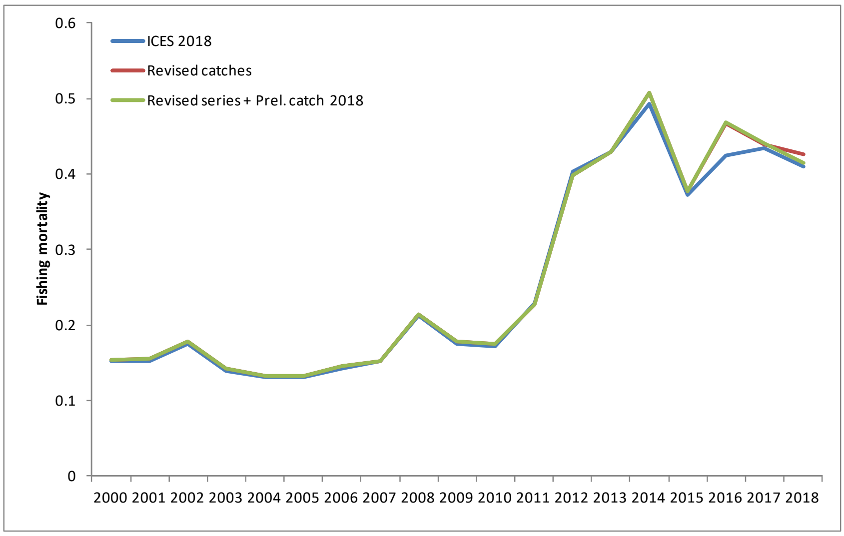


Figure 2: Fishing mortality estimates from the different runs (Blue: ICES WGHANSA - reference run, Red: run with revised catches and assumption for 2018, Green: run with revised catches and preliminary catches for 2018).

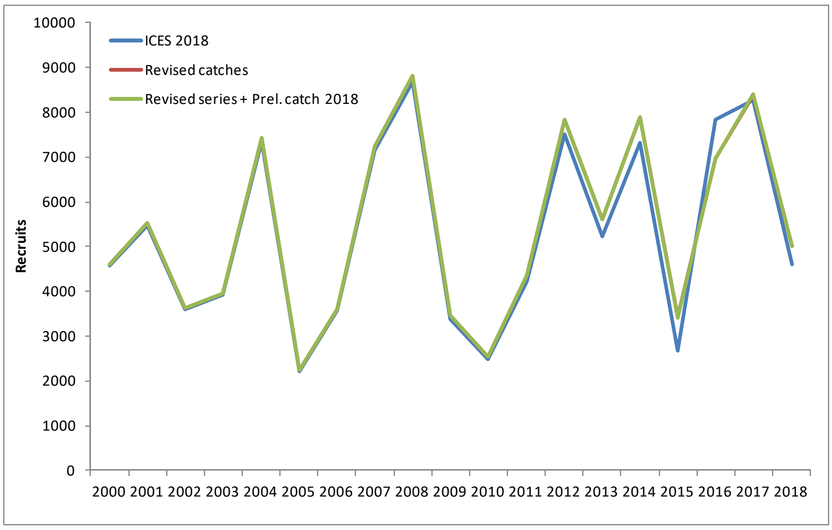


Figure 3: Recruitment estimates from the different runs (Blue: ICES WGHANSA - reference run, Red: run with revised catches and assumption for 2018, Green: run with revised catches and preliminary catches for 2018).

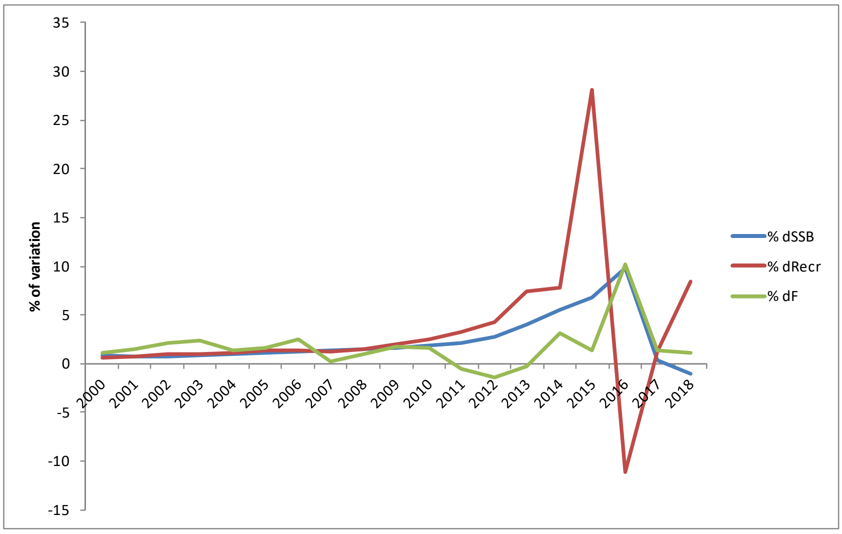


Figure 4: Variations of SSB, recruitment and fishing mortality between ICES WGHANSA run and the final run with revised catches and preliminary catches for 2018.

Overall, the revision of the catches does not change the perception of the stock. The revision led to an increase of biomass and recruitment estimates mostly from 2013 to 2016. Fishing mortality also increase with most difference in 2016. Figure 4 highlights the difference for all variables between the ICES run and the run with the most up-to-date times of series of catches. The revision of the catches led to an increase of biomass by around 10% in 2016 as well as for the fishing mortality. While the increase of fishing mortality looks normal qualitatively speaking considering the increase of catches, the increase of 4000t of catches leading to an increase by 10% of fishing mortality seems too high. This suggests some overestimation of fishing mortality maybe linked to local depletion effects. Recruitment exhibits an oscillating pattern leading to very strong variations from 2014 to 2018.

The estimate for 2018 are nearly unchanged for SSB (-1%). Fishing mortality increases by 1.1% and recruitment estimates increases by 8.4%.

The effect of using assumption of catches or preliminary catches is only substantial for 2018 and does not impact outputs for previous years. However, the revision of the times series impacts the catch assumption estimate for 2018 which also leads to a different value of fishing mortality for that year.

3. Revision of the reference points according to new catches and revised sigma

As a consequence of the revision of the catch data, the assessment and forecast procedures carried in July 2018 at WGHANSA have to be reconducted. As the assessment exhibits strong retrospective patterns, it was agreed during WGHANSA 2018 to recalculate reference points for any update for the assessment (*"the working group recommends recalculating yearly the biological and MSY reference points based on the most up-to-date assessment. This option was adopted by the group to do the short-term forecasts",* page 183 of ICES,2018). The ICES procedure was followed and in order to remain consistent with the approach taken during the ICES working group, new reference points are estimated.

The principle is to, first estimate limit and precautionary reference points for spawning–stock biomass (SSB) and fishing mortality (F), namely Blim, Bpa, Flim and Fpa. In a second step, Fmsy and MSYBtrigger are estimated using Eqsim (stochastic equilibrium reference point software developed by ICES) which provides MSY reference points based on the equilibrium distribution of stochastic projections.

Results are expressed on table 2 as absolute and relative to the average of their respective time series estimates.

Table 2. Previous and new reference point estimates.

		Absolute value		Relative value	
Framework	Reference point	WGHANSA'18	Update jan'19	WGHANSA'18	Update jan'19
MSY approach	MSY $B_{trigger}$	88000	91000	0.70	0.72
	F_{MSY}	0.270	0.29	1.08	1.10
Precautionary approach	B_{lim}	63328	65487	0.51	0.52
	B_{pa}	88000	91000	0.70	0.72
	F_{lim}	0.478	0.496	1.92	1.88
	F_{pa}	0.302	0.318	1.21	1.20

Overall, the update of the time series of catches has resulted in slight changes in reference points estimates. Bpa, Blim and MSY Btrigger increase by 3.5%, Fpa and Flim by 3.7% and Fmsy by 7.0%.

One pending discussion at WGHANSA 2018 was the value σ used to estimate Blim (Blim = Bpa x exp(-1.645 σ) which is set to 0.2 (as recommended by the ICES guideline for estimating the reference points for Category 2 stocks – ICES 2017c) while the value from the latest model run is actually 0.23.

Work carried out at ICES WKMSYREF5 (ICES2017b) suggested a default value of 0.3 for short-lived species. WGHANSA considered the value of σ used for this stock should be further discussed, but for the WGHANSA exercise σ the value was set to 0.2 (as in the previous year). Estimates of reference points for 0.23 are presented as an exploratory exercise in table 3.

Moreover, sigma seems to follow a retrospective pattern. The figure 5 compare the SS3 ouputs with the retrospective runs to the 2002-2018 time series (last run). It is clear, the addition of more years reduces the uncertainty (sigma) of the Biomass estimates for the last year. Then, it is not clear that a fixed value of sigma would be the best approach to estimate Blim from Bpa. Further work should be carried out.

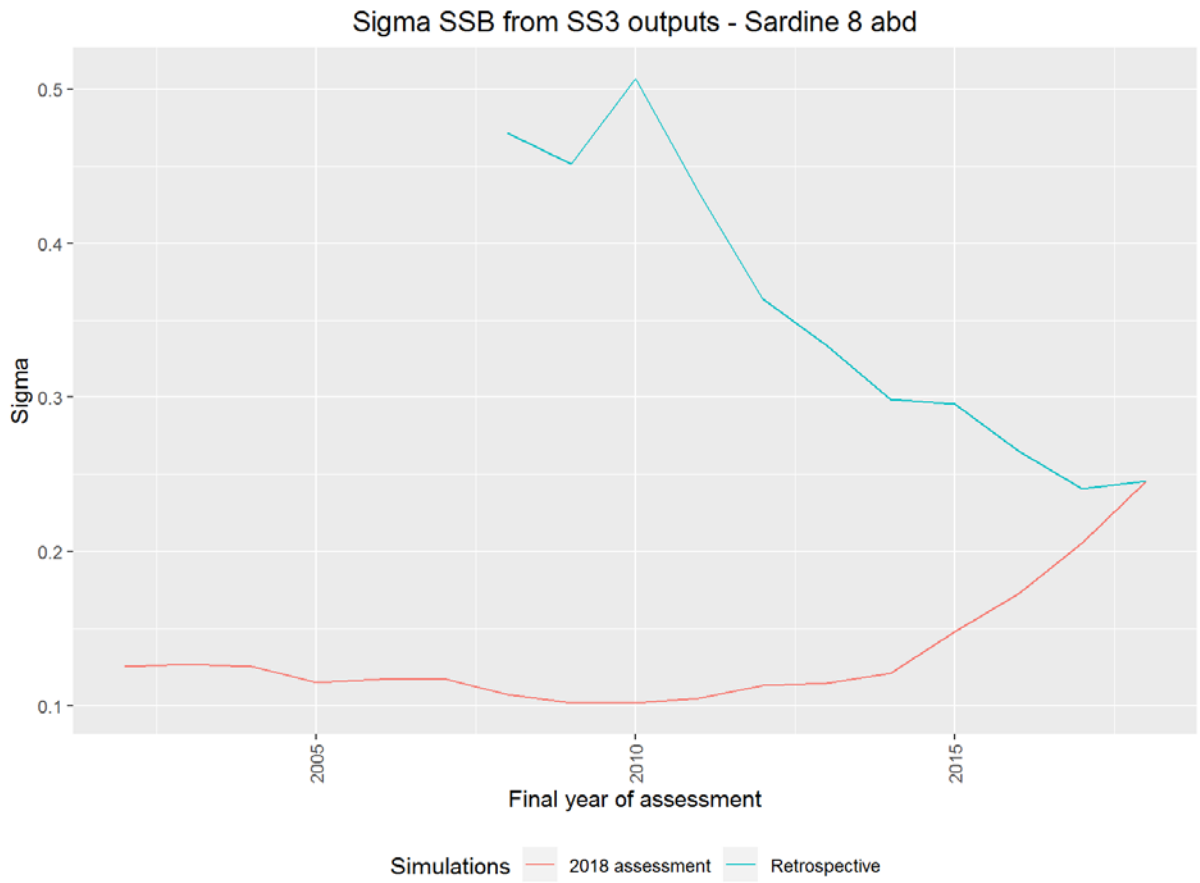


Figure 5: retrospective values of sigma SSB (2008-2018) vs the 2002-2018 times series assessment. SS3 outputs for sardine 8abd.

As Blim depends upon the value of Bpa and sigma, reference point estimation is highly sensible to the choice of σ. Considering those reference points, especially Fmsy and MSY Btrigger estimates are used as target and threshold in the short-term forecasts, it is worth noting that the perception of the stock may change drastically depending on the value of σ. However, with the value of 0.23, the perception of the stock does not change in 2018 (table 4), but it would have changed if sigma would have been assumed with a value of 0.3, especially if we consider the Fmsy unconstrained (figure 6).

Several simulations with EqSim were run for different value of sigma (between 0.1 and 0.4) and for different times series in order to compare the retrospective BRPs with the one from the 2002-2018 times series. For each value of sigma the BRPs were calculated and compared to the last year indicator (SSB or F) of the time series considered (figure 6).

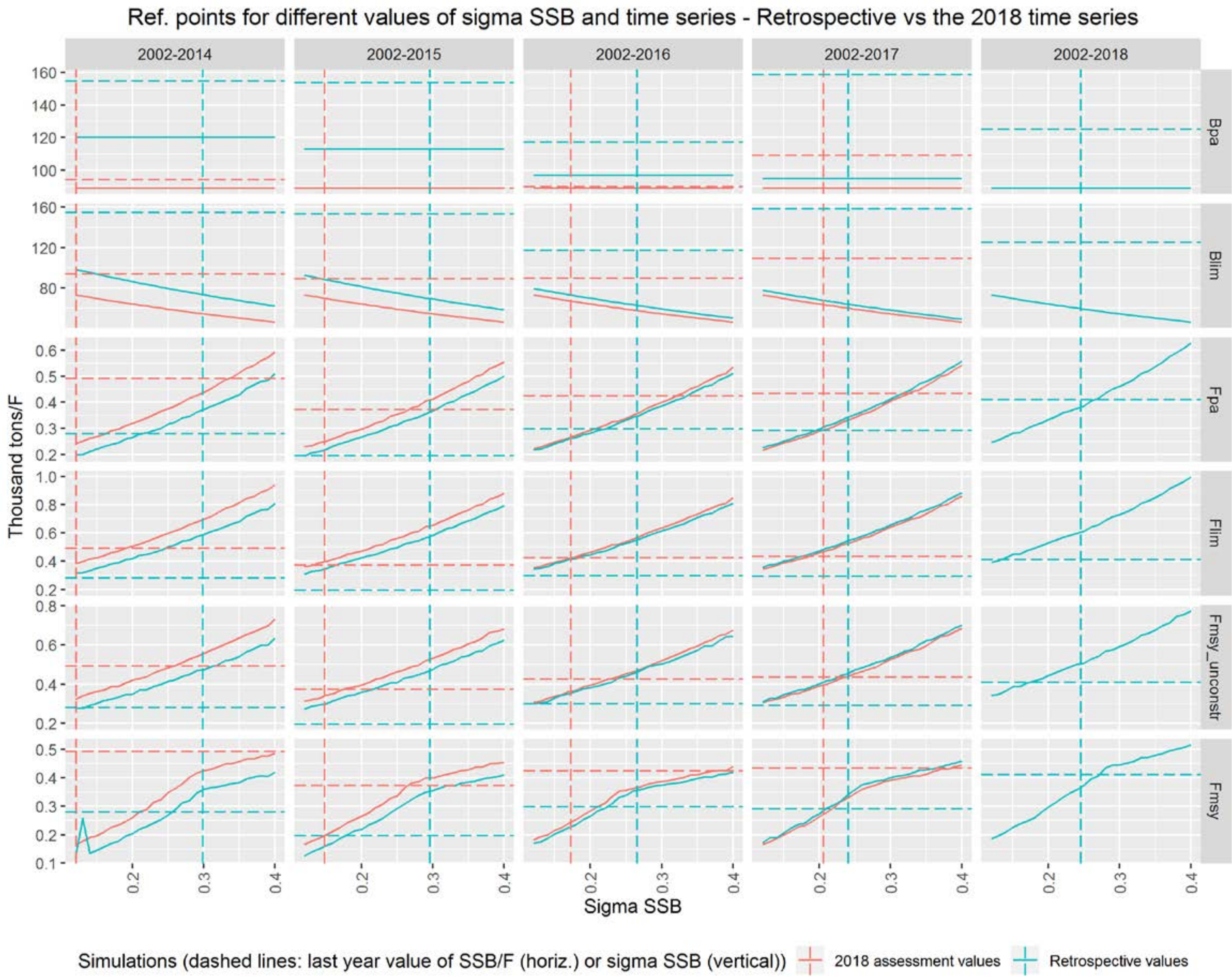


Figure 6: Simulation of all the biological reference points (right) for several values of sigma SSB and for different time series (top). In orange the estimations made with the shortcut 2018 assessment time series and in blue the same estimations but with the retrospective data for each time series. Dashed lines represent the last year estimation of each time series (F or SSB in horizontal; sigma SSB in vertical). For the 2002-2018 time series, retrospective and 2018 assessment values are the same.

The simulations presented at the figure 6 show some significant results.

1) For each time series tested, the differences between the retrospective and the 2018 assessment reference points are the same whatever the sigma value. Logically, the scale between the retrospective and the 2018 assessment are reduced as the time series considered is close to the 2002-2018 time series. As pointed out by WGHANSA last report (ICES, 2018), the retrospective runs shows overestimation of the SSB reference points and underestimation the F reference points during the five last years. It is worth noting that the absolute scale of the difference can be very important. For instance, over the 2002-2014 time series, the retrospective overestimates by 35% Blim and Bpa and underestimates by -16% Fpa and Flim, -14% Fmsy and -18% Fmsy unconstrained on average.

2) The perception of the stock can be evaluated by the position of the solid curves with the dashed horizontal lines (last year estimation of SSB or F for each time series). We can take the 2002-2018 time series as an example. For a 0.2 value of sigma SSB, we can see that the SSB estimated is well above Bpa and Blim and F is under Flim but above Fpa. In addition F is slightly above the Fmsy unconstrained. Consequently, F is far above the final Fmsy (constrained by ICES rules). If we set the sigma value at 0.3, the stock perception is quite different. F is slightly under Fpa and Fmsy and well under Fmsy unconstrained.

3) These results also show that Fmsy is always above Fpa whenever the time series considered (Fig. 6). That might be due to the age composition of the stock and the fast growth of the sardine. The yield per recruit is essentially driven by the first ages (1-2) so the maximization of the yield would imply to increase the fishing effort to catch these fish before they die and stop to grow. That might be in contradiction with the precautionary approach while the age 1 is not fully mature. But the stock recruitment relationship highly depends of the estimation of the Blim inflexion point which seems not satisfying at this stage. A preliminary yield per recruit analysis based on SS3 outputs (not presented here) seems to confirm this explanation (i.e. underexploitation of growth due to high natural mortality and fast growth of the sardine).

Table 3. Reference point estimates based on $\sigma = 0.23$.

Framework	Reference point	Absolute exploratory sigma=0.23	Relative exploratory sigma=0.23
MSY approach	MSY $B_{trigger}$	91000	0.71
	F_{MSY}	0.340	1.36
Precautionary approach	B_{lim}	62334	0.49
	B_{pa}	91000	0.71
	F_{lim}	0.553	2.21
	F_{pa}	0.355	1.42

Table 4. Change of perception of stock status depending on the choice of σ.

	Value	Update Jan'19	exploratory sigma=0.23
Relative SSB2018	0.98	Above MSY Btrigger	Above MSY Btrigger
Relative F2018	1.57	Above Fmsy Above Fpa Below Flim	Above Fmsy Above Fpa Below Flim

4. Revision of the short-term forecasts for 2019 considering the preliminary catches in 2018 and new sigma

As a consequence of the new runs, the basis for the catch options were also updated (table 5) with reference for comparison with previous ones (table 6).

Table 5. Recalculated basis for the catch options. All values, except for the catch, are relative to the average of the time-series in the stock assessment.

Variable	Value	Notes
Relative $F_{ages\ 2\text{-}5}$ (2018)	1.59	Estimated from preliminary landings.
Relative SSB (2019)	0.88	Resulting from preliminary landings
$R_{age\ 0}$ (2018/2019)	0.91	Unchanged
Total catch (2018)	32 040 tonnes	Preliminary landings data as of 19th jan 2019. Used to derive F2018.
Discards (2018)	0 tonnes	Negligible

As catch is now constraining forecast in this new configuration instead of Fsq, short term forecasts provide relative estimate of F in 2018. Resulting SSB for 2019 is also derived from the intermediate year assumption.

Table 6. Sardine in divisions 8.a–b and 8.d. Comparison between F and SSB estimates resulting from the change from catch assumption to preliminary catches for 2018.

Variable	Value in ICES advice	Estimates from updated and revised catches	% Change
Catch (2018, tons)	32 776	32 040	-2.2
Relative F ages 2-5 (2018)	1.56	1.59	1.9
Relative F/Fmsy	1.44	1.37	-4.9
Relative SSB (2019)	1.06	0.88	-17.0
Relative SSB (2019) / MSYBtrigger	1.51	1.24	-17.9

The above values (tables 2 and 5) are used to compute a new catch option table (table 7). ICES advised that when the MSY approach is applied, catches in 2019 should be no more than 22 410 tonnes. Following the MSY approach, the updated catch advice would be 23 679 tonnes, a 5.6% increase. The perception of the stock status does not change with SSB being above MSY Btrigger and fishing mortality.

Table 7. Annual catch options considering the preliminary catches in 2018. Catch is in tonnes.

Basis	Total catch (2019)	F (2019)	SSB (2020)	% SSB change **	% Catch change ***
ICES advice basis					
MSY approach: F_{MSY}	23 640	0.29	105 945	-5.9	-22.3
Other options					
F = 0	0	0	126 025	12.0	-100.0
F = F_{pa}	25 672	0.318	104 245	-7.4	-15.7
F = F_{lim}	37 693	0.496	94 287	-16.2	23.8
SSB (2020) = B_{lim}	74 057	1.2210	65 483	-41.8	143.3
SSB (2020) = B_{pa}	41724	0.5610	90 989	-19.2	37.1
F = F_{sq}	31 199	0.3971	99 645	-11.5	2.5
F = Fmsy	23 640	0.29	105 945	-5.9	-22.3

* SSB 2020 relative to SSB 2019.
** Catch in 2019 relative to catch in 2017 (30 435 t).

If the exploratory $\sigma = 0.23$ is considered, table 8 shows that under the MSY approach, the catch advice would increase to 27 240 tonnes, a 15% increase in comparison to standard run but this does not reflect some change in the stock status but some change in assessment threshold. This however highlights the impact of the biological reference points estimates to the short term forecasts. Therefore it appears important that some work is carried out to define in a robust manner suitable reference points.

Table 8. Exploratory catch options considering the preliminary catches in 2018 and $\sigma = 0.23$. Catch is in tonnes. The values in the columns "Relative F" and "Relative SSB" are relative to the average of the time-series in the stock assessment.

Basis	Total catch (2019)	F (2019)	SSB (2020)	% SSB change **	% Catch change ***
ICES advice basis					
MSY approach: F_{MSY}	27 240	1.36	0.80	-8.5	-10.5
Other options					
F = 0	0	0.00	0.99	12.0	-100.0
F = F_{pa}	28 296	1.42	0.80	-9.3	-7.0
F = F_{lim}	41 238	2.21	0.71	-18.8	35.5
SSB (2020) = B_{lim}	78 260	5.33	0.49	-44.6	157.1
SSB (2020) = B_{pa}	41 724	2.25	0.71	-19.2	37.1
F = F_{sq}	31 199	1.59	0.78	-11.5	2.5
F = Fmsy	27 240	1.36	0.80	-8.5	-10.5

* SSB 2020 relative to SSB 2019.
** Catch in 2019 relative to catch in 2017 (30 435 t).

5. **Some perspectives on the retrospective pattern.**

Current assessment shows a drop in biomass the period 2012-2016 without any major indication of such decrease in the survey aggregated indexes of biomass (Figure 7). It is not clear which information triggers such a reduction in the assessment.

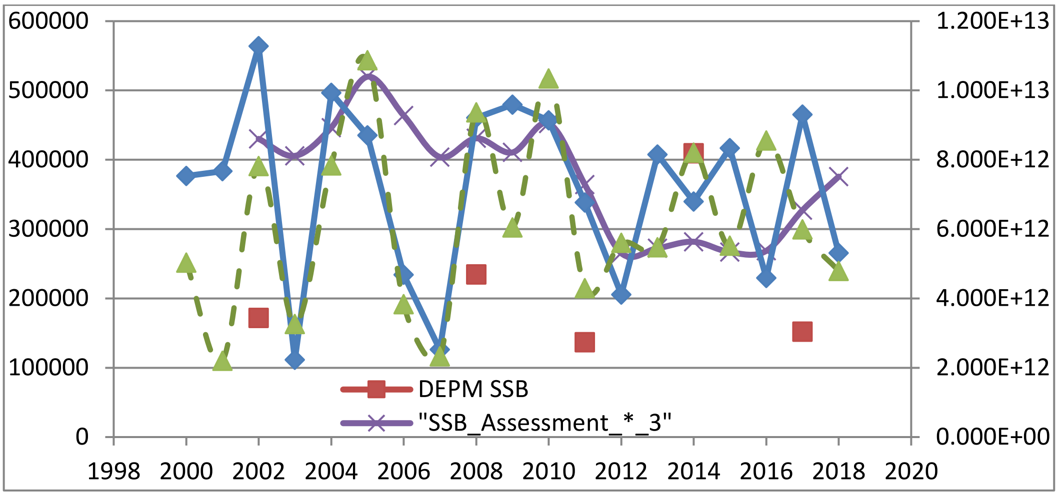


Figure 7: Indicator of biomass produced by the acoustic survey Pelgas, the DEPM IEO+AZTI (or AZTI alone in 2002) surveys and the egg abundance index from BIOMAN versus the biomass estimates from the SS3 Assessment in 2018 (multiplied by 3 to scale it with the indexes of biomass).

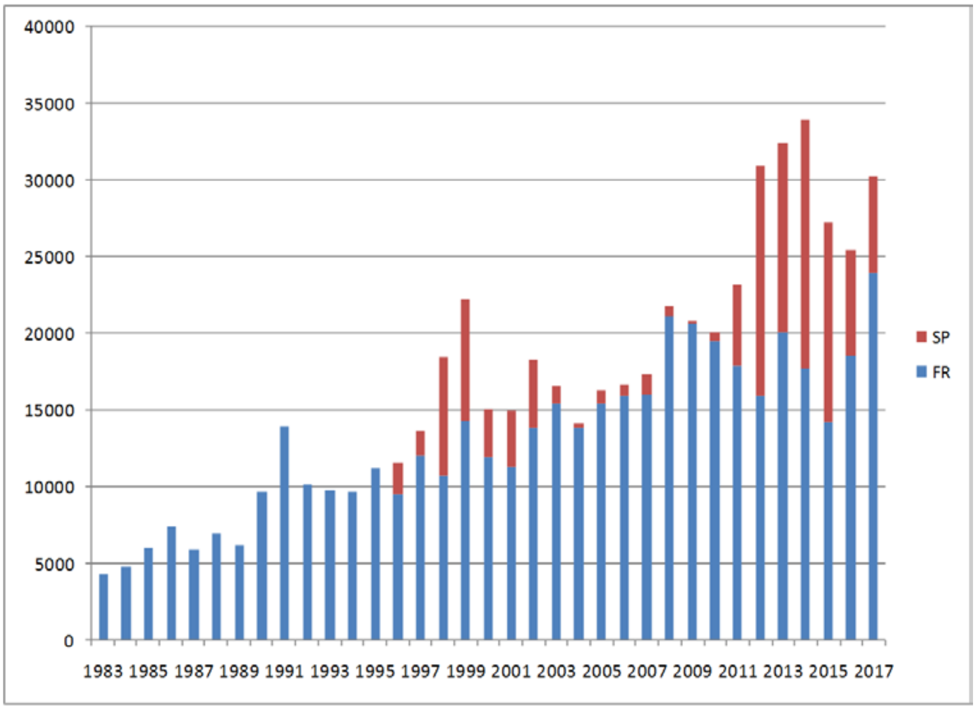


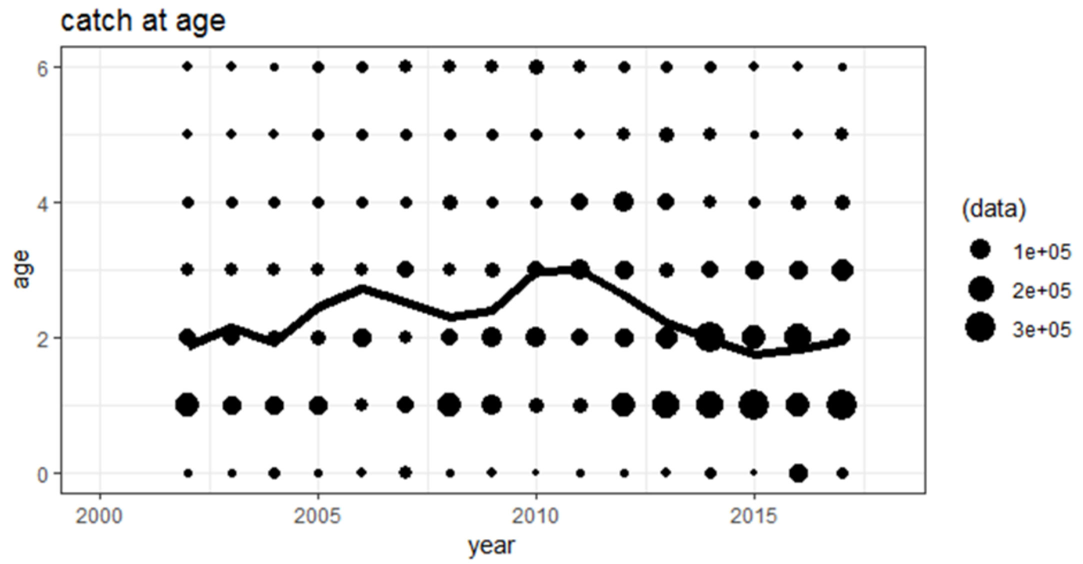
Figure 8: Catches in tons by countries (Spain and France) in the bay of Biscay since 1983 (WGHANSA 2018).

The Catches of sardine in the Bay of Biscay has been increasing in time, and in recent years (since 2011) there is a greater contribution from the Spanish fishing boats than in the past (Figure 8).

When analyzing the age structure of the Catches and the Acoustic abundance index we see that there have been some changes in the age structure of this information used as inputs for the assessment (Figures 9): Since 2012 the catch at age structure shows a consistent larger occurrence of ages 1 and 2 than in previous years. This might be due to a shift in the selectivity or to an actual reduction of the stock as a result of higher fishing mortality related to highest catches since 2012. Such period is roughly coincident with the greater contribution of the Spanish catches to the International fishery (although this starts in 2011). The bottom panel of Figure 9 shows that the major shift in the age composition of the catches since 2012 occurs first and with more intensity in the French catches than in the Spanish catches. Therefore such a shift in the age composition of the International catches is not due to the greater contribution of the Spanish catches relative to the French catches in those years (i.e. the change towards a predominance of younger ages in the age composition of the international catches can not be attributed to a different selectivity of the Spanish fishery). If the change in mean age would be due to a change in the selectivity at age then that would require a change in the assessment settings because so far selectivity is kept constant om the SS3 assessment throughout the time series.

In any case the change in the age composition of catches deserves some further analysis during the Interbenchmark to discard that a) no change in the methodological estimation procedures or b) no changes in the fishing pattern (seasonality, fishing areas, or relative contribution by gears to the French catches, i.e, purse seine vs pelagic trawling, are affecting the results on the catch at age composition).

An ongoing work from Ifremer in partnership with the french industry aims to identify the potential noise in the cohort tracking coming from the French purse seine fishery age composition of catches. Indeed these vessels operate between the 8 and 7 Ices divisions and depending on the year they may catch Channel sardine wich may has a different population dynamic. Depending on the available data, a comparison of length and age structure will be performed between Audierne's bay and Douarnenez's bay.



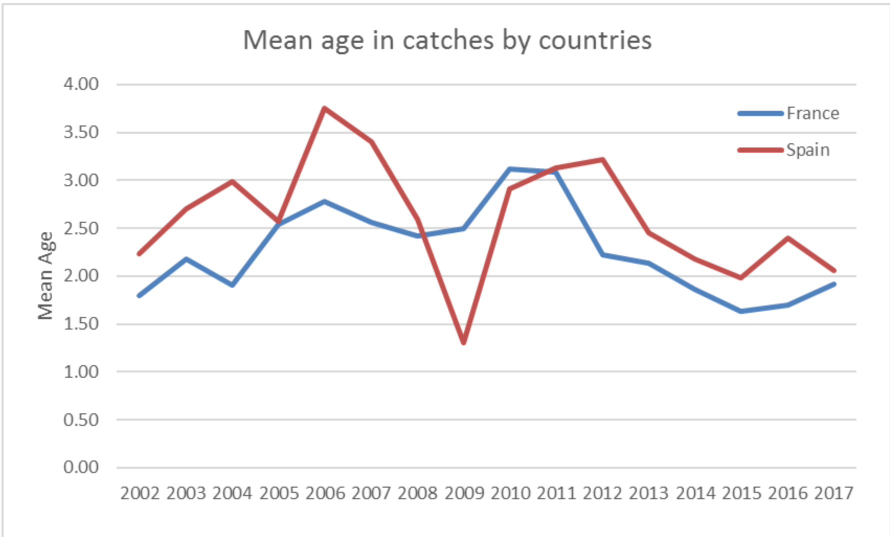


Figure 9: In the top panel catch at age (bubble plots) and mean age in the International catches (black line going through the mean age by year) and in the bottom panel mean age in the catches by countries.

Pelgas Population at age estimates (Figure 10) also show a global declining trend in the mean age of the population, particularly since 2013, but of lesser magnitude than in catches. This may be related to either an actual shift in the age structure of the population linked to a larger mortality or by some change in the catchability towards younger ages.

The former contrasts in the data inputs suggests that either changing selectivity in the fishery or, secondarily, changing catchability in the survey may be worth exploring to see if that can improve the assessment and results eventually in a reduction of the retrospective pattern.

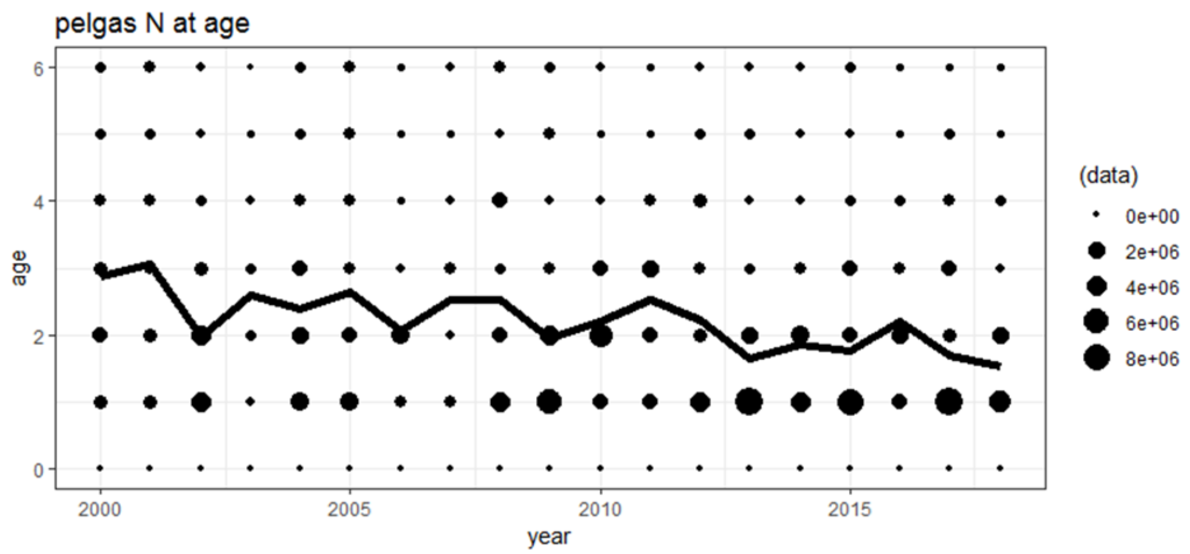


Figure 10: Age composition in the Population estimates from PELGAS acoustic survey, with a black line going through the mean age by year.

6. Conclusions

We propose the initiation of an inter-benchmark process for sardine in 8abd. The main issues to be addressed, after due revision of the French yearly catches, are:

- Revision of the methodology to derive reference points. It is acknowledged that the default value of sigma (standard deviation of SSB in the last year of assessment) might not be adequate for this stock. Other settings could be more adequate. This has a direct impact on the estimates of Fmsy, on which ICES advice is based. Preliminary exploratory analysis in this document showed that changing sigma to 0.2 to 0.23 results in an Fmsy increase about 15%, with parallel implications on the catch options. Exploratory analysis shows a correlation exists between the value of sigma and retrospective bias. The issue of the procedure of calculation of reference points, their use in absolute or relative terms and the frequency of updating them, remains still open within ICES, and should be further investigated. The period with respect to which the relative estimates are calculated should also be reconsidered.
- Current stock assessment still has some unresolved issues. The estimates of the survey catchabilities are still considered too high and there is a retrospective pattern. Is the later issue related to a recent change in the selection pattern of the fleet (currently not considered in the assessment)?. It is deemed necessary to explore alternative model settings (fleet/period segmentation, quarterly settings) and evaluate if this leads to a reduction of the retrospective pattern.
- Investigate potential noise in the cohort tracking, especially for French purse seine fishery operating between the ICES divisions 8 and 7.

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Updated Gadget for anchovy 9a South: Model description and results to provide catch advice and reference points (WGHANSA-1 2019)

Margarita María Rincón[a,*], Fernando Ramos[b], Andrés Uriarte[c], Leire Ibaibarriaga[c], Susana Garrido[d], Alexandra Silva[d]

[a]*Department of Coastal Ecology and Management, Instituto de Ciencias Marinas de Andalucía, Consejo Superior de Investigaciones Científicas, Avda República Saharaui 2, 11519 Puerto Real, Cádiz, Spain*
[b]*Instituto Español de Oceanografía, Centro Oceanográfico de Cádiz, Puerto pesquero, Muelle de Levante s/n, Apdo. 2609, 11006 Cádiz, Spain*
[c]*Azti-Tecnalia, Herrera Kaia-Portu aldea z/g, E-20110 Pasaia, Gipuzkoa, Basque Country, Spain*
[d]*Instituto Portugues do Mar e da Atmosfera-IPMA, Av. Brasília, 6, 1449-006 Lisboa, Portugal*

1. Background

The model specifications presented below correspond to those benchmarked in WKPELA 2018. The only difference is that results are presented now for the end of the second quarter of each year instead of be presented at the end of the fourth quarter. This responds to practical modifications in the definition of the assessment year, now it goes from July 1st to June 30th of the next year.

2. Model Description

Gadget is an age-length-structured model that integrates different sources of information in order to produce a diagnose of the stock dynamics. It works making forward simulations and minimizing an objective (negative log-likelihood) function that measures the difference between the model and data, the discrepancy is presented as a likelihood score for each time period and model component.

The general Gadget model description and all the options available can be found in Gadget manual (Begley, 2004) and some specific examples can be found in Taylor et al. (2007), Elvarsson et al. (2014) and WKICEMSE assessment for Ling (Elvarsson, 2017). The latest was used as a guide for this document.

The Gadget model implementation consists in three parts, a simulation of biological dynamics of the population (simulation model), a fitting of the model to observed data using a weighted log-likelihood function (observation model) and the optimization of the parameters using different iterative algorithms.

A list of the symbols used is presented in Table 2 and a graph with the Gadget model structure benchmarked in WKPELA 2018 is available at http://prezi.com/j8rinhq5kstg/?utm_campaign=share&utm_medium=copy.

*Corresponding author
Email address: margarita.rincon@icman.csic.es (Margarita María Rincón)

2.1. Simulation model

The model consists of one stock component of anchovy (*Engraulis encrasicolus*) in the ICES subdivision, 9.a South-Atlantic Iberian waters, Gulf of Cádiz. Gadget works by keeping track of the number of individuals, $N_{a,l,y,t}$, at age $a = 0, \ldots, 3$, at length $l = 3, 3.5, 4, 4.5, \ldots, 22$, at year $y = 1989, \ldots, 2018$, and each year divided into quarters $t = 1, \ldots, 4$.. The last time step of a year involves increasing the age by one year, except for the last age group, which its age remains unchanged and the age group next to is added to it, like a 'plus group' including all ages from the oldest age onwards (Taylor et al., 2007).

Growth

The growth function is a simplified version of the Von Bertalanffy growth equation, defined in Begley (2004) as the LengthVBSimple Growth Function (*lengthvbsimple*). Length increase for each length group of the stock is given by the equation below:

$$\Delta l = (l_\infty - l)(1 - e^{k\Delta t}), \tag{1}$$

where Δt is the length of the timestep, $l_\infty = 19\ cm$ (fixed) is the terminal length and k is the growth rate parameter.

The corresponding increase in weight (in Kg) of the stock is given by:

$$\Delta w = a((l + \Delta l)^b - l^b), \tag{2}$$

with $a = 3.128958e^{-6}$ and $b = 3.277667619$ set as fixed and extracted from all the samples available in third and fourth quarters from 2003 to 2017. The growth functions described above calculate the mean growth for the stock within the model. In a second step the growth is translated into a beta-binomial distribution of actual growths around that mean with parameters β and n. The first is fitted by the model as described in Taylor et al. (2007) and the second represents the number of length classes that an individual is allowed to grow in a quarter and it is fixed and equal to 5.

Initial abundance and recruitment

Stock population in numbers at the starting point of the simulation is defined as:

$$N_{a,l,1,1} = 10000\nu_a q_{a,l}, \quad a = 0, \ldots, 3, l = 3, \ldots, 20$$

Where ν_a is an age factor to be calculated by the model and $q_{a,l}$ is the proportion at lengthgroup l that is determined by a normal density with a specified mean length and standard deviation for each age group. Mean length at age (μ_a) and its standard deviation (σ_a) were extracted from all the data available from 1989 to 2018 including three surveys that are not included in the model: ARSA, ECOCADIZ-RECLUTAS and SAR survey (See table 2). The mean weight at age for this initial population is calculated by multiplying a reference weight corresponding to the length by a relative condition factor assumed as 1. This reference weight at length was calculated using the formula $w = al^b$, with a and b as defined before. In Gadget files this was specified as a normal condition distribution (*Normalcondfile*).

Similarly to the process of calculate the initial abundance described above, the recruitment specifies how the stock will be renewed. Recruits enter to the age 0 population at quarters 2, 3, 4 (because of the Gadget order of calculations for each time step this is equivalent to have recruitment one quarter later, i.e. in quarters 3,4 and 1 of the next year) of all years, respectively, as follows:

$$N_{0,l,y,t} = p_{l,t} R_{y,t}, \quad t = 2, 3, 4, l = 3, \ldots, 15,$$

where $R_{y,t}$ represents recruitment at year y and quarter t, and $p_{l,t}$ the proportion in lengthgroup l that is recruited at quarter t which is sampled from a normal density with mean (μ) and standard deviation (σ_t) calculated by the model. The mean weight for these recruits is calculated by multiplying the reference weight corresponding to the length by a relative condition factor assumed as 1. Reference weight at age was the same used to calculate the initial population mean weight at age explained above. In Gadget files this was specified also as a normal condition distribution (*Normalcondfile*).

Fleet operations

In the model the fleets act as predators. There are three fleets inside the model: two for surveys (ECOCADIZ acoustic survey and PELAGO acoustic survey) and one for commercial landings including all fleets: Spanish purse-seine, trawlers, Portuguese purse-seine, and others. The main fleet is Spanish purse-seine representing more than a 90 % of all the catches from 2001 to 2016 and more than a 80 % from 1989 to 2000. It is also the only fleet with a lenght distribution available, then we decide to include all commercial reported data in the same fleet which is mostly the Spanish purse-seine.

Surveys fleets are assumed to remove 1 Kg in each of the quarters when the surveys take place while the commercial fleet is assumed to remove the reported number of individuals each quarter. This total amount of biomass (for the surveys) or numbers (for the commercial fleet) landed is then split between the length groups according to the equations 3 and 4 respectively, as follows:

$$C_{l,y,t} = \frac{E_{y,t} S_{l,T} N_{l,y,t} W_l}{\sum\limits_l S_{l,T} N_{l,y,t} W_l}, \tag{3}$$

and

$$C_{l,y,t} = \frac{E_{y,t} S_{l,T} N_{l,y,t}}{\sum\limits_l S_{l,T} N_{l,y,t}}, \tag{4}$$

where $E_{y,t}$ represents biomass landed (in Kg) at year y and quarter t in equation 3 and numbers landed in equation 4, W_l corresponds to weight at length and $S_{l,T}$ represents the suitability function that determines the proportion of prey of length l that the fleet is willing to consume during period $T, T = 1, 2, 3$ where $T = 1$ corresponds to the period 1989-2000, $T = 2$ to 2001-2018 and $T = 3$ to 1989-2018.

For this model the suitability function chosen for the fleet and surveys is specified in Gadget manual as an ExponentialL50 function (*expsuitfuncl50*), and it is defined as follows:

$$S_{l,T} = \frac{1}{1 + e^{\alpha_T (l - l_{50,T})}} \tag{5}$$

where $l_{50,T}$ is the length of the prey with a 50% probability of predation during period T and α_T a parameter related to the shape of the function, both parameters are estimated from the data within the Gadget model. The whole model time period (1989-2018) has been splited into two different periods for suitability parameters of the commercial fleet because of changes in size regulation for the fishery around 1995 that become effective around 2001.

2.2. Observation model

Data are assimilated by Gadget using a weighted log-likelihood function. The model uses as likelihood components two biomass survey indices: ECOCADIZ acoustic survey and PELAGO acoustic survey; age - length keys from the commercial fleet (Spanish purse-seine), PELAGO survey and the ECOCADIZ survey; and length distributions for the commercial fleet, PELAGO and ECOCADIZ surveys (see Table 2.2 for a detailed description of the likelihood data used in the model).

Biomass Survey indices

The survey indices are defined as the total biomass of fish caught in a survey. The survey index is compared to the modelled abundance using a log linear regression with slope equal to 1 (*fixedslopeloglinearfit*), as follows:

$$\ell = \sum_t (\log(I_{y,t}) - (\alpha + \log(N_{y,t}))^2 \tag{6}$$

where $I_{y,t}$ is the observed survey index at year y and quarter t and $N_{y,t}$ is the corresponding population biomass calculated within the model. Note that the intercept of the log-linear regression, $\alpha = \log(q)$, with q as the catchability of the fleet (i.e $I_{y,t} = qN_{y,t}$).

Catch distribution

Age-length distributions are compared using l lengthgroup at age a and time-step y, t for both, commercial and survey fleets with a sum of squares likelihood function (*sumofsquares*):

$$\ell = \sum_y \sum_t \sum_l (P_{a,l,y,t} - \pi_{a,l,y,t})^2 \tag{7}$$

where $P_{a,l,t,y}$ is the proportion of the data sample for that time/age/length combination, while $\pi_{a,l,t,y}$ is the proportion of the model sample for the same combination, as follows:

$$P_{a,l,t,y} = \frac{O_{a,l,y,t}}{\sum\limits_a \sum\limits_l O_{a,l,y,t}} \tag{8}$$

and

$$\pi_{a,l,t,y} = \frac{N_{a,l,y,t}}{\sum_a \sum_l N_{a,l,y,t}}, \tag{9}$$

where $O_{a,l,y,t}$ corresponds to observed data.

When only length or age distribution is available. It is compared using equation 7 described above but considering all ages or all lengths, respectively.

Understocking

If the total consumption of fish by all the predators (fleets in this case) amounts to more than the biomass of prey available, then the model runs into "understocking". In this case, the consumption by the predators is adjusted so that no more than 95% of the available prey biomass is consumed, and a penalty, given by the equation 10 below, is applied to the likelihood score obtained from the simulation (Stefansson 2005, sec 4.1.)

$$\ell = \sum_t U_t^2 \tag{10}$$

where U_t is the understocking that has occurred in the model for that timestep.

Penalties

The BoundLikelihood likelihood component is used to give a penalty weight to parameters that have moved beyond the bounds in the optimisation process. This component does specify the penalty that is to be applied when these bounds are exceeded.

$$\ell_i = \begin{cases} lw_i(val_i - lb_i)^2 & \text{if } val_i < lb_i \\ uw_i(val_i - ub_i)^2 & \text{if } val_i > ub_i \\ 0 & otherwise \end{cases}$$

Where $lw_i = 10000$ and $uw_i = 10000$ are the weights applied when the parameter exceeds the lower and upper bounds, respectively, val_i is the value of the parameter and, lb_i and ub_i are the lower and upper bounds defined for the parameter.

2.3. Order of calculations

The order of calulations is as follows:

1. **Printing**: model output at the beginning of the time-step
2. **Consumption**: by the fleets
3. **Natural mortality**
4. **Growth**
5. **Recruitment**: new individuals enter to the population
6. **Likelihood comparison**: Comparison of estimated and observed data, a likelihood score is calculated

7. **Printing**: model output at the end of the time-step
8. **Ageing**: if this is the end of year the age is increased

Because of this order of calculations the time step of indexes, age-length keys and length distributions of the surveys are defined in Gadget a quarter before.

2.4. Implementation, weighting procedure

Input data (Likelihood files) were prepared for Gadget format using the *mfdb* R package (Lentin, 2014), running and weighting procedures were implemented in R with the gadget.iterative function from *Rgadget* package. This function follows the approach presented in Taylor et al. (2007) and in the appendix of Elvarsson et al. (2014) based on the iterative reweighting scheme of Stefánsson (1998) and Stefansson (2003), which is summarized as follows:

Let $\mathbf{w_r}$ be a vector of length L with the weights of the likelihood components (excluding understocking and penalties) for the run r, and $SS_{i,r}, i = 1, \dots, L$, the likelihood score of component i after run r. First, a Gadget optimization run is performed to get a likelihood score ($SS_{i,1}$) for each likelihood component assuming that all components have a weight equal to one, i.e., $\mathbf{w_1} = (1, 1, \dots, 1)$. Then, a separated optimization run for each of the components (L optimization runs) is performed using the following weight vectors:

$$\mathbf{w_{i+1}} = (1/SS_{1,1}, \dots, (1/SS_{i,1}) * 10000, 1/SS_{i+1,1}, \dots, 1/SS_{L,1}), i = 1, \dots, L.$$

Resulting likelihood scores $SS_{i,i+1}$ are then used to calculate the residual variance, $\hat{\sigma}_i^2 = SS_{i,i+1}/df^*$ for each component, that is used to define the final weight vector as

$$\mathbf{w} = (1/\hat{\sigma}_1^2, \dots, 1/\hat{\sigma}_L^2).$$

Where degrees of freedom df^* are approximated by the number of non-zero data points in the observed data for each component. Finally, the total objective function is the sum of all likelihoods components multiplied by their respective weights according to the vector $\mathbf{w}$.

In order to assign weights to the individual likelihood components (See table 2.2) in the procedure described above, all the survey indices were grouped together.

2.5. Initial parameters and optimization

Initial parameter values with their boundaries and settings for the optimising algorithms can be found in `https://github.com/mmrinconh/gadgetanchovy/blob/master/Assessment2019_27may_ecocadiz2018_estesi_junio30/params.in` and `https://github.com/mmrinconh/gadgetanchovy/blob/master/Assessment2019_27may_ecocadiz2018_estesi_junio30/optfile`. The optimization algorithms converged in individual and weighted runs.

3. Remarkable Model Assumptions

- The model was implemented quarterly from 1989 to the second quarter of 2019.
- All commercial fleets where grouped into only one from 1989 to 2019 second quarter: The Spanish purse-seine. The Spanish purse-seine which represents more than a 90 % of all the catches from 2001 to 2016 and more than a 80 % from 1989 to 2000. It is also the only fleet with a lenght distribution available. For the first two quarters of year 2019, provisional catches estimations of Spanish (until May 27th) purse-seine fleet were used and catches for June were estimated as the 37% of January to May catches based on historical records from 2009 to 2018. There were not any catches for Portuguese purse-seine in these two quarters.
- The parameters for weight-length relationship equation ($w = al^b$,) were assumed fixed and defined as $a = 3.128958e^{-6}$ and $b = 3.277667619$. Those values were calculated from all the samples available in third and fourth quarters from 2003 to 2017.
- Natural mortality at age was also considered fixed with $M_0 = 2.21$ and $M_1, M_2, M_3 = 1.3$,.
- There was a size restriction from 1995, that were only effective until 2001. As a consequence it was neccesary to define different suitability parameters for two different periods. One from 1989 to 2000, and the other from 2001 to 2019.
- Age 0 individuals were removed for all the data input corresponding to ECOCADIZ survey.
- PELAGO Age-length key for 2017 were available for the time of the assessment in 2018 (only for Spanish samples, no Portuguese information available) but it was not included in that assessment. For this year it has been included and also a sensitivity analysis was conducted to see the consequences of this missing data in 2018 assessment (See Model comparison at the end of the present document). Results of this analysis show that this missing data had not remarkable consequences in stock estimations for 2018.
- Recruits enter to the age 0 population at quarters 2, 3 and 4 (because of the Gadget order of calculations for each time step this is equivalent to have recruitment one quarter later, i.e. in quarters 3,4 and 1 of the next year) of all years except the last year, because at the end of June there are no recruits (zero age individuals). Then, biomass and abundance estimates at the end of the second quarter need to be corrected removing age 0 individuals.

4. Natural mortality selection

Natural mortality selection is justified by the following arguments:

- Natural mortality was preferred to be selected from classical indirect formulations based on life history parameters. For it we used the R package *FSA* to obtain empirical estimates of natural mortality.

- For the estimation of the natural mortality rate, the Von Bertalanffy growth parameters and the maximum age that the species can live were used. Growth parameters of the Von Bertalanffy function were taken from Bellido et al. (2000) ($l_\infty = 18.95, k = 0.89, t_0 = -0.02$), and for the maximum observed age, we explored a range from age 3 to 5, but finally age 4 was considered adequate. A total of 13 estimators were produced using the R package *FSA* and the a value of $M = 1.3$ was undertaken (midway between the median and the mean of the available estimates for Agemax=4).

- Currently is generally accepted that Natural mortality may decrease with age, as far as it presumed to be particularly greater at the juvenile phase. It was agreed to adopt for the adult ages of anchovy (ages 1 to 4) the constant natural mortality estimated before (1.3), but for the juveniles (age 0) a greater one in proportion to the ratio of natural mortality at ages 0 and 1 (M_0/M_1) resulting from the application of the Gislason et al. (2010) method for modelling natural mortality as a function of the growth parameters. For it we used four vectors of length-at-age: derived from the Von Bertalanffy growth function in Bellido et al. (2000) for ages 1-5, from the ECOCADIZ-RECLUTAS survey for ages 0-3, the average of the length-at-age in the catches from 1987 to 2016 and the average of the length-at-age in the catches from 2007 to 2016. There was no major basis to select one or the other, we directly choosed the pattern shown by the ECOCADIZ-RECLUTAS data just because it seemed to be smoothest one (particularly for age 1 onwards as presumed here). The ratio M_0/M_1 is 2.722670/ 1.595922 = 1.7. Therefore $M_0 = 1.3 * 1.7 = 2.21$.

- In summary for anchovy 9a South, the adopted natural mortality by ages are $M_0 = 2.21, M_1 = 1.3$ and $M_2^+ = 1.3$ (similar at any older age).

5. Fit to data

A summary of likelihood scores is presented in Figure 1 while a comparison of estimated versus observed data is summarized in the following Figures:

Length distributions

- Figure 2: Length distribution of the commercial fleet.
- Figure 3: Length distribution of the ECOCADIZ acoustic survey.
- Figure 4: Length distribution of the PELAGO acoustic survey.
- Figure 5: Summary of residuals for length distributions.

Age distributions

- Figure 6: Age distribution of the commercial fleet.
- Figure 7: Age distribution of the ECOCADIZ acoustic survey.
- Figure 8: Age distribution of the PELAGO acoustic survey.

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- Figure 9: Summary of residuals for age distributions.

Biomass survey indices fit

- Figure 10: Summary of biomass survey indices fit.

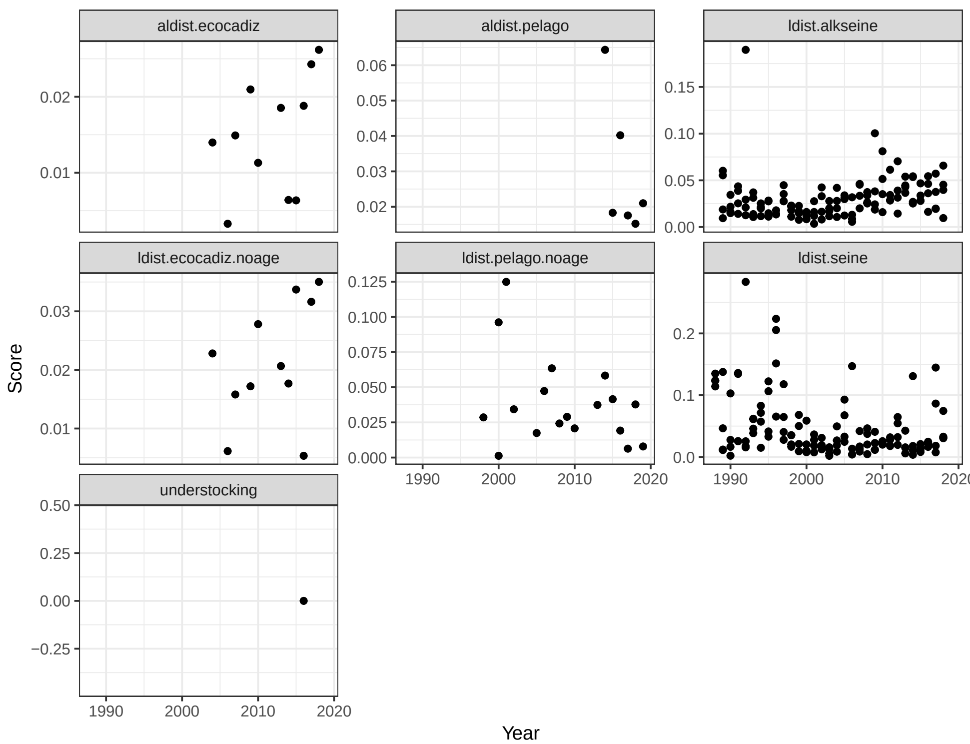

Figure 1: Likelihood scores for age-length key of ECOCADIZ survey, PELAGO survey and commercial landings (Upper panel) and length distribution of ECOCADIZ survey, PELAGO survey and landings. Dots represent the score for each quarter.

Index	
a	Age, $a = 0,\dots,3$
l	Length, $l = 3,3.5,4,4.5,\dots,22$
y	Years, $y = 1989,\dots,2018$
t	Quartely timestep, $t = 1,\dots,4$
T	$T = 1$ for period 1989-2000, $T = 2$ for period 2001-2018
Parameters	
Fixed	
a	Parameter of weight-length relationship $w = al^b$, $a = 3.128958 \times 10^{-6}$
b	Parameter of weight-length relationship $w = al^b$, $b = 3.277667619$
μ_a	Initial population mean length at age
	$\mu_0 = 9.99, \mu_1 = 12.1, \mu_2 = 15.2, \mu_3 = 16.1$
σ_a	Initial population standard deviation for length at age
	$\sigma_0 = 0.836, \sigma_1 = 0.5, \sigma_2 = 1, \sigma_3 = 1.2$
M_a	Natural mortality, $M_0 = 2.21, M_1 = 1.3, M_2 = 1.3, M_3 = 1.3$
n	Maximum number of length classes that an individual is supposed to grow $n = 5$
Estimated	
l_∞	Asympthotic length, l_∞=28.9296
k	Annual growth rate, $k = 0.0559056$
β	Beta-binomial parameter, $\beta = 2.46157$
ν_a	Age factor, $\nu_0 = 0.06, \nu_1 = 0.06,$
	$\nu_2 = 0.06, \nu_3 = 1.91e-08$
μ	Recruitment mean length, $\mu = 9.67398$
σ_t	Recruitment length standard deviation by quarter, $\sigma_2 = 3.0823$, $\sigma_3 = 1.81347$, $\sigma_4 = 3.80204$
$l_{50,T}$	Length with a 50% probability of predation during period T,
	$l_{50,1}^{seine} = 11.8$, $l_{50,2}^{seine} = 11$, $l_{50,3}^{ECO} = 13.7$, $l_{50,3}^{PEL} = 13.3$
α_T	Shape of function, $\alpha_1^{seine} = 0.402$, $\alpha_2^{seine} = 0.993$, $\alpha_3^{ECO} = 1.01$, $\alpha_3^{PEL} = 0.652$
Observed Data	
$E_{y,t}$	Number or biomass landed at year y and quarter t
W_l	Weight at length
$I_{y,t}$	Observed survey index at year y and quarter t
$P_{a,l,y,t}$	Proportion of the data sample over all ages and lengths for timestep/age/length combination
$O_{a,l,y,t}$	Observed data sample for time/age/length combination
$x_{a,y,t}$	Sample mean weight from the data for the timestep/age combination
Others	
Δl	Length increase
Δw	Weight increase
Δt	Length of timestep
$N_{a,l,y,t}$	Number of individuals of age a, length l in the stock at year and quarter y and t, respectively.
$q_{a,l}$	Proportion in lengthgroup l for each age group
$R_{y,t}$	Recruitment at year y and quarter t
$p_{l,t}$	Proportion in lengthgroup l that is recruited at quarter t
$C_{l,y,t}$	Total amount in biomass landed by surveys and in number landed by commercial fleet
$S_{l,T}$	Proportion of prey of length l that the fleet/predator is willing to consume during period T
$\pi_{a,l,y,t}$	Proportion of the model sample over all ages and lengths for that timestep/age/length combination
$\mu_{a,y,t}$	Mean length at age for the timestep/age combination
U_t	Understocking for timestep t
lw_i and uw_i	Weights applied when the parameter exceeds the lower or upper bound
lb_i and ub_i	Lower and upper bound defined for the parameter
val_i	Value of the parameter

Table 1: List of Symbols used in model specification

Data source	type	Timespan	Likelihood function
Commercial landings	Length distribution	All quarters, 1989-2018	See eq. 7
	Age-length key	All quarters, 1989-2018	See eq. 7
ECOCADIZ acoustic survey	Biomass survey indexes	Second quarter 2004, 2006	see eq. 6
		third quarter 2007, 2009, 2010, 2013-2018	
	Length distribution	Second quarter 2004, 2006	see eq. 7
		third quarter 2007, 2009, 2010, 2013-2018	
	Age-length key	Second quarter 2004, 2006	see eq. 7
		third quarter 2007, 2009, 2010, 2013-2018	
PELAGO acoustic survey	Biomass survey indexes	First quarter 1999, 2001-2003	see eq. 6
		second quarter 2005-2010 and 2013-2019	
	length distribution	First quarter 1999, 2001-2003	see eq. 7
		second quarter 2000, 2005-2010, 2013-2019	
	Age-length key	second quarter 2014-2019	see eq. 7

Table 2: Overview of the likelihood data used in the model

Figure 2: Comparison between observed and estimated catches length distribution. Black lines represent estimated data while gray lines represent observed data

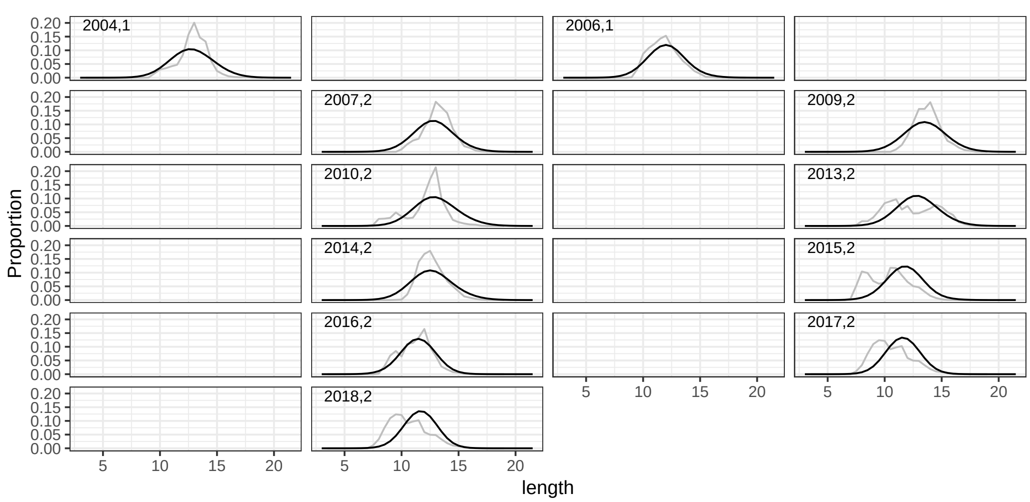

Figure 3: Comparison between observed and estimated catches length distribution for ECOCADIZ survey. Black lines represent estimated data while gray lines represent observed data

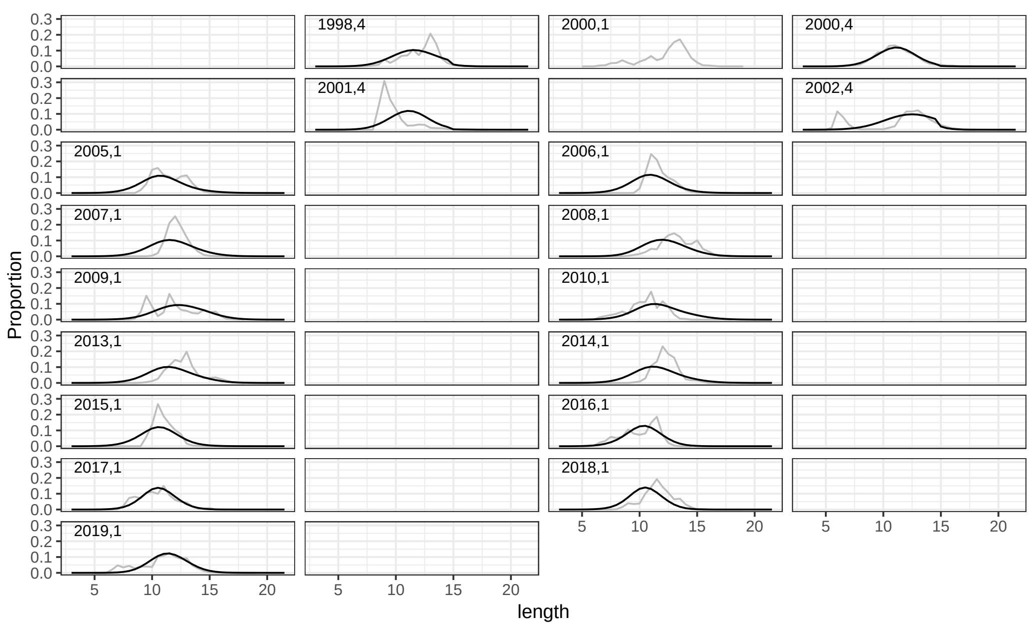

Figure 4: Comparison between observed and estimated catches length distribution for PELAGO survey. Black lines represent estimated data while gray lines represent observed data

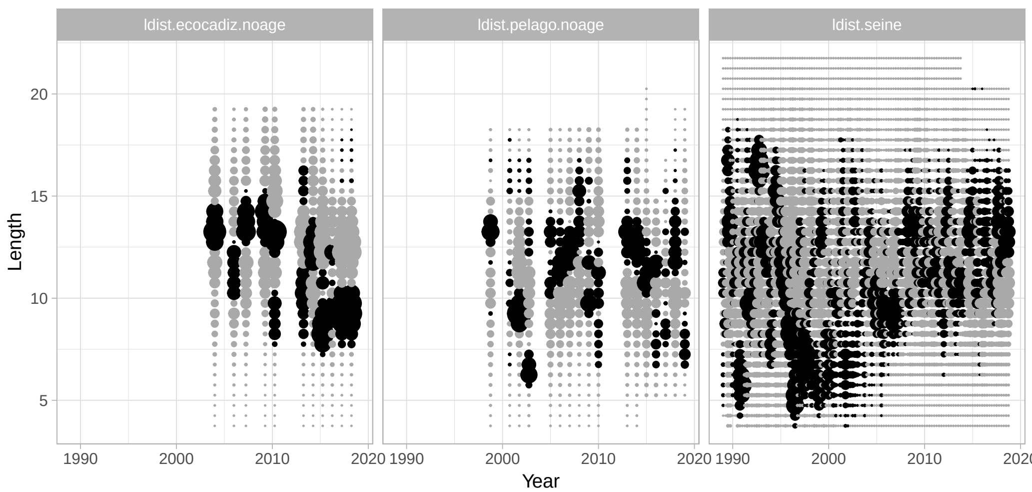

Figure 5: Standardised residual plots for the fitted length distribution from the ECOCADIZ survey, PELAGO survey and commercial landings. Black points denote a model underestimate and gray points an overestimated. The size of the points denote the scale of the standardised residual.

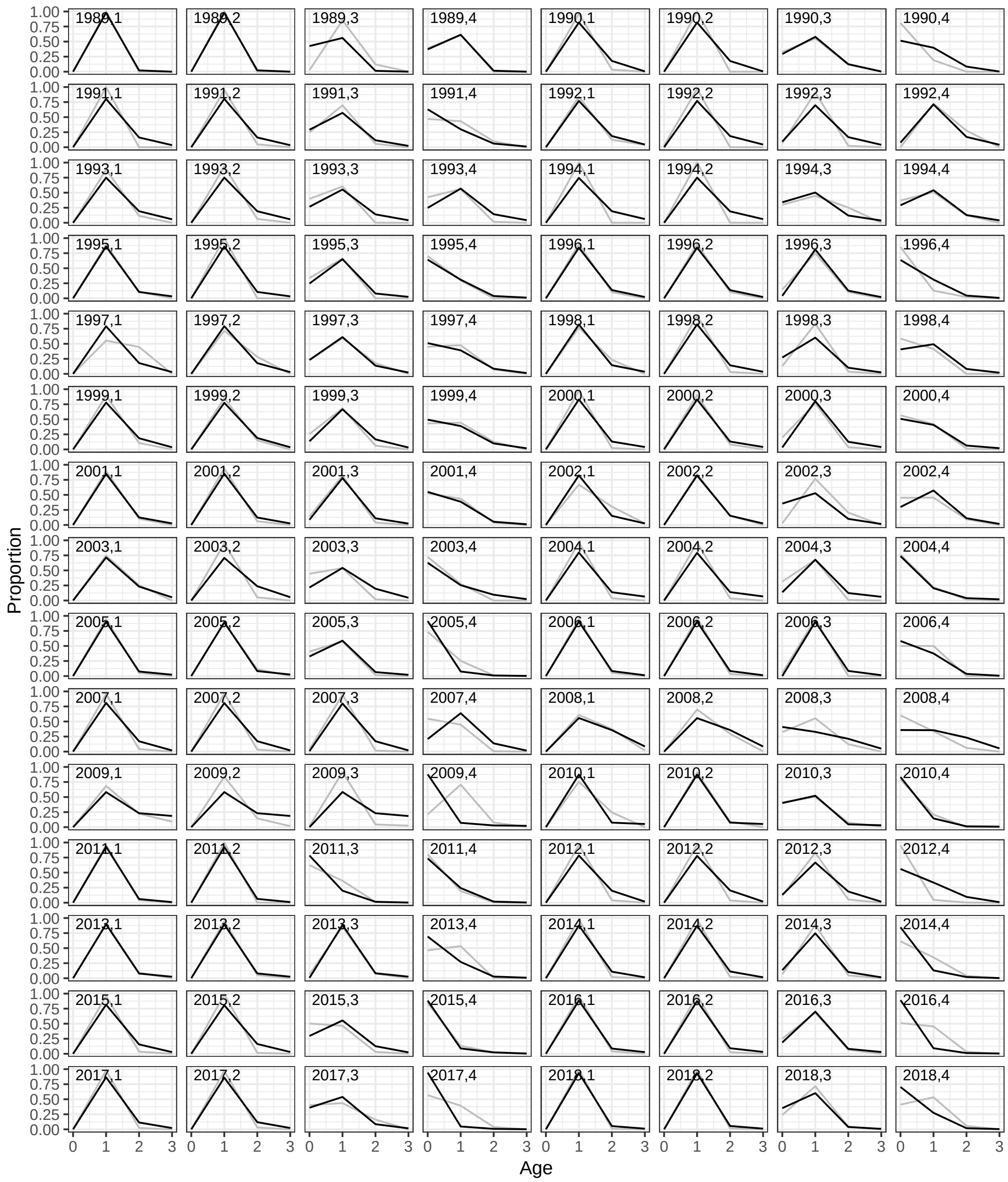

Figure 6: Comparison between observed and estimated catches age distribution. Black lines represent estimated data while gray lines represent observed data.

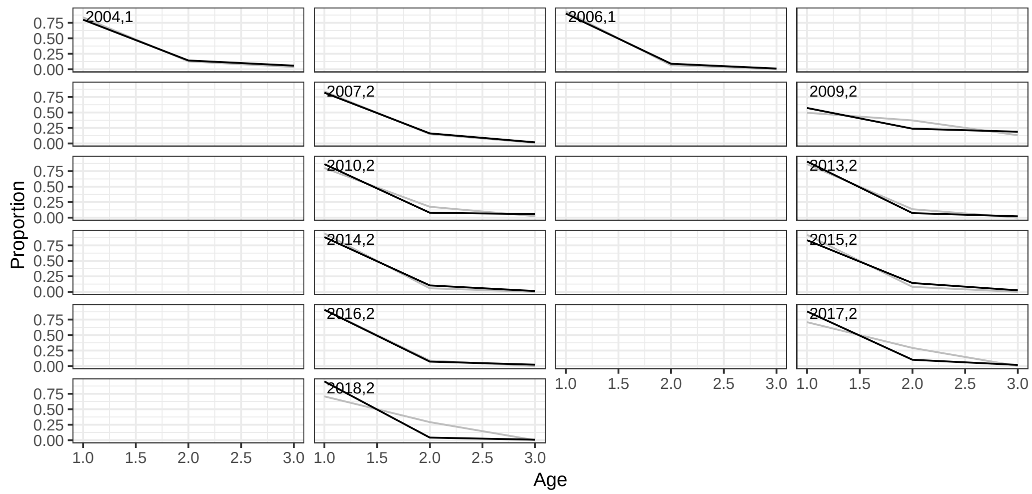

Figure 7: Comparison between observed and estimated ECOCADIZ survey age distribution. Black lines represent estimated data while gray lines represent observed data.

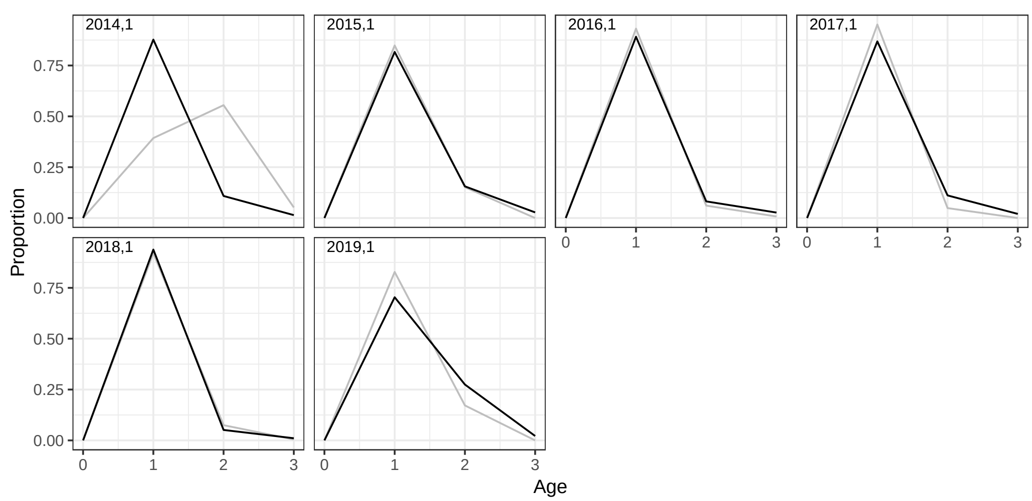

Figure 8: Comparison between observed and estimated PELAGO survey age distribution. Black lines represent estimated data while gray lines represent observed data.

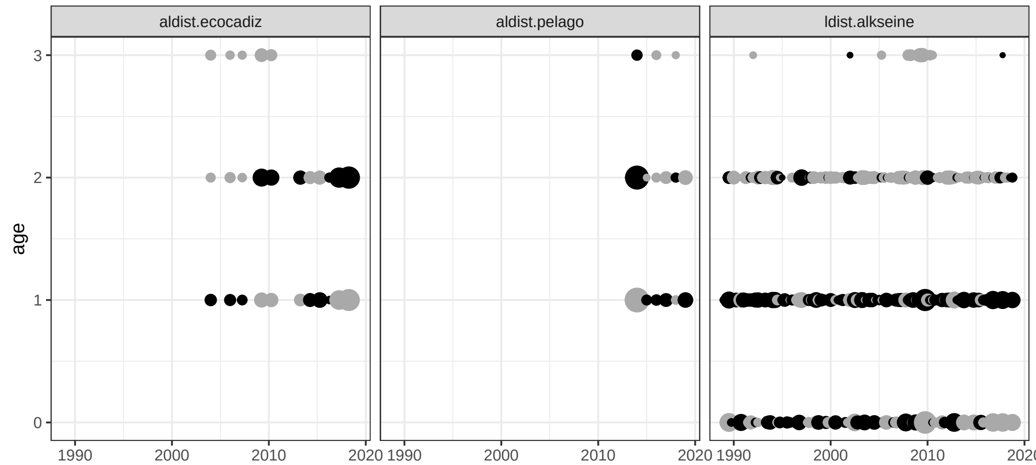

Figure 9: Standardised residual plots for the fitted age distribution from the ECOCADIZ survey, PELAGO survey and commercial fleet. Black points denote a model underestimate and gray points an overestimated. The size of the points denote the scale of the standardised residual.

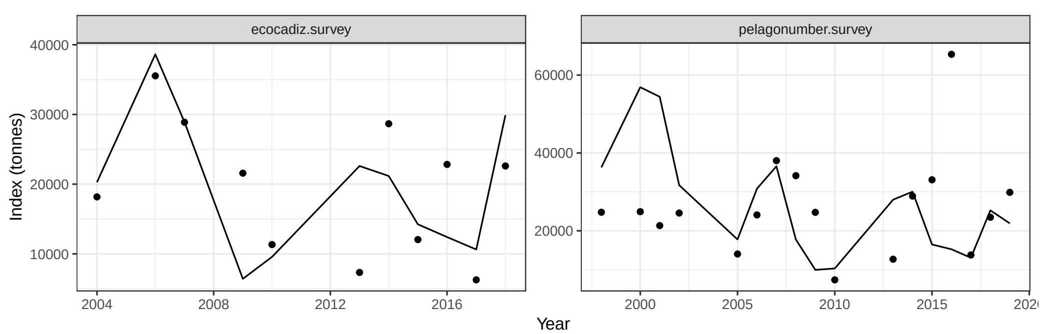

Figure 10: Comparison between observed and estimated survey indices. Black points represent observed data while black line represent estimated data

6. Model estimates

Parameter estimates after optimization are presented in Table 2.

6.1. Catchability

Figure 11 shows the catchability estimated by the model for the different surveys indices

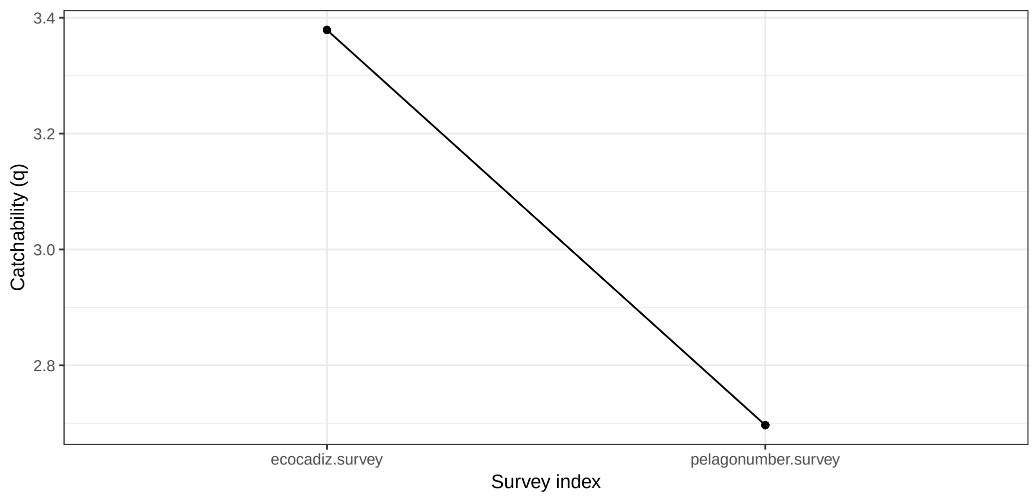

Figure 11: Estimated catchability parameters for the different survey indices

6.2. Suitability

Figure 12 shows the fleet suitability functions estimated by the model for the commercial fleet and different surveys

6.3. Abundance, recruitment and Fishing mortality

Figure 13 presents model annual estimates for biomass, abundance (removing age 0 individuals to be accurate with the time of the assessment, see section 3 above for a detailed explanation), recruitment, fishing mortality and catches **at the end of the second quarter of each year**. Figure 14 shows annual estimates for biomass of individuals of age 1+ at the end of the second quarter of each year. Due to some inconsistencies in the maturity ogives not noticed during WKPELA 2018, we assume that all individuals with age 1 or higher (B_1+), are mature i.e. these abundance estimates result equivalent to spawning stock biomass estimates.

7. Catch advice for July 2019 to June 2020

The ratio between the last year biomass estimate and the mean of the two previous years is:

$$\frac{B_y}{\overline{B_{y-1} + B_{y-2}}} = \frac{5470}{(5720 + 2070)/2} = 1.41$$

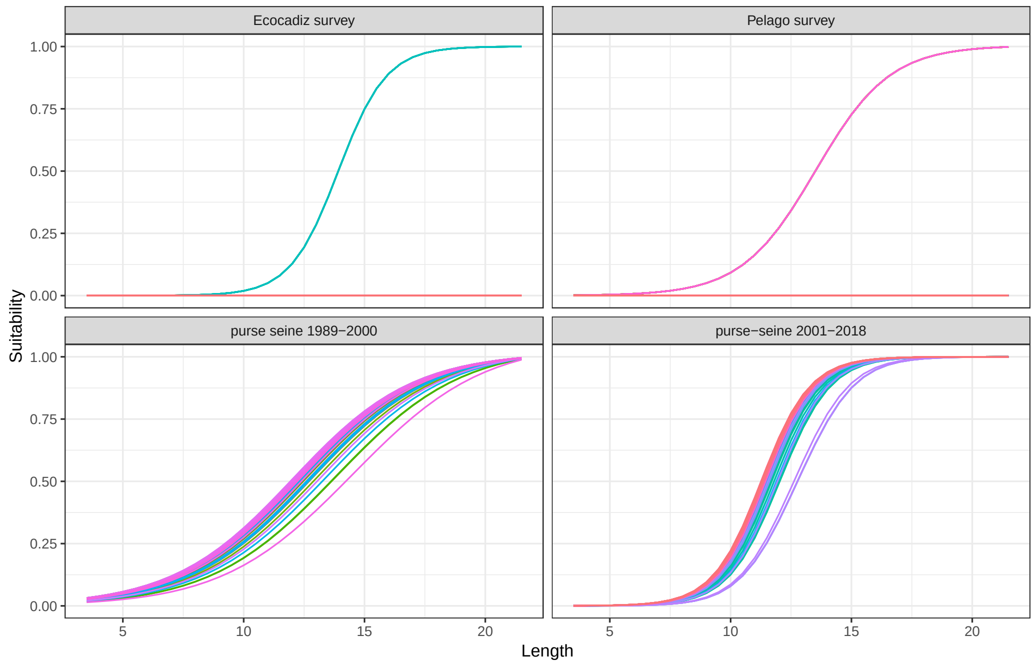

Figure 12: Estimated fleet suitability functions for the commercial fleet and different surveys.

for B representing the estimated abundance by the model as shown in Figure 14. According to Uriarte et al. (2018) presented in WKLIFEVIII and in accordance with the procedure adopted for Anchovy 9.a. West, it was decided by the group to not apply the rule specified in the Stock annex for 2019 advice, instead, it was decided that adviced catches for the next year would be calculated as follows:

$$C_{y+1} = \hat{C}_y \frac{B_y}{(B_{y-1} + B_{y-2})/2}$$

where $\hat{C}_y$ is the value of adviced catches in 2018. Then the adviced catches (in tonnes) for the next year (July 2019 to June 2020) would be:

$$C_{y+1} = 4476 * \frac{5470}{(5720 + 2070)/2} = 6290.$$

8. Reference points

The methodology applied was the same decided in WKPELA 2018 (page 286 of WKPELA 2018 report (ICES, 2018)) following ICES guidelines for calculation of reference points for category 1 and 2 stocks and the report of the workshop to review the ICES advisory framework for short lived species ICES WKMSYREF5 2017 (ICES, 2017).

According to the above ICES guidelines and the S-R plot characteristics (Figure 15), this stock component can be classified as a “stock type 5” (i.e. stocks showing no evidence of impaired recruitment or with no clear relation between stock and recruitment (no apparent $S - R$ signal)). According to this classification, $Blim$ estimation is possible according to the standard method and it is assumed to be equal to $Bloss$ ($Blim = Bloss$).

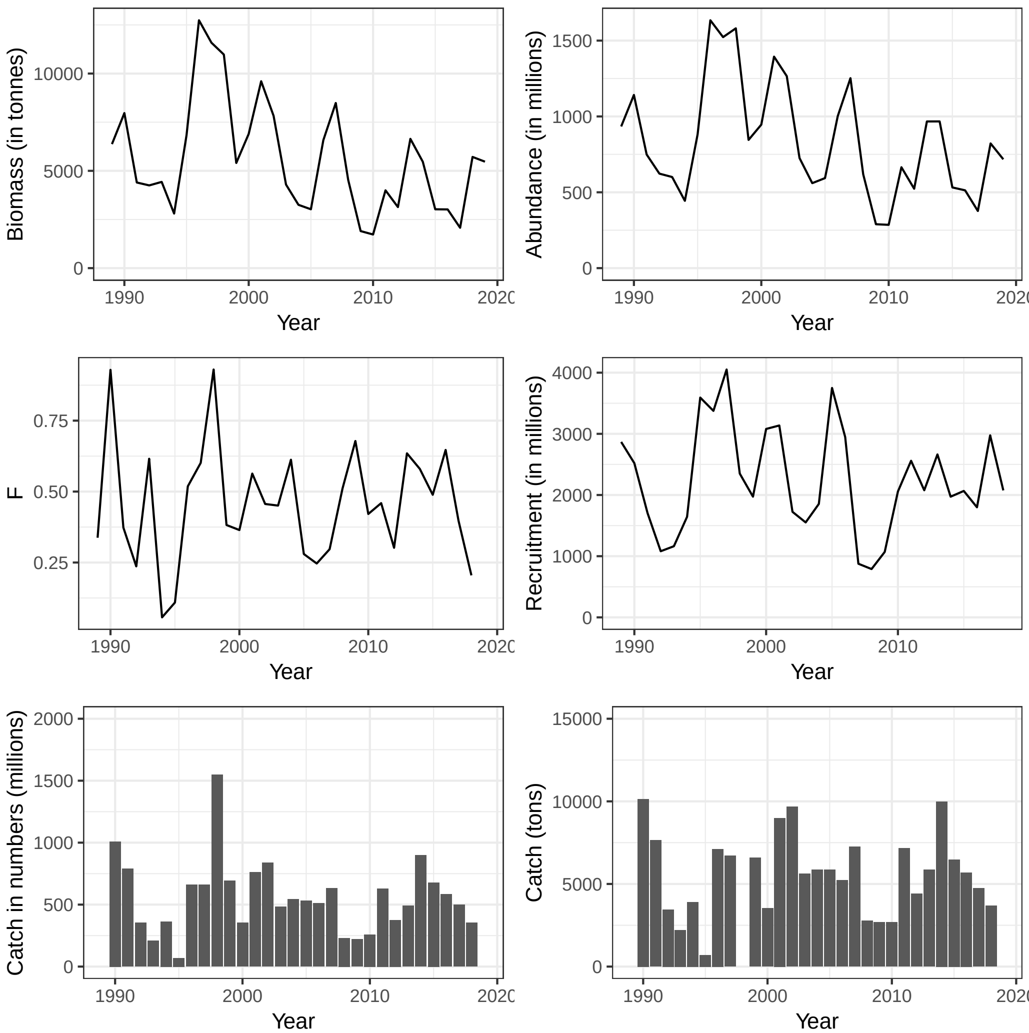

Figure 13: Annual catches time series (in numbers and biomass) compared with annual model estimates for abundance (in numbers and biomass) recruitment and fishing mortality. Measures were summarized at the end of June each year, assuming that a year starts in July and ends in June of the next year.

For 2019 the value of $Bloss$ for the 9a South anchovy corresponds to the estimated SSB in 2010 (1730 t), hence $Blim$ is set at 1730 t and the relative $Blim$ (divided by the mean value of B_1+) results equal to 0.307. Note that due to some inconsistencies in the maturity ogives used in WKPELA2018, age 1+ individuals (B_1+) are assumed as mature i.e. B_1+ class is equivalent to Stock Spawning Biomass (SSB) (see subsection 6.3 above).

ICES recommends to calculate Bpa as follows:

$$Bpa = e^{(1.645\sigma)}Blim,$$

where σ is the estimated standard deviation of $ln(SSB)$ in the last year of the assessment, accounting for the uncertainty in SSB for the terminal year. If σ is unknown and for short living species, as it is in our case, it can be assumed that $\sigma = 0.30$ (see page 34 of ICES WKMSYREF5 2017 report (ICES, 2017)), then $Bpa = e^{(1.645\sigma)}Blim = 1.64Blim$. According to this Bpa is set at 2837.2 t.

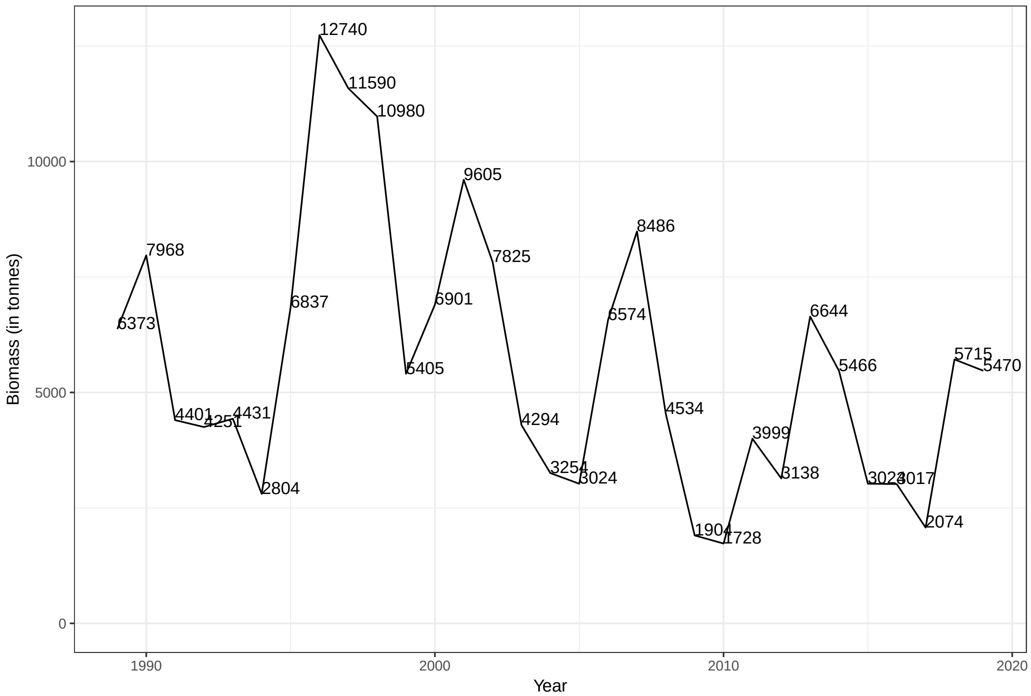

Figure 14: Estimated biomass time series at the end of quarter two (Age 0 removed to be consistent with recruitment at the end of the second quarter of the year). Note that under the assumption that all individuals in $B1+$ class are mature, this biomass is equivalent to SSB

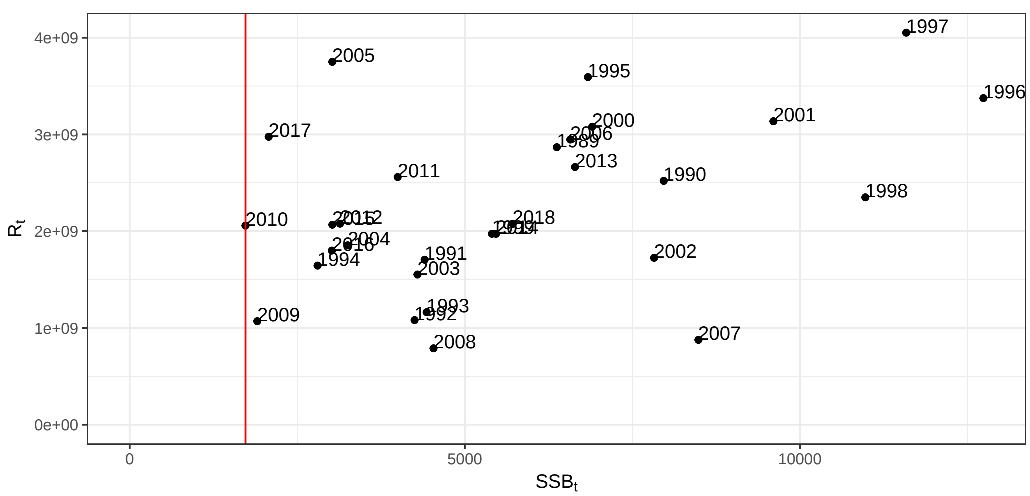

Figure 15: Estimated Stock Spawning biomass (SSB_t) vs. Recruitment (R_t), SSB_t corresponds to the Stock Spawning Biomass at the end of quarter 2 of year t, while R_t corresponds to the sum of the recruitment at the beginning of quarters 3,4 and 1 of years t and $t+1$, respectively.

9. Acknowledgements

We thank Jamie Lentin from Shuttlethread for the automatization of data input, Bjarki Elvarsson for having an open repository with very useful Gadget data processing routines and his valuable help, and to the members of WGHANSA group for their guidance and support.

We gratefully thank CESGA (Galician Supercomputing Center) for computational time at the FTII Supercomputer and technical assistance.

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Model comparison for Anchovy 9.a.South (WGHANSA 2019)

Margarita María Rincón[a,*], Fernando Ramos[b], Andrés Uriarte[c], Leire Ibaibarriaga[c], Susana Garrido[d], Alexandra Silva[d]

[a] *Department of Coastal Ecology and Management, Instituto de Ciencias Marinas de Andalucía, Consejo Superior de Investigaciones Científicas, Avda República Saharaui 2, 11519 Puerto Real, Cádiz, Spain*
[b] *Instituto Español de Oceanografía, Centro Oceanográfico de Cádiz, Puerto pesquero, Muelle de Levante s/n, Apdo. 2609, 11006 Cádiz, Spain*
[c] *Azti-Tecnalia, Herrera Kaia-Portu aldea z/g, E-20110 Pasaia, Gipuzkoa, Basque Country, Spain*
[d] *Instituto Portugues do Mar e da Atmosfera-IPMA, Av. Brasília, 6, 1449-006 Lisboa, Portugal*

The following are the corresponding particular model specifications for the next figures:

* Model 1: Model for 2019 Assessment including catches until June 30th as the 37% of the January to May catches based on historical records

* Model 2: Model for 2018 Assessment (II)

* Model 3: Model for 2018 assessment (II) including Pelago Age-length keys (ALK) 2017 y 2018.

*Corresponding author
Email address: margarita.rincon@icman.csic.es (Margarita María Rincón)

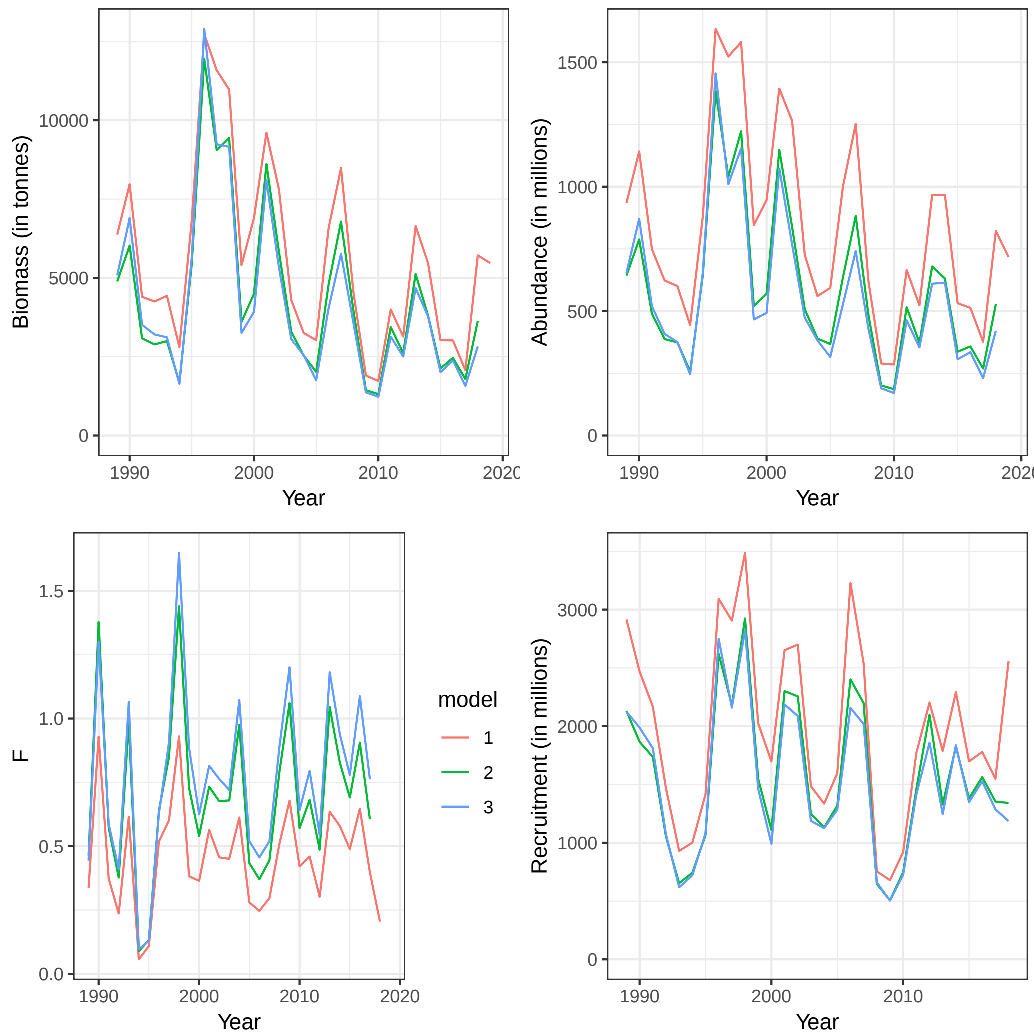


Figure 1: Annual catches time series (in numbers and biomass) compared with annual model estimates for abundance (in numbers and biomass) recruitment and fishing mortality. Measures were summarized at the end of June each year, assuming that a year starts in July and ends in June of the next year.

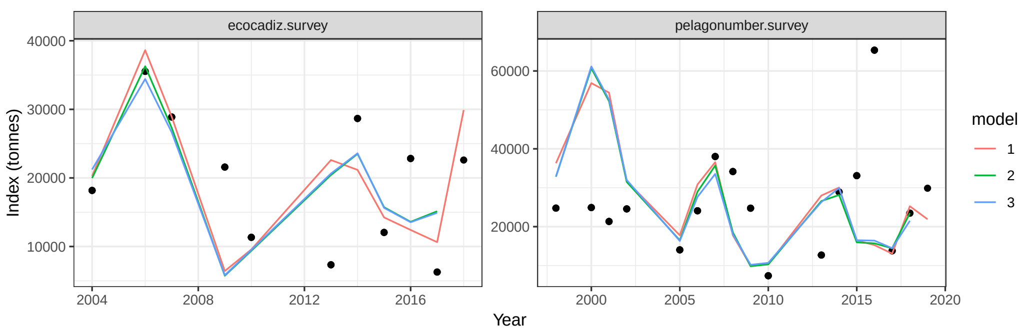


Figure 2: Comparison between observed and estimated survey indices. Black points represent observed data lines represent estimated data

Working document presented in the ICES Working Group on Southern Horse Mackerel, Sardine and Anchovy (WGHANSA-1). By correspondence, 03-07 June 2019.

Analysis of the consistency of the *ECOCADIZ-RECLUTAS* survey series.

Fernando Ramos[(1)], Alexandra Silva[(2)], Margarita Rincón[(3)],Susana Garrido[(2)],

(1) Instituto Español de Oceanografía (IEO), Centro Oceanográfico de Cádiz. Spain.
(2)Instituto Português do Mar e da Atmosfera (IPMA). Portugal.
(3) Instituto de Ciencias Marinas de Andalucía (ICMAN). Consejo Superior de Investigaciones Científicas. España.

Abstract

ECOCADIZ-RECLUTAS is the autumn acoustic survey series conducted by the IEO in the Gulf of Cadiz shelf waters (GoC, ICES subdivision 9a S, 20 – 200 m depth). This series, although planned as a pelagic community/ecosystem survey, is aimed at the acoustic estimation of both GoC anchovy and sardine juveniles. The present WD shows an updating of the previous analysis of the consistency of the *ECOCADIZ-RECLUTAS* series carried out during WKPELA 2018 benchmark with the new available data. Length of the series, geographical and bathymetric coverage and within- and between-survey (against spring *PELAGO* and summer *ECOCADIZ* acoustic surveys) are analyzed. The length of the survey series is still short. The whole survey's area was only surveyed in 2014, 2015, 2016 and 2018, i.e 4 non consecutive data points (a gap in 2017). However, results from the 2018 survey should be considered with caution because of some methodological problems. The results from the analyses on survey consistency, although very promising, are not yet representative enough to consider the inclusion of this surveys series in the Gadget model. *ECOCADIZ-RECLUTAS* series could be used in the future as a good indicator of the recruitment (which is the basis of the fishery) once a longer time-series is available. A time-series with at least 6-7 observations will not be available until 2021.

1. Introduction.

During the 2007 and 2008 meetings of the *ICES Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES areas VIII and IX* (*WGACEGG*) was advanced the possibility of carrying out, since 2009 on, internationally coordinated yearly surveys aimed at the direct estimation of the anchovy and sardine recruitment in the Division 9a (ICES, 2007b, 2008).

The general objective of these autumn surveys should initially be focused in the acoustic assessment by vertical echo-integration and mapping of the abundance and biomass of recruits of small pelagic species (especially anchovy and sardine), as well as the mapping of both the oceanographic and biological conditions featuring the recruitment areas of these species in the Division 9a. The long term objective of the surveys would be to be able to assess the strength of the incoming recruitment to the fishery the next year.

ECOCADIZ-RECLUTAS is the autumn acoustic survey series conducted by the IEO in the GoC (ICES subdivision 9a S) shelf waters (20 – 200 m depth). This series, although planned as a pelagic community/ecosystem survey, is aimed at the acoustic estimation of both GoC anchovy and sardine juveniles. The surveys series, usually conducted during the second fortnight of October, started in 2012 (RV *Emma Bardán*, only Spanish waters sampled), it was then interrupted in 2013, and continued in 2014 (since then onboard RV *Ramón Margalef* and financed with EMFF funds). However, as commented below, the series has suffered of some recent setbacks in 2017 (a very incomplete coverage of the surveyed area caused by a failure in the research vessel propeller system) and 2018 (misconfiguration of the echo-sounder ping rate resulting in a lower ping rate than the standard).

A first assessment of the consistency of this survey series was carried out the last year, during the first benchmark process on the anchovy stock in Division 9a (ane.27.9.a; WKPELA 2018; ICES, 2018a). WKPELA 2018 stated that the *ECOCADIZ-RECLUTAS* series could be used in the future as a good indicator of anchovy recruitment (which is the basis of the fishery) in 9a South once a longer time-series is available. As described before, there are no estimates for the whole area in 2012 and 2017, and a time-series with at least 6-7 observations will not be available until 2021, when the suitability of this series for its inclusion in the assessment could be re-evaluated in a future benchmark.

The ToR b of the WGHANSA-1 in 2019 is focused in the data exploration from juvenile surveys (e.g. *JUVESAR*, *JUVENA*, *ECOCADIZ-RECLUTAS*) for their future incorporation in the respective assessments. The present WD will therefore show an updating of the previous analysis of the consistency of the *ECOCADIZ-RECLUTAS* series with the available new data.

2. Material and methods.

2.1. General

Table 2.1 shows the list of surveys series providing direct estimates for anchovy in Sub-division 9a S. Acoustic and DEPM surveys' methodologies deployed by the respective national Institutes (IPMA and IEO) are thoroughly described in ICES (2008a, 2009) and Massé *et al*. (2018), (see also ane.27.9a Stock Annex). These surveys are coordinated and standardized (updated surveys protocols) since 2005, within the frame of the *ICES Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in areas 7, 8 and 9* (*WGACEGG*). SISP protocols for both acoustic and egg surveys are still in progress. *ARSA* groundfish surveys' protocols are standardized within *ICES International Bottom Trawl Survey Working Group* (*IBTS*). SISP protocols for these IBTS surveys are described in ICES (2017).

Figure 2.1 shows the sampling grid adopted in *ECOCADIZ-RECLUTAS* survey series.

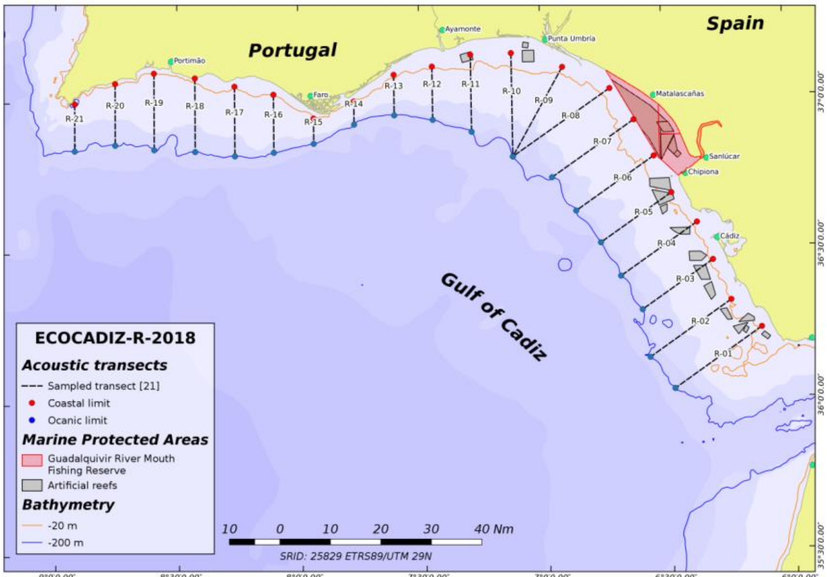


Figure 2.1. Ane.27.9a stock. Southern component. *ECOCADIZ-RECLUTAS* autumn survey series. Location of the acoustic transects sampled during the survey (2018 survey used as example). The different protected areas inside the Guadalquivir river mouth Fishing Reserve and artificial reef polygons are also shown.

Table 2.1. Ane.27.9a stock. Southern component. Surveys providing direct estimates for anchovy in Subdivision 9a South. (1): surveys analyzed since 2008 in the trends-based qualitative assessment (since 2018 a Gadget model is used for providing biomass indicators); (2): *ECOCADIZ-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). Sources: ICES WGHANSA, ICES WGACEGG, ICES IBTS.

Survey	**PELAGO**		**SAR**	**ECOCADIZ**		**ECOCADIZ-RECLUTAS**	**BOCADEVA**		**ARSA**
Institute (Country)	**IPMA (Portugal)**		**IPMA (Portugal)**	**IEO (Spain)**		**IEO (Spain)**	**IEO (Spain)**		**IEO (Spain)**
Method	**Acoustic**		**Acoustic**	**Acoustic**		**Acoustic**	**DEPM**		**Bottom trawl**
Year/Quarter	**Q1**	**Q2**	**Q4**	**Q2**	**Q3**	**Q4**	**Q2**	**Q3**	**Q4**
1993									Nov
1994									
1995									
1996									
1997									Nov
1998			Nov						Nov
1999	Mar (1)								Nov
2000			Nov						Nov
2001	Mar (1)		Nov						Nov
2002	Mar (1)								Nov
2003	Feb (1)		(Nov)						Nov
2004		(Jun)		Jun(1)					Nov
2005		Apr(1)	(Nov)				Jun(1)		Nov
2006		Apr(1)	(Nov)	Jun(1)					Nov
2007		Apr(1)	Nov		Jul (1)				Nov
2008		Apr(1)	(Nov)				Jun(1)		Nov
2009		Apr(1)		Jun(1)	(Jul)(2)	(Oct)			Nov
2010		Apr(1)			(Jul)(1)				Nov
2011		Apr(1)						Jul(1)	Nov
2012						Nov			Nov
2013		Apr(1)			Aug(1)				Nov
2014		Apr(1)			Jul(1)	Oct		Jul(1)	Nov
2015		Apr(1)			Jul(1)	Oct			Nov
2016		Apr(1)			Jul(1)	Oct			Nov
2017		Apr(1)			Jul(1)	(Oct)		Jul(1)	Nov
2018		April			Jul	Oct			Nov

2.2. Survey consistency.

Two methods of examining *ECOCADIZ-RECLUTAS* survey consistency have been used for anchovy in 9a S: within-survey consistency and between-survey consistency. These methods mainly follow to those adopted in the 2004 ICES Study Group on Assessment Methods Applicable to Assessment of Norwegian Spring-Spawning Herring and Blue Whiting Stocks (SGAMHBW; ICES, 2004; see also Payne *et al*., 2009).

Within-survey consistency:

$\boldsymbol{N_{a,y,s}}$ is the abundance index for age *a*, year *y*, and survey *s*. Within-survey consistency may be expressed as correlation coefficients calculated over years between the $\boldsymbol{N_{a,y,s}}$ and $\boldsymbol{N_{a+1,y+1,s}}$. These correlation coefficients offer an indication of the ability of survey *s* to track year class strength effects. This has been done in the linear domain to allow for zeros as these are often present in the data, if correlation of log(***N***) was preferred, the log of (***N+k***) would need to be used, where ***k*** is a small constant depending on the scaling of ***N***. A value of ***k*** of half of the ***min{N}*** might be preferred (ICES, 2004b). In the current analyses ***k*** was set equal to 4 million fish (***min{N}*** = $\boldsymbol{N_{2,2015}}$=7.2 millions) In addition to the correlation coefficients, bi-variate plots were examined to check for linearity and the absence of a spuriously high correlation resulting from one or two outliers.

There are limits to the interpretation of such correlation coefficients. If for a stock the variability of the true year class strength is low within the observed period, this leads to lower correlations and conversely high variability in recruitment leads to potentially high correlation. Also, when we calculate a correlation coefficient between the two variables ***X1(y)*** and ***X2(y)*** with $\boldsymbol{X1(y) = N_{a,y,s}}$ and $\boldsymbol{X2(y) = N_{a+1,y+1,s}}$ we are measuring the adequacy of a linear relation of the form $\boldsymbol{X2(y) = \alpha\, X1(y) + \beta}$. We accept or assume that the corresponding value for $\boldsymbol{\alpha}$ may not be equal to one due to mortality or survey catchability. But this also implies that we may need to accept that the catchability coefficients associated to age ***a*** and/or ***a+1*** may vary with year class strength. In most cases, in assessments this is not allowed. However, for the sake of simplicity, it was decided to use basic correlation coefficients, as they prove a useful indicator. They may highlight specific difficulties, including phenomena that would deserve further biological interpretation, for instance, when it appears that a survey can efficiently track year class strength effects within an age range, but not necessarily the same age range as another survey. This implies even for adult it may be preferable to limit the upper ages used for tuning for some surveys.

To visualize the correlation in the surveys, plots were made, where the numbers at age ***a*** are plotted versus the numbers at age ***a+1*** in the series. The points are marked as the year class so it is possible to follow the year classes through the time series. A linear regression was made where the line is forced through the origin. The fitted line is shown. Age indices from the 2018 survey were not considered in the analyses because of the abovementioned methodological problems with this survey.

Within-survey consistency is completed with survey-based catch curves for each of the year classes (i.e. cohorts) present in the assessed population and an analysis of survey's catchabilities at age. In the first case, natural logarithms of abundance indices (***ln(N+k)***) for successive ages composing the cohort are plotted and a regression line and model is fitted to the right descending limb of the curve. The abundance index for age 0 (not fully recruited to the adult population), was neither plotted nor fitted to the regression line for the purposes of graphical representation. This analysis allows rapid assessment of the consistency of the abundance indices with the presumed model that such indices (in numbers) should decline consistently with age, as influenced by natural and fishing mortality and appropriate catchabilities at age for survey catches. If cohorts are poorly tracked due to fluctuating distribution patterns, poor sampling or other factors influencing seasonal or annual catchability, then catch curves should not demonstrate consistent descending right-hand limbs.

Survey's catchabilities at age throughout those cohorts tracked by the survey series (for those surveys with a complete geographical coverage), $q_{a,a+1;y,y+1;s}$, were computed as follows:

$$\left(\frac{I_{a,y}}{q} - C_{a,y}\right) e^{-M_a} = \frac{I_{a+1,y+1}}{q}$$

$$\left(\frac{I_{a,y}}{q}\right) e^{-M_a} - \frac{I_{a+1,y+1}}{q} = C_{a,y}\, e^{-M_a}$$

$$q = \frac{I_{a,y}\, e^{-M_a} - I_{a+1,y+1}}{C_{a,y}\, e^{-M_a}}$$

Where I denotes the survey index at age and C the catch number at age. The natural mortality estimates, M, at age 0, 1 and 2+ are 2.21, 1.30 and 1.30, respectively (ICES, 2018a,b).

(Ad hoc)Between-survey consistency

The approach followed here differs from the described one in ICES (2004). In that report, the between-survey consistence for a given age was analyzed by measuring the existing correlation between abundance indices for that age provided by two surveys, s_1 and s_2. In our particular case, plots were made where the numbers at age 0 in the autumn survey were separately plotted against the numbers at age 1 in the following year in the spring *PELAGO* and summer *ECOCADIZ* surveys. An additional correlation was also made between juvenile age 0 fish from the autumn survey and the estimate of the recruitment in the following year as estimated by the assessment analytical model (Gadget model, see ICES 2018b). A linear regression was made where the line was forced through the origin. The fitted line is shown in the plots.

A comparison of within-survey consistency and between-survey consistency may be used as a first stage to identifying ages that may be unsuitable for tuning (ICES, 2004b).

3. Results.

3.1. Length of the series.

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, **Table 2.1**). 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 was considered as the first survey within its series (Ramos *et al*., 2013).

ECOCADIZ-RECLUTAS 2014-10 re-started the series and it was conducted with the R/V *Ramón Margalef*. There were also surveys in 2015 and 2016. The 2017 survey should be the fifth survey within its series. However, an unexpected a serious breakdown of the vessel's propulsion system led to an early termination of the survey, which restricted the surveyed area to the one comprised by the seven Spanish easternmost transects only.

The most recent survey, *ECOCADIZ-RECLUTAS 2018-10*, will be, therefore, the fifth survey in the series surveying the whole area, although some methodological problems related with the acoustic sampling coverage (ping rate) should be carefully taken into account when dealing with the final acoustic estimates and interpreting their trends. The recently installed EK80 echo-sounder was utilized for the first time by our team. Unfortunately, a misconfiguration of the echo-sounder ping rate was detected *a posteriori*, during the phase of acoustic data post-processing. The ping-rate during the acoustic sampling resulted to be very low, about 1.5-2.0 seconds, and this was caused by the erroneous generation of an active layer with a range deeper than the recording depth or visualization scale. Such an error entailed to slow down the ping rate (1.5-2.0 seconds) in relation to the standard values (at about 0.3 seconds), resulting an acoustic sampling rate much lower than it should be. Therefore, the recording of acoustic densities may possibly be lower than the real one. This error may have implications in the final estimates of abundance and biomass which may be computed from the above under-sampled acoustic densities. Therefore, the results from this acoustic sampling and the resulting estimates from this survey should be considered with caution.

Summarising, **the length of the survey series is still short**. The whole survey's area was only surveyed in 2014, 2015, 2016 and 2018, **4 non consecutive data points (a gap in 2017)**. A time-series with at least 6-7 observations will not be available until 2021.

3.2. Geographical and bathymetric coverage.

The survey series, although planned as a pelagic community survey, is aimed at the acoustic estimation of both GoC anchovy and sardine juveniles and restricted to the Sub-division 9a S (20 – 200 m depth).

A deepest limit of the surveyed area established at the shelf break does not pose any problem in the sampling coverage of the GoC anchovy juvenile fraction since they are distributed over the inner-middle shelf waters. The problem here, however, concerns to the shallowest limit to be sampled in these autumn surveys. Thus, the conduction of such surveys should require, at least in the Gulf of Cadiz (GoC), of an appropriate acoustic sampling of the shallowest waters (< 20 m depth) 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 fish biomass in this area might be important and must be taken into account in assessment methods in order to avoid underestimation and misleading interpretations in population dynamics (Brehmer *et al*., 2006). In fact, several evidences reported in the literature (García-Isarch *et al*., 2003; Baldó *et al*., 2006; ICES, 2007a); emphasize the importance of this unsampled area as spawning, nursery and recruitment area for anchovy and sardine.

For the reasons given above, in this last area the inshore coverage should be extended below the 20 m isobath to accommodate the potential presence of anchovy (and sardine) juveniles (especially young anchovy) at lower depths. Furthermore, this inshore coverage also should be taken into account when planning the conventional “pelagic ecosystem” surveys.

The standard approach to tackle the problem of acoustically surveying shallow waters using vertical echosounding (VES) is based on the conduction of a survey of these waters with a small-draught vessel complementary to the “standard” survey carried out by the conventional research vessel (see e.g. Gerlotto *et al*., 1992; Guillard and Lebourges, 1998; Brehmer *et al*., 2006). In this context, the *PACAS* experiments (*Pilot experiments of Acoustic surveying of pelagic resources in the Gulf of CÁdiz Shallow waters* (< 20 m depth)) were planned by IEO during 2008 (ICES, 2008; **Figure 3.2.1**). The available research vessels selected as candidates to be tested in these pilot surveys were the IEO’s R/V *Francisco de Paula Navarro* and the Ministry of the Environment, and Rural and Marine Affairs’s R/V *Emma Bardán*, but their respective draughts (4.26 and 3.90 m, respectively) were not surprisingly much smaller than the one of the IEO’s flagship in those years (R/V *Cornide de Saavedra*, 4.65 m draught). Unfortunately, ship-time available for each vessel was short: 7 days in July for the R/V *Fco. de Paula Navarro* (*PACAS 0708* survey: 17 – 24 July) and 6 days in October for the R/V *Emma Bardán* (*PACAS 1008* survey: 11 – 17 October). For such reasons the objectives of these experiences only focused on the assessment of the suitability for the surveying of shallow pelagic waters of both the available acoustic equipment (echo-sounders and net-sonders and/or sensors) onboard each research vessel and their sampler gears. The acoustic assessment itself was not considered a relevant issue for these experiences, hence no extra-time was invested in the calibration of acoustic equipments although some tests for recording the “self-noise” generated either on or by the vessel were performed. From both experiments it was demonstrated that the acoustic surveying of very shallow waters in the study area is possible whenever the sea conditions are lower than state 4 in the Douglas scale. The recorded echograms during those experiences showed the occurrence in conventionally unsampled shallow waters of much contrasted situations in relation to the school number, size and density of schools, also including relatively big and dense schools. Such data were, therefore, clearly indicative of the necessity of surveying these shallow waters in order to obtain an unbiased estimation of the population abundance of neritic species in the study area. More details on these experiments were reported in the 2008 WGACEEG report (ICES, 2008).

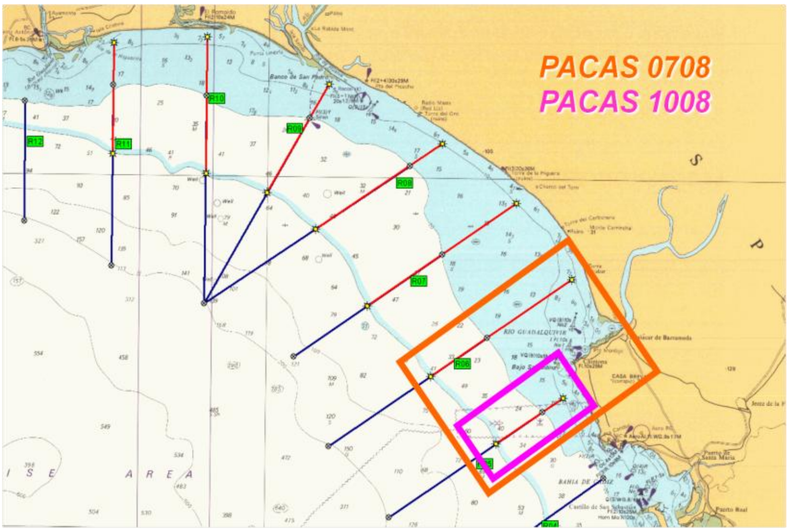


Figure 3.2.1. Ane.27.9a stock. Southern component. *ECOCADIZ-RECLUTAS* autumn survey series. *PACAS* pilot surveys in 2008. Initially foreseen sampling grid for the *PACAS* pilot experiences (transects in red, inter-spaced 8 nm, from the 50 m depth up to the shallowest depth possible). This sampling grid partially overlaps with the one of the conventional IEO acoustic surveys in the area (in blue, *ECOCADIZ* survey series, from 20 – 200 m depth). Orange and purple boxes include to the acoustic transects finally surveyed in the *PACAS 0708* and *PACAS 1008* surveys, respectively.

Following the above approach, the *ECOCADIZ 0609* survey in 2009 was complemented with a new one, *ECOCADIZ-COSTA 0709*, conducted almost synchronously to the former conventional survey with the IEO's R/V *Francisco de Paula Navarro* in shallower waters than 20 m depth off the central part of the study area (Ramos *et al.,* 2010; **Figure 3.2.2**). Given that the acoustic equipment used in the coastal survey *ECOCADIZ-COSTA 0709* was not properly calibrated, the resulting estimates from this coastal survey could only be considered as an approximation. Acoustic energies were not very high in the shallowest waters in that survey. Nevertheless, the results demonstrated that coastal shallow waters not covered by conventional surveys may hold a relatively important biomass.

In any case, the use of single-beam vertical echo-sounding (and sonar) in very shallow waters (<10-5 m depth) poses serious limitations (Gerlotto *et al*., 2000), namely:

- The transducer's distance to the target, *R*: may be of the same order of magnitude than the target dimension *l* (and not negligible as it should be) and, therefore, theoretical assumptions on underwater acoustics may be violated (e.g., assumptions on target cross section, σ). The near field (distance) of the transducer may also dramatically increase in very shallow waters where use of narrow beams is required.
- The multiple reverberations between target and very close boundaries (surface and bottom) result in an echo which will appear either longer or even multiple.
- The sampling volume: extremely small, insufficient and not representative of the area.
- The significance of target strength *TS* values: shallow waters imply that high frequencies be selected (e.g., 120 kHz), in order to allow a reduction in the pulse length, and necessitate the use of narrow beam transducers with reasonable dimensions. This may induce an increasing directivity of the fish echoes and a high variability of *TS* according to the tilt (or incident) angle of the fish main axis (furthermore, available *TS* values are estimated at 38 kHz).
- The fish behaviour: at small distances, in particular vertically, fish behaviour becomes a major source of bias. Under most conditions, in depths smaller than 10 m, vertical

acoustics should be used with extreme care due to the high probability of avoidance behaviour.

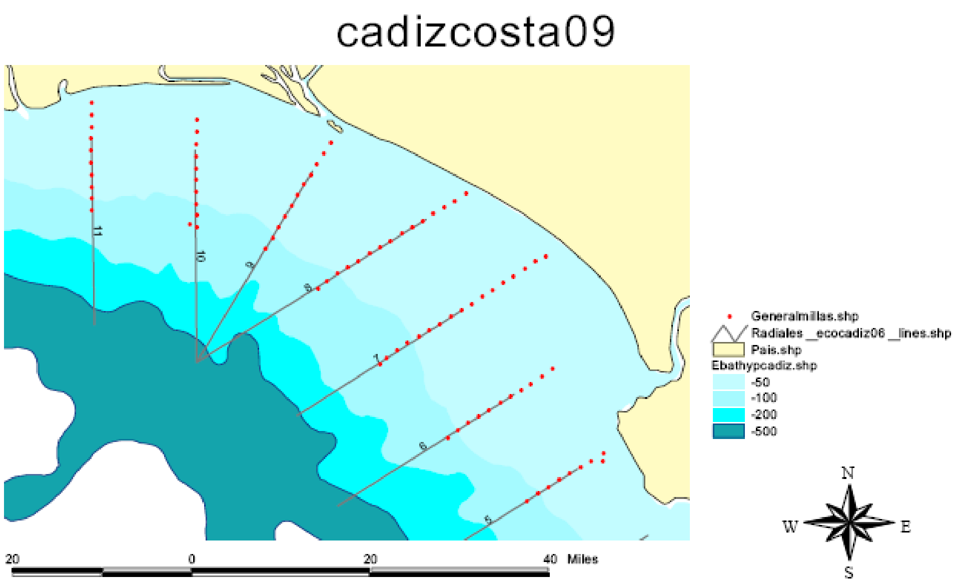


Figure 3.2.2. Ane.27.9a stock. Southern component. *ECOCADIZ-RECLUTAS* autumn survey series. *ECOCADIZ-COSTA 0709* survey. Survey transects (red dotted lines) for the coastal survey superimposed for comparison to the sampling grid of the conventional survey (grey numbered lines).

Since 2014, the RV *Ramón Margalef* is the vessel utilized in the conduction of the *ECOCADIZ-RECLUTAS* surveys. The vessel has a 4.20 m draught but it is increased up to 6.70 m during the acoustic sampling because of the use of echo-sounder transducers arranged in a 2.5 m protracted keel. The abovementioned limitations on the use of the vertical echo-sounding in shallow waters are still applicable to the current situation and led us **to maintain** since then **the shallowest limit of the surveyed area in the "standard" 20 m depth limit and to necessarily assume some undersampling of the anchovy and sardine juvenile (and adult) population fraction(s)**.

As mentioned above, **the whole survey area was not covered in 2 surveys**: 2012 (only Spanish waters) and 2017 (only the 7 easternmost transects over the Spanish waters).

3.3. Data availability.

GoC anchovy population estimates are provided without a measure of dispersion. **The series provides the size composition (LFD) and age-structure of the estimated population in numbers and biomass**. **Table 3.3.1** summarizes the data availability from Portuguese and Spanish surveys surveying the anchovy population in 9a S.

Figure 3.3.1 shows the (still short) time series of abundance and biomass estimates. The estimated abundances for the whole population (for the period with a complete coverage of the surveyed area, i.e. surveys in 2014-2016 and 2018) oscillated between 953 (2018) and 5 227 (2015) million fish (average: 2 708 million fish). The range of biomass estimates oscillates between 8 113 (2014) and 30 827 (2015) t (average: 17 324 t). Estimates for Age 0 anchovies ranged between 51 (2014) and 5 117 (2015) million fish (average: 2 289 million fish) for abundance and between 541 (2004) and 29 219 (2015) t (average: 12 391 t) for biomass.

Size composition of the estimated population ranged between 4.5 and 17.5 cm size classes (**Figure 3.3.2**). The time series of LFDs of the estimated population usually shows bi-modal LFDs, with the smallest, and usually the dominant mode between 7.5 and 10.0 cm size classes and the largest one between 10.0 and 15.0 cm size classes depending on the year.

Age-structure of the estimated population is shown in **Figure 3.3.3**. In the surveyed population in autumn are only present from 0 to 2 years old anchovies, with the bulk of the population, excepting in 2014, being composed by age 0 juveniles (with contributions of 94-99% in abundance, and 80-97% in biomass). Juveniles in the anomalous 2014 only contributed with 5% in abundance and 7% in biomass. Only the 2013 year class clearly outstand as a strong cohort (as age 1 anchovies in 2014). The 2015 year class started to strongly recruit to the population in autumn 2015, and such strength still persists in the following year, at least as Age 1 anchovies estimated by the *PELAGO* spring- and *ECOCADIZ* summer surveys. The 2016 year class, however, showed weaker as incoming year class in 2017.

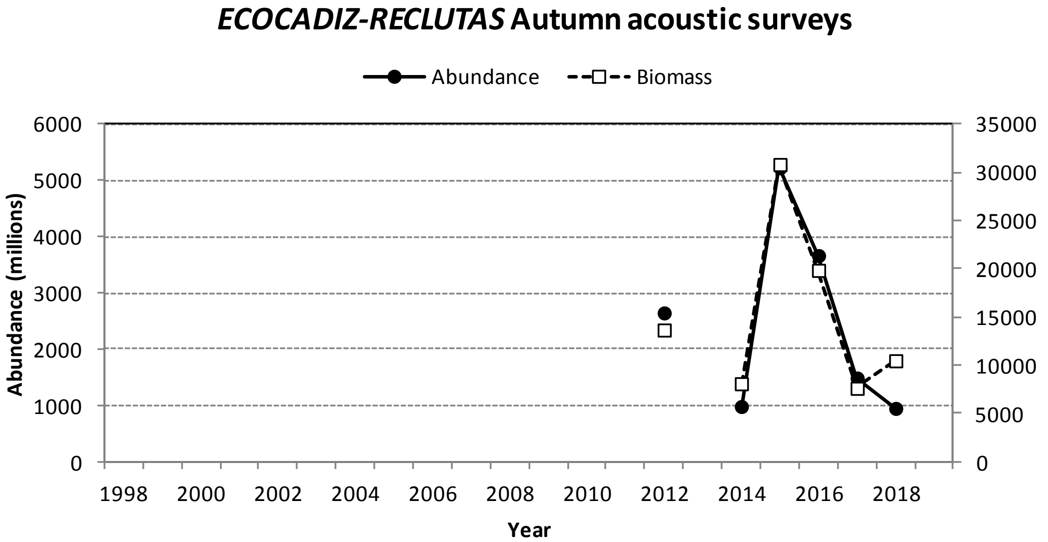
Table 3.3.1. Ane.27.9a stock. Southern component. Data availability of surveys estimates from the Portuguese (PT) and Spanish (ES) surveys. All but *BOCADEVA* survey (DEPM) and *ARSA* (bottom trawl) are acoustic surveys. White background means no data, orange: aggregated biomass only-based estimates; blue: length-based estimates available and green: both length- and age-based estimates.

SURVEY	SUB-DIVISION	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
PELAGO	9a S (PT)																											
	9a S (ES)																											
ECOCADIZ	9a S (PT)																											
	9a S (ES)																											

SURVEY	SUB-DIVISION	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
BOCADEVA	9a S (PT & ES)																											

SURVEY	SUB-DIVISION	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
SAR (AUT)	9a S (PT)																											
	9a S (ES)																											
ECOCADIZ-RECLUTAS	9a S (PT)																											
	9a S (ES)																											

	Aggregated estimates
	Length-based estimates
	Length- and age-structured estimates



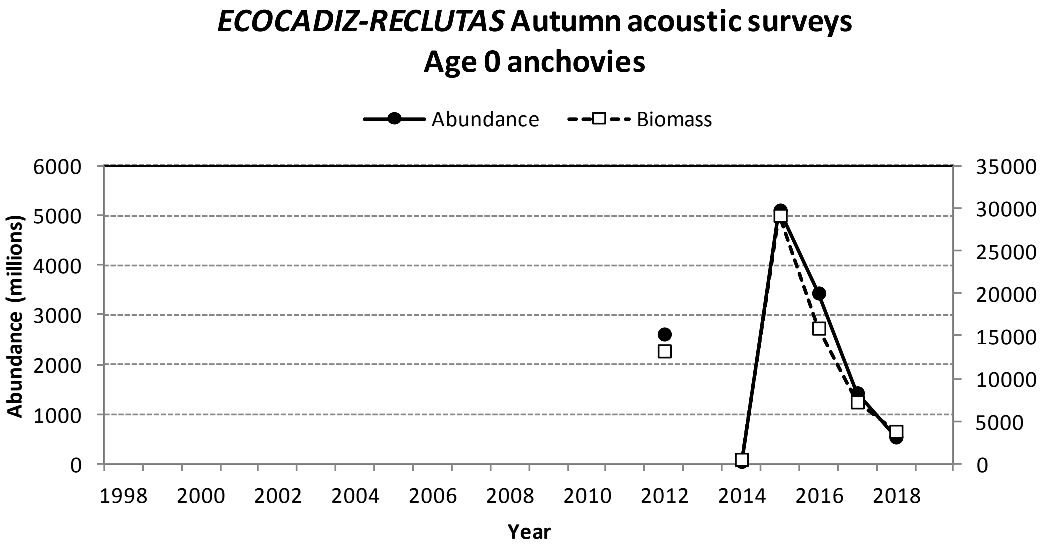


Figure 3.3.1. Ane.27.9a stock. Southern component. *ECOCADIZ-RECLUTAS* autumn survey series. Time series of abundance (millions) and biomass (t) acoustic estimates. The 2012 survey only surveyed the Spanish waters of the Gulf of Cadiz, the 2017 survey only surveyed the seven Spanish easternmost transects. Upper panel: total population estimates. Bottom panel: Age 0 fish estimates.

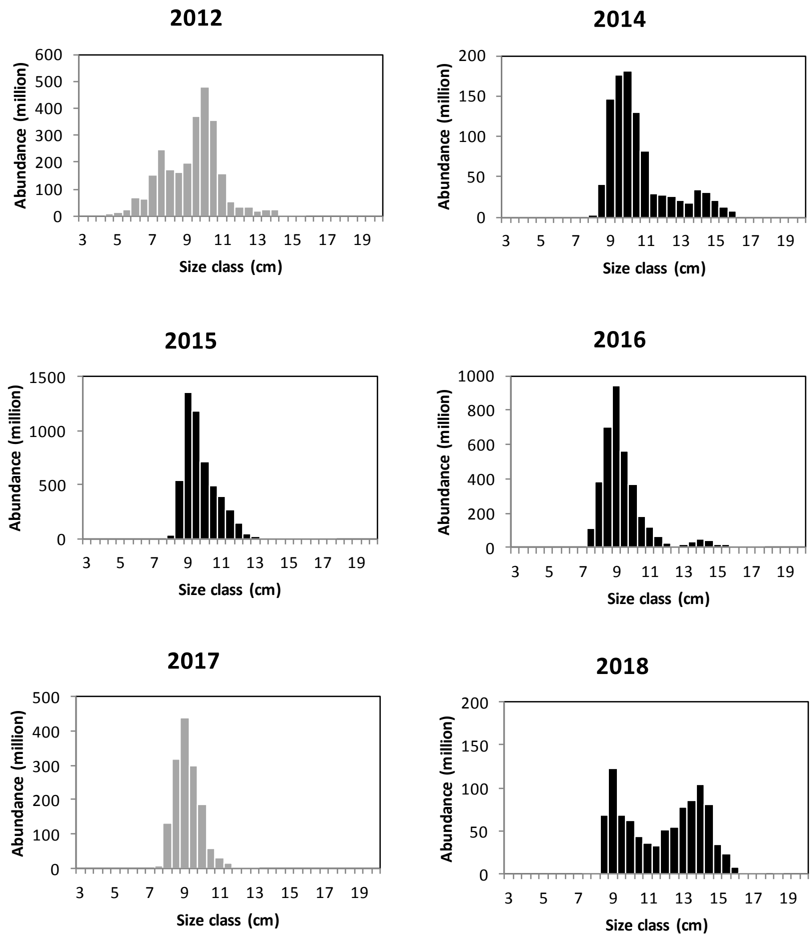


Figure 3.3.2. Ane.27.9a stock. Southern component. *ECOCADIZ-RECLUTAS* autumn survey series. Size composition (0.5 cm size classes) of the estimated population (millions). Note the different scale of the y axis and the occurrence of gaps through the series. In dark grey those surveys with incomplete coverage of the surveyed area (2012: Spanish waters only; 2017: only surveyed the seven Spanish easternmost transects).

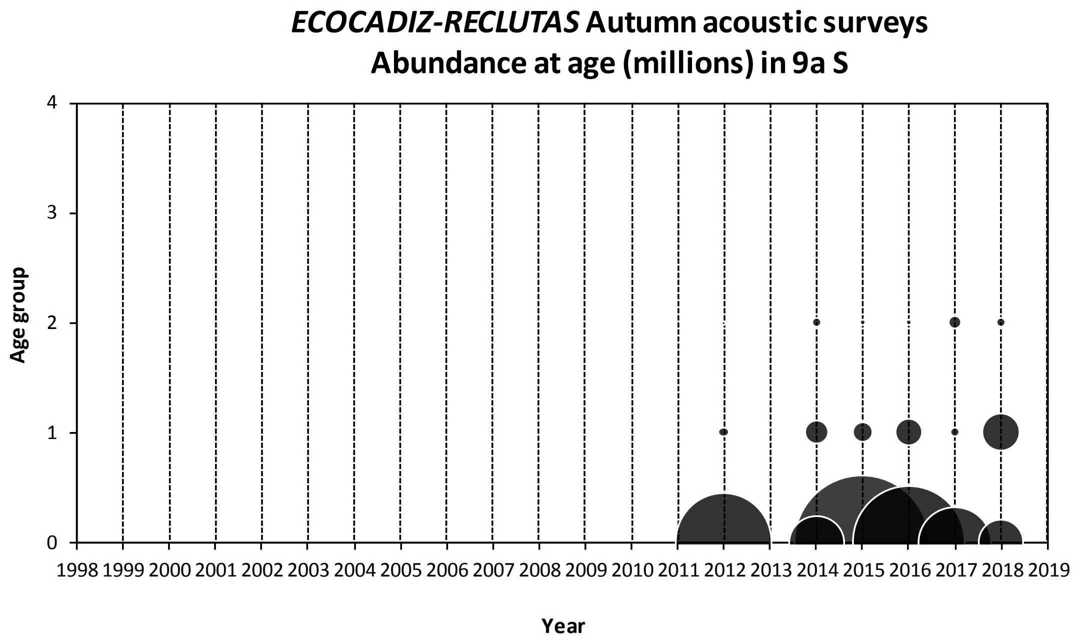


Figure 3.3.3. Ane.27.9a stock. Southern component. *ECOCADIZ-RECLUTAS* autumn survey series. Age structure of the estimated population (millions). The 2012 survey only surveyed the Spanish waters of the Gulf of Cadiz, the 2017 survey only surveyed the seven Spanish easternmost transects.

3.4. Within-survey consistency.

Within-survey consistency is illustrated with scatter plots and correlations of $\boldsymbol{N}_{a,y,ECOCADIZ\text{-}RECLUTAS}$ against $\boldsymbol{N}_{a+1,y+1,ECOCADIZ\text{-}RECLUTAS}$ in **Figure 3.4.1** and with catch curves of different year classes in **Figures 3.4.2** and **3.4.3**.

Scatterplots and correlation values indicate positive and high correlations between Age 0 and Age 1 indices only, and negative or no correlations between older ages. However, these results should be considered with caution because are based on a not representative sample (only 2 data pairs, 2018 age indices not included in the analyses).

Available but reliable data allows the tracking of 2012 (in part), 2013 and 2014 year classes only. **Catch curves indicate a relative good cohort tracking (R^2 > 0.90) of these three year classes.**

Results from the analysis of the survey's catchability through cohorts ($\boldsymbol{q}_{a,\ a+1;\ y,\ y+1;\ s}$) indicate great inter-annual variations in the catchability for a determinate age as well as throughout the cohorts (**Table 3.4.1**). Unfortunately, a comparison of *q* between complete cohorts is not yet possible with the available data.

Table 3.4.1. Ane.27.9a stock. Southern component. *ECOCADIZ-RECLUTAS* autumn survey series. Survey's catchability at age, $q_{a,a+1;y,y+1;s}$, for those cohorts tracked by surveys with complete coverage. 2012 cohort highlighted in orange, 2013 cohort in green, 2014 cohort in light blue, 2015 cohort in yellow.

q	2014-2015	2015-2016
0-1	10,6	25,9
1-2	2,3	0,2
2-3	5,8	0,5

3.5. (*Ad hoc*) Between-survey consistency.

Figure 3.5.1 shows the correlation analyses between the Age 0 abundance index in year ***y*** in *ECOCADIZ-RECLUTAS* (autumn-juvenile) surveys (2017 and 2018 surveys not considered) and Age 1 abundance index in year ***y+1*** in *PELAGO* (spring; top) and *ECOCADIZ* (summer, bottom) surveys. Both comparisons indicate some between-survey consistence (for the comparison with the *PELAGO* spring survey series r=0.61; n=3; for the comparison with the *ECOCADIZ* summer survey series r=0.33; n=3).

Figure 3.5.2 shows the scatter plot of the juvenile Age-0 fish abundance estimated in the autumn survey, $N_{0,y,ECOCADIZ\text{-}RECLUTAS}$, against the recruitment in the following year as estimated by the Gadget assessment model in 2018, $R_{y+1,Gadget\ Assess\_2018}$ (ICES, 2018b). The correlation between both indices is relatively high (r = 0.67), but based on only 3 data pairs (i.e. only those surveys with complete geographical coverage). If such behaviour is still maintained with the addition of new data pairs, ***ECOCADIZ-RECLUTAS* series could be then used in the future as a good indicator of the recruitment (which is the basis of the fishery) once a longer time-series is available.**

The results from the above analyses on survey consistency, although very promising, are not yet representative enough to consider the inclusion of this surveys series in the Gadget model. As described before, there is no complete estimate in 2012 and 2017 and there are some doubts on the reliability of the 2018 estimate, and a time-series with at least 6 observations will not be available until 2021, when the suitability of this series for its inclusion in the assessment could be re-evaluated.

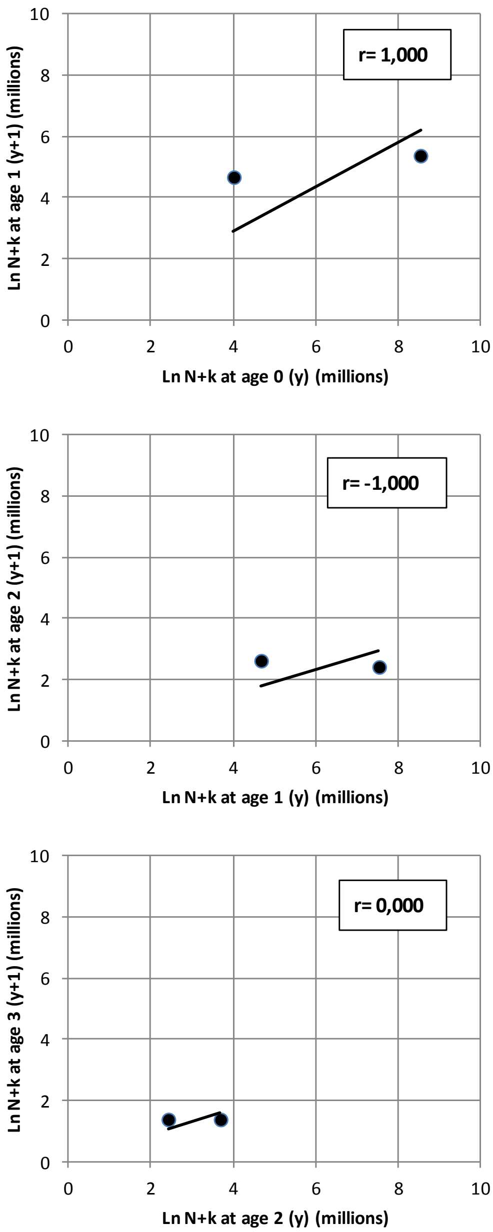


Figure 3.4.1. Ane.27.9a stock. Southern component. *ECOCADIZ-RECLUTAS* autumn survey series. Correlation within survey. Pearson correlation coefficient and the fitted linear regression line (forced through the origin) are also shown.

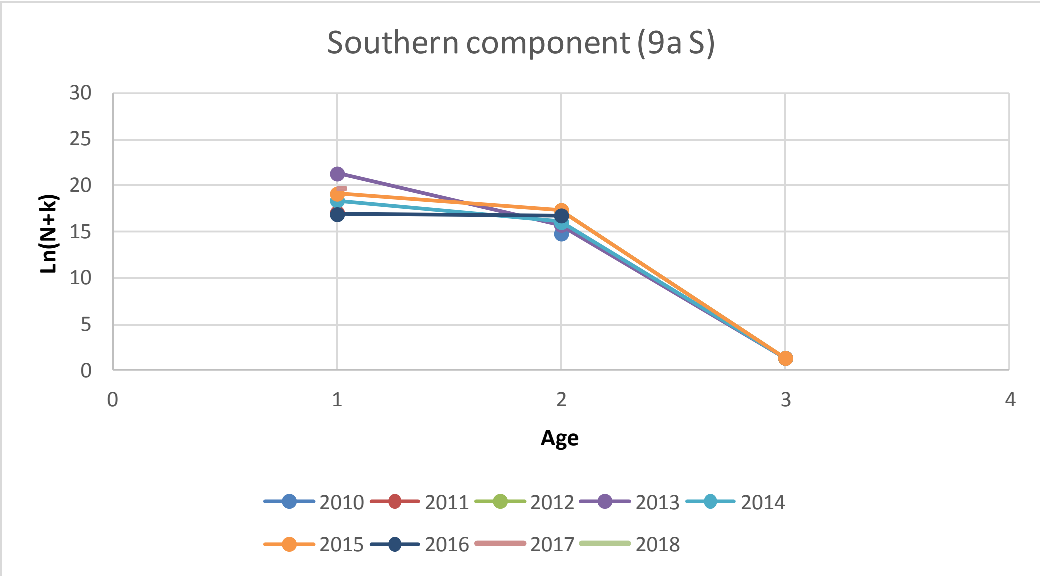


Figure 3.4.2. Ane.27.9a stock. Southern component. *ECOCADIZ-RECLUTAS* autumn survey series. Cohorts (ln(N+k) per age group; k = 4 millions) tracked by the survey series.

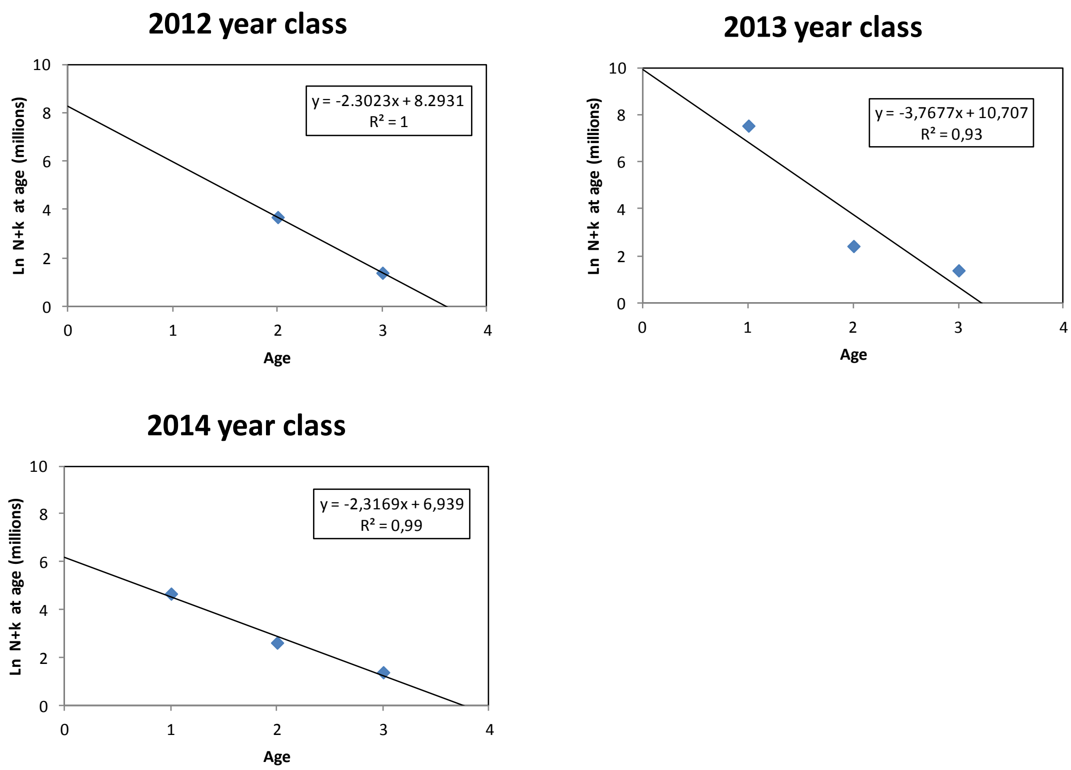


Figure 3.4.3. Ane.27.9a stock. Southern component. *ECOCADIZ-RECLUTAS* autumn survey series. Catch curves by year class for anchovy in 9a South. Only those cohorts with reliable age indices are represented. The regression coefficient and the fitted linear regression line and model are also shown. Age 0 anchovies, for simplicity in the linear fitting, have not been fitted in the model and graphs (only the right limb of the catch curve is shown).

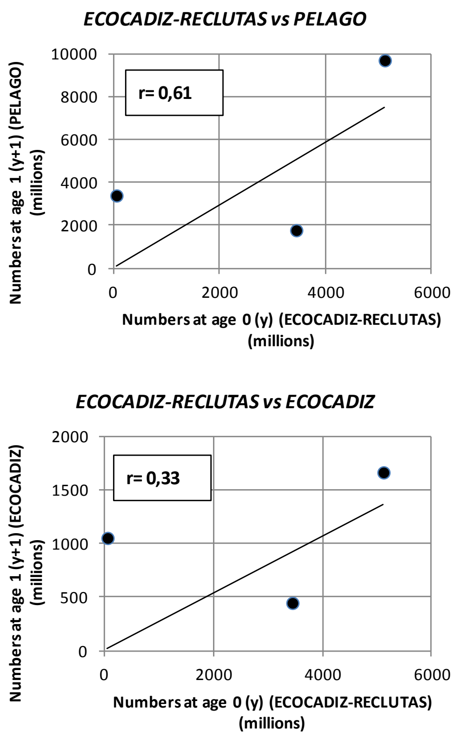


Figure 3.5.1. Ane.27.9a stock. Southern component. *ECOCADIZ-RECLUTAS* autumn survey series. Correlation between Age 0 abundance index in year *y* in *ECOCADIZ-RECLUTAS* (autumn-juveniles) surveys and Age 1 abundance index in year *y+1* in *PELAGO* (spring; top) and *ECOCADIZ* (summer, bottom) surveys. Pearson correlation coefficient and the fitted linear regression line (forced through the origin) are also shown.

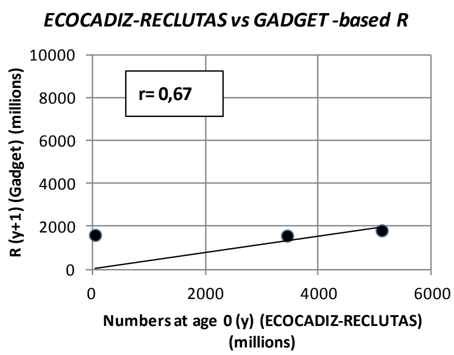


Figure 3.5.2. Ane.27.9a stock. Southern component. *ECOCADIZ-RECLUTAS* autumn survey series. Correlation between Age 0 abundance index in year *y* in *ECOCADIZ-RECLUTAS* (autumn-juveniles) surveys and Recruitment in year *y+1* as estimated by the Gadget model in the 2018 assessment. Pearson correlation coefficient and the fitted linear regression line (forced through the origin) are also shown.

4. Conclusions.

- ❑ The series is still very short. There are 4 non-consecutive data points since 2014 (a gap in 2017). The 2018 data point should be considered with caution.
- ❑ A time-series with at least 6-7 observations will not be available until 2021.
- ❑ Geographic range: anchovy and sardine recruitment areas are well covered by the surveys as they are planned. Perhaps the recruitment area was almost fully covered in the 2012 survey (Age 0 estimates might be valid), but not covered in 2017.
- ❑ Bathymetric range: 20 -200 m. The shallowest limit implies to assume some under-sampling of the anchovy and sardine juvenile (and adult) population fraction(s) in the central part of the Gulf. However, the vertical echo-sounding of shallower waters than 20 m is problematic. Juveniles are commonly concentrated in coastal waters and close to the bottom with day light (like the adults). This behaviour differs from the one exhibited by Bay of Biscay anchovy juveniles as sampled in JUVENA surveys.
- ❑ Consistence analyses: the significance of the results is jeopardised by the very low number of data points (pairs).
  - ➢ Within-consistency:
    - High correlations between Age 0_y *vs* Age 1_{y+1} (but only 2 data pairs).
    - Catch curves indicate a relative good cohort tracking ($r^2 > 0.90$) of 2012, 2013 and 2014 cohorts, the only ones that could be properly tracked with the (reliable) available data.
    - Great inter-annual variations in the catchability at age as well as throughout the cohorts (the causes for such a varying *q* should be thoroughly explored).
  - ➢ (*Ad hoc*) Between-survey consistency:
    - Correlations between Age $0_{y,\ ECOCADIZ\text{-}R}$ *vs* Age $1_{y+1,\ PELAGO}$ or Age $1_{y+1,\ ECOCADIZ}$: some between-survey consistence, higher in the *PELAGO* spring survey series (r = 0.61; more signal of the incoming recruitment), (but only 3 data pairs).
    - Correlation between Age $0_{y,\ ECOCADIZ\text{-}R}$ *vs* $R_{y+1,\ GADGET\ ASSESS}$: correlation between both indices is relatively high (r = 0.67), (but based on only 3 data pairs).
- ❑ The results from the above analyses, although very promising, are not yet representative enough to consider the inclusion of this surveys series in the Gadget model. As described before, there is no complete estimate in 2012 and 2017 and there are some doubts on the reliability of the 2018 estimate, and a time-series with at least 6 observations will not be available until 2021, when the suitability of this series for its inclusion in the assessment could be re-evaluated.

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Acoustic assessment and distribution of the main pelagic fish species in ICES Subdivision 9a South during the *ECOCADIZ 2018-07* Spanish survey (July-August 2018).

By

Fernando Ramos [1, *], Jorge Tornero [1], Paz Jiménez [1], Paz Díaz [2], Jesús Gago [2], Andrés de la Cruz [3], Ricardo Sánchez-Leal [1]

(1) Instituto Español de Oceanografía (IEO), Centro Oceanográfico Costero de Cádiz.
(2) IEO, Centro Oceanográfico Costero de Vigo.
(3) Facultad de Ciencias del Mar y Ambientales. Universidad de Cádiz.
(*)Cruise leader and corresponding author: e-mail: fernando.ramos@cd.ieo.es

ABSTRACT

The present working document summarises the main results obtained from the Spanish (pelagic ecosystem-) acoustic survey conducted by IEO between 31st July and 13rd August 2018 in the Portuguese and Spanish shelf waters (20-200 m isobaths) off the Gulf of Cadiz onboard the R/V *Miguel Oliver*. The 21 foreseen acoustic transects were sampled. A total of 25 valid fishing hauls were carried out for echo-trace ground-truthing purposes. A census of top predator species was also carried out along the sampled acoustic transects. Chub mackerel was the most frequent species in the fishing hauls, followed by sardine, anchovy, mackerel and bogue. *Trachurus* spp. showed a medium relative frequency of occurrence. Pearlside, snipefish and boarfish only occurred in hauls conducted in the deepest limit of the surveyed area. Anchovy was the most abundant species in these hauls, followed by pearlside, sardine and chub mackerel, with the remaining species showing negligible relative contributions. The estimate of total NASC allocated to the "pelagic fish species assemblage" has been the highest one ever recorded within the time series, denoting a high fish density during the survey. Anchovy was widely distributed over the surveyed area, although showing the highest densities in the Spanish shelf waters and in a secondary nucleus located over the western Portuguese shelf. Largest (and oldest) anchovies were distributed both in the westernmost and easternmost waters and the smallest (and youngest) ones were concentrated in the surroundings of the Guadalquivir river mouth and adjacent shallow waters, including those ones in front of the Bay of Cadiz. Anchovy acoustic estimates in summer 2018 were of 3 063 million fish and 34 908 t (i.e. the second historical biomass maximum in the time-series), well above the historical average (ca. 22 kt), but without showing any clear recent trend. Sardine recorded a very high acoustic echo-integration in summer 2018 as a consequence of the occurrence of very dense mid-water schools in the coastal fringe (20-50 m depth) comprised between Tavira and the surroundings of the Guadalquivir river mouth. The distribution pattern of acoustic densities is quite similar to the one provided by the *PELAGO 18* survey in spring although the occurrence of sardine in the surveyed area was more continuous in summer. These facts resulted in summer estimates of 7 955 million fish and 114 631 t, the historical maximum record in terms of abundance and the second maximum in biomass. Spanish waters concentrated the bulk of the population. Such an increasing trend seems to be the result of a greater accessibility of the species to the survey, with the occurrence of many dense schools (mainly Age-0 fish) in the shallowest limits of the surveyed area which are not usually recorded in the most recent years. In any case, this behaviour should be analysed in more detail between WGACEGG experts.

INTRODUCTION

The *ECOCADIZ* surveys constitute a series of yearly acoustic surveys conducted by IEO in the Subdivision 9a South (Algarve and Gulf of Cadiz, between 20 – 200 m depth) under the "pelagic ecosystem survey" approach, firstly onboard R/V *Cornide de Saavedra* (until 2013) and 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 reports the main results from the *ECOCADIZ 2018-07* survey. These results will refer to the acoustic estimates (age-structured for anchovy and sardine) and spatial distribution of the assessed species.

MATERIAL AND METHODS

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

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

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

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

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

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

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

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

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

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

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

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

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

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

RESULTS

Acoustic sampling

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

Groundtruthing hauls

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

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

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

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

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

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

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

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

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

A total of 335 nmi (ESDU) from 21 transects has been acoustically sampled by echo-integration for assessment purposes. From this total, 218 nmi (11 transects) were sampled in Spanish waters, and 117 nmi (10 transects) in the Portuguese waters. The enclosed text table below provides the nautical area-scattering coefficients attributed to each of the selected target species and for the whole "pelagic fish assemblage".

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

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

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

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

Spatial distribution and abundance/biomass estimates

Anchovy

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

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

Twelve (12) coherent post-strata have been differentiated according to the S_A value distribution and the size composition in the fishing stations (**Figure 17**). The acoustic estimates by homogeneous post-stratum and total area are shown in **Tables 5** and **6** and **Figures 18** and **19**. Overall acoustic estimates in summer 2018 were of 3 063 million fish and 34 908 tonnes. By geographical strata, the Spanish waters yielded 93% (2 839 million) and 88% (30 683 t) of the total estimated abundance and biomass in the Gulf, confirming the importance of these waters in the species' distribution. The estimates for the Portuguese waters were 224 million and 4 225 t. The current biomass estimate (34 908 t) becomes in the second historical maximum within the time-series (2006: 35 539 t; 2016: 34 184 t; see **Figure 31**). The *PELAGO 18* spring Portuguese survey previously estimated for this same area 23 473 t (2 157 million): 4 328 t (300 million) in Portuguese waters and 19 145 t (1 857 million) in Spanish waters.

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

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

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

Sardine

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

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

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

Sizes of the assessed population ranged between 8.0 and 20.5 cm size classes. The length frequency distribution of the population was clearly bimodal, with one main mode at 11.5 cm size class and a secondary one at 17.0 cm (**Table 7**; **Figure 22**). The 2018 summer estimate of mean size (122 mm) is among the lowest estimates within the series. This fact might be explained by the relative importance of the juvenile fraction in the estimated population (Age 0 fish, ≤11.5 cm, 94% in numbers), which was mainly located in relatively shallow waters in front of the Cape Santa Maria and especially along the coastal fringe comprised between the Guadiana and Guadalquivir river mouths and the Bay of Cadiz (**Tables 7** and **8**; **Figure 22**; see also **Figure 7**). Such a decrease in mean size was coupled with a similar decreasing trend in the mean weight (14.4 g), which was well below the historical average. The contribution in biomass of the adult fraction in the assessed population (around at a main modal size class at 17.5 cm) may be not enough to compensate the greater relative contribution of juveniles. The population was only structured by the 0, 1, 2 and 3 age groups.

Mackerel

Parameters of the survey's length-weight relationship are shown in **Table 4**. The distribution of the back-scattering energy attributed to this species is shown in **Figure 24**. Estimated abundance and biomass by size class are given in **Table 9** and **Figure 25**.

Atlantic mackerel showed very low acoustic records during the 2018 survey, which were mainly observed all over the shelf located in the central part of the Gulf of Cadiz (**Figure 24**).

Six (6) coherent post-strata were differentiated (**Figure 24**). The acoustic estimates by homogeneous post-stratum and total area are shown in **Table 9** and **Figure 25**. Overall acoustic estimates in summer 2018 were of 5 million fish and 1070 tonnes, with the 78% and 80% of the total of abundance and biomass respectively being recorded in the Spanish waters (4 million, 856 t). Sizes of the assessed population ranged between 22.0 and 34.5 cm size classes, with a modal size class at around 30.0-31.0 cm size classes (**Table 9**, **Figure 25**).

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 26**. Estimated abundance and biomass by size class are given in **Table 10** and **Figure 27**.

Contrarily to the pattern described for the Atlantic mackerel, the acoustic energy allocated to its close relative, Chub mackerel, accounted for 21.5% of the total acoustic energy attributed to fishes in the survey. The population was mainly concentrated in the westernmost waters of the Gulf, between Cape San Vicente and Cape Santa Maria, with a secondary nucleus of fish density in the easternmost waters, from the Bay of Cadiz to the Strait of Gibraltar (**Figure 26**).

A total of seven (7) coherent post-strata were differentiated (**Figure 25**). The acoustic estimates by homogeneous post-stratum and total area are shown in **Table 10** and **Figure 27**. Overall acoustic estimates were of 580 million fish and 31 811 t. A great part of the population was distributed over the Portuguese shelf, accounting for 71% of both the total estimated abundance (415 million) and biomass (22 609 t). The size range of the estimated population was comprised between the 15.0 and 28.0 cm size classes and showed a clear modal class at 18.0 cm. This modal class was also the dominant one in both the Portuguese and Spanish waters, although a secondary mode at about 19.5-20.0 cm size classes is also observed in both areas (**Table 10** and **Figure 27**).

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 28**. Estimated abundance and biomass by size class are given in **Table 11** and **Figure 29**.

The distribution pattern of the very low acoustic densities attributed to Blue jack mackerel closely resembles to the described one below for horse mackerel (**Figure 28**).

Six (6) coherent post-strata were delimited for the acoustic assessment (**Figure 28**). The acoustic estimates by homogeneous post-stratum and total area are shown in **Table 11** and **Figure 29**. Overall acoustic estimates in summer 2018 were of 1 million fish and 23 t. At about 88% of both the total estimated abundance and biomass was recorded in the Portuguese waters. Sizes of the assessed population ranged between 11.5 and 27.5 cm size classes, but this size range was not well covered because the low species' abundance. For this same reason, modal size class were not clearly identified, although fishes belonging to the 16.5 cm size class relatively were the most frequent (**Table 11**, **Figure 29**).

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 30**. Estimated abundance and biomass by size class are given in **Table 12** and **Figure 31**.

Horse mackerel showed very low acoustic densities in the surveyed area, with the species being almost absent in the easternmost shelf and showing relatively higher densities in the shelf area comprised between Cape San Vicente and Cape Santa Maria (**Figure 30**).

Ten (10) coherent post-strata have been delimitated for the acoustic assessment purposes (**Figure 30**). The acoustic estimates by homogeneous post-stratum and total area are shown in **Table 12** and **Figure 31**. Overall acoustic estimates were of 4 million fish and 410 t. The bulk of the estimated population was located in the Portuguese shelf waters (96% of the total abundance, 4 million; 94% of the total biomass, 386 t). The size range of the estimated population was comprised between the 11.5 and 28.0 cm size classes and showed a bi-modal distribution, outstanding a main modal class at 20.5 cm (the dominant mode in Portuguese waters), and a secondary mode at 24.0 cm size class (the dominant one in Spanish waters), (**Table 12** and **Figure 31**).

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 32**. Estimated abundance and biomass by size class are given in **Table 13** and **Figure 33**.

Mediterranean horse mackerel was restricted, as usual, to the Spanish waters, with the highest densities being recorded in the inner shelf waters of the central part of the Gulf (**Figure 32**).

A single coherent post-stratum (located in Spanish waters) have been differentiated according to the S_A value distribution and the size composition in the fishing stations (**Figure 32**). Overall acoustic estimates in summer 2018 were of 8 million fish and 1 436 t. Sizes in the population ranged between 20.0 and 36.5 cm size classes, with three relatively well differentiated modes, the smallest and dominant one at 27.0 cm size class, the secondary mode at 29.5 cm, and the largest but less important one at 31.5 cm (**Table 13**, **Figure 33**).

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 34**. Estimated abundance and biomass by size class are given in **Table 14** and **Figure 35**.

Bogue was distributed practically all over the shelf of the surveyed area, although showed its highest densities over the inner shelf of both the central and westernmost waters of the Gulf (**Figure 34**).

Three (3) post-strata have been delimited for the acoustic assessment (**Figure 34**). Overall acoustic estimates in summer 2018 were of 18 million fish and 2 331 t. Fifty five per cent (55%) of the total abundance (10 million) and 68% of the biomass (1 585 t) was located in the Spanish waters. The size range of the estimated population was comprised between the 17.5 and 28.5 cm size classes, with a secondary mode at 21.5 cm and with not very well defined main modes at 25.0 cm and 26.5 cm size classes (**Table 14**, **Figure 35**).

Boarfish

The survey's length-weight relationship for this species is shown in **Table 4**. Back-scattering energy attributed to the species is represented in **Figure 36**. Estimated abundance and biomass by size class are given in **Table 15** and **Figure 37**.

Boarfish showed an incidental occurrence restricted to the outer shelf waters just to the west of Cape of Santa Maria (**Figure 36**).

A single coherent post-stratum (located in Portuguese waters) have been differentiated according to the S_A value distribution and the size composition in the fishing stations (**Figure 36**). Overall acoustic estimates in summer 2018 were of 1 million fish and 3 t. The size range of the estimated population was comprised between the 4.5 and 6.5 cm size classes, with the mode at 6 cm size class (**Table 15**, **Figure 37**).

Pearlside

The survey's length-weight relationship for this species is shown in **Table 4**. Back-scattering energy attributed to the species is represented in **Figure 38**. Estimated abundance and biomass by size class are given in **Table 16** and **Figure 39**.

The constant occurrence of pearlside in somewhat shallower waters than usual in the 2018 survey has resulted in its acoustic detection in the surveyed area (9% of the total acoustic energy), just in the transition between outer shelf and upper slope waters. Higher densities were recorded in the Spanish outer shelf (**Figure 38**).

Two (2) post-strata have been delimited for the acoustic assessment (**Figure 38**). Overall acoustic estimates in summer 2018 were of 10 183 million fish and 6 155 t. Eighty three per cent (83%) of both the total abundance and biomass (8 450 million, 5 108 t) was located in the Spanish waters. The size range of the estimated population was comprised between the 3.5 and 6.0 cm size classes, with a clear dominant mode at 4.0 cm size class (**Table 16**, **Figure 39**).

(SHORT) DISCUSSION

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

The current anchovy biomass estimate (34 908 t) becomes in the second historical maximum within the time-series (2006: 35 539 t; 2016: 34 184 t; see **Figure 40**) and denotes a strong increase in relation to the previous year, up to levels well above the historical average (ca. 22 kt), but without showing any clear recent trend. Although the spring *PELAGO 18* survey also estimated increased population levels, such increase was not so pronounced as the estimated by its summer counterpart.

The estimates of Gulf of Cadiz sardine abundance and biomass in summer 2018 were 7 955 million fish and 114 631 t, the historical maximum record in terms of abundance and the second maximum in biomass (the historical maximum was reached in 2006: 123 849 t; see **Figure 40**). As described above, such an increasing trend seems to be the result of a greater availability of the species to the survey, with the occurrence of many dense schools (mainly composed by juvenile fish) in the shallowest limits of the surveyed area not usually recorded in the most recent years. In any case, these estimates should be analysed in more depth and compared with those ones provided by the Portuguese spring *PELAGO* survey in a standardisation exercise of echograms scrutiny.

ACKNOWLEDGMENTS

We are very grateful to the crew of the R/V *Miguel Oliver* and to all the scientific and technical staff participating in the present survey.

Unión Europea
Fondo Europeo Marítimo y de Pesca (FEMP)

This survey has been funded by the EU through the European Maritime and Fisheries Fund (EMFF) within the National Program of collection, management and use of data in the fisheries sector and support for scientific advice regarding the Common Fisheries Policy.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Table 8. *ECOCADIZ 2018-07* 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 21** and ordered from west to east.

Age class	POL01	POL02	POL03	POL04	POL05	POL06	POL07	POL08	POL09	POL10	POL11	POL12	POL13	POL14	PT	ES	TOTAL
	N	N	N	N	N	N	Nr	N	N	N	N	N	N	N	N	N	N
0	69	49593	151929	150	141	117837	20244	15321	72750	28329	18054	4799769	2210869	275	355285	7130045	7485330
I	8	62350	15136	18	8	4192	139616	54	58740	431	1482	10372	1959	502	221381	73486	294867
II	0	43201	0	0	1	0	88798	0	33531	0	78	0	0	208	132000	33817	165817
III	0	4284	0	0	0	0	2952	0	1260	0	0	0	0	31	7236	1290	8527
TOTAL	77	159428	167065	168	149	122029	251610	15375	166281	28759	19614	4810141	2212828	1015	715902	7238638	7954541

Age class	POL01	POL02	POL03	POL04	POL05	POL06	POL07	POL08	POL09	POL10	POL11	POL12	POL13	POL14	PT	ES	TOTAL
	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
0	2	1411	3338	4	2	1670	705	207	1551	441	402	60326	22755	9	7339	85484	92823
I	0.2	2911	350	0.5	0.2	108	6599	1	2666	9	43	217	49	22	9970	3006	12976
II	0	2254	0	0	0.03	0	4414	0	1655	0	3	0	0	10	6668	1668	8336
III	0	281	0	0	0	0	165	0	75	0	0	0	0	2	446	77	523
TOTAL	2	6857	3688	4	3	1778	11883	208	5946	450	448	60543	22804	43	24422	90235	114657

Table 9. *ECOCADIZ 2018-07* survey. Atlantic 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 21**.

ECOCADIZ 2018-07 . *Scomber scombrus* . ABUNDANCE (in numbers and million fish)												
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	***n***			**Millions**		
							PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
21	0	0	0	0	0	0	0	0	0	0	0	0
21,5	0	0	0	0	0	0	0	0	0	0	0	0
22	9551	49	0	0	0	18364	9600	18364	27964	0,01	0,02	0,03
22,5	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0
23,5	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0
24,5	0	0	0	0	0	0	0	0	0	0	0	0
25	25894	132	0	0	0	49787	26026	49787	75813	0,03	0,05	0,1
25,5	16343	84	0	0	0	31423	16427	31423	47850	0,02	0,03	0,05
26	47754	244	304	3261	20719	91820	51563	112539	164102	0,1	0,1	0,2
26,5	70889	363	0	0	0	136302	71252	136302	207554	0,1	0,1	0,2
27	65370	334	488	5241	33298	125692	71433	158990	230423	0,1	0,2	0,2
27,5	107607	550	672	7220	45877	206902	116049	252779	368828	0,1	0,3	0,4
28	59852	306	1226	13160	83614	115082	74544	198696	273240	0,1	0,2	0,3
28,5	39477	202	1963	21078	133931	75905	62720	209836	272556	0,1	0,2	0,3
29	33959	174	2332	25038	159089	65294	61503	224383	285886	0,1	0,2	0,3
29,5	50301	257	3427	36800	233824	96717	90785	330541	421326	0,1	0,3	0,4
30	27167	139	6920	74299	472087	52236	108525	524323	632848	0,1	0,5	1
30,5	36718	188	3970	42623	270821	70600	83499	341421	424920	0,1	0,3	0,4
31	13583	69	7700	82684	525363	26118	104036	551481	655517	0,1	0,6	1
31,5	6792	35	3601	38663	245663	13059	49091	258722	307813	0,05	0,3	0,3
32	0	0	3655	39246	249363	0	42901	249363	292264	0,04	0,2	0,3
32,5	0	0	2614	28066	178328	0	30680	178328	209008	0,03	0,2	0,2
33	0	0	607	6522	41437	0	7129	41437	48566	0,01	0,04	0,05
33,5	0	0	911	9782	62156	0	10693	62156	72849	0,01	0,1	0,1
34	0	0	607	6522	41437	0	7129	41437	48566	0,01	0,04	0,05
34,5	0	0	304	3261	20719	0	3565	20719	24284	0,004	0,02	0,02
35	0	0	0	0	0	0	0	0	0	0	0	0
35,5	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL *n*	611257	3126	41301	443466	2817726	1175301	1099150	3993027	5092177	**1**	**4**	**5**
Millions	**1**	**0,003**	**0,04**	**0,4**	**3**	**1**						

Table 9. *ECOCADIZ 2018-07* survey. Atlantic mackerel (*S. scombrus*). Cont'd.

ECOCADIZ 2018-07 . Scomber scombrus . BIOMASS (t)									
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**PORTUGAL**	**SPAIN**	**TOTAL**
21	0	0	0	0	0	0	0	0	0
21,5	0	0	0	0	0	0	0	0	0
22	0,615	0,003	0	0	0	1,182	0,618	1,182	1,800
22,5	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0
23,5	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0
24,5	0	0	0	0	0	0	0	0	0
25	2,744	0,014	0	0	0	5,276	2,758	5,276	8,034
25,5	1,871	0,010	0	0	0	3,598	1,881	3,598	5,478
26	5,898	0,030	0,038	0,403	2,559	11,341	6,369	13,900	20,268
26,5	9,432	0,048	0	0	0	18,135	9,480	18,135	27,615
27	9,356	0,048	0,069848	0,750149	4,76597	17,990	10,224	22,756	32,981
27,5	16,547	0,085	0,103334	1,110222	7,054521	31,815	17,845	38,870	56,715
28	9,875	0,050	0,202277	2,171259	13,795417	18,987	12,299	32,783	45,082
28,5	6,980	0,036	0,347075	3,726764	23,680107	13,421	11,089	37,101	48,190
29	6,427	0,033	0,441326	4,73839	30,107268	12,357	11,639	42,464	54,103
29,5	10,177	0,052	0,693383	7,445728	47,309505	19,569	18,368	66,878	85,247
30	5,870	0,030	1,495236	16,054123	102,005989	11,287	23,449	113,293	136,742
30,5	8,464	0,043	0,915104	9,824806	62,425541	16,274	19,247	78,699	97,946
31	3,337	0,017	1,891447	20,310702	129,051467	6,416	25,556	135,467	161,023
31,5	1,776	0,009	0,941698	10,110765	64,243354	3,415	12,838	67,658	80,496
32	0	0	1,017	10,916	69,355	0	11,932	69,355	81,288
32,5	0	0	0,773	8,294	52,701	0	9,067	52,701	61,768
33	0	0	0,190	2,046	13,000	0	2,237	13,000	15,236
33,5	0	0	0,303	3,255	20,682	0	3,558	20,682	24,240
34	0	0	0,214	2,300	14,611	0	2,514	14,611	17,125
34,5	0	0	0,113	1,217	7,735	0	1,331	7,735	9,066
35	0	0	0	0	0	0	0	0	0
35,5	0	0	0	0	0	0	0	0	0
TOTAL	**99,368**	**0,508**	**9,748**	**104,674**	**665,083**	**191,062**	**214,299**	**856,144**	**1070,443**

Table 10. *ECOCADIZ 2018-07* 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 26**.

ECOCADIZ 2018-07 . *Scomber colias* . ABUNDANCE (in numbers and million fish)													
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	***n***			**Millions**		
								PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
14	0	0	0	0	0	0	0	0	0	0	0	0	0
14,5	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	651978	0	0	0	651978	651978	0	1	1
15,5	0	0	0	59497	232182	0	2426	0	294105	294105	0	0,3	0,3
16	1053963	0	147053	201432	631030	3874	7278	1201016	843614	2044630	1	1	2
16,5	4237363	671690	710996	440789	2354053	14868	2426	5620049	2812136	8432185	6	3	8
17	7442272	7412070	999197	1239692	13218860	37852	7278	15853539	14503682	30357221	16	15	30
17,5	35038906	19981026	1206716	2723935	21616744	63455	4852	56226648	24408986	80635634	56	24	81
18	11679635	28042797	1787978	5139198	37513026	196825	2426	41510410	42851475	84361885	42	43	84
18,5	4237363	26560734	1705876	3907914	24777600	312853	9704	32503973	29008071	61512044	33	29	62
19	3183400	32955974	1278597	1269022	20628809	271274	9704	37417971	22178809	59596780	37	22	60
19,5	2129436	29919159	1105121	720833	8165632	97176	7278	33153716	8990919	42144635	33	9	42
20	1053963	38281452	1920572	660502	4977706	41098	7278	41255987	5686584	46942571	41	6	47
20,5	0	27232399	4240508	540824	9582556	26488	9704	31472907	10159572	41632479	31	10	42
21	0	32742723	5188371	1010786	7053453	61351	14556	37931094	8140146	46071240	38	8	46
21,5	0	20133707	3555602	435574	6306844	57847	33964	23689309	6834229	30523538	24	7	31
22	0	10762539	3064181	233218	2661030	85589	65503	13826720	3045340	16872060	14	3	17
22,5	0	6846061	2807377	216823	1575833	73599	31538	9653438	1897793	11551231	10	2	12
23	0	2822361	2802796	377359	1131671	58104	14556	5625157	1581690	7206847	6	2	7
23,5	0	1357414	1675833	194288	460218	42610	7278	3033247	704394	3737641	3	1	4
24	0	0	1118153	97144	232182	3874	14556	1118153	347756	1465909	1	0,3	1
24,5	0	536064	1099498	0	232182	0	16982	1635562	249164	1884726	2	0,2	2
25	0	0	412454	45715	0	7747	9704	412454	63166	475620	0,4	0,1	0,5
25,5	0	0	818631	45715	0	3874	4852	818631	54441	873072	1	0,1	1
26	0	0	241450	0	0	0	0	241450	0	241450	0,2	0	0,2
26,5	0	0	303710	0	0	0	0	303710	0	303710	0,3	0	0,3
27	0	0	224275	0	0	0	0	224275	0	224275	0,2	0	0,2
27,5	0	0	158869	0	0	3874	0	158869	3874	162743	0,2	0,004	0,2
28	0	0	107635	0	0	0	0	107635	0	107635	0	0	0
28,5	0	0	0	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL *n*	70056301	286258170	38681449	19560260	164003589	1464232	283843	394995920	185311924	580307844	**395**	**185**	**580**
Millions	**70**	**286**	**39**	**20**	**164**	**1**	**0,3**						

Table 10. *ECOCADIZ 2018-07* survey. Chub mackerel (*S. colias*). Cont'd.

ECOCADIZ 2018-07 . Scomber colias . BIOMASS (t)										
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**PORTUGAL**	**SPAIN**	**TOTAL**
14	0	0	0	0	0	0	0	0	0	0
14,5	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	14,566	0	0	0	14,566	14,566
15,5	0	0	0	1,489	5,810	0	0,061	0	7,360	7,360
16	29,439	0	4,107	5,626	17,626	0,108	0,203	33,546	23,563	57,109
16,5	131,663	20,871	22,092	13,696	73,145	0,462	0,075	174,626	87,378	262,004
17	256,440	255,399	34,430	42,716	455,485	1,304	0,251	546,269	499,756	1046,025
17,5	1334,933	761,249	45,974	103,778	823,567	2,418	0,185	2142,156	929,948	3072,104
18	490,631	1178,005	75,108	215,884	1575,825	8,268	0,102	1743,744	1800,079	3543,823
18,5	195,746	1226,977	78,803	180,527	1144,605	14,452	0,448	1501,526	1340,032	2841,558
19	161,314	1669,995	64,791	64,306	1045,334	13,746	0,492	1896,1	1123,878	3019,978
19,5	118,086	1659,144	61,284	39,973	452,819	5,389	0,404	1838,514	498,585	2337,099
20	63,817	2317,918	116,289	39,993	301,397	2,488	0,441	2498,024	344,319	2842,343
20,5	0	1796,550	279,751	35,679	632,171	1,747	0,640	2076,301	670,237	2746,538
21	0	2348,687	372,170	72,505	505,955	4,401	1,044	2720,857	583,905	3304,762
21,5	0	1567,276	276,780	33,907	490,946	4,503	2,644	1844,056	532,000	2376,056
22	0	907,487	258,369	19,665	224,376	7,217	5,523	1165,856	256,781	1422,637
22,5	0	624,165	255,953	19,768	143,671	6,710	2,875	880,118	173,024	1053,142
23	0	277,758	275,832	37,137	111,372	5,718	1,433	553,59	155,660	709,250
23,5	0	143,964	177,735	20,606	48,810	4,519	0,772	321,699	74,707	396,406
24	0	0	127,602	11,086	26,496	0,442	1,661	127,602	39,685	167,287
24,5	0	65,726	134,807	0	28,467	0,000	2,082	200,533	30,549	231,082
25	0	0	54,254	6,013	0	1,019	1,276	54,254	8,308	62,562
25,5	0	0	115,368	6,443	0	0,546	0,684	115,368	7,673	123,041
26	0	0	36,407	0	0	0	0	36,407	0	36,407
26,5	0	0	48,936	0	0	0	0	48,936	0	48,936
27	0	0	38,568	0	0	0	0	38,568	0	38,568
27,5	0	0	29,124	0	0	0,71	0	29,124	0,710	29,834
28	0	0	21,010	0	0	0	0	21,01	0	21,010
28,5	0	0	0	0	0	0		0	0	0
29	0	0	0	0	0	0		0	0	0
TOTAL	**2782,069**	**16821,171**	**3005,544**	**970,797**	**8122,443**	**86,167**	**23,296**	**22608,784**	**9202,703**	**31811,487**

Table 11. *ECOCADIZ 2018-07* 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 28**.

***ECOCADIZ 2018-07 . Trachurus picturatus .* ABUNDANCE (in numbers and million fish)**											
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	***n***			**Millions**		
						PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
10	0	0	0	0	0	0	0	0	0	0	0
10,5	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0
11,5	30297	0	41121	0	0	71418	0	71418	0,1	0	0,1
12	0	0	0	0	0	0	0	0	0	0	0
12,5	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0
13,5	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	2062	2362	2062	2362	4424	0,002	0,002	0,004
14,5	41659	0	56541	1546	1771	99746	1771	101517	0,1	0,002	0,1
15	22723	2746	30840	24227	27751	80536	27751	108287	0,1	0,03	0,1
15,5	22723	0	30840	18557	21256	72120	21256	93376	0,1	0,02	0,1
16	11362	0	15420	5670	6495	32452	6495	38947	0	0,01	0,04
16,5	53020	0	71961	8763	10038	133744	10038	143782	0	0,01	0,1
17	0	0	0	13402	15352	13402	15352	28754	0	0,02	0,03
17,5	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0
18,5	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0
19,5	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0
20,5	0	17086	0	0	0	17086	0	17086	0,02	0	0,02
21	0	0	0	0	0	0	0	0	0	0	0
21,5	0	3204	0	0	0	3204	0	3204	0,003	0	0,003
22	0	10221	0	0	0	10221	0	10221	0,01	0	0,01
22,5	0	0	0	0	0	0	0	0	0	0	0
23	0	4882	0	0	0	4882	0	4882	0,005	0	0,005
23,5	0	11289	0	0	0	11289	0	11289	0,01	0	0,01
24	0	0	0	0	0	0	0	0	0	0	0
24,5	0	2746	0	0	0	2746	0	2746	0,003	0	0,003
25	0	0	0	0	0	0	0	0	0	0	0
25,5	0	0	0	0	0	0	0	0	0	0	0
26	0	2746	0	0	0	2746	0	2746	0,003	0	0,003
26,5	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0
27,5	0	2746	0	0	0	2746	0	2746	0,003	0	0,003
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
TOTAL *n*	181784	57666	246723	74227	85025	560400	85025	645425	**1**	**0,1**	**1**
Millions	**0,2**	**0,1**	**0,2**	**0,1**	**0,1**						

Table 11. *ECOCADIZ 2018-07* survey. Blue jack mackerel (*T. picturatus*). Cont'd.

***ECOCADIZ 2018-07 . Trachurus picturatus* . BIOMASS (t)**								
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**PORTUGAL**	**SPAIN**	**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	0	0	0	0
11,5	0,329	0	0,447	0	0	0,776	0	0,776
12	0	0	0	0	0	0	0	0
12,5	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0
13,5	0	0	0	0	0	0	0	0
14	0	0	0	0,043	0,050	0,043	0,050	0,093
14,5	0,986	0	1,338	0,037	0,042	2,360	0,042	2,402
15	0,603	0,073	0,818	0,642	0,736	2,136	0,736	2,871
15,5	0,673	0	0,913	0,550	0,629	2,136	0,629	2,765
16	0,374	0	0,508	0,187	0,214	1,070	0,214	1,284
16,5	1,938	0	2,631	0,320	0,367	4,890	0,367	5,257
17	0	0	0	0,542	0,621	0,542	0,621	1,163
17,5	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0
18,5	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0
19,5	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0
20,5	0	1,300	0	0	0	1,300	0	1,300
21	0	0	0	0	0	0	0	0
21,5	0	0,286	0	0	0	0,286	0	0,286
22	0	0,988	0	0	0	0,988	0	0,988
22,5	0	0	0	0	0	0	0	0
23	0	0,548	0	0	0	0,548	0	0,548
23,5	0	1,364	0	0	0	1,364	0	1,364
24	0	0	0	0	0	0	0	0
24,5	0	0,382	0	0	0	0,382	0	0,382
25	0	0	0	0	0	0	0	0
25,5	0	0	0	0	0	0	0	0
26	0	0,467	0	0	0	0,467	0	0,467
26,5	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0
27,5	0	0,565	0	0	0	0,565	0	0,565
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
TOTAL	**4,903**	**5,974**	**6,654**	**2,321**	**2,659**	**19,853**	**2,659**	**22,511**

Table 12. *ECOCADIZ 2018-07* 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 30**.

ECOCADIZ 2018-07. *Trachurus trachurus*. ABUNDANCE (in numbers and million fish)																
Size class	POL01	POL02	POL03	POL04	POL05	POL06	POL07	POL08	POL09	POL10	*n*			Millions		
											PORTUGAL	SPAIN	TOTAL	PORTUGAL	SPAIN	TOTAL
10	0	0	0	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	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11,5	0	0	0	0	5605	0	219	1577	0	55	5824	1632	7456	0,01	0,002	0,01
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	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	0	0
18	0	0	0	59879	0	5711	0	0	1197	0	65590	1197	66787	0,1	0,001	0,1
18,5	0	0	0	29939	0	2855	0	0	599	0	32794	599	33393	0,03	0,001	0,03
19	0	0	0	29939	0	2855	0	0	599	0	32794	599	33393	0,03	0,001	0,03
19,5	0	13722	0	119757	0	11422	0	0	2395	0	144901	2395	147296	0,1	0,002	0,1
20	0	260713	0	359271	0	34265	0	0	7184	0	654249	7184	661433	1	0,01	1
20,5	0	246991	0	179636	0	17133	0	0	3592	0	443760	3592	447352	0,4	0,004	0,4
21	6314	260713	4231	209575	5605	19988	219	1577	4191	55	506645	5823	512468	1	0,01	1
21,5	1579	205826	1058	209575	0	19988	0	0	4191	0	438026	4191	442217	0,4	0,004	0,4
22	3157	192104	2116	59879	7287	5711	284	2049	1197	71	270538	3317	273855	0,3	0,003	0,3
22,5	6314	96052	4231	29939	5605	2855	219	1577	599	55	145215	2231	147446	0,1	0,002	0,1
23	17365	137217	11635	0	21299	0	830	5991	0	209	188346	6200	194546	0,2	0,01	0,2
23,5	11050	13722	7404	89818	48764	8566	1901	13716	1796	478	181225	15990	197215	0,2	0,02	0,2
24	7893	82330	5289	119757	89121	11422	3475	25066	2395	874	319287	28335	347622	0,3	0,03	0,3
24,5	7893	82330	5289	29939	113223	2855	4415	31845	599	1110	245944	33554	279498	0,2	0,03	0,3
25	4736	27443	3173	29939	124434	2855	4852	34998	599	1220	197432	36817	234249	0,2	0,04	0,2
25,5	0	0	0	0	65580	0	2557	18445	0	643	68137	19088	87225	0,1	0,02	0,1
26	0	0	0	0	33070	0	1289	9301	0	324	34359	9625	43984	0,03	0,01	0,04
26,5	0	0	0	0	13452	0	525	3784	0	132	13977	3916	17893	0,01	0,004	0,02
27	0	0	0	0	3363	0	131	946	0	33	3494	979	4473	0,003	0,001	0,004
27,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	1682	0	66	473	0	16	1748	489	2237	0,002	0,0005	0,002
28,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL *n*	66301	1619163	44426	1556842	538090	148481	20982	151345	31133	5275	3994285	187753	4182038	**4**	**0,2**	**4**
Millions	**0,1**	**2**	**0,04**	**2**	**1**	**0,1**	**0,02**	**0,2**	**0,03**	**0,01**						

Table 12. *ECOCADIZ 2018-07* survey. Horse mackerel (*T. trachurus*). Cont'd.

ECOCADIZ 2018-07 . *Trachurus trachurus* . BIOMASS (t)													
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	**POL09**	**POL10**	**PORTUGAL**	**SPAIN**	**TOTAL**
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	0,072	0	0,003	0,020	0	0,001	0,075	0,021	0,095
12	0	0	0	0	0	0	0	0	0	0	0	0	0
12,5	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0
13,5	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0
14,5	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0
15,5	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0
16,5	0	0	0	0	0	0	0	0	0	0	0	0	0
17	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
18	0	0	0	3,093	0	0,295	0	0	0,061838	0	3,388	0,062	3,450
18,5	0	0	0	1,685	0	0,161	0	0	0,033713	0	1,846	0,034	1,879
19	0	0	0	1,832	0	0,175	0	0	0,036645	0	2,006	0,037	2,043
19,5	0	0,911	0	7,947	0	0,758	0	0	0,158926	0	9,615	0,159	9,774
20	0	18,727	0	25,806	0	2,461	0	0	0,516025	0	46,995	0,516	47,511
20,5	0	19,167	0	13,940	0	1,330	0	0	0,278751	0	34,437	0,279	34,716
21	0,528	21,818	0,354	17,539	0,469	1,673	0,018	0,132	0,35073	0,005	42,399	0,487	42,887
21,5	0,142	18,543	0,095	18,880	0	1,801	0	0	0,37756	0	39,461	0,378	39,839
22	0,306	18,599	0,205	5,797	0,706	0,553	0,027	0,198	0,115891	0,007	26,193	0,321	26,514
22,5	0,656	9,978	0,440	3,110	0,582	0,297	0,023	0,164	0,062226	0,006	15,085	0,232	15,317
23	1,933	15,271	1,295	0	2,370	0	0,092	0,667	0	0,023	20,962	0,69	21,652
23,5	1,316	1,634	0,882	10,694	5,806	1,020	0,226	1,633	0,213828	0,057	21,576	1,904	23,480
24	1,004	10,471	0,673	15,231	11,335	1,453	0,442	3,188	0,304609	0,111	40,609	3,604	44,212
24,5	1,071	11,171	0,718	4,062	15,363	0,387	0,599	4,321	0,081275	0,151	33,371	4,553	37,924
25	0,685	3,967	0,459	4,328	17,989	0,413	0,701	5,059	0,086594	0,176	28,542	5,322	33,864
25,5	0	0	0	0	10,088	0	0,393	2,837	0	0,099	10,482	2,936	13,418
26	0	0	0	0	5,407	0	0,211	1,521	0	0,053	5,618	1,574	7,192
26,5	0	0	0	0	2,335	0	0,091	0,657	0	0,023	2,426	0,680	3,106
27	0	0	0	0	0,619	0	0,024	0,174	0	0,006	0,643	0,180	0,823
27,5	0	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0,347	0	0,014	0,098	0	0,003	0,361	0,101	0,462
28,5	0	0	0	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	**7,640**	**150,257**	**5,119**	**133,945**	**73,488**	**12,775**	**2,865**	**20,669**	**2,679**	**0,720**	**386,089**	**24,068**	**410,158**

Table 13. *ECOCADIZ 2018-07* 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 32**.

ECOCADIZ 2018-07 . *Trachurus mediterraneus* . ABUNDANCE (in numbers and million fish)							
Size class	**POL01**	***n***			**Millions**		
		PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
19	0	0	0	0	0	0	0
19,5	0	0	0	0	0	0	0
20	22068	0	22068	22068	0	0,02	0,02
20,5	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0
21,5	0	0	0	0	0	0	0
22	22068	0	22068	22068	0	0,02	0,02
22,5	22068	0	22068	22068	0	0,02	0,02
23	22068	0	22068	22068	0	0,02	0,02
23,5	66578	0	66578	66578	0	0,1	0,1
24	154849	0	154849	154849	0	0,2	0,2
24,5	154475	0	154475	154475	0	0,2	0,2
25	186001	0	186001	186001	0	0,2	0,2
25,5	315630	0	315630	315630	0	0,3	0,3
26	502379	0	502379	502379	0	0,5	0,5
26,5	439328	0	439328	439328	0	0,4	0,4
27	819505	0	819505	819505	0	0,8	0,8
27,5	512211	0	512211	512211	0	0,5	0,5
28	369597	0	369597	369597	0	0,4	0,4
28,5	440076	0	440076	440076	0	0,4	0,4
29	622176	0	622176	622176	0	0,6	0,6
29,5	742347	0	742347	742347	0	0,7	0,7
30	644244	0	644244	644244	0	0,6	0,6
30,5	296715	0	296715	296715	0	0,3	0,3
31	372376	0	372376	372376	0	0,4	0,4
31,5	475502	0	475502	475502	0	0,5	0,5
32	110714	0	110714	110714	0	0,1	0,1
32,5	133530	0	133530	133530	0	0,1	0,1
33	44510	0	44510	44510	0	0,04	0,0
33,5	142613	0	142613	142613	0	0,1	0,1
34	111088	0	111088	111088	0	0,1	0,1
34,5	89020	0	89020	89020	0	0,1	0,1
35	0	0	0	0	0	0	0
35,5	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0
36,5	44510	0	44510	44510	0	0,04	0,04
37	0	0	0	0	0	0	0
37,5	0	0	0	0	0	0	0
38	0	0	0	0	0	0	0
TOTAL *n*	7878246	0	7878246	7878246	**0**	**8**	**8**
Millions	**8**	**0**					

Table 13. *ECOCADIZ 2018-07* survey. Mediterranean horse mackerel (*T. mediterraneus*). Cont'd.

ECOCADIZ 2018-07 . Trachurus mediterraneus . BIOMASS (t)				
Size class	**POL01**	**PORTUGAL**	**SPAIN**	**TOTAL**
19	0	0	0	0
19,5	0	0	0	0
20	1,662	0	1,662	1,662
20,5	0	0	0	0
21	0	0	0	0
21,5	0	0	0	0
22	2,098	0	2,098	2,098
22,5	2,216	0	2,216	2,216
23	2,338	0	2,338	2,338
23,5	7,434	0	7,434	7,434
24	18,202	0	18,202	18,202
24,5	19,096	0	19,096	19,096
25	24,157	0	24,157	24,157
25,5	43,026	0	43,026	43,026
26	71,812	0	71,812	71,812
26,5	65,793	0	65,793	65,793
27	128,467	0	128,467	128,467
27,5	83,981	0	83,981	83,981
28	63,329	0	63,329	63,329
28,5	78,742	0	78,742	78,742
29	116,165	0	116,165	116,165
29,5	144,524	0	144,524	144,524
30	130,692	0	130,692	130,692
30,5	62,677	0	62,677	62,677
31	81,855	0	81,855	81,855
31,5	108,700	0	108,700	108,700
32	26,304	0	26,304	26,304
32,5	32,953	0	32,953	32,953
33	11,403	0	11,403	11,403
33,5	37,907	0	37,907	37,907
34	30,619	0	30,619	30,619
34,5	25,430	0	25,430	25,430
35	0	0	0	0
35,5	0	0	0	0
36	0	0	0	0
36,5	14,598	0	14,598	14,598
37	0	0	0	0
37,5	0	0	0	0
38	0	0	0	0
TOTAL	**1436,180**	**0**	**1436,180**	**1436,180**

Table 14. *ECOCADIZ 2018-07* 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 34**.

***ECOCADIZ 2018-07* . *Boops boops* . ABUNDANCE (in numbers and million fish)**									
Size class	**POL01**	**POL02**	**POL03**	***n***			**Millions**		
				PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
16	0	0	0	0	0	0	0	0	0
16,5	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0
17,5	0	6807	0	6807	0	6807	0,01	0	0,01
18	179256	6807	0	186063	0	186063	0,2	0	0,2
18,5	160828	0	0	160828	0	160828	0,2	0	0,2
19	682514	0	0	682514	0	682514	1	0	1
19,5	806821	0	0	806821	0	806821	1	0	1
20	802130	0	0	802130	0	802130	1	0	1
20,5	820558	0	0	820558	0	820558	1	0	1
21	967649	38608	0	1006257	0	1006257	1	0	1
21,5	962958	79450	0	1042408	0	1042408	1	0	1
22	606791	99973	0	706764	0	706764	1	0	1
22,5	165519	113588	0	279107	0	279107	0,3	0	0,3
23	245933	163574	359226	409507	359226	768733	0,4	0,4	1
23,5	0	177290	359226	177290	359226	536516	0,2	0,4	1
24	0	325117	987873	325117	987873	1312990	0,3	1	1
24,5	0	163574	987873	163574	987873	1151447	0,2	1	1
25	0	145490	1616519	145490	1616519	1762009	0,1	2	2
25,5	0	79552	1167486	79552	1167486	1247038	0,1	1	1
26	0	61366	987873	61366	987873	1049239	0,1	1	1
26,5	0	13614	1796132	13614	1796132	1809746	0,01	2	2
27	0	18186	987873	18186	987873	1006059	0,02	1	1
27,5	0	0	0	0	0	0	0	0	0
28	0	18186	359226	18186	359226	377412	0,02	0,4	0,4
28,5	0	13614	179613	13614	179613	193227	0,01	0,2	0,2
29	0	0	0	0	0	0	0	0	0
29,5	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0
TOTAL *n*	6400957	1524796	9788920	7925753	9788920	17714673	**8**	**10**	**18**
Millions	**6**	**2**	**10**						

Table 14. *ECOCADIZ 2018-07* survey. Bogue (*B. boops*). Cont'd.

***ECOCADIZ 2018-07 . Boops boops* . BIOMASS (t)**						
Size class	**POL01**	**POL02**	**POL03**	**PORTUGAL**	**SPAIN**	**TOTAL**
16	0	0	0	0	0	0
16,5	0	0	0	0	0	0
17	0	0	0	0	0	0
17,5	0	0,356	0	0,356	0	0,356
18	10,185	0,387	0	10,572	0	10,572
18,5	9,913	0	0	9,913	0	9,913
19	45,538	0	0	45,538	0	45,538
19,5	58,152	0	0	58,152	0	58,152
20	62,334	0	0	62,334	0	62,334
20,5	68,625	0	0	68,625	0	68,625
21	86,940	3,469	0	90,409	0	90,409
21,5	92,794	7,656	0	100,450	0	100,450
22	62,614	10,316	0	72,930	0	72,930
22,5	18,262	12,532	0	30,794	0	30,794
23	28,969	19,268	42,314	48,237	42,314	90,550
23,5	0	22,265	45,113	22,265	45,113	67,378
24	0	43,473	132,093	43,473	132,093	175,565
24,5	0	23,258	140,464	23,258	140,464	163,722
25	0	21,971	244,116	21,971	244,116	266,086
25,5	0	12,744	187,027	12,744	187,027	199,771
26	0	10,417	167,687	10,417	167,687	178,104
26,5	0	2,446	322,707	2,446	322,707	325,153
27	0	3,455	187,666	3,455	187,666	191,121
27,5	0	0	0	0	0	0
28	0	3,851	76,064	3,851	76,064	79,914
28,5	0	3,039	40,095	3,039	40,095	43,134
29	0	0	0	0	0	0
29,5	0	0	0	0	0	0
30	0	0	0	0	0	0
TOTAL	**544,325**	**200,901**	**1585,346**	**745,226**	**1585,346**	**2330,572**

Table 15. *ECOCADIZ 2018-07* 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 36**.

ECOCADIZ 2018-07 . Capros aper . ABUNDANCE (in numbers and million fish)							
Size class	POL01	*n*			Millions		
		PORTUGAL	SPAIN	TOTAL	PORTUGAL	SPAIN	TOTAL
1	0	0	0	0	0	0	0
1,5	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0
2,5	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0
3,5	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0
4,5	12214	12214	0	12214	0,01	0	0,01
5	67176	67176	0	67176	0,1	0	0,1
5,5	219847	219847	0	219847	0,2	0	0,2
6	230026	230026	0	230026	0,2	0	0,2
6,5	83461	83461	0	83461	0,1	0	0,1
7	0	0	0	0	0	0	0
7,5	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0
8,5	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0
TOTAL *n*	612724	612724	0	612724	1	0	1
Millions	1	1					

Table 15. *ECOCADIZ 2018-07* survey. Boarfish (*C. aper*). Cont'd.

ECOCADIZ 2018-07 . Capros aper . BIOMASS (t)				
Size class	POL01	PORTUGAL	SPAIN	TOTAL
1	0	0	0	0
1,5	0	0	0	0
2	0	0	0	0
2,5	0	0	0	0
3	0	0	0	0
3,5	0	0	0	0
4	0	0	0	0
4,5	0,027	0,027	0	0,027
5	0,201	0,201	0	0,201
5,5	0,871	0,871	0	0,871
6	1,177	1,177	0	1,177
6,5	0,541	0,541	0	0,541
7	0,049	0,049	0	0,049
7,5	0	0	0	0
8	0	0	0	0
8,5	0	0	0	0
9	0	0	0	0
TOTAL	**2,867**	**2,867**	**0**	**2,867**

Table 16. *ECOCADIZ 2018-07* survey. Pearlside (*M. muelleri*). 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 38**.

***ECOCADIZ 2018-07* . *Maurolicus muelleri* . ABUNDANCE (in numbers and million fish)**								
Size class	**POL01**	**POL02**	***n***			**Millions**		
			PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
1	0	0	0	0	0	0	0	0
1,5	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
2,5	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
3,5	463555815	2260522504	463555815	2260522504	2724078319	464	2261	2724
4	827777753	4036644949	827777753	4036644949	4864422702	828	4037	4864
4,5	364221938	1776122445	364221938	1776122445	2140344383	364	1776	2140
5	22075713	107651859	22075713	107651859	129727572	22	108	130
5,5	33113569	161477789	33113569	161477789	194591358	33	161	195
6	22075713	107651859	22075713	107651859	129727572	22	108	130
6,5	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0
7,5	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0
8,5	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0
TOTAL *n*	1732820501	8450071405	1732820501	8450071405	10182891906	**1733**	**8450**	**10183**
Millions	**1733**	**8450**						

Table 16. *ECOCADIZ 2018-07* survey. Pearlside (*M. muelleri*). Cont'd.

***ECOCADIZ 2018-07* . *Maurolicus muelleri* . BIOMASS (t)**					
Size class	**POL01**	**POL02**	**PORTUGAL**	**SPAIN**	**TOTAL**
1	0	0	0	0	0
1,5	0	0	0	0	0
2	0	0	0	0	0
2,5	0	0	0	0	0
3	0	0	0	0	0
3,5	177,703	866,566	177,703	866,566	1044,269
4	467,215	2278,368	467,215	2278,368	2745,584
4,5	289,915	1413,768	289,915	1413,768	1703,683
5	23,942	116,754	23,942	116,754	140,696
5,5	47,574	231,995	47,574	231,995	279,569
6	41,040	200,130	41,040	200,130	241,170
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
TOTAL	**1047,390**	**5107,581**	**1047,390**	**5107,581**	**6154,971**

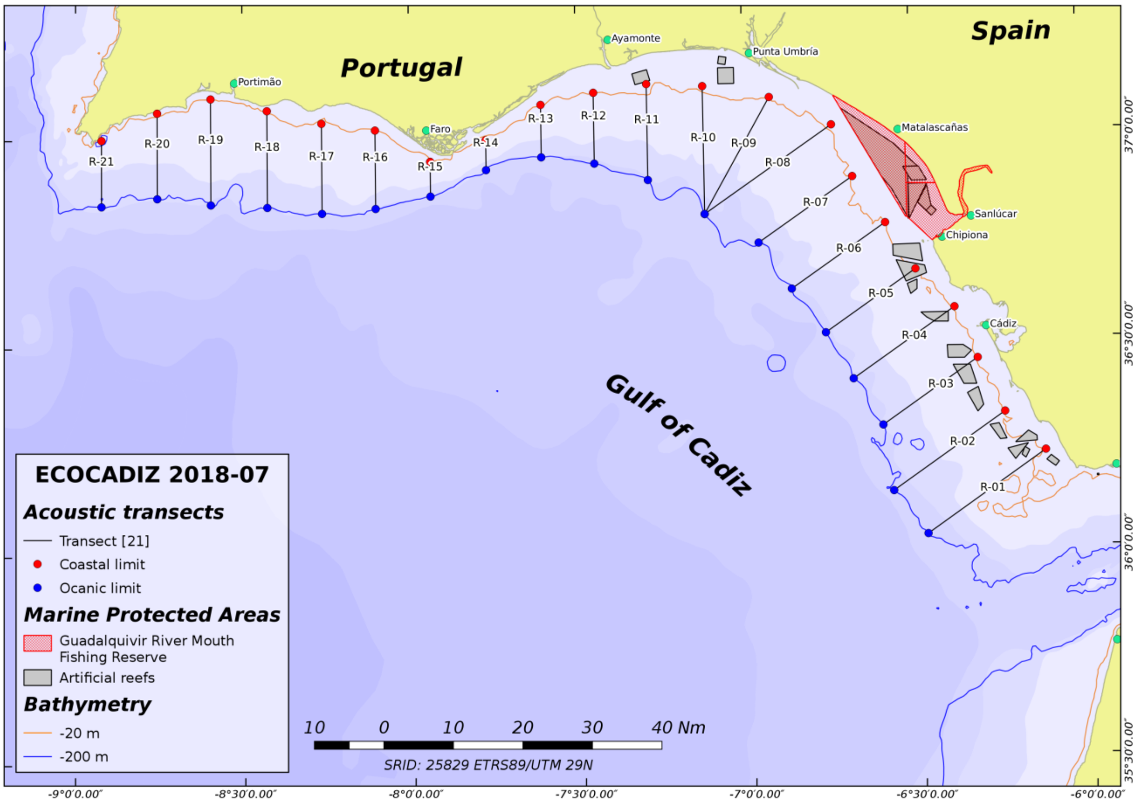


Figure 1. *ECOCADIZ 2018-07* survey. Location of the acoustic transects sampled during the survey. The different protected areas inside the Guadalquivir river mouth Fishing Reserve and artificial reef polygons are also shown.

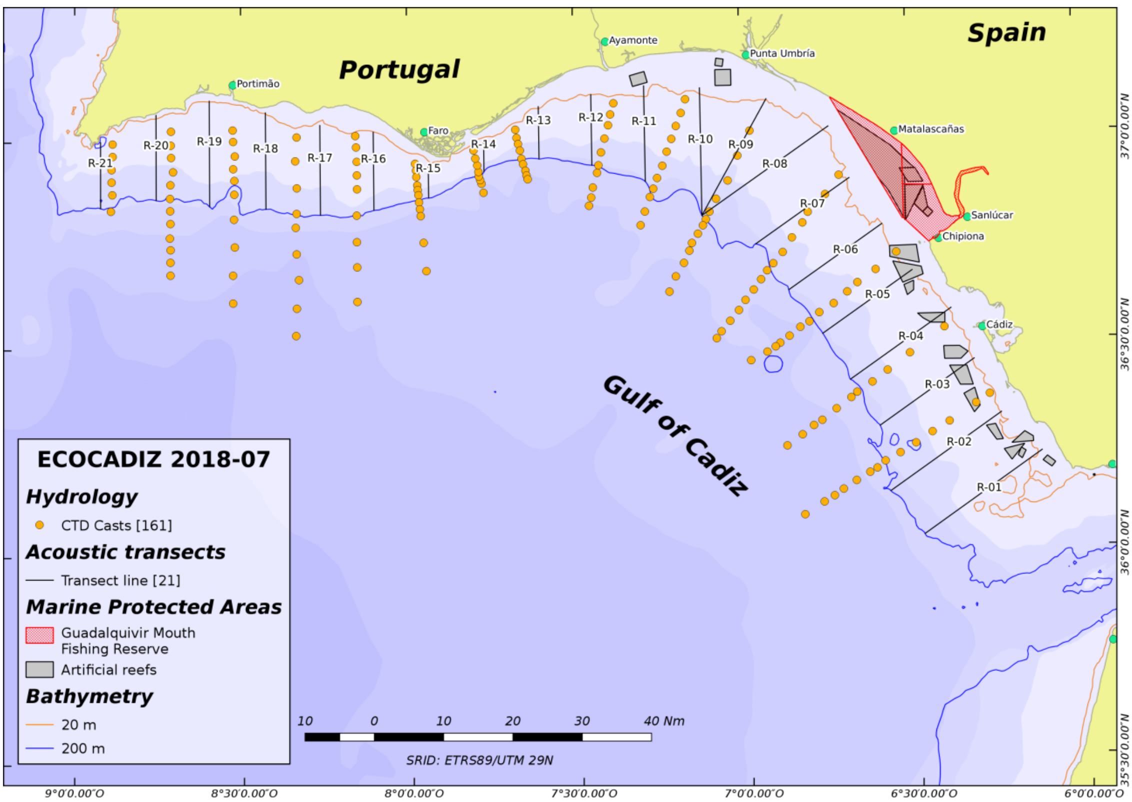


Figure 2. *ECOCADIZ 2018-07* survey. Location of CTD-LADCP stations.

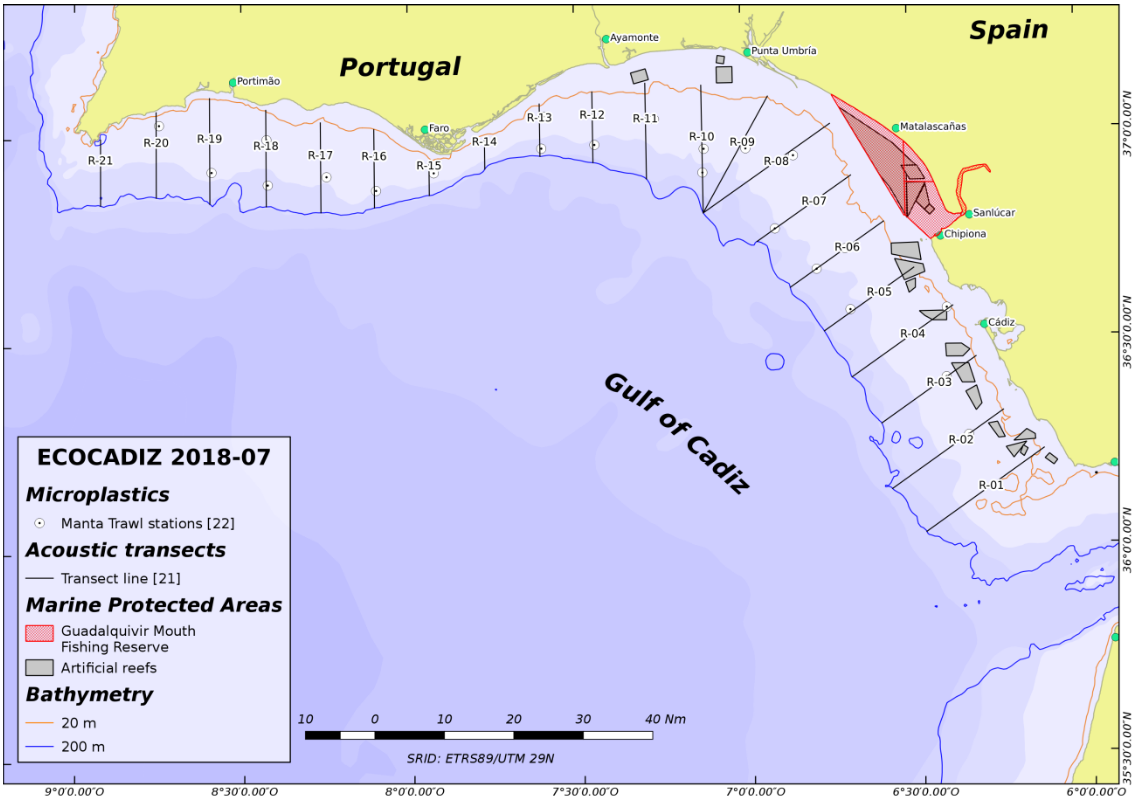


Figure 3. *ECOCADIZ 2018-07* survey. Location of Manta trawl hauls (micro-plastics).

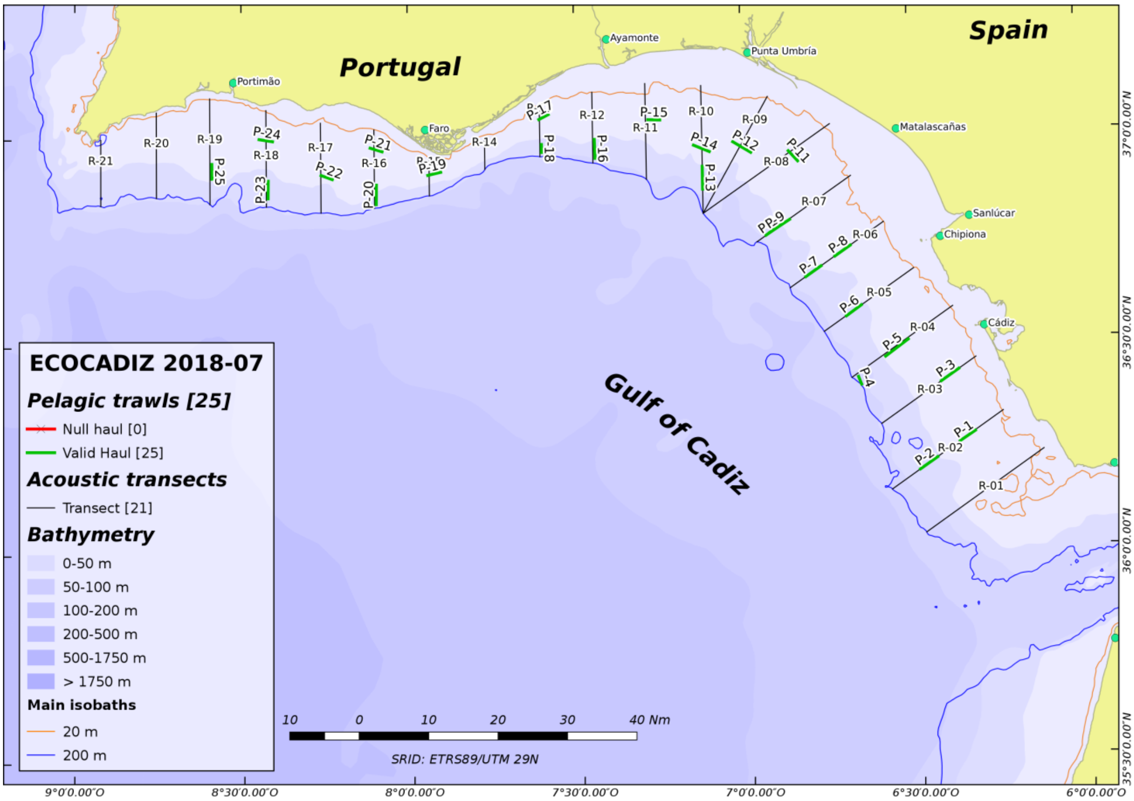


Figure 4. *ECOCADIZ 2018-07* survey. Location of ground-truthing fishing hauls.

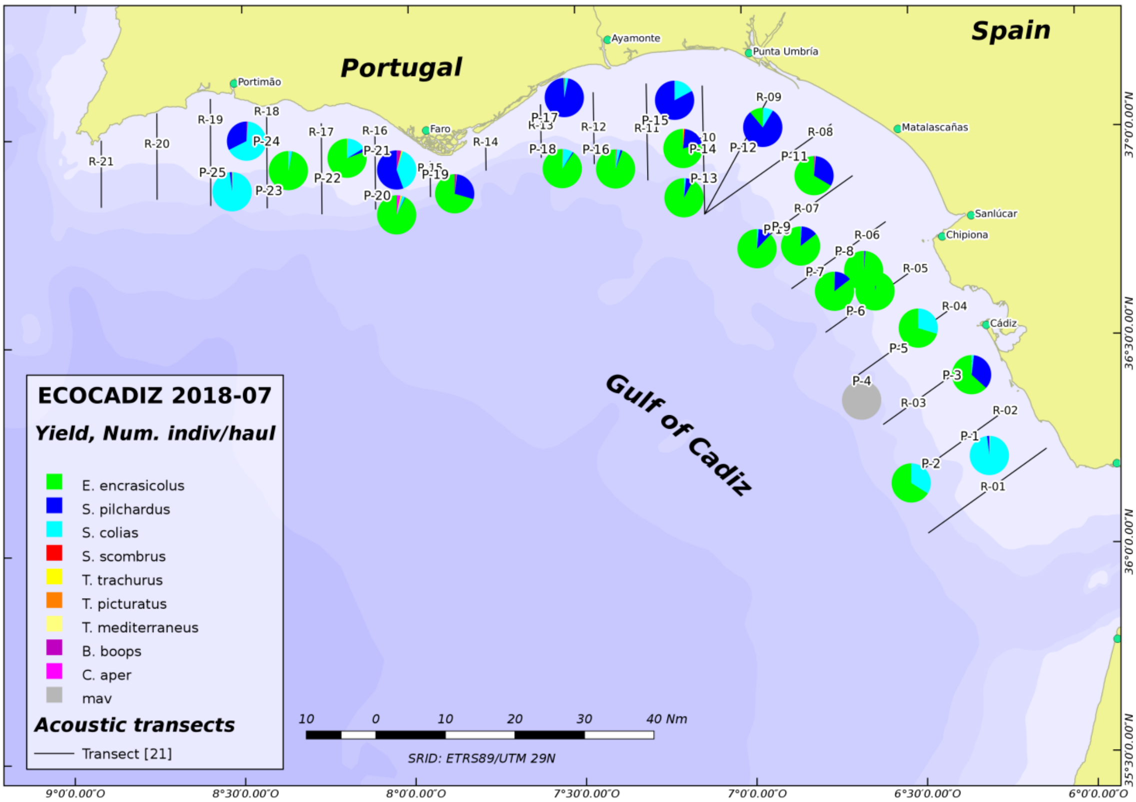


Figure 5. *ECOCADIZ 2018-07* survey. Species composition (percentages in number) in fishing hauls.

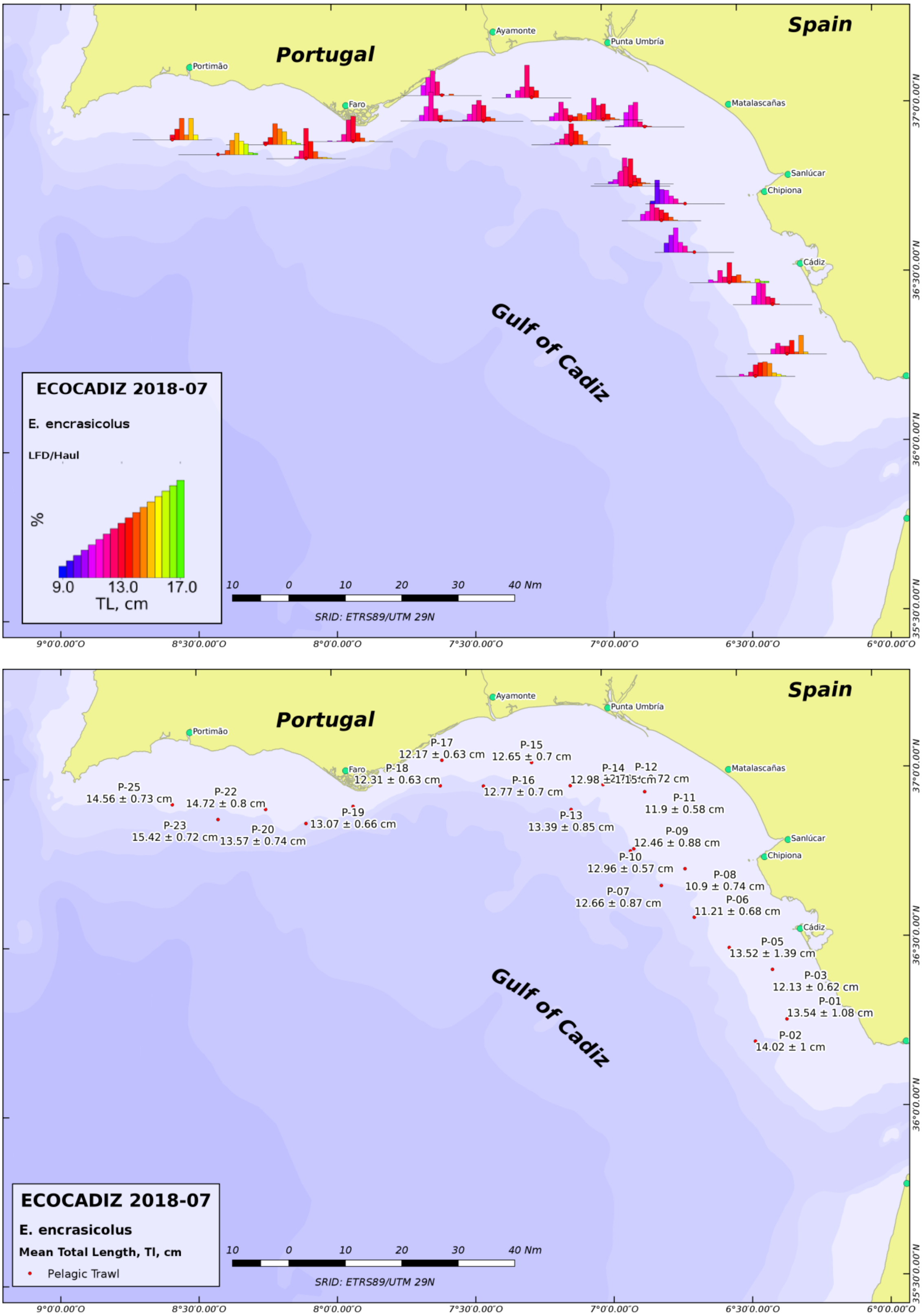
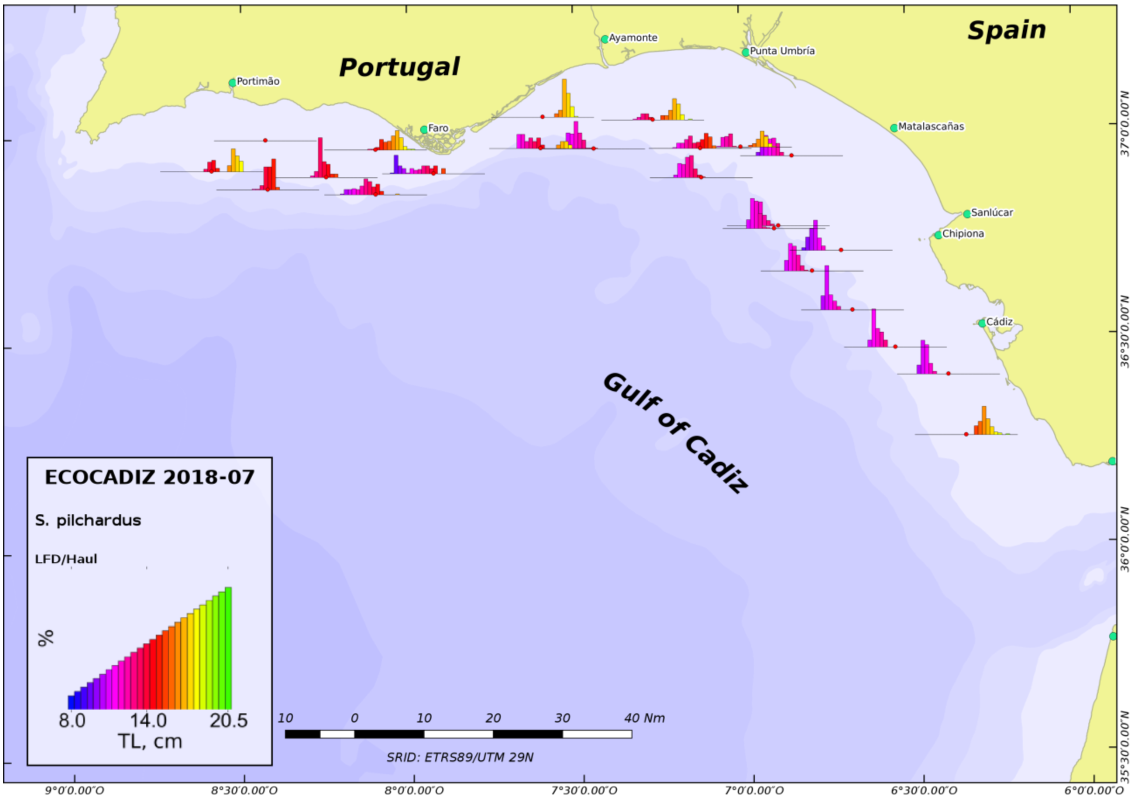


Figure 6. *ECOCADIZ 2018-07* survey. *Engraulis encrasicolus*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.



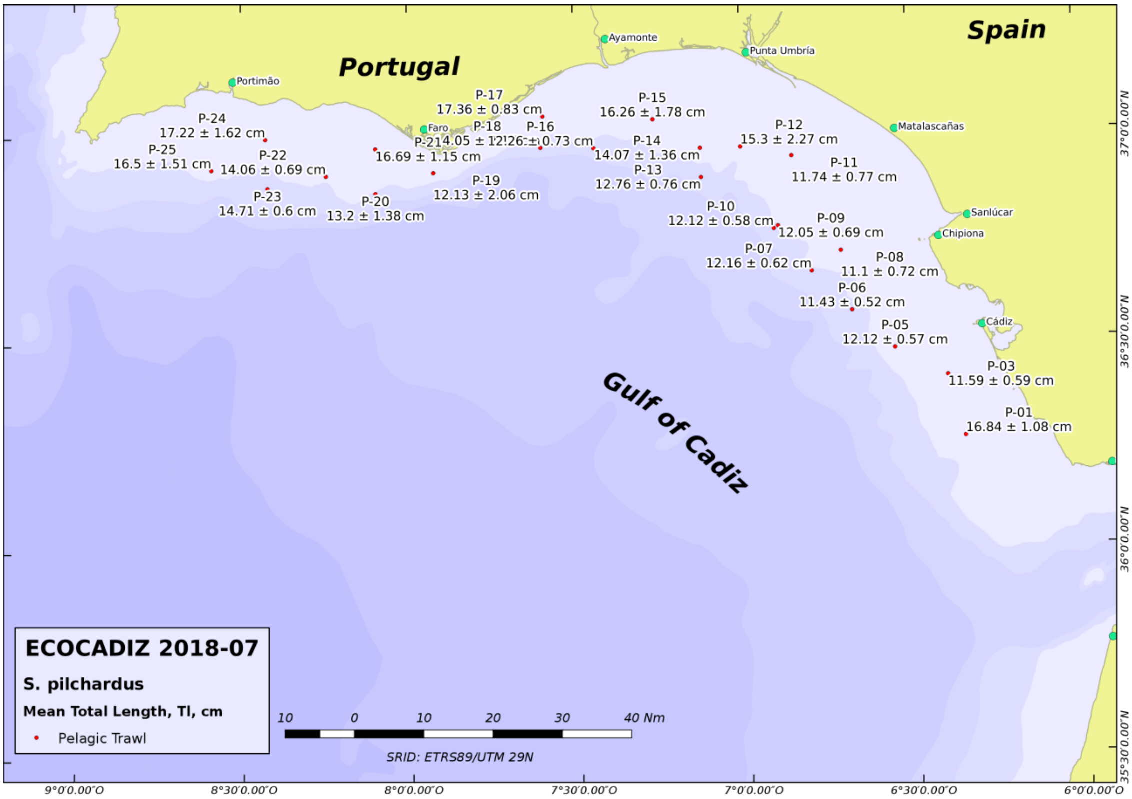


Figure 7. *ECOCADIZ 2018-07* survey. *Sardina pilchardus*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

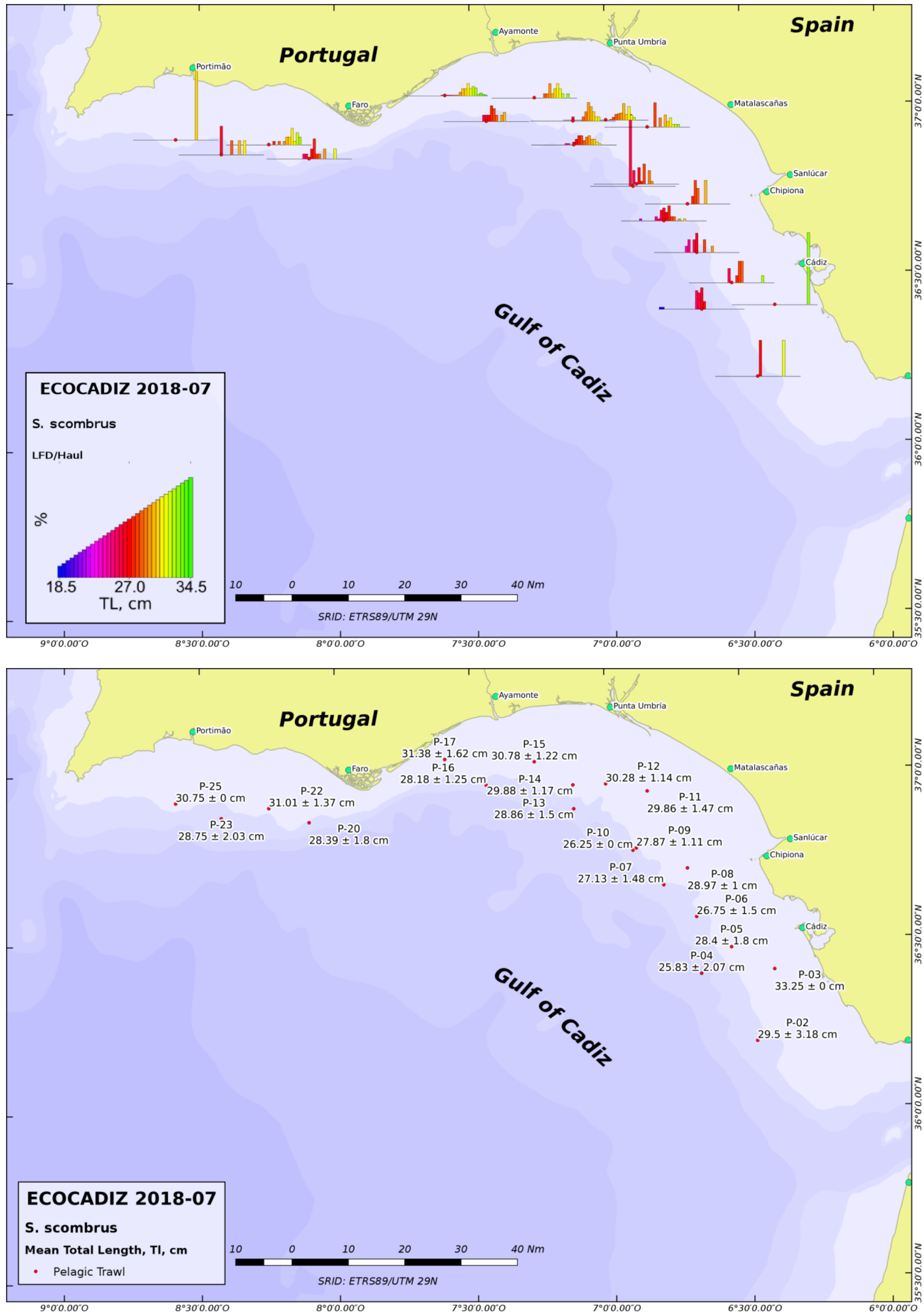


Figure 8. *ECOCADIZ 2018-07* survey. *Scomber scombrus*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

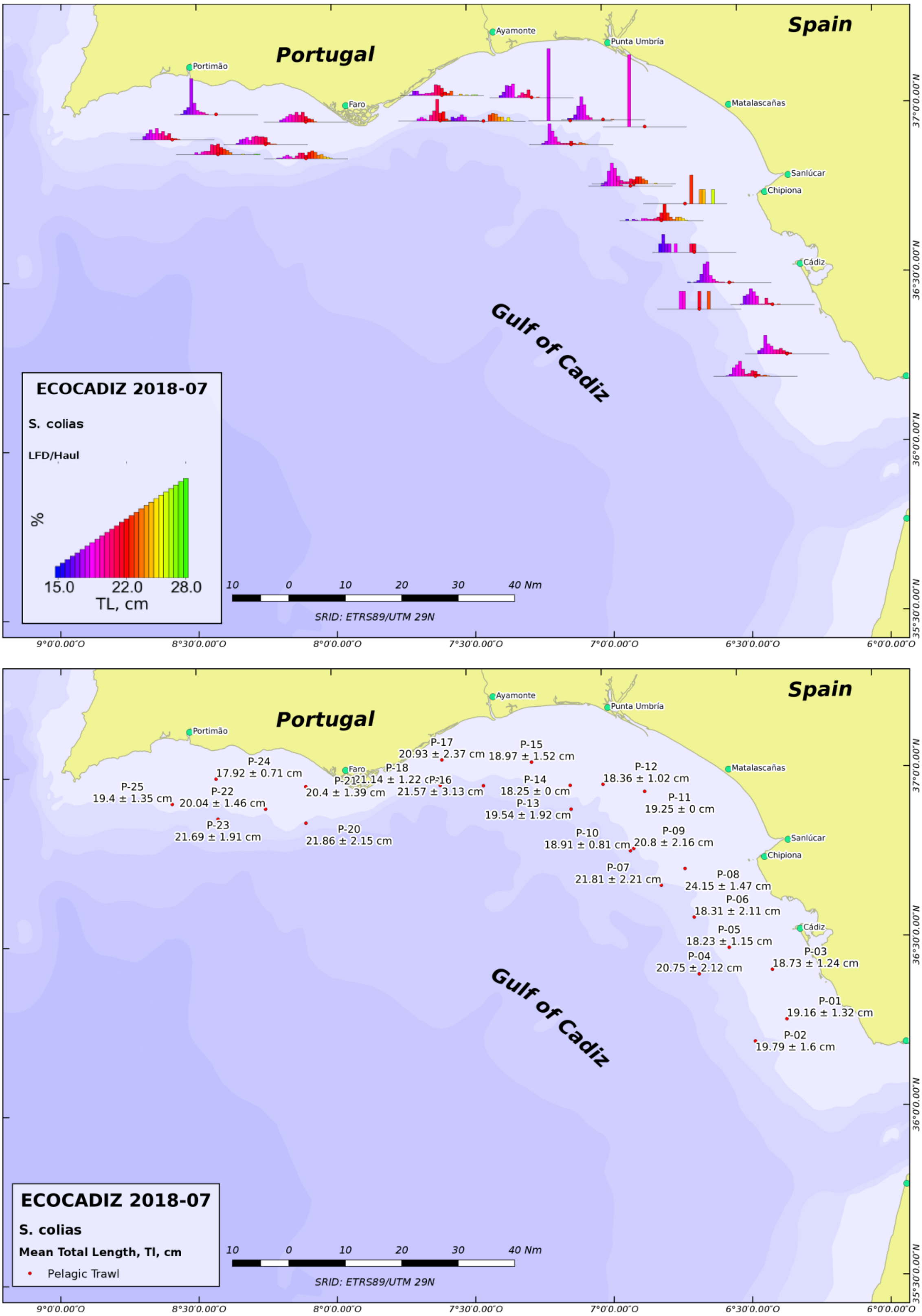
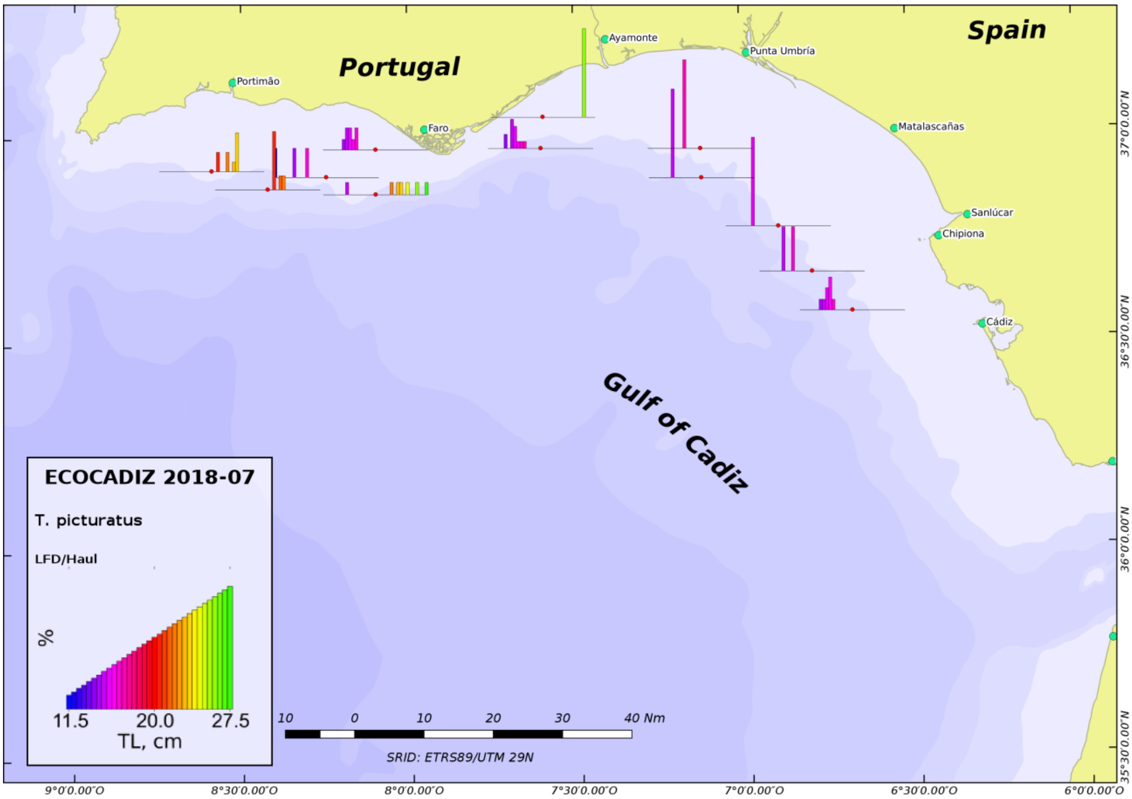


Figure 9. *ECOCADIZ 2018-07* survey. *Scomber colias*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.



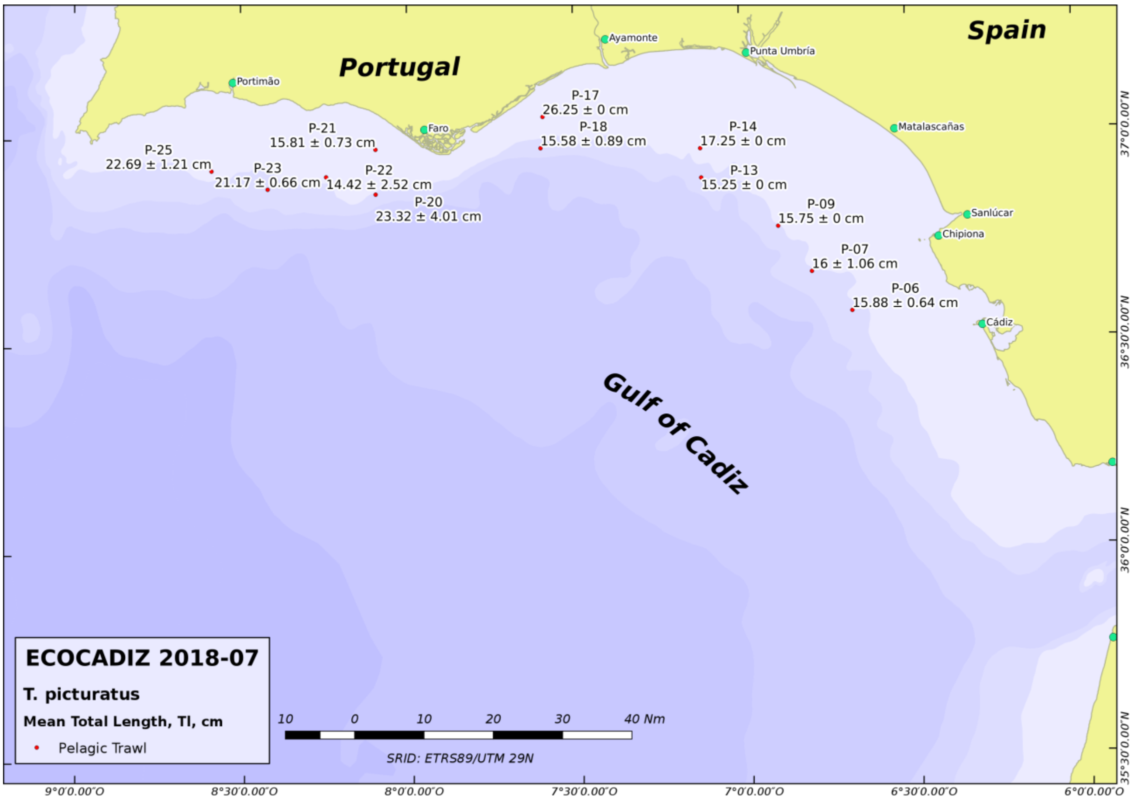


Figure 10. *ECOCADIZ 2018-07* survey. *Trachurus picturatus*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

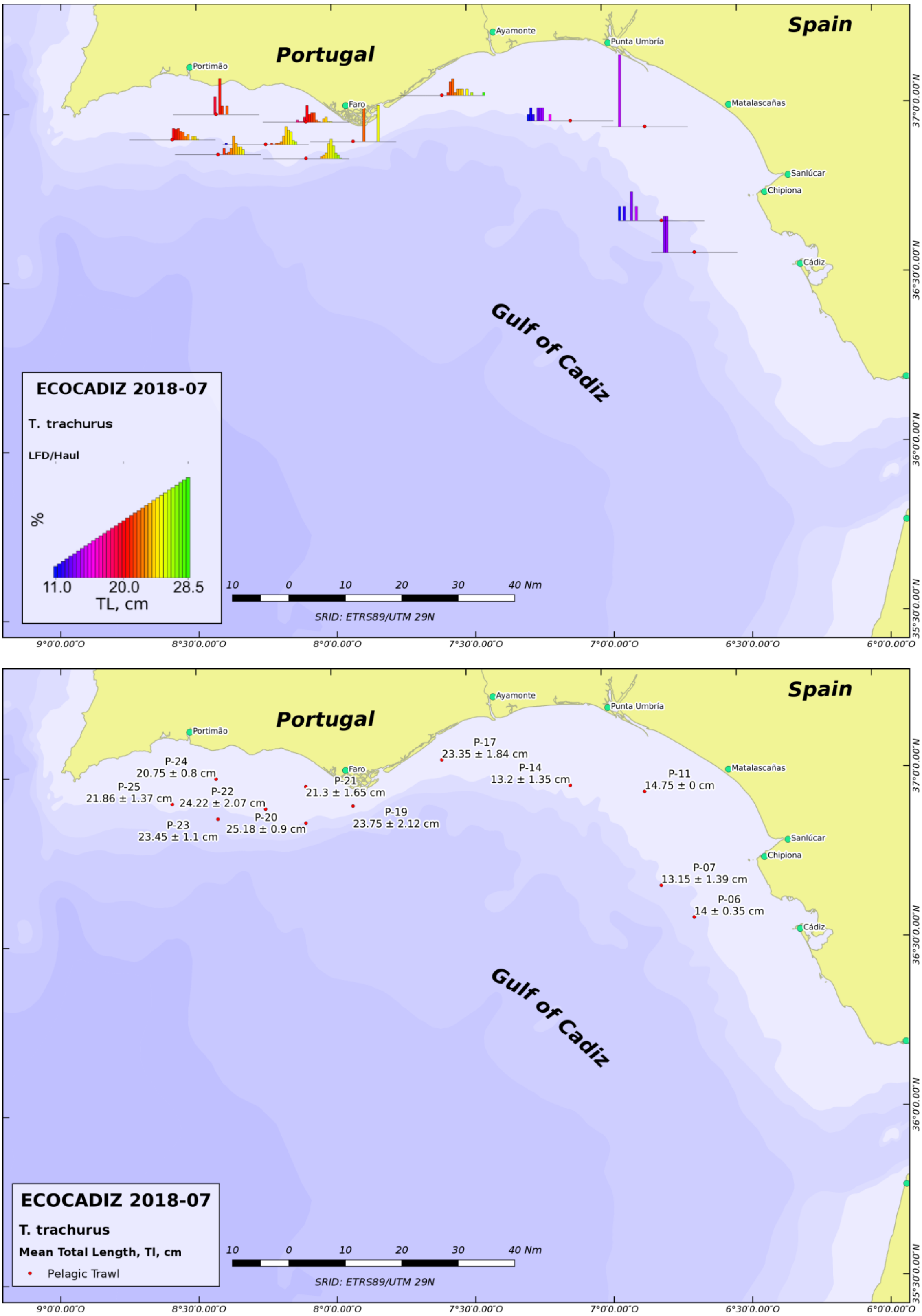


Figure 11. *ECOCADIZ 2018-07* survey. *Trachurus trachurus*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

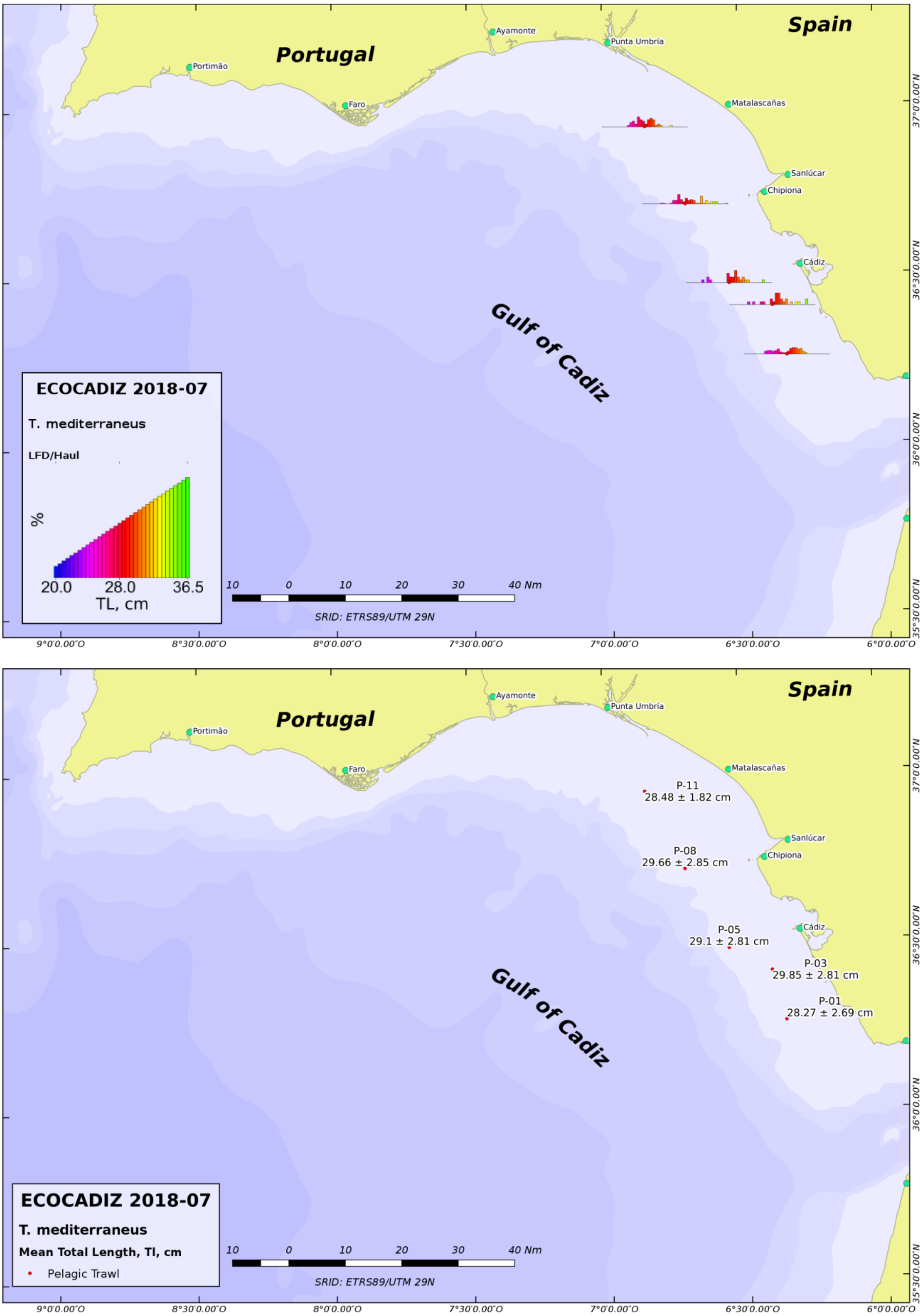


Figure 12. *ECOCADIZ 2018-07* survey. *Trachurus mediterraneus*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

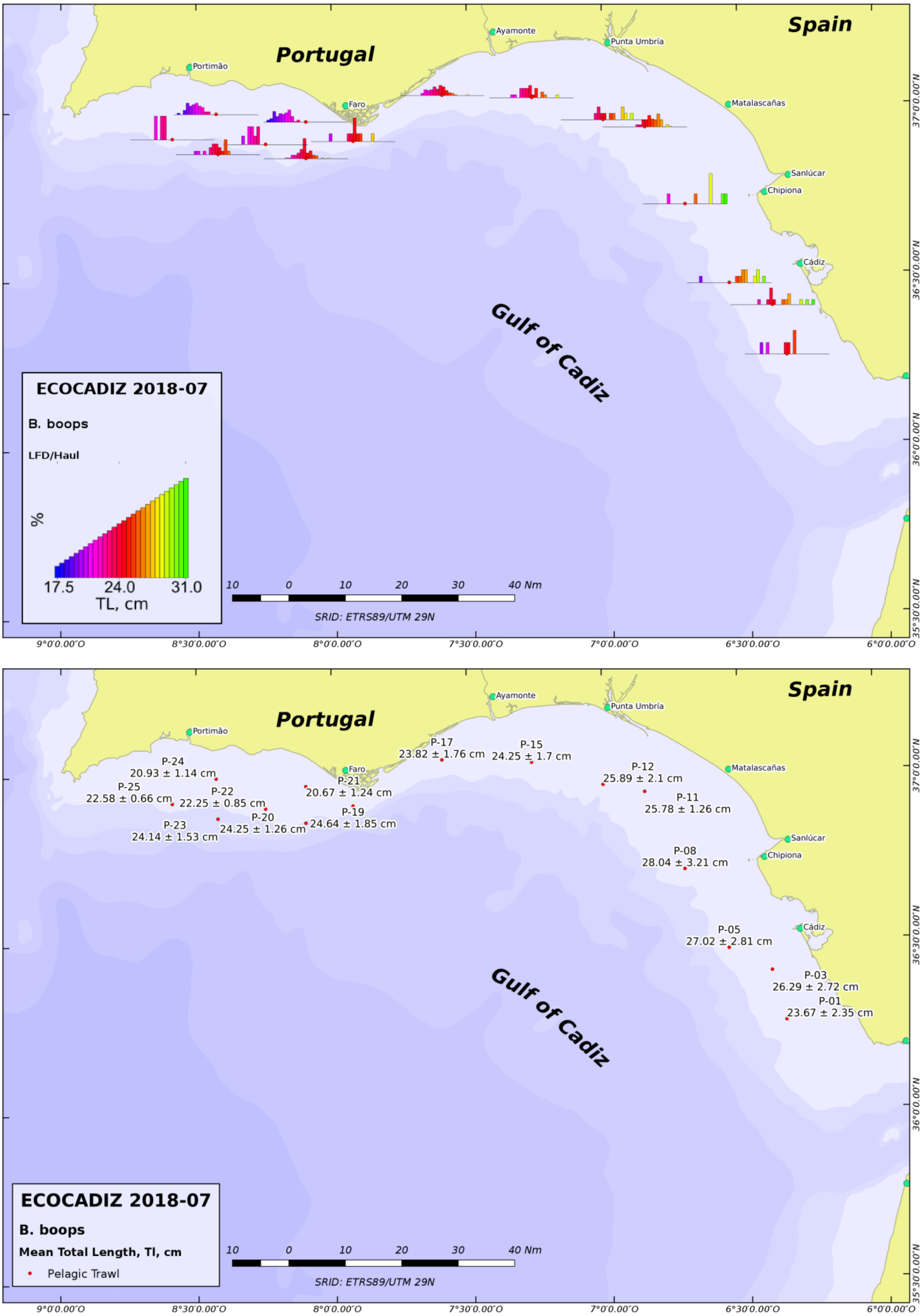
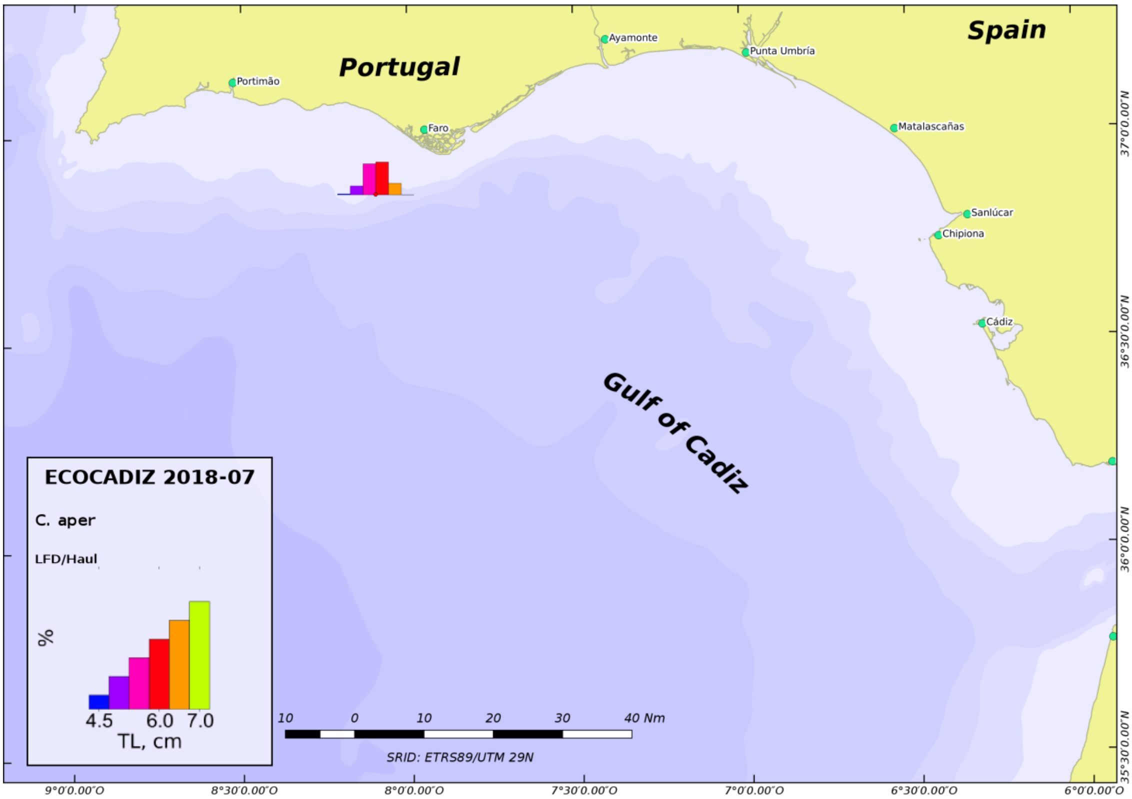


Figure 13. *ECOCADIZ 2018-07* survey. *Boops boops*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.



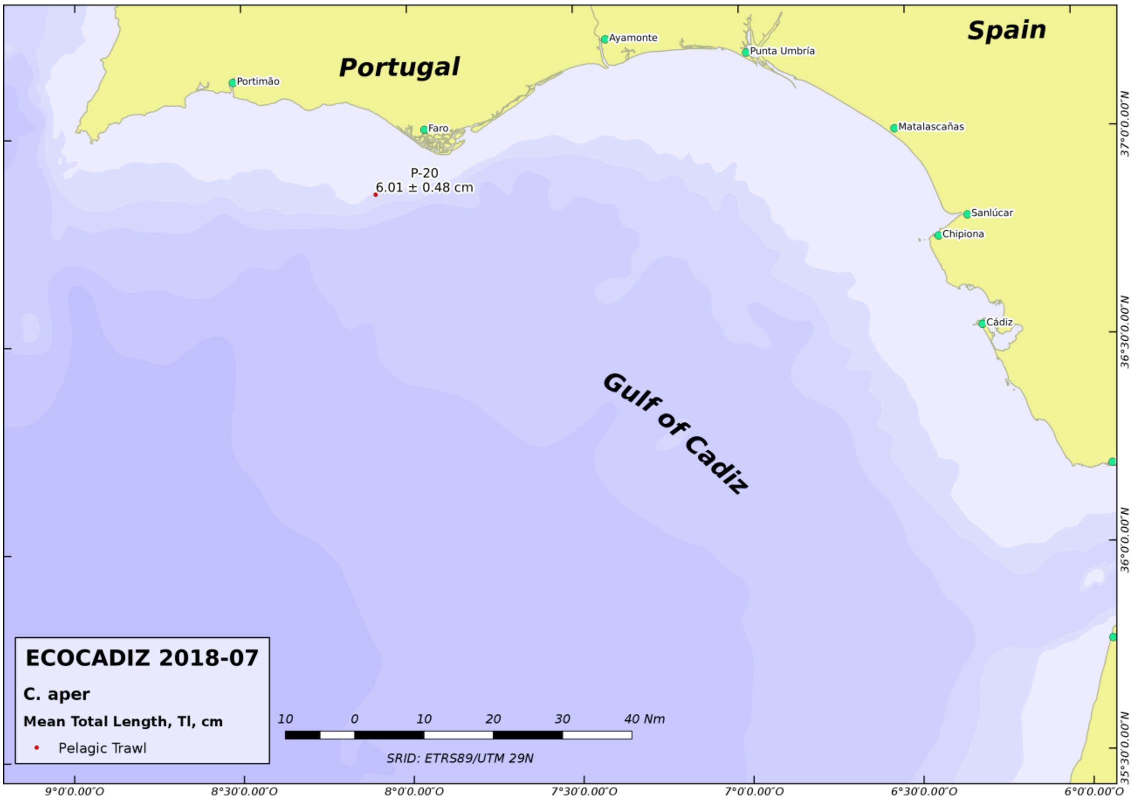


Figure 14. *ECOCADIZ 2017-07* survey. *Capros aper*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

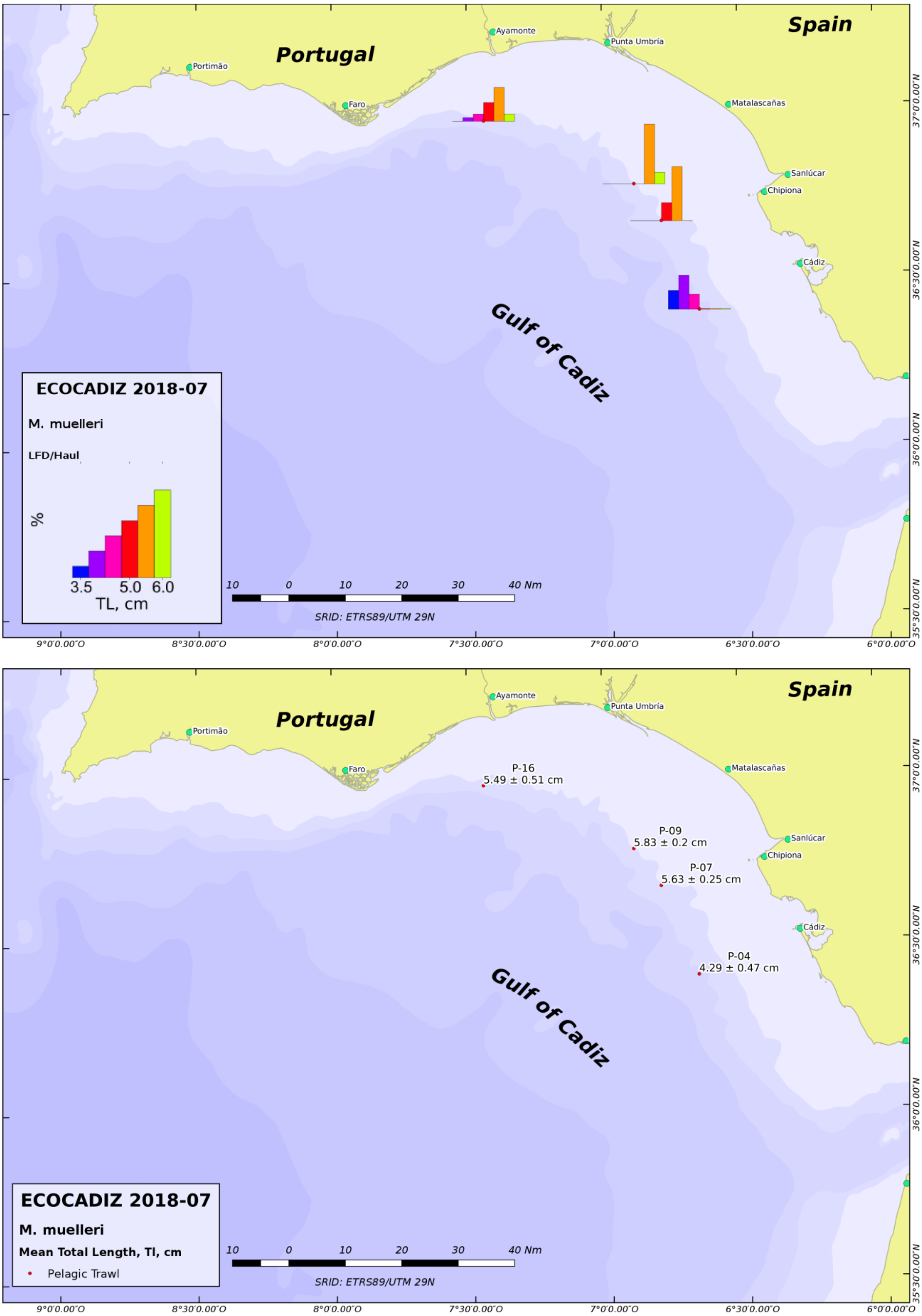


Figure 15. *ECOCADIZ 2017-07* survey. *Maurolicus muelleri*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

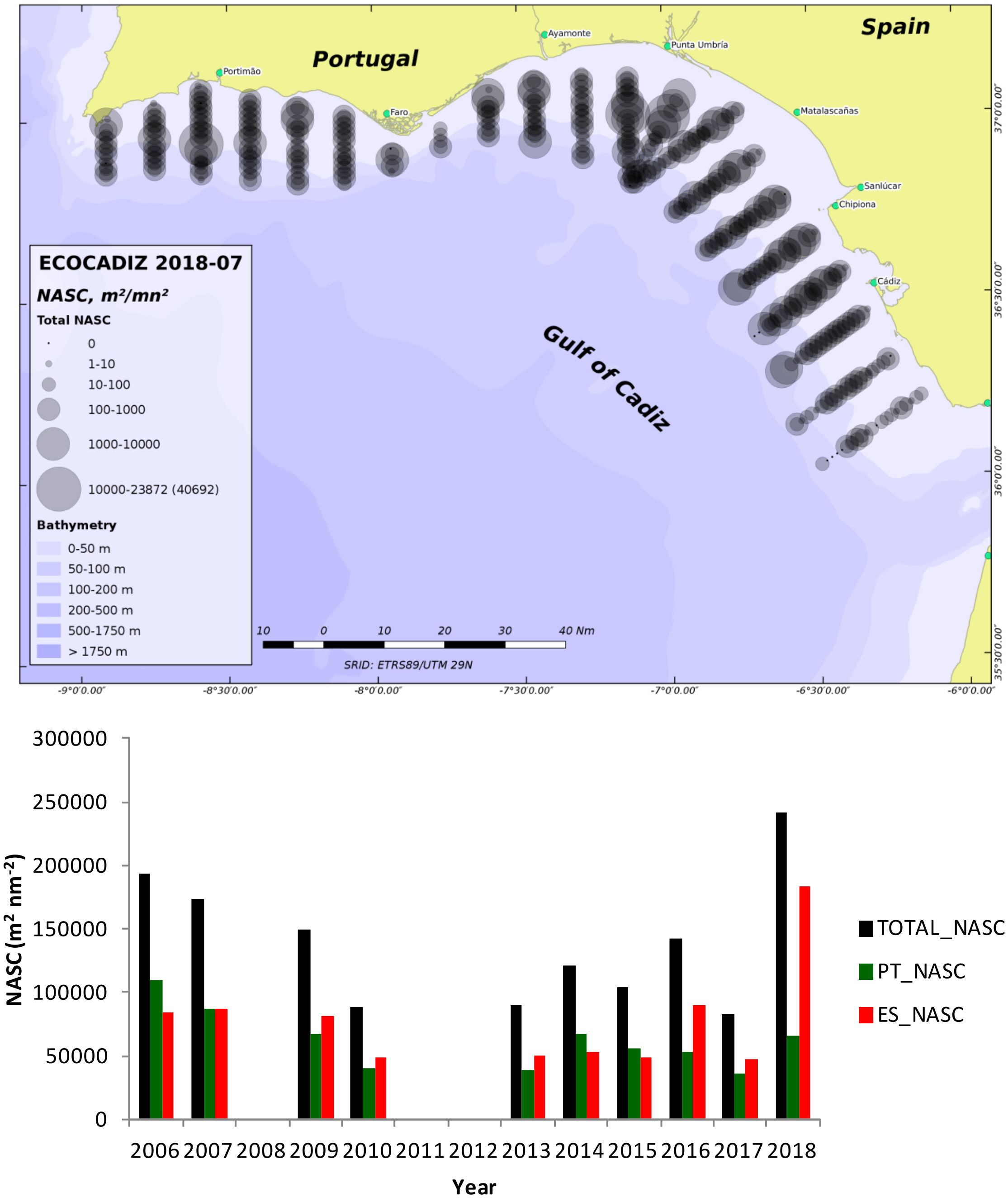
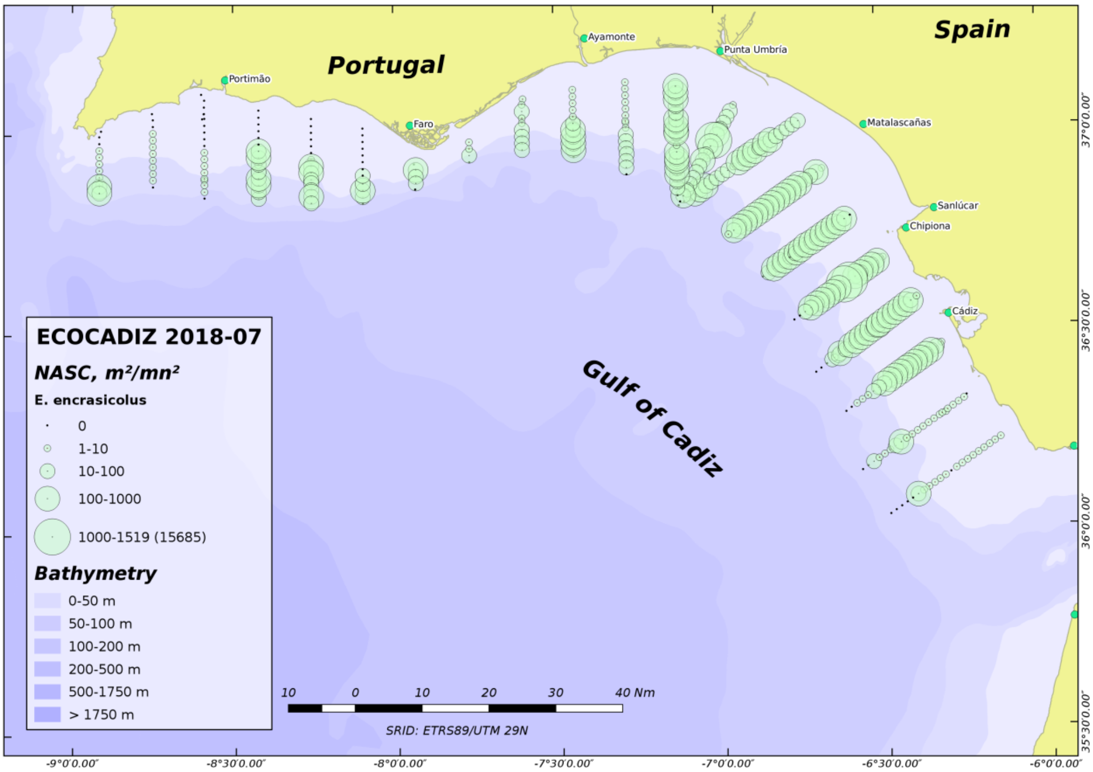


Figure 16. *ECOCADIZ 2018-07* survey. Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the pelagic fish species assemblage. Bottom: time-series of total NASC estimates per survey.



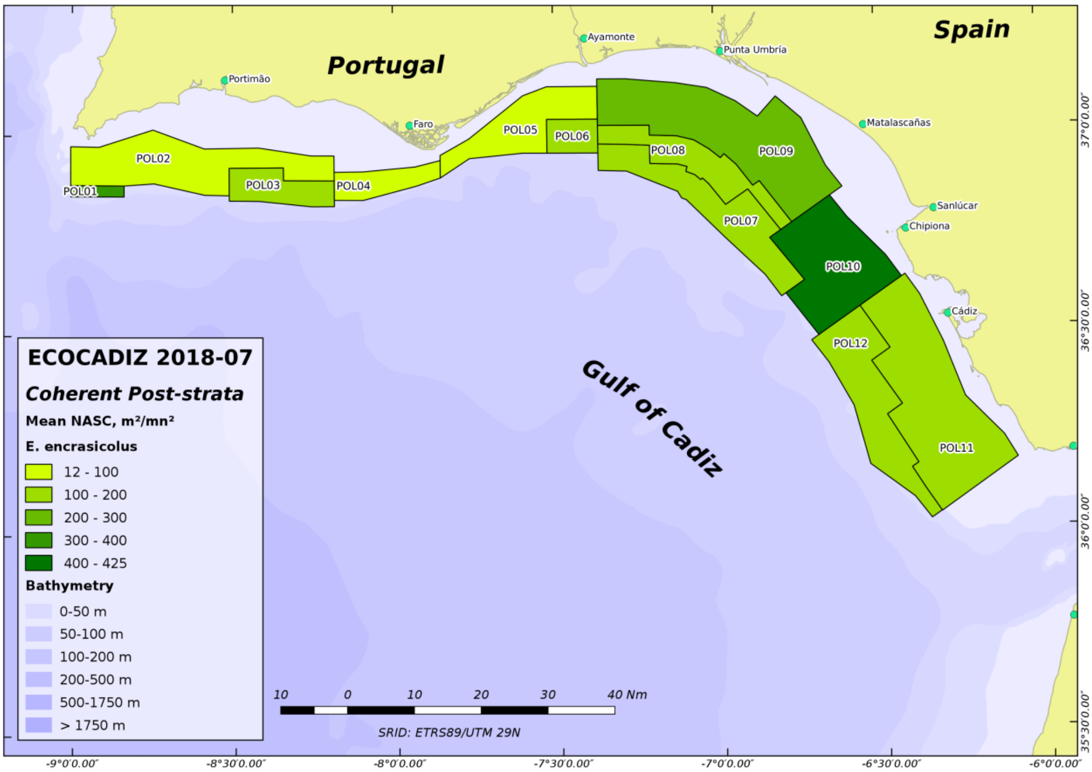


Figure 17. *ECOCADIZ 2018-07* survey. Anchovy (*Engraulis encrasicolus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance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

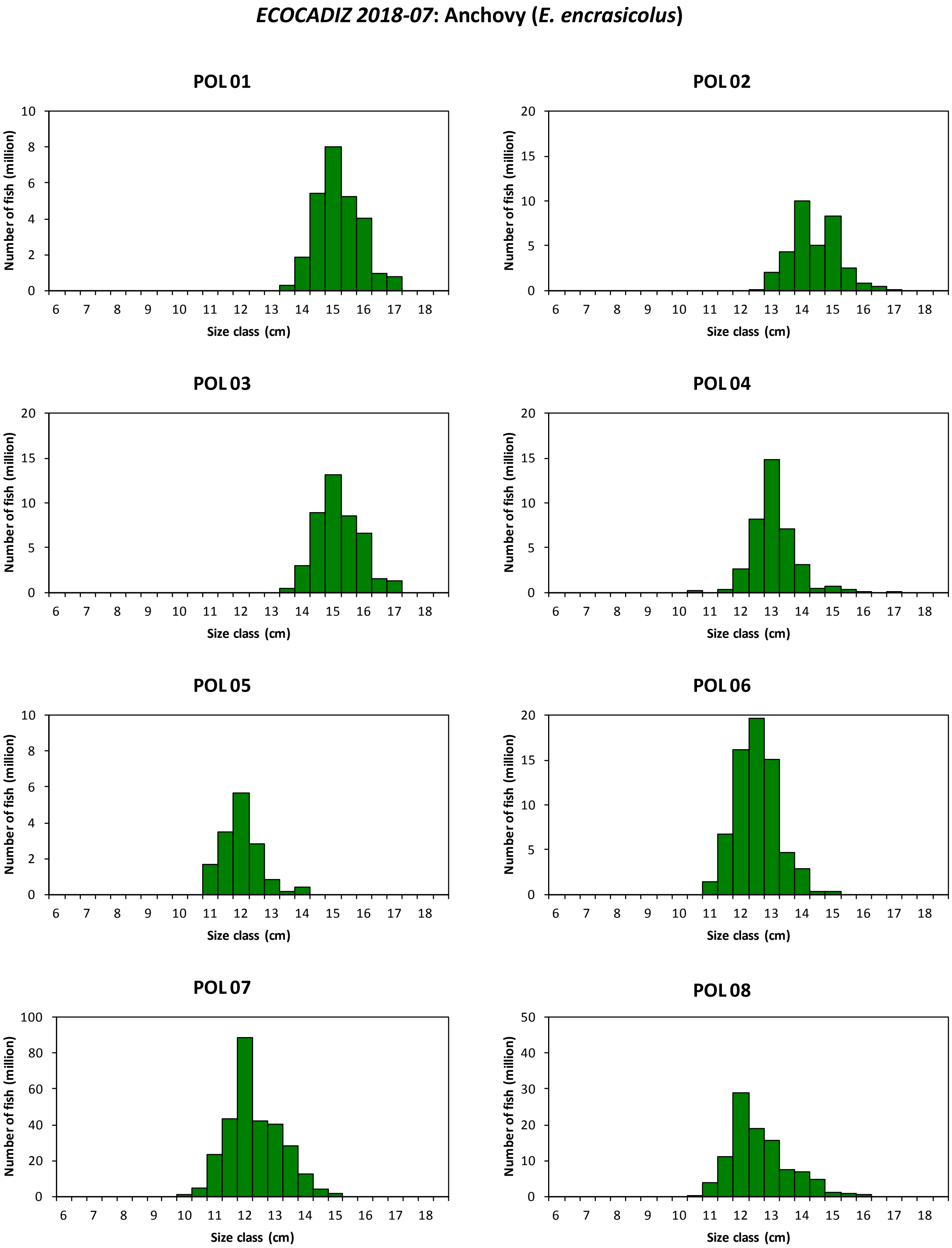


Figure 18. *ECOCADIZ 2018-07* survey. Anchovy (*E. encrasicolus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 17**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by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

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

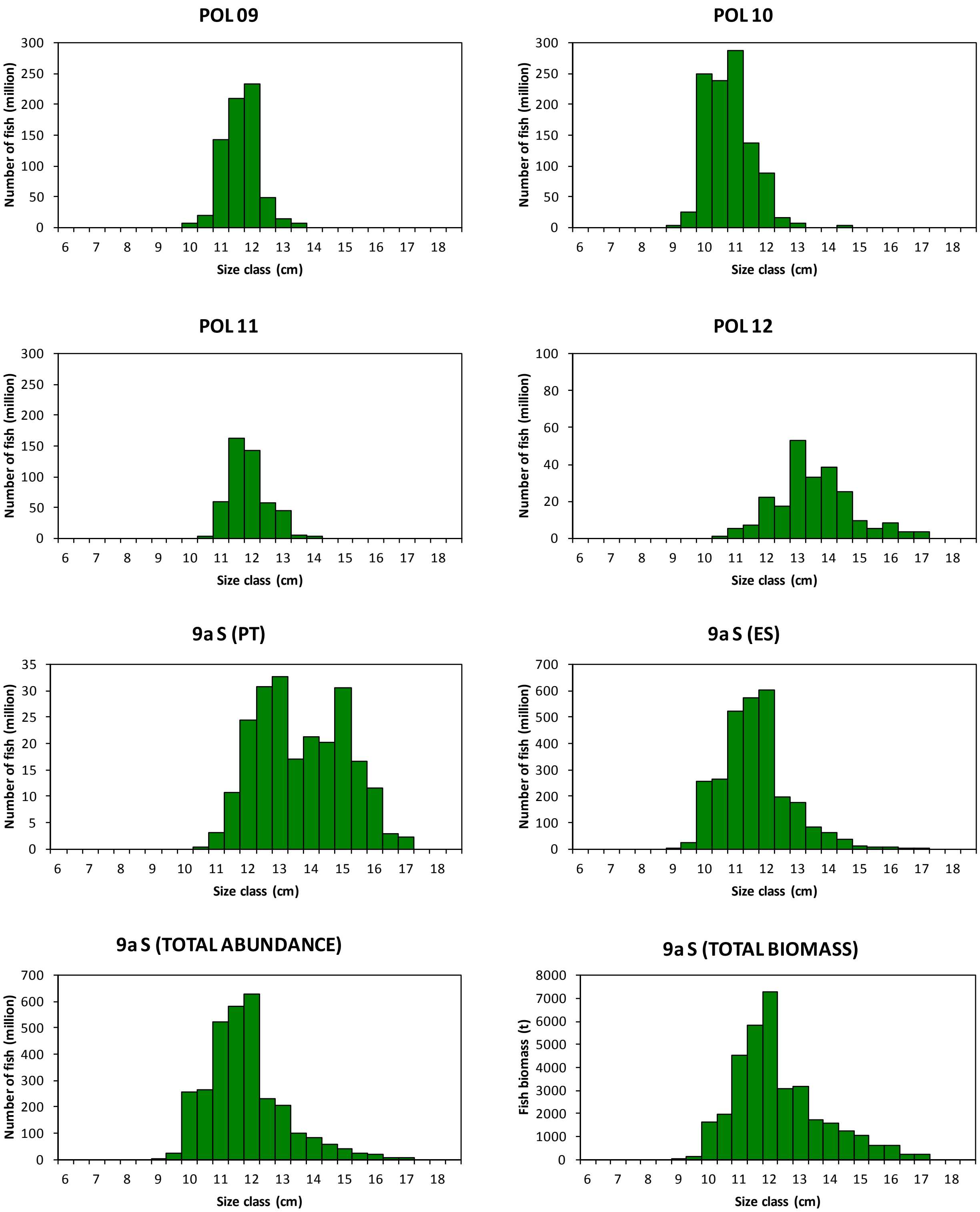


Figure 18. *ECOCADIZ 2018-07* survey. Anchovy (*E. encrasicolus*). Cont'd.

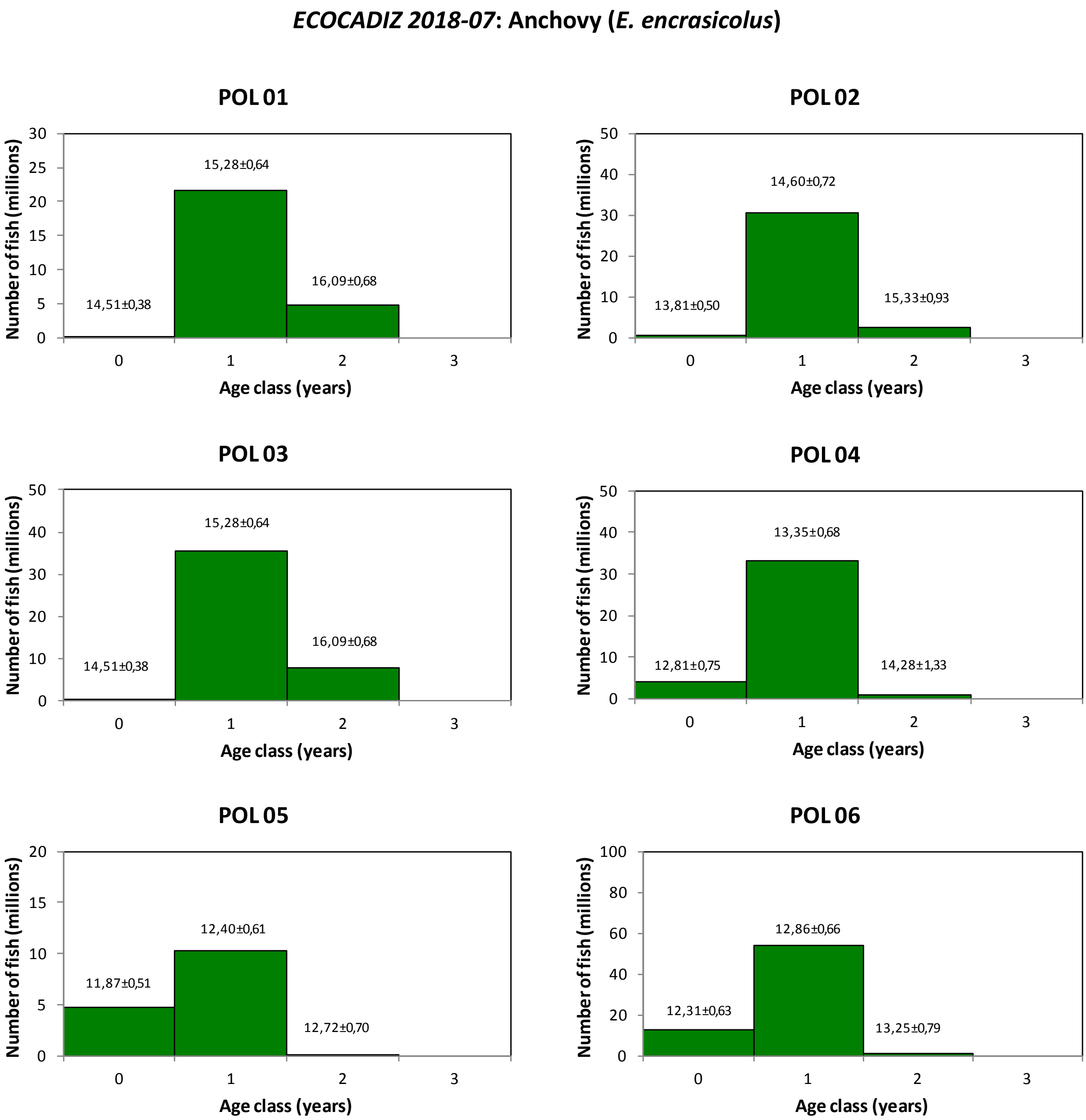


Figure 19. *ECOCADIZ 2018-07* survey. Anchovy (*E. encrasicolus*). Estimated abundances (number of fish in millions) by age group (years) by homogeneous stratum (POL01-POLn, numeration as in **Figure 17**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by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

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

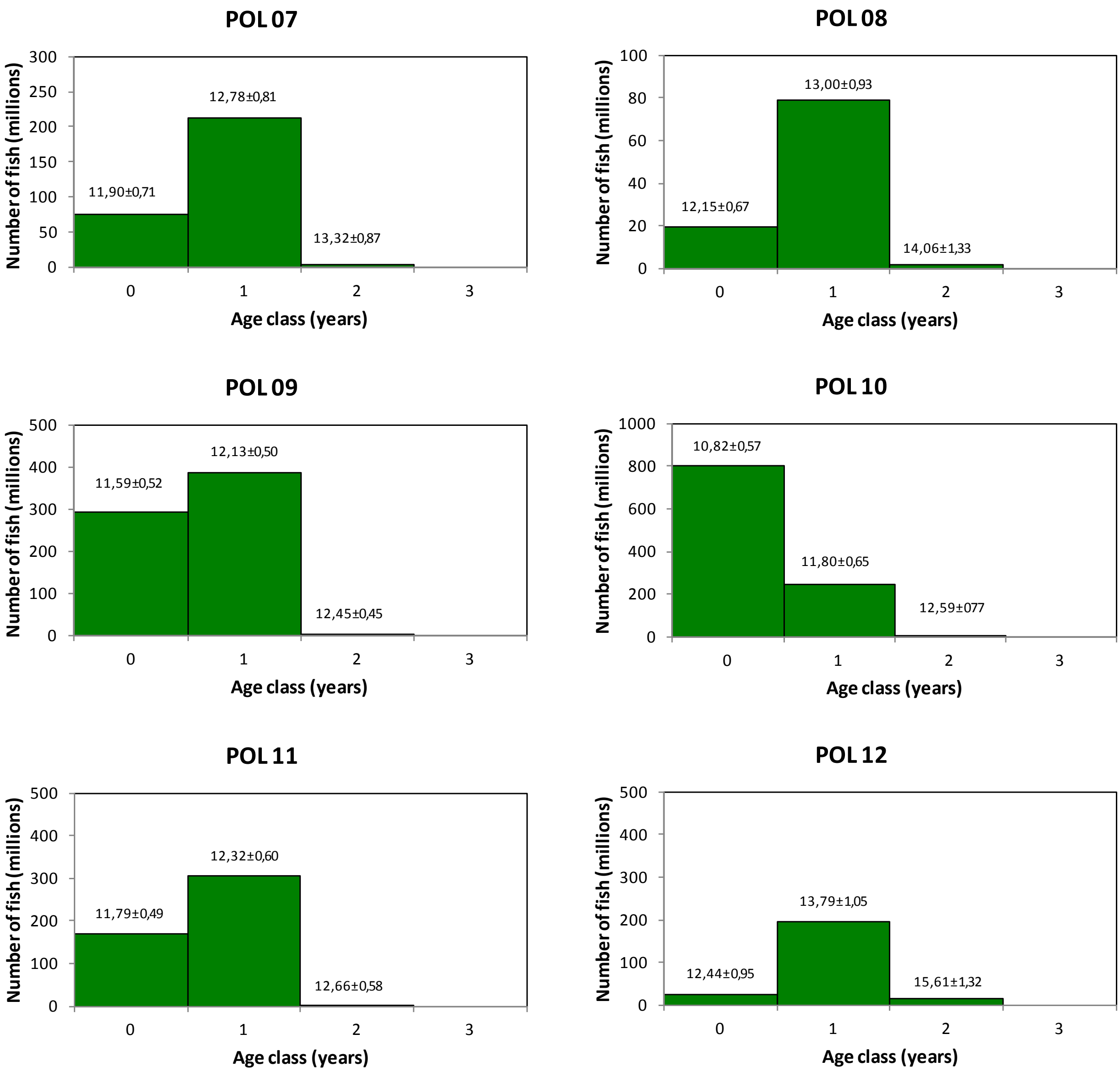


Figure 19. *ECOCADIZ 2018-07* survey. Anchovy (*E. encrasicolus*). Cont'd.

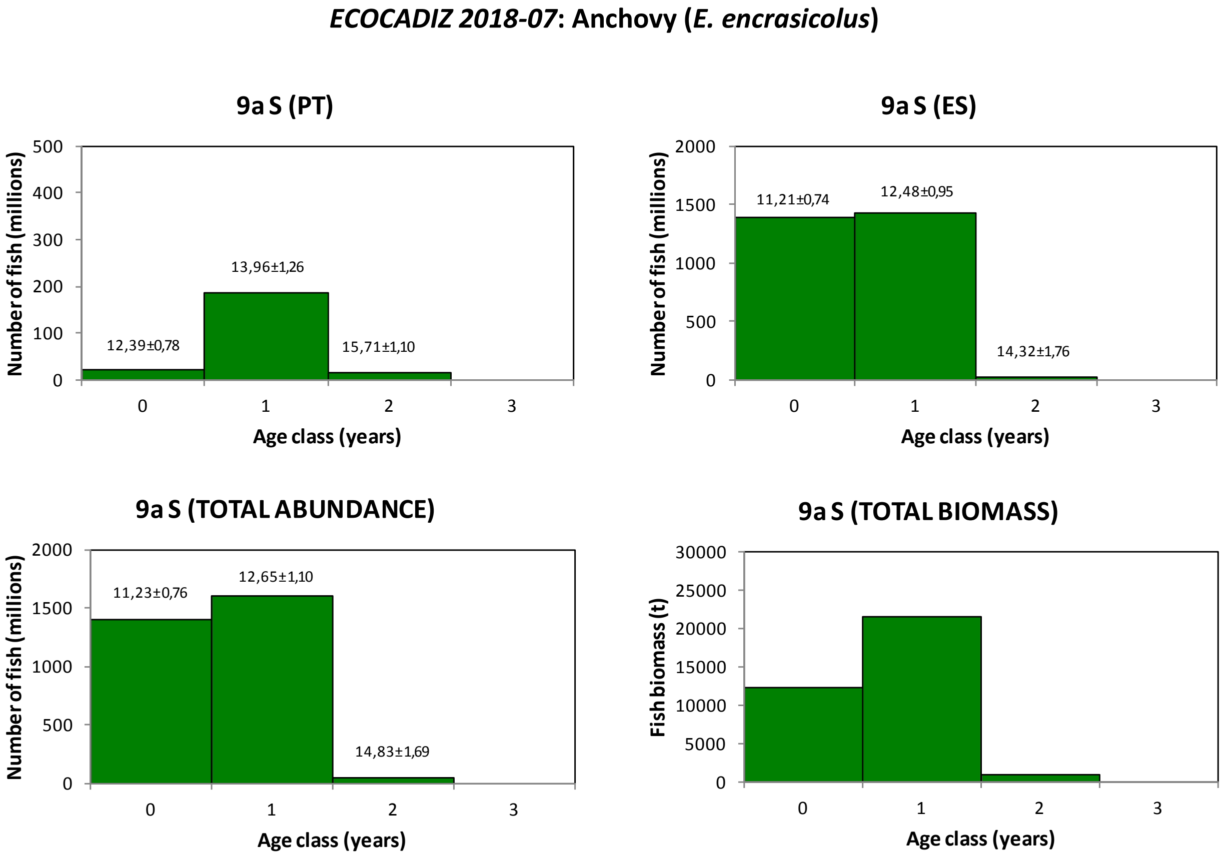
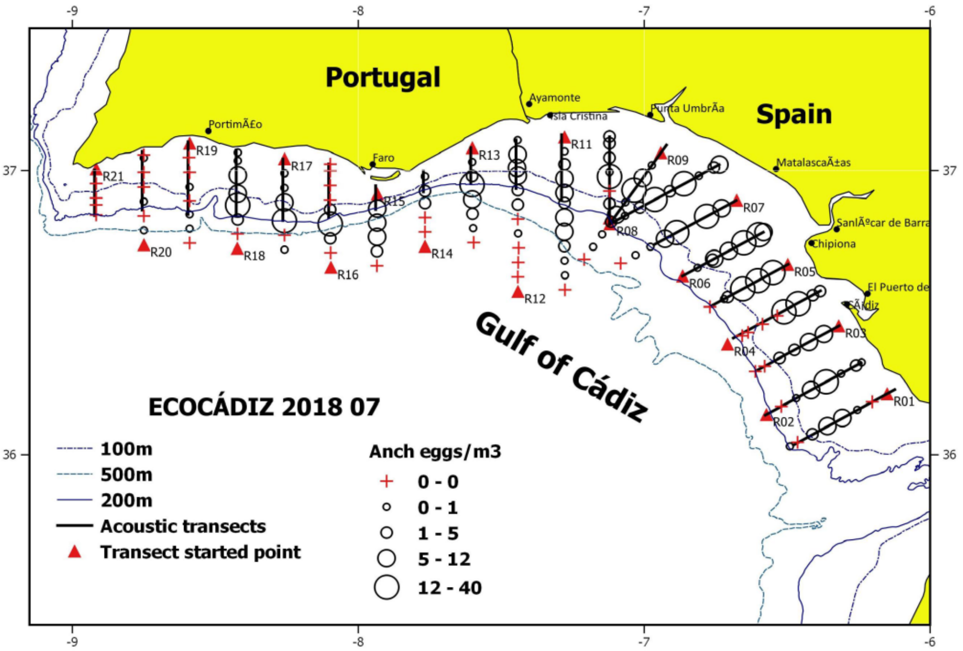
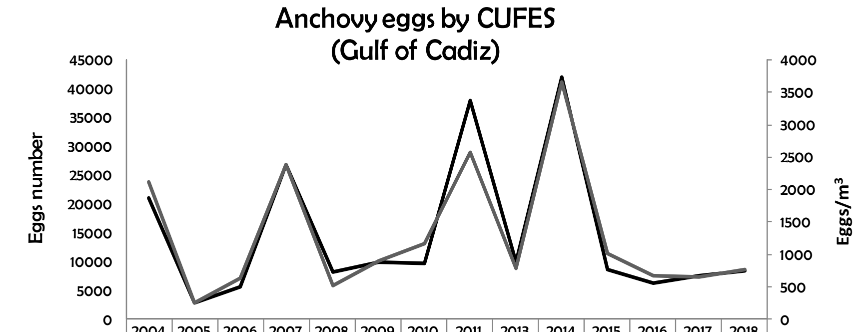


Figure 19. *ECOCADIZ 2018-07* survey. Anchovy (*E. encrasicolus*). Cont'd.

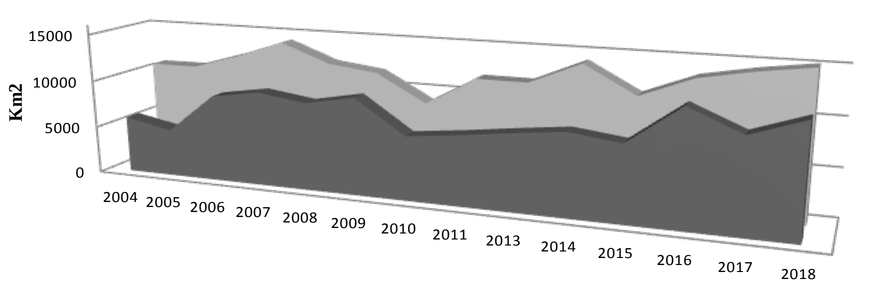


ECOCADIZ 2018-07	
CUFES st	151
Positive anchovy st	111 (73.5 %)
Max number eggs by st	485
Total anchovy eggs (in number)	8331
Max density by st (eggs/100 m^3)	40.5
Total density (eggs/100 m^3)	766

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

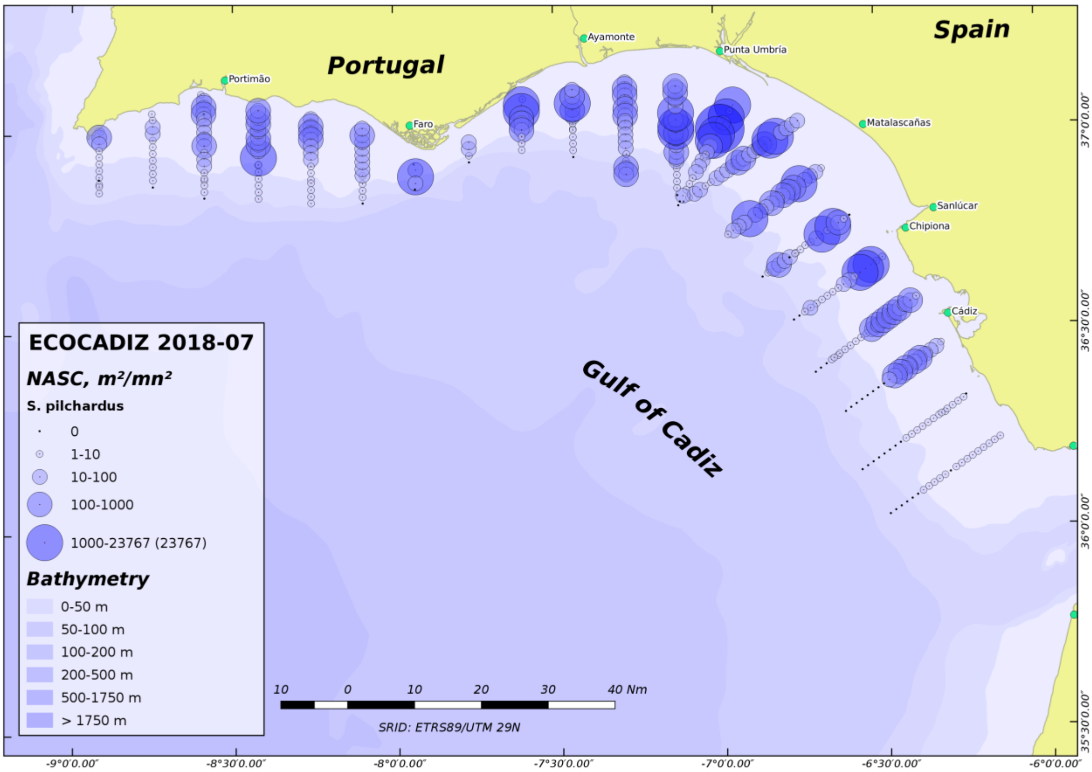


	2004	2005	2006	2007	2008	2009	2010	2011	2013	2014	2015	2016	2017	2018
Tot number	21109	2955	5723	26770	8219	9885	9615	37831	10005	41941	8606	6298	7630	8331
Tot density	2108	257	641	2374	530	901	1176	2565	786	3657	1010	672	656	766



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

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



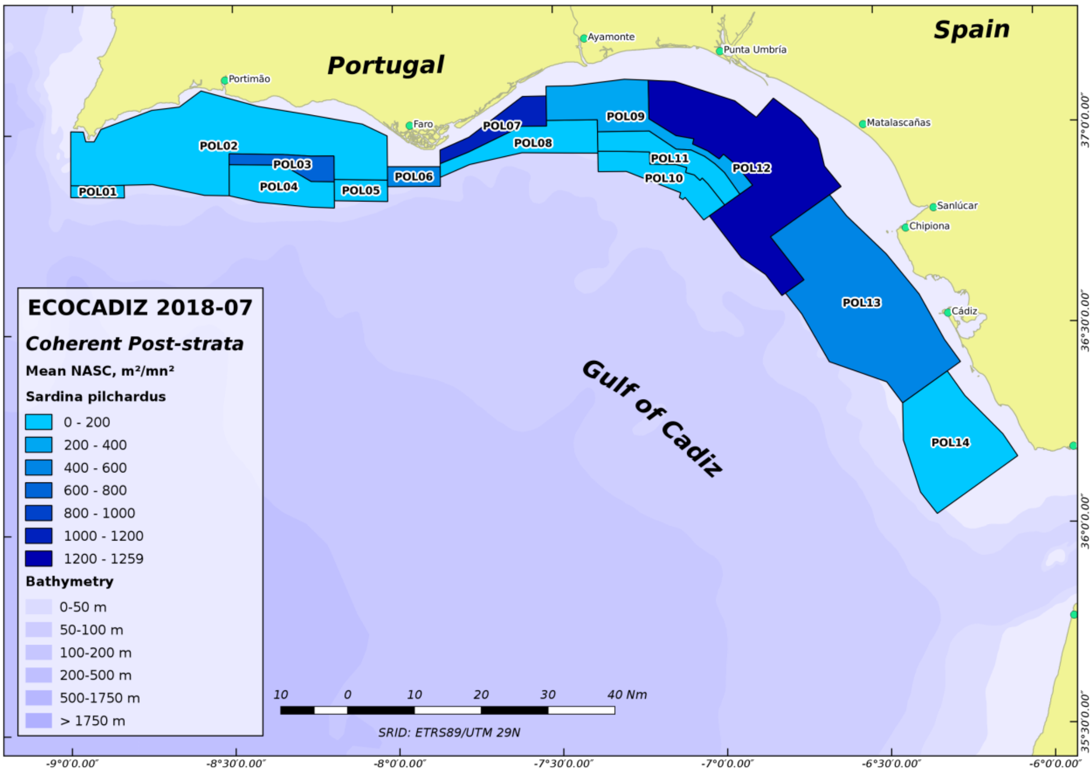


Figure 21. *ECOCADIZ 2018-07* survey. Sardine (*Sardina pilchardus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance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

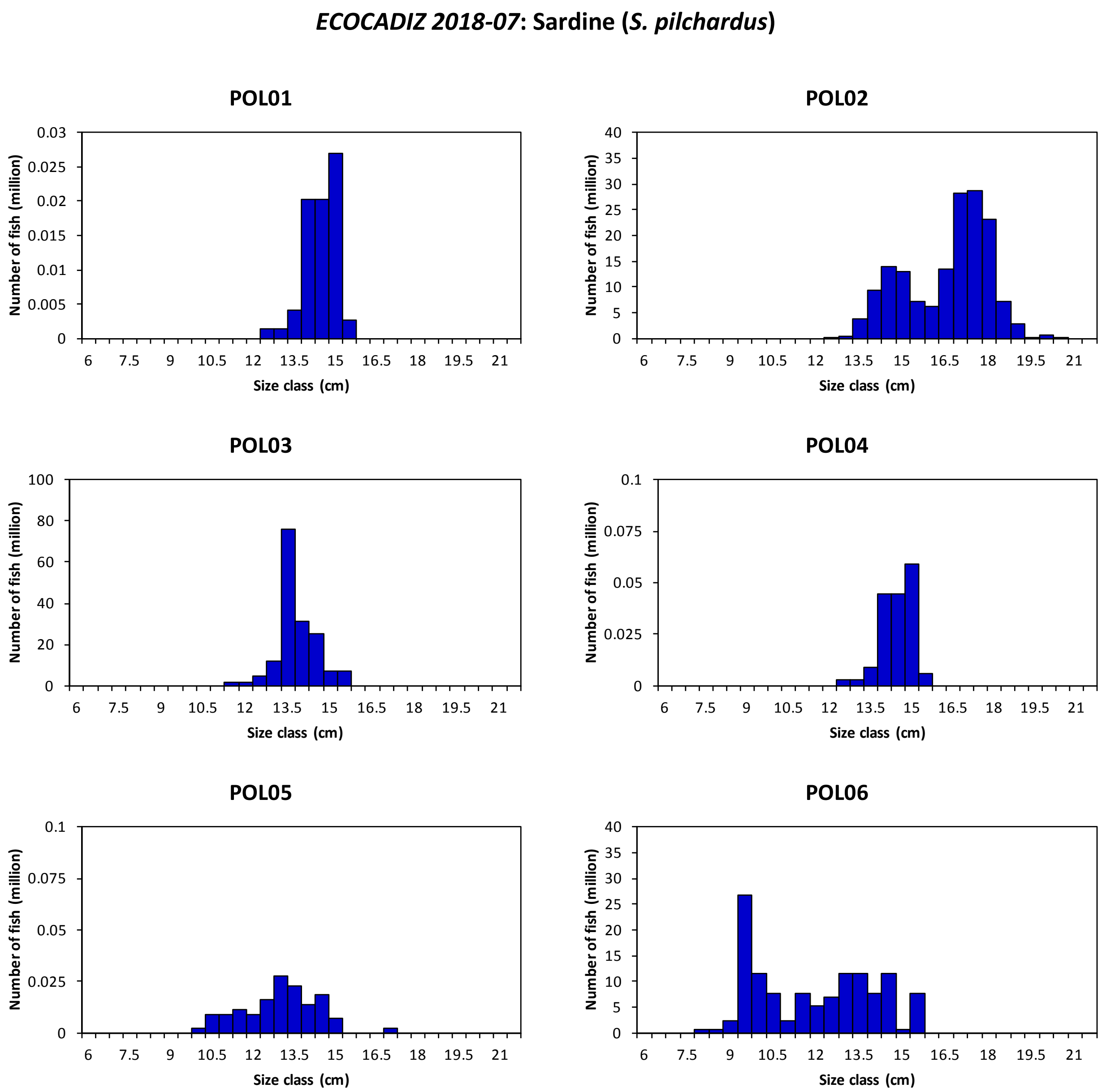


Figure 22. *ECOCADIZ 2018-07* survey. Sardine (*S. pilchardus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 21**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size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

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

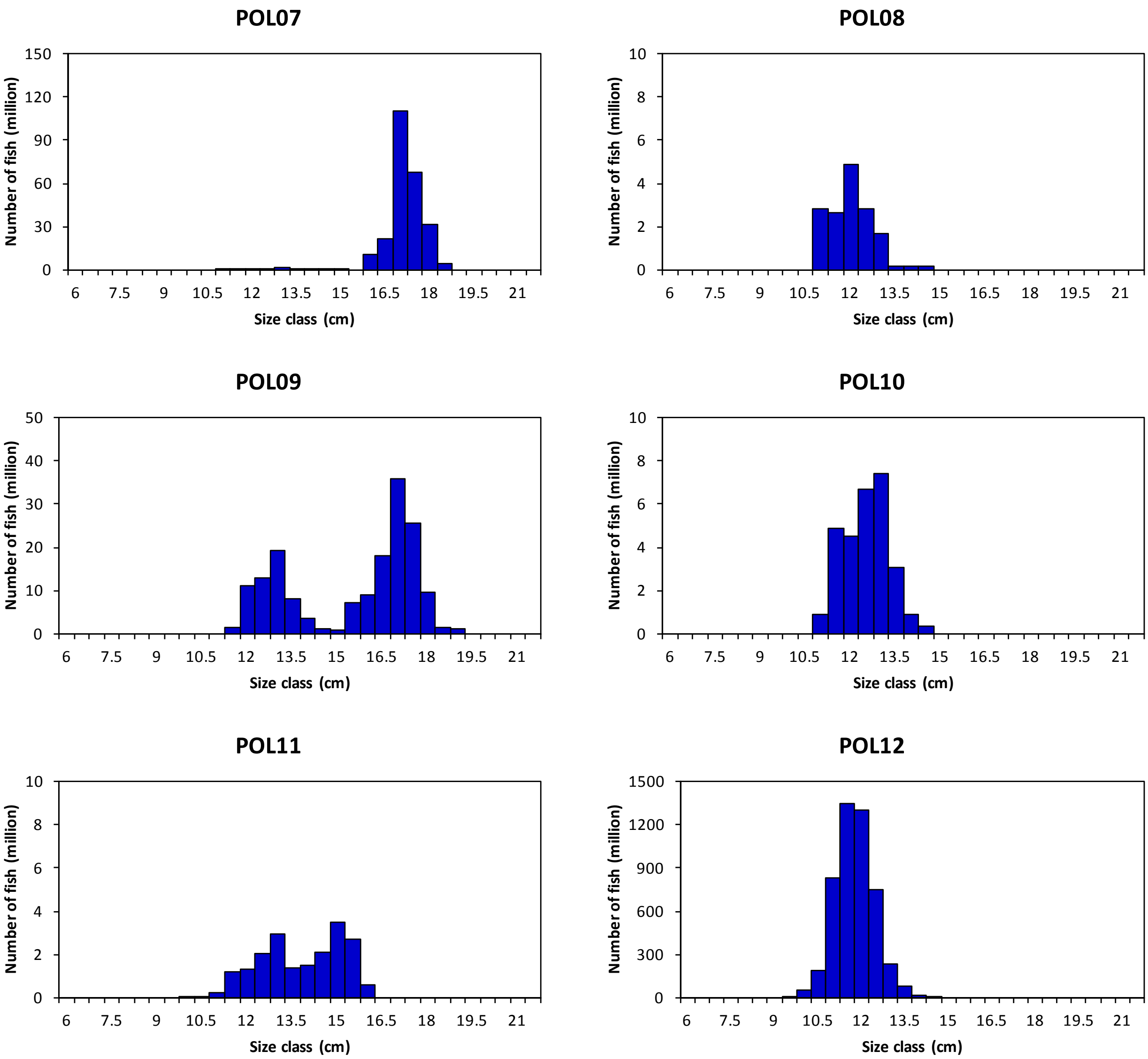


Figure 22. *ECOCADIZ 2018-07* survey. Sardine (*S. pilchardus*). Cont'd.

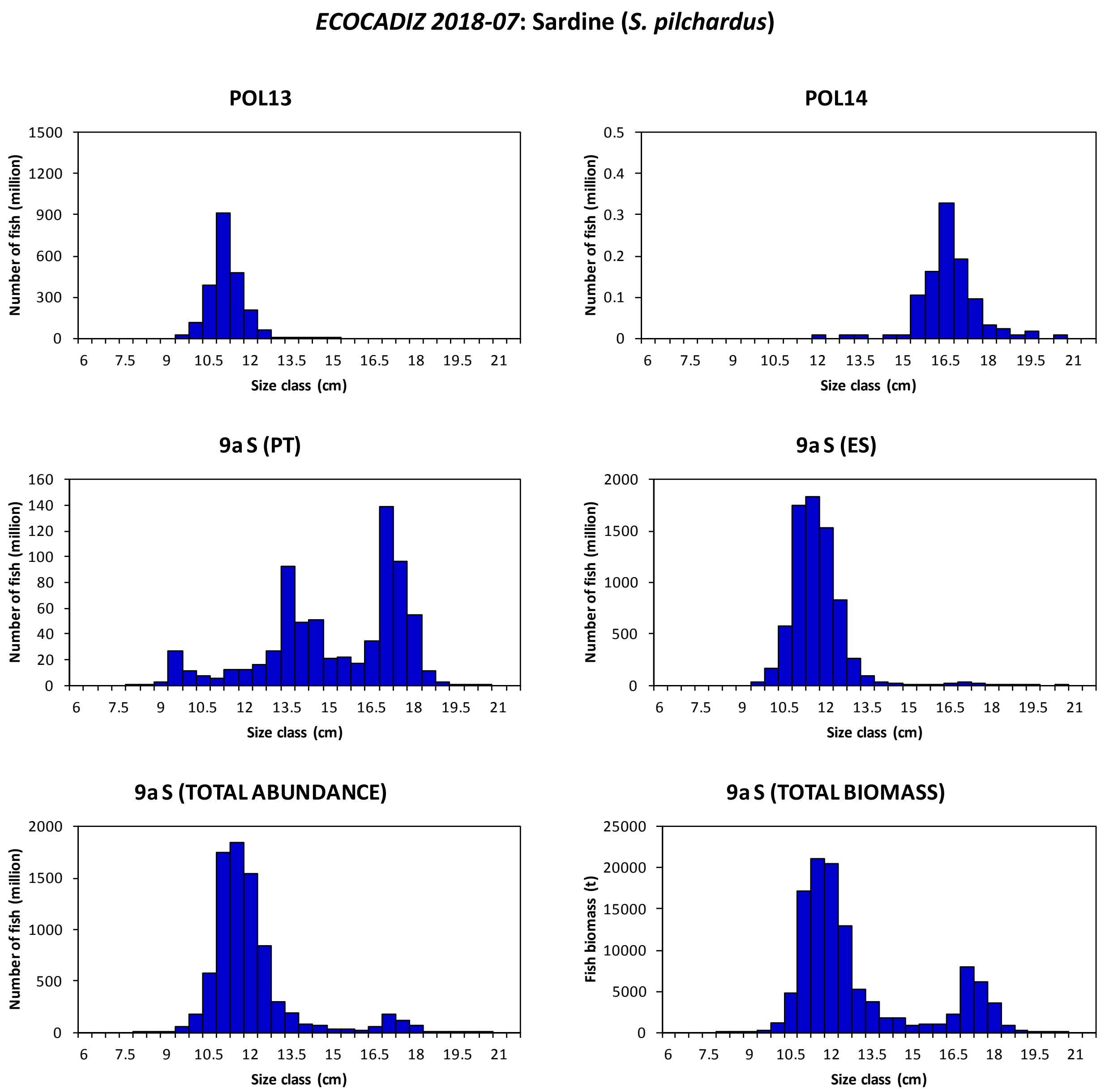


Figure 22. *ECOCADIZ 2018-07* survey. Sardine (*S. pilchardus*). Cont'd.

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

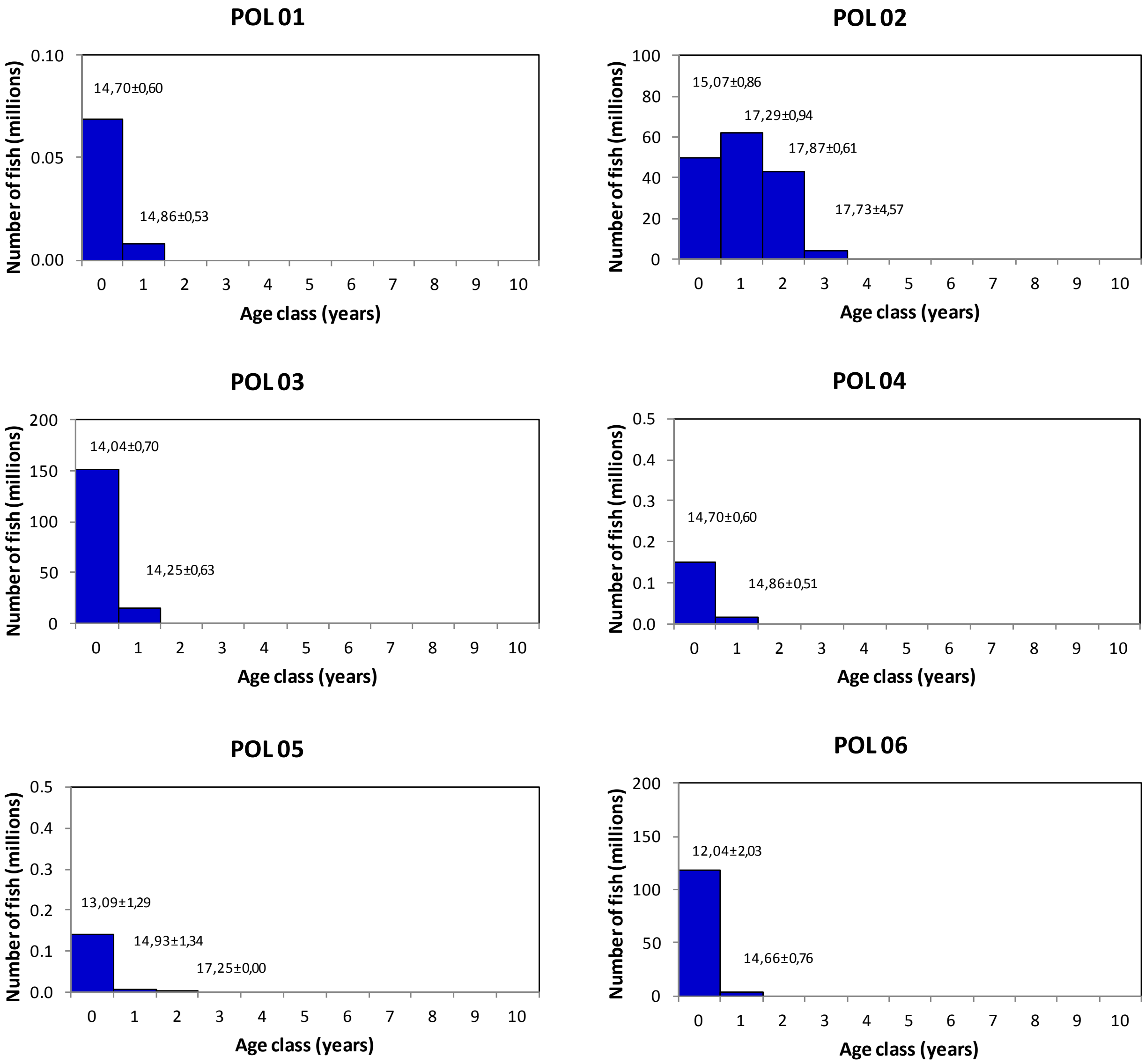


Figure 23. *ECOCADIZ 2018-07* survey. Sardine (*S. pilchardus*).. Estimated abundances (number of fish in millions) by age group (years) by homogeneous stratum (POL01-POLn, numeration as in **Figure 21**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by age group for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

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

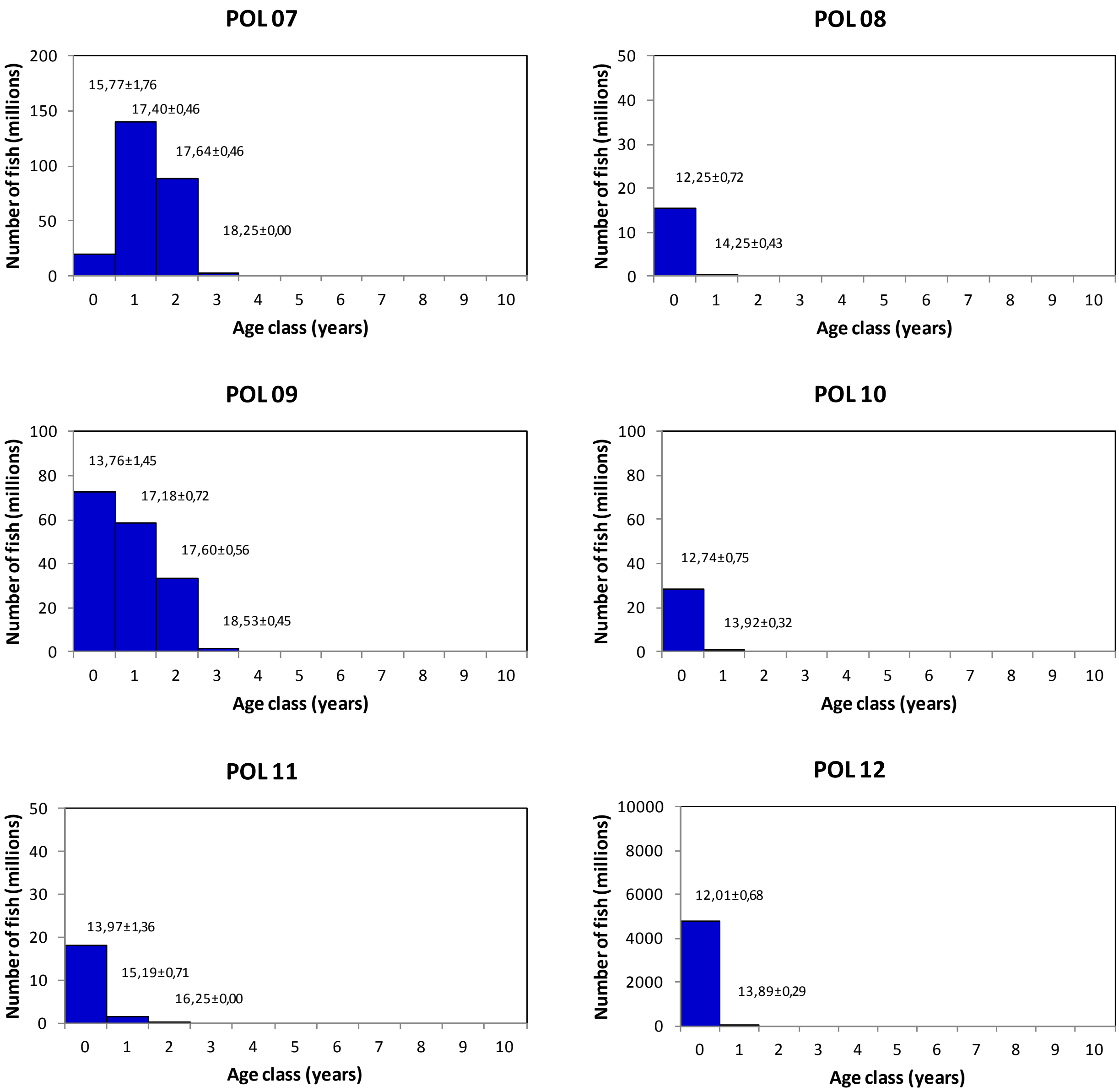


Figure 23. *ECOCADIZ 2018-07* survey. Sardine (*S. pilchardus*). Cont'd.

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

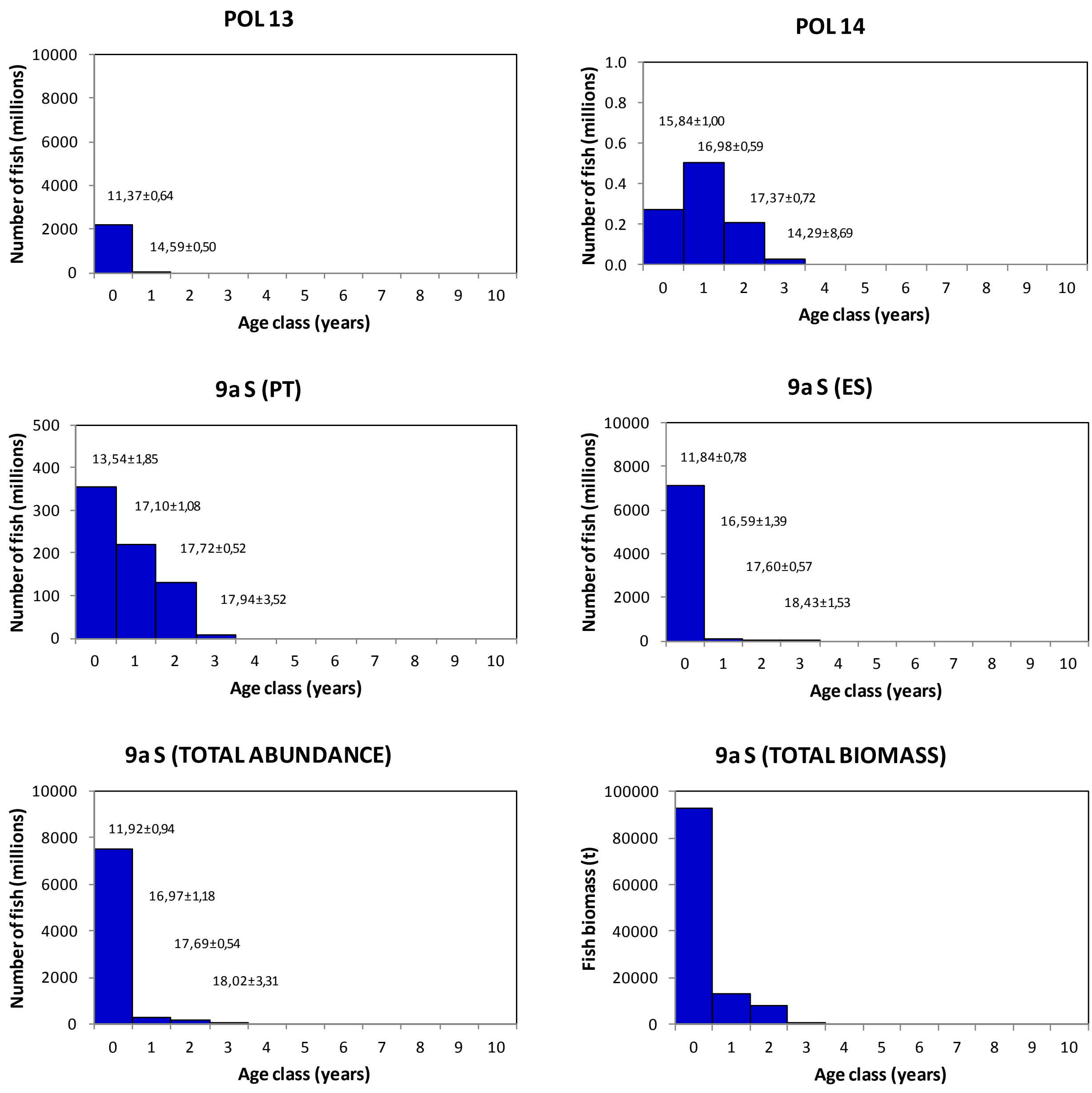


Figure 23. *ECOCADIZ 2018-07* survey. Sardine (*S. pilchardus*). Cont'd.

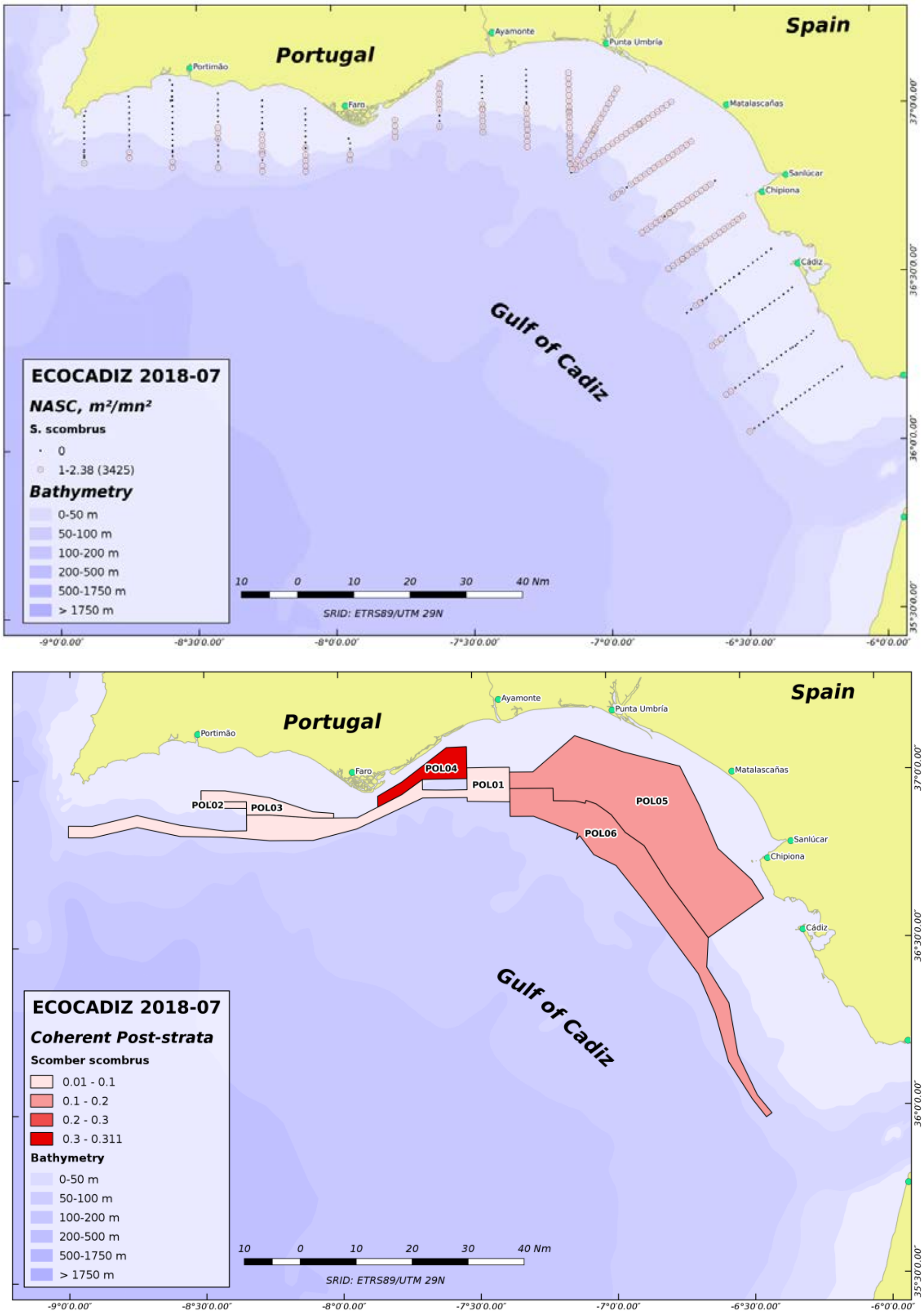


Figure 24. *ECOCADIZ 2018-07* survey. Mackerel (*Scomber scombrus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

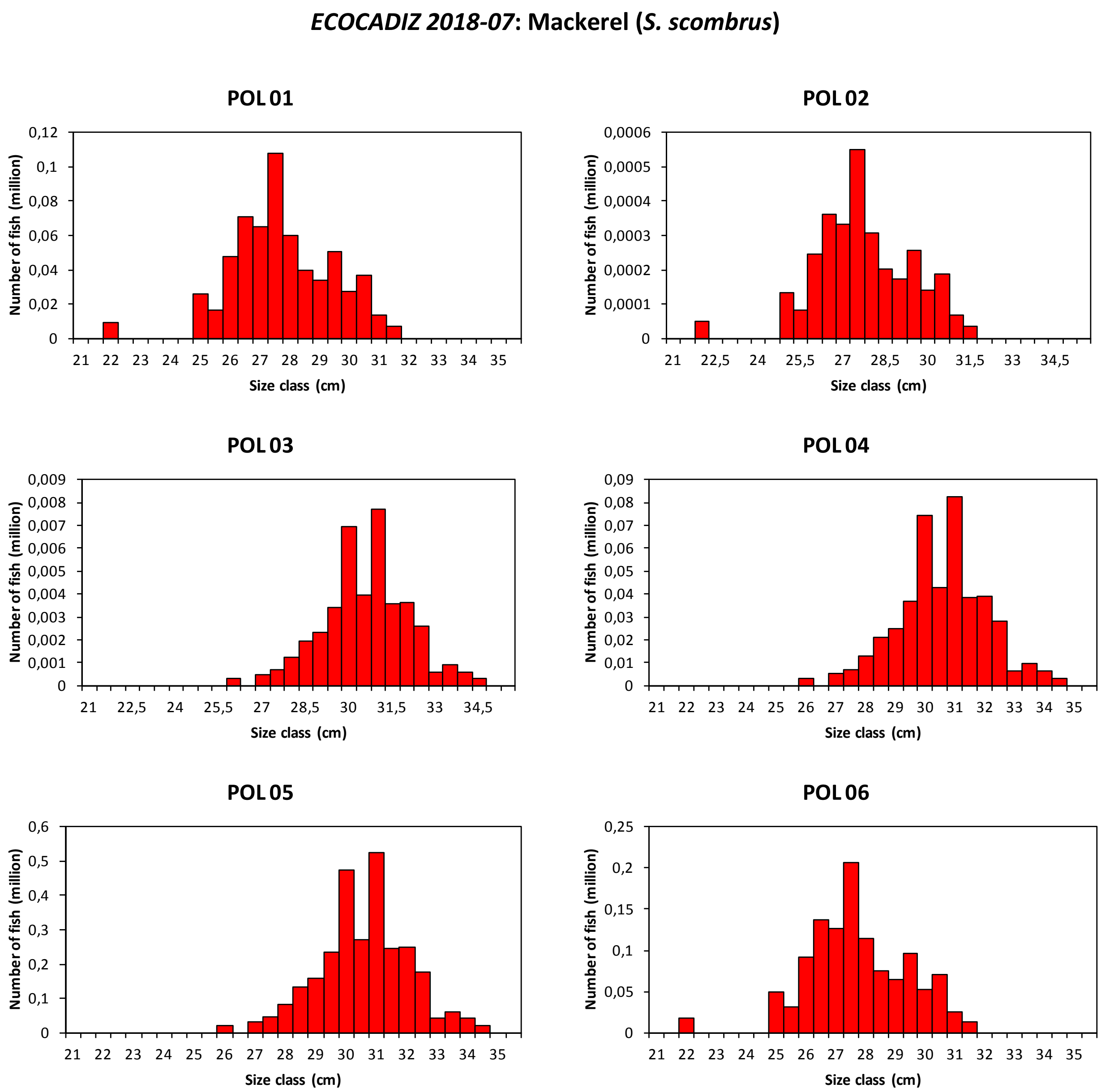


Figure 25. *ECOCADIZ 2018-07* survey. Mackerel (*Scomber scombrus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 24**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

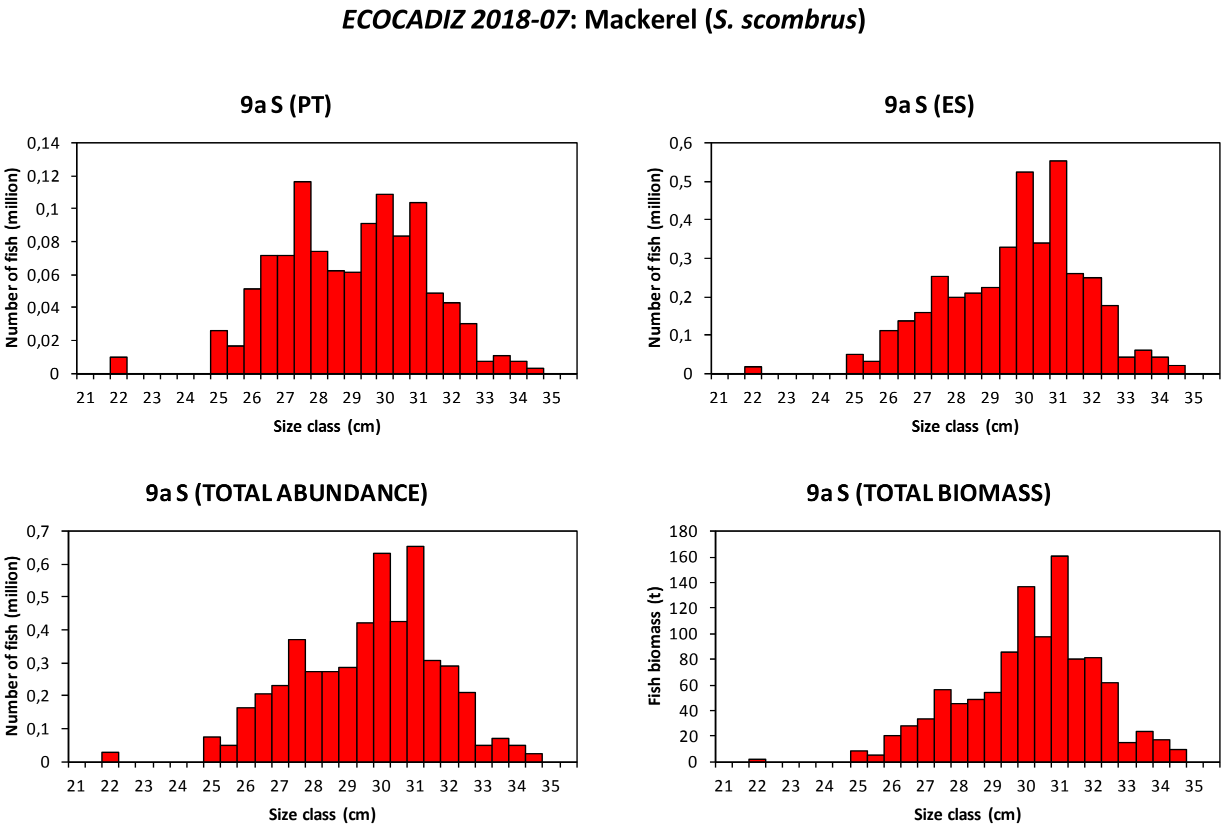


Figure 25. *ECOCADIZ 2018-07* survey. Mackerel (*Scomber scombrus*). Cont'd.

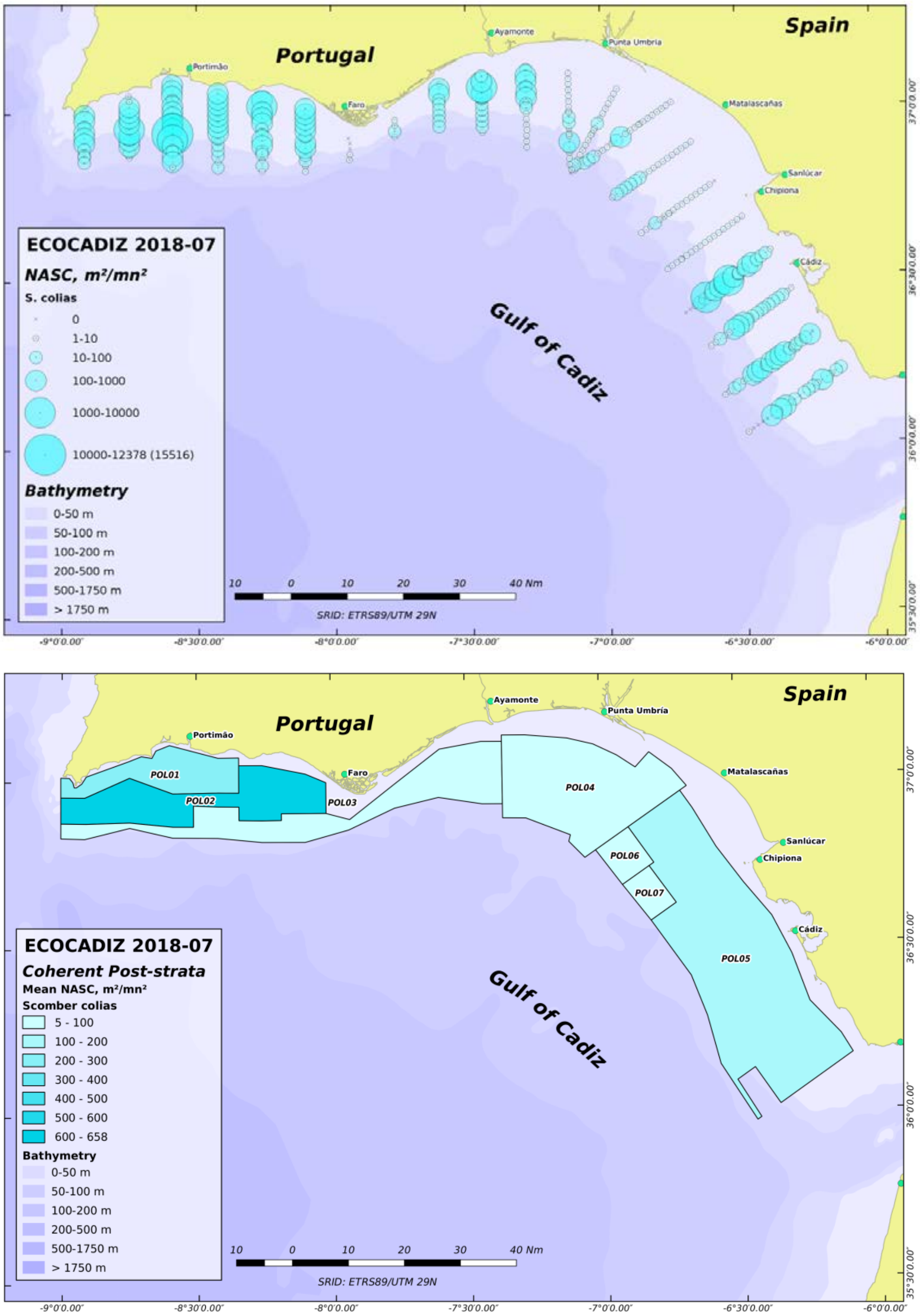


Figure 26. *ECOCADIZ 2018-07* survey. Chub mackerel (*Scomber colias*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

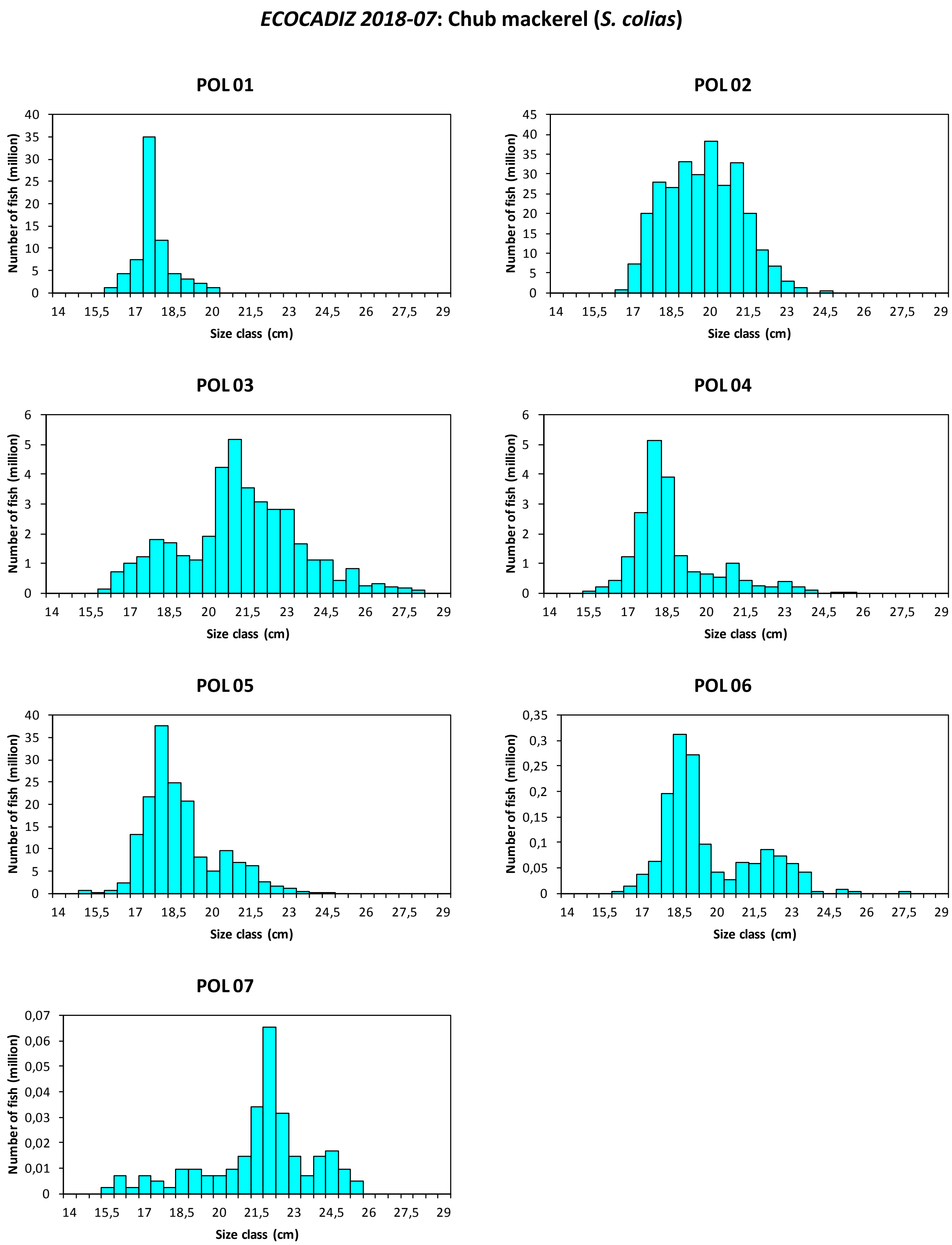


Figure 27. *ECOCADIZ 2018-07* survey. Chub mackerel (*Scomber colias*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 26**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

***ECOCADIZ 2018-07*: Chub mackerel (*S. colias*)**

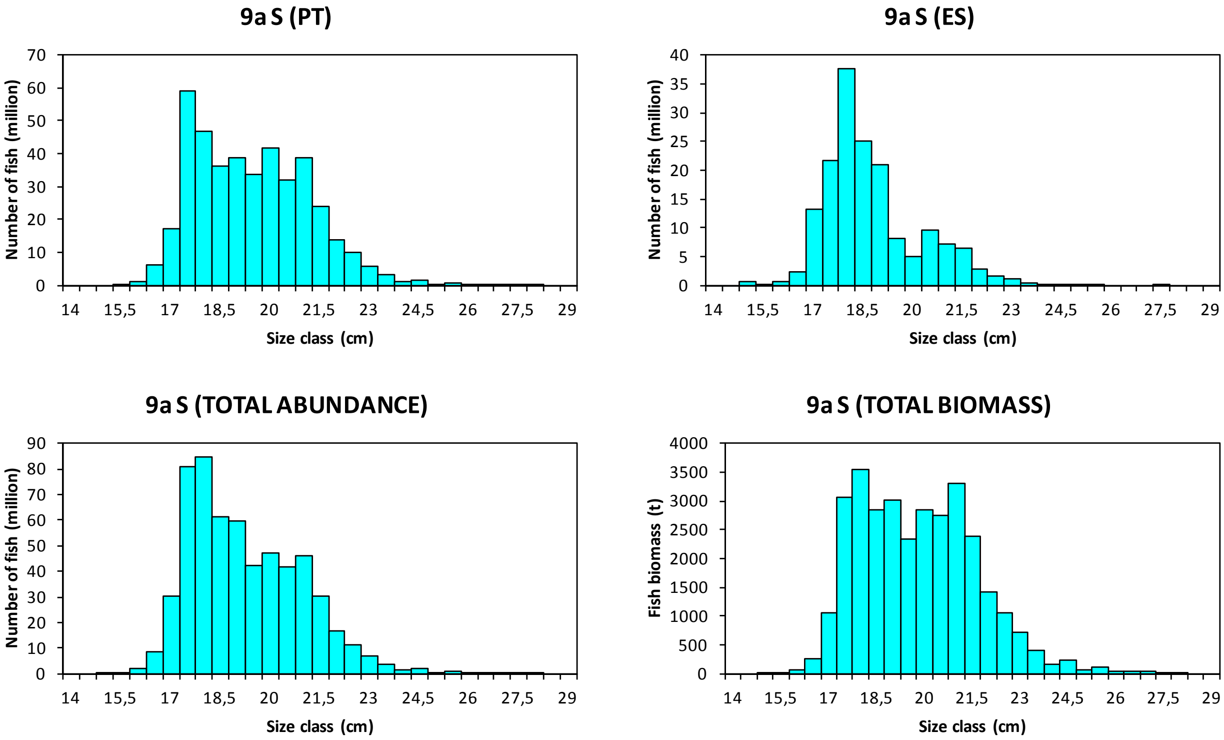


Figure 27. *ECOCADIZ 2018-07* survey. Chub mackerel (*Scomber colias*). Cont'd.

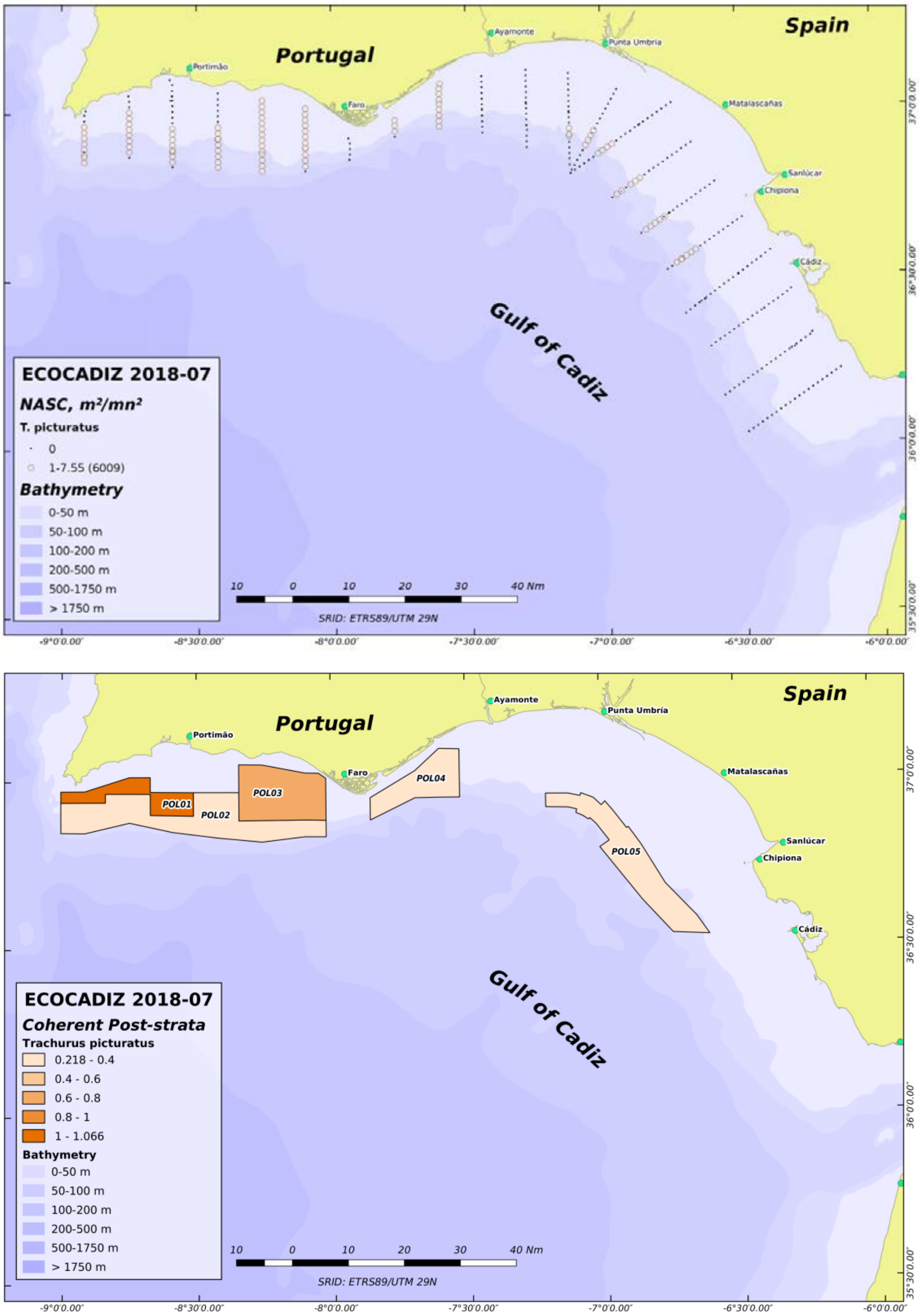


Figure 28. *ECOCADIZ 2018-07* survey. Blue jack mackerel (*Trachurus picturatus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

***ECOCADIZ 2018-07*: Blue jack mackerel (*T. picturatus*)**

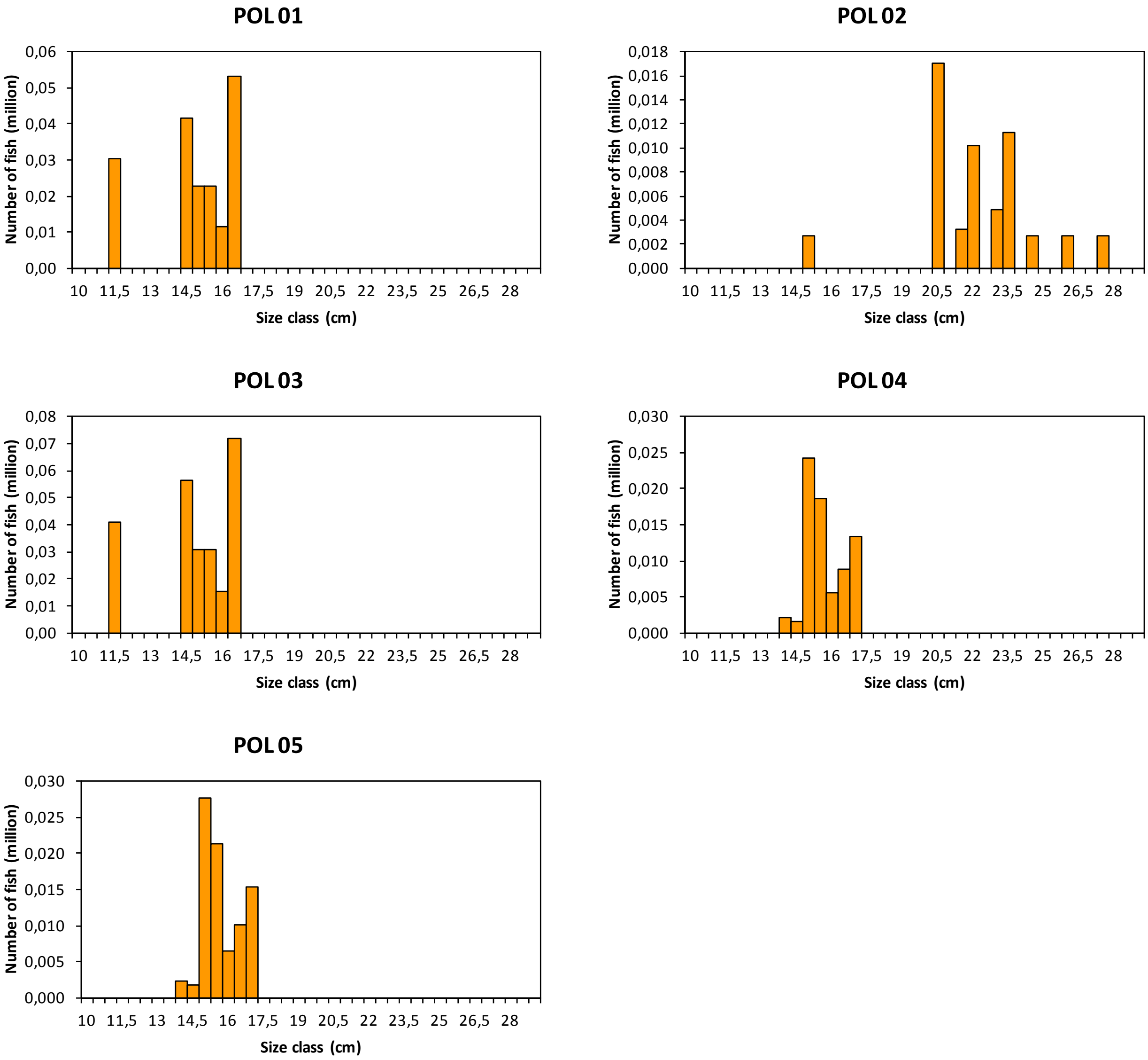


Figure 29. *ECOCADIZ 2018-07* survey. Blue jack mackerel (*T. picturatus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 28**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

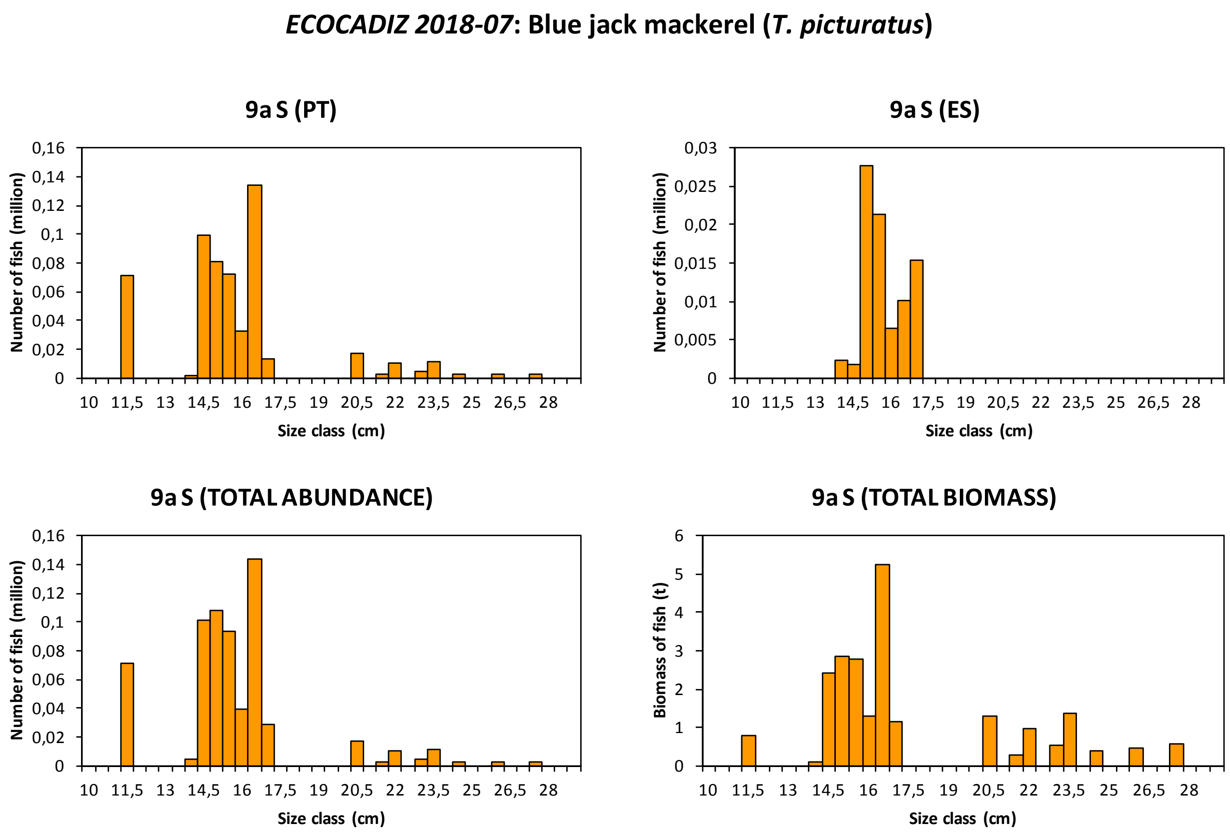
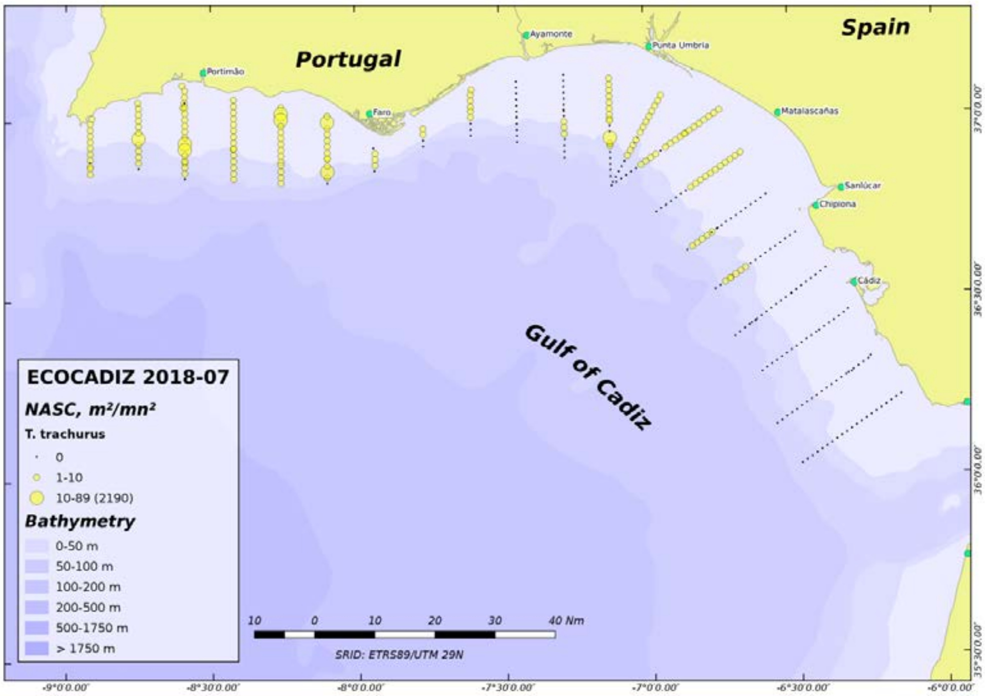


Figure 29. *ECOCADIZ 2018-07* survey. Blue jack mackerel (*T. picturatus*). Cont'd.



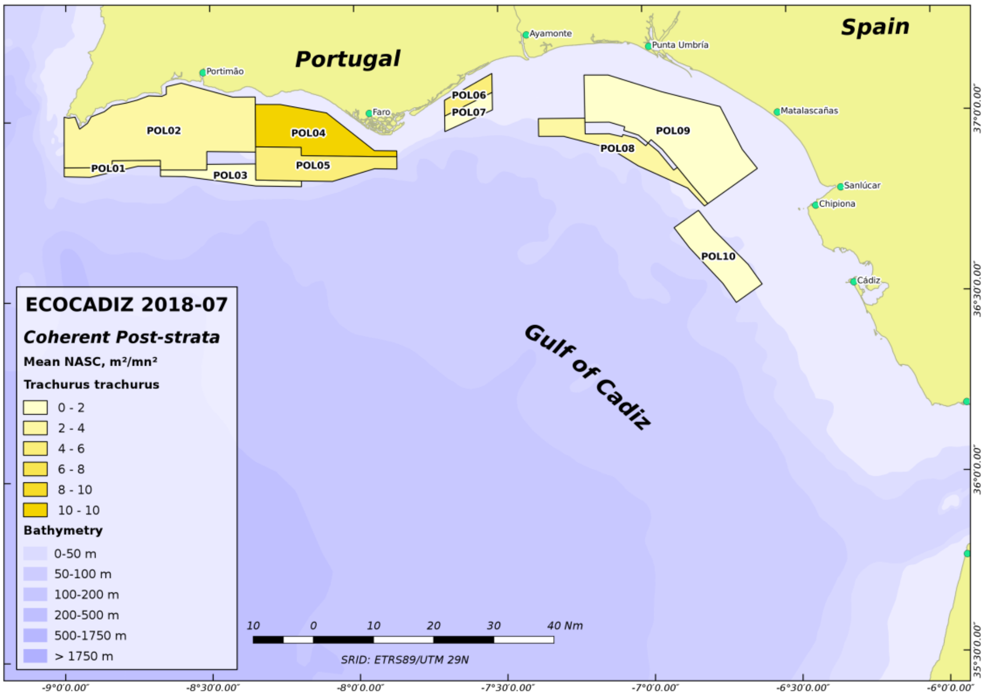


Figure 30. *ECOCADIZ 2018-07* survey. Horse mackerel (*Trachurus trachurus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

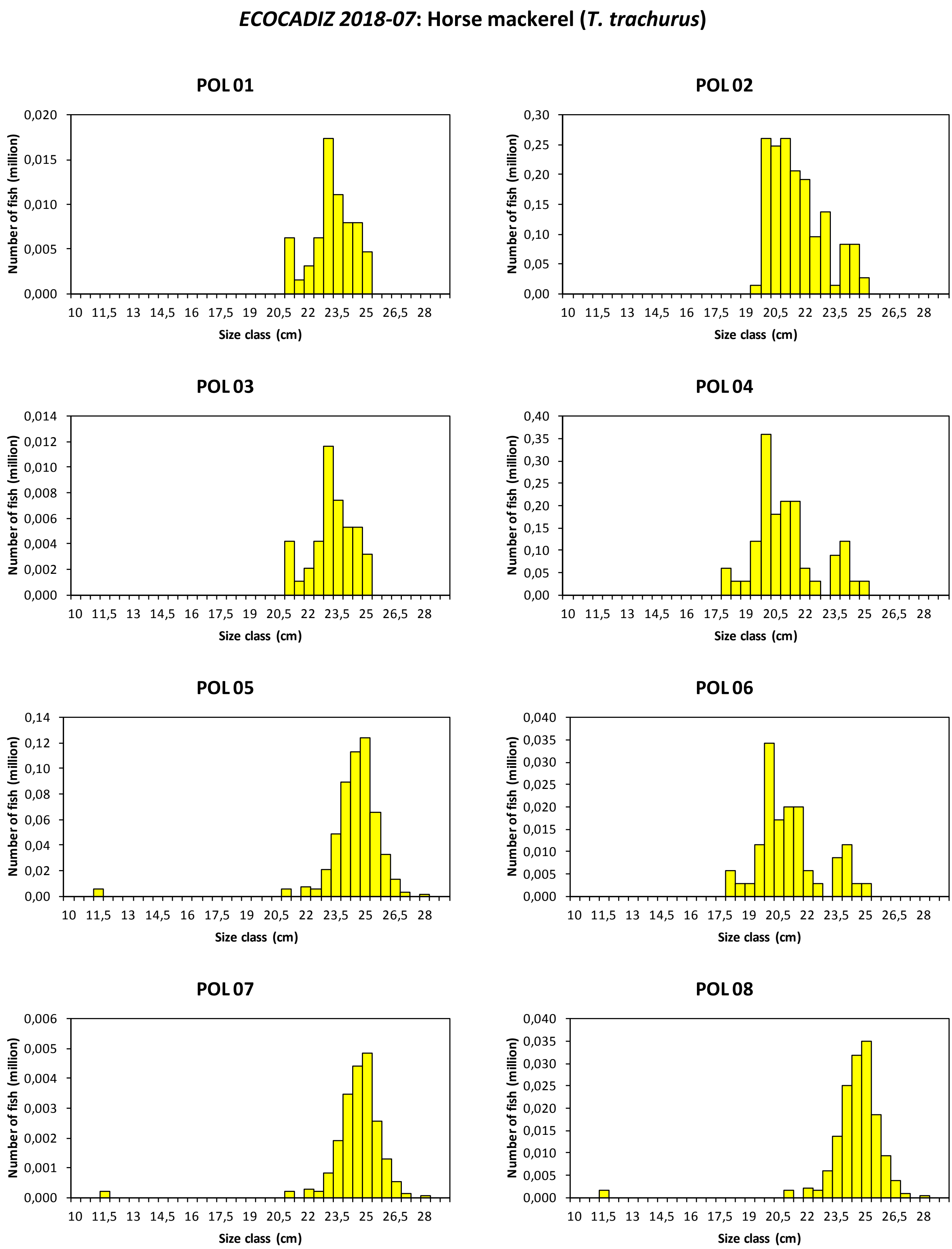


Figure 31. *ECOCADIZ 2018-07* survey. Horse mackerel (*Trachurus trachurus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 30**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

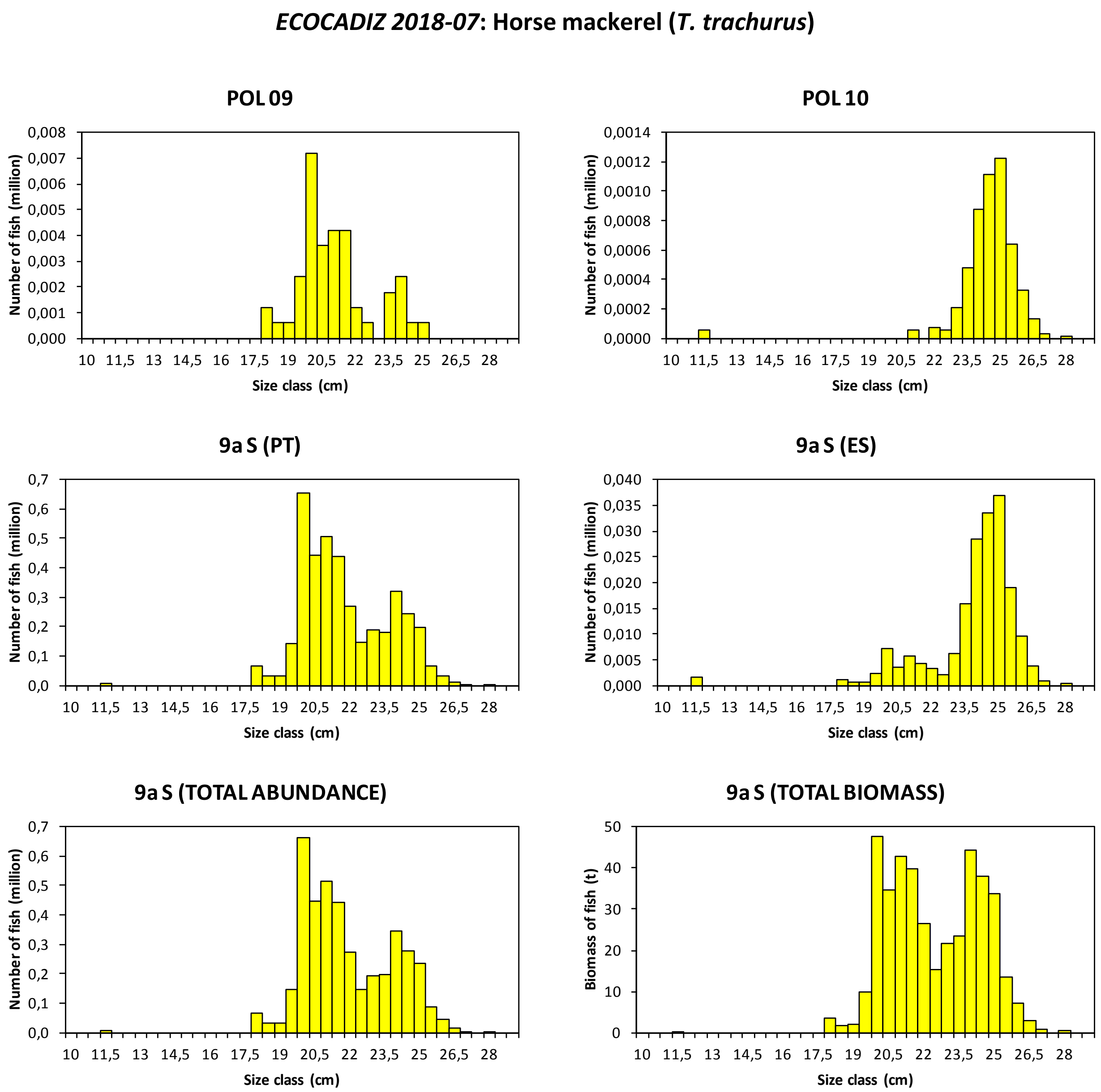


Figure 29. *ECOCADIZ 2018-07* survey. Horse mackerel (*Trachurus trachurus*). Cont'd.

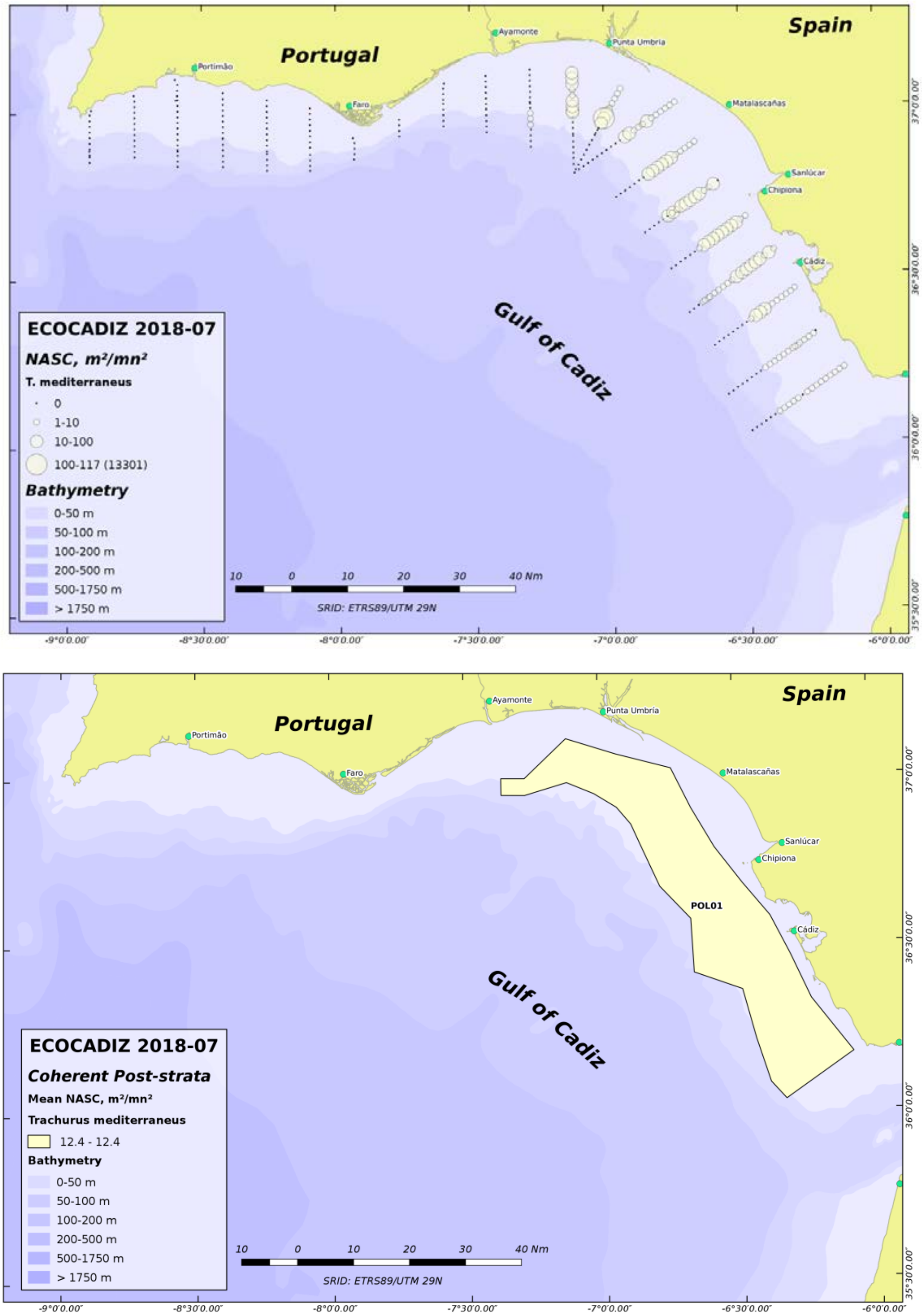


Figure 32. *ECOCADIZ 2018-07* survey. Mediterranean horse mackerel (*Trachurus mediterraneus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

ECOCADIZ 2018-07: Mediterranean horse mackerel (*T. mediterraneus*)

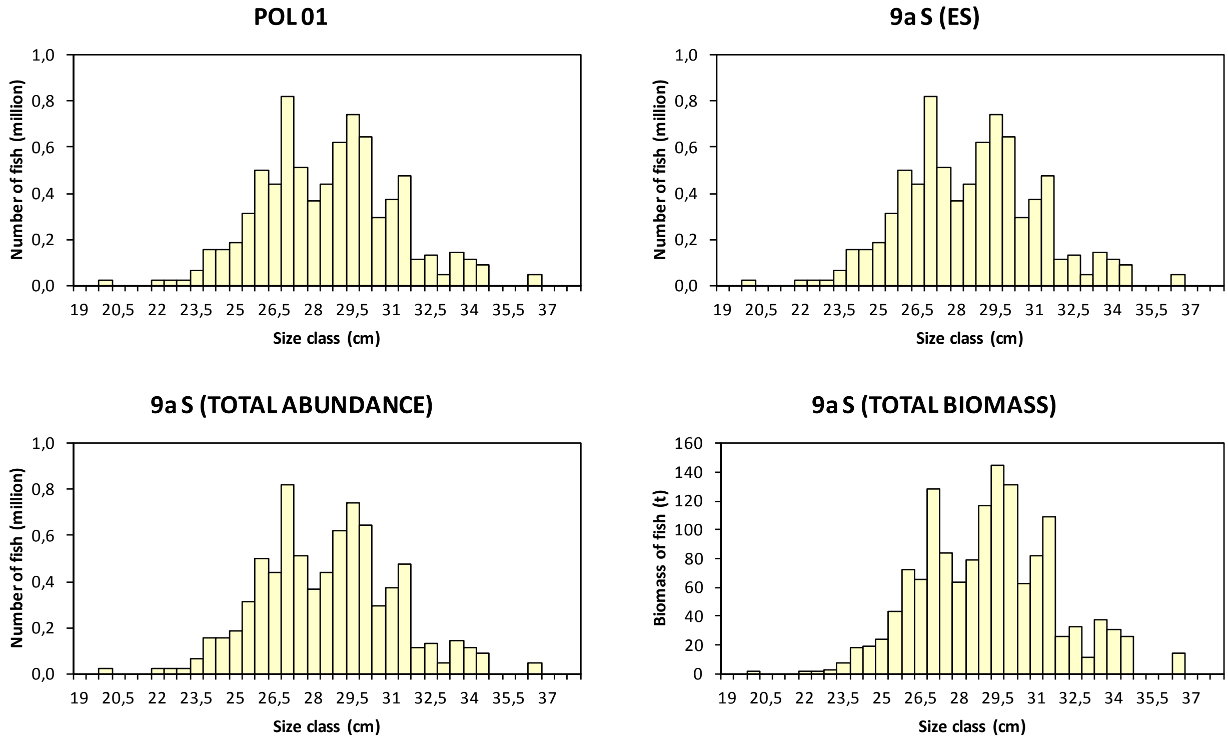


Figure 33. *ECOCADIZ 2018-07* survey. Mediterranean horse mackerel (*Trachurus mediterraneus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 32**) and total sampled area. Post-strata ordered in the W-E direction. 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.

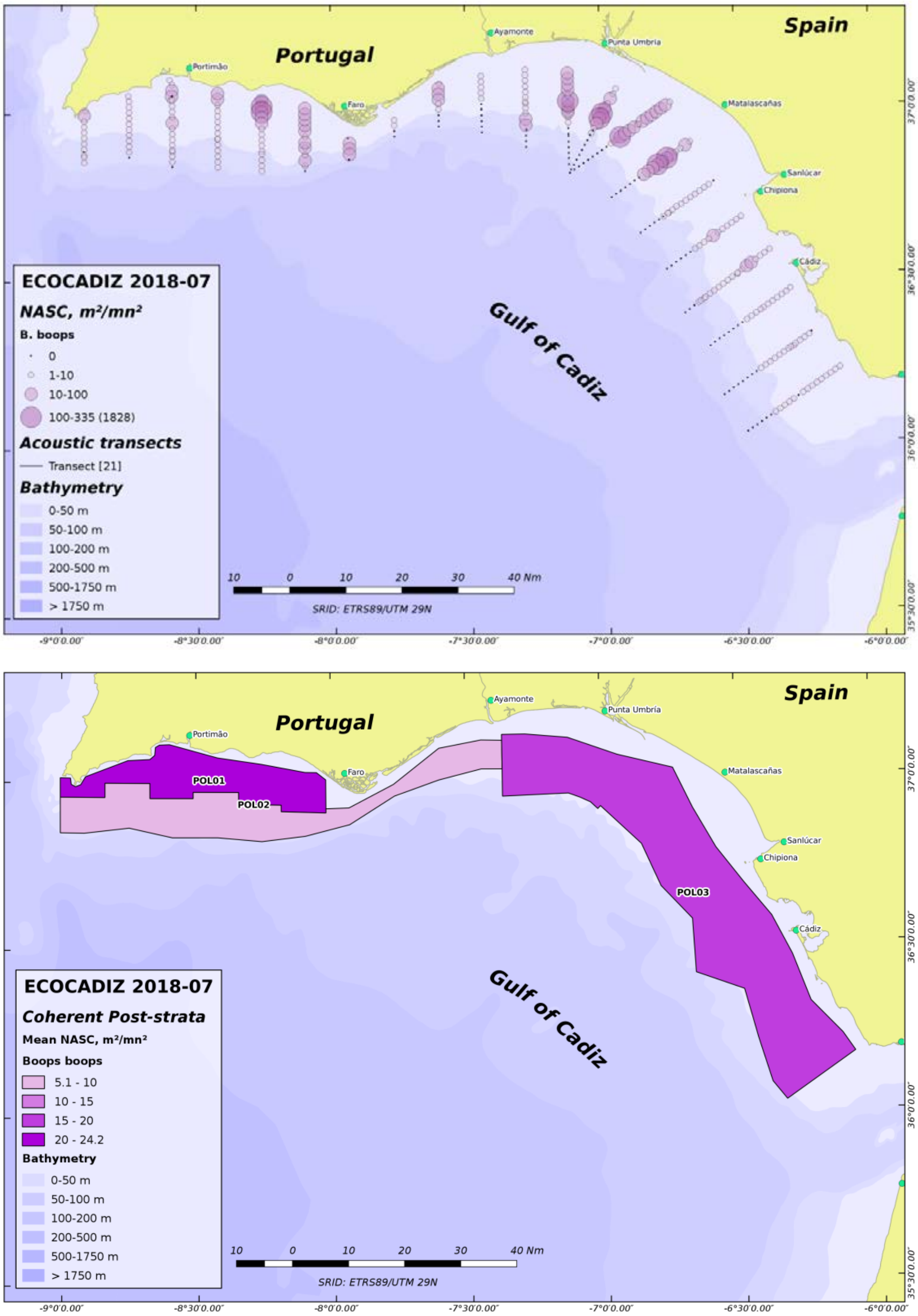


Figure 34. *ECOCADIZ 2018-07* survey. Bogue (*Boops boops*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

ECOCADIZ 2018-07: Bogue (_B. boops_)

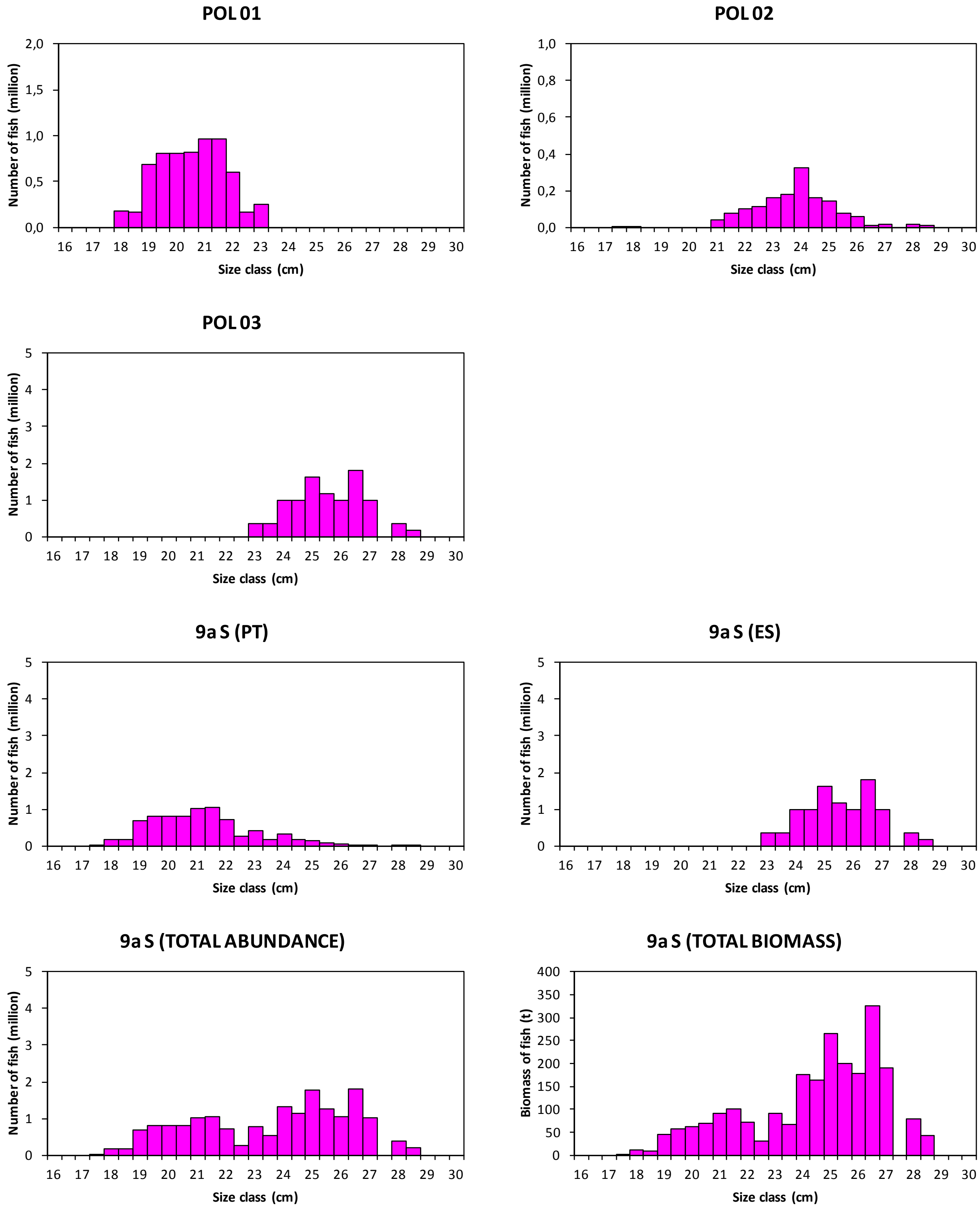


Figure 35. *ECOCADIZ 2018-07* survey. Bogue (*Boops boops*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 34**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

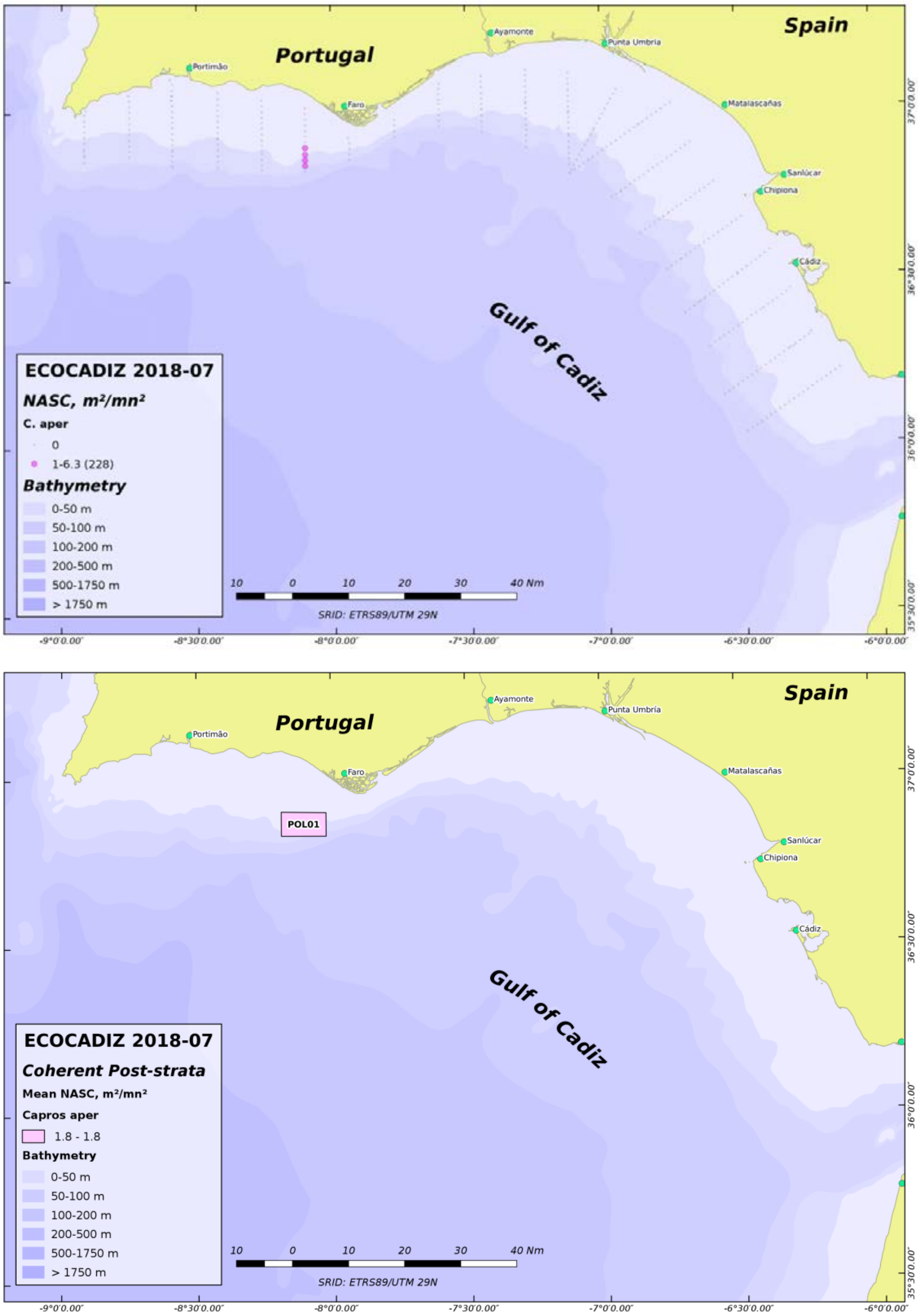


Figure 36. *ECOCADIZ 2018-07* survey. Boarfish (*Capros aper*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

***ECOCADIZ 2018-07*: Boarfish (*C. aper*).**

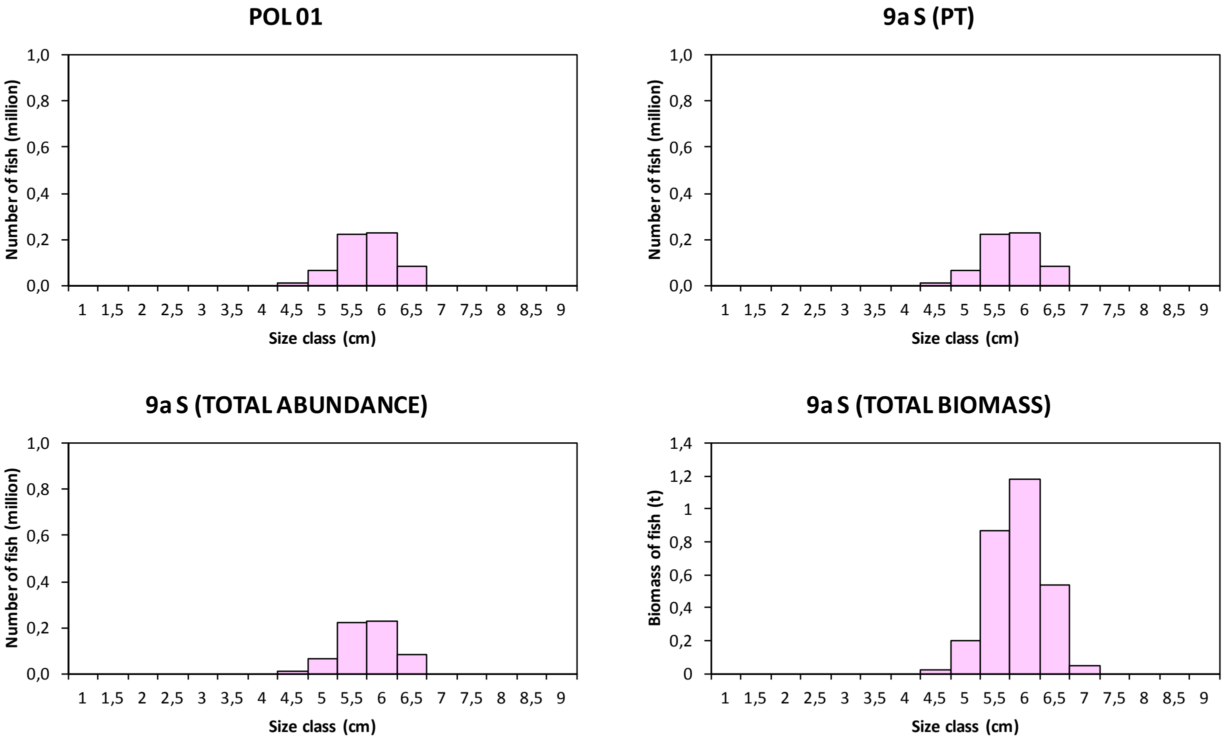


Figure 37. *ECOCADIZ 2018-07* survey. Boarfish (*Capros aper*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 36**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

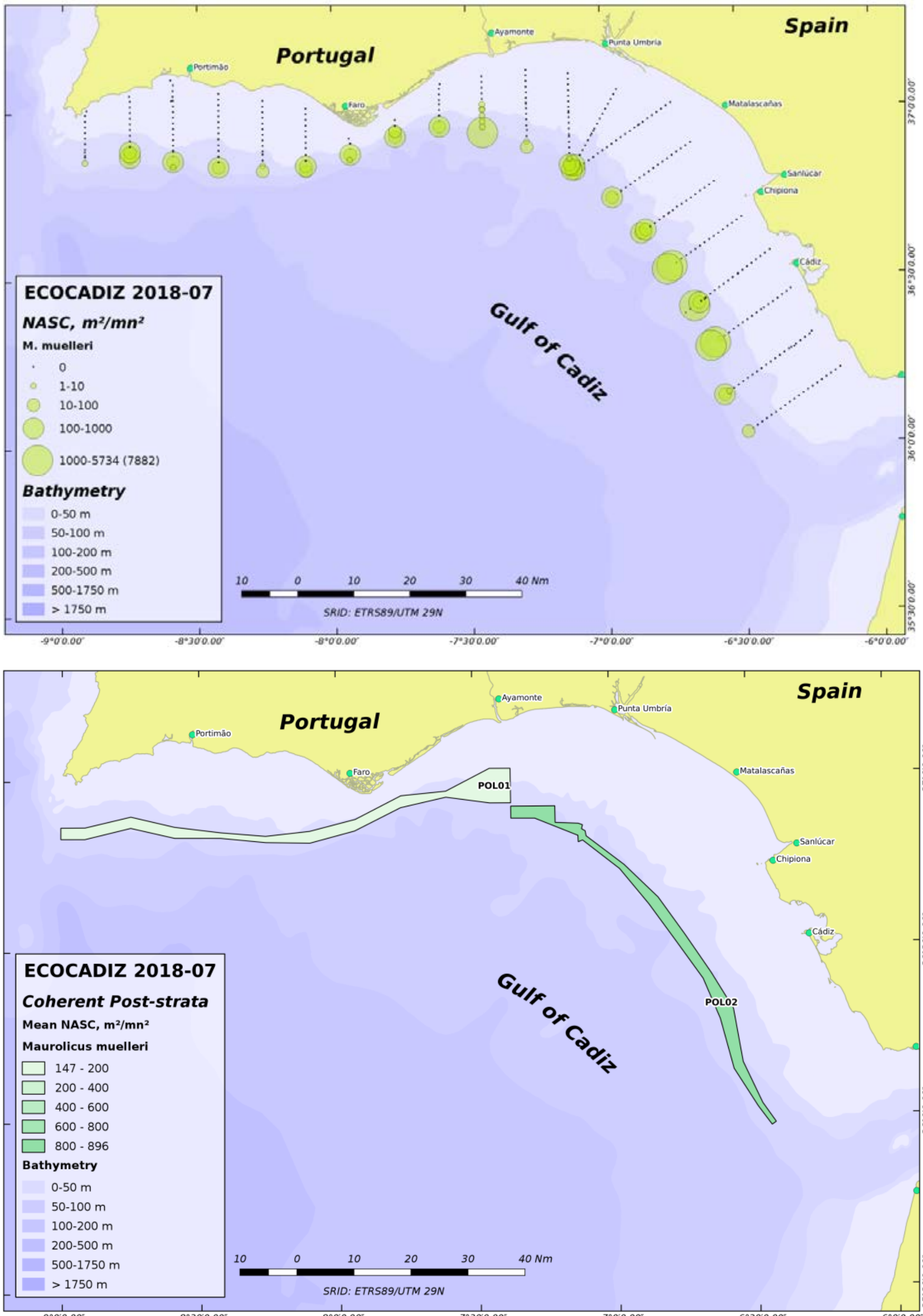


Figure 38. *ECOCADIZ 2018-07* survey. Pearlside (*Maurolicus muelleri*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

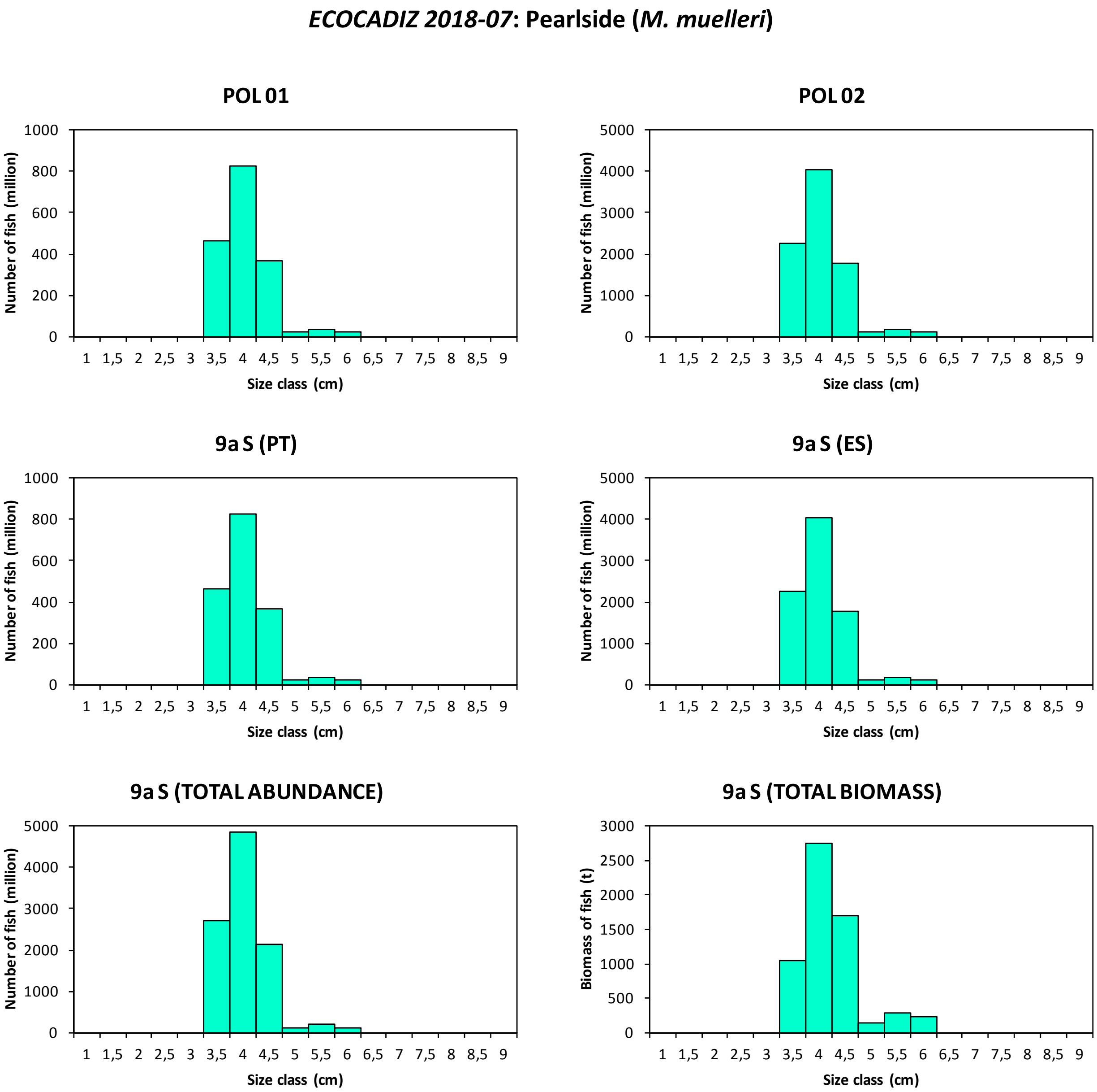


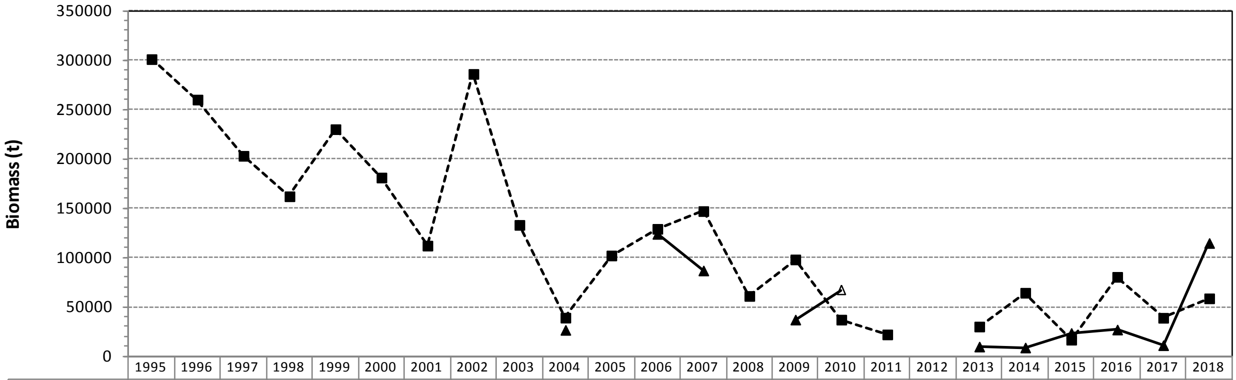
Figure 39. *ECOCADIZ 2018-07* survey. Pearlside (*Maurolicus muelleri*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 38**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) 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

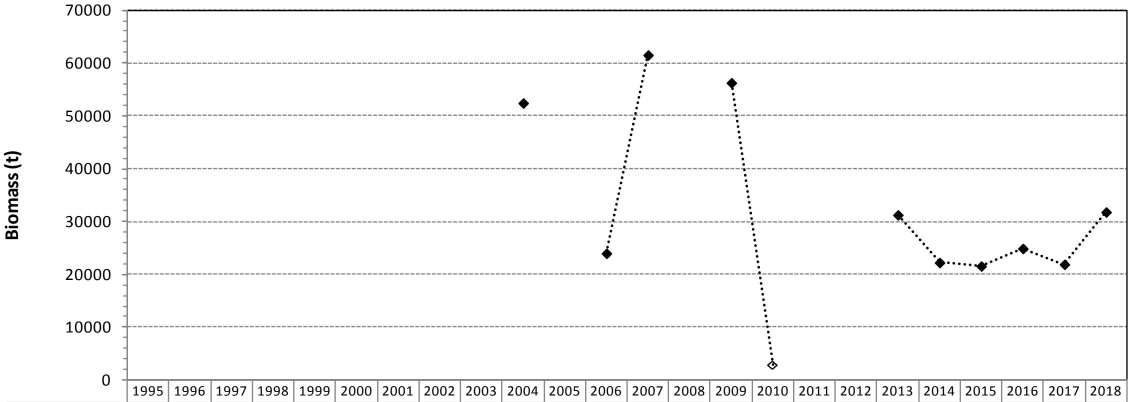
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
PELAGO					24763		24913	21335			14041	24082	38020	34200	24800	7395	0		12700	28408	33100	65345	13797	23473
ECOCADIZ										18177		35539	28882		21580	12339			8487	29219	21305	34184	12229	34908
BOCADEVA											14637			31527			30037			31569			12392	

Sardine biomass estimates



	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
PELAGO	301000	260000	203000	162000	230000	181000	112000	286000	133000	39000	102000	129000	147000	61000	98000	37000	22000		30000	64227	16663	80356	38873	58561
ECOCADIZ										26568		123849	86777		37020	66964			9670	8697	23460	26919	11053	114631

Chub mackerel biomass estimates



	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
ECOCADIZ										52440		23994	61530		56276	2861			31267	22258	21593	24918	21918	31811

Figure 40. Trends in biomass estimates (in tons) for the main assessed species in Portuguese (*PELAGO*) and Spanish (*ECOCADIZ* and *BOCADEVA*) survey series. Note that the *ECOCADIZ* survey in 2010 partially covered the whole study area. The anchovy null estimate in 2011 from the *PELAGO* survey should be considered with caution.

ANNEX

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

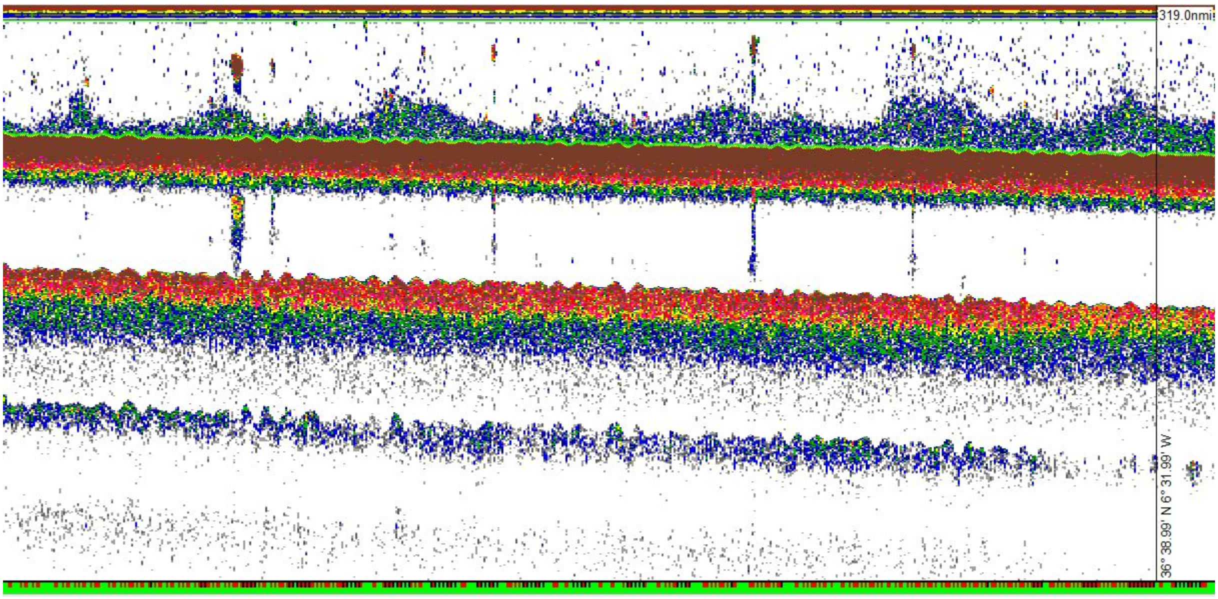


Figure A1. Transect RA05 (Chipiona), 23-25 m depth.

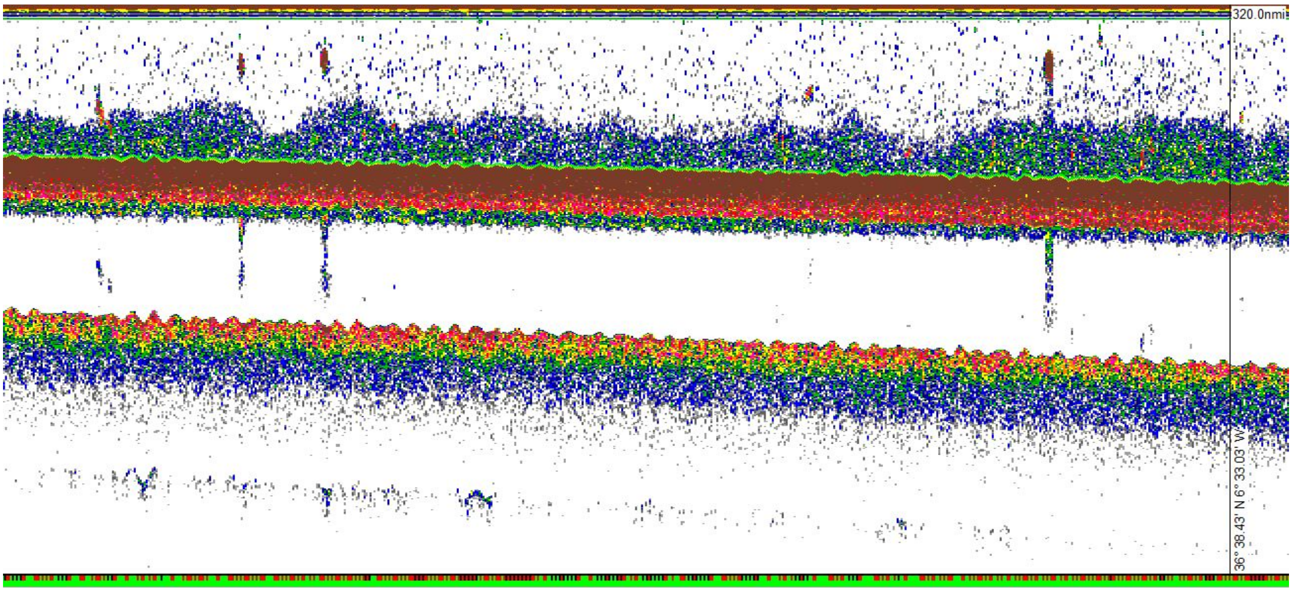


Figure A2. Transect RA05 (Chipiona), 27-29 m depth.

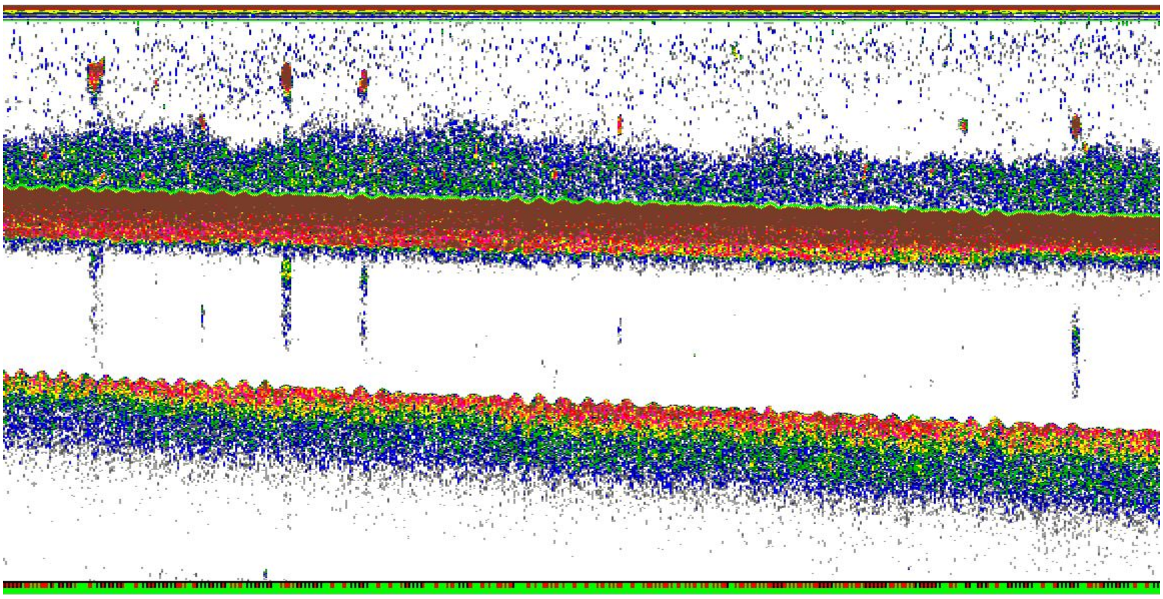


Figure A3. Transect RA05 (Chipiona), 31-37 m depth.

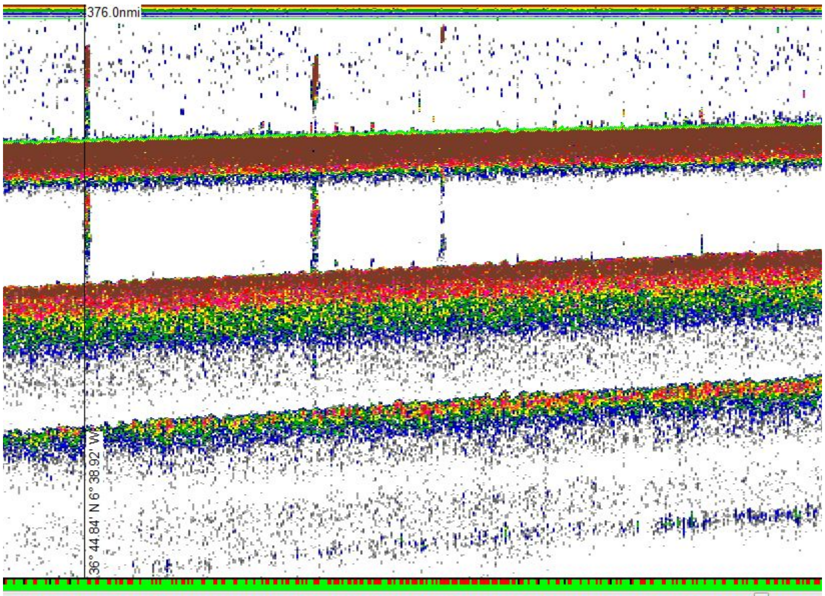


Figure A4. Transect RA06 (Doñana), 23-24 m depth.

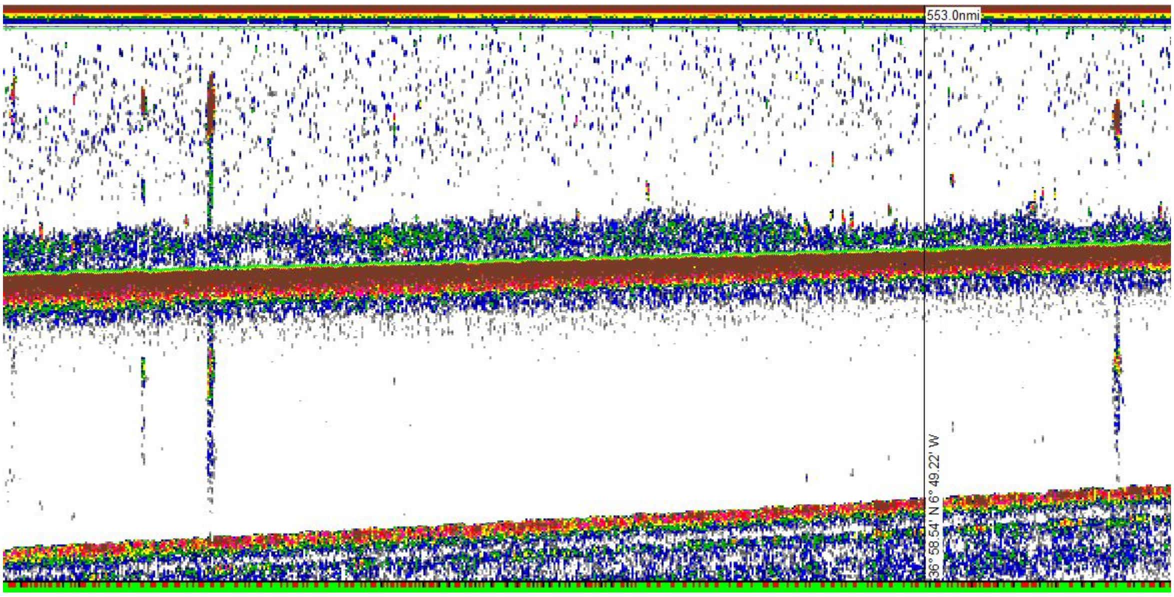


Figure A5. Transect RA08 (Mazagón), 23-24 m depth.

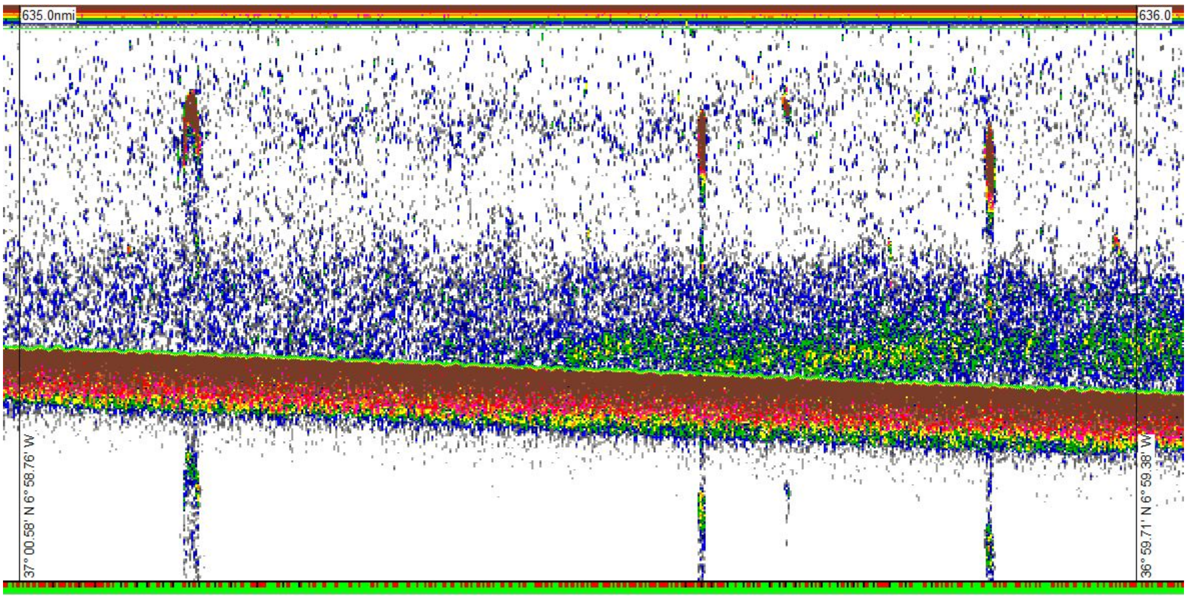


Figure A6. Transect RA10 (El Rompido), 40-44 m depth.

Working document presented in the ICES Working Group on Southern Horse Mackerel, Sardine and Anchovy (WGHANSA-1). By correspondence, 03-07 June 2019.

Acoustic assessment and distribution of the main pelagic fish species in ICES Subdivision 9a South during the *ECOCADIZ-RECLUTAS 2018-10* Spanish survey (October 2017).

By

Fernando Ramos [1, *], Pablo Carrera [2], Jorge Tornero [1], Pilar Córdoba [3]

(1) Instituto Español de Oceanografía (IEO), Centro Oceanográfico Costero de Cádiz.
(2) IEO, Centro Oceanográfico de Vigo.
(3) IEO, Centro Oceanográfico de las Islas Baleares.
(*) Cruise leader and corresponding author: e-mail: fernando.ramos@cd.ieo.es

ABSTRACT

The present working document summarises the main results obtained during the *ECOCADIZ-RECLUTAS 2018-10* Spanish (pelagic ecosystem-) acoustic survey. The survey was conducted by IEO between 10th and 29th October 2018 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. The 21 foreseen acoustic transects were sampled. A total of 25 valid fishing hauls were carried out for echo-trace ground-truthing purposes. Chub mackerel was the most frequent species in those hauls, followed by sardine, anchovy, horse mackerel, mackerel, bogue and Mediterranean horse mackerel. Acoustic sampling was carried out with the recently installed *Simrad™ EK80* echo-sounder working in multi-frequency and in CW mode. A misconfiguration of the range of the acoustic active layer entailed to slow down the ping rate (1.5-2.0 seconds) in relation to the standard values (at about 0.3 seconds), resulting an acoustic sampling rate much lower than it should be. **Therefore, the results from this acoustic sampling and the resulting estimates from this survey should be considered with caution**. Anchovy abundance and biomass were of 953 million fish and 10 493 t. The abundance and biomass of age-0 anchovies were estimated at 543 million fish and 3 834 t, 57% and 36% of the total population abundance and biomass, respectively. Despite the methodological problems, these estimates seem to suggest a recent decrease in relation to previous years. The estimates for Gulf of Cadiz sardine in the surveyed area were of 1 134 million fish and 20 679 t. Estimates of age-0 sardine were of 1 036 million fish and 15 224 t, 91% and 74% of the total estimated abundance and biomass, respectively. Even taking into account a possible underestimation for the abovementioned methodological problems, the values reached in 2018 were above the historical mean for the total population and recruits abundance and for the recruit biomass, and they might suggest a relatively stable situation since the maxima registered in 2016.

INTRODUCTION

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

The general objective of these surveys should initially be focused in the acoustic assessment by vertical echo-integration and mapping of the abundance and biomass of recruits of small pelagic species (especially anchovy and secondarily sardine), as well as the mapping of both the oceanographic and biological conditions featuring the recruitment areas of these species in the Division 9a. The long term objective of the surveys would be to be able to assess the strength of the incoming recruitment to the fishery the next year.

The first attempt by the IEO of acoustically assessing the abundance of anchovy and sardine juveniles in their main recruitment areas off the Gulf of Cadiz dates back to 2009 (*ECOCADIZ-RECLUTAS 1009* survey). However, that survey was unsuccessful as to the achievement of their objectives because of the succession of a series of unforeseen problems which led to drastically reduce the foreseen sampling area to only the 6 easternmost transects. The continuation of this survey series was not guaranteed for next years and, in fact, no survey of these characteristics was carried out in 2010 and 2011. In 2012, the *ECOCADIZ-RECLUTAS 1112* survey was financed by the Spanish Fisheries Secretariat and planned and conducted by the IEO with the aim of obtaining an autumn estimate of Gulf of Cadiz anchovy biomass and abundance. The survey was conducted with the R/V *Emma Bardán*. Although the survey was restricted to the Spanish waters only it has been considered as the first survey within its series (Ramos *et al*., 2013). *ECOCADIZ-RECLUTAS 2014-10* re-started the series and it was conducted with the R/V *Ramón Margalef*. The 2017 survey should be the fifth survey within its series. However, an unexpected a serious breakdown of the vessel's propulsion system led to an early termination of the survey, which restricted the surveyed area to the one comprised by the seven easternmost transects only.

The present survey, *ECOCADIZ-RECLUTAS 2018-10*, will be, therefore, the fifth survey in the series, although some methodological problems related with the acoustic sampling coverage (ping rate) should be carefully taken into account when dealing with the final acoustic estimates and interpreting their trends.

MATERIAL AND METHODS

The *ECOCADIZ-RECLUTAS 2018-10* survey was conducted between 10th and 29th October 2018 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 recently installed *Simrad™ EK80* echo-sounder working in the multi-frequency fashion (18, 38, 70, 120, 200, 333 kHz) and in CW mode. Average survey speed was about 10 knots and the acoustic signals were integrated over 1-nm intervals (ESDU). Raw acoustic data were stored for further post-processing using *Myriax Software Echoview™* software package (by *Myriax Software Pty. Ltd.,* ex *SonarData Pty. Ltd.*). Acoustic equipment was calibrated between 11st and 16th October in the Bay of Algeciras following the new ICES standard procedures (Demer *et al*., 2015; see also Foote *et al*., 1987).

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

Fishing stations for echo-trace ground-truthing were opportunistic, according to the echogram information, and they were carried out using a *Gloria HOD 352* pelagic trawl gear (ca. 10 m-mean vertical opening net) at an average speed of 4-4.5 knots. Gear performance and geometry during the effective fishing was monitored with *Simrad™ Mesotech FS20/25* trawl sonar. Trawl sonar data from each haul were recorded and stored for further analyses.

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

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

Individual biological sampling (length, weight, sex, maturity stage, stomach fullness, and mesenteric fat content) was performed in each haul for anchovy, sardine (in both species with otolith extraction), mackerel (2 spp.) and horse-mackerel species (3 spp.), and bogue.

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

Species	b_{20}
Sardine (*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, IEO, 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.

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 150 $CTDO_2$ casts using a *Sea-bird Electronics™ SBE 911+ SEACAT* (with coupled *Datasonics* altimeter, *SBE 43* oximeter, *WetLabs ECO-FL-NTU* fluorimeter and *WetLabs C-Star 25 cm* transmissometer sensors) profiler (**Figure 2**). *VMADCP RDI 150 kHz* records were also continuously recorded by night between CTD stations. Census of top predators was not recorded during the survey.

RESULTS

Acoustic sampling

The acoustic sampling was restricted to the period comprised between 17th and 28th October. The complete grid (21 transects) was acoustically sampled (**Table 1**; **Figure 1**). The sampling scheme followed to accomplish this grid was conditioned by the weather conditions during the survey. Thus, the acoustic sampling started by the coastal end of the transect R01 on 17th October and proceeded westward up to the R04 on 19th October. The survey was interrupted on 20th October in order to satisfy the R/V's refueling and provisioning needs. The second leg proceeded between 21st and 24th October by acoustically sampling the R05 to R12 transects in the usual E-W direction. On 25th October the acoustic sampling started by the westernmost transect, the R21, and the sampling proceeded then in the W-E direction up to the transect R13, with the intent to avoid a very low pressure system approaching to Cape San Vicente. In order to perform the acoustic sampling with daylight, this sampling started at 06:45-07:00 UTC, although this time might vary depending on the duration of the works related with the hydrographic sampling the previous night.

Unfortunately, a misconfiguration of the echo-sounder ping rate was detected *a posteriori*, during the phase of acoustic data post-processing. The ping-rate during the acoustic sampling resulted to be very low, about 1.5-2.0 seconds, and this was caused by the erroneous generation of an active layer with a range deeper than the recording depth or visualization scale. Such an error entailed to slow down the ping rate (1.5-2.0 seconds) in relation to the standard values (at about 0.3 seconds), resulting an acoustic sampling rate much lower than it should be. Therefore, the recording of acoustic densities may possibly be lower than the real one. This error may have implications in the final estimates of abundance and biomass which may be computed from the above under-sampled acoustic densities. **Therefore, the results from this acoustic sampling and the resulting estimates from this survey should be considered with caution**.

Groundtruthing hauls

A total of twenty five (25) fishing operations for echo-trace ground-truthing (all of them were valid according to a correct gear performance and resulting catches), were carried out during the survey (**Table 2**, **Figure 3**). 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 27 and 198 m.

During the survey were captured 3 Chondrichthyan, 42 Osteichthyes, 1 Crustacean, 7 Cephalopod, 1 Gastropod, and 2 Echinoderm species. The percentage of occurrence of the more frequent fish 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, chub mackerel and sardine were the most frequent species in the valid hauls (96% and 92% presence index), followed by anchovy (84%), horse mackerel and mackerel (76%), bogue (52%) and Mediterranean horse mackerel (44%). Round sardinella, Blue jack mackerel, Pearlside, Blue whiting, Boarfish and Snipefish, Pearlside showed an incidental occurrence in the hauls performed in the surveyed area.

For the purposes of the acoustic assessment, anchovy, sardine, round sardinella, mackerel species, horse & jack mackerel species, bogue, blue whiting, boarfish, snipefish and pearlside were initially considered as the survey target species. Cephalopods were excluded from the computation of the total catches in weight and in number from those fishing stations where they occurred. Catches of the remaining non-target species were included in an operational category termed as “Others”.

According to the above premises, during the survey were captured a total of 9355 kg and 495 thousand fish (**Table 3**). Forty seven per cent (47%) of this “total” fished biomass corresponded to anchovy, 27% to sardine, 17% to chub mackerel, 4% to horse mackerel, and contributions lower than 1% for the remaining species. The most abundant species in ground-truthing trawl hauls were also anchovy and sardine (68% and 25% respectively), followed by chub mackerel (5%), with each of the remaining species accounting for equal to or less than 1%.

Species	**# of fishing stations**	**Occurrence (%)**	**Total weight (kg)**	**Total number**
Scomber colias	24	96	1550,230	24645
Sardina pilchardus	23	92	2522,203	124535
Merluccius merluccius	21	84	89,903	704
Engraulis encrasicolus	21	84	4417,979	337002
Trachurus trachurus	19	76	383,048	3084
Scomber scombrus	19	76	46,133	222
Boops boops	13	52	49,557	238
Spondyliosoma cantharus	11	44	10,637	83
Trachurus mediterraneus	11	44	119,981	678
Pagellus acarne	6	24	21,249	76
Pagellus erythrinus	6	24	17,520	120
Diplodus bellottii	5	20	3,221	53
Diplodus vulgaris	4	16	47,886	299
Capros aper	4	16	0,272	25
Thunnus thynnus	4	16	4,873	6
Zenopsis conchifer	4	16	3,913	9
Trachinotus ovatus	4	16	4,900	21
Pagellus bellottii bellottii	3	12	1,565	12
Alosa fallax	3	12	1,178	5
Mola mola	3	12	10,481	5
Spicara flexuosa	3	12	0,702	10
Sphoeroides pachygaster	2	8	4,540	4
Maurolicus muelleri	2	8	1,822	2901
Macroramphosus scolopax	2	8	0,244	70
Diplodus annularis	2	8	0,149	6
Pomadasys incisus	2	8	3,688	37
Pteromylaeus bovinus	2	8	45,301	3
Balistes carolinensis	1	4	1,008	1
Cepola macrophthalma	1	4	0,015	1
Serranus hepatus	1	4	0,034	1
Microchirus azevia	1	4	0,135	1
Serranus cabrilla	1	4	0,172	1
Zeus faber	1	4	0,044	1
Micromesistius poutassou	1	4	0,184	6
Torpedo marmorata	1	4	1,276	1
Squalus acanthias	1	4	6,963	3
Sardinella aurita	1	4	0,79	2
Argyrosomus regius	1	4	31,62	1
Mullus barbatus	1	4	0,071	1
Mullus surmuletus	1	4	0,721	7
Trachinus draco	1	4	0,357	4
Sarda sarda	1	4	1,09	1
Trachurus picturatus	1	4	0,063	1
Scorpaena notata	1	4	0,056	1
Lepidotrigla cavillone	1	4	0,585	14

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

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

A total of 324 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.	PIL	ANE	MAC	MAS	HOM	HMM	JAA	BOG	WHB
Total Area (%)	57392 (100,0)	20601 (35,9)	14392 (25,1)	7 (0,01)	11036 (19,2)	978 (1,7)	2746 (4,8)	0,03 (0,0001)	1214 (2,1)	0,2 (0,0003)
Portugal (%)	19346 (33,7)	3077 (14,9)	7443 (51,7)	4 (63,2)	6561 (59,5)	905 (92,6)	14 (0,5)	0,03 (100,0)	867 (71,5)	0 (0,0)
Spain (%)	38045 (66,3)	17524 (85,1)	6950 (48,3)	3 (36,8)	4475 (40,5)	72 (7,4)	2732 (99,5)	0 (0,0)	346 (28,5)	0,2 (100,0)

S_A (m^2 nmi^{-2})	BOC	SNS	MAV
Total Area (%)	0,1 (0,0001)	2 (0,004)	6415 (11,2)
Portugal (%)	0,1 (79,9)	2 (100,0)	472 (7,4)
Spain (%)	0,01 (20,1)	0 (0,0)	5943 (92,6)

For this "pelagic fish assemblage" has been estimated a total of 57 392 m^2 nmi^{-2}. The highest NASC value was recorded in the coastal waters (35 m) in front of Tavira (transect R13, **Figure 5**). By species, sardine accounted for 36% of this total back-scattered energy, followed by anchovy (25%), chub mackerel (19%) and pearlside (11%), and the remaining species with relative contributions of acoustic energies lower than 5%.

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

Spatial distribution and abundance/biomass estimates

Anchovy

Parameters of the survey's length-weight relationship for anchovy are given in **Table 4**. Size composition and mean size in the fishing hauls are represented in the spatial context in **Figure 6**. 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 7**. The estimated abundance and biomass by size and age class are given in **Tables 5** and **6** and **Figures 8** and **9**.

Anchovy avoid in autumn 2018 the easternmost waters of the Gulf. Something similar also happened in the shallower waters of the western Algarve. The spatial pattern of distribution of the acoustic density was further characterized by a concentration of a great part of the population in a relatively restricted area comprising the shelf waters between Cape Santa Maria and the Guadiana river mouth. The remaining population was widely distributed between this last landmark and the Bay of Cadiz (**Figure 7**). The size composition of anchovy catches indicates that smallest recruits occurred mainly in those last Spanish coastal waters (**Figure 6**).

Gulf of Cadiz anchovy abundance and biomass in autumn 2018 were of 953 million fish and 10 493 t. Spanish waters concentrated 58% (548 million) and 40% (4 234 t) of the total estimated abundance and biomass respectively. Portuguese estimates amounted to 405 million and 6 259 t (**Table 5**, **Figure 8**).

The size range recorded for the estimated population was comprised between 7.5 and 18.5 cm size classes, with two marked modes at the 9.0 (the dominant one) and 14.0 cm size classes. Both modes were also present in the size composition of the estimated biomass, but showing in this case a reversed importance (**Table 5**, **Figure 8**). The mean size and weight of the estimated population were 12.1 cm and 11.0 g, respectively. The anchovy size composition by coherent post-strata in the surveyed area evidences that juveniles were widely distributed in the coastal-inner shelf waters between the Guadiana river mouth and Bay of Cadiz, with the Matalascañas-Bay of Cadiz area being the area where the highest densities of anchovy juveniles were recorded (**Table 5**, **Figure 8**).

The age-0 population fraction was estimated at 543 million fish and 3 834 t, 57% and 36% of the total population abundance and biomass respectively (**Table 6**, **Figure 9**).

Sardine

Parameters of the survey's size-weight relationship for sardine are shown in **Table 4**. Size composition and mean size in the fishing hauls are represented in the spatial context in **Figure 10**. 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 8** and **9**, and **Figures 12** and **13**.

Sardine was widely distributed all over the surveyed area, although showed a main nucleus of acoustic density comprising the inner-mid shelf waters between the Guadiana river mouth and Bay of Cadiz. The species also showed relatively high densities all over the shelf waters between San Vicente and Santa Maria capes (**Figure 11**). The sardine size composition in the positive hauls indicates that juveniles were mainly distributed in the Spanish coastal waters between Matalascañas and Bay of Cadiz (**Figure 10**).

Sardine abundance and biomass in the surveyed area were of 1 134 million fish and 20 679 t (**Table 8**, **Figure 12**). Spanish waters concentrated 70% (792 million) and 75% (15 499 t) of the total estimated abundance and biomass, respectively. Portuguese estimates amounted to 343 million and 5 181 t (**Table 8**, **Figure 12**).

The size range recorded for the estimated population was comprised between 10.5 and 23.5 cm size classes, with a dominant mode at 12.0 cm size class. A similar size composition is also recorded for the estimated biomass (**Table 8**, **Figure 12**). The mean size and weight of the estimated population were 13.5 cm and 18.2 g, respectively. The sardine size and age composition by coherent post-strata in the surveyed area evidence that juveniles were also widely distributed in the coastal-inner shelf waters between the Guadiana river mouth and Bay of Cadiz, with the area comprised between Matalascañas and the Bay of Cadiz being the area where the highest densities of sardine juveniles were recorded (**Tables 8** and **9**, **Figures 12** and **13**).

The age-0 population fraction in the surveyed area was estimated at 1 036 million fish and 15 224 t, 91% and 74% of the total estimated abundance and biomass, respectively. Spanish waters concentrated the 97% of age-0 fish (1 004 million, 14 750 t), whereas the Portuguese ones recorded the remaining 3% of the recruits' population (32 million, 654 t), (**Table 9**, **Figure 13**).

Mackerel

Parameters of the survey's length-weight relationship are shown in **Table 4**. Size composition and mean size in the fishing hauls are represented in the spatial context in **Figure 14**. 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 15**. Estimated abundance and biomass by size class are given in **Table 11** and **Figure 16**.

Mackerel was absent in the easternmost waters and showed a scattered distribution over the shelf waters comprised between Cape San Vicente and the Bay of Cadiz, with the relatively highest densities being located in the western Algarve (**Figure 15**). The mackerel size composition in the positive hauls does not indicate any clear trend either in the latitudinal or bathymetric gradients (**Figure 14**).

Mackerel abundance and biomass in the surveyed area were estimated at about 1 million fish and 226 t (**Table 11**, **Figure 16**). Sixty two per cent (62%) of both total abundance and biomass were estimated in the Portuguese waters (0.9 million; 141 t). Spanish waters yielded a population of 0.5 million and 85 t.

The size range recorded for the estimated population was comprised between 21.0 and 35.5 cm size classes, with a dominant mode at 27.0 cm size class. A similar size composition is also recorded for the estimated biomass (**Table 11**, **Figure 16**).

Chub mackerel

Parameters of the survey's length-weight relationship are shown in **Table 4**. Size composition and mean size in the fishing hauls are represented in the spatial context in **Figure 17**. 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 18**. Estimated abundance and biomass by size class are given in **Table 12** and **Figure 19**.

Chub mackerel, although widely distributed, showed, however, a relatively wide void in the inner-middle shelf waters located between Doñana National Park and Chipiona. The highest integration values were recorded between Cape San Vicente and Guadiana (**Figure 18**). Size composition in the species' positive hauls indicates that juvenile/sub-adult fish mainly occurred in the outer-shelf waters of the surveyed area whereas larger fish were distributed in shallower waters (**Figure 17**).

Chub mackerel abundance and biomass in the surveyed area were of 108 million fish and 6 950 t (**Table 12**, **Figure 19**). Portuguese waters accounted for 63% (68 million) and 60% (4 179 t) of the total abundance and biomass, respectively. Spanish waters yielded a population of 40 million and 2 770 t.

The size range recorded for the estimated population was comprised between 16.0 and 31.5 cm size classes, with a dominant mode at 19.0 cm size class, a secondary mode at 21.5 cm size class and even a probable third mode at 28.5 cm size class. A rather similar size composition is also recorded for the estimated biomass (**Table 12**, **Figure 19**).

Horse mackerel

The survey's length-weight relationship for this species is shown in **Table 4**. Size composition and mean size in the fishing hauls are represented in the spatial context in **Figure 20**. 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 21**. Estimated abundance and biomass by size class are given in **Table 13** and **Figure 22**.

The species showed a scarce occurrence in the easternmost third of the surveyed area and the highest densities in the Portuguese waters (**Figure 21**). Size composition in the species' positive hauls does not show any clear trend excepting the localisation of larger specimens in the outer shelf of the central waters of the surveyed area, whereas spots of juvenile fish are mainly located in Spanish waters (**Figure 20**).

Horse mackerel abundance and biomass in the surveyed area were of 8 million fish and 740 t (**Table 13**, **Figure 22**). Portuguese waters accounted for 91% (7.7 million) and 96% (708 t) of the total abundance and biomass, respectively. Spanish waters yielded a population of 0.7 million and 32 t.

The size range recorded for the estimated population was comprised between 13.0 and 34.0 cm size classes, with a dominant mode at 20.0 cm size class (the dominant mode in Portuguese waters) and a secondary mode at 15.0 cm size class (the dominant mode in Spanish waters). A rather similar size composition is also recorded for the estimated biomass (**Table 13**, **Figure 22**).

Mediterranean horse-mackerel

The survey's length-weight relationship for this species is shown in **Table 4**. Size composition and mean size in the fishing hauls are represented in the spatial context in **Figure 23**. 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 24**. Estimated abundance and biomass by size class are given in **Table 14** and **Figure 25**.

The species was mainly distributed over the inner-middle shelf of the Spanish waters, especially in the easternmost waters, although a residual nucleus was also recorded west of Cape Santa Maria, in the western Algarve (**Figure 24**). Size composition in the species' positive hauls shows that the largest specimens were located in the outer shelf of easternmost waters of the surveyed area, whereas the rest of the surveyed area is frequented by smaller but adult fish (**Figure 23**).

Mediterranean horse mackerel abundance and biomass in the surveyed area were of 14 million fish and 2 156 t (**Table 14**, **Figure 25**). Spanish waters accounted for more than 99% of both the total abundance (14 million) and biomass (2 146 t), respectively. Portuguese waters yielded a population of 0.1 million and 10 t.

The size range recorded for the estimated population was comprised between 18.5 and 38.0 cm size classes, with a main mode at 26.0 cm and a secondary one at 30.0 cm. The same modal classes and relative importance were also recorded in the distribution of the estimated biomass by size class (**Table 14**, **Figure 25**).

Bogue

The survey's length-weight relationship for this species is shown in **Table 4**. Size composition and mean size in the fishing hauls are represented in the spatial context in **Figure 26**. 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 27**. Estimated abundance and biomass by size class are given in **Table 15** and **Figure 28**.

The species showed a scattered distribution all over the shelf of the surveyed area, with several spots of high acoustic density, with the densest one being located in inner-middle shelf in front of Tavira coast (**Figure 27**). Size composition in the species' positive hauls shows that larger specimens are located in the middle-outer shelf of the central and eastern waters of the surveyed area, whereas the rest of the surveyed area was frequented by smaller adult fish (**Figure 26**).

Bogue abundance and biomass in the surveyed area were of 6 million fish and 806 t (**Table 15**, **Figure 28**). Portuguese waters accounted for 79% (5 million) and 71% (572 t) of the total abundance and biomass, respectively. Spanish waters yielded a population of 1 million and 234 t.

The size range recorded for the estimated population was comprised between 17.0 and 29.5 cm size classes, with a main mode at 24.0 cm. The same dominant modal class was also recorded in the distribution of the estimated biomass by size class (**Table 15**, **Figure 28**).

Pearlside

The survey's length-weight relationship for this species is shown in **Table 4**. Size composition and mean size in the fishing hauls are represented in the spatial context in **Figure 29**. 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 30**. Estimated abundance and biomass by size class are given in **Table 16** and **Figure 31**.

The species was acoustically detected over the outer shelf and shelf break of the central and western waters of the surveyed area, although showing a very scattered distribution pattern (**Figure 30**). The very low number of positive and representative hauls prevents from identifying any spatial pattern regarding the size composition in such hauls. Average size was 4.55 cm (**Figure 29**).

Pearlside abundance and biomass in the surveyed area were of 1 798 million fish and 1 161 t (**Table 16**, **Figure 31**). Spanish waters accounted for 87% of both the total abundance (1 570 million) and biomass (1 013 t), respectively. Portuguese waters yielded estimates of 228 million and 147 t.

The size range recorded for the estimated population was comprised between 3.0 and 6.5 cm size classes, with a main mode at 4.0 cm size class and a secondary one at 5.5 cm size class. The same modal classes were also recorded in the distribution of the estimated biomass by size class (**Table 16**, **Figure 31**).

Other species

The mapping of the backscattering energy (nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to blue jack mackerel, blue whiting, boarfish and snipefish are shown in **Figure 32**.

Blue jack mackerel was only detected just to the west of Cape Santa Maria, between 85 and 180 m depth. Blue whiting only occurred in the outer shelf (100-200 m depth) if front of Punta Umbria coast. Boarfish also was detected both in that same location and depths that blue whiting and in front of Cape San Vicente. Snipefish only occurred over the shelf waters comprised between Quarteira and Fuzeta, just to the east of Cape Santa Maria.

(SHORT) DISCUSSION

The time series of anchovy and sardine estimates from this survey series are described in **Tables 7** and **10** and **Figure 33**. For those surveys covering the whole survey's area (i.e. 2014, 2015, 2016 and 2018), the 2018 anchovy estimates were the lowest ones in the series, both for the total population and recruit fraction. However, the 2018 estimates should be considered with caution because the abovementioned problems in the acoustic sampling coverage (lower ping rate than the standard), which could lead to a possible underestimation of the true population levels. The magnitude of this possible underestimation is hard to be assessed. Notwithstanding the above, such a decreasing trend in anchovy population levels should not be discarded (see in **Table 7** that 2017 abundance estimates, despite being only very partial ones, covering only a part of the Spanish waters, were even higher than the 2018 estimates).

The same above considerations on the acoustic sampling coverage are also valid for sardine (**Table 10**, **Figure 33**). In this case, even taking into account a possible underestimation, the values reached in 2018 were above the historical mean for the total population and recruits abundance and recruit biomass and they might suggest a relatively stable situation since the maxima registered in 2016.

ACKNOWLEDGEMENTS

We are very grateful to the crew of the R/V *Ramón Margalef* and to all the scientific and technical staff participating in the present survey.

Unión Europea
Fondo Europeo Marítimo y de Pesca (FEMP)

ECOCADIZ-RECLUTAS 2018-10 has been funded by the EU through the European Maritime and Fisheries Fund (EMFF) within the National Program of collection, management and use of data in the fisheries sector and support for scientific advice regarding the Common Fisheries Policy. The survey has been conducted onboard the *R/V Ramón Margalef*, which was built within the frame of the Program FEDER, FICTS-2011-03-01.

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Table 1. *ECOCADIZ-RECLUTAS 2018-10* 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**	17/10/2018	36º 13,820' N	06º 07,222' W	06:44	26	36º 01,965' N	06º 28,770' W	08:47	246
R02	**Sancti-Petri**	17/10/2018	36º 08,483' N	06º 34,346' W	09:37	195	36º 19,350' N	06º 14,432' W	14:17	25
R03	**Cádiz**	18/10/2018	36º 27,287' N	06º 18,940' W	08:39	25	36º 17,348' N	06º 36,895' W	13:34	217
R04	**Rota**	19/10/2018	36º 34,690' N	06º 23,050' W	06:41	22	36º 24,692' N	06º 41,009' W	10:26	202
R05	**Chipiona**	21/10/2018	36º 40,440' N	06º 29,450' W	06:48	22	36º 31,100' N	06º 46,350' W	10:18	229
R06	**Doñana**	21/10/2018	36º 38,060' N	06º 51,460' W	13:48	183	36º 46,600' N	06º 35,580' W	17:20	19
R07	**Matalascañas**	22/10/2018	36º 53,710' N	06º 40,980' W	06:37	23	36º 44,010' N	06º 58,440' W	10:09	200
R08	**Mazagón**	22/10/18	37º 01,250' N	06º 44,610' W	13:34	22	36º 49,220' N	07º 06,010' W	17:39	217
R09	**Punta Umbría**	23/10/18	37º 03,800' N	06º 56,590' W	06:39	30	36º 48,830' N	07º 06,950' W	10:17	247
R10	**El Rompido**	23/10/18	36º 49,940' N	07º 06,520' W	13:03	218	37º 06,640' N	07º 06,510' W	16:38	21
R11	**Isla Cristina**	24/10/18	37º 06,770' N	07º 17,320' W	06:44	23	36º 53,470' N	07º 17,248' W	10:04	211
R12	**V.R. do Sto. Antonio**	24/10/18	36º 56,210' N	07º 26,310' W	11:00	141	37º 06,118' N	07º 26,487' W	14:03	24
R13	**Tavira**	28/10/18	37º 03,633' N	07º 36,230' W	07:42	34	36º 56,000' N	07º 36,320' W	11:00	200
R14	**Fuzeta**	27/10/18	36º 55'710' N	07º 46'330' W	16:29	130	36º 59,110' N	07º 46,330' W	16:51	60
R15	**Cabo Sta. María**	27/10/18	36º 52,146' N	07º 56,244' W	13:17	133	36º 55,060' N	07º 56,385' W	13:35	70
R16	**Cuarteira**	27/10/18	37º 01,222' N	08º 06,182' W	06:47	23	36º 49,880' N	08º 06,159' W	09:51	219
R17	**Albufeira**	26/10/18	36º 49,390' N	08º 15,712' W	11:23	185	37º 02,652' N	08º 15,865' W	12:38	20
R18	**Alfanzinha**	26/10/18	37º 04,010' N	08º 25,600' W	07:02	24	36º 50,160' N	08º 25,510' W	10:35	227
R19	**Portimao**	25/10/18	37º 05,710' N	08º 35,740' W	12:20	31	36º 51,090' N	08º 35,690' W	17:29	200
R20	**Burgau**	25/10/2018	36º 52,320' N	08º 45,380' W	10:18	112	37º 03,850' N	08º 45,370' W	11:23	35
R21	**Ponta de Sagres**	25/10/2018	36º 59,700' N	08º 55,351' W	6:54	31	36º 50,640' N	08º 55,360' W	7:46	231

Table 2. *ECOCADIZ-RECLUTAS 2018-10* survey. Descriptive characteristics of the fishing hauls.

Fishing haul	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			
1	17-10-2018	36º 10.5597 N	6º 30.4339 W	36º 09.0423 N	6º 33.4170 W	11:07	11:58	114,20	160,45	00:41		2,851	R02	Sancti-Petri
2	18-10-2018	36º 23.0844 N	6º 26.2970 W	36º 24.8778 N	6º 23.0325 W	10:54	11:40	59,31	48,77	00:45	1:20	3,186	R03	Cádiz
3	18-10-2018	36º 18.1122 N	6º 35.4080 W	36º 19.5097 N	6º 32.8911 W	14:08	14:45	199,10	109,35	00:37	1:22	2,467	R03	Cádiz
4	19-10-2018	36º 30.0358 N	6º 31.3561 W	36º 31.7728 N	6º 28.3226 W	8:01	8:45	62,36	47,58	00:43	1:16	2,998	R04	Rota
5	19-10-2018	36º 25.8781 N	6º 38.8791 W	36º 28.0515 N	6º 34.8876 W	11:17	12:13	122,90	86,82	00:56	1:36	3,883	R04	Rota
6	21-10-2018	36º 36.2281 N	6º 36.9245 W	36º 37.9672 N	6º 33.9639 W	0,3	8:41	60,91	41,18	00:43	1:14	2,949	R05	Chipiona
7	21-10-2018	36º 32.0076 N	6º 44.6475 W	36º 34.1137 N	6º 40.8500 W	11:11	12:05	132,50	91,54	00:54	1:42	3,713	R05	Chipiona
8	21-10-2018	36º 42.6492 N	6º 42.6762 W	36º 40.9432 N	6º 46.1030 W	15:01	15:48	56,97	90,28	00:46	1:23	3,24	R06	Doñana
9	22/10/2018	36º 50.3900 N	6º 46.7255 W	36º 52.0101 N	6º 43.8381 W	7:33	8:14	44,98	27,40	0:41	1:14	2,826	R07	Matalascañas
10	22/10/2018	36º 46.4678 N	6º 53.9155 W	36º 47.9163 N	6º 51.3246 W	11:08	0,5	105,10	84,7	0:37	1:24	2,535	R07	Matalascañas
11	22/10/2018	36º 56.3362 N	6º 53.1560 W	36º 58.0814 N	6º 49.9278 W	14:58	15:43	50,04	37,66	0:45	1:20	3,12	R08	Mazagón
12	23/10/2018	36º 55.2982 N	7º 02.5734 W	36º 57.8259 N	7º 00.7698 W	08:04	8:46	90,15	63,48	0:42	1:17	2,909	R09	Punta Umbría
13	23/10/2018	36º 49.4726 N	7º 06.0735 W	36º 52.1596 N	7º 04.0302 W	11:11	11:57	198,80	114,85	0:45	1:36	3,145	R09	Punta Umbría
14	23/10/2018	37º 04.1596 N	7º 06.5007 W	37º 00.9786 N	7º 06.5121 W	14:52	15:38	38,79	56,00	0:46	1:16	3,177	R10	El Rompido
15	24/10/2018	36º 56.1778 N	7º 17.4102 W	36º 59.2590 N	7º 17.3515 W	08:14	8:58	112,60	90,40	0:44	1:23	3,078	R11	Isla Cristina
16	24/10/2018	36º 59.7296 N	7º 26.2778 W	36º 56.7858 N	7º 26.3352 W	11:44	12:27	99,75	135,29	0:43	1:28	2,94	R12	Vila R. do Sto Antonio
17	25/10/2018	36º 53.2951 N	8º 55.4324 W	36º 55.2914 N	8º 55.4380 W	08:21	8:51	120,9	110,67	0:29	1:22	1,994	R21	Ponta de Sagres
18	25/10/2018	37º 04.0755 N	8º 34.5544 W	37º 03.8899 N	8º 37.1072 W	13:26	13:55	40,72	41,08	0:28	1:02	2,052	R19	Portimao
19	25/10/2018	36º 54.8672 N	8º 34.2443 W	36º 55.0481 N	8º 37.3169 W	15:57	16:33	99,70	101,00	0:36	1:10	2,471	R19	Portimao
20	26/10/2018	36º 54.3837 N	8º 25.8487 W	36º 57.6797 N	8º 25.6522 W	8:29	9:18	114,50	77,48	0:48	1:28	3,296	R18	Alfanzina
21	26/10/2018	37º 00.6081 N	8º 17.7079 W	37º 00.5492 N	8º 14.6373 W	13:45	14:21	40,48	41,41	0:35	1:10	2,46	R17	Albufeira
22	27/10/2018	36º 56.0608 N	8º 06.1255 W	36º 59.1617 N	8º 06.1655 W	7:44	8:29	49,33	38,82	0:44	1:19	3,097	R16	Cuarteira
23	27/10/2018	36º 52.1869 N	8º 04.7961 W	36º 51.2938 N	8º 08.0353 W	11:01	11:41	113,30	104,58	0:40	1:26	2,748	R16	Cuarteira
24	27/10/2018	36º 52.9063 N	7º 58.0099 W	36º 53.2713 N	7º 54.8999 W	14:37	15:13	104,60	104,92	0:36	1:29	2,521	R15	Cabo de Sta María
25	28/10/2018	37º 02.4592 N	7º 35.2349 W	37º 01.2892 N	7º 38.6924 W	8:53	9:38	75,52	74,56	0:45	1:43	3,005	R13	Tavira

Table 3. *ECOCADIZ-RECLUTAS 2018-10* survey. Catches by species in number (upper panel) and weight (in kg, lower panel) from valid fishing stations.

Fishing haul	CATCH IN NUMBER (n)														
	Anchovy	*Sardine*	*Round sardinella*	*Chub mack.*	*Mackerel*	*Blue Jack mack.*	*Horse-mack.*	*Medit. Horse-mack.*	*Bogue*	*Blue whiting*	*Boarfish*	*Snipefish*	*Pearlside*	Other spp.	TOTAL
01	1	0	0	1079	0	0	0	0	0	0	0	0	0	0	**1080**
02	2	564	2	152	0	0	2	384	11	0	0	0	0	24	**1141**
03	0	3	0	6231	2	0	10	12	0	0	1	0	0	13	**6272**
04	1897	4237	0	12	0	0	5	23	7	0	0	0	0	8	**6189**
05	4869	23	0	483	16	0	2	0	0	0	4	0	0	118	**5515**
06	22552	12939	0	2	9	0	1	2	0	0	0	0	0	36	**35541**
07	103463	2177	0	287	17	0	1	0	0	0	0	0	0	105	**106050**
08	23401	30234	0	2	6	0	0	0	0	0	0	0	0	11	**53654**
09	305	27350	0	44	1	0	0	148	37	0	0	0	0	137	**28022**
10	100181	9	0	11	50	0	0	1	1	0	0	0	0	33	**100286**
11	488	10869	0	146	2	0	0	90	18	0	0	0	0	45	**11658**
12	9215	3429	0	172	22	0	44	3	2	0	0	0	0	54	**12941**
13	3314	2	0	2898	6	0	73	0	0	6	12	0	2900	32	**9243**
14	14	23338	0	7138	4	0	0	9	7	0	0	1	0	2	**30513**
15	7584	50	0	2	3	0	2	0	0	0	0	0	0	37	**7678**
16	3536	0	0	0	1	0	1	0	0	0	0	0	0	16	**3554**
17	169	1	0	4	52	0	519	0	45	0	8	0	0	113	**911**
18	0	8555	0	4	0	0	3	0	4	0	0	0	0	135	**8701**
19	186	4	0	7	2	0	1	0	0	0	0	0	0	37	**237**
20	526	55	0	829	10	0	5	0	7	0	0	0	0	90	**1522**
21	0	1	0	87	0	0	118	5	14	0	0	0	0	31	**256**
22	0	23	0	259	0	0	431	1	35	0	0	0	0	266	**1015**
23	41093	44	0	1769	10	1	10	0	0	0	0	0	1	24	**42952**
24	2028	49	0	2119	3	0	1689	0	0	0	0	0	0	40	**5928**
25	12178	579	0	908	6	0	167	0	50	0	0	69	0	43	**14000**
TOTAL	**337002**	**124535**	**2**	**24645**	**222**	**1**	**3084**	**678**	**238**	**6**	**25**	**70**	**2901**	**1450**	**494859**

Table 3. *ECOCADIZ-RECLUTAS 2018-10* survey. Cont'd.

Fishing haul	CATCH IN WEIGHT (kg)													
	Anchovy	*Sardine*	*Round sardinella*	*Chub mack.*	*Mackerel*	*Blue Jack mack.*	*Horse-mack.*	*Medit. Horse-mack.*	*Bogue*	*Blue whiting*	*Boarfish*	*Snipefish*	*Pearlside*	Other spp.	TOTAL
01	0,028	0	0	86,770	0	0	0	0	0	0	0	0	0	0	**86,798**
02	0,037	13,740	0,790	13,780	0	0	0,111	71,680	2,092	0	0	0	0	4,547	**106,777**
03	0	0,115	0	388,280	0,188	0	0,453	5,773	0	0	0,006	0	0	4,106	**398,921**
04	13,198	51,652	0	0,989	0	0	0,233	2,707	1,350	0	0	0	0	32,352	**102,481**
05	65,320	0,529	0	38,060	2,486	0	0,054	0	0	0	0,167	0	0	16,935	**123,551**
06	107,178	188,370	0	0,177	2,059	0	0,079	0,832	0	0	0	0	0	3,595	**302,290**
07	1446,998	36,093	0	21,350	2,680	0	0,180	0	0	0	0	0	0	17,335	**1524,636**
08	163,201	433,137	0	0,094	1,161	0	0	0	0	0	0	0	0	1,206	**598,799**
09	2,050	380,840	0	4,046	0,212	0	0	21,540	7,035	0	0	0	0	14,929	**430,652**
10	1263,338	0,122	0	0,797	8,120	0	0	0,122	0,164	0	0	0	0	13,673	**1286,336**
11	4,048	347,642	0	13,120	0,469	0	0	14,960	2,999	0	0	0	0	6,304	**389,542**
12	99,940	82,520	0	10,620	4,142	0	1,519	0,295	0,313	0	0	0	0	4,077	**203,426**
13	56,007	0,143	0	174,287	0,921	0	16,120	0	0	0,184	0,045	0	1,821	4,180	**253,708**
14	0,116	417,777	0	421,251	1,127	0	0	1,280	1,165	0	0	0,003	0	0,220	**842,939**
15	99,780	0,867	0	0,094	0,398	0	0,056	0	0	0	0	0	0	4,713	**105,908**
16	55,680	0	0	0	0,124	0	0,204	0	0	0	0	0	0	3,145	**59,153**
17	4,012	0,025	0	0,170	13,240	0	56,740	0	4,324	0	0,054	0	0	28,310	**106,875**
18	0	553,334	0	0,253	0	0	0,309	0	0,306	0	0	0	0	21,864	**576,066**
19	4,040	0,139	0	0,472	0,333	0	0,141	0	0	0	0	0	0	8,457	**13,582**
20	10,816	1,327	0	40,840	2,154	0	0,369	0	0,073	0	0	0	0	10,588	**66,167**
21	0	0,068	0	9,660	0	0	9,180	0,645	1,138	0	0	0	0	4,411	**25,102**
22	0	0,414	0	14,660	0	0	37,560	0,147	3,418	0	0	0	0	43,750	**99,949**
23	777,672	0,874	0	125,020	1,289	0,063	0,680	0	0	0	0	0	0,001	1,887	**907,486**
24	43,000	1,695	0	127,620	4,360	0	247,540	0	0	0	0	0	0	4,550	**428,765**
25	201,520	10,780	0	57,820	0,670	0	11,520	0	25,180	0	0	0,241	0	7,079	**314,810**
TOTAL	**4417,979**	**2522,203**	**0,790**	**1550,230**	**46,133**	**0,063**	**383,048**	**119,981**	**49,557**	**0,184**	**0,272**	**0,244**	**1,822**	**262,213**	**9354,719**

Table 4. *ECOCADIZ-RECLUTAS 2018-10* survey. Parameters of the size-weight relationships for the survey's target species susceptible of being assessed. FAO codes for the species: ANE: *Engraulis encrasicolus*; PIL: *Sardina pilchardus*; SAA: *Sardinella aurita*; MAS: *Scomber colias*; MAC: *Scomber scombrus*; HMM: *Trachurus mediterraneus*.

Parameter	ANE	PIL	MAS	MAC	HOM	HMM	BOG	MAV
Size range (mm)	76-184	104-233	165-318	200-386	20-341	117-482	160-312	32-66
n	944	985	836	220	378	205	286	129
a	0,005886134	0,001959529	0,001311841	0,000667182	0,049940934	0,01862158	0,009774912	0,006143344
b	2,984386331	3,466989068	3,553312648	3,699042765	2,407050492	2,720476789	2,975809544	3,028111499
r^2	0,987059273	0,97005141	0,932427064	0,946022212	0,773164253	0,935408782	0,929407994	0,9373326

Table 5. *ECOCADIZ-RECLUTAS 2017-10* survey. Anchovy (*E. encrasicolus*). Estimated abundance (absolute numbers and million fish) and biomass (t) by size class (in cm). Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figure 7**.

***ECOCADIZ-RECLUTAS 2018-10 . Engraulis encrasicolus* . ABUNDANCE (in numbers and million fish)**																		
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	**POL09**	**POL10**	**POL11**	**POL12**	***n***			**Millions**		
													PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7,5	618	20	0	0	0	0	0	0	0	0	0	0	638	0	638	0,001	0	0,001
8	618	20	0	0	0	0	0	0	0	0	0	0	638	0	638	0,001	0	0,001
8,5	618	20	0	0	499554	1945070	0	0	65439696	0	0	0	500192	67384766	67884958	1	67	68
9	824	26	0	0	3562404	13870621	0	0	105172435	0	0	0	3563254	119043056	122606310	4	119	123
9,5	412	13	0	0	7374468	28713321	0	0	32719848	0	0	0	7374893	61433169	68808062	7	61	69
10	1030	33	0	0	9381903	36529493	0	0	16359924	0	0	0	9382966	52889417	62272383	9	53	62
10,5	824	26	0	93484	7882321	30690701	150733	0	4678750	41029	162	33	7976655	35561408	43538063	8	36	44
11	412	13	0	823377	5719093	22267931	1327604	0	4678750	361364	1430	288	6542895	28637367	35180262	7	29	35
11,5	412	13	0	2629994	4025628	15674236	4240576	0	4678750	1154254	4567	921	6656047	25753304	32409351	7	26	32
12	0	0	728010	10906220	2966553	11550606	17585082	9894	2334141	4786531	18940	3818	14600783	36289012	50889795	15	36	51
12,5	0	0	7719558	12719846	1397404	5440951	20509355	104917	0	5582496	22089	4453	21836808	31664261	53501069	22	32	54
13	232531	7384	26973016	15259059	690825	2689805	24603557	366590	0	6696908	26499	5342	43162815	34388701	77551516	43	34	78
13,5	1014992	32231	43524545	11602675	895998	3488668	18708039	591542	0	5092191	20149	4062	57070441	27904651	84975092	57	28	85
14	3974894	126223	75278354	7490760	140945	548787	12078028	1023109	0	3287551	13008	2622	87011176	16953105	103964281	87	17	104
14,5	8547496	271427	61846173	2722093	144982	564504	4389077	840552	0	1194675	4727	953	73532171	6994488	80526659	74	7	81
15	10502179	333498	21265493	724148	0	0	1167610	289019	0	317815	1258	254	32825318	1775956	34601274	33	2	35
15,5	9320916	295987	12748604	280453	0	0	452200	173266	0	123086	487	98	22645960	749137	23395097	23	1	23
16	6050243	192126	832603	93484	0	0	150733	11316	0	41029	162	33	7168456	203273	7371729	7	0	7
16,5	1829693	58102	0	93484	0	0	150733	0	0	41029	162	33	1981279	191957	2173236	2	0	2
17	757126	24043	0	0	0	0	0	0	0	0	0	0	781169	0	781169	1	0	1
17,5	45765	1453	0	0	0	0	0	0	0	0	0	0	47218	0	47218	0,05	0	0,05
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18,5	50684	1609	0	0	0	0	0	0	0	0	0	0	52293	0	52293	0,05	0	0,05
TOTAL *n*	42332287	1344267	250916356	65439077	44682078	173974694	105513327	3410205	236062294	28719958	113640	22910	404714065	547817028	952531093	**405**	**548**	**953**
Millions	**42**	**1**	**251**	**65**	**45**	**174**	**106**	**3**	**236**	**29**	**0,1**	**0,02**						

Table 5. *ECOCADIZ-RECLUTAS 2018-10* survey. Anchovy (*E. encrasicolus*). Cont'd.

ECOCADIZ-RECLUTAS 2018-10 . Engraulis encrasicolus **. BIOMASS (t)**															
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	**POL09**	**POL10**	**POL11**	**POL12**	**PORTUGAL**	**SPAIN**	**TOTAL**
6	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
6,5	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
7	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
7,5	0,002	0	0	0	0	0	0	0	0	0	0	0	**0,002**	**0**	**0,002**
8	0,002	0	0	0	0	0	0	0	0	0	0	0	**0,002**	**0**	**0,002**
8,5	0,002	0	0	0	1,904	7,414	0	0	249,452	0	0	0	**1,906**	**256,866**	**258,772**
9	0,004	0	0	0	16,029	62,412	0	0	473,230	0	0	0	**16,033**	**535,642**	**551,675**
9,5	0,002	0	0	0	38,827	151,177	0	0	172,271	0	0	0	**38,829**	**323,448**	**362,277**
10	0,006	0	0	0	57,347	223,287	0	0	100,000	0	0	0	**57,353**	**323,287**	**380,640**
10,5	0,006	0	0	0,659	55,540	216,251	1,062	0	32,967	0,289	0,001	0	**56,205**	**250,570**	**306,775**
11	0,003	0	0	6,645	46,153	179,703	10,714	0	37,758	2,916	0,012	0,002	**52,801**	**231,105**	**283,906**
11,5	0,004	0	0	24,165	36,989	144,020	38,964	0	42,990	10,606	0,042	0,008	**61,158**	**236,63**	**297,788**
12	0	0	7,575	113,481	30,867	120,186	182,976	0,103	24,287	49,805	0,197	0,040	**151,923**	**377,594**	**529,517**
12,5	0	0	90,509	149,136	16,384	63,793	240,465	1,230	0	65,453	0,259	0,052	**256,029**	**371,252**	**627,281**
13	3,058	0,097	354,720	200,671	9,085	35,373	323,559	4,821	0	88,070	0,348	0,070	**567,631**	**452,241**	**1019,872**
13,5	14,908	0,473	639,292	170,421	13,160	51,242	274,785	8,689	0	74,795	0,296	0,060	**838,254**	**409,867**	**1248,121**
14	64,951	2,063	1230,069	122,401	2,303	8,967	197,358	16,718	0	53,720	0,213	0,043	**1421,787**	**277,019**	**1698,806**
14,5	154,809	4,916	1120,134	49,301	2,626	10,224	79,493	15,224	0	21,637	0,086	0,017	**1331,786**	**126,681**	**1458,467**
15	210,109	6,672	425,442	14,487	0	0	23,359	5,782	0	6,358	0,025	0,005	**656,710**	**35,529**	**692,239**
15,5	205,322	6,520	280,828	6,178	0	0	9,961	3,817	0	2,711	0,011	0,002	**498,848**	**16,502**	**515,350**
16	146,304	4,646	20,134	2,261	0	0	3,645	0,274	0	0,992	0,004	0,001	**173,345**	**4,916**	**178,261**
16,5	48,433	1,538	0	2,475	0	0	3,990	0	0	1,086	0,004	0,001	**52,446**	**5,081**	**57,527**
17	21,880	0,695	0	0	0	0	0	0	0	0	0	0	**22,575**	**0**	**22,575**
17,5	1,440	0,046	0	0	0	0	0	0	0	0	0	0	**1,486**	**0**	**1,486**
18	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
18,5	1,879	0,060	0	0	0	0	0	0	0	0	0	0	**1,939**	**0**	**1,939**
TOTAL	**873,124**	**27,726**	**4168,703**	**862,281**	**327,214**	**1274,049**	**1390,331**	**56,658**	**1132,955**	**378,438**	**1,498**	**0,301**	**6259,048**	**4234,230**	**10493,278**

Table 6. *ECOCADIZ-RECLUTAS 2018-10* 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 **Figure 7** and ordered from west to east.

Age class	POL01	POL02	POL03	POL04	POL05	POL06	POL07	POL08	POL09	POL10	POL11	POL12	PORTUGAL	SPAIN	SURVEYED AREA
	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
0	1103	35	28594	24659	41401	161200	39759	389	235127	10822	43	9	95791	447348	543140
I	34688	1102	211794	39969	3251	12659	64446	2878	935	17542	69	14	290804	98544	389348
II	6541	208	10529	811	30	116	1308	143	0	356	1	0	18119	1925	20043
III	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	42332	1344	250916	65439	44682	173975	105513	3410	236062	28720	114	23	404714	547817	952531

Age class	POL01	POL02	POL03	POL04	POL05	POL06	POL07	POL08	POL09	POL10	POL11	POL12	PORTUGAL	SPAIN	SURVEYED AREA
	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
0	19	1	413	285	286	1114	460	6	1124	125	0,5	0,1	1005	2830	3834
I	703	22	3557	563	41	158	907	48	9	247	1	0,2	4885	1371	6256
II	151	5	199	14	0	2	23	3	0	6	0,02	0,005	369	34	403
III	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	873	28	4169	862	327	1274	1390	57	1133	378	1	0,3	6259	4234	10493

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

Estimate/Year	Total Population (Recruits at age 0)					
	2012	**2014**	**2015**	**2016**	**2017**	**2018**
Biomass (t)	13680 (13354)	8113 (5131)	30827 (29219)	19861 (15969)	7642 (7290)	10493 (3834)
Abundance (millions)	2469 (2619)	986 (814)	5227 (5117)	3667 (3445)	1492 (1433)	953 (543)

Table 8. *ECOCADIZ-RECLUTAS 2018-10* survey. Sardine (*Sardina pilchardus*). Estimated abundance (absolute numbers and million fish) and biomass (t) by size class (in cm). Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figure 11**.

ECOCADIZ-RECLUTAS 2018-10. *Sardina pilchardus*. ABUNDANCE (in numbers and million fish)																	
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	**POL09**	**POL10**	**POL11**	***n***			**Millions**		
												PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10,5	0	0	0	0	672416	0	3529078	0	0	0	0	672416	3529078	4201494	1	4	4
11	0	0	0	0	3892241	0	20427855	0	0	0	0	3892241	20427855	24320096	4	20	24
11,5	0	0	0	0	28748690	0	150883289	223970	0	0	0	28748690	151107259	179855949	29	151	180
12	0	0	0	147738	40549540	601163	212818321	959871	38663	192227	0	40697278	214610245	255307523	41	215	255
12,5	35218	0	0	705541	24096335	2870922	126466085	1401411	184641	1153364	2	24837094	132076425	156913519	25	132	157
13	264135	8758	0	5149452	17729254	20953675	93049394	671909	1347616	2146539	15	23151599	118169148	141320747	23	118	141
13,5	308157	70068	0	9067082	8827281	36894931	46328690	127983	2372863	800947	26	18272588	86525440	104798028	18	87	105
14	633924	183928	741	6579441	4146547	26772455	21762547	537527	1721846	2595069	19	11544581	53389463	64934044	12	53	65
14,5	1056540	332822	0	2188704	1322899	8906071	6943042	1017463	572786	2338766	6	4900965	19778134	24679099	5	20	25
15	783600	183928	741	704349	1399639	2866071	7345802	9176362	184329	2242652	2	3072257	21815218	24887475	3	22	25
15,5	220112	271513	4447	262327	797009	1067438	4182983	13271810	68651	2691183	1	1555408	21282066	22837474	2	21	23
16	281744	1138602	13342	91187	401420	371051	2106794	23369648	23864	2146539	0	1926295	28017896	29944191	2	28	30
16,5	114458	1015983	8895	146200	117466	594904	616503	8638835	38261	1089288	0	1403002	10977791	12380793	1	11	12
17	0	2531200	5189	143987	83152	585897	436413	5080915	37681	448530	0	2763528	6589436	9352964	3	7	9
17,5	35218	1261221	1482	168258	35690	684661	187316	3045989	44033	96114	0	1501869	4058113	5559982	2	4	6
18	35218	9643084	0	161571	17721	657448	93008	2034926	42283	0	0	9857594	2827665	12685259	10	3	13
18,5	70436	8802270	0	148018	0	602300	0	0	38736	0	0	9020724	641036	9661760	9	1	10
19	0	12156767	741	65416	0	266186	0	0	17120	0	0	12222924	283306	12506230	12	0	13
19,5	35218	7129401	0	39153	0	159316	0	0	10246	96114	0	7203772	265676	7469448	7	0	7
20	0	5027366	0	19576	0	79658	0	0	5123	0	0	5046942	84781	5131723	5	0	5
20,5	0	8381863	741	19576	0	79658	0	0	5123	0	0	8402180	84781	8486961	8	0	8
21	0	7549808	0	13553	0	55148	0	0	3547	0	0	7563361	58695	7622056	8	0	8
21,5	0	5447773	0	6023	0	24510	0	0	1576	0	0	5453796	26086	5479882	5	0	5
22	0	3354497	0	6023	0	24510	0	0	1576	0	0	3360520	26086	3386606	3	0	3
22,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	420407	0	0	0	0	0	0	0	0	0	420407	0	420407	0	0	0
23,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL *n*	3873978	74911259	36319	25833175	132837300	105117973	697177120	69558619	6760564	18037332	71	237492031	896651679	1134143710	**237**	**897**	**1134**
Millions	**4**	**75**	**0,04**	**26**	**133**	**105**	**697**	**70**	**7**	**18**	**0,0001**						

Table 8. *ECOCADIZ-RECLUTAS 2018-10* survey. Sardine (*Sardina pilchardus*). Cont'd.

ECOCADIZ-RECLUTAS 2018-10 . Sardina pilchardus . BIOMASS (t)														
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	**POL09**	**POL10**	**POL11**	**PORTUGAL**	**SPAIN**	**TOTAL**
6	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
6,5	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
7	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
7,5	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
8	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
8,5	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
9	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
9,5	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
10	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
10,5	0	0	0	0	4,962	0	26,043	0	0	0	0	**0**	**31,005**	**31,005**
11	0	0	0	0	33,627	0	176,485	0	0	0	0	**0**	**210,112**	**210,112**
11,5	0	0	0	0	288,788	0	1515,662	2,250	0	0	0	**0**	**1806,700**	**1806,700**
12	0	0	0	1,715	470,645	6,977	2470,111	11,141	0,449	2,231	0	**1,715**	**2961,555**	**2963,269**
12,5	0,470	0	0	9,407	321,288	38,279	1686,232	18,686	2,462	15,378	0,00003	**9,877**	**2082,325**	**2092,202**
13	4,024	0,133	0	78,455	270,117	319,243	1417,671	10,237	20,532	32,704	0,0002	**82,613**	**2070,504**	**2153,117**
13,5	5,338	1,214	0	157,073	152,919	639,148	802,573	2,217	41,106	13,875	0,0005	**163,625**	**1651,839**	**1815,464**
14	12,429	3,606	0,015	129,004	81,302	524,932	426,702	10,539	33,761	50,882	0,0004	**145,055**	**1128,119**	**1273,173**
14,5	23,347	7,354	0	48,365	29,233	196,801	153,423	22,483	12,657	51,681	0,0001	**79,066**	**466,278**	**545,343**
15	19,437	4,562	0,018	17,471	34,718	71,092	182,211	227,618	4,572	55,628	0,00005	**41,489**	**575,839**	**617,328**
15,5	6,106	7,532	0,123	7,277	22,109	29,611	116,037	368,163	1,904	74,654	0,00003	**21,038**	**612,479**	**633,517**
16	8,710	35,200	0,412	2,819	12,410	11,471	65,131	722,469	0,738	66,360	0	**47,141**	**878,579**	**925,720**
16,5	3,930	34,889	0,305	5,020	4,034	20,429	21,171	296,656	1,314	37,406	0	**44,145**	**381,009**	**425,154**
17	0	96,253	0,197	5,475	3,162	22,280	16,595	193,209	1,433	17,056	0	**101,925**	**253,735**	**355,660**
17,5	1,479	52,954	0,062	7,065	1,498	28,746	7,865	127,890	1,849	4,035	0	**61,560**	**171,884**	**233,444**
18	1,628	445,812	0	7,470	0,819	30,395	4,300	94,077	1,955	0	0	**454,910**	**131,546**	**586,456**
18,5	3,576	446,918	0	7,515	0	30,581	0	0	1,967	0	0	**458,009**	**32,547**	**490,557**
19	0	676,203	0,041	3,639	0	14,806	0	0	0,952	0	0	**679,883**	**15,758**	**695,641**
19,5	2,141	433,433	0	2,380	0	9,686	0	0	0,623	5,843	0	**437,954**	**16,152**	**454,106**
20	0	333,314	0	1,298	0	5,281	0	0	0,340	0	0	**334,612**	**5,621**	**340,233**
20,5	0	604,755	0,053	1,412	0	5,747	0	0	0,370	0	0	**606,221**	**6,117**	**612,338**
21	0	591,598	0	1,062	0	4,321	0	0	0,278	0	0	**592,660**	**4,599**	**597,259**
21,5	0	462,730	0	0,512	0	2,082	0	0	0,134	0	0	**463,241**	**2,216**	**465,457**
22	0	308,289	0	0,554	0	2,253	0	0	0,145	0	0	**308,842**	**2,397**	**311,239**
22,5	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
23	0	44,998	0	0	0	0	0	0	0	0	0	**44,998**	**0**	**44,998**
23,5	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
24	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
24,5	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
25	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
TOTAL	**92,616**	**4591,746**	**1,228**	**494,989**	**1731,631**	**2014,162**	**9088,212**	**2107,635**	**129,539**	**427,734**	**0,001**	**5180,579**	**15498,915**	**20679,494**

Table 9. *ECOCADIZ-RECLUTAS 2017-07* survey. Sardine (*Sardina pilchardus*). Estimated abundance (thousands of individuals) and biomass (tonnes) by age group. Polygons (i.e., coherent or homogeneous post-strata) numbered as in **Figure 11** and ordered from west to east.

Age class	POL01	POL02	POL03	POL04	POL05	POL06	POL07	POL08	POL09	POL10	POL11	PORTUGAL	SPAIN	SURVEYED AREA
	N	N	N	N	N	N	N	N	N	N	N	N	N	N
0	3542	3792	24	24857	132445	101145	695118	52558	6505	16409	0,1	32215	1004180	1036395
I	208	12938	9	557	325	2268	1705	13514	146	1300	0,001	13713	19258	32971
II	106	27465	2	333	63	1357	333	3244	87	259	0,00004	27906	5344	33250
III	13	13739	1	52	4	214	21	242	14	57	0	13805	551	14357
IV	4	7558	0	20	0	81	0	0	5	12	0	7582	98	7681
V	0	5436	0	9	0	36	0	0	2	0	0	5445	38	5483
VI	0	3983	0	5	0	18	0	0	1	0	0	3987	20	4007
TOTAL	3874	74911	36	25833	132837	105118	697177	69559	6761	18037	0,1	104655	1029489	1134144

Age class	POL01	POL02	POL03	POL04	POL05	POL06	POL07	POL08	POL09	POL10	POL11	PORTUGAL	SPAIN	SURVEYED AREA
	B	B	B	B	B	B	B	B	B	B	B	B	B	B
0	79	121	1	453	1720	1843	9025	1492	119	372	0,001	654	14570	15224
I	7	618	0,3	20	10	81	51	479	5	43	0,00001	646	668	1314
II	5	1537	0,1	16	2	66	11	128	4	9	0,000001	1558	221	1779
III	1	974	0,03	3	0,2	13	1	9	1	3	0	978	27	1006
IV	0,3	542	0,04	1	0	6	0	0	0,4	1	0	544	7	550
V	0	446	0	1	0	3	0	0	0,2	0	0	447	3	450
VI	0	353	0	0,4	0	2	0	0	0,1	0	0	354	2	356
TOTAL	93	4592	1	495	1732	2014	9088	2108	130	428	0,001	5181	15499	20679

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

Estimate/Year	**Total Population (Recruits at age 0)**					
	2012	**2014**	**2015**	**2016**	**2017**	**2018**
Biomass (t)	22119 (9182)	36571 (705)	30992 (8645)	35173 (21899)	12119 (8778)	20679 (15224)
Abundance (millions)	603 (359)	507 (26)	861 (509)	2379 (1940)	591 (483)	1134 (1036)

Table 11. *ECOCADIZ-RECLUTAS 2018-10* survey. Atlantic mackerel (*Scomber scombrus*). Estimated abundance (absolute numbers and million fish) and biomass (t) by size class (in cm). Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figure 15**.

***ECOCADIZ-RECLUTAS 2018-10*. *Scomber scombrus*. ABUNDANCE (in numbers and million fish)**											
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	***n***			**Millions**		
						PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
20	0	0	0	0	0	0	0	0	0	0	0
20,5	0	0	0	0	0	0	0	0	0	0	0
21	15995	0	1801	6887	3948	17796	10835	28631	0,02	0,01	0,03
21,5	0	0	0	0	0	0	0	0	0	0	0
22	15995	0	1801	6887	3948	17796	10835	28631	0,02	0,01	0,03
22,5	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0
23,5	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0
24,5	0	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0	0
25,5	0	0	0	0	0	0	0	0	0	0	0
26	79976	0	9003	34434	19739	88979	54173	143152	0,1	0,1	0,1
26,5	79976	0	9003	34434	19739	88979	54173	143152	0,1	0,1	0,1
27	143956	0	16206	61982	35530	160162	97512	257674	0,2	0,1	0,3
27,5	79976	0	9003	34434	19739	88979	54173	143152	0,1	0,1	0,1
28	63981	0	7202	27548	15791	71183	43339	114522	0,1	0,04	0,1
28,5	47985	0	5402	20661	11843	53387	32504	85891	0,1	0,03	0,1
29	79976	0	9003	34434	19739	88979	54173	143152	0,1	0,1	0,1
29,5	31990	264	3601	13774	7895	35855	21669	57524	0,0	0,02	0,1
30	63981	264	7202	27548	15791	71447	43339	114786	0,1	0,04	0,1
30,5	15995	660	1801	6887	3948	18456	10835	29291	0,02	0,01	0,03
31	63981	660	7202	27548	15791	71843	43339	115182	0,1	0,04	0,1
31,5	15995	660	1801	6887	3948	18456	10835	29291	0,02	0,01	0,03
32	0	2242	0	0	0	2242	0	2242	0,002	0	0,002
32,5	0	132	0	0	0	132	0	132	0,0001	0	0,0001
33	0	1055	0	0	0	1055	0	1055	0,001	0	0,001
33,5	0	528	0	0	0	528	0	528	0,001	0	0,001
34	0	132	0	0	0	132	0	132	0,0001	0	0,0001
34,5	0	132	0	0	0	132	0	132	0,0001	0	0,0001
35	0	0	0	0	0	0	0	0	0	0	0
35,5	0	132	0	0	0	132	0	132	0,0001	0	0,0001
36	0	0	0	0	0	0	0	0	0	0	0
36,5	0	0	0	0	0	0	0	0	0	0	0
37	0	0	0	0	0	0	0	0	0	0	0
37,5	0	0	0	0	0	0	0	0	0	0	0
38	0	0	0	0	0	0	0	0	0	0	0
38,5	0	0	0	0	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0	0	0	0	0
39,5	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0
TOTAL *n*	799758	6861	90031	344345	197389	896650	541734	1438384	**1**	**1**	**1**
Millions	**1**	**0,01**	**0,1**	**0,3**	**0,2**						

Table 11. *ECOCADIZ-RECLUTAS 2018-10* survey. Atlantic mackerel (*Scomber scombrus*). Cont'd.

***ECOCADIZ-RECLUTAS 2018-10 . Scomber scombrus .* BIOMASS (t)**								
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**PORTUGAL**	**SPAIN**	**TOTAL**
20	0	0	0	0	0	0	0	0
20,5	0	0	0	0	0	0	0	0
21	0,867333	0	0,098	0,373	0,214	0,965	0,588	1,553
21,5	0	0	0	0	0	0	0	0
22	1,028	0	0,116	0,443	0,254	1,144	0,696	1,840
22,5	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0
23,5	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0
24,5	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0
25,5	0	0	0	0	0	0	0	0
26	9,476	0	1,067	4,080	2,339	10,543	6,419	16,961
26,5	10,161	0	1,144	4,375	2,508	11,305	6,883	18,188
27	19,586	0	2,205	8,433	4,834	21,791	13,267	35,059
27,5	11,638	0	1,310	5,011	2,873	12,949	7,883	20,832
28	9,947	0	1,120	4,283	2,455	11,066	6,738	17,804
28,5	7,960	0	0,896	3,427	1,965	8,856	5,392	14,248
29	14,141	0	1,592	6,088	3,490	15,732	9,578	25,311
29,5	6,022	0,050	0,678	2,593	1,486	6,750	4,079	10,829
30	12,810	0,053	1,442	5,516	3,162	14,305	8,677	22,983
30,5	3,403	0,140	0,383	1,465	0,840	3,926	2,305	6,231
31	14,448	0,149	1,626	6,221	3,566	16,223	9,787	26,010
31,5	3,830	0,158	0,431	1,649	0,945	4,420	2,595	7,014
32	0	0,569	0	0	0	0,569	0	0,569
32,5	0	0,035	0	0	0	0,035	0	0,035
33	0	0,300	0	0	0	0,300	0	0,300
33,5	0	0,159	0	0	0	0,159	0	0,159
34	0	0,042	0	0	0	0,042	0	0,042
34,5	0	0,044	0	0	0	0,044	0	0,044
35	0	0	0	0	0	0	0	0
35,5	0	0,049	0	0	0	0,049	0	0,049
36	0	0	0	0	0	0	0	0
36,5	0	0	0	0	0	0	0	0
37	0	0	0	0	0	0	0	0
37,5	0	0	0	0	0	0	0	0
38	0	0	0	0	0	0	0	0
38,5	0	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0	0
39,5	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0
TOTAL	**125,318**	**1,748**	**14,107**	**53,957**	**30,930**	**141,173**	**84,887**	**226,060**

Table 12. *ECOCADIZ-RECLUTAS 2018-10* survey. Chub mackerel (*Scomber colias*). Estimated abundance (absolute numbers and million fish) and biomass (t) by size class (in cm). Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figure 18**.

ECOCADIZ-RECLUTAS 2018-10 . Scomber colias . ABUNDANCE (in numbers and million fish)											
Size class	POL01	POL02	POL03	POL04	POL05	*n*			Millions		
						PORTUGAL	SPAIN	TOTAL	PORTUGAL	SPAIN	TOTAL
14	0	0	0	0	0	0	0	0	0	0	0
14,5	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0
15,5	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	2346	23296	2346	23296	25642	0,00	0,02	0,03
16,5	0	381971	546	4692	46592	387209	46592	433801	0,4	0,05	0,4
17	0	879541	1257	19918	197768	900716	197768	1098484	1	0,2	1,1
17,5	0	3389687	4843	72924	724071	3467454	724071	4191525	3	1	4
18	0	6147747	8784	153073	1519889	6309604	1519889	7829493	6	2	8
18,5	0	8052937	11506	295738	2936431	8360181	2936431	11296612	8	3	11
19	0	9029951	12902	459013	4557610	9501866	4557610	14059476	10	5	14
19,5	0	6467372	9241	464361	4610715	6940974	4610715	11551689	7	5	12
20	0	5434663	7765	411315	4084010	5853743	4084010	9937753	6	4	10
20,5	110804	3909694	5586	352946	3504455	4379030	3504455	7883485	4	4	8
21	55402	2291182	3274	289276	2872270	2639134	2872270	5511404	3	3	6
21,5	221609	4123463	5892	289698	2876455	4640662	2876455	7517117	5	3	8
22	147739	2890991	4131	283108	2811021	3325969	2811021	6136990	3	3	6
22,5	55402	2674537	3821	235934	2342626	2969694	2342626	5312320	3	2	5
23	313945	2740111	3915	229139	2275152	3287110	2275152	5562262	3	2	6
23,5	221609	1676094	2395	133839	1328905	2033937	1328905	3362842	2	1	3
24	147739	1129753	1614	125066	1241800	1404172	1241800	2645972	1	1	3
24,5	92337	658218	940	41277	409845	792772	409845	1202617	1	0	1
25	92337	356564	509	68946	684577	518356	684577	1202933	1	1	1
25,5	36935	174924	250	18099	179711	230208	179711	409919	0,2	0,2	0,4
26	55402	0	0	19968	198262	75370	198262	273632	0,1	0,2	0,3
26,5	0	0	0	4580	45472	4580	45472	50052	0,00	0,05	0,1
27	0	49470	71	13582	134854	63123	134854	197977	0,1	0,1	0,2
27,5	36935	0	0	12109	120233	49044	120233	169277	0,05	0,1	0,2
28	36935	0	0	12109	120233	49044	120233	169277	0,05	0,1	0,2
28,5	0	49470	71	18626	184938	68167	184938	253105	0,1	0,2	0,3
29	0	0	0	339	3368	339	3368	3707	0,0003	0,003	0,004
29,5	0	0	0	2994	29729	2994	29729	32723	0,003	0,03	0,03
30	0	0	0	57	561	57	561	618	0,0001	0,001	0,001
30,5	0	0	0	170	1684	170	1684	1854	0,0002	0,002	0,002
31	0	0	0	113	1123	113	1123	1236	0,0001	0,001	0,001
31,5	0	0	0	113	1123	113	1123	1236	0,0001	0,001	0,001
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
33	0	0	0	0	0	0	0	0	0	0	0
33,5	0	0	0	0	0	0	0	0	0	0	0
34	0	0	0	0	0	0	0	0	0	0	0
TOTAL *n*	1625130	62508340	89313	4035468	40068779	68258251	40068779	108327030	68	40	108
Millions	2	63	0,1	4	40						

Table 12. *ECOCADIZ-RECLUTAS 2018-10* survey. Chub mackerel (*Scomber colias*). Cont'd.

ECOCADIZ-RECLUTAS 2018-10 . Scomber colias . BIOMASS (t)								
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**PORTUGAL**	**SPAIN**	**TOTAL**
14	0	0	0	0	0	0	0	0
14,5	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0
15,5	0	0	0	0	0	0	0	0
16	0	0	0	0,062	0,613	0,062	0,613	0,675
16,5	0	11,200	0,016	0,138	1,366	11,354	1,366	12,720
17	0	28,631	0,041	0,648	6,438	29,320	6,438	35,758
17,5	0	122,133	0,174	2,628	26,089	124,935	26,089	151,024
18	0	244,489	0,349	6,088	60,444	250,926	60,444	311,370
18,5	0	352,539	0,504	12,947	128,550	365,990	128,55	494,540
19	0	434,061	0,62	22,064	219,080	456,745	219,080	675,825
19,5	0	340,537	0,487	24,451	242,775	365,475	242,775	608,250
20	0	312,745	0,447	23,670	235,02	336,862	235,020	571,882
20,5	6,954	245,358	0,351	22,150	219,927	274,813	219,927	494,740
21	3,784	156,481	0,224	19,757	196,168	180,246	196,168	376,414
21,5	16,439	305,882	0,437	21,490	213,378	344,248	213,378	557,626
22	11,881	232,495	0,332	22,768	226,063	267,476	226,063	493,539
22,5	4,822	232,760	0,333	20,533	203,875	258,448	203,875	462,323
23	29,516	257,619	0,368	21,543	213,904	309,046	213,904	522,95
23,5	22,471	169,958	0,243	13,571	134,753	206,243	134,753	340,996
24	16,132	123,361	0,176	13,656	135,596	153,325	135,596	288,921
24,5	10,841	77,279	0,110	4,846	48,118	93,076	48,118	141,194
25	11,639	44,946	0,064	8,691	86,293	65,340	86,293	151,633
25,5	4,992	23,641	0,034	2,446	24,288	31,113	24,288	55,401
26	8,017	0	0	2,890	28,690	10,907	28,690	39,597
26,5	0	0	0	0,709	7,036	0,709	7,036	7,745
27	0	8,176	0,012	2,245	22,287	10,433	22,287	32,720
27,5	6,512	0	0	2,135	21,197	8,647	21,197	29,844
28	6,938	0	0	2,275	22,585	9,213	22,585	31,798
28,5	0	9,891	0,014	3,724	36,975	13,629	36,975	50,604
29	0	0	0	0,072	0,716	0,072	0,716	0,788
29,5	0	0	0	0,676	6,712	0,676	6,712	7,388
30	0	0	0	0,014	0,134	0,014	0,134	0,148
30,5	0	0	0	0,043	0,428	0,043	0,428	0,471
31	0	0	0	0,030	0,302	0,030	0,302	0,332
31,5	0	0	0	0,032	0,319	0,032	0,319	0,351
32	0	0	0	0	0	0	0	0
32,5	0	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0	0
33,5	0	0	0	0	0	0	0	0
34	0	0	0	0	0	0	0	0
TOTAL	**160,938**	**3734,182**	**5,336**	**278,992**	**2770,119**	**4179,448**	**2770,119**	**6949,567**

Table 13. *ECOCADIZ-RECLUTAS 2018-10* 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 **Figure 21**.

ECOCADIZ-RECLUTAS 2018-10 . Trachurus trachurus . ABUNDANCE (in numbers and million fish)																
Size class	POL01	POL02	POL03	POL04	POL05	POL06	POL07	POL08	POL09	POL10	POL11	*n*			Millions	
												PORTUGAL	SPAIN	TOTAL	PORTUGAL	SPAIN	TOTAL
10	0	0	0	0	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		0	0	0
11	0	0	0	0	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	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	4714	0	5878	7402	0	8252	0	0	0	10592	15654	26246	0,01	0,02	0,03
13,5	0	0	32201	0	40148	22207	0	24755	0	0	0	72349	46962	119311	0,1	0,0	0,1
14	0	0	4714	0	5878	37012	0	41258	0	0	0	10592	78270	88862	0,01	0,1	0,1
14,5	0	0	40535	0	50538	74025	0	82516	0	0	0	91073	156541	247614	0,1	0,2	0,2
15	0	0	52217	0	65103	96232	0	107271	0	0	0	117320	203503	320823	0,1	0,2	0,3
15,5	0	0	26960	0	33613	37012	0	41258	0	0	0	60573	78270	138843	0,1	0,1	0,1
16	0	0	29716	0	37050	7402	0	8252	0	0	0	66766	15654	82420	0,1	0,02	0,1
16,5	0	0	44155	0	55051	29610	0	33007	0	0	0	99206	62617	161823	0,1	0,1	0,2
17	0	0	36388	0	45368	0	0	0	0	0	0	81756	0	81756	0,1	0	0,1
17,5	0	0	18058	0	22515	0	0	0	0	0	0	40573	0	40573	0,04	0	0,04
18	0	0	39441	0	49174	0	0	0	0	0	0	88615	0	88615	0,1	0	0,1
18,5	0	0	51730	0	64496	0	0	0	0	0	0	116226	0	116226	0,1	0	0,1
19	0	0	68926	0	85935	0	0	0	0	0	0	154861	0	154861	0,2	0	0,2
19,5	0	0	60528	0	75464	0	0	0	0	0	0	135992	0	135992	0,1	0	0,1
20	0	0	122361	0	152557	0	0	0	0	0	0	274918	0	274918	0,3	0	0,3
20,5	0	0	127519	0	158988	0	0	0	0	0	0	286507	0	286507	0,3	0	0,3
21	18915	21	262402	0	327156	7402	0	8252	0	0	0	608494	15654	624148	1	0,02	1
21,5	44135	49	290480	7193	362163	0	0	0	0	0	0	704020	0	704020	1	0	1
22	56745	63	334467	15185	417005	0	0	0	0	0	0	823465	0	823465	1	0	1
22,5	147116	163	190592	0	237626	7402	0	8252	0	0	0	575497	15654	591151	1	0,02	1
23	166031	184	201747	7193	251533	0	0	0	0	0	0	626688	0	626688	1	0	1
23,5	210165	233	53121	44757	66229	0	0	0	0	0	0	374505	0	374505	0,4	0	0,4
24	191250	212	98327	142262	122591	0	493	0	1	2	0	554642	496	555138	1	0,0005	1
24,5	172336	191	62170	119883	77512	0	0	0	0	0	0	432092	0	432092	0,4	0	0,4
25	25220	28	22813	202204	28443	0	0	0	0	0	0	278708	0	278708	0,3	0	0,3
25,5	37830	42	48866	179825	60925	0	493	0	1	2	0	327488	496	327984	0,3	0,0005	0,3
26	12610	14	29485	262145	36761	0	0	0	0	0	0	341015	0	341015	0,3	0	0,3
26,5	0	0	3620	135069	4513	0	493	0	1	2	0	143202	496	143698	0,1	0,0005	0,1
27	0	0	0	157447	0	0	493	0	1	2	0	157447	496	157943	0,2	0,0005	0,2
27,5	0	0	3620	52749	4513	0	1972	0	5	10	0	60882	1987	62869	0,1	0,002	0,1
28	0	0	0	7193	0	0	1479	0	4	7	0	7193	1490	8683	0,01	0,001	0,01
28,5	0	0	0	15185	0	0	1479	0	4	7	0	15185	1490	16675	0,02	0,001	0,02
29	0	0	0	0	0	0	2465	0	6	12	0	0	2483	2483	0	0,002	0,002
29,5	0	0	0	0	0	0	2465	0	6	12	0	0	2483	2483	0	0,002	0,002
30	0	0	0	0	0	0	3943	0	10	20	0	0	3973	3973	0	0,004	0,004
30,5	0	0	0	0	0	0	2958	0	7	15	0	0	2980	2980	0	0,003	0,003
31	0	0	0	0	0	0	5915	0	14	30	0	0	5959	5959	0	0,01	0,01
31,5	6305	7	0	0	0	0	3943	0	10	20	0	6312	3973	10285	0,01	0,004	0,01
32	0	0	0	0	0	0	1972	0	5	10	0	0	1987	1987	0	0,002	0,002
32,5	0	0	0	0	0	0	986	0	2	5	0	0	993	993	0	0,001	0,001
33	0	0	0	0	0	0	493	0	1	2	0	0	496	496	0	0,0005	0,0005
33,5	0	0	0	0	0	0	1972	0	5	10	0	0	1987	1987	0	0,002	0,002
34	0	0	0	0	0	0	1972	0	5	10	0	0	1987	1987	0	0,002	0,002
34,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL *n*	1088658	1207	2361873	1348290	2944726	325706	35986	363073	88	178	0	7744754	725031	8469785	**8**	**1**	**8**
Millions	**1**	**0,001**	**2**	**1**	**3**	**0,3**	**0,04**	**0,4**	**0,0001**	**0,0002**	**0,0000**						

Table 13. *ECOCADIZ-RECLUTAS 2018-10* survey. Horse mackerel (*Trachurus trachurus*). Cont'd.

ECOCADIZ-RECLUTAS 2018-10 . Trachurus trachurus. BIOMASS (t)														
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	**POL09**	**POL10**	**POL11**	**PORTUGAL**	**SPAIN**	**TOTAL**
10	0	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	0
11	0	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	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0,118	0	0,148	0,186	0	0,207	0	0	0	0,266	0,393	0,659
13,5	0	0	0,884	0	1,102	0,609	0	0,679	0	0	0	1,985	1,289	3,274
14	0	0	0,141	0	0,176	1,107	0	1,234	0	0	0	0,317	2,341	2,657
14,5	0	0	1,317	0	1,642	2,405	0	2,681	0	0	0	2,959	5,087	8,046
15	0	0	1,838	0	2,292	3,388	0	3,777	0	0	0	4,131	7,165	11,296
15,5	0	0	1,026	0	1,279	1,408	0	1,570	0	0	0	2,305	2,978	5,283
16	0	0	1,219	0	1,520	0,304	0	0,339	0	0	0	2,739	0,642	3,381
16,5	0	0	1,949	0	2,429	1,307	0	1,457	0	0	0	4,378	2,763	7,141
17	0	0	1,724	0	2,149	0	0	0	0	0	0	3,872	0	3,872
17,5	0	0	0,916	0	1,142	0	0	0	0	0	0	2,059	0	2,059
18	0	0	2,140	0	2,668	0	0	0	0	0	0	4,807	0	4,807
18,5	0	0	2,995	0	3,734	0	0	0	0	0	0	6,729	0	6,729
19	0	0	4,251	0	5,300	0	0	0	0	0	0	9,552	0	9,552
19,5	0	0	3,971	0	4,951	0	0	0	0	0	0	8,922	0	8,922
20	0	0	8,526	0	10,630	0	0	0	0	0	0	19,155	0	19,155
20,5	0	0	9,422	0	11,748	0	0	0	0	0	0	21,170	0	21,170
21	1,480	0,002	20,533	0	25,600	0,579	0	0,646	0	0	0	47,614	1,225	48,839
21,5	3,652	0,004	24,038	0,595	29,970	0	0	0	0	0	0	58,260	0	58,260
22	4,960	0,006	29,235	1,327	36,449	0	0	0	0	0	0	71,977	0	71,977
22,5	13,566	0,015	17,575	0	21,912	0,683	0	0,761	0	0	0	53,067	1,443	54,510
23	16,132	0,018	19,603	0,699	24,440	0	0	0	0	0	0	60,892	0	60,892
23,5	21,494	0,024	5,433	4,577	6,773	0	0	0	0	0	0	38,301	0	38,301
24	20,565	0,023	10,573	15,297	13,182	0	0,053	0	0,0001	0,000215	0	59,640	0,053	59,694
24,5	19,464	0,022	7,022	13,540	8,755	0	0	0	0	0	0	48,802	0	48,802
25	2,989	0,003	2,704	23,964	3,371	0	0	0	0	0	0	33,031	0	33,031
25,5	4,700	0,005	6,071	22,342	7,569	0	0,061	0	0,0001	0,000248	0	40,688	0,062	40,749
26	1,641	0,002	3,837	34,113	4,784	0	0	0	0	0	0	44,376	0	44,376
26,5	0	0	0,493	18,393	0,615	0	0,067	0	0,0001	0,0003	0	19,501	0,068	19,568
27	0	0	0	22,418	0	0	0,070	0	0,0001	0,0003	0	22,418	0,071	22,488
27,5	0	0	0,538	7,847	0,671	0	0,293	0	0,001	0,001	0	9,056	0,296	9,352
28	0	0	0	1,117	0	0	0,230	0	0,001	0,001	0	1,117	0,231	1,348
28,5	0	0	0	2,460	0	0	0,240	0	0,001	0,001	0	2,460	0,241	2,701
29	0	0	0	0	0	0	0,416	0	0,001	0,002	0	0	0,419	0,419
29,5	0	0	0	0	0	0	0,434	0	0,001	0,002	0	0	0,437	0,437
30	0	0	0	0	0	0	0,722	0	0,002	0,004	0	0	0,727	0,727
30,5	0	0	0	0	0	0	0,563	0	0,001	0,003	0	0	0,568	0,568
31	0	0	0	0	0	0	1,171	0	0,003	0,006	0	0	1,180	1,180
31,5	1,297	0,001	0	0	0	0	0,811	0	0,002	0,004	0	1,298	0,817	2,116
32	0	0	0	0	0	0	0,421	0	0,001	0,002	0	0	0,424	0,424
32,5	0	0	0	0	0	0	0,219	0	0,000	0,001	0	0	0,220	0,220
33	0	0	0	0	0	0	0,113	0	0,000	0,000	0	0	0,114	0,114
33,5	0	0	0	0	0	0	0,470	0	0,001	0,002	0	0	0,473	0,473
34	0	0	0	0	0	0	0,487	0	0,001	0,002	0	0	0,491	0,491
34,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	**111,940**	**0,124**	**190,090**	**168,688**	**237,000**	**11,976**	**6,841**	**13,350**	**0,017**	**0,034**	**0,000**	**707,843**	**32,218**	**740,061**

Table 14. *ECOCADIZ-RECLUTAS 2018-10* survey. Mediterranean horse mackerel (*Trachurus mediterraneus*). Estimated abundance (absolute numbers and million fish) and biomass (t) by size class (in cm). Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figure 24**.

***ECOCADIZ-RECLUTAS 2018-10 . Trachurus mediterraneus.* ABUNDANCE (in numbers and million fish)**										
Size class	**POL01**	**POL02**	**POL03**	**POL04**	***n***			**Millions**		
					PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
16	0	0	0	0	0	0	0	0	0	0
16,5	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	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	144	13	32012	33	157	32045	32202	0,0002	0,03	0,03
19	0	0	0	0	0	0	0	0	0	0
19,5	144	13	32012	33	157	32045	32202	0,0002	0,03	0,03
20	144	13	32012	33	157	32045	32202	0,0002	0,03	0,03
20,5	0	0	0	0	0	0	0	0	0	0
21	110	10	24485	25	120	24510	24630	0,0001	0,02	0,02
21,5	254	23	56497	58	277	56555	56832	0,0003	0,1	0,1
22	490	45	109140	112	535	109252	109787	0,001	0,11	0,11
22,5	165	15	36727	38	180	36765	36945	0,0002	0,04	0,04
23	440	40	97939	100	480	98039	98519	0,0005	0,1	0,1
23,5	1278	117	284388	291	1395	284679	286074	0,001	0,3	0,3
24	1468	134	326740	335	1602	327075	328677	0,002	0,3	0,3
24,5	2779	254	618292	633	3033	618925	621958	0,003	1	1
25	6078	555	1352440	1385	6633	1353825	1360458	0,01	1	1
25,5	5896	538	1311990	1344	6434	1313334	1319768	0,01	1	1
26	11238	1025	2500514	2561	12263	2503075	2515338	0,01	3	3
26,5	7951	726	1769178	1812	8677	1770990	1779667	0,01	2	2
27	3907	357	869443	890	4264	870333	874597	0,004	1	1
27,5	1967	180	437782	448	2147	438230	440377	0,002	0,4	0,4
28	3282	299	730194	748	3581	730942	734523	0,004	1	1
28,5	1695	155	377248	386	1850	377634	379484	0,002	0,4	0,4
29	2533	231	563697	577	2764	564274	567038	0,003	1	1
29,5	2625	240	584145	598	2865	584743	587608	0,003	1	1
30	3120	285	694327	711	3405	695038	698443	0,003	1	1
30,5	1802	164	400873	411	1966	401284	403250	0,002	0,4	0,4
31	1442	132	320933	329	1574	321262	322836	0,002	0,3	0,3
31,5	964	88	214606	220	1052	214826	215878	0,001	0,2	0,2
32	660	60	146909	150	720	147059	147779	0,001	0,1	0,1
32,5	512	47	113854	117	559	113971	114530	0,001	0,1	0,1
33	165	15	36727	38	180	36765	36945	0,0002	0,04	0,04
33,5	237	22	52642	54	259	52696	52955	0,0003	0,1	0,05
34	165	15	36727	38	180	36765	36945	0,0002	0,04	0,04
34,5	0	0	0	0	0	0	0	0	0	0
35	110	10	24485	25	120	24510	24630	0,0001	0,02	0,02
35,5	0	0	0	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0	0	0	0
36,5	0	0	0	0	0	0	0	0	0	0
37	0	0	0	0	0	0	0	0	0	0
37,5	0	0	0	0	0	0	0	0	0	0
38	110	10	24485	25	120	24510	24630	0,0001	0,02	0,02
38,5	0	0	0	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0	0	0	0
39,5	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0
TOTAL *n*	63875	5831	14213443	14558	69706	14228001	14297707	**0,1**	**14**	**14**
Millions	**0,1**	**0,01**	**14**	**0,01**						

Table 14. *ECOCADIZ-RECLUTAS 2018-10* survey. Mediterranean horse mackerel (*Trachurus mediterraneus*). Cont'd.

ECOCADIZ-RECLUTAS 2018-10 .Trachurus mediterraneus . BIOMASS (t)							
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**PORTUGAL**	**SPAIN**	**TOTAL**
16	0	0	0	0	0	0	0
16,5	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0
17,5	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0
18,5	0,008	0,001	1,732	0,002	0,008	1,734	1,742
19	0	0	0	0	0	0	0
19,5	0,009	0,001	1,995	0,002	0,010	1,997	2,007
20	0,010	0,001	2,135	0,002	0,010	2,137	2,148
20,5	0	0	0	0	0	0	0
21	0,008	0,001	1,862	0,002	0,009	1,864	1,873
21,5	0,021	0,002	4,577	0,005	0,022	4,582	4,604
22	0,042	0,004	9,405	0,010	0,046	9,415	9,461
22,5	0,015	0,001	3,362	0,003	0,016	3,366	3,382
23	0,043	0,004	9,512	0,010	0,047	9,522	9,569
23,5	0,132	0,012	29,268	0,030	0,144	29,298	29,441
24	0,160	0,015	35,587	0,036	0,174	35,624	35,798
24,5	0,320	0,029	71,187	0,073	0,349	71,260	71,609
25	0,739	0,067	164,420	0,168	0,806	164,588	165,395
25,5	0,756	0,069	168,242	0,172	0,825	168,414	169,239
26	1,518	0,139	337,874	0,346	1,657	338,220	339,877
26,5	1,131	0,103	251,646	0,258	1,234	251,903	253,138
27	0,584	0,053	130,059	0,133	0,638	130,192	130,830
27,5	0,309	0,028	68,808	0,070	0,337	68,878	69,216
28	0,542	0,049	120,481	0,123	0,591	120,604	121,195
28,5	0,293	0,027	65,288	0,067	0,320	65,355	65,675
29	0,459	0,042	102,241	0,105	0,501	102,345	102,847
29,5	0,499	0,046	110,949	0,114	0,544	111,063	111,607
30	0,620	0,057	137,994	0,141	0,677	138,135	138,812
30,5	0,374	0,034	83,305	0,085	0,409	83,390	83,799
31	0,313	0,029	69,684	0,071	0,342	69,756	70,098
31,5	0,219	0,020	48,654	0,050	0,239	48,704	48,942
32	0,156	0,014	34,752	0,035	0,170	34,788	34,958
32,5	0,126	0,012	28,084	0,029	0,138	28,113	28,251
33	0,042	0,004	9,441	0,010	0,046	9,450	9,497
33,5	0,063	0,006	14,092	0,014	0,069	14,107	14,176
34	0,046	0,004	10,233	0,011	0,050	10,244	10,294
34,5	0	0	0	0	0	0	0
35	0,033	0,003	7,378	0,008	0,036	7,385	7,421
35,5	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0
36,5	0	0	0	0	0	0	0
37	0	0	0	0	0	0	0
37,5	0	0	0	0	0	0	0
38	0,041	0,004	9,214	0,009	0,045	9,223	9,268
38,5	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0
39,5	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0
TOTAL	**9,633**	**0,879**	**2143,459**	**2,195**	**10,512**	**2145,655**	**2156,167**

Table 15. *ECOCADIZ-RECLUTAS 2018-10* 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 **Figure 27**.

ECOCADIZ-RECLUTAS 2018-10 . Boops boops . ABUNDANCE (in numbers and million fish)												
Size class	POL01	POL02	POL03	POL04	POL05	POL06	*n*			Millions		
							PORTUGAL	SPAIN	TOTAL	PORTUGAL	SPAIN	TOTAL
14	0	0	0	0	0	0	0	0	0	0	0	0
14,5	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0
15,5	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0
16,5	0	0	0	0	0	0	0	0	0	0	0	0
17	11420	688	0	0	0	0	12108	0	12108	0,01	0	0,01
17,5	0	0	0	0	0	0	0	0	0	0	0	0
18	22840	1377	0	0	0	0	24217	0	24217	0,02	0	0,02
18,5	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0
19,5	34260	2065	0	0	0	0	36325	0	36325	0,04	0	0,04
20	54561	3289	20014	0	0	0	77864	0	77864	0,1	0	0,1
20,5	49486	2983	20014	0	0	0	72483	0	72483	0,1	0	0,1
21	93896	5660	60043	0	0	0	159599	0	159599	0,2	0	0,2
21,5	78670	4742	140100	0	0	0	223512	0	223512	0,2	0	0,2
22	143382	8643	360258	0	0	0	512283	0	512283	1	0	1
22,5	87552	5277	360258	0	0	0	453087	0	453087	0,5	0	0,5
23	62175	3748	460329	17947	16660	10	526252	34617	560869	1	0,03	1
23,5	52024	3136	580415	0	0	0	635575	0	635575	1	0	1
24	52024	3136	620444	0	0	0	675604	0	675604	1	0	1
24,5	22840	1377	580415	0	0	0	604632	0	604632	1	0	1
25	11420	688	360258	53842	49981	29	372366	103852	476218	0,4	0,1	0,5
25,5	11420	688	180129	0	0	0	192237	0	192237	0,2	0	0,2
26	11420	688	100072	89736	83301	49	112180	173086	285266	0,1	0,2	0,3
26,5	0	0	20014	143578	133281	78	20014	276937	296951	0,02	0,3	0,3
27	0	0	20014	143578	133281	78	20014	276937	296951	0,02	0,3	0,3
27,5	0	0	0	17947	16660	10	0	34617	34617	0	0,03	0,03
28	0	0	0	89736	83301	49	0	173086	173086	0	0,2	0,2
28,5	0	0	0	35894	33320	19	0	69233	69233	0	0,1	0,1
29	0	0	0	35894	33320	19	0	69233	69233	0	0,1	0,1
29,5	0	0	20014	35894	33320	19	20014	69233	89247	0,02	0,1	0,1
30	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
31	0	0	0	0	0	0	0	0	0	0	0	0
31,5	0	0	0	0	0	0	0	0	0	0	0	0
32	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
33	0	0	0	0	0	0	0	0	0	0	0	0
33,5	0	0	0	0	0	0	0	0	0	0	0	0
34	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL *n*	799390	48185	3902791	664046	616425	360	4750366	1280831	6031197	5	1	6
Millions	1	0,05	4	1	1							

Table 15. *ECOCADIZ-RECLUTAS 2018-10* survey. Bogue (*Boops boops*). Cont'd.

***ECOCADIZ-RECLUTAS 2018-10 . Boops boops* . BIOMASS (t)**									
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**PORTUGAL**	**SPAIN**	**TOTAL**
14	0	0	0	0	0	0	0	0	0
14,5	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0
15,5	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0
16,5	0	0	0	0	0	0	0	0	0
17	0,535	0,032	0	0	0	0	0,567	0	0,567
17,5	0	0	0	0	0	0	0	0	0
18	1,265	0,076	0	0	0	0	1,341	0	1,341
18,5	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0
19,5	2,400	0,145	0	0	0	0	2,545	0	2,545
20	4,118	0,248	1,510	0	0	0	5,877	0	5,877
20,5	4,016	0,242	1,624	0	0	0	5,882	0	5,882
21	8,180	0,493	5,230	0	0	0	13,903	0	13,903
21,5	7,344	0,443	13,079	0	0	0	20,866	0	20,866
22	14,322	0,863	35,985	0	0	0	51,171	0	51,171
22,5	9,343	0,563	38,445	0	0	0	48,352	0	48,352
23	7,079	0,427	52,408	2,043	1,897	0,001	59,913	3,941	63,854
23,5	6,310	0,380	70,399	0	0	0	77,089	0	77,089
24	6,714	0,405	80,067	0	0	0	87,185	0	87,185
24,5	3,132	0,189	79,591	0	0	0	82,912	0	82,912
25	1,662	0,100	52,431	7,836	7,274	0,004	54,193	15,114	69,308
25,5	1,762	0,106	27,791	0	0	0	29,659	0	29,659
26	1,866	0,112	16,349	14,660	13,609	0,008	18,327	28,277	46,604
26,5	0	0	3,459	24,811	23,032	0,013	3,459	47,856	51,315
27	0	0	3,654	26,217	24,337	0,014	3,654	50,567	54,222
27,5	0	0	0	3,459	3,211	0,002	0	6,672	6,672
28	0	0	0	18,240	16,932	0,010	0	35,183	35,183
28,5	0	0	0	7,687	7,136	0,004	0	14,827	14,827
29	0	0	0	8,092	7,512	0,004	0	15,608	15,608
29,5	0	0	4,745	8,510	7,900	0,005	4,745	16,415	21,160
30	0	0	0	0	0	0	0	0	0
30,5	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0
31,5	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0
32,5	0	0	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0	0	0
33,5	0	0	0	0	0	0	0	0	0
34	0	0	0	0	0	0	0	0	0
TOTAL	**80,047**	**4,825**	**486,769**	**121,556**	**112,839**	**0,066**	**571,640**	**234,461**	**806,101**

Table 16. *ECOCADIZ-RECLUTAS 2018-10* survey. Pearlside (*Maurolicus muelleri*). 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-RECLUTAS 2018-10 . Maurolicus muelleri . ABUNDANCE (in numbers and million fish)									
Size class	POL01	POL02	POL03	*n*			Millions		
				PORTUGAL	SPAIN	TOTAL	PORTUGAL	SPAIN	TOTAL
0	0	0	0	0	0	0	0	0	0
0,5	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0
1,5	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
2,5	0	0	0	0	0	0	0	0	0
3	1160953	571730	11911250	1732683	11911250	13643933	2	12	14
3,5	23746756	11694484	243639207	35441240	243639207	279080447	35	244	279
4	62902519	30977389	645373188	93879908	645373188	739253096	94	645	739
4,5	37942039	18685187	389281310	56627226	389281310	445908536	57	389	446
5	8284979	4080076	85003012	12365055	85003012	97368067	12	85	97
5,5	13034331	6418972	133730853	19453303	133730853	153184156	19	134	153
6	4749351	2338897	48727841	7088248	48727841	55816089	7	49	56
6,5	1160953	571730	11911250	1732683	11911250	13643933	2	12	14
7	0	0	0	0	0	0	0	0	0
7,5	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0
8,5	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0
9,5	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0
TOTAL *n*	152981881	75338465	1569577911	228320346	1569577911	1797898257	**228**	**1570**	**1798**
Millions	**153**	**75**	**1570**						

ECOCADIZ-RECLUTAS 2018-10 . Maurolicus muelleri . BIOMASS (t)						
Size class	POL01	POL02	POL03	PORTUGAL	SPAIN	TOTAL
0	0	0	0	0	0	0
0,5	0	0	0	0	0	0
1	0	0	0	0	0	0
1,5	0	0	0	0	0	0
2	0	0	0	0	0	0
2,5	0	0	0	0	0	0
3	0,253	0,125	2,597	0,378	2,597	2,974
3,5	7,984	3,932	81,919	11,916	81,919	93,835
4	30,896	15,215	316,991	46,112	316,991	363,103
4,5	26,099	12,853	267,776	38,952	267,776	306,729
5	7,716	3,800	79,170	11,517	79,170	90,687
5,5	15,990	7,875	164,057	23,865	164,057	187,922
6	7,500	3,693	76,948	11,193	76,948	88,141
6,5	2,314	1,140	23,746	3,454	23,746	27,200
7	0	0	0	0	0	0
7,5	0	0	0	0	0	0
8	0	0	0	0	0	0
8,5	0	0	0	0	0	0
9	0	0	0	0	0	0
9,5	0	0	0	0	0	0
10	0	0	0	0	0	0
TOTAL	**98,754**	**48,633**	**1013,204**	**147,387**	**1013,204**	**1160,591**

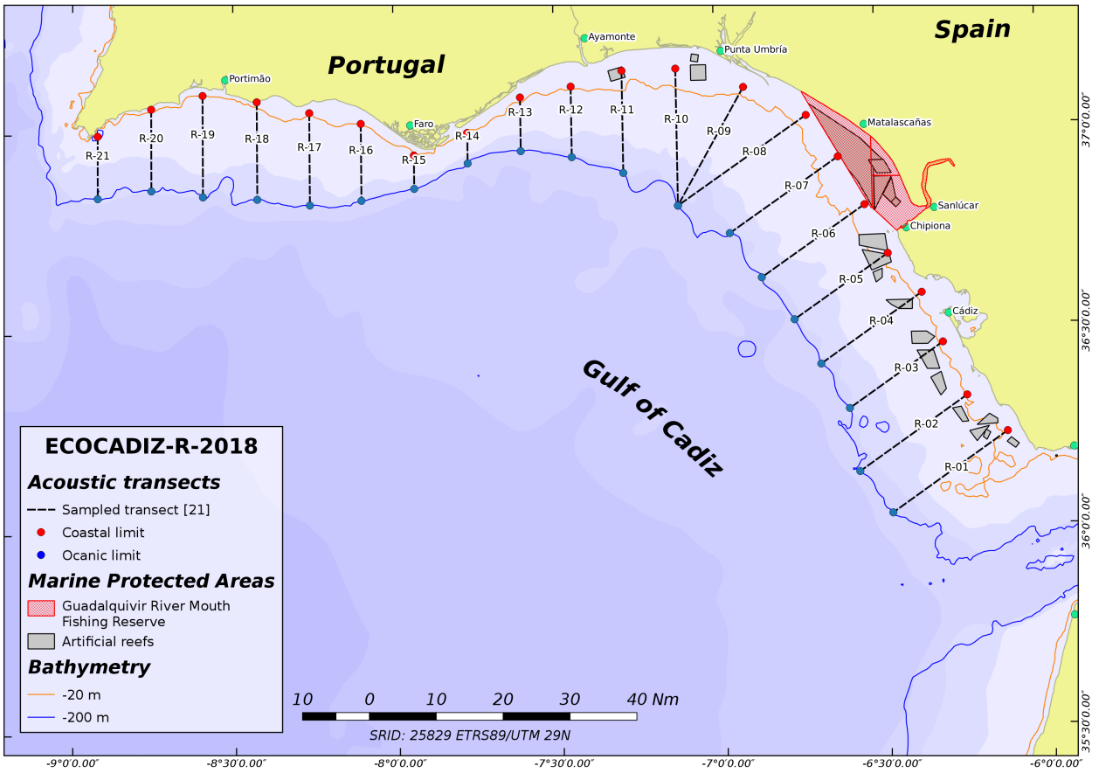


Figure 1. *ECOCADIZ-RECLUTAS 2018-10* survey. Location of the acoustic transects sampled during the survey. The different protected areas inside the Guadalquivir river mouth Fishing Reserve and artificial reef polygons are also shown.

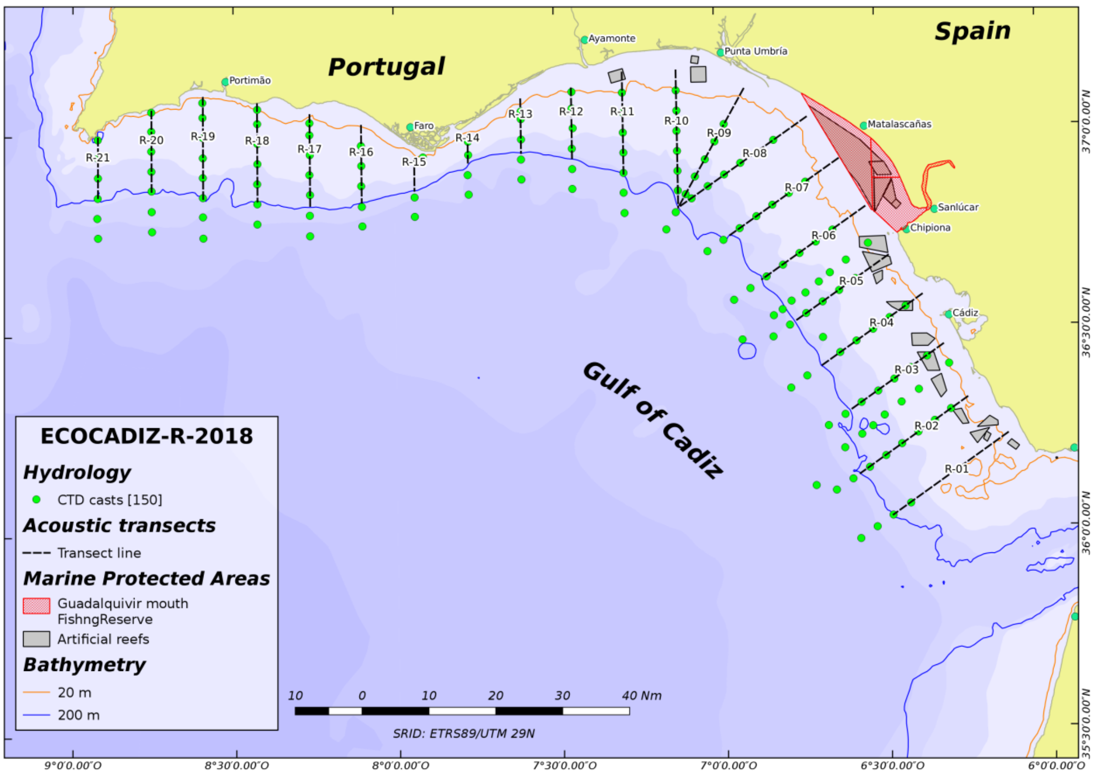


Figure 2. *ECOCADIZ-RECLUTAS 2018-10* survey. Location of CTD stations.

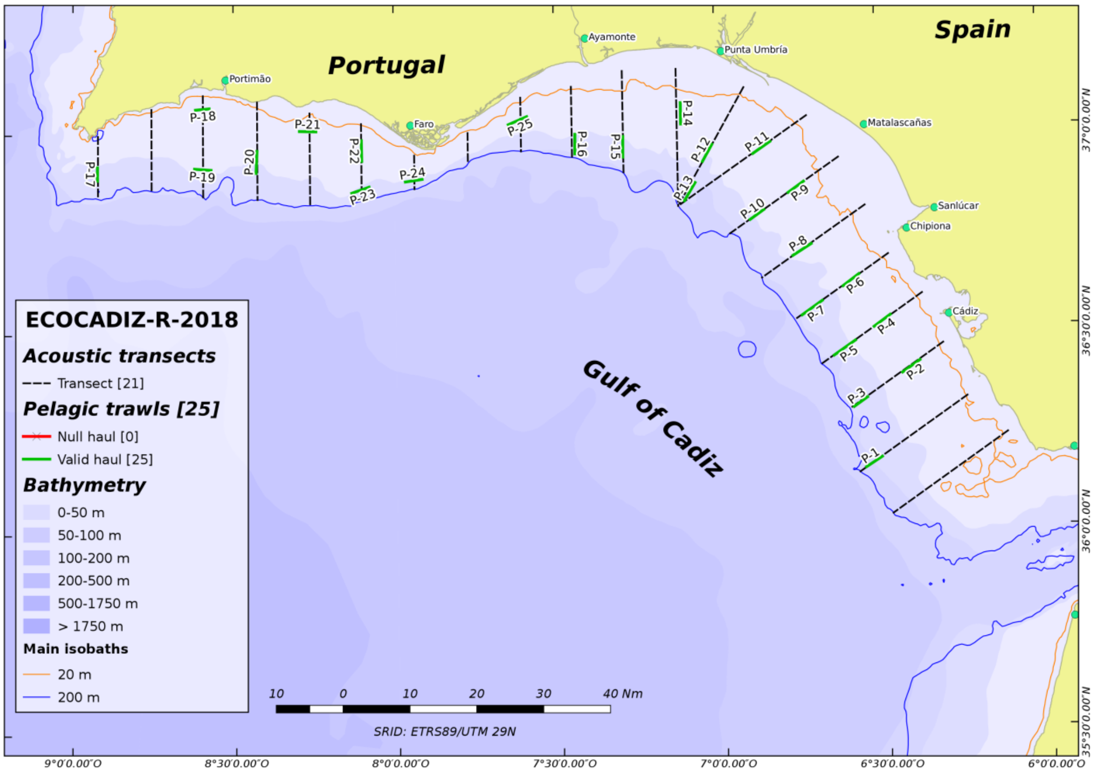


Figure 3. *ECOCADIZ-RECLUTAS 2018-10* survey. Location of ground-truthing fishing hauls.

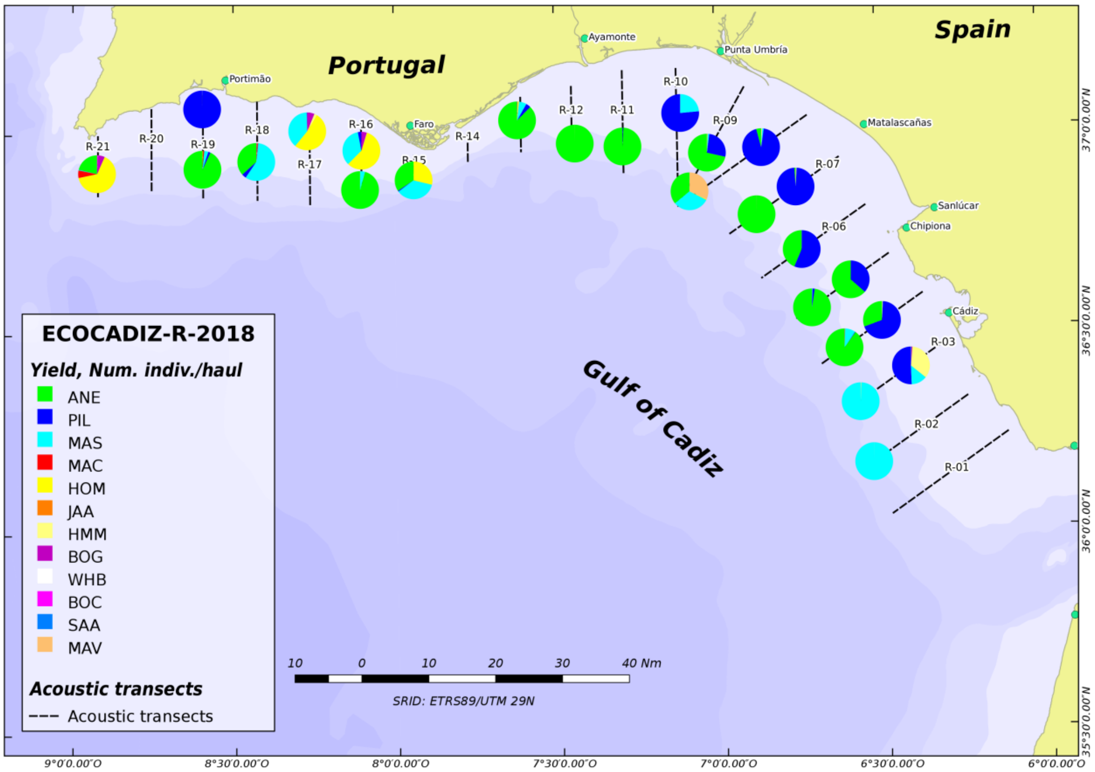


Figure 4. *ECOCADIZ-RECLUTAS 2018-10* survey. Species composition (percentages in number) in valid fishing hauls.

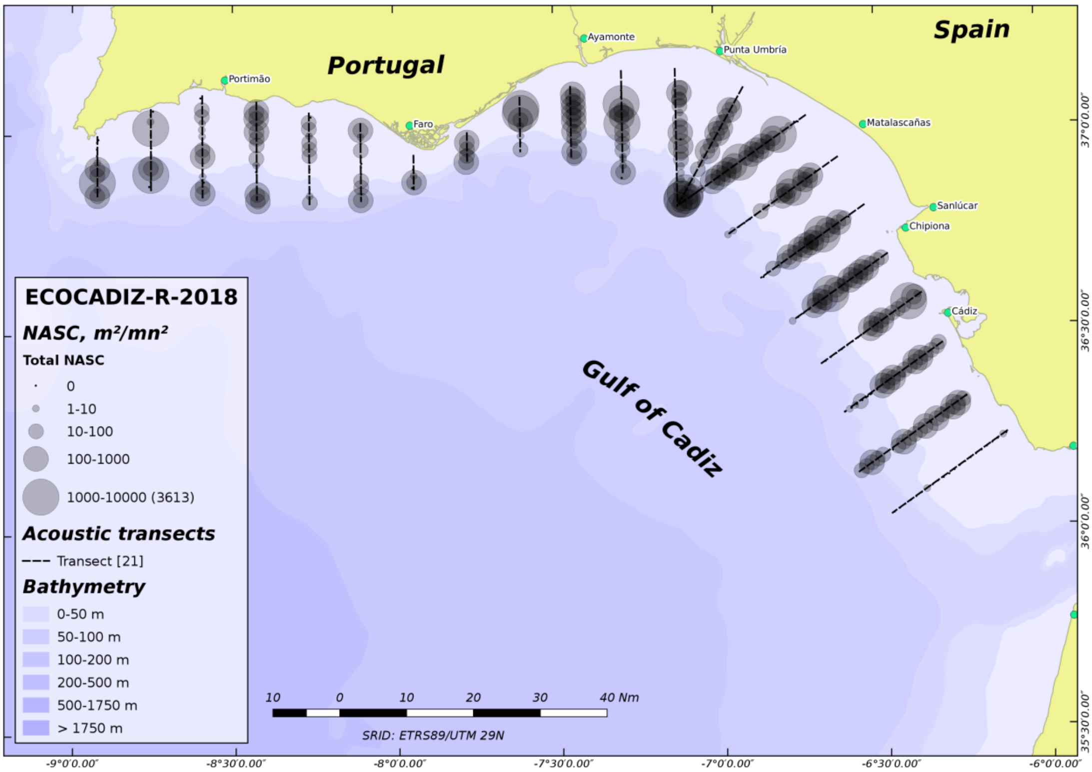
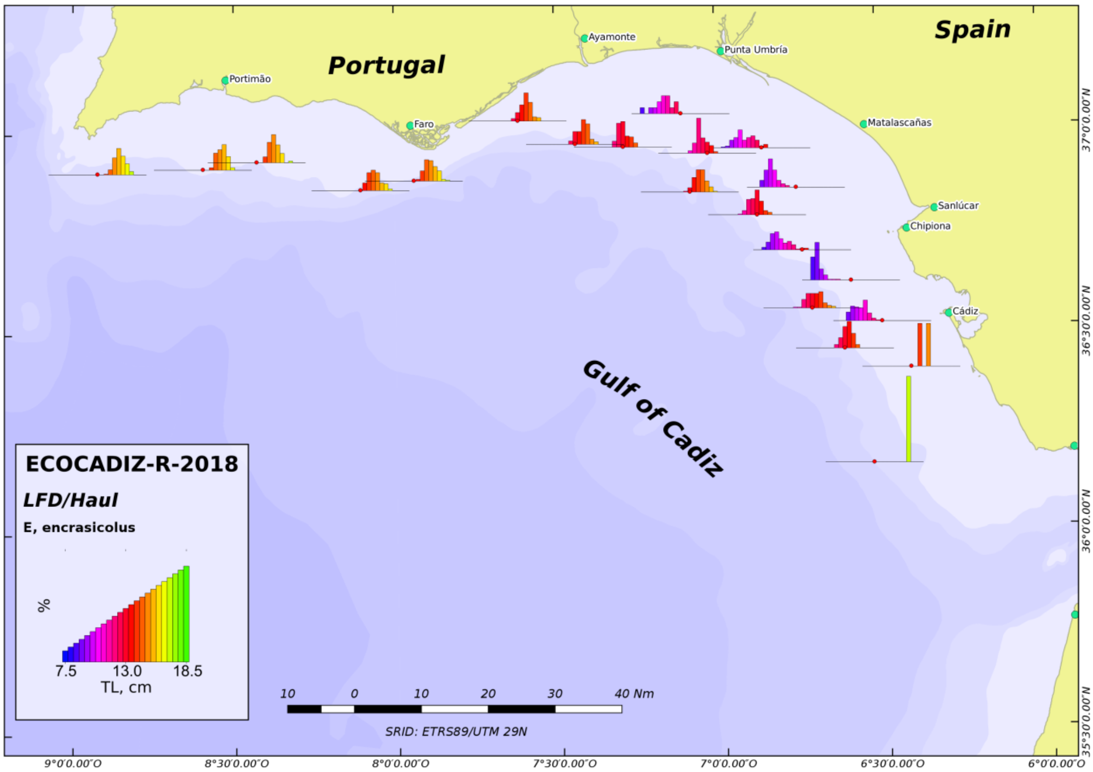


Figure 5. *ECOCADIZ-RECLUTAS 2018-10* survey. Distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the pelagic fish species assemblage.



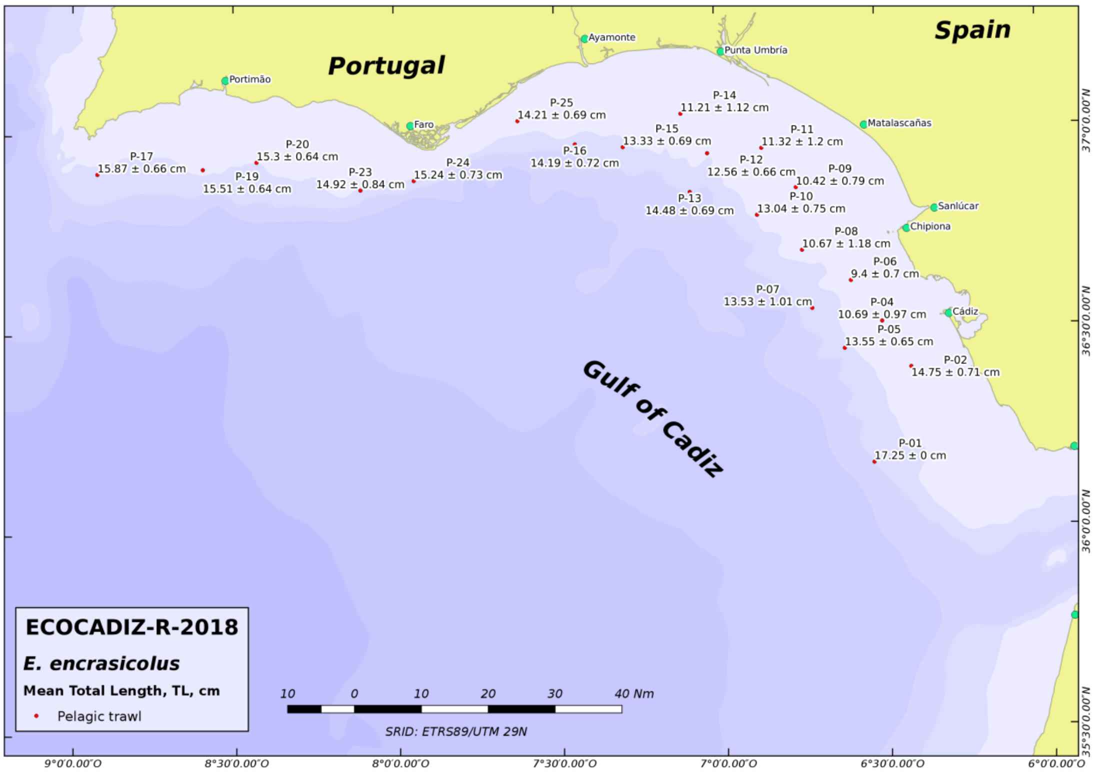
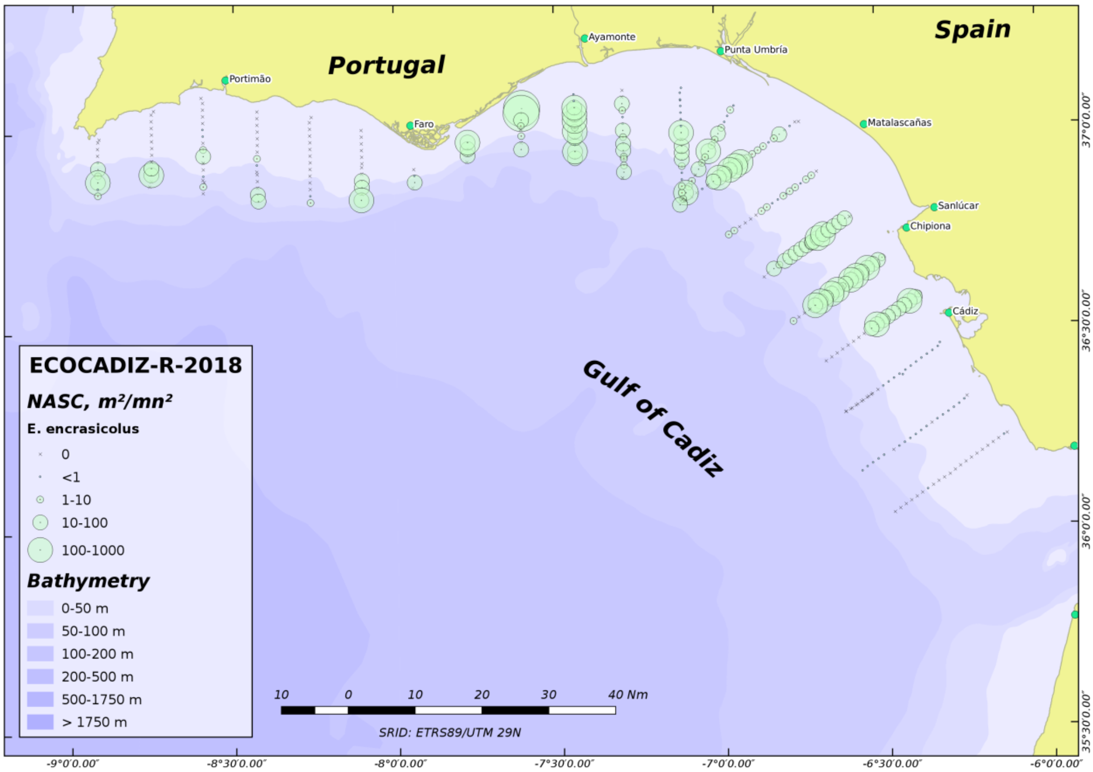


Figure 6. *ECOCADIZ-RECLUTAS 2018-10* survey. Anchovy (*Engraulis encrasicolus*). Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.



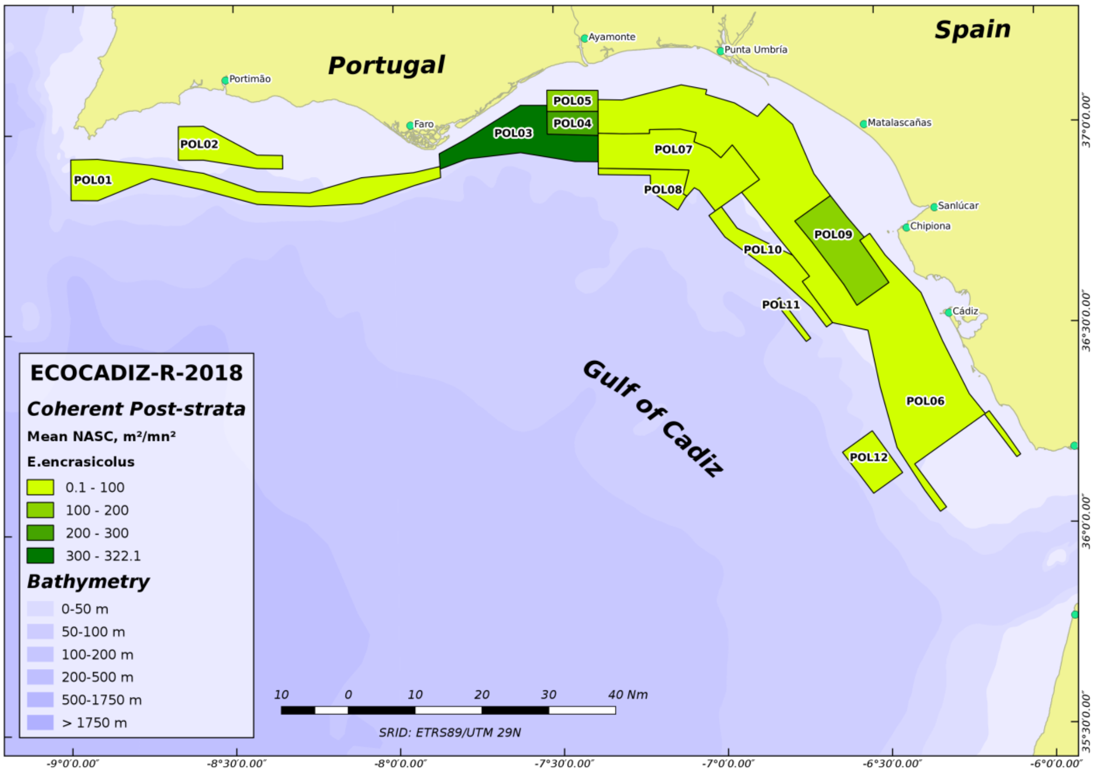


Figure 7. *ECOCADIZ-RECLUTAS 2018-10* survey. Anchovy (*Engraulis encrasicolus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

ECOCADIZ-RECLUTAS 2018-10: Anchovy (*E. encrasicolus*)

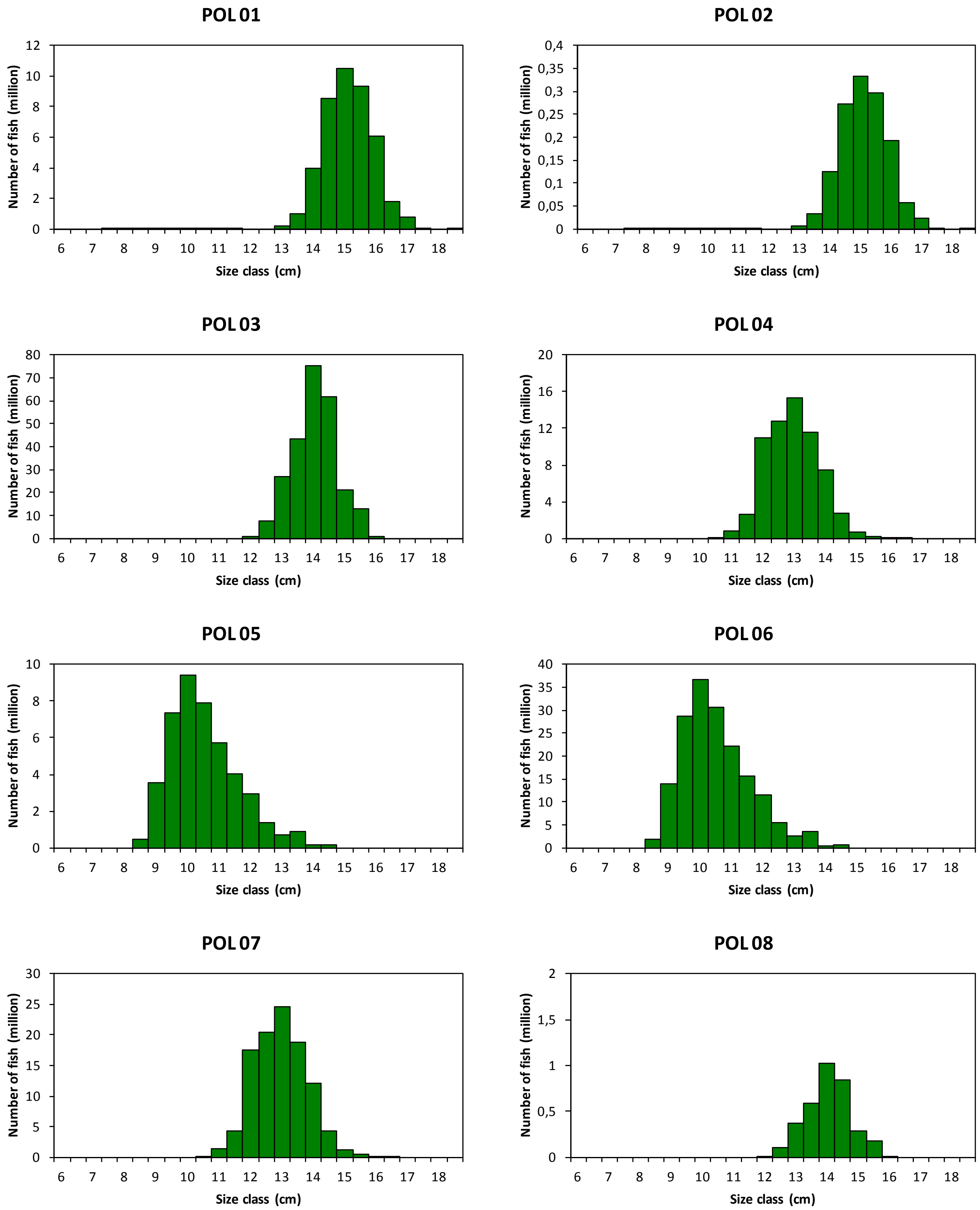


Figure 8. *ECOCADIZ-RECLUTAS 2018-10* survey. Anchovy (*Engraulis encrasicolus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 7**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

***ECOCADIZ-RECLUTAS 2018-10*: Anchovy (*E. encrasicolus*)**

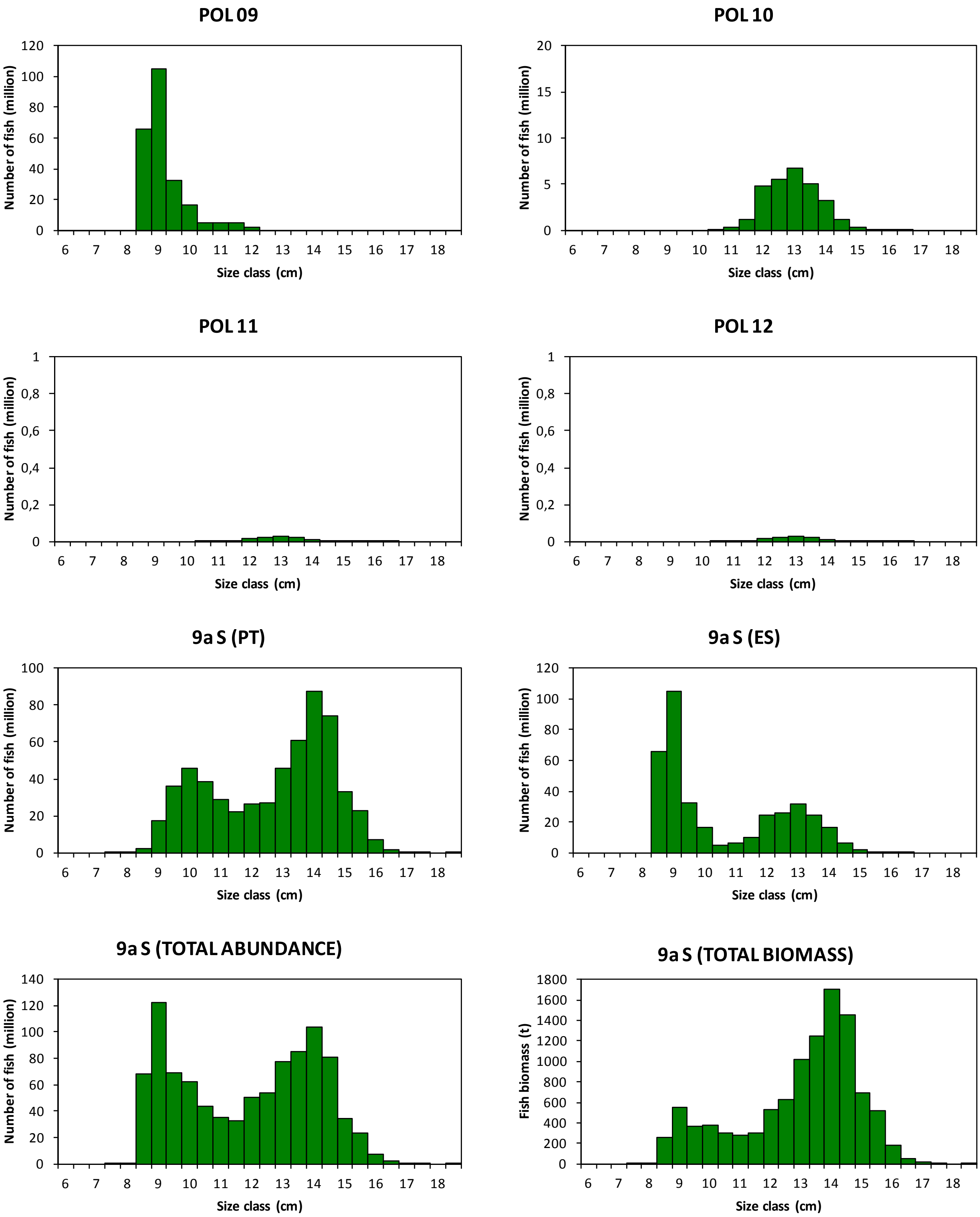


Figure 8. *ECOCADIZ-RECLUTAS 2018-10* survey. Anchovy (*Engraulis encrasicolus*). Cont'd.

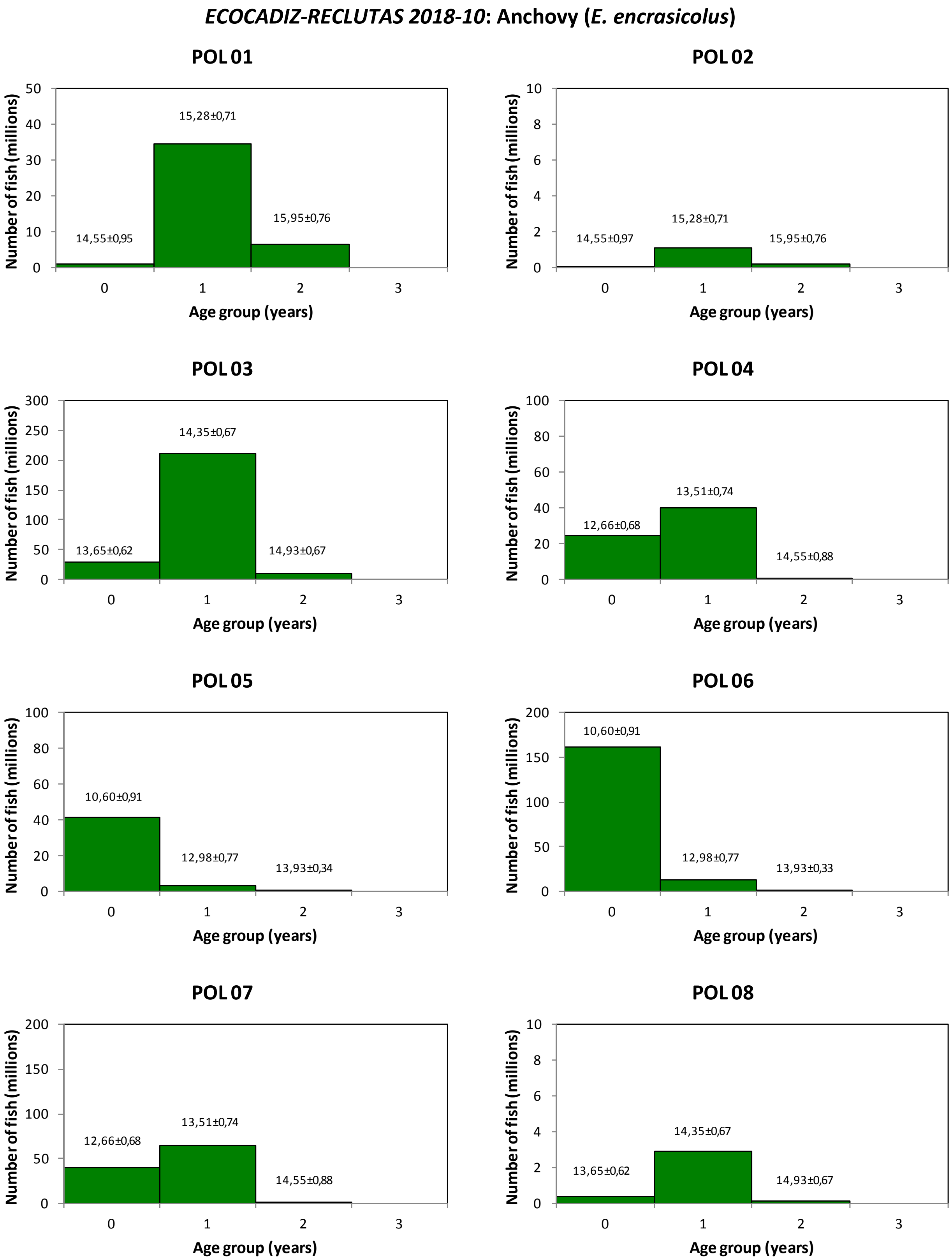


Figure 9. *ECOCADIZ-RECLUTAS 2018-10* survey. Anchovy (*Engraulis encrasicolus*). Estimated abundances (number of fish in millions) by age group (years) by homogeneous stratum (POL01-POLn, numeration as in **Figure 7**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

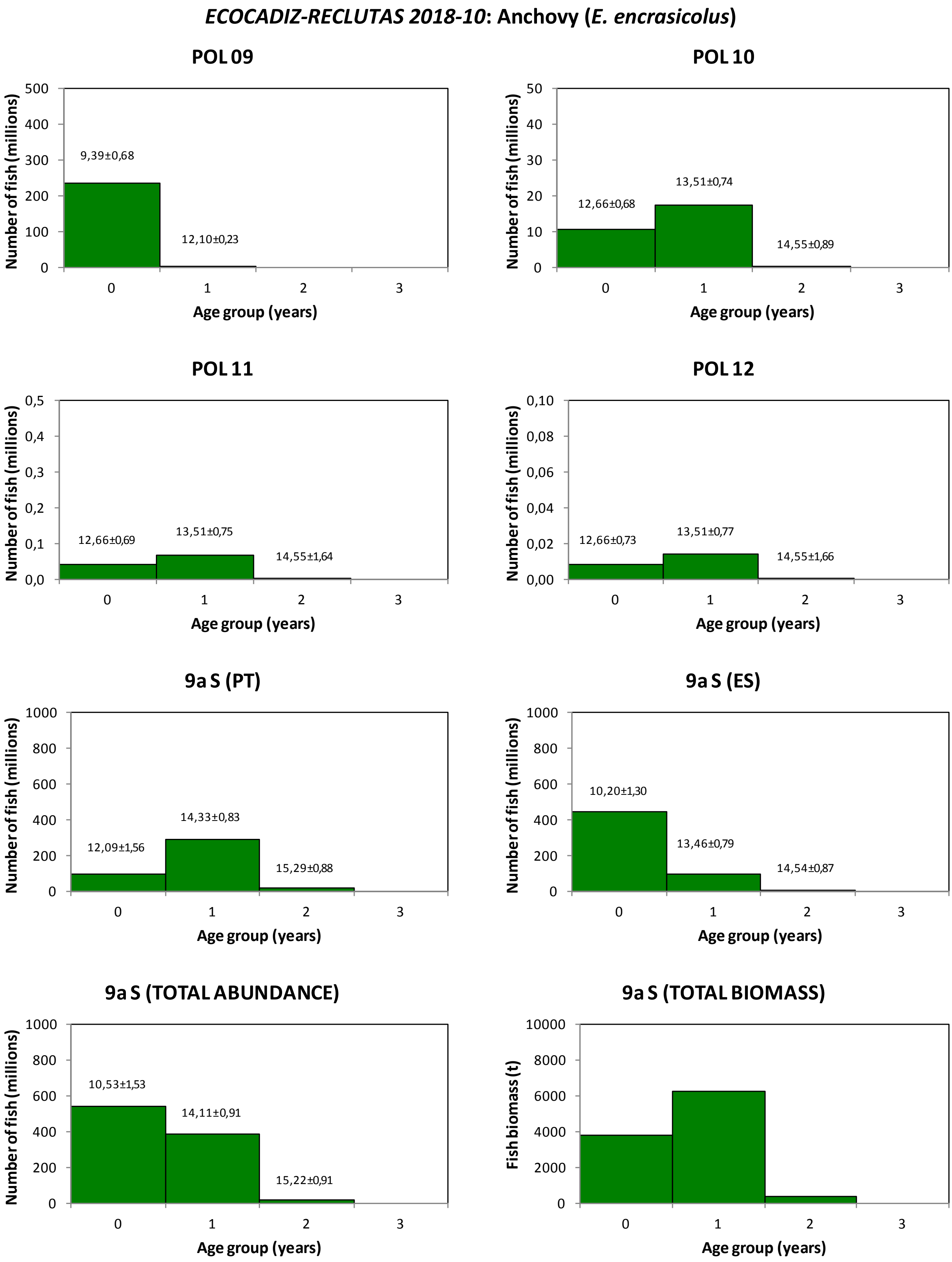


Figure 9. *ECOCADIZ-RECLUTAS 2018-10* survey. Anchovy (*Engraulis encrasicolus*). Cont'd.

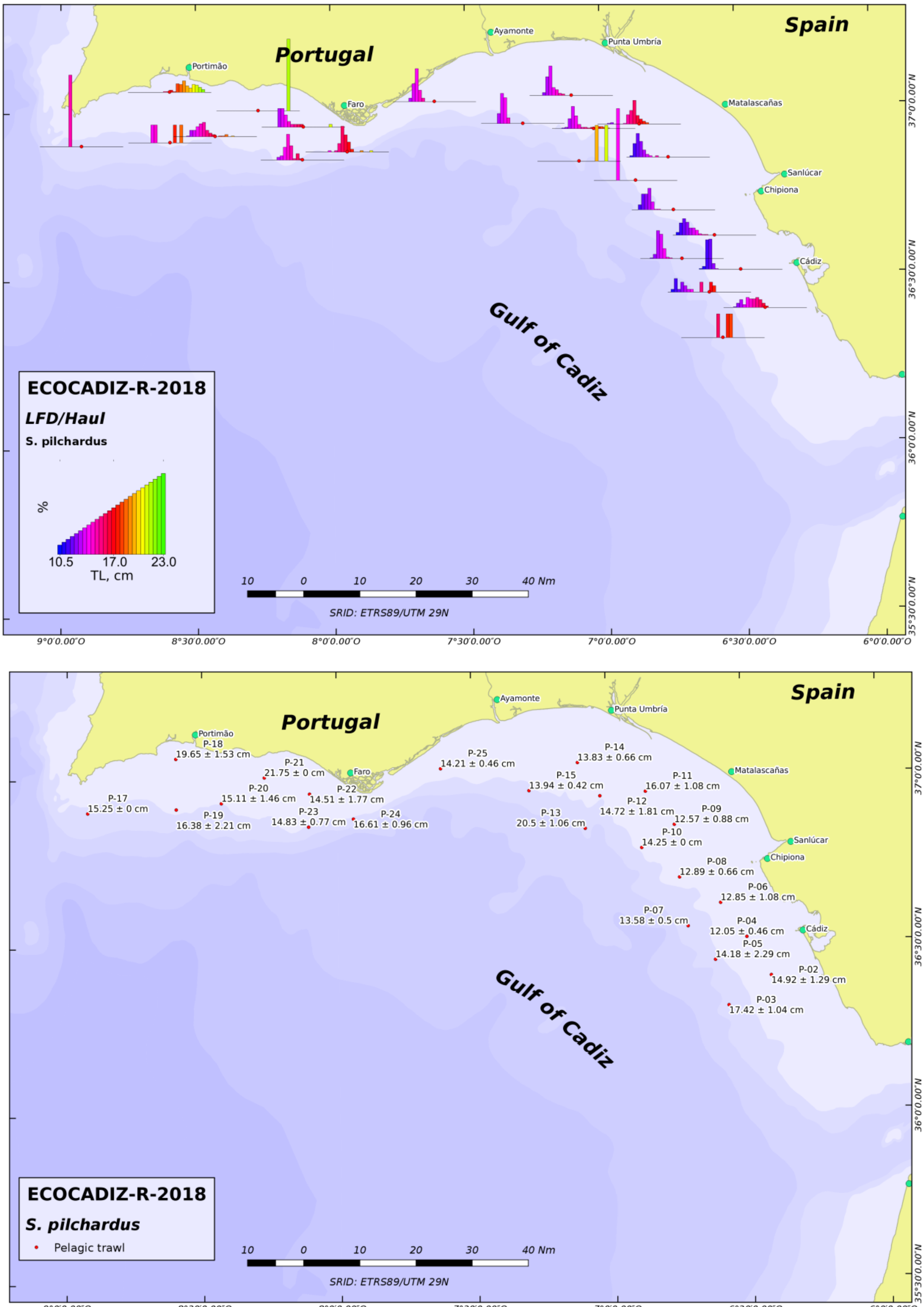


Figure 10. *ECOCADIZ-RECLUTAS 2018-10* survey. Sardine (*Sardina pilchardus*). Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

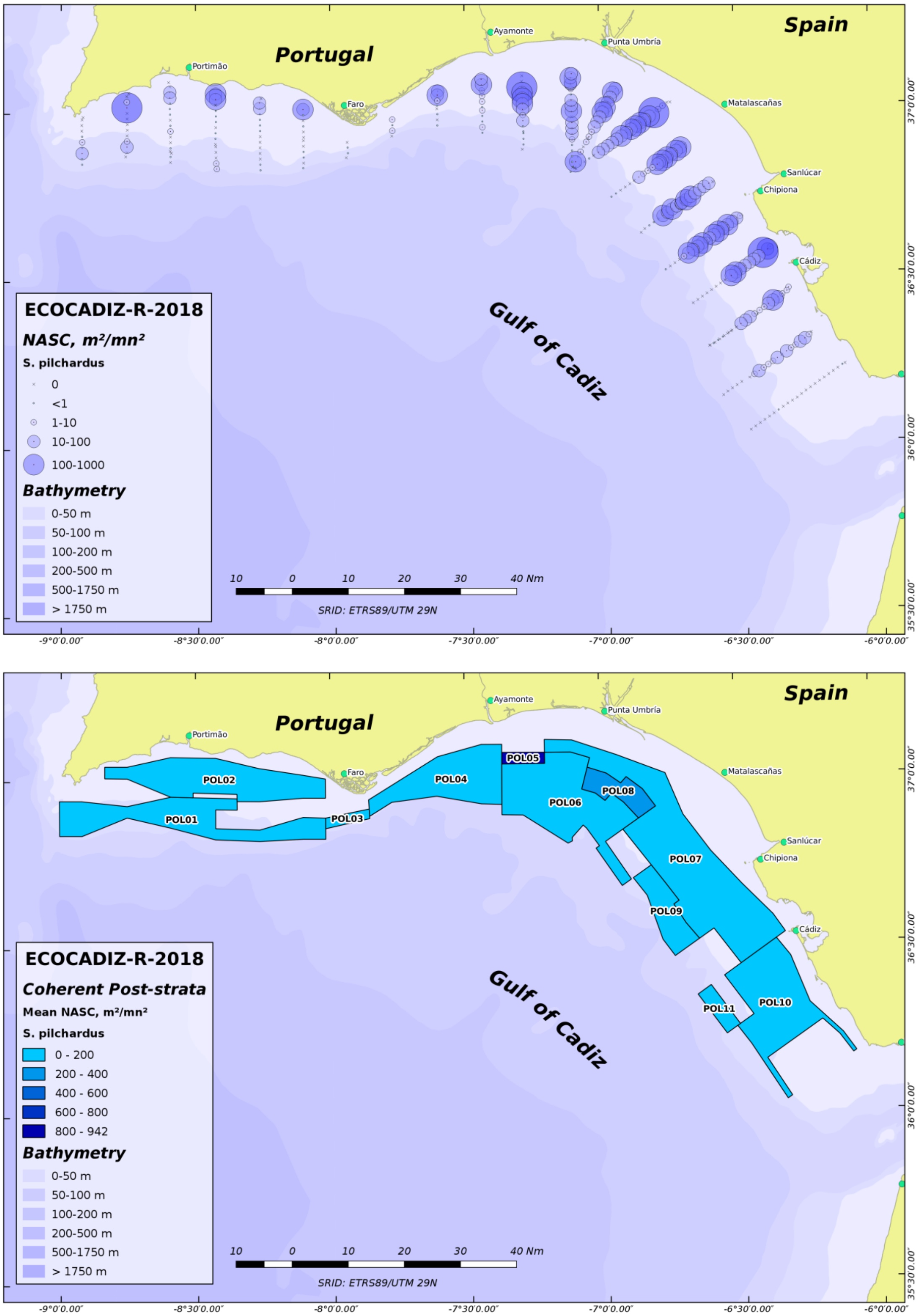


Figure 11. *ECOCADIZ-RECLUTAS 2018-10* survey. Sardine (*Sardina pilchardus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

***ECOCADIZ-RECLUTAS 2018-10*: Sardine (*S. pilchardus*)**

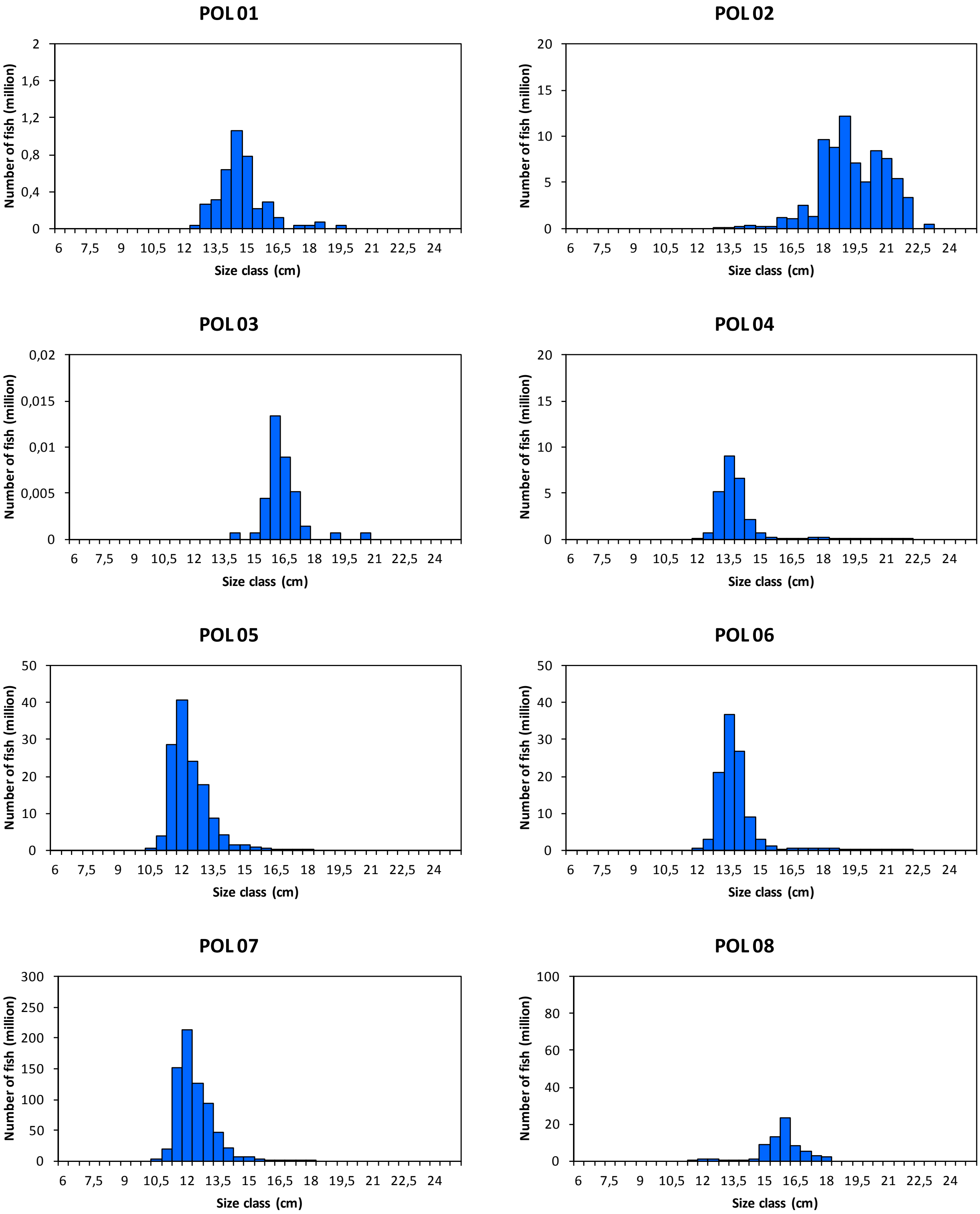


Figure 12. *ECOCADIZ-RECLUTAS 2018-10* survey. Sardine (*Sardina pilchardus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 11**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

***ECOCADIZ-RECLUTAS 2018-10*: Sardine (*S. pilchardus*)**

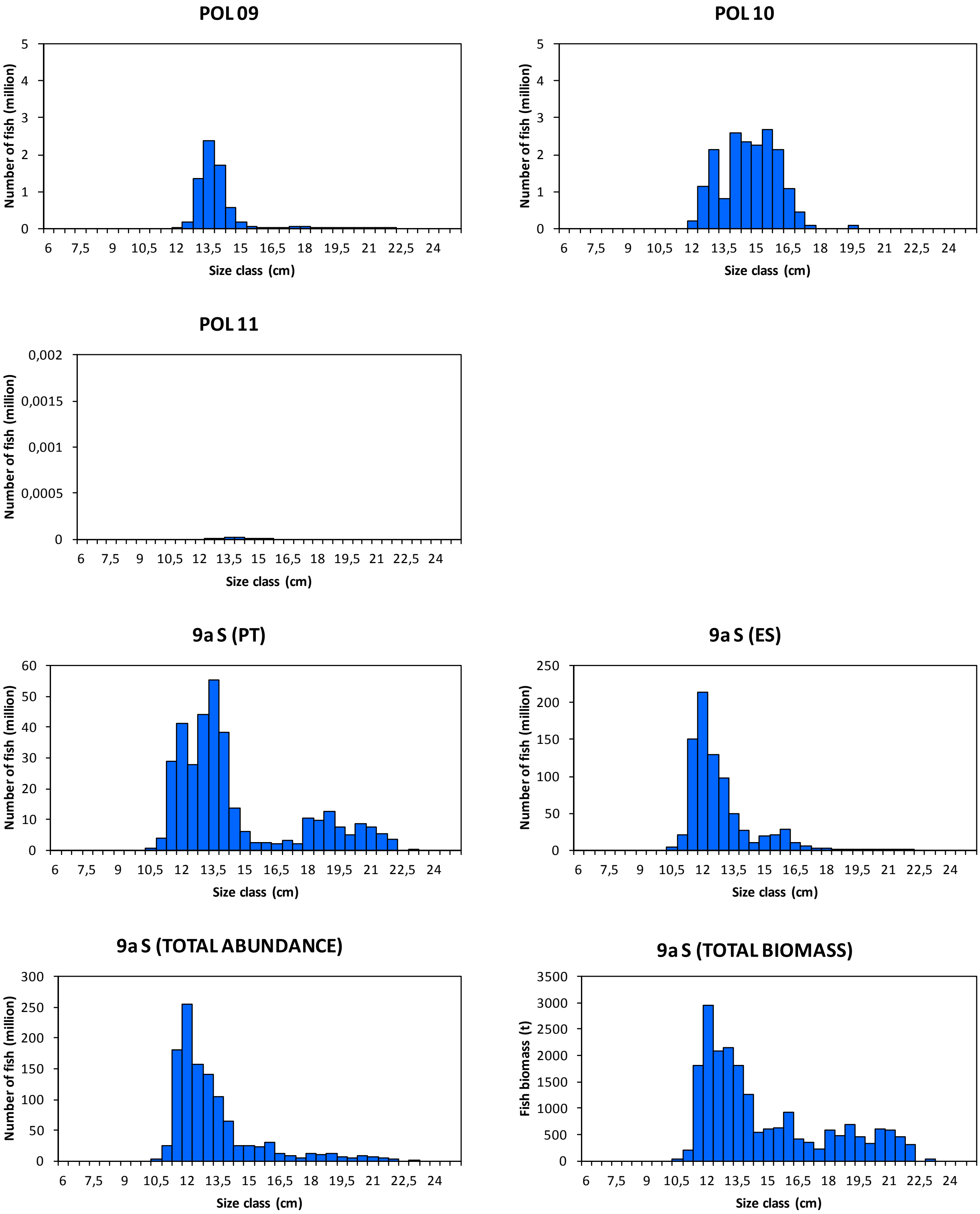


Figure 12. *ECOCADIZ-RECLUTAS 2018-10* survey. Sardine (*Sardina pilchardus*). Cont'd.

***ECOCADIZ-RECLUTAS 2018-10*: Sardine (*S. pilchardus*)**

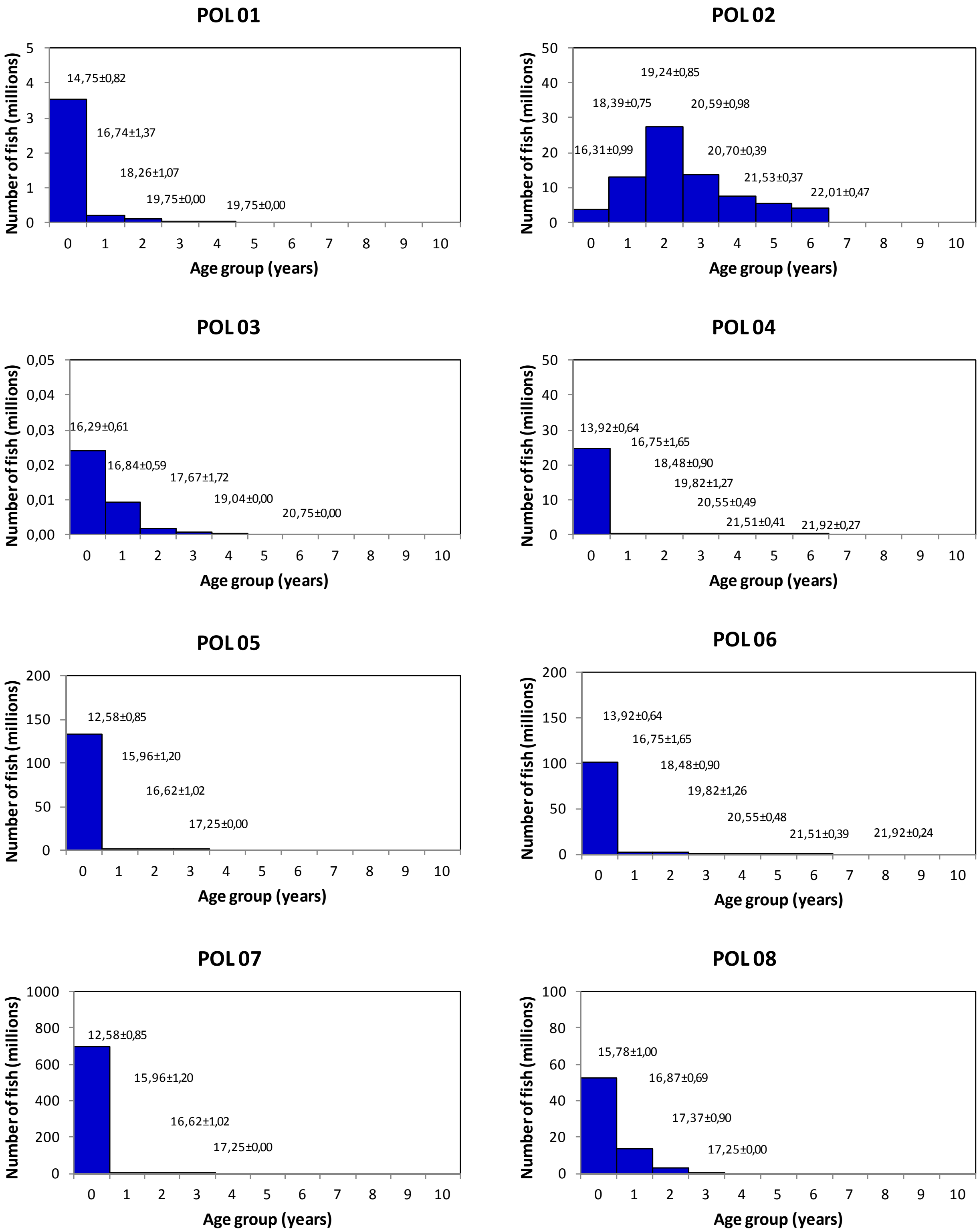


Figure 13. *ECOCADIZ-RECLUTAS 2018-10* survey. Sardine (*Sardina pilchardus*). Estimated abundances (number of fish in millions) by age group (years) by homogeneous stratum (POL01-POLn, numeration as in **Figure 11**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

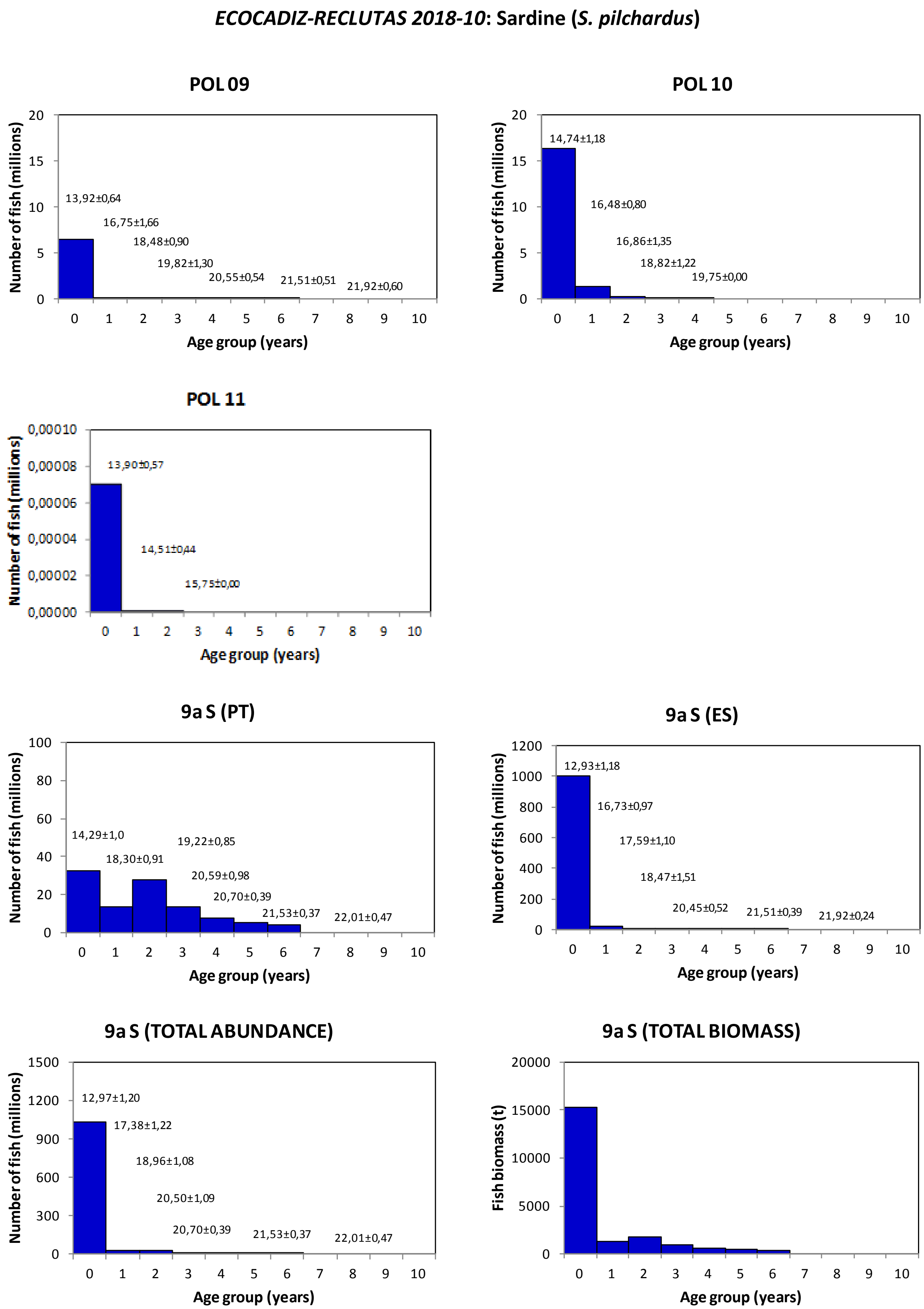
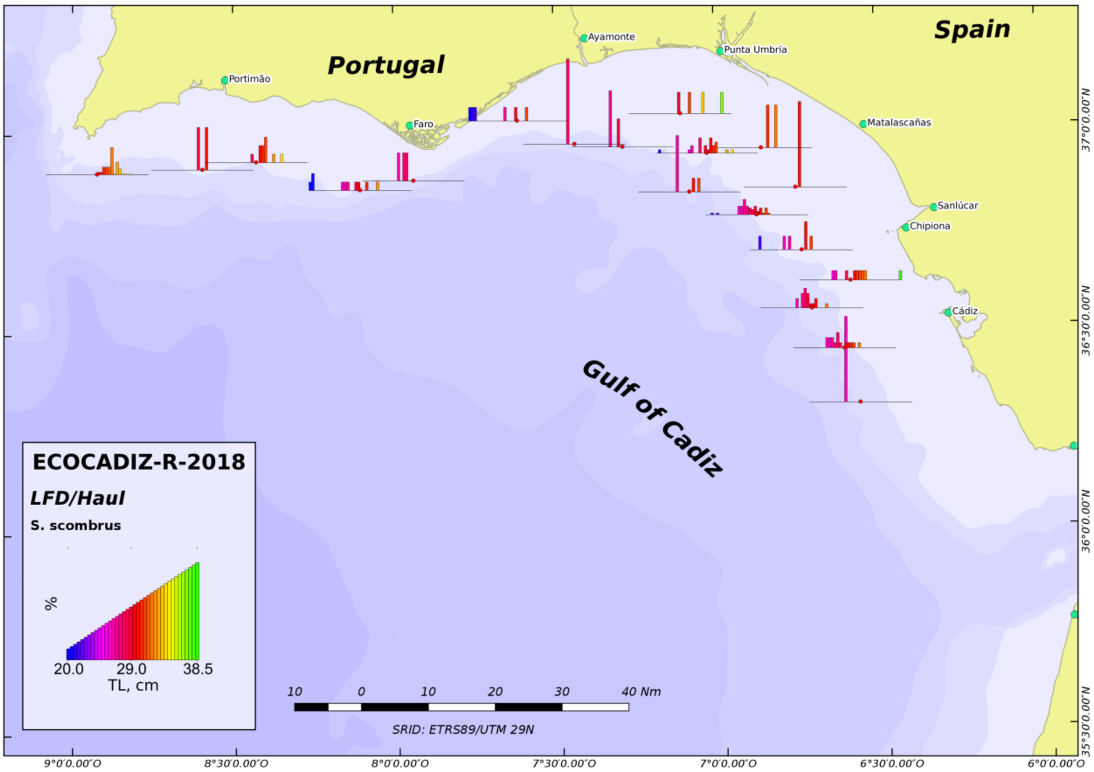


Figure 13. *ECOCADIZ-RECLUTAS 2018-10* survey. Sardine (*Sardina pilchardus*). Cont'd



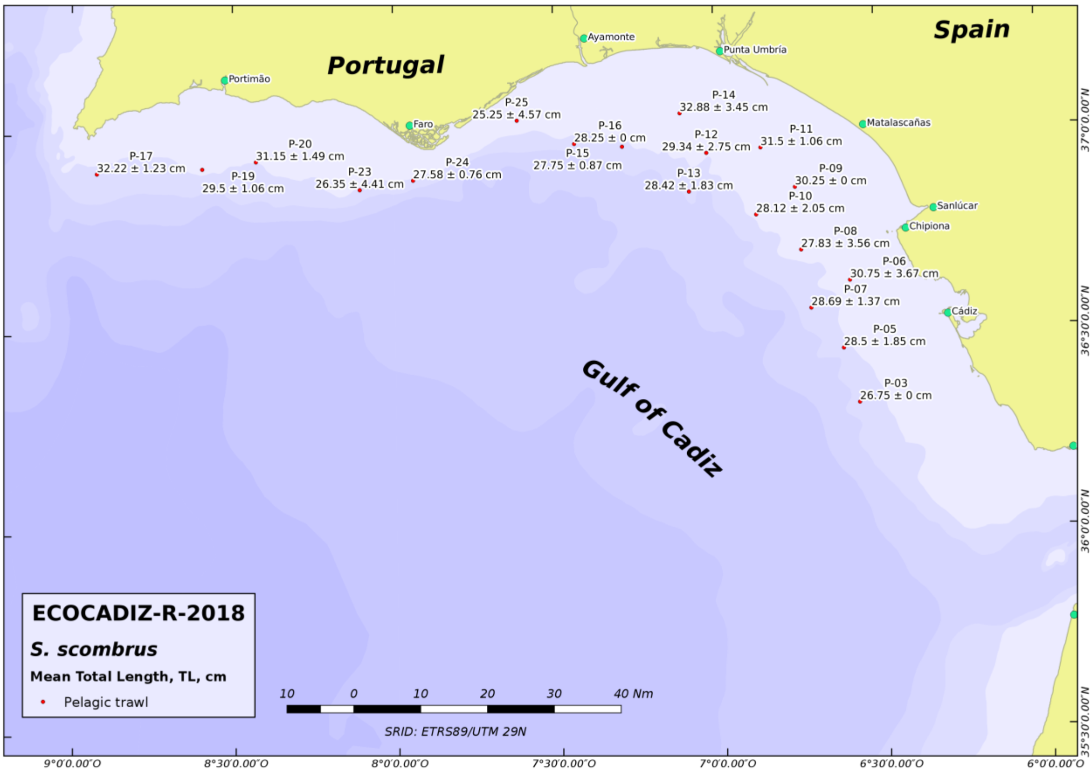
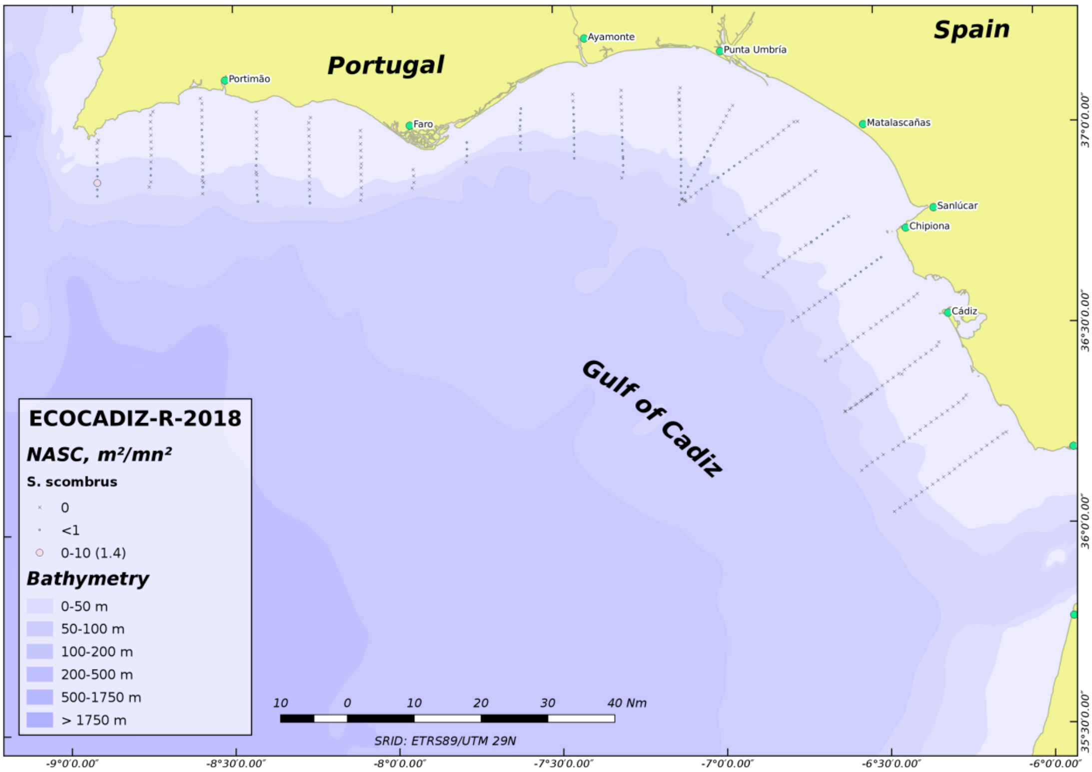


Figure 14. *ECOCADIZ-RECLUTAS 2017-10* survey. Atlantic mackerel (*Scomber scombrus*). Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.



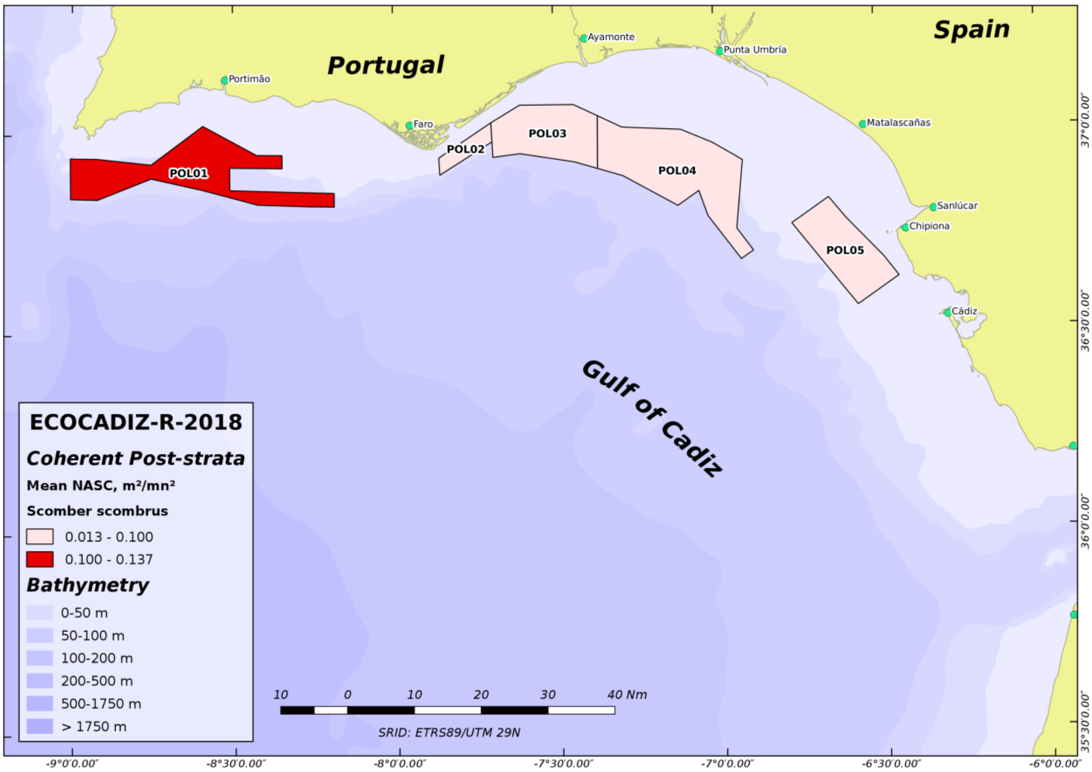


Figure 15. *ECOCADIZ-RECLUTAS 2018-10* survey. Atlantic mackerel (*Scomber scombrus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

***ECOCADIZ-RECLUTAS 2018-10*: Atlantic mackerel (*S. scombrus*)**

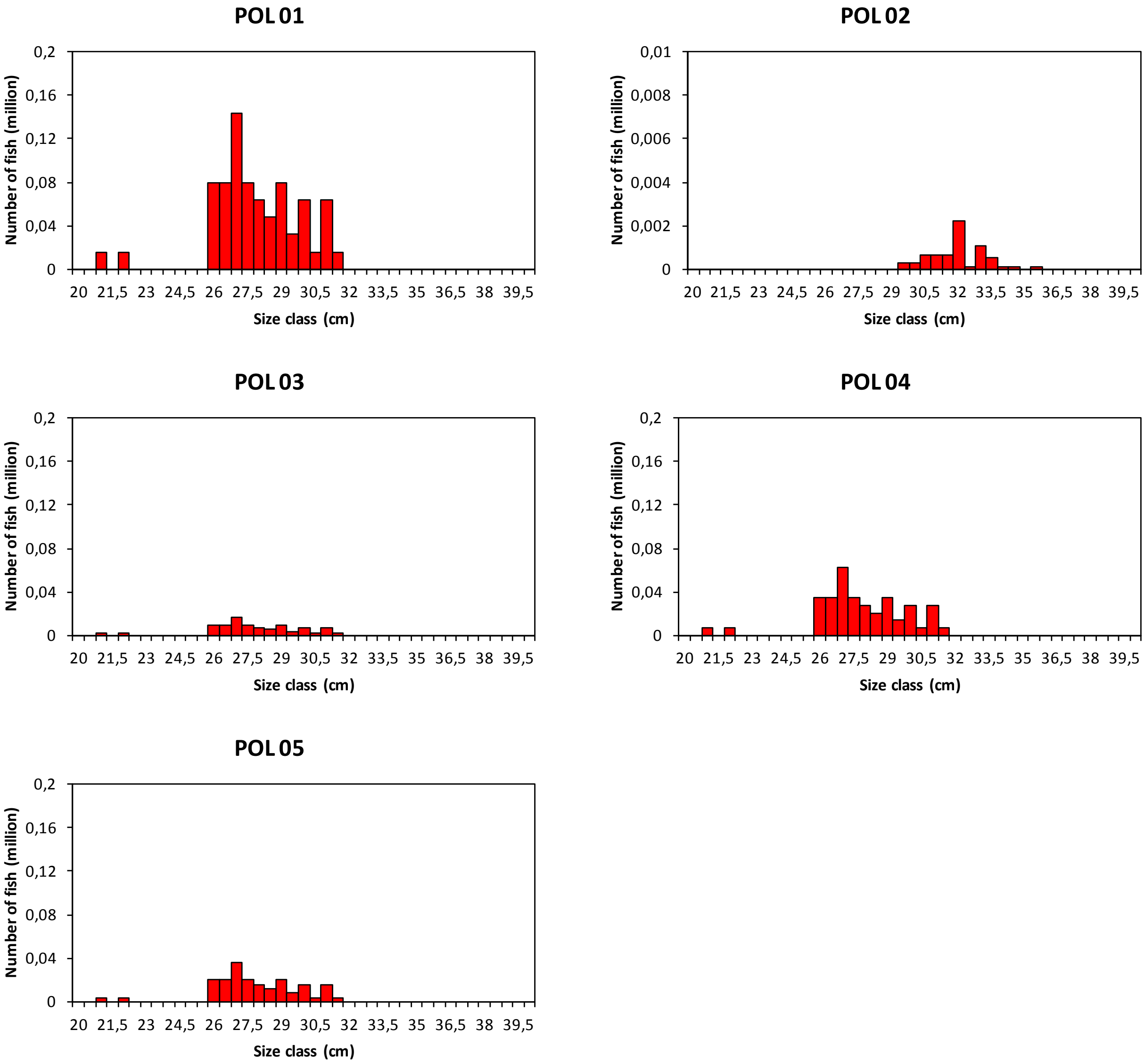


Figure 16. *ECOCADIZ-RECLUTAS 2018-10* survey. Atlantic mackerel (*Scomber scombrus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 15**) and total sampled area. Post-strata ordered in the W-E direction. The estimated 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 2018-10*: Atlantic mackerel (*S. scombrus*)**

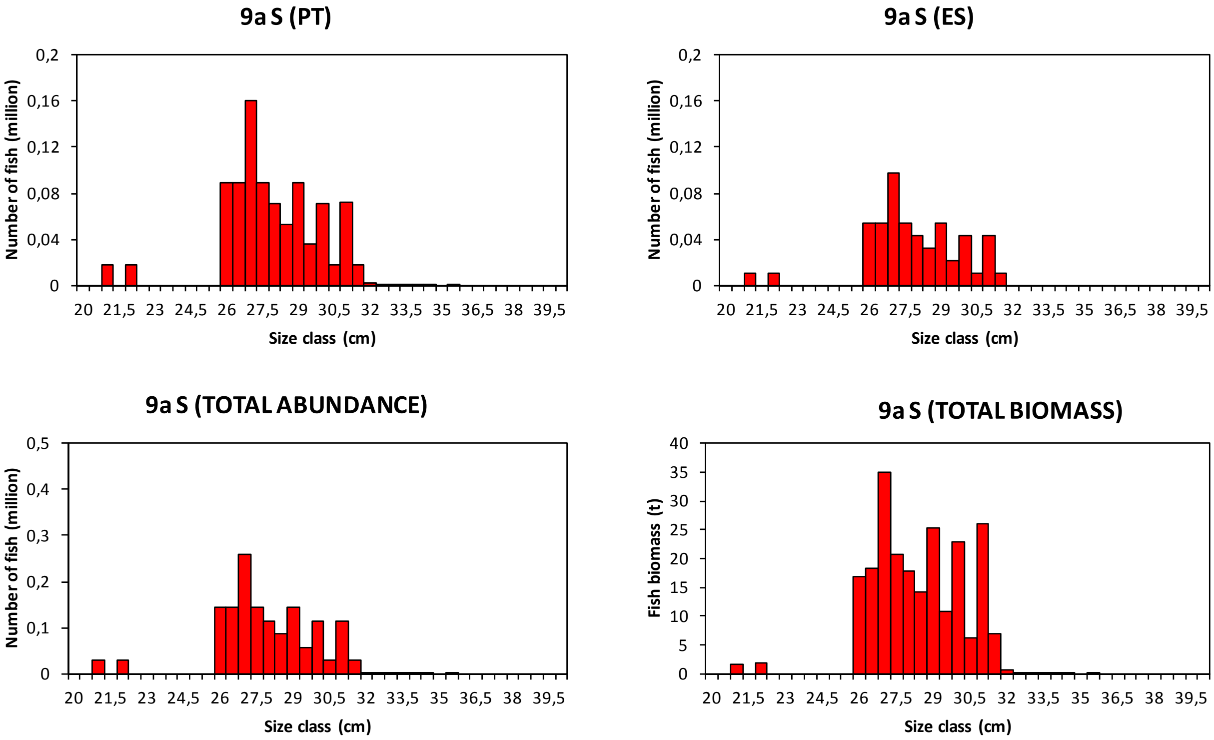
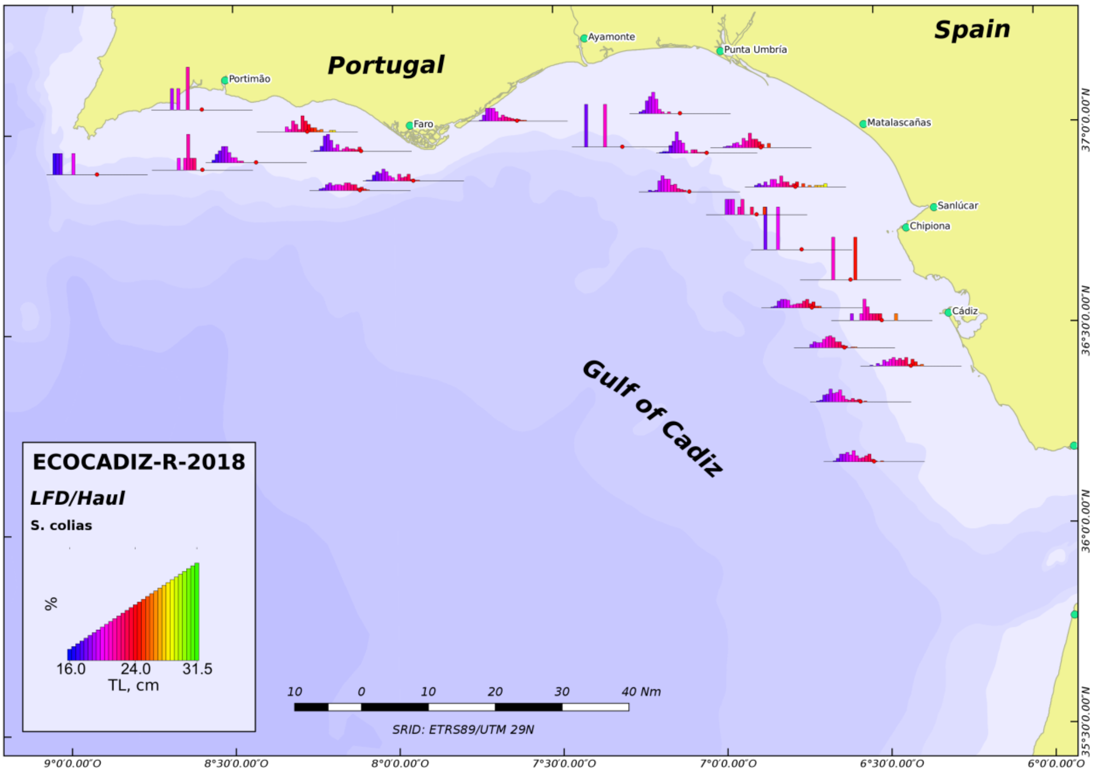


Figure 16. *ECOCADIZ-RECLUTAS 2018-10* survey. Atlantic mackerel (*Scomber scombrus*). Cont'd.



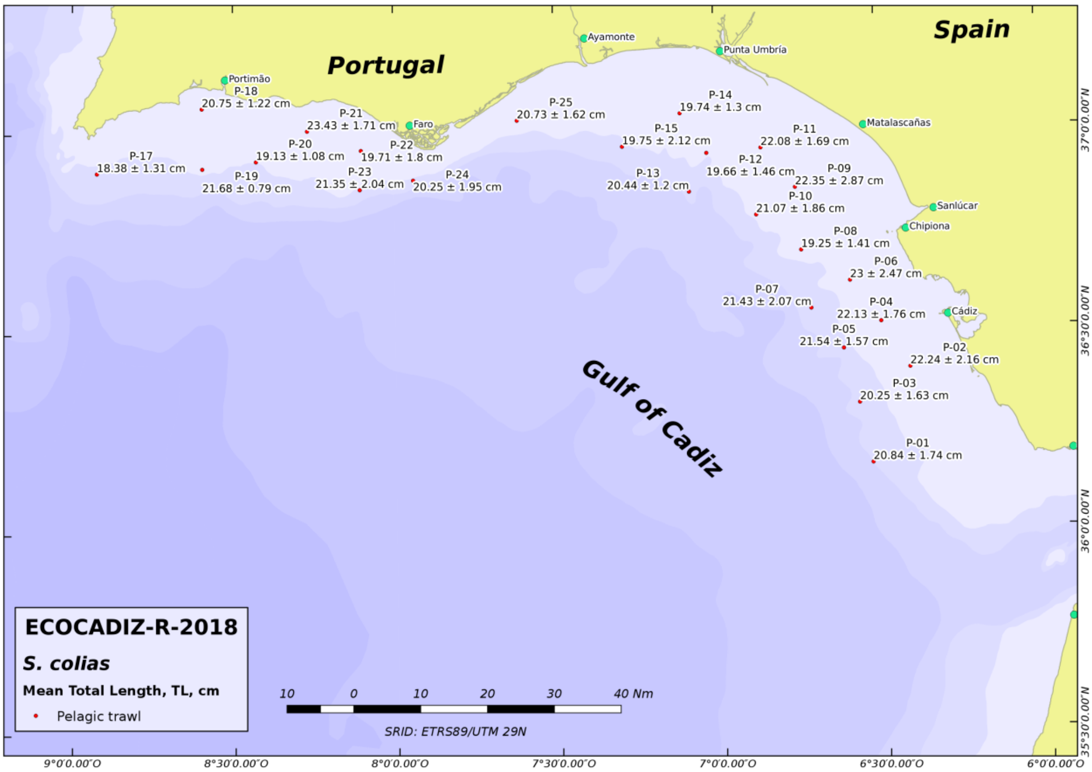


Figure 17. *ECOCADIZ-RECLUTAS 2018-10* survey. Chub mackerel (*Scomber colias*). Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

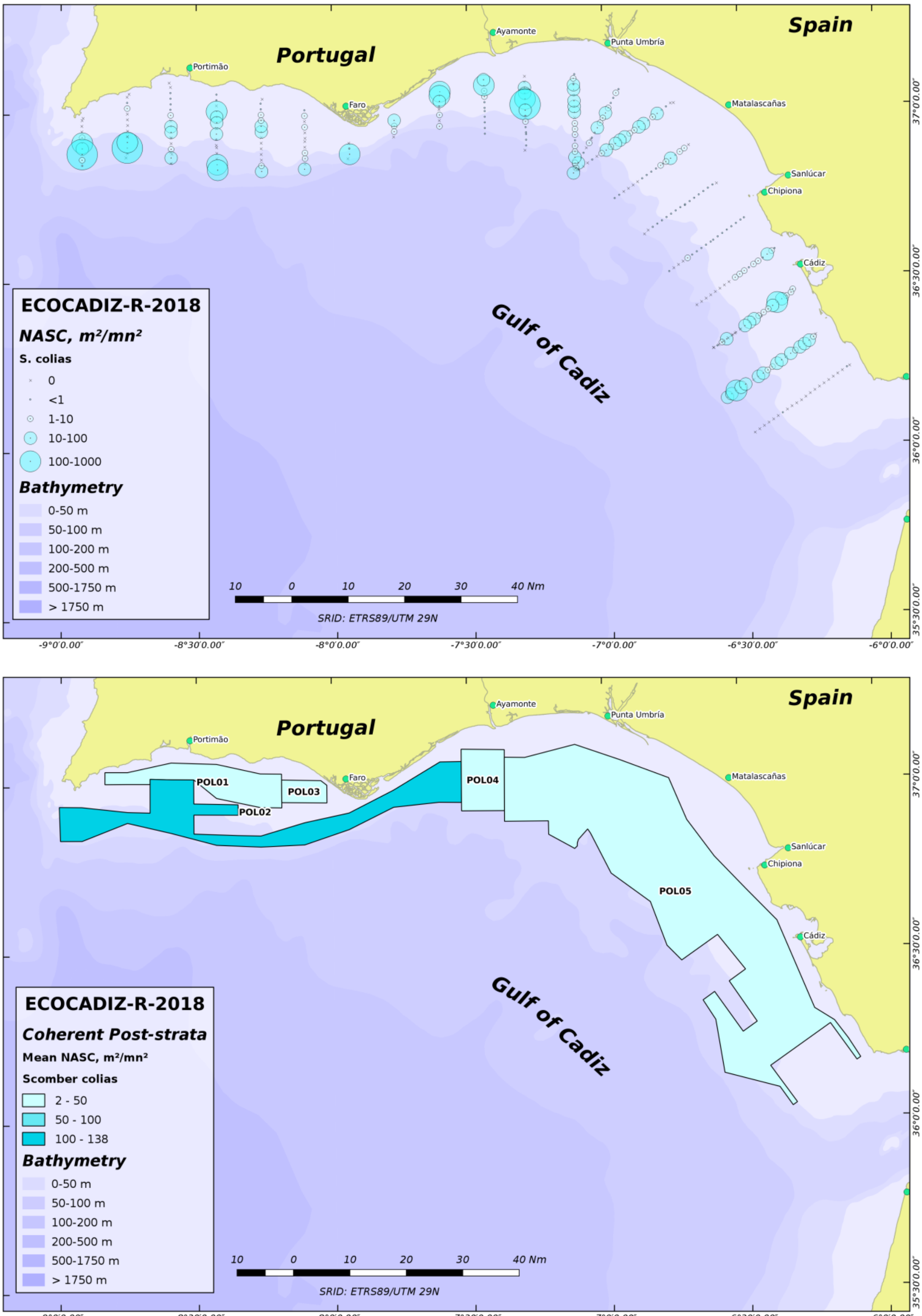


Figure 18. *ECOCADIZ-RECLUTAS 2017-10* survey. Chub mackerel (*Scomber colias*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

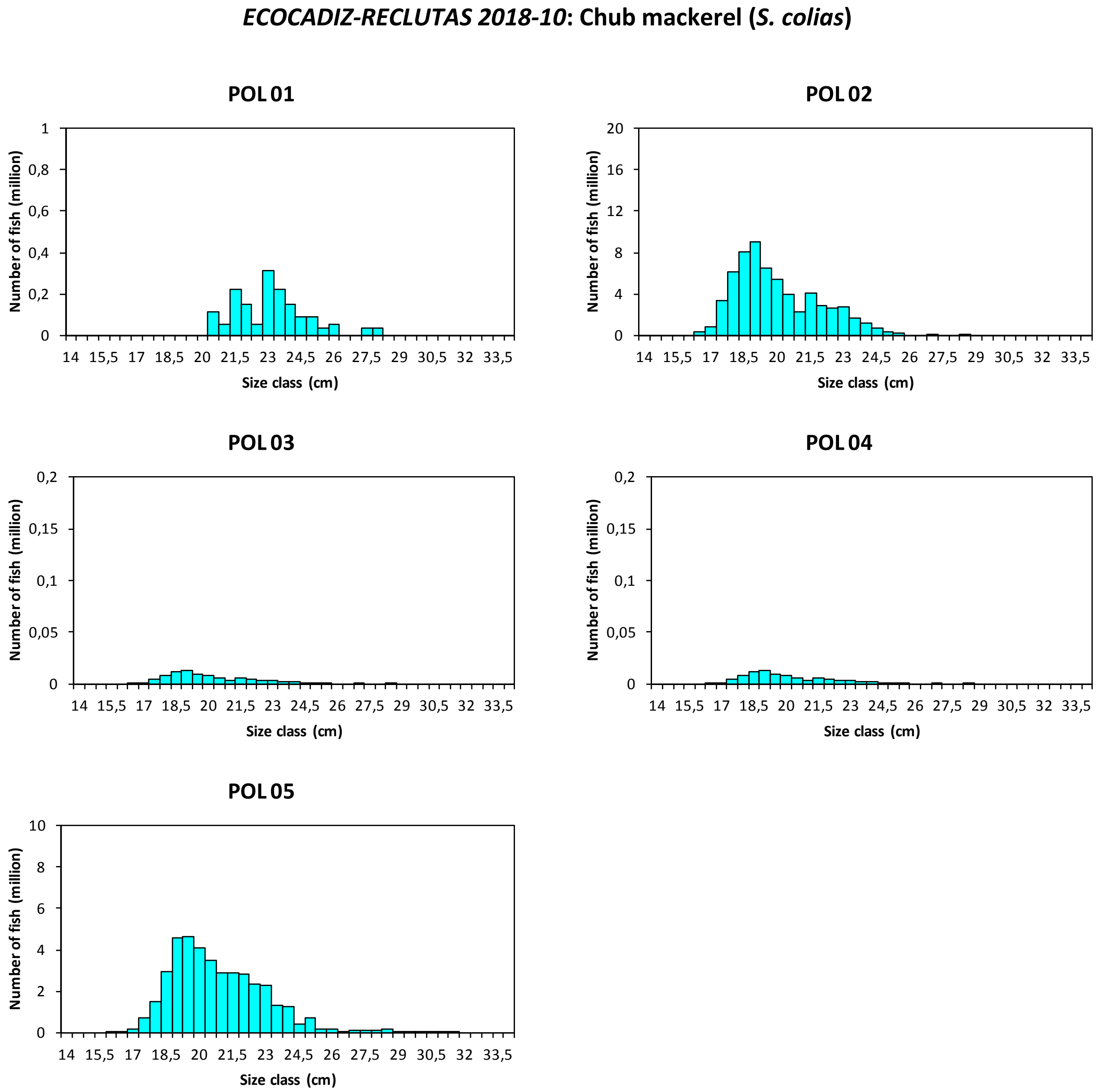


Figure 19. *ECOCADIZ-RECLUTAS 2018-10* survey. Chub mackerel (*Scomber colias*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 18**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

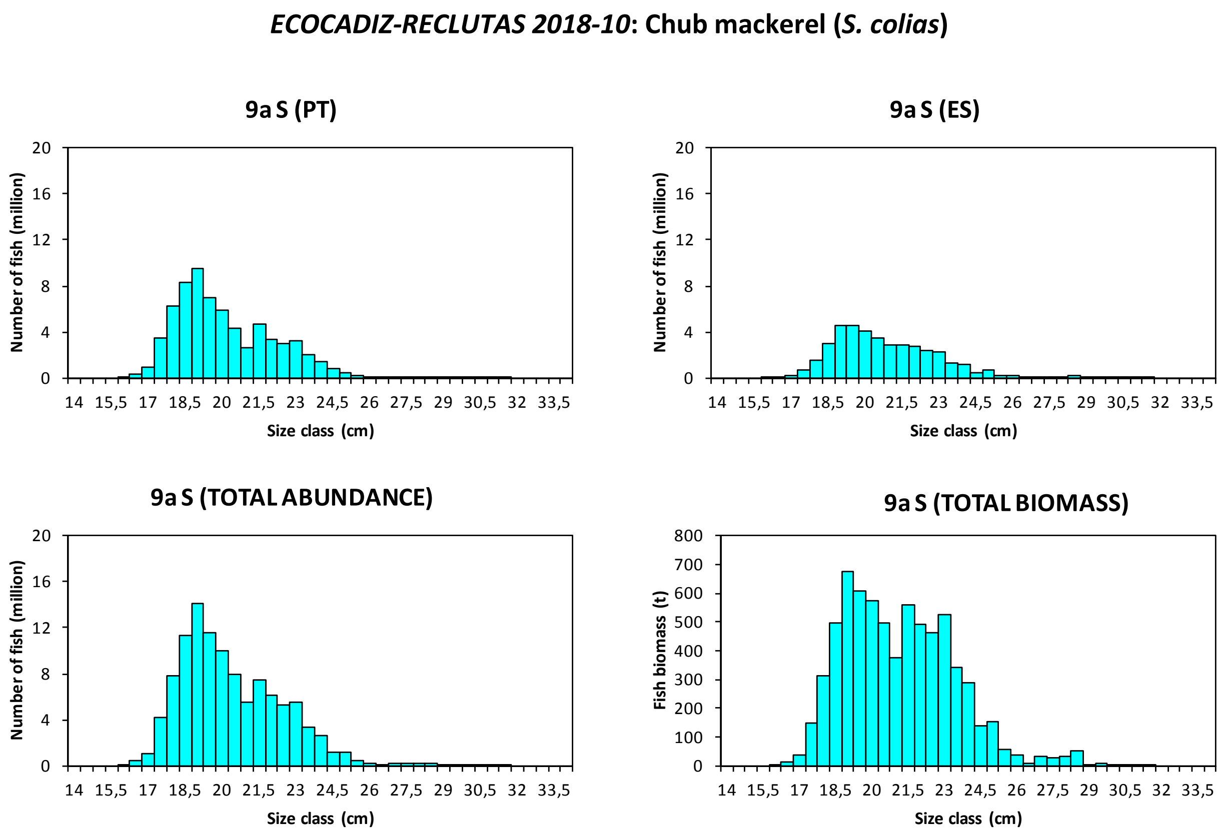


Figure 19. *ECOCADIZ-RECLUTAS 2018-10* survey. Chub mackerel (*Scomber colias*). Cont'd.

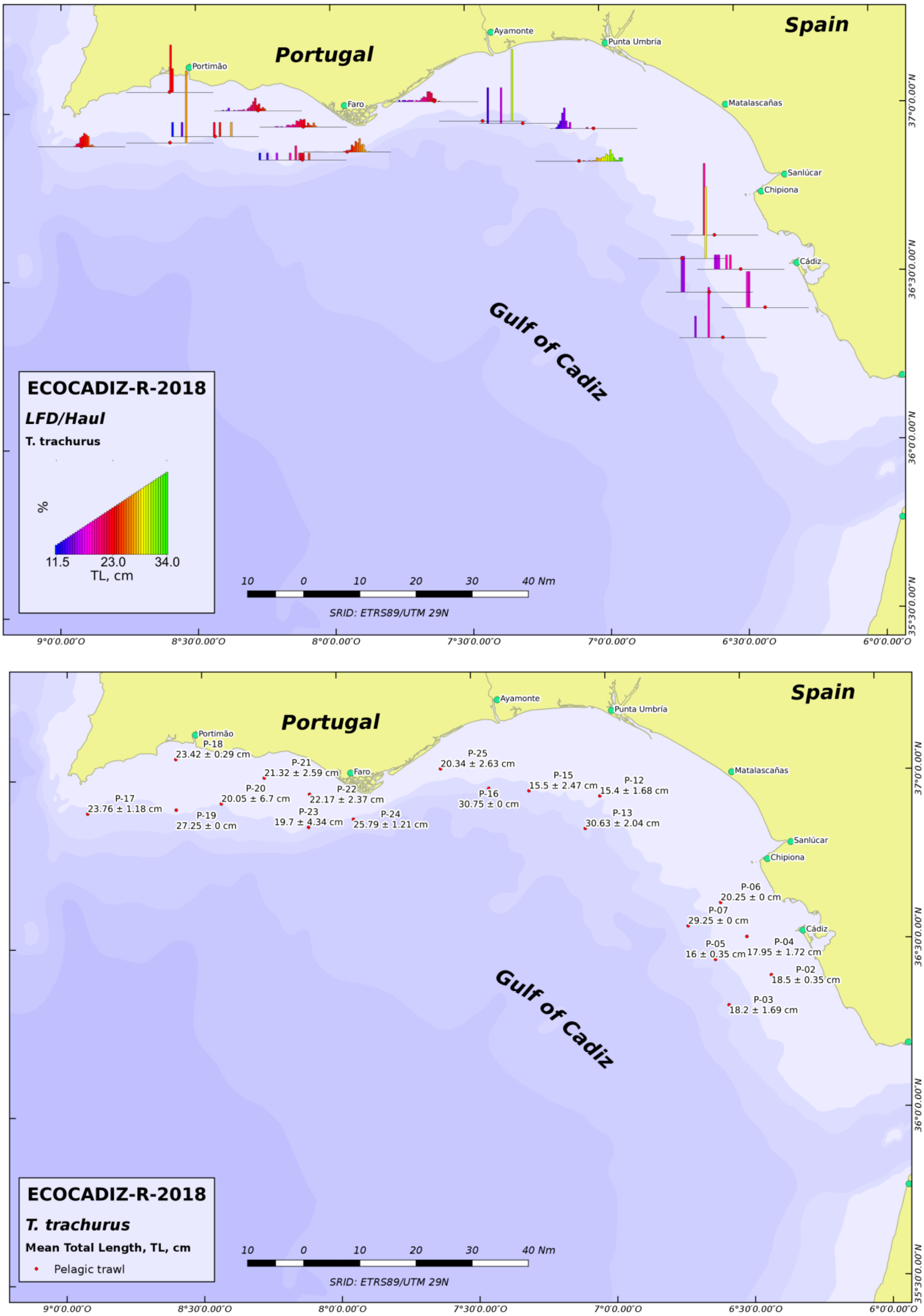
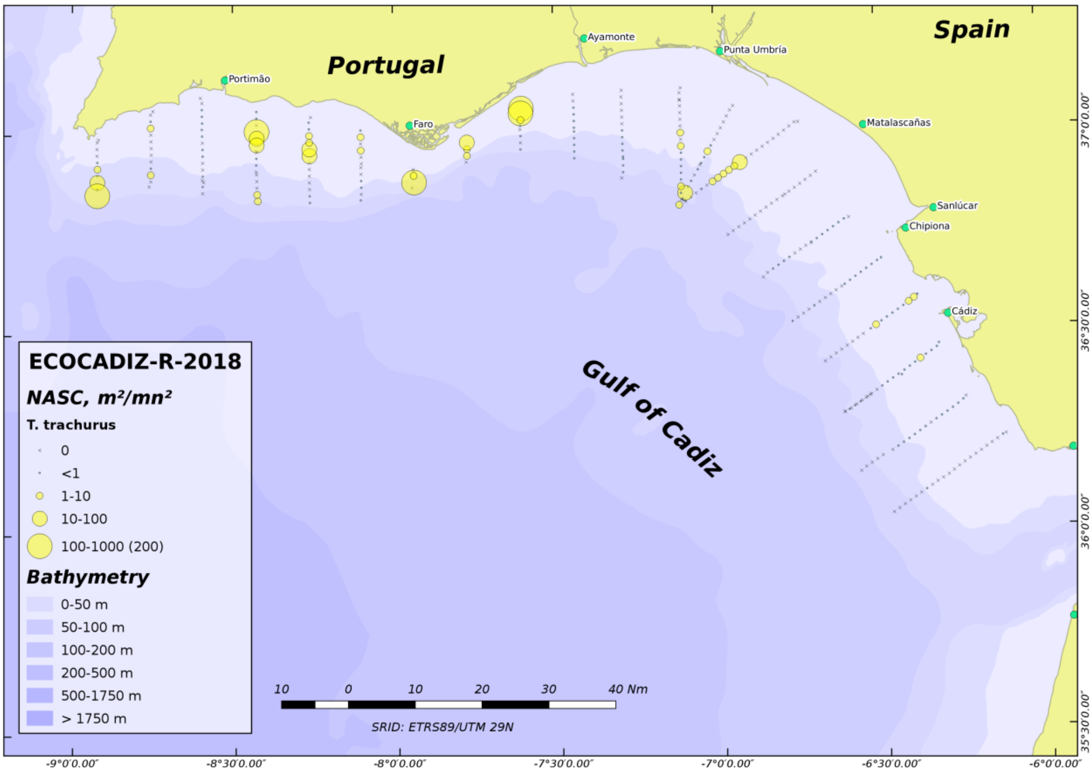


Figure 20. *ECOCADIZ-RECLUTAS 2018-10* survey. Horse mackerel (*Trachurus trachurus*). Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.



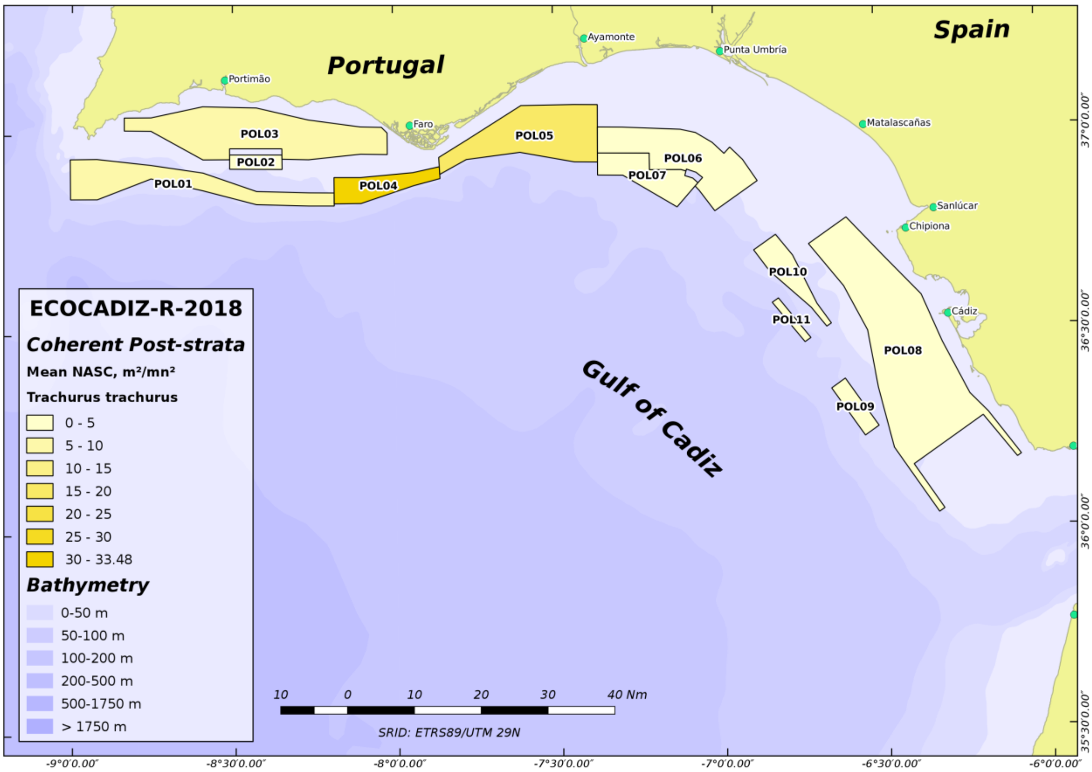


Figure 21. *ECOCADIZ-RECLUTAS 2018-10* survey. Horse mackerel (*Trachurus trachurus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

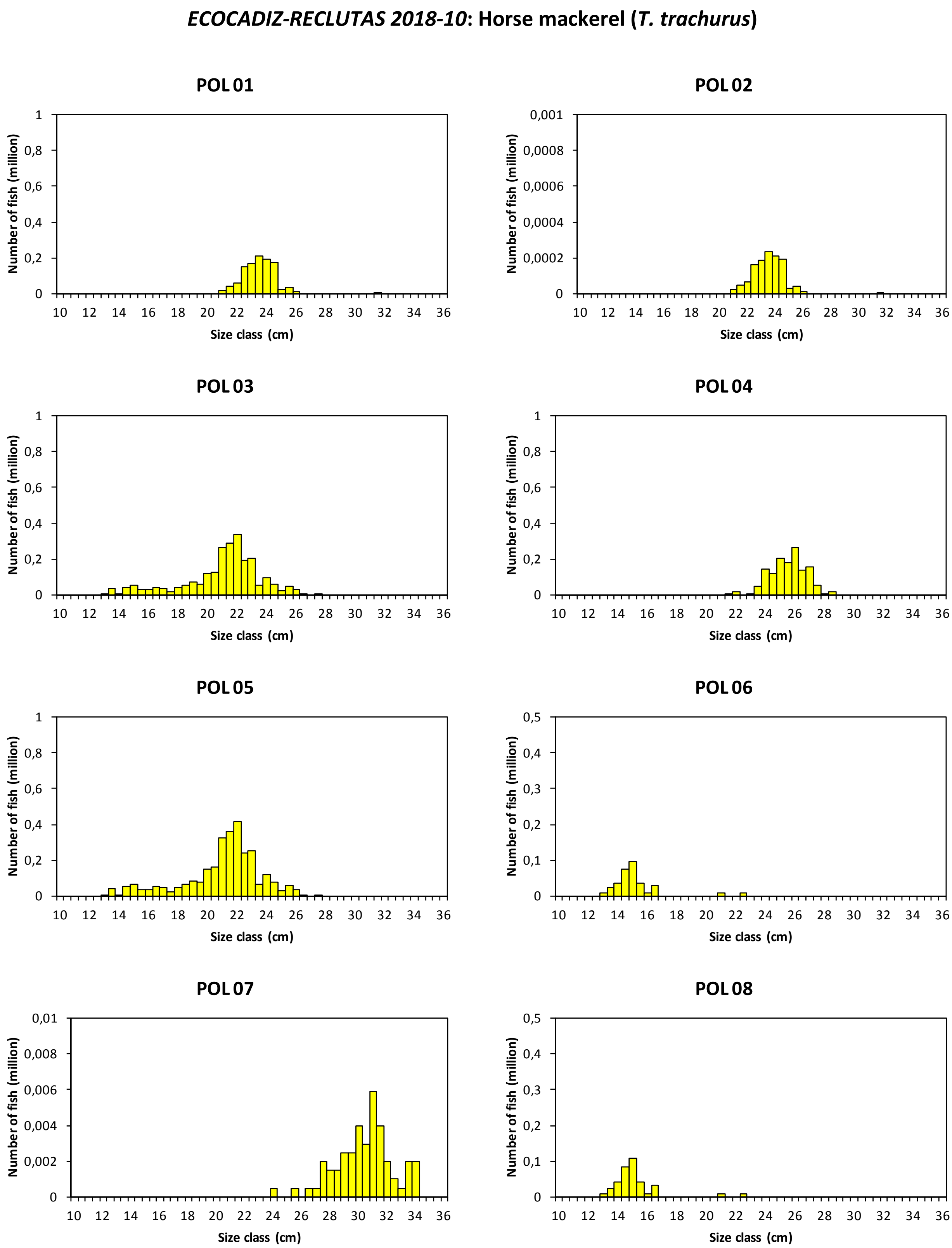


Figure 22. *ECOCADIZ-RECLUTAS 2018-10* survey. Horse mackerel (*Trachurus trachurus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 21**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

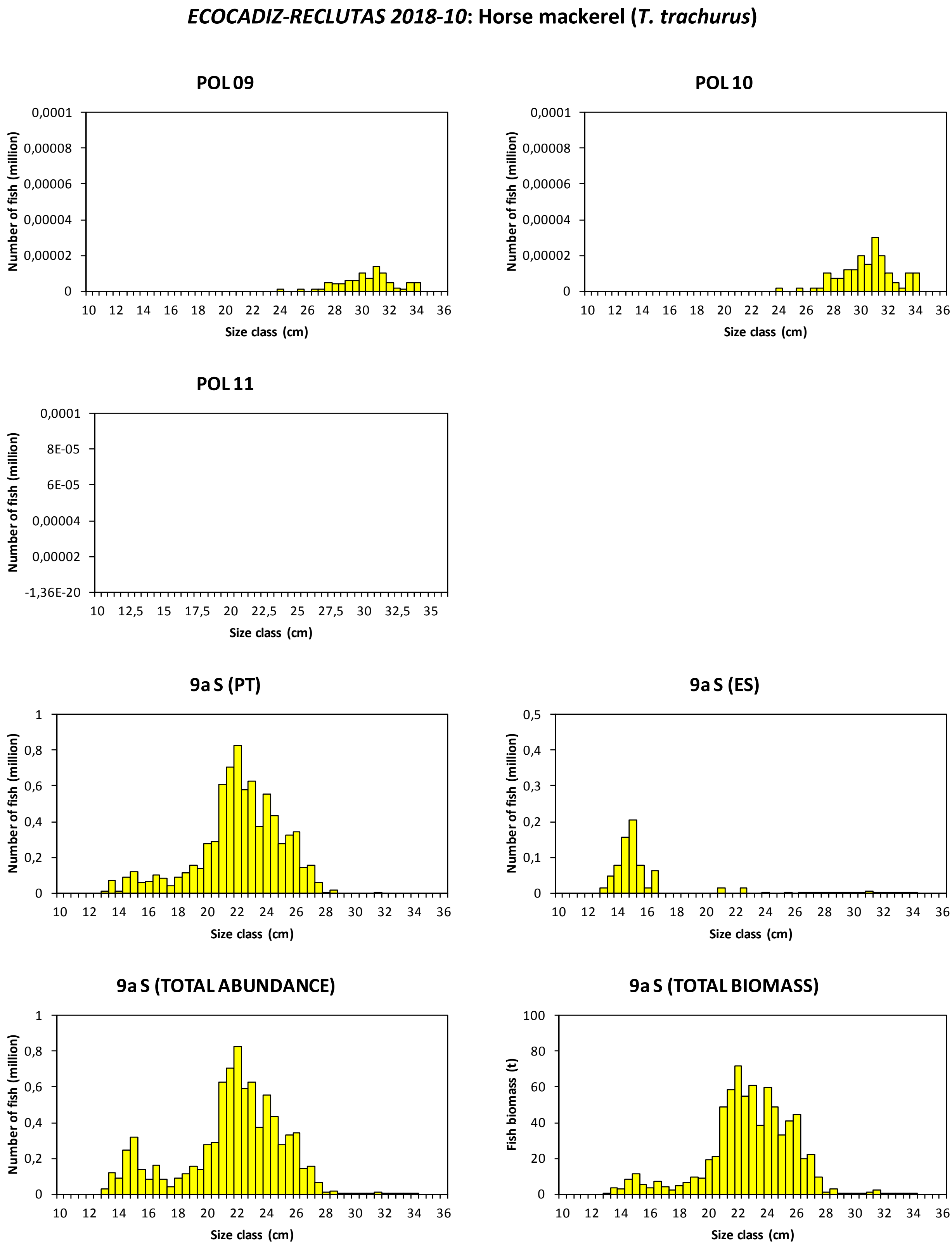
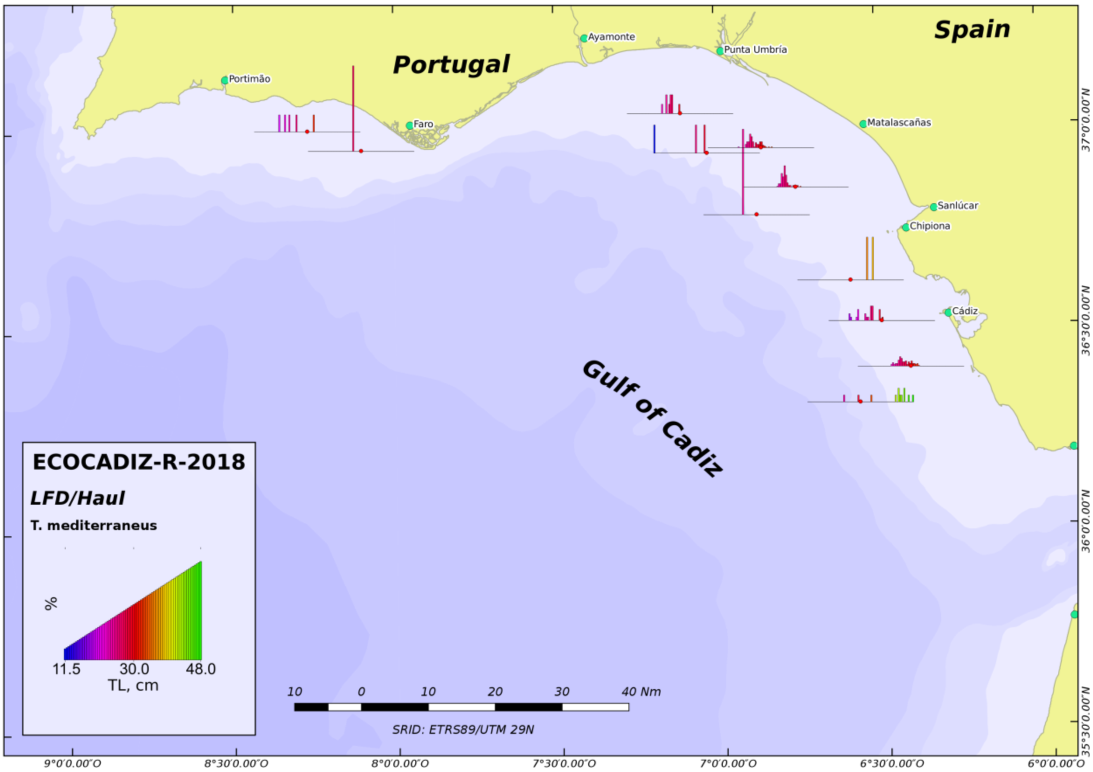


Figure 22. *ECOCADIZ-RECLUTAS 2018-10* survey. Horse mackerel (*Trachurus trachurus*). Cont'd.



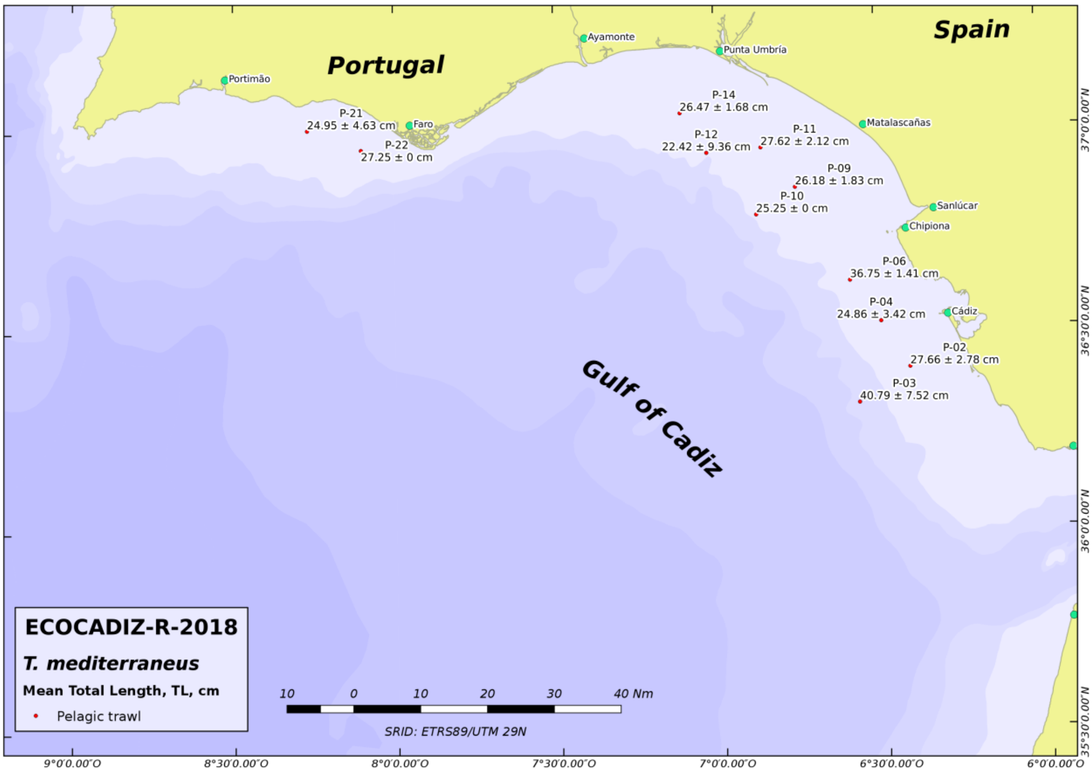
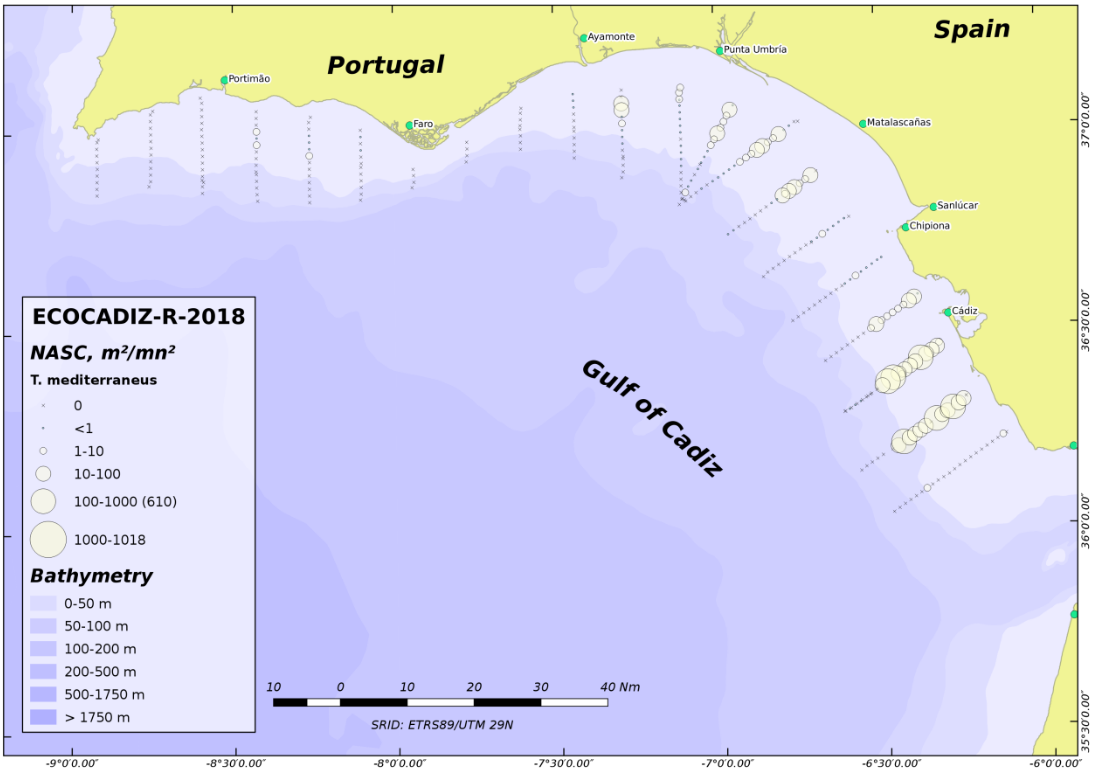


Figure 23. *ECOCADIZ-RECLUTAS 2018-10* survey. Mediterranean horse mackerel (*Trachurus mediterraneus*). Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.



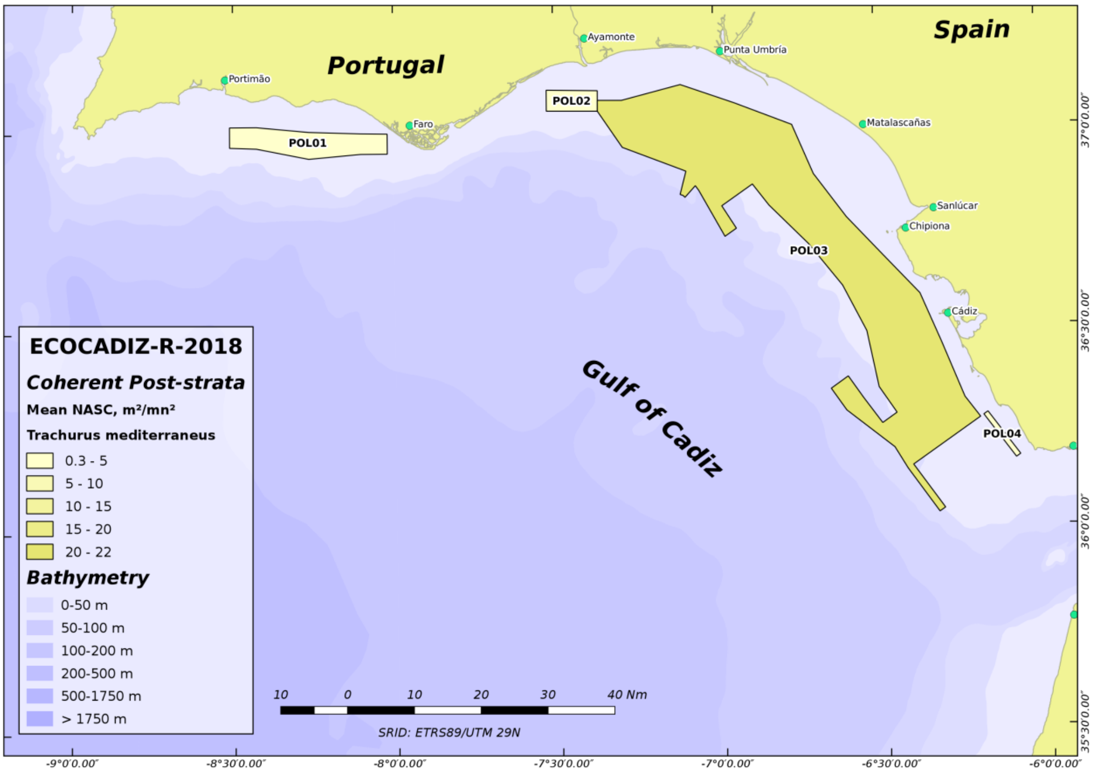


Figure 24. *ECOCADIZ-RECLUTAS 2018-10* survey. Mediterranean horse mackerel (*Trachurus mediterraneus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata 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 2018-10: Mediterranean horse mackerel (*T. mediterraneus*)

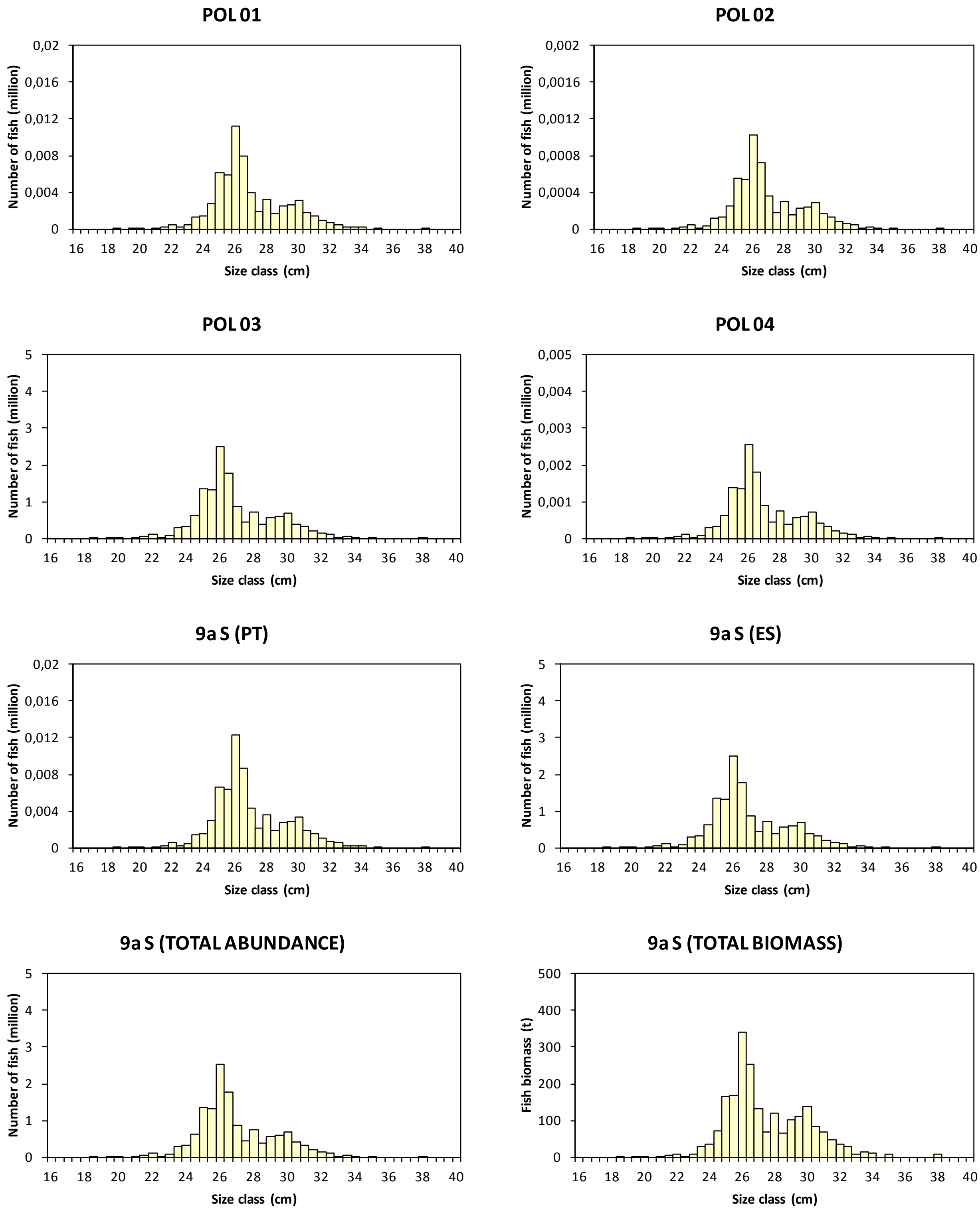


Figure 25. *ECOCADIZ-RECLUTAS 2018-10* survey. Mediterranean horse mackerel (*Trachurus mediterraneus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 24**) and total sampled area. Post-strata ordered in the W-E direction. 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.

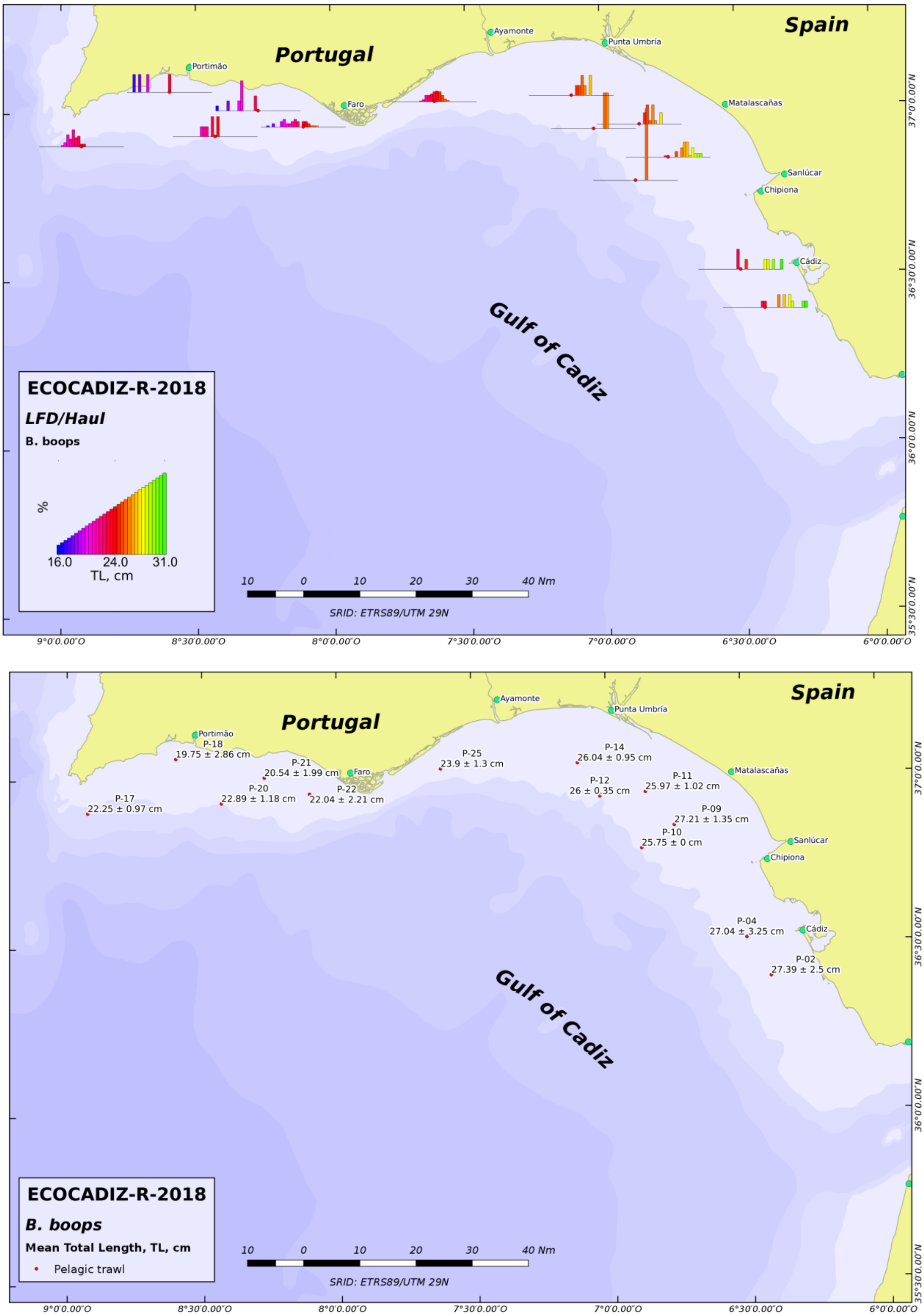


Figure 26. *ECOCADIZ-RECLUTAS 2018-10* survey. Bogue (*Boops boops*). Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

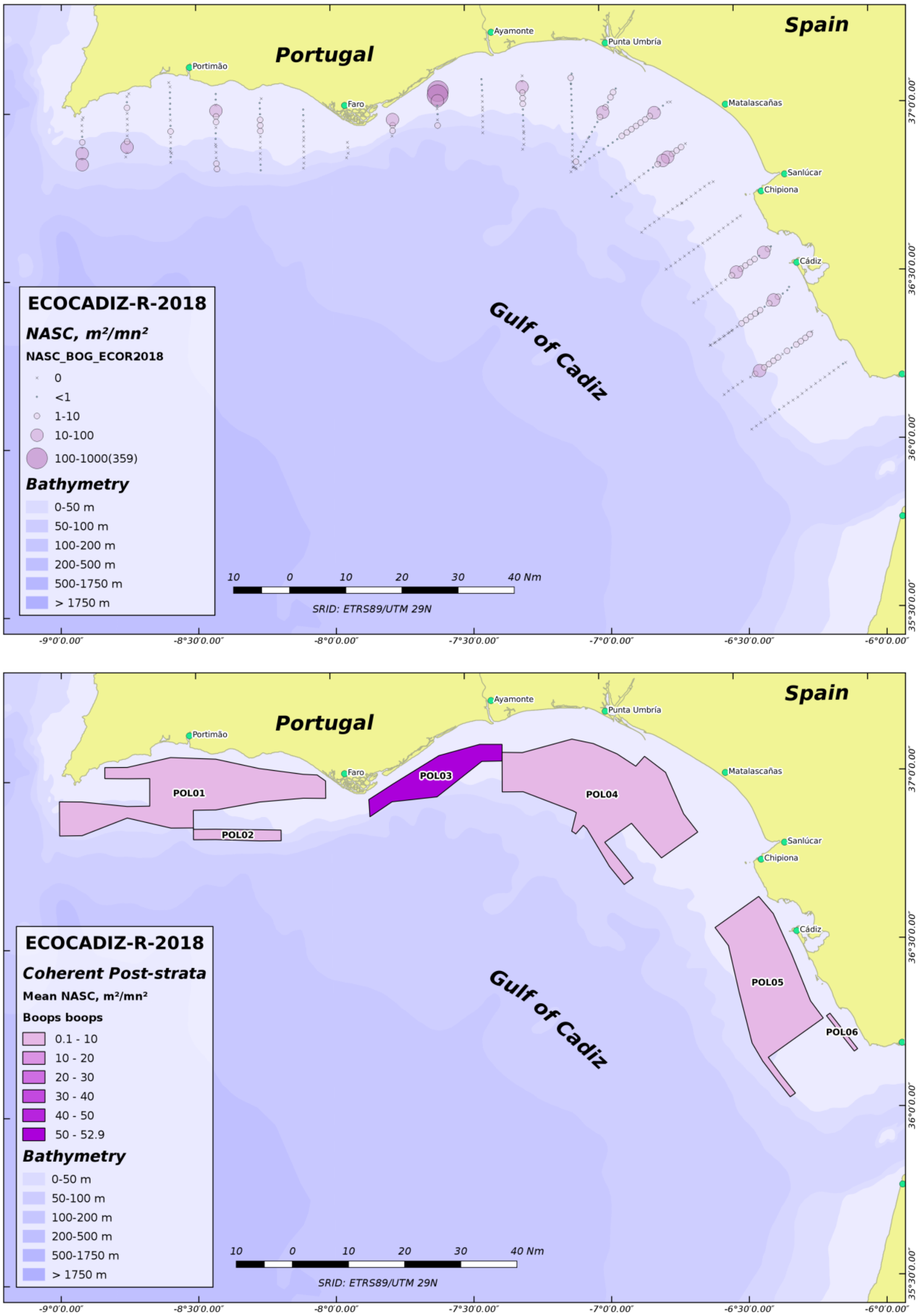


Figure 27. *ECOCADIZ-RECLUTAS 2018-10* survey. Bogue (*Boops boops*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

***ECOCADIZ-RECLUTAS 2018-10*: Bogue (*B. boops*)**

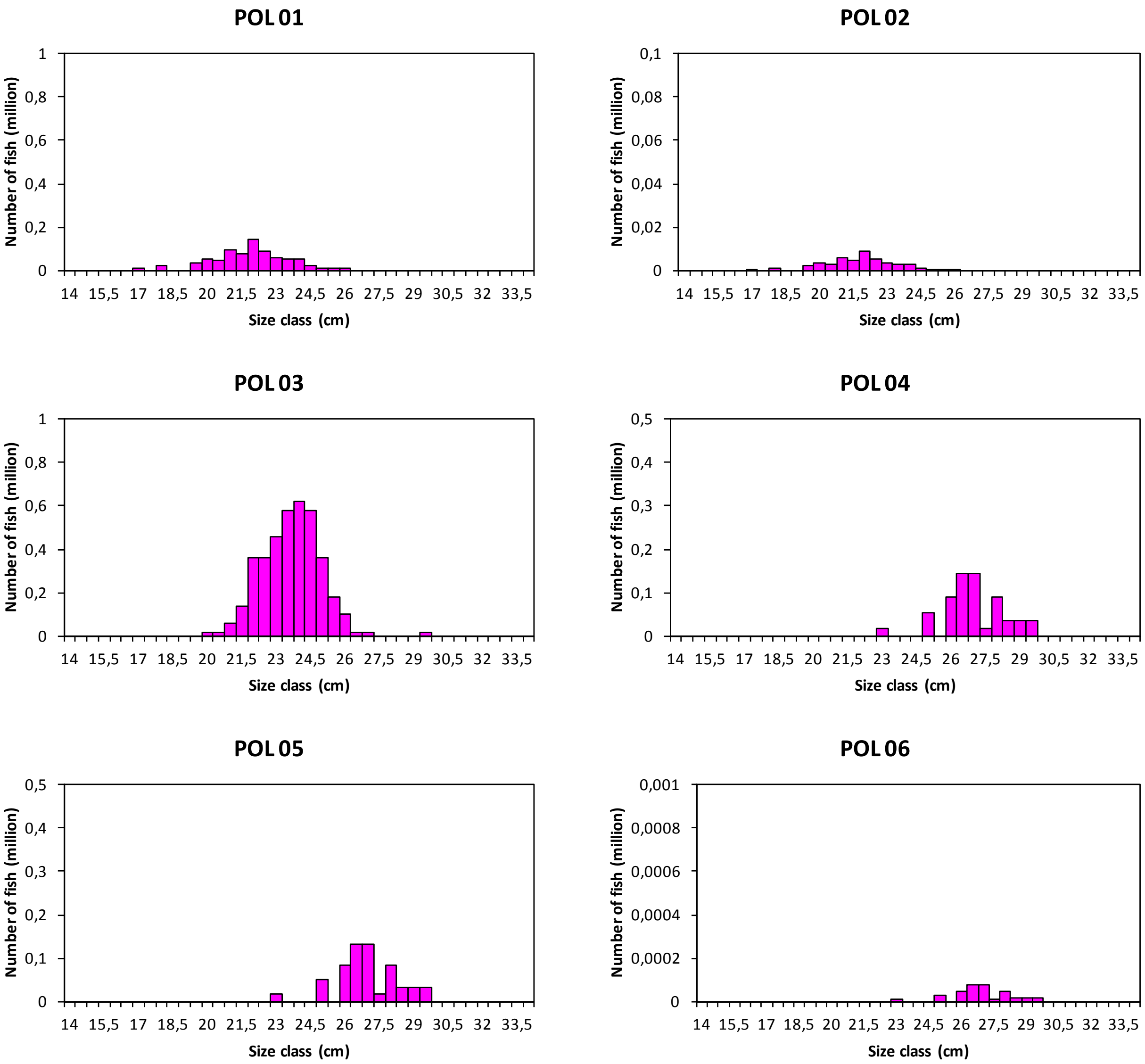


Figure 28. *ECOCADIZ-RECLUTAS 2018-10* survey. Bogue (*Boops boops*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 27**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

***ECOCADIZ-RECLUTAS 2018-10*: Bogue (*B. boops*)**

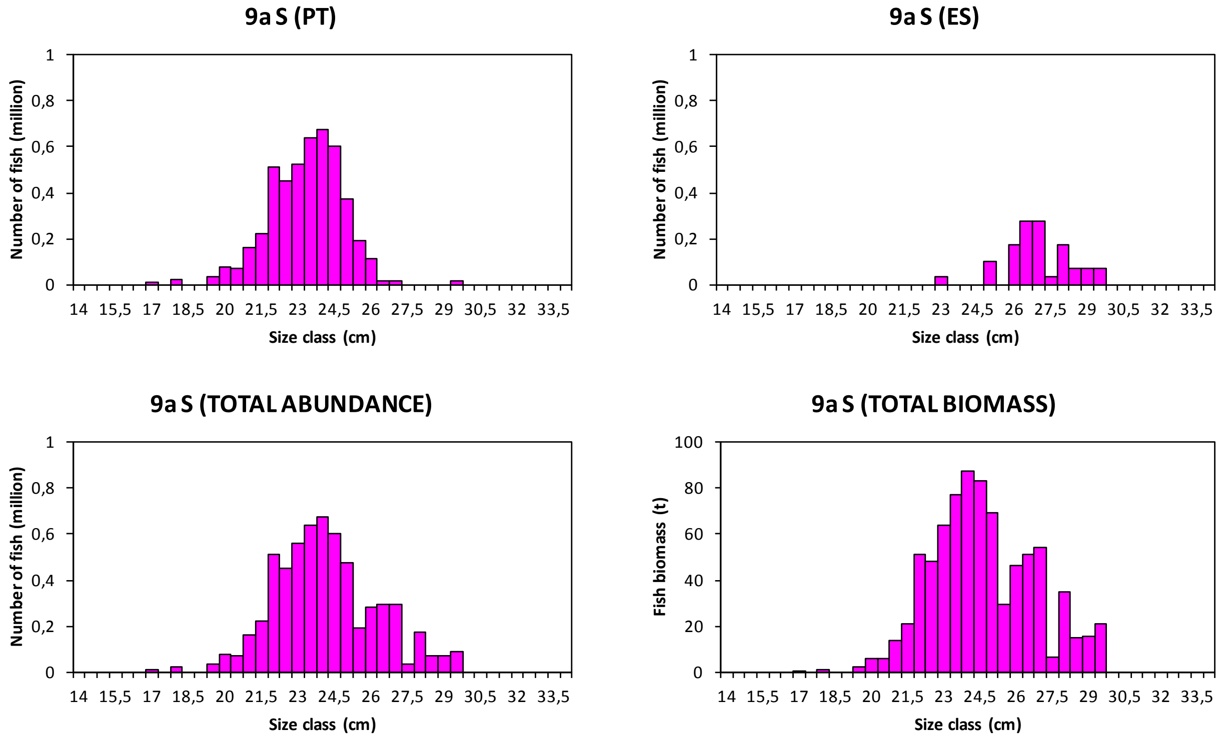
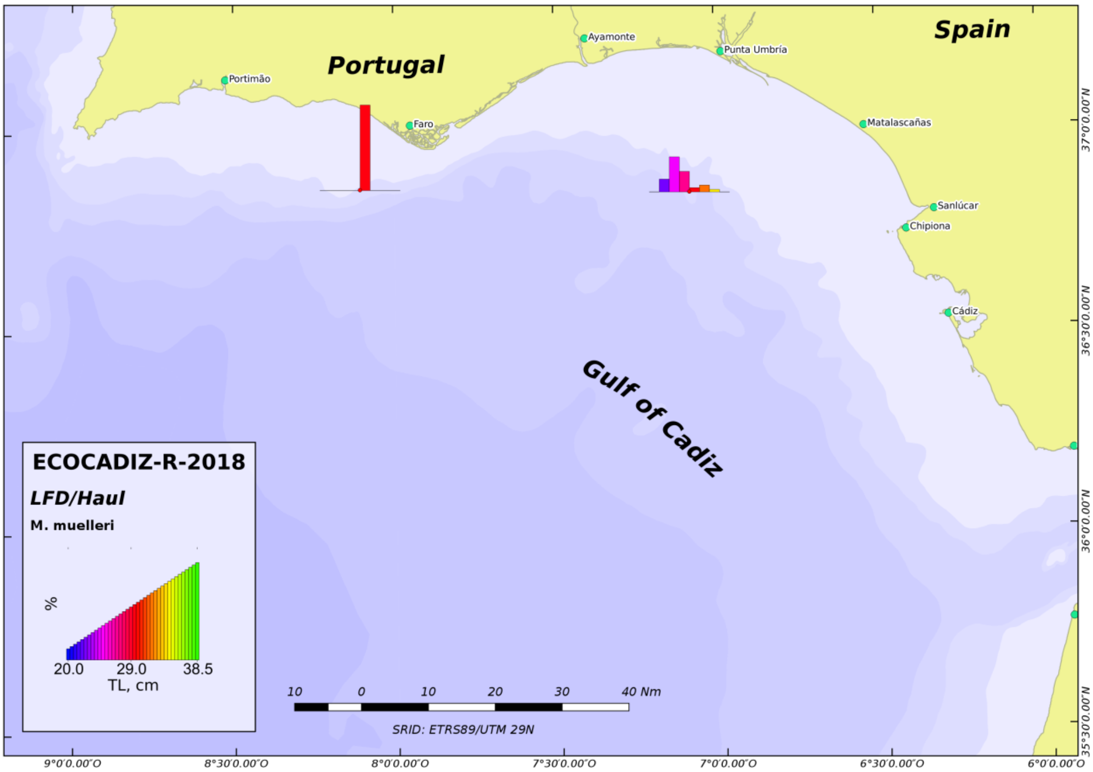


Figure 28. *ECOCADIZ-RECLUTAS 2018-10* survey. Bogue (*Boops boops*). Cont'd.



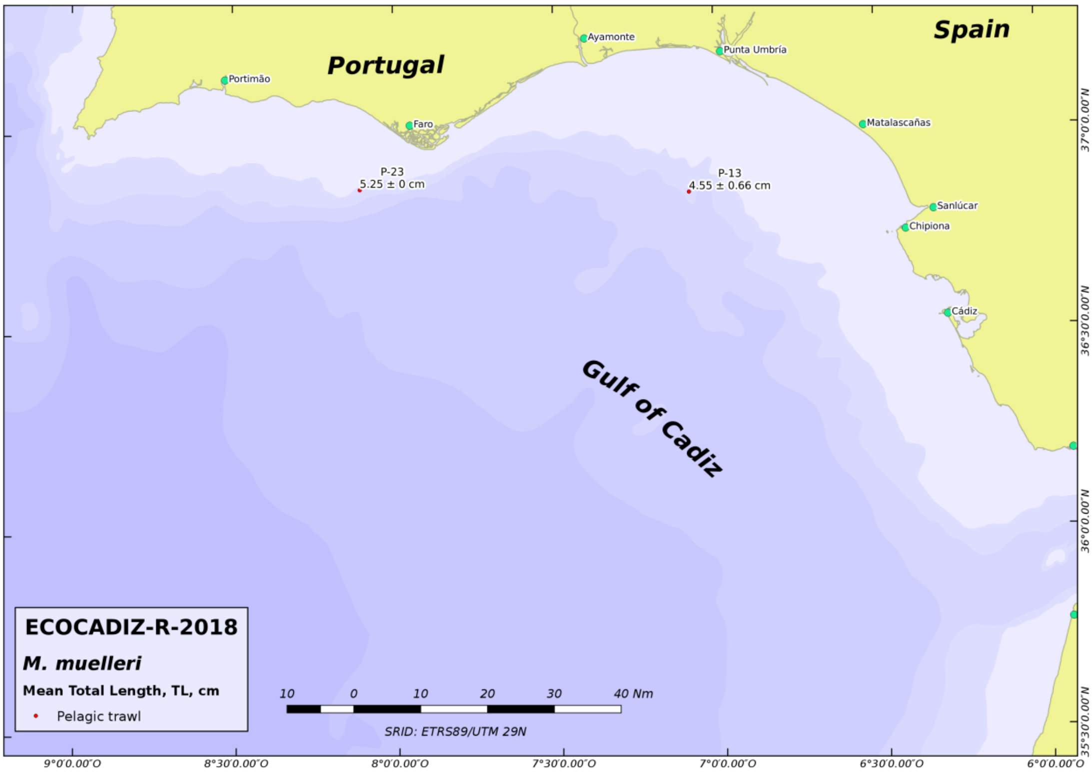


Figure 29. *ECOCADIZ-RECLUTAS 2018-10* survey. Pearlside (*Maurolicus muelleri*). Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

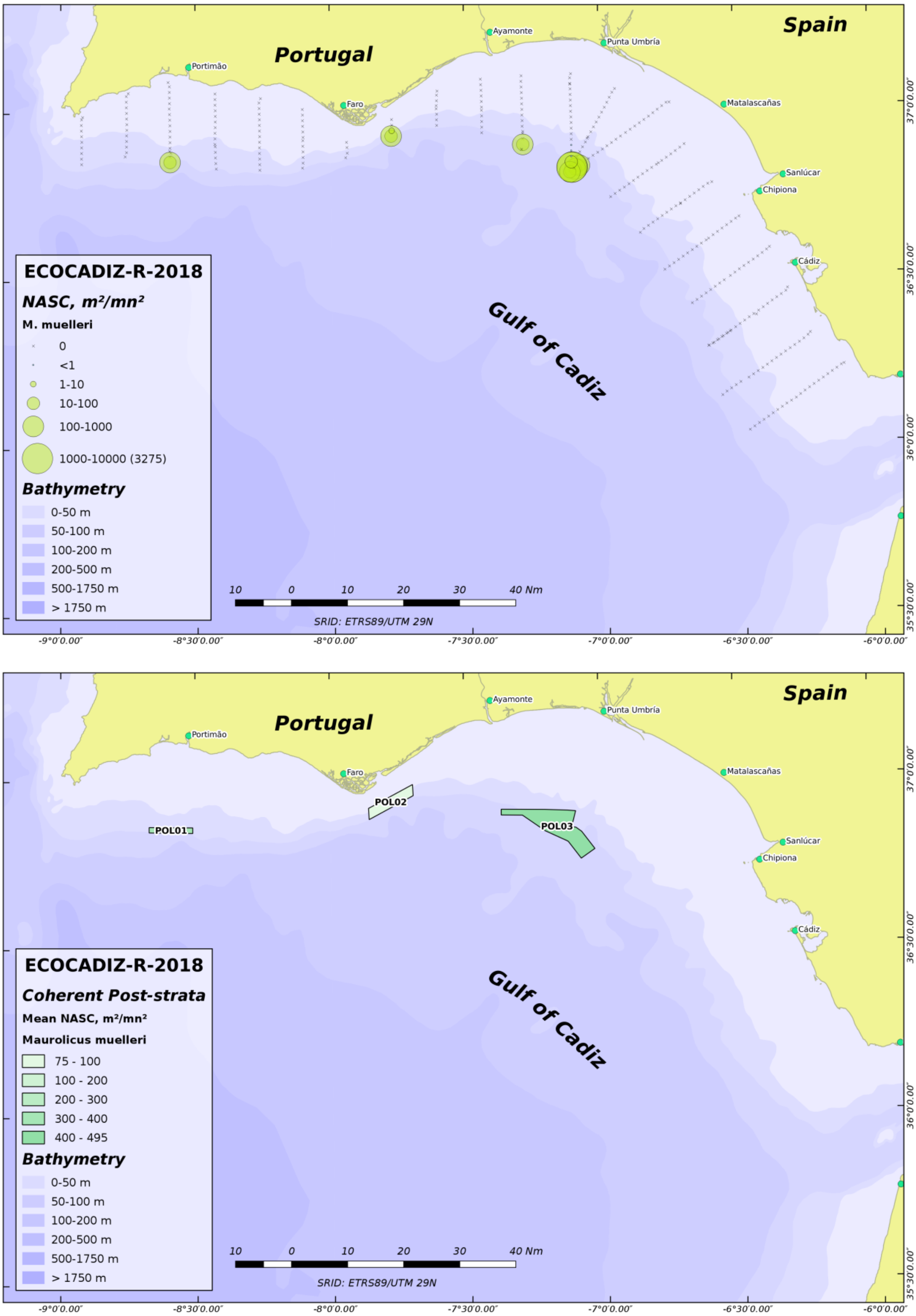


Figure 30. *ECOCADIZ-RECLUTAS 2018-10* survey. Pearlside (*Maurolicus muelleri*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

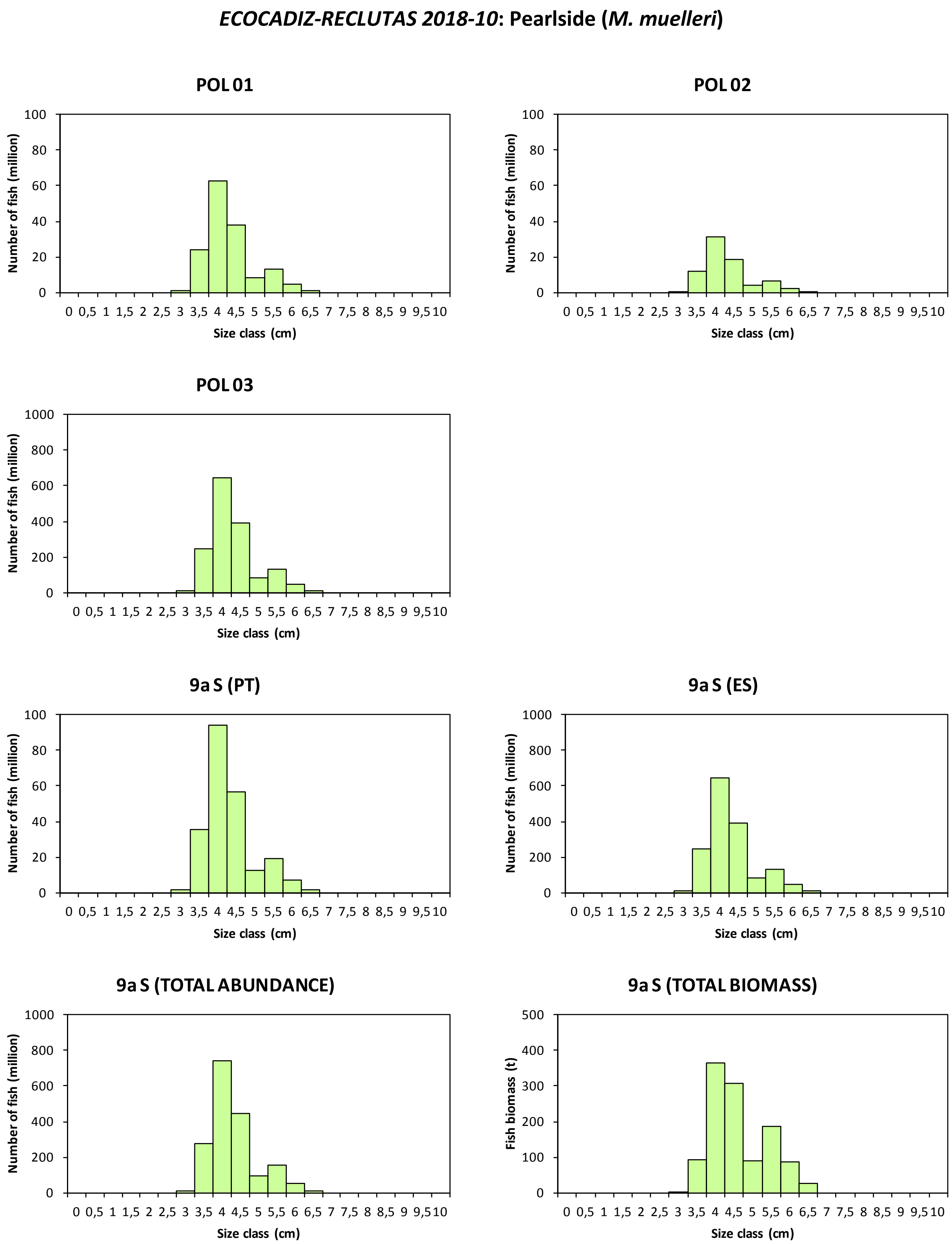
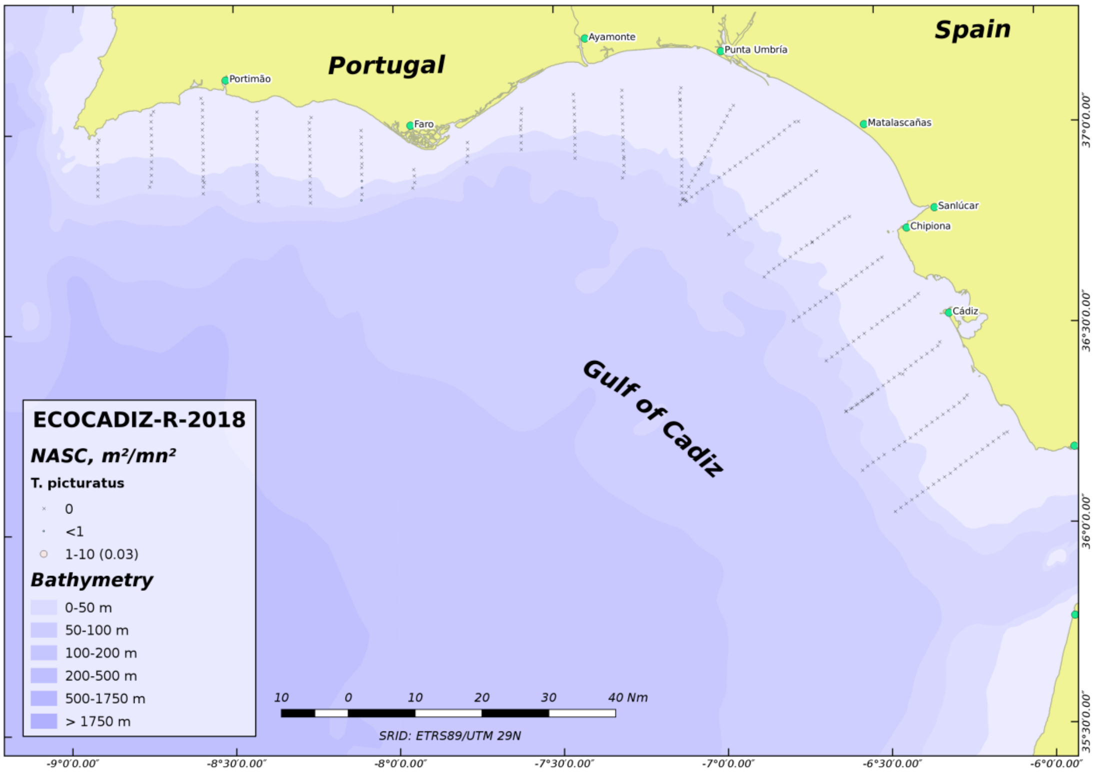


Figure 31. *ECOCADIZ-RECLUTAS 2018-10* survey. Pearlside (*Maurolicus muelleri*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 30**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.



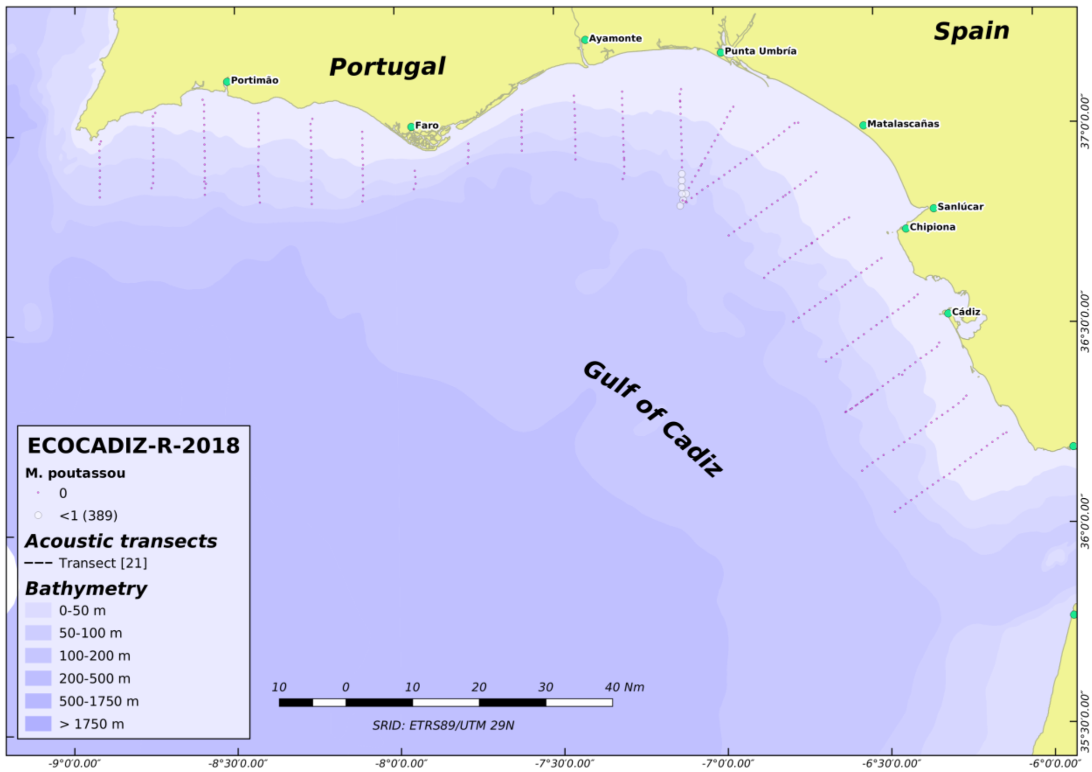
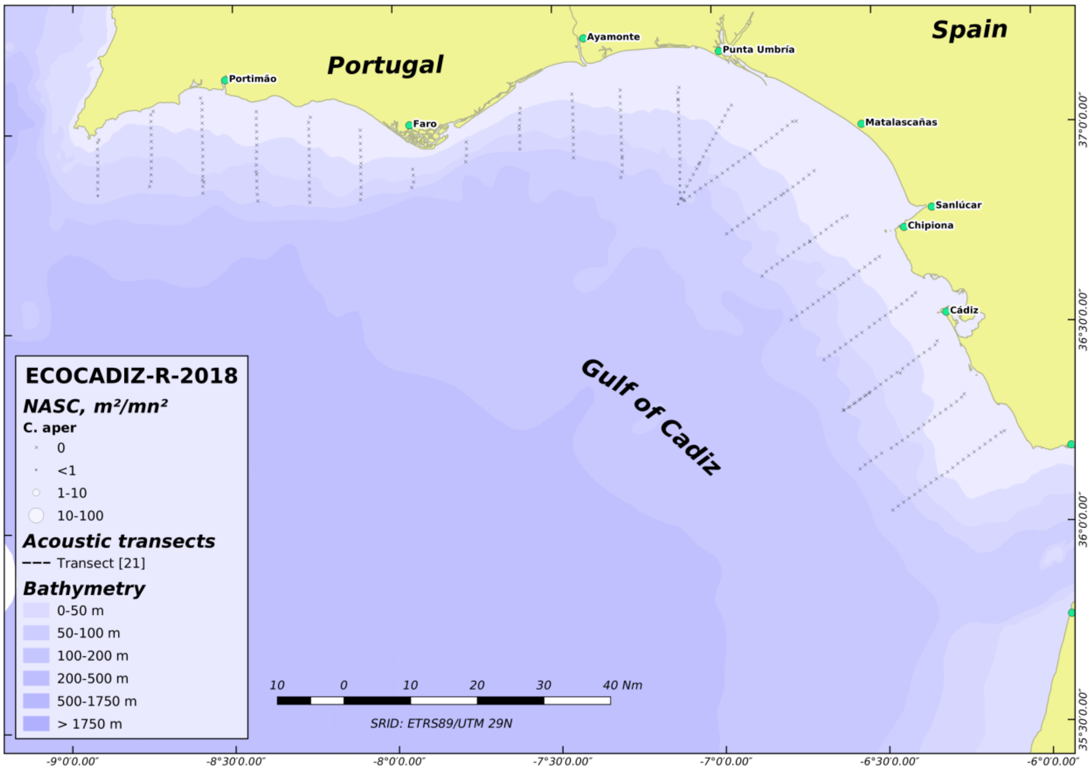


Figure 32. *ECOCADIZ-RECLUTAS 2018-10* survey. Distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to incidental species which have not been acoustically assessed. Top: Blue jack mackerel (*Trachurus picturatus*). Bottom: Blue whiting (*Micromesistius poutassou*).



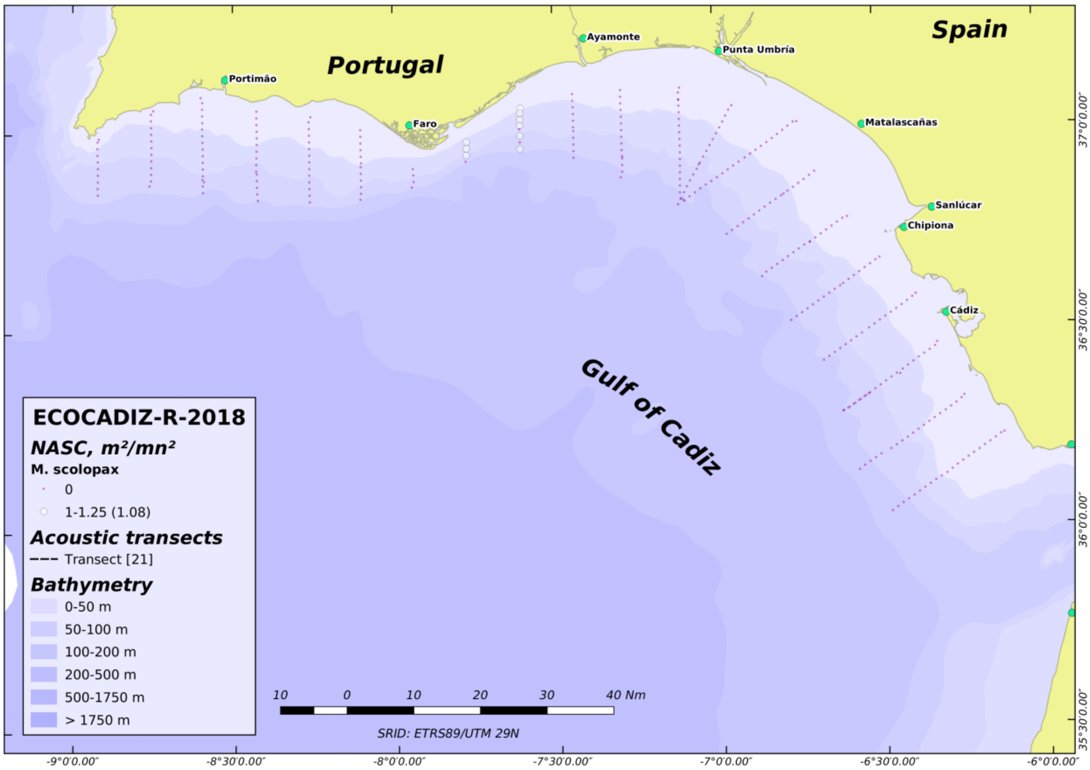


Figure 32. *ECOCADIZ-RECLUTAS 2018-10* survey. Cont'd. Top: Boarfish (*Capros aper*). Bottom: Snipefish (*Macrorhamphosus scolopax*).

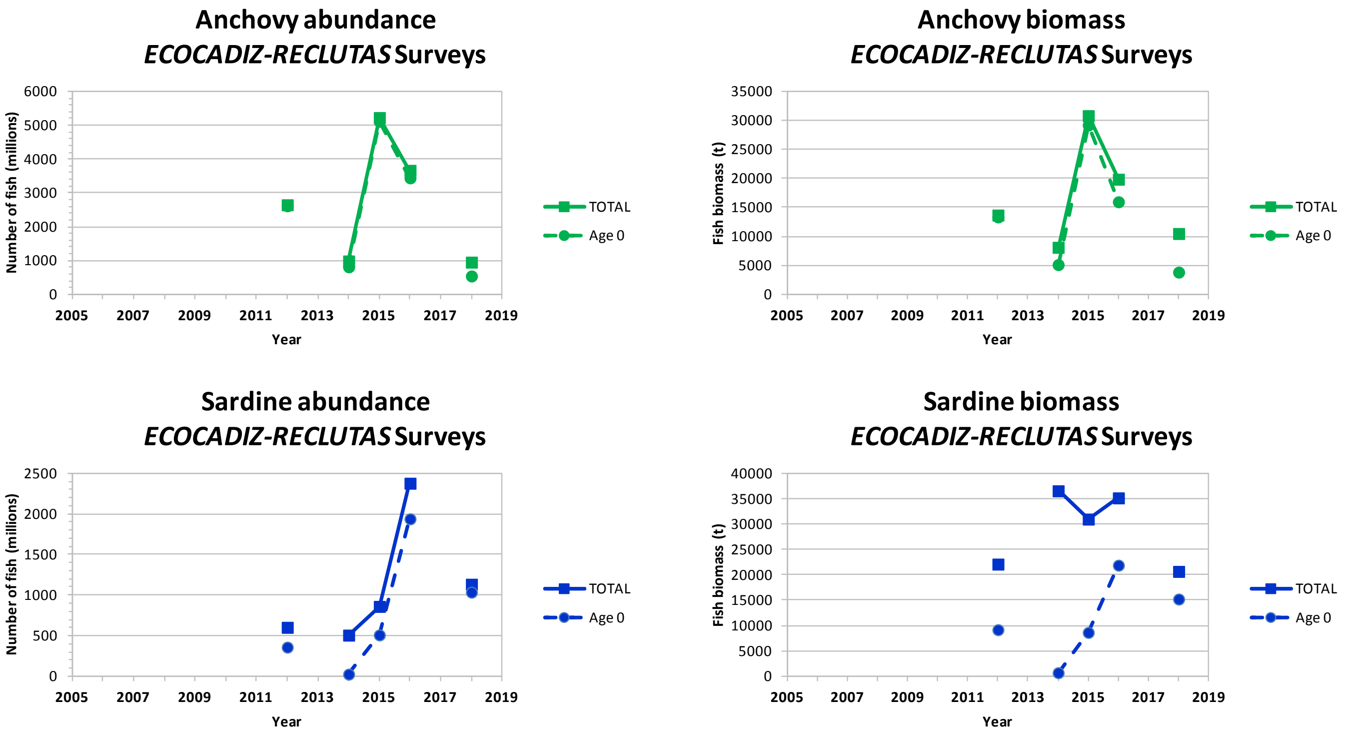


Figure 33. *ECOCADIZ-RECLUTAS* surveys series. Historical series of autumn acoustic estimates of anchovy and sardine abundance (million) and biomass (t) in Sub-division 9.a South. The estimates correspond to the total population and age 0 fish. The 2012 survey only surveyed the Spanish waters. No survey was conducted in 2013. Although a survey was conducted in 2017, the survey was interrupted for a serious breakdown of the vessel's propulsion system and no estimates were computed. The 2018 estimates should be considered with caution because a possible under-estimation (see text for details).

Working document presented in the ICES Working Group on Southern Horse Mackerel, Sardine and Anchovy (WGHANSA-1). By correspondence, 03-07 June 2019.

Report of the Age Calibration Exercise Analysis for Anchovy in Division 9a (IBERAS survey 2018) - IEO-IPMA Readers

Begoña Villamor(1), Susana Garrido(2), and Pablo Carrera(3), Ana Antolinez(1), Clara Dueñas-Liaño(1), Eduardo Soares(2)

(1) Instituto Español de Oceanografía (IEO), Centro Oceanográfico de Santander, Spain

(2) Instituto Português do Mar e da Atmosfera (IPMA), Portugal.

(3) Instituto Español de Oceanografía (IEO), Centro Oceanográfico de Santander, Spain

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1. Introduction

In November 2018, a new acoustic survey (IBERAS) coordinated by IEO and IPMA was carried out in order to estimate the strength of sardine and anchovy recruitment in the Atlantic waters of the Iberian Peninsula (ICES Division 9a) and to map its distribution area. As well as determine the main biological characteristics of these species in the area.

In January-February 2019, an otolith reading exercise was carried out on the anchovy from the survey to determine its age, with the objective of calibrating the age readings among the anchovy readers of the IEO and the IPMA, and estimating the accuracy and discrepancies in the determination of anchovy age among these readers. As well as, to obtain the age length keys of the survey.

2. Participants

A total of 3 readers were involved in the present Calibration, two of them from IEO (Spain) and the third from IPMA (IPMA).

The two readers of the IEO are experts in determining the age of the anchovy, but only one of them is an advanced reader (Advanced being those who provide age data for assessment purposes). The IPMA reader's experience in determining the age of the anchovy is intermediate, and he is also an advanced reader. In IPMA there are two new anchovy readers who have not participated in this calibration, since they still need a period of training, and for this a workshop will be included in May 2019 in the CO of Santander. The three readers participated in the last International Exchange of 2018, but nevertheless the reader of the IPMA did not participate in the last workshop of 2016 (ICES WKARA2), where the current criteria for determining the age of the anchovy were standardized and implemented. A list of the participants with a summary about their experience in age estimation of anchovy and the area where they are readers is shown in the **Table 2.1**.

3. Material and Methods

A set the 334 otoliths of anchovy distributed in Atlantic waters of Iberian Peninsula (ICES Division 9a) from the IBERAS 2018 survey were reading and analyzed (**Tabla 3.1**)

Tabla 3.1. Overview of samples used of Anchovy calibration

Division 9a	Number of Otoliths	Size range	Month
Central-South (9a-CS)	30	100-162 mm	November
Central North (9a-CN)	304	107-183 mm	November
Whole area	334	100-183 mm	November

For the analysis of the results, AGE COMPARISON excel workbook (Eltink, 2000) has been used and the analysis has been made for the whole area, since the number of otoliths in the Subdivision 9a CS was very small.

Table 2.1. Participants and qualification of readers.

**Advanced being those who provide age data for assessment purposes and basic if they do not*

Country	Participants in this calibration 2019 (preliminary list, contact person in bold)	Email	Age reading expertise: Trainee / Intermediate / Expert	Reads for assessment (Yes/No)	Level of expertise in Smartdots (Advanced/ Basic)*	Anchovy Stock/Area of Expertise	Participation in Workshop 2016 (Yes/No)	Participation in Exchange 2018 (Yes/No)	Final Paticipation in this Calibration and reader code
Spain-IEO	**Begoña Villamor**	begona.villamor@ieo.es	Coordinator	Yes	Advanced	Bay of Biscay (Subarea 8) and Sub-Division 9a North	Yes (Co-chair)	Yes (coordinator)	Yes (coordinator)
	Clara Dueñas	clara.duenas@ieo.es	Expert	Yes	Advanced		Yes	Yes	Yes- R01 (CD)
	Ana Antolinez	ana.antolinez@ieo.es	Expert	No	Basic		Yes	Yes	Yes- R03 (AA)
Portugal - IPMA	**Eduardo Soares**	esoares@ipma.pt	Intermediate	yes	Advanced	Portuguese Coast (Sub-Divs. IXa CN, CS and S)	No	Yes	Yes- R02 (ES)
	Raquel Milhazes	rmilhazes@ipma.pt	Trainee	No	Basic		No	Yes	No
	Diana Feijó	dfeijo@ipma.pt	Trainee	No	Basic		No	Yes	No

4. Results

Analyses were performed for the total area. Overall age reading results for each otolith and reader are shown in **Annex 1**. From the total of 334 otoliths of anchovy two readers analyzed 332 otoliths and one reader analyzed 318.

The weighted average percentage agreement (PA) based on modal ages for all readers and samples are 93.4 %, with the weighted average CV of 8.4 % (**Table 4.1**). Most of the anchovy otoliths were well classified by the readers during the 2019 calibration, with a good agreement and precision. 267 out of the 334 otoliths reached 100% of agreement

Table 4.1 shows the PA, CV and Bias by age. The best agreements are reached for age 0 (91%) and age 1 (95.8%), and the lowest agreement for age 2 (75%). No individuals over 2 years of age were assigned in the sample.

The analysis including all age readers revealed a low coefficient of variation (CV) of 8.4% (**Table 4.1**). Lowest CVs were revealed for modal age group 1 (5.9%). CV peaked at 25.8% for modal age 2 (the CV was not calculated at age 0) and it shows a negative bias in age 2, which means that some readers assign younger ages.

Table 4.1. Summary of the average percentage of agreement (PA), Coefficient of variation (CV) and relative bias by age.

Modal Age	Otolith N	CV	% Agreement	Bias
0	70		91.9%	0.08
1	236	5.9%	95.8%	0.03
2	26	25.8%	75.0%	-0.25
3		-	-	-
4		-	-	-
5		-	-	-
Total	**332**	**8.4%**	**93.4%**	**0.02**

Figure 4.1 shows age bias plots for each reader. Some deviations from the modal age (solid line) can be seen in the Reader 2 for the age 2.

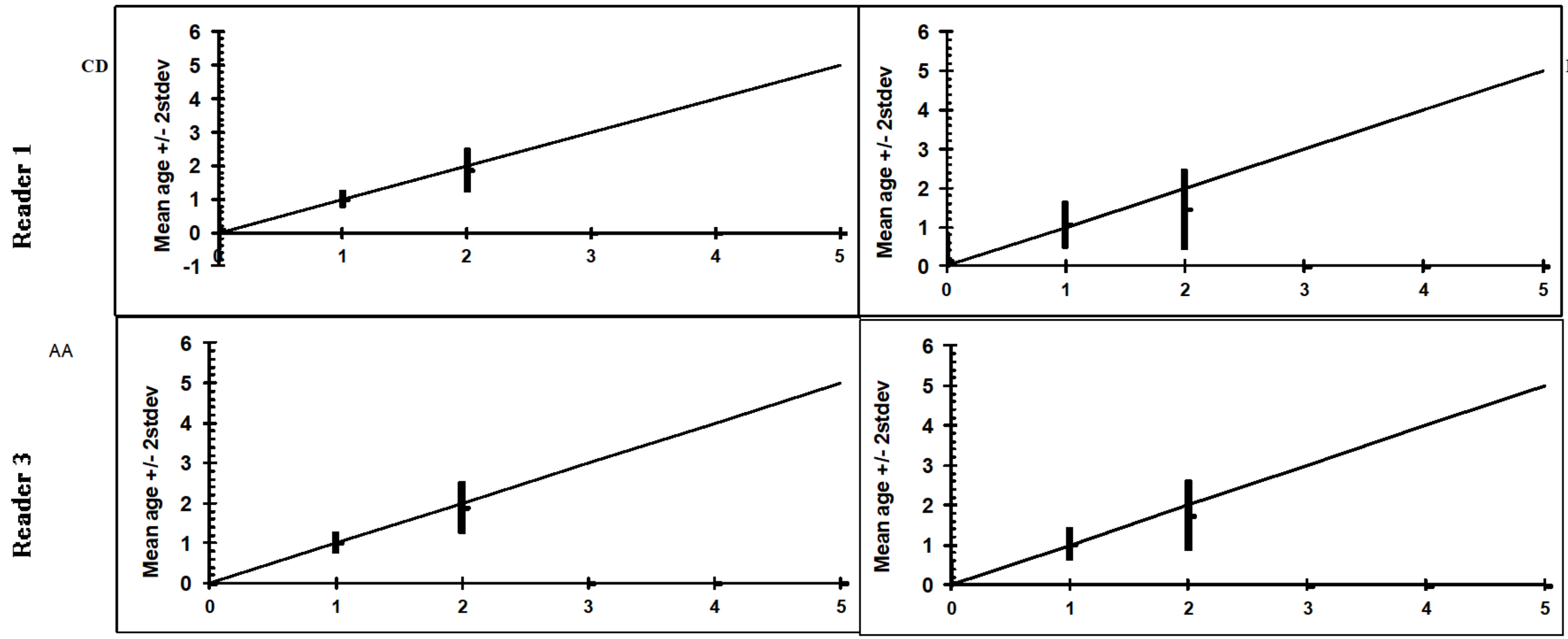

Figure 4.1. Age bias plot for each reader and all readers. Mean age recorded +/- 2 stdev of each reader and all readers combined are plotted against modal age by group. The estimated mean age corresponds to modal age when the estimated mean age is on the 1:1 equilibrium line (solid line). Relative bias is the age difference between estimated mean age and modal age.

The agreement of each reader with the modal age is higher than 86%, reaching the reader 3 (AA) to the highest agreement with the modal age (97.6%). Among readers, the advanced readers (CD and ES) have an agreement between them of 81%, and the reader 3 (AA) has an agreement of 94% with the reader of the same laboratory (CD) and drops to 84% with the Advanced reader of Portugal (ES). Another fact is that there are no signal biases of each reader with the modal age and neither between them, which means that they have a good precision in the determination of the age of the anchovy in the studied area (**Table 4.2**).

Table 4.2. Inter-reader bias test and reader against modal age bias test. Advanced readers in red color: Advanced being those who provide age data for assessment purposes.

	CD Reader 1	ES Reader 2	AA Reader 3
Reader 1	**95.8**	**-**	**-**
Reader 2	**81.8**	**86.2**	**-**
Reader 3	**94.0**	**84.3**	**97.9**
MODAL age	**-**	**-**	**-**

-	**= no sign of bias (p>0.05)**
*****	**= possibility of bias (0.01<p<0.05)**
*** ***	**= certainty of bias (p<0.01)**
	= percentage of reading agreement between each reader and the MODAL age

Individual otolith cases of disagreement and their examination is shown in **Annex 2**. This Annex show images of otoliths resulting in divergent annotations/interpretations. In **Annex 3** of this report the synoptic table from WKARA2 has been added to facilitate the understanding of the anchovy growth pattern.

5. Conclusions

- In general, it can be said that in view of the results (high agreements, low CV and without biases) of this Calibration the three readers apply well the current age determination criteria updated in the last workshop of the anchovy age (ICES WKARA2, 2016).

- Taking as reference the Bay of Biscay anchovy where several workshops and exchanges have regularly taken place (since 1989) (and age validations are achieved), WKARA2 suggested threshold values of agreements around 80% and of CVs around 20% in the training process as a minimum for age readers to be operative to deliver inputs for assessment. And targets should be for agreements above 90% and CV of 10% or less. The results of this Calibration among of these readers are in the levels of the objectives of agreement and CV suggested by WKARA2.
- The three readers have achieved higher agreements and lower CVs in this Calibration than in the last International Exchange of anchovy in the Bay of Biscay in 2018 (Villamor et al., 2019), especially noted the improvement of the IPMA reader. In 2018 Exchange, the two readers of the IEO had a PA above 90% (91 and 92% respectively with the modal age) and a CV of 15% and the IPMA reader had a PA of 76% and CV 21%.
- If we compare this Calibration with the results of the 2014 international exchange of the anchovy from the same area (Division 9a), we see that the improvement is great for the three readers (in 2014, PA between 45 and 71% and CV between 34 and 37% with respect to modal age) (Villamor et al., 2015).
- The biggest discrepancies found in this Calibration were in age 2. This is mainly due to the fact that in some cases the false spawn ring that deposits the anchovy in summer is confused with the annual winter ring (See **Annex 2**).
- The greatest agreements in this Calibration were found between the IEO readers (CD and AA), and this is logical since they are from the same laboratory, and therefore they present a good consistency in their readings.
- It is recommended to continue and follow the protocols and criteria for the interpretation of anchovy age in all areas proposed in WKARA-2.
- We recommend the readers to review and read the WKARA2 report (where there are many examples) and to review the collection of otoliths of reference which is in the Age Reader's Forum website (https://community.ices.dk/ExternalSites/arf/default.aspx) in the folder called 'Engraulis encrasicolus Otolith Reference Collection'.

- In WKARA2 after discussing and recognizing the reasons for the discrepancies, the following conclusions were reached for the interpretation of an otolith of anchovy:

- Try not to look at the size of the fish: see the structure of the otolith and growth pattern;

- Next try to interpret the otolith: What winter hyaline rings can be recognized resulting in a coherent growth pattern? How much has the edge grown throughout the year until its capture? Do the resulting annual growth pattern and edge formation match with known pattern of otolith growth and seasonality of edge formation by ages respectively?

- If a coherent interpretation is achieved then apply the age allocation rule corresponding to the adopted birthdates for the population (in our case first of January), if not try another interpretation or discard the otolith.

- For the application of the ageing rules, it is compulsory to use the number of winter translucent rings recognized (after interpretation), rather than the total number of hyaline marks seen (which may include some checks).

6. References

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7. Annex 1. Additional results

Table 1 — **Anchovy Otolith 9a (Campaña IBERAS 2018**

Stratum	Sample year	Sample no	h SmartD no	Fish length	Sex	Landing month	CD Reader 1	ES Reader 2	AA Reader 3	RANGE r. 1-5 MODAL age	Percent agreement	Precision CV
ocs	06/11/2018	AP.10	1	10.0		11	0	0	0	0	100%	
ocs	06/11/2018	AP.10	2	10.1		11	0	0	0	0	100%	
ocs	06/11/2018	AP.10	3	10.1		11	0	0	0	0	100%	
ocs	06/11/2018	AP.10	4	10.1		11	0	0	0	0	100%	
ocs	06/11/2018	AP.10	5	10.6		11	0	0	0	0	100%	
ocs	06/11/2018	AP.10	6	10.5		11	0	0	0	0	100%	
ocs	06/11/2018	AP.10	7	10.6		11	0	0	0	0	100%	
ocs	06/11/2018	AP.10	8	11.3		11	1	0	1	1	67%	87%
ocs	06/11/2018	AP.10	9	11.4		11	0	1	0	0	67%	
ocs	06/11/2018	AP.10	10	11.3		11	0	1	0	0	67%	
ocs	06/11/2018	AP.10	11	11.8		11	1	1	1	1	100%	0%
ocs	06/11/2018	AP.10	12	11.9		11	0	0	0	0	100%	
ocs	06/11/2018	AP.10	13	11.9		11	0	1	0	0	67%	
ocs	06/11/2018	AP.10	14	11.5		11	1	1	1	1	100%	0%
ocs	06/11/2018	AP.10	15	11.5		11	0	1	0	0	67%	
ocs	06/11/2018	AP.10	16	11.7		11	0	1	0	0	67%	
ocs	06/11/2018	AP.10	17	11.7		11	0	1	0	0	67%	
ocs	06/11/2018	AP.10	18	11.8		11	0	1	0	0	67%	
ocs	06/11/2018	AP.10	19	12.2		11	1	1	1	1	100%	0%
ocs	06/11/2018	AP.10	20	12.1		11	0	1	0	0	67%	
ocs	06/11/2018	AP.10	21	12.2		11	0	1	0	0	67%	
ocs	06/11/2018	AP.10	22	12.3		11	0	0	0	0	100%	0%
ocs	06/11/2018	AP.10	23	12.4		11	1	1	1	1	100%	0%
ocs	06/11/2018	AP.10	24	12.2		11	1	1	1	1	100%	0%
ocs	06/11/2018	AP.10	25	12.6		11	1	0	1	1	67%	87%
ocs	06/11/2018	AP.10	26	12.8		11	1	1	1	1	100%	0%
ocs	06/11/2018	AP.10	27	13.0		11	1	1	1	1	100%	0%
ocs	06/11/2018	AP.10	28	15.2		11	1	2	1	1	67%	43%
ocs	06/11/2018	AP.10	29	16.2		11	1	1	1	1	100%	0%
ocs	06/11/2018	AP.10	30	16.2		11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.14	1	12.4		11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.14	2	11.9		11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.14	3	12.6		11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.14	4	12.9		11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.14	5	13.9		11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.14	6	13.9		11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.14	7	13.8		11	1	2	1	1	67%	43%
ocn	14/11/2018	AP.14	8	13.3		11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.14	9	14.1		11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.14	10	14.4		11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.14	11	14.2		11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.14	12	14.3		11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.14	13	14.2		11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.14	14	14.3		11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.14	15	13.4		11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.14	16	13.5		11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.14	17	13.8		11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.14	18	14.0		11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.14	19	14.8		11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.14	20	14.6		11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.14	21	14.9		11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.14	22	14.9		11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.14	23	14.9		11	2	1	1	1	67%	43%
ocn	14/11/2018	AP.14	24	14.8		11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.14	25	14.5		11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.14	26	14.6		11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.14	27	14.7		11	1	1	2	1	67%	43%
ocn	14/11/2018	AP.14	28	14.9		11	2	1	2	2	67%	35%
ocn	14/11/2018	AP.14	29	15.7		11	2	1	2	2	67%	35%
ocn	14/11/2018	AP.14	30	15.6		11	2	1	1	1	67%	43%
ocn	14/11/2018	AP.14	31	15.9		11	2	1	2	2	67%	35%
ocn	14/11/2018	AP.14	32	15.0		11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.14	33	15.2		11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.14	34	15.3		11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.14	35	15.4		11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.14	36	14.4		11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.14	37	15.9		11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.14	38	15.7		11	2	1	2	2	67%	35%
ocn	14/11/2018	AP.14	39	15.8		11	2	1	2	2	67%	35%
ocn	14/11/2018	AP.14	40	15.9		11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.14	41	15.3		11	2	1	1	1	67%	43%
ocn	14/11/2018	AP.14	42	15.4		11	2	1	2	2	67%	35%

ocn	14/11/2018	AP.14	43	15.1	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.14	44	15.5	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.14	45	15.3	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.14	46	16.0	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.14	47	16.0	11	1	1	2	1	67%	43%
ocn	14/11/2018	AP.14	48	16.4	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.14	49	16.5	11	2	1	2	2	67%	35%
ocn	14/11/2018	AP.14	50	16.6	11	1	1	2	1	67%	43%
ocn	14/11/2018	AP.14	51	16.8	11	2	1	2	2	67%	35%
ocn	14/11/2018	AP.14	52	17.0	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.14	53	17.6	11	2	1	2	2	67%	35%
ocn	14/11/2018	AP.14	54	18.2	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.15	1	10.8	11	0	1	0	0	67%	173%
ocn	14/11/2018	AP.15	2	11.4	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.15	3	11.3	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.15	4	11.4	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.15	5	11.4	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.15	6	11.8	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.15	7	11.9	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.15	8	12.3	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.15	9	12.0	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.15	10	12.3	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.15	11	12.8	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.15	12	12.7	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.15	13	12.6	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.15	14	12.5	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.15	15	12.6	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.15	16	12.9	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.15	17	13.3	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.15	18	13.0	11	-	-	-			
ocn	14/11/2018	AP.15	19	13.2	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.15	20	13.1	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.15	21	13.3	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.15	22	13.0	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.15	23	13.4	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.15	24	13.6	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.15	25	13.8	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.15	26	13.6	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.15	27	13.9	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.15	28	13.6	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.15	29	13.8	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.15	30	13.6	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.15	31	13.7	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.15	32	13.8	11	1	-	1	1	100%	0%
ocn	14/11/2018	AP.15	33	14.4	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.15	34	14.1	11	1	-	1	1	100%	0%
ocn	14/11/2018	AP.15	35	14.2	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.15	36	14.0	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.15	37	14.2	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.15	38	14.1	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.15	39	14.9	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.15	40	14.8	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.15	41	14.7	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.15	42	14.8	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.15	43	14.7	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.15	44	15.0	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.15	45	15.2	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.15	46	15.5	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.15	47	15.6	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.15	48	15.5	11	2	1	2	2	67%	35%
ocn	14/11/2018	AP.15	49	16.8	11	2	-	1	2	50%	47%
ocn	14/11/2018	AP.15	50	17.6	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.16	1	14.3	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.16	2	14.4	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.16	3	14.9	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.16	4	14.8	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.16	5	14.5	11	2	2	1	2	67%	35%
ocn	14/11/2018	AP.16	6	14.9	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.16	7	14.8	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.16	8	14.8	11	2	1	2	2	67%	35%
ocn	14/11/2018	AP.16	9	14.9	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.16	10	14.9	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.16	11	14.9	11	2	1	2	2	67%	35%
ocn	14/11/2018	AP.16	12	14.8	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.16	13	14.9	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.16	14	14.9	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.16	15	15.3	11	2	2	2	2	100%	0%
ocn	14/11/2018	AP.16	16	15.3	11	1	2	1	1	67%	43%
ocn	14/11/2018	AP.16	17	15.4	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.16	18	15.4	11	1	2	1	1	67%	43%
ocn	14/11/2018	AP.16	19	15.3	11	1	2	1	1	67%	43%
ocn	14/11/2018	AP.16	20	15.2	11	1	2	1	1	67%	43%
ocn	14/11/2018	AP.16	21	15.3	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.16	22	15.3	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.16	23	15.8	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.16	24	15.9	11	2	2	2	2	100%	0%
ocn	14/11/2018	AP.16	25	15.6	11	1	2	2	2	67%	35%
ocn	14/11/2018	AP.16	26	15.6	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.16	27	16.1	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.16	28	16.3	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.16	29	16.2	11	1	2	1	1	67%	43%
ocn	14/11/2018	AP.16	30	16.2	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.16	31	16.3	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.16	32	16.3	11	2	2	2	2	100%	0%
ocn	14/11/2018	AP.16	33	16.1	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.16	34	16.5	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.16	35	16.9	11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.16	36	16.5	11	1	1	1	1	100%	0%

ocn	14/11/2018	AP.16	37	16.6		11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.16	38	16.6		11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.16	39	16.7		11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.16	40	16.5		11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.16	41	16.6		11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.16	42	16.5		11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.16	43	17.1		11	1	2	1	1	67%	43%
ocn	14/11/2018	AP.16	44	17.0		11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.16	45	17.1		11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.16	46	17.5		11	2	2	1	2	67%	35%
ocn	14/11/2018	AP.16	47	17.8		11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.16	48	17.6		11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.16	49	17.7		11	1	1	1	1	100%	0%
ocn	14/11/2018	AP.16	50	18.1		11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.17	1	12.3		11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.17	2	12.3		11	1	-	1	1	100%	0%
ocn	15/11/2018	AP.17	3	12.6		11	1	2	1	1	67%	43%
ocn	15/11/2018	AP.17	4	12.9		11	1	2	1	1	67%	43%
ocn	15/11/2018	AP.17	5	13.3		11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.17	6	13.2		11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.17	7	13.4		11	1	2	2	2	67%	35%
ocn	15/11/2018	AP.17	8	13.0		11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.17	9	13.0		11	1	-	1	1	100%	0%
ocn	15/11/2018	AP.17	10	13.8		11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.17	11	13.6		11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.17	12	13.9		11	1	-	1	1	100%	0%
ocn	15/11/2018	AP.17	13	13.6		11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.17	14	14.0		11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.17	15	14.0		11	1	2	1	1	67%	43%
ocn	15/11/2018	AP.17	16	14.1		11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.17	17	14.3		11	1	-	1	1	100%	0%
ocn	15/11/2018	AP.17	18	14.1		11	1	2	1	1	67%	43%
ocn	15/11/2018	AP.17	19	14.3		11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.17	20	14.1		11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.17	21	14.0		11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.17	22	14.1		11	1	2	1	1	67%	43%
ocn	15/11/2018	AP.17	23	14.9		11	1	2	1	1	67%	43%
ocn	15/11/2018	AP.17	24	14.6		11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.17	25	14.9		11	1	-	1	1	100%	0%
ocn	15/11/2018	AP.17	26	14.7		11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.17	27	14.8		11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.17	28	14.6		11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.17	29	14.7		11	2	2	2	2	100%	0%
ocn	15/11/2018	AP.17	30	14.9		11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.17	31	14.6		11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.17	32	14.6		11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.17	33	14.7		11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.17	34	15.0		11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.17	35	15.2		11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.17	36	15.2		11	1	2	1	1	67%	43%
ocn	15/11/2018	AP.17	37	15.5		11	1	2	1	1	67%	43%
ocn	15/11/2018	AP.17	38	15.2		11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.17	39	15.1		11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.17	40	15.6		11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.17	41	15.5		11	2	2	2	2	100%	0%
ocn	15/11/2018	AP.17	42	15.6		11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.17	43	15.7		11	1	2	1	1	67%	43%
ocn	15/11/2018	AP.17	44	16.2		11	1	-	1	1	100%	0%
ocn	15/11/2018	AP.17	45	16.2		11	1	-	1	1	100%	0%
ocn	15/11/2018	AP.17	46	16.3		11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.17	47	16.7		11	1	2	1	1	67%	43%
ocn	15/11/2018	AP.17	48	16.7		11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.17	49	16.7		11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.17	50	16.8		11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.18	1	12.7		11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.18	2	12.6		11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.18	3	13.1		11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.18	4	13.2		11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.18	5	13.3		11	0	0	0	0	100%	
ocn	15/11/2018	AP.18	6	13.2		11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.18	7	13.9		11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.18	8	13.8		11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.18	9	13.8		11	0	0	0	0	100%	
ocn	15/11/2018	AP.18	10	13.7		11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.18	11	13.6		11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.18	12	14.2		11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.18	13	14.4		11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.18	14	14.3		11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.18	15	14.1		11	1	-	1	1	100%	0%
ocn	15/11/2018	AP.18	16	14.2		11	1	1	1	1	100%	0%

ocn	15/11/2018	AP.18	17	14.3	11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.18	18	14.3	11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.18	19	14.3	11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.18	20	14.8	11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.18	21	14.6	11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.18	22	14.8	11	1	2	1	1	67%	43%
ocn	15/11/2018	AP.18	23	14.5	11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.18	24	14.7	11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.18	25	14.7	11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.18	26	14.6	11	1	-	1	1	100%	0%
ocn	15/11/2018	AP.18	27	14.5	11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.18	28	14.6	11	2	-	2	2	100%	0%
ocn	15/11/2018	AP.18	29	14.5	11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.18	30	15.0	11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.18	31	15.1	11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.18	32	15.3	11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.18	33	15.2	11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.18	34	15.3	11	2	2	2	2	100%	0%
ocn	15/11/2018	AP.18	35	15.7	11	2	1	2	2	67%	35%
ocn	15/11/2018	AP.18	36	15.6	11	1	2	2	2	67%	35%
ocn	15/11/2018	AP.18	37	15.7	11	1	-	1	1	100%	0%
ocn	15/11/2018	AP.18	38	15.9	11	-	-	-			
ocn	15/11/2018	AP.18	39	15.7	11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.18	40	15.7	11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.18	41	16.2	11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.18	42	16.3	11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.18	43	16.4	11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.18	44	16.1	11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.18	45	16.8	11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.18	46	16.9	11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.18	47	16.7	11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.18	48	17.4	11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.18	49	17.9	11	1	1	1	1	100%	0%
ocn	15/11/2018	AP.18	50	18.3	11	2	1	1	1	67%	43%
ocn	16/11/2018	AP.20	1	10.8	11	0	0	0	0	100%	
ocn	16/11/2018	AP.20	2	10.7	11	0	0	0	0	100%	
ocn	16/11/2018	AP.20	3	10.9	11	0	0	0	0	100%	
ocn	16/11/2018	AP.20	4	10.8	11	0	0	0	0	100%	
ocn	16/11/2018	AP.20	5	10.9	11	0	0	0	0	100%	
ocn	16/11/2018	AP.20	6	10.8	11	0	0	0	0	100%	
ocn	16/11/2018	AP.20	7	11.2	11	0	0	0	0	100%	
ocn	16/11/2018	AP.20	8	11.4	11	0	0	0	0	100%	
ocn	16/11/2018	AP.20	9	11.1	11	0	0	0	0	100%	
ocn	16/11/2018	AP.20	10	11.0	11	0	0	0	0	100%	
ocn	16/11/2018	AP.20	11	11.4	11	0	0	0	0	100%	
ocn	16/11/2018	AP.20	12	11.3	11	0	0	0	0	100%	
ocn	16/11/2018	AP.20	13	11.2	11	0	0	0	0	100%	
ocn	16/11/2018	AP.20	14	11.3	11	0	0	0	0	100%	
ocn	16/11/2018	AP.20	15	11.3	11	0	0	0	0	100%	
ocn	16/11/2018	AP.20	16	11.2	11	0	0	0	0	100%	
ocn	16/11/2018	AP.20	17	11.4	11	0	0	0	0	100%	
ocn	16/11/2018	AP.20	18	11.4	11	0	0	0	0	100%	
ocn	16/11/2018	AP.20	19	11.2	11	0	0	0	0	100%	
ocn	16/11/2018	AP.20	20	11.3	11	0	0	0	0	100%	
ocn	16/11/2018	AP.20	21	11.4	11	0	0	0	0	100%	
ocn	16/11/2018	AP.20	22	11.2	11	0	0	0	0	100%	
ocn	16/11/2018	AP.20	23	11.7	11	0	0	0	0	100%	
ocn	16/11/2018	AP.20	24	11.8	11	0	0	0	0	100%	
ocn	16/11/2018	AP.20	25	11.9	11	0	0	0	0	100%	
ocn	16/11/2018	AP.20	26	11.7	11	0	0	0	0	100%	
ocn	16/11/2018	AP.20	27	11.7	11	0	0	0	0	100%	
ocn	16/11/2018	AP.20	28	11.9	11	0	0	0	0	100%	
ocn	16/11/2018	AP.20	29	11.6	11	0	0	0	0	100%	
ocn	16/11/2018	AP.20	30	11.7	11	0	0	0	0	100%	
ocn	16/11/2018	AP.20	31	11.6	11	0	0	0	0	100%	
ocn	16/11/2018	AP.20	32	11.9	11	0	0	0	0	100%	
ocn	16/11/2018	AP.20	33	11.6	11	0	0	0	0	100%	
ocn	16/11/2018	AP.20	34	11.7	11	0	0	0	0	100%	
ocn	16/11/2018	AP.20	35	12.3	11	1	0	0	0	67%	
ocn	16/11/2018	AP.20	36	12.4	11	1	0	0	0	67%	
ocn	16/11/2018	AP.20	37	12.2	11	0	0	0	0	100%	
ocn	16/11/2018	AP.20	38	12.4	11	0	0	0	0	100%	
ocn	16/11/2018	AP.20	39	12.2	11	0	0	0	0	100%	
ocn	16/11/2018	AP.20	40	12.3	11	1	0	0	0	67%	
ocn	16/11/2018	AP.20	41	12.2	11	0	0	0	0	100%	
ocn	16/11/2018	AP.20	42	12.4	11	1	0	0	0	67%	
ocn	16/11/2018	AP.20	43	12.3	11	1	0	0	0	67%	
ocn	16/11/2018	AP.20	44	12.4	11	1	0	0	0	67%	
ocn	16/11/2018	AP.20	45	12.3	11	0	0	0	0	100%	
ocn	16/11/2018	AP.20	46	12.3	11	0	0	0	0	100%	
ocn	16/11/2018	AP.20	47	12.1	11	0	0	0	0	100%	
ocn	16/11/2018	AP.20	48	12.7	11	1	0	0	0	67%	
ocn	16/11/2018	AP.20	49	12.8	11	1	1	0	1	67%	87%
ocn	16/11/2018	AP.20	50	13.8	11	0	0	0	0	100%	
					Total read	332	318	332		**93.4%**	**8.4%**
					Total NOT read	0	14	0			

Table 7.2 Number of age readings table gives an overview of number of readings per reader and modal age. The total numbers of readings per reader and per modal age are summarized at the end of the table.

	MODAL age	CD Reader 1	ES Reader 2	AA Reader 3	TOTAL
	0	70	70	70	**210**
	1	236	224	236	**696**
	2	26	24	26	**76**
	3	-	-	-	**-**
	4	-	-	-	**-**
	5	-	-	-	**-**
Total	**0-15**	**332**	**318**	**332**	**982**

Table 7.3. Age composition by reader gives a summary of number of readings per reader

	Age	CD Reader 1	ES Reader 2	AA Reader 3	TOTAL
	0	63	62	71	**196**
	1	242	226	235	**703**
	2	27	30	26	**83**
	3	-	-	-	**-**
	4	-	-	-	**-**
	5	-	-	-	**-**
Total	**0-15**	**332**	**318**	**332**	**982**

Table 7.4. Mean length at age per reader is calculated per reader and age (not modal age) and for all readers combined per age. A weighted mean is also given.

	Age	CD Reader 1	ES Reader 2	AA Reader 3	ALL
	0	11.5	11.6	11.6	**11.6**
	1	14.5	14.6	14.6	**14.6**
	2	15.8	15.1	15.6	**15.5**
	3	-	-	-	**-**
	4	-	-	-	**-**
	5	-	-	-	**-**
Weighted mean	**0-15**	**14.1**	**14.0**	**14.1**	**14.1**

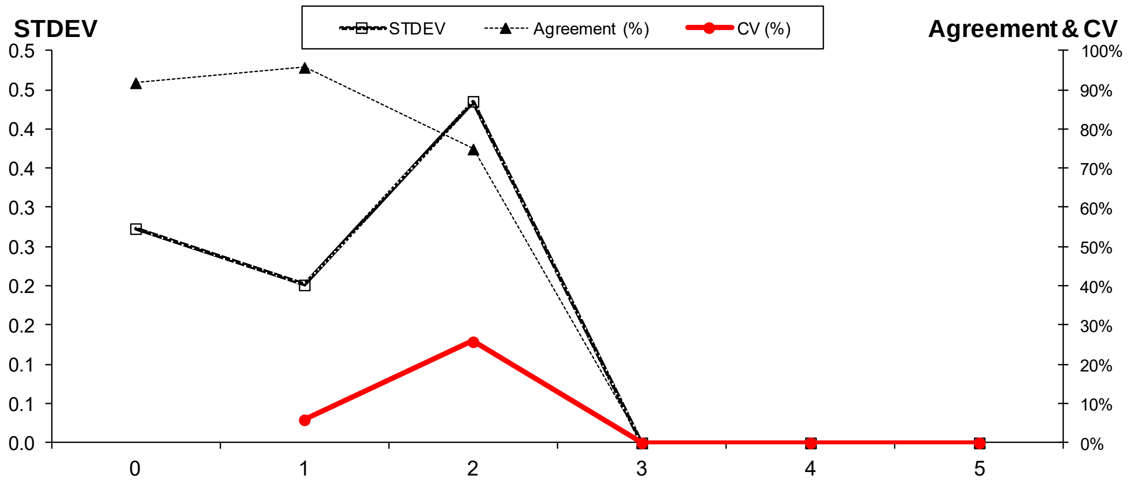


Figure 7.1. CV, PA and (STDEV (standard deviation) are plotted against modal age

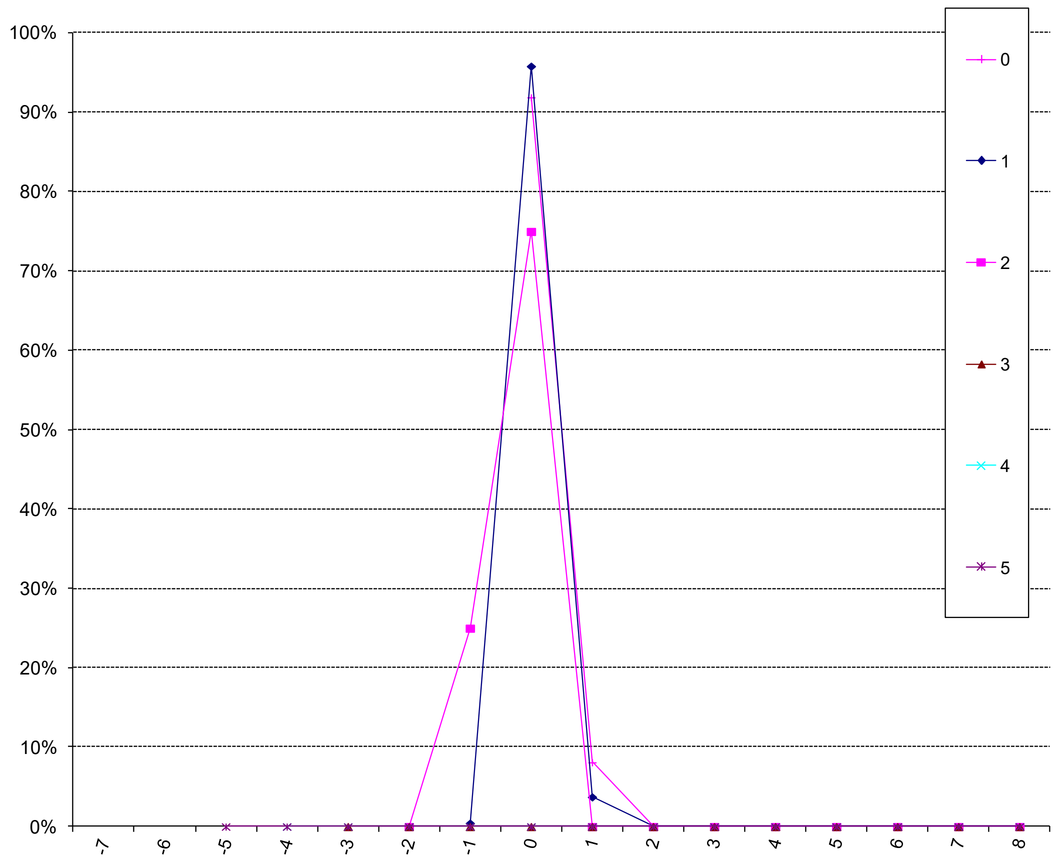


Figure 7.2. The distribution of the age reading errors in percentage by modal age as observed from the whole group of age readers in an age reading comparison to modal age. The achieved precision in age reading by MODAL age group is shown by the spread of the age readings errors. There appears to be no relative bias, if the age reading errors are normally distributed. The distributions are skewed, if relative bias occurs.

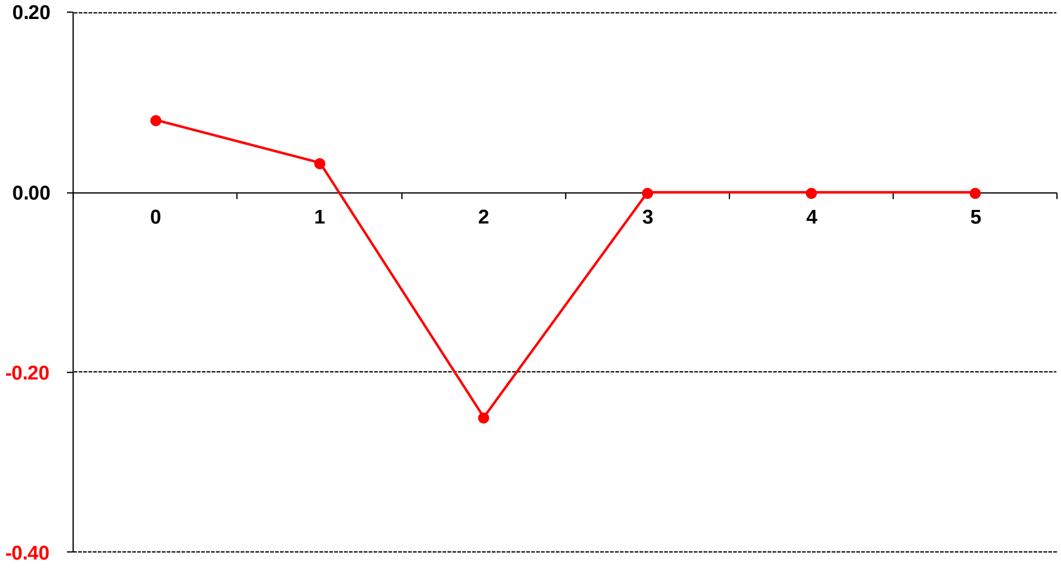


Figure 6.3. The relative bias by modal age as estimated by all age readers combined.

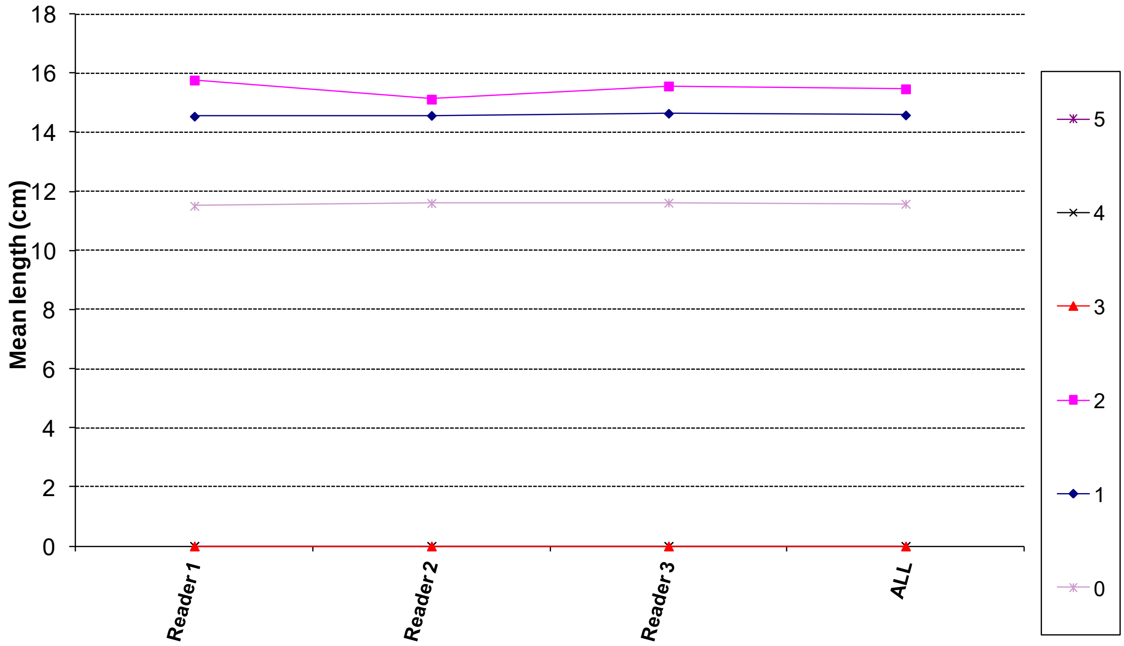


Figure 7.4: The mean length at age as estimated by each age reader.

8. Annex 2. Images of Anchovy (Division 9a-IBERAS survey))

Figure 8.1. Age Reading for anchovy AP.20 nº11, 11.4 cm; caught in November 2018. **100% agreement Age 0**. Conventional birthdates: 1st January. The marked ring is very close to the nucleus of the otolith, it cannot be considered a winter ring because it does not meet the expected rapid growth of the growth pattern in the first months of life. For what is considered a check (green circle) C05 since from the center to the ring there is a 50% of the growth that must be expected until forming its first winter ring.

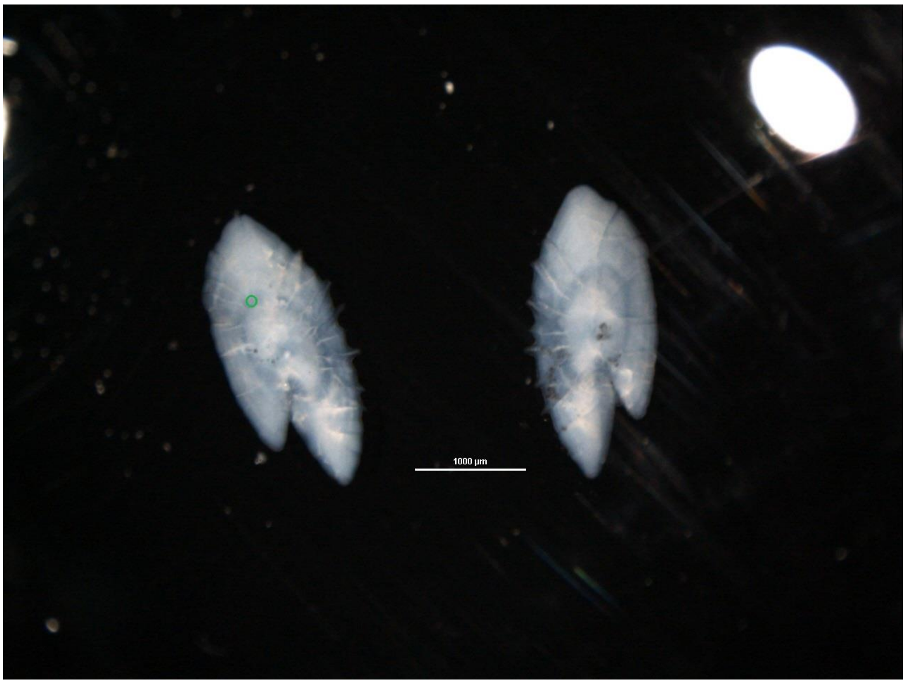


Figure 8.2. Age Reading for anchovy AP.20.nº 17, 11.4 cm; caught in November 2018. **100% agreement Age 0**. Conventional birthdates: 1st January. The ring marked is understood by all readers as a central check C08, that it is a false ring (green circle) deposited to 80% of the estimate from the center of the otolith until reaching its final estimated growth, where it would form the real winter ring (so age 0). There is no winter mark (all is growth during its first months of life).

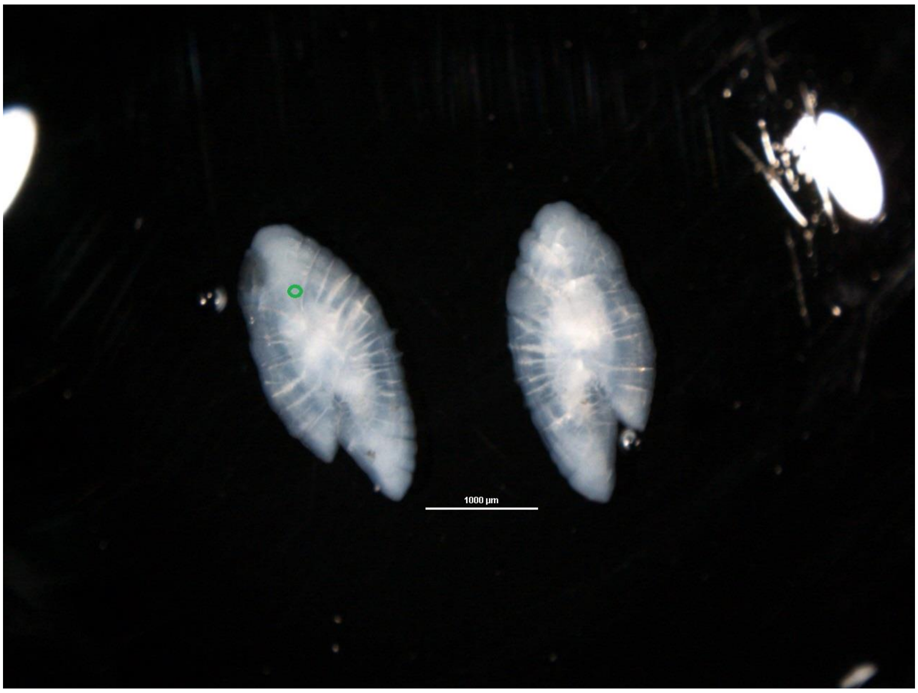


Figure 8.3. Age Reading for anchovy AP.10.nº18; 11.8 cm; caught in November 2018. **67% of agreement: Age 0 (IEO readers age 0; IPMA reader age 1)**. Conventional birthdates: 1st January. A fish that we estimate was born in the second quarter and that has been captured in the fourth and last quarter of that same year, we hope it has a final edge hyaline. The winter ring must be marked in a clear and continuous way around the nucleus of the otolith. The check marked as first winter mark is understood as a check (green circle) (C08) by most of the readers (so age 0).This otolith illustrates that a bad recognition of the typical growth pattern and of checks leads to over estimation of the actual age. There is no winter mark (all is growth during its first months of life)

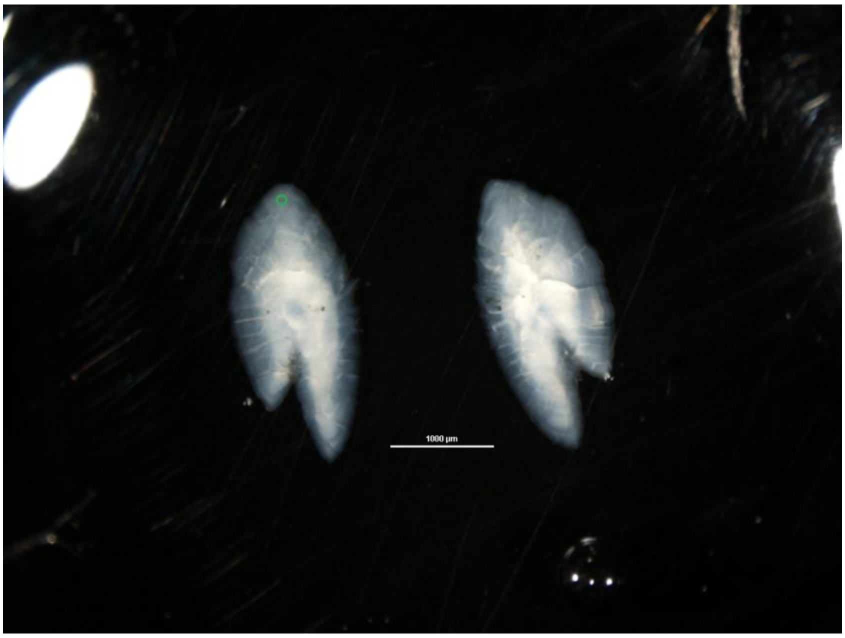


Figure 8.4. Age Reading for anchovy AP.10.nº 20; 12.1 cm; caught in November 2018. **67% agreement: Age 0 (IEO readers ages 0; IPMA reader age 1)**. Conventional birthdates: 1st January. In the rostrum of the otolith several faint rings are observed and one of them can see their outline from the nucleus, but it is not well marked nor does it have the great estimated growth that characterizes the first months of life, reason why it is considered a false central rings (green circles) by most of the readers

(so age 0).This otolith illustrates that a bad recognition of the typical growth pattern and of checks leads to over estimation of the actual age. There is no winter mark (all is growth during its first months of life)

Figure 8.5. Age Reading for anchovy AP20.nº 50; 13.8cm; caught in November 2018. **100% agreement: Age 0**. Conventional birthdates: 1st January A weak ring is intuited around the nucleus of the otolith that is little marked and presents small growth. It is considered a false central ring C08 by all readers (so age 0). There is no winter mark (all is growth during its first months of life).

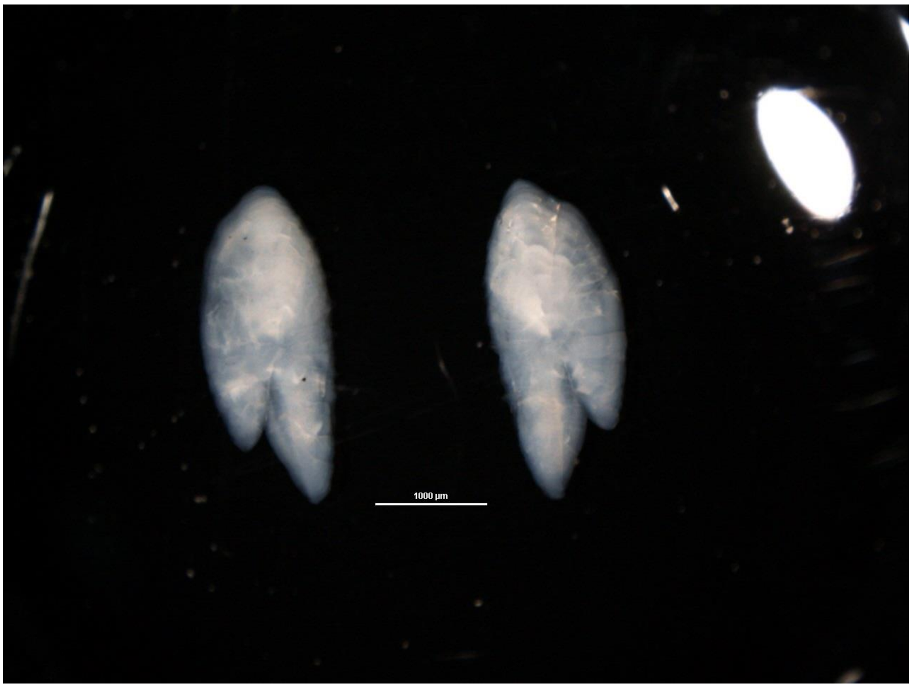


Figure 8. 6. Age reading for anchovy AP10. nº30; 16.2cm; caught in November 2018. **100% agreement: Age 1**. Conventional brithdates: 1st Junuary. The otolith shows the typical pattern for such age/season, with a strong marked first winter hyaline ring followed by an opaque band corresponding to the season's growth. Central ring mark can be identified as annual (winter) ring. A wide opaque band correspond the intense growth pattern expected during the second year of life –as age 1. At the edge some hyaline edge formation seems to be occurring. In this case, no checks appear in the otolith; despite some spawning/summer checks could occur.

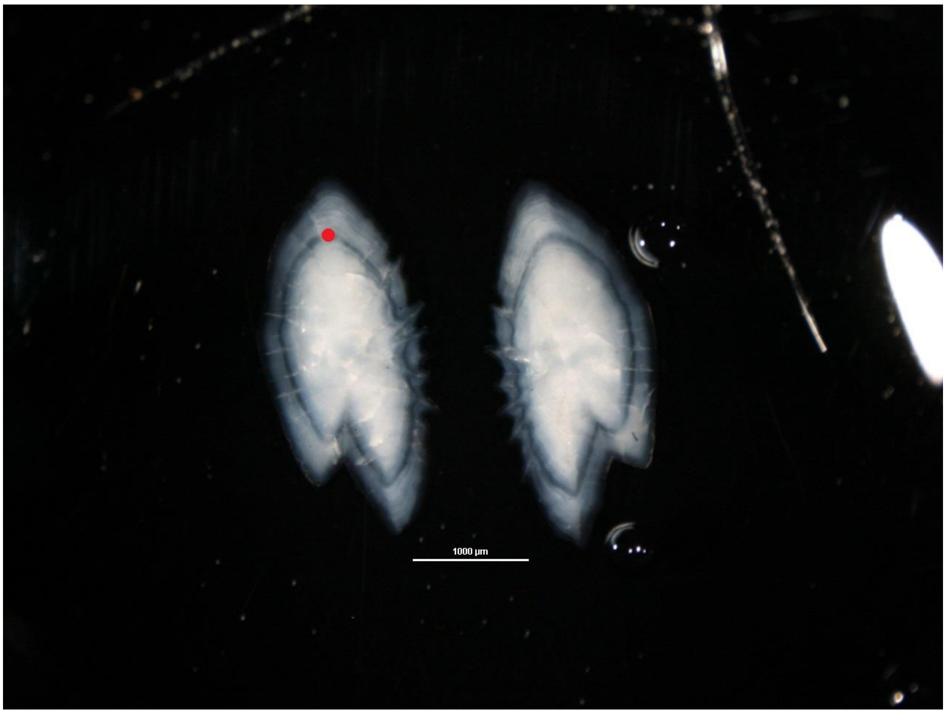


Figure 8.7. Age Reading for anchovy AP.15.nº 46; 15.5 cm; caught in November 2018. **100% agreement Age 1**. Conventional birthdates: 1st January. This otolith is very similar previous example. The otolith shows the typical pattern for such age/season, with a strong marked first winter hyaline ring followed by an opaque band corresponding to the season's growth. Central ring mark can be identified as annual (winter) ring. A wide opaque band correspond the intense growth pattern expected during the second year of life –as age 1. At the edge some hyaline edge formation seems to be occurring. In this case, no checks appear in the otolith; despite some spawning/summer checks could occur.

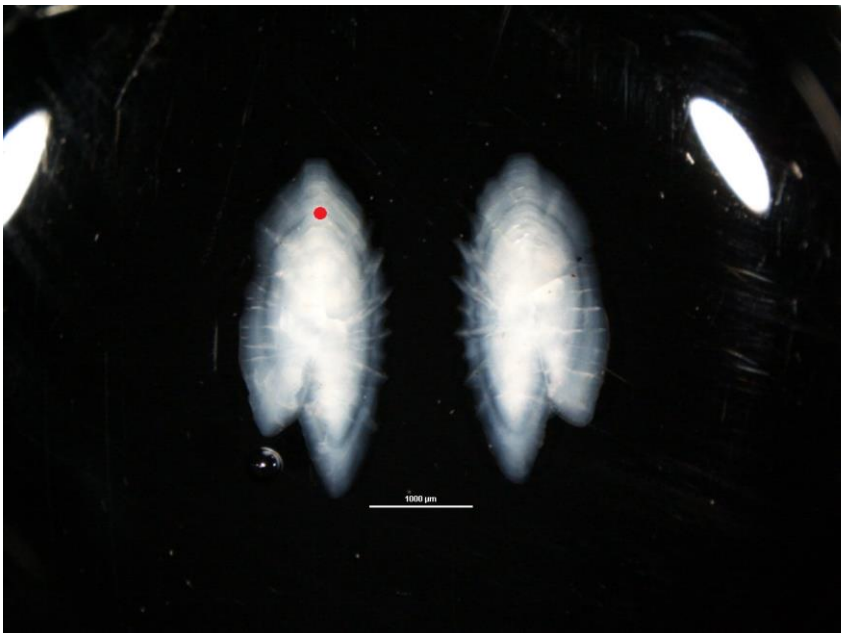


Figure 8.8. Age Reading for anchovy APE.15.no 27; 13.9 cm; caught in November 2018. **100% agreement Age 1**. Conventional birthdates: 1st January. Very similar to the previous example, the intense central ring mark can be identified as annual (winter) ring. A wide opaque band correspond the intense growth pattern expected during the second year of life –as age 1. Around the nucleus weak

concentric rings are intuited that would be central checks. At the edge some hyaline edge formation seems to be occurring.

Figure 8.9. Age Reading for anchovy AP.17.nº 36; 15.2 cm; caught in November 2018. **67% agreement Age 1. (IEO readers ages 1; IPMA reader age 2)**. Conventional birthdates: 1st January. Rings marked on the rostrum and anti-rostrum. Of the 1st winter annual ring (red point) to the edge, there is one almost equidistant strong hyaline ring (green circle) which might be a spawning check (C18) or a true winter ring (then it would show an atypical growth pattern). Difficulties in distinguishing between C18 or second winter ring because of the strong hyaline mark.

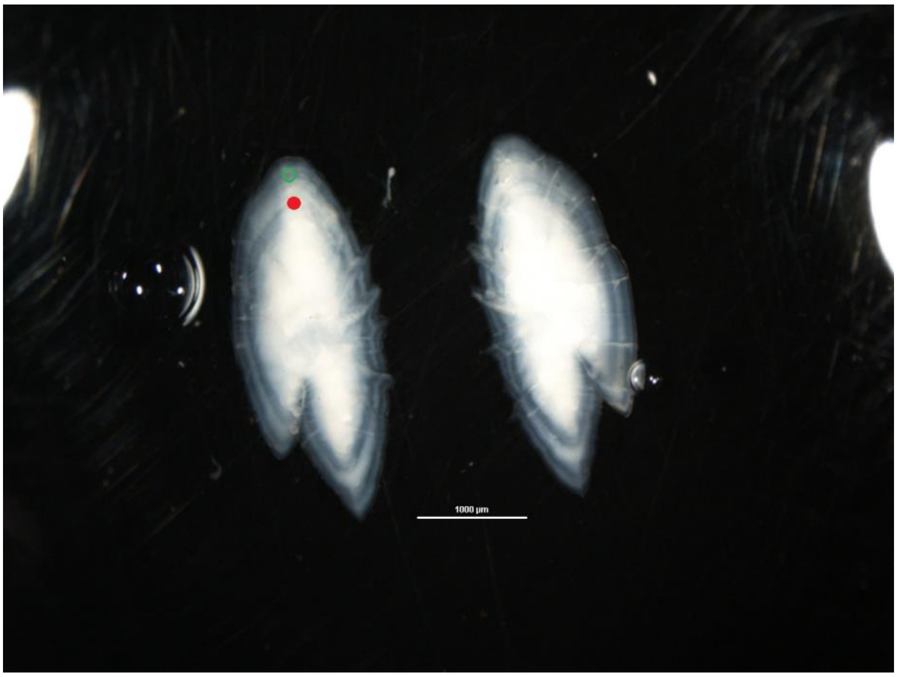


Figure 8.10. Age Reading for anchovy AP.17.nº 22, 14.1 cm, caught November 2018. **67% agreement: Age 1 (IEO readers ages 1; IPMA reader age 2)**. Conventional birthdates: 1st January. This otolith

is a similar to the previous example and in addition with a weak central mark taken as check C08. This otolith illustrates that a bad recognition of the typical growth pattern and of checks leads to over estimation of the actual age (resulting in that case in a less intense growth pattern than expected in particular during the second year of life –as age 1)

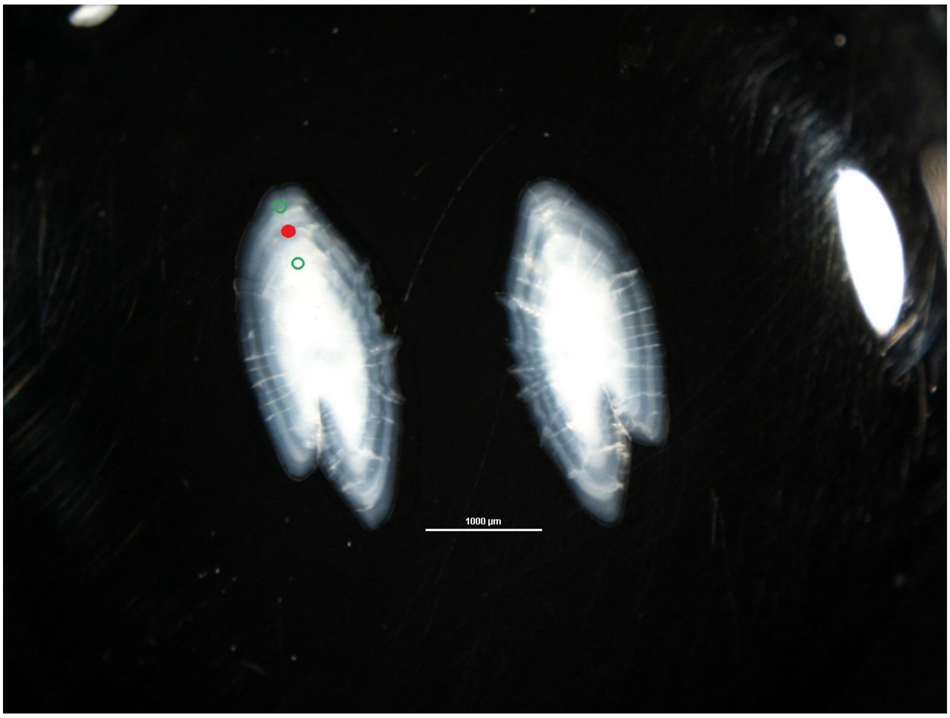


Figure 8. 11. Age Reading for anchovy AP16. Nº24; 15.9cm; caught November 2018. **100% agreement Age 2**.Conventional birthdates: 1st January. The otolith shows the first winter ring, in this case, very narrow but strongly marked all around the otolith; A wide opaque band correspond the intense growth pattern expected during the second year of life; the second winter hyaline ring follows and finally an narrow opaque band corresponding to the most recent season growth.

Figure 8.12. Age Reading for anchovy AP16. Nº32; 16.3cm; caught November 2018. **100% agreement Age 2**. <u>Conventional birthdates: 1st January</u>. The otolith shows the first winter ring, in this case, very narrow but strongly marked all around the otolith; A wide opaque band correspond the intense growth pattern expected during the second year of life; the second winter hyaline ring follows and finally an narrow opaque band corresponding to the most recent season growth.

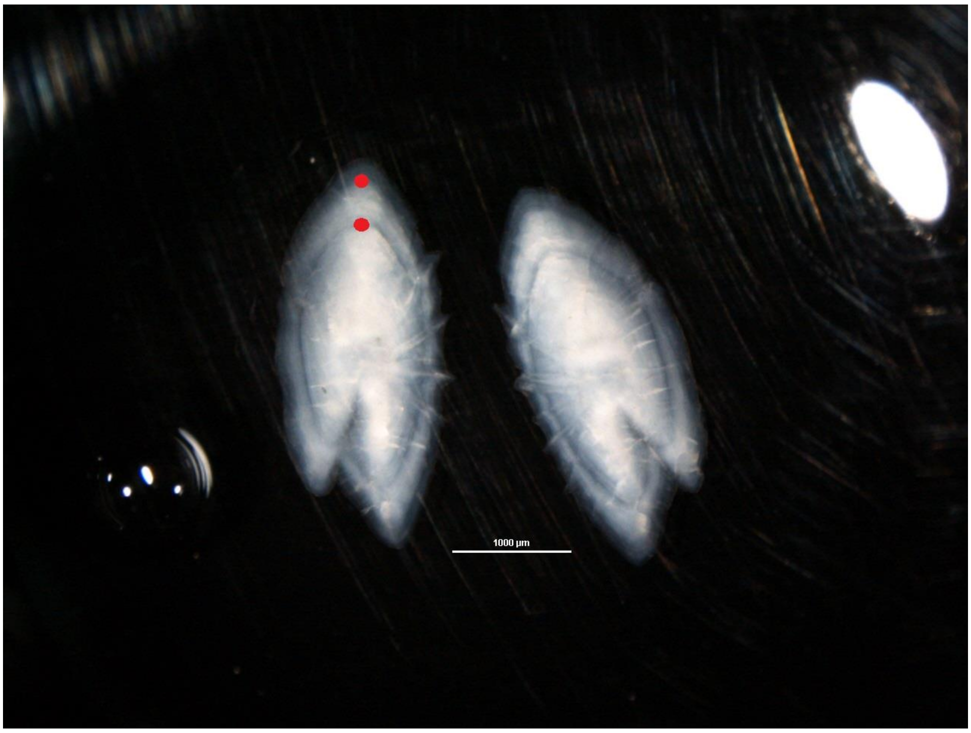
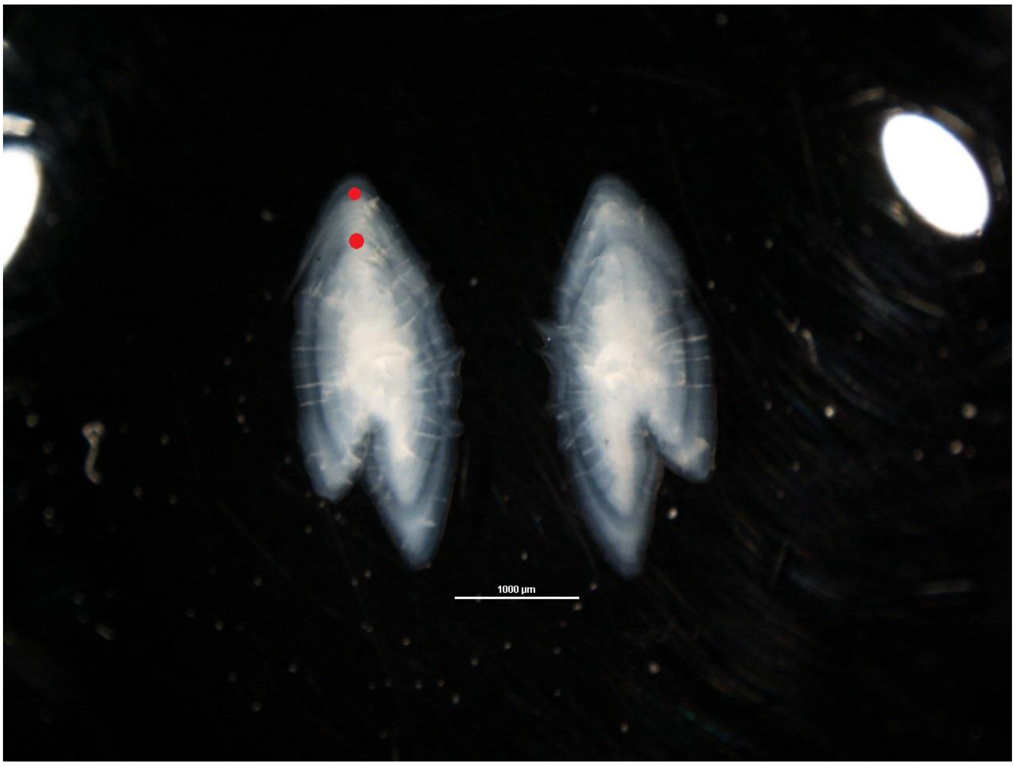


Figure 8.13. Age Reading for anchovy AP.14.nº53; 17.6 cm; caught November 2018. **67% agreement: Age 2 (IEO readers ages 2; IPMA reader age 1)**. <u>Conventional birthdates: 1st January.</u> The otolith shows the first winter ring, in this case, very narrow but strongly marked all around the otolith; A wide opaque band correspond the intense growth pattern expected during the second year of life; the second winter hyaline ring follows and finally an narrow opaque band corresponding to the most recent season growth.

Figure 8.14. Age Reading for anchovy AP.17.nº 7; 13.4cm; caught November 2018. **67% agreement Age 2 (IEO and IPMA readers ages 2; IEO reader age 1)**. Conventional birthdates: 1st January. This otolith is Very similar to the previous example. The growth pattern shows a progressive decreasing of growth bands between subsequent age classes. Around to the center of the otolith there is a weak mark that would be a false central ring. This individual is a good example that its small length should not condition the estimate of age.



9. Annex 3. Recommended reading Axis and Synoptic representation of the anchovy otolith development in time.

Reading axis: The translucent rings (hyaline) are counted preferably in the anterior (rostrum) and posterior (post-rostrum) of the otolith (Figure 9.1).

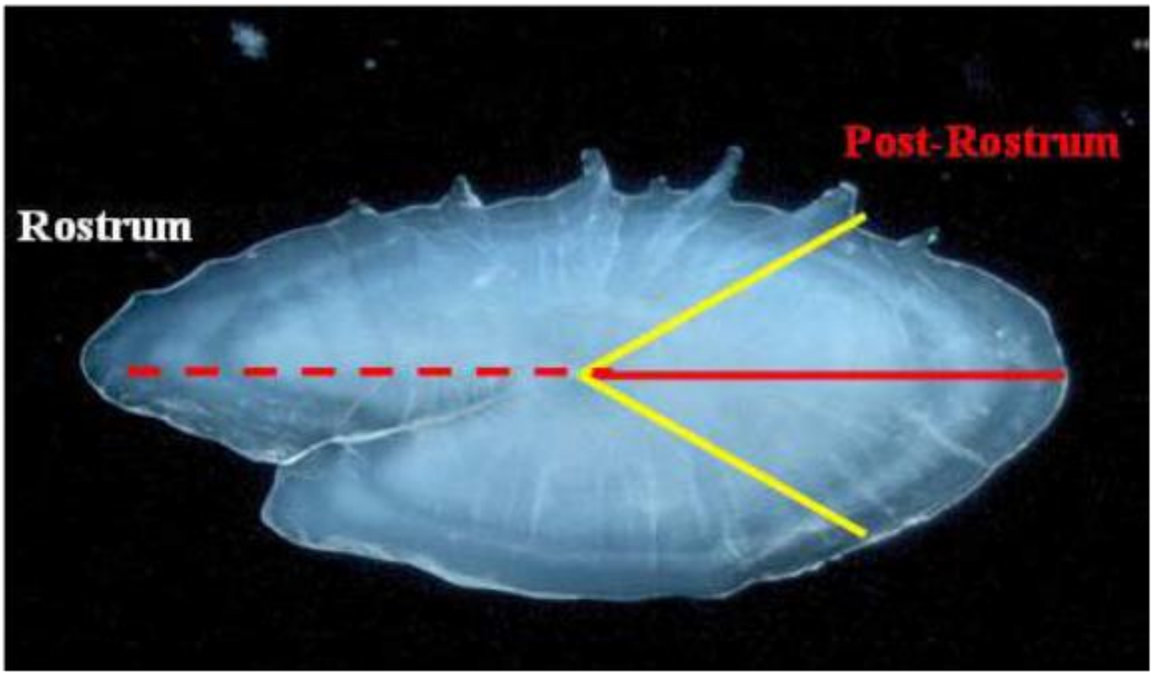


Figura 9.1. Recommended reading axis by WKARA1 and WKARA2 (ICES 2009 and 2016). Photo taken from the report of the Anchovy Otoliths Workshop WKARA2009 (ICES, 2009)

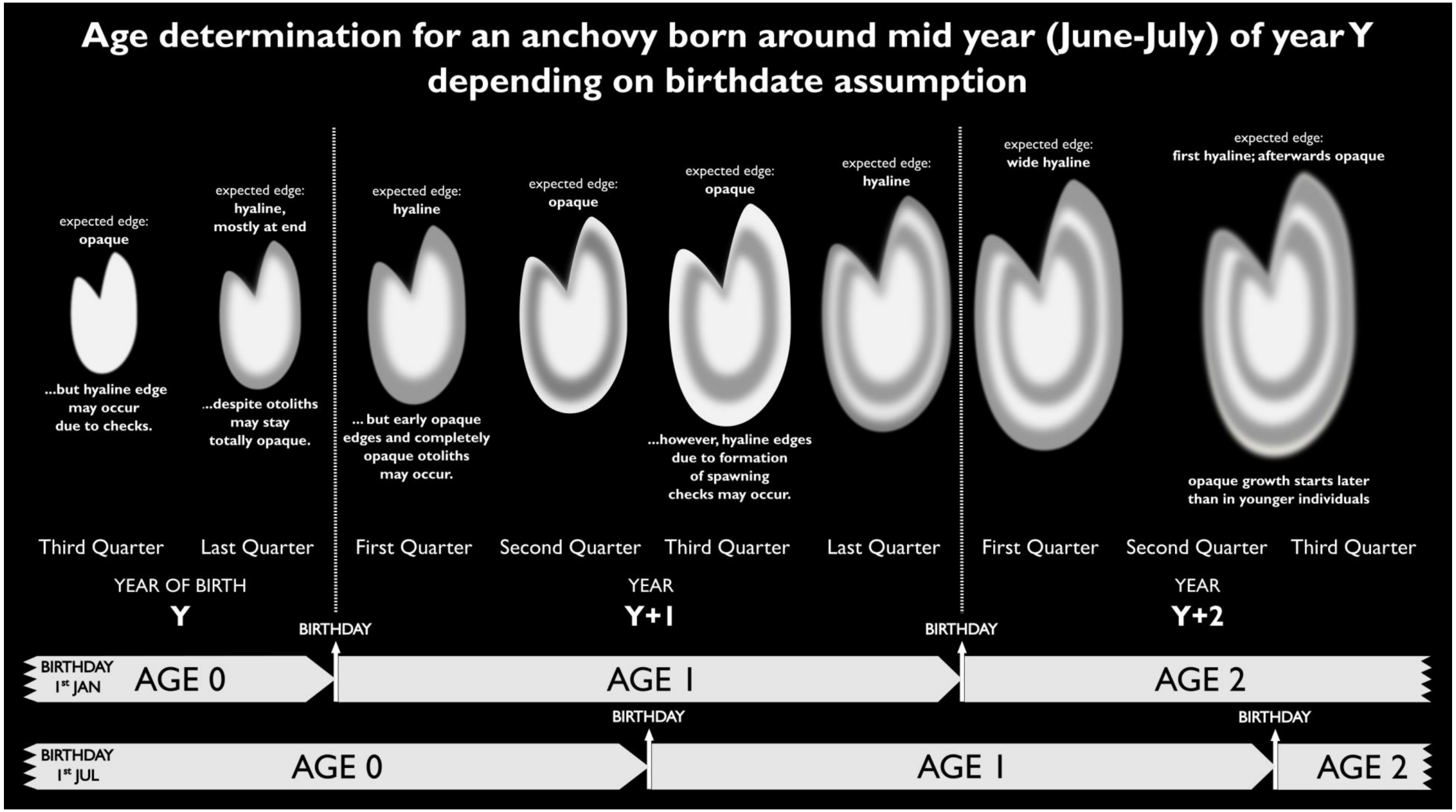


Figure 9.2. Synoptic representation of the anchovy otolith development in time and the different age allocation according to the two conventional birth dates at 1st January and at 1st July. Outline taken from the workshop report of anchovy otoliths WKARA2 2016 (ICES, 2016)

Annex 3: 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.27.8	Anchovy (*Engraulis encrasicolus*) in Subarea 8 (Bay of Biscay)	October 2013	Anchovy 8
ane.27.9a	Anchovy (*Engraulis encrasicolus*) in Division 9.a (Atlantic Iberian waters)	July 2018	Anchovy 9a
hom.27.9a	Horse mackerel (*Trachurus trachurus*) in Division 9.a (Atlantic Iberian waters)	February 2017	Southern horse mackerel 9a
jaa.27.10a2	Blue jack mackerel (*Trachurus picturatus*) in Subdivision 10.a.2 (Azores grounds)	June 2015	Blue jack mackerel 10a2
pil.27.7	Sardine (*Sardina pilchardus*) in Subarea 7 (Bay of Biscay, southern Celtic Seas, and the English Channel)	February 2017	Sardine 7
pil.27.8abd	Sardine (*Sardina pilchardus*) in divisions 8.a–b and 8.d (Bay of Biscay)	November 2019	Sardine 8abd
pil.27.8c9a	Sardine (*Sardina pilchardus*) in divisions 8.c and 9.a (Cantabrian Sea and Atlantic Iberian waters)	November 2019	Sardine 8c and 9a

Annex 4: Audits

Audit of Anchovy 9a South

Date: 10/06/2019

Auditor: Andrés Uriarte & Leire Ibaibarriaga

General

The stock of anchovy in 9a is divided in western and southern components following the 2018 benchmark. Each component is assessed separately. The southern component (distributed in 9a South) is classified in category 3. The stock size indicator is the SSB (that equals B1+) at the end of the second quarter estimated from the GADGET model. This is the second year using the agreed procedure.

The assessment of Anchovy 9a South:

- carried out as expected (SALY) incorporating the new information from surveys, and commercial catch in the last year and total assumed catch until 30 June 2019.
- An error in the reported series of B1+ that is used as stock size indicator, has been corrected during the working group.
- The advice deviates from the standard ICES guidelines for category 3 stocks advice by not applying a 20% Uncertainty Cap constraint, but one of 80% which is deemed more appropriate for short-lived species (see technical details).

For single stock summary sheet advice:

1. Assessment type: SALY (benchmarked in 2018)
2. Assessment: analytical, but for a Category 3 stock used only as indicator of stock trends
3. Forecast: not presented/ Not required (this is like In year advice)
4. Assessment model: Gadget in quarterly time steps using catches by length and ALKs + two acoustic surveys (biomass index, length distribution and ALKs): PELAGO (Spring, 2019 index included) and ECOCADIZ (Summer, 2018 index is the latest index available).
5. Data issues:

   Data were fully used. Information on the age structure (ALKs) from the spring acoustic surveys in 2017 and 2018, which was missing for the assessment in 2018, have now become available and included in the assessment in 2019.

   Some additional surveys (Juvesar, Ecocadiz-Reclutas and Bocadeva), though available, are not used in the assessment as agreed in the benchmark because of their time-series being considered too short (e.g. Bocadeva) or because of being in a testing phase of performance (e.g. Juvesar, Ecocadiz-Reclutas).

6. Consistency: There has been an apparent major revision of the series of relative biomass estimates, compared to that reported in July 2018. But this is due to a reporting error of the B1+ in the series assessed in 2018 (which unduly included the age 0 as well, except for the terminal year). The new series corresponding to B1+ (as agreed in the stock annex) is now correctly reported and the consistency between the corrected relative index series of the 2018 assessment and the new one produced in 2019 (after the addition of the new information for the current assessment) is high.

Therefore the inclusion of the new survey indexes during the last year (ECOCADIZ 2018 and PELAGO 2019) do not lead to a revision of the series of B1+ in the past. The inclusion of the ALKs from PELAGO survey in 2017 and 2018 causes just a minor revision of 2018 assessment. The new accepted assessments following WKPELA benchmark (2018) were carried out accordingly to stock annex.

7. Stock status: Although the assessment is not taken as absolute but as relative, current B around 5500 t is close to historical mean series and supposes that $B>B_{lim}$ (taken as B_{loss} in 2010 in this assessment i.e. around 1730 t) and $B>B_{pa}$ (deduced from B_{lim} at 2837 t)
8. Management Plan: There is no management plan
9. Basis of the advice: A trend based advice, following the "one-over-two" ratio of B1+ indexes from the gadget assessment model applied to the advicsd catch for the previous management season (from 1 July 2018 to 30 June 2019). This is like in-year advice as approved in the stock annex for this category 3 stock. The ratio is 1.41 and in this year, the standard recommendation of applying a 20% uncertainty cap (in ICES guidelines for category 3 stocks) has not been applied (see technical comments). The uncertainty cap selected of 80% is considered more suitable for short-lived species, but in this case as the ratio (1.41) is smaller than 1.8, has not been applied. This implied a catch advice for the 2019 management period 41% higher than in 2018.

General comments

The assessment was well documented and deviations from the stock annex were duly justified and explained in the report.

Technical comments

<u>On the revision of the series B1+ reported in 2018</u>: The fact that in 2018 the assessment was right but the reported series of Biomass was incorrect has had the implication of affecting the trend of biomasses upon which the advice was provided in last year. This implied that the trend of "one over two" survey indexes for the formulation of advice, resulted in 2018 in a ratio of 1.01 whereas the correct series of B1+ of the same assessment of 2018 would have resulted in a ratio of 1.71. Acknowledging that last year an uncertainty cap of 20% was agreed to be applied to the advice, this would imply a revision of the advice for 2018 20% upward, moving the 2018 catch advice from 3371 t to 4476 t (applicable from July 2018 to June 2019).

That revision of the 2018 advice affects also the advice for 2019 (applicable from July 2019 to June 2020), because the "one over two" indexes ratio is applied to the catch advised in last year to produce the new catch advice for the current year. WGHANSA decided to use the corrected catch advice for 2018 to produce the catch advice for 2019.

<u>On the basis of the advice</u>: ADVICE deviates from the standard ICES guidelines for category 3 stocks advice by not applying a 20% Uncertainty Cap constraint, but instead allowing higher uncertainty cap of 80%, according to the Guidance on the applications of the advisory rules for category 3 short-lived stocks drafted by WKLIFE VIII in its Annex 8 (ICES 2018, page 167), and by analogy with the approach adopted for Anchovy 9a West. For this component, as the interannual change in the unconstrained advice was smaller than 80% the uncertainty cap has not been applied for the 2019 advice.

Conclusions

- The assessment has been performed correctly SALY.
- The stock is assessed to be around the historical mean value in 2018 and 2019.
- A revision of the series B1+ reported in 2018 has led to revise what catch would have been advised for 2018, as it is used for the 2019 catch advice.

- The advice deviates from the standard ICES guidelines for category 3 stocks advice by allowing a 80% uncertainty cap according to the WKLIFEVIII suggestion for short-lived species.

Checklist for audit process

General aspects

- Has the EG answered those ToRs relevant to providing advice? Yes
- Is the assessment according to the stock annex description? Yes, except for the uncertainty cap.
- If a management plan is used as the basis of the advice, has it been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary? Not Applicable.
- Have the data been used as specified in the stock annex? Yes
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex? Yes
- Is there any **major** reason to deviate from the standard procedure for this stock? Yes regarding the application of the standard uncertainty cap of 20%, which was not applied because the preferred one (of 80%, more suitable for short-lived species) was higher than the interannual change in the unconstrained advice. This has been well justified in the report
- Does the update assessment give a valid basis for advice? If not, suggest what other basis should be sought for the advice? Yes.

Audit of Anchovy 9a West

Date: 20/06/2019

Auditor: Lionel Pawlowski

General

The stock of anchovy in 9a is divided in western and southern components following the 2018 benchmark. Each component is assessed separately.

The western component biomass size indicator shows a 90% decrease from 2018 to 2019, after a period of an increasing trend observed since 2014. The harvest rate in 2018 (0.19) was below the median (0.28) of the historical time-series.

The western component (distributed in 9a West) is classified in category 3. The stock size indicator is the combined PELACUS (area 9.a North) and PELAGO (areas 9.a Central-North, Central-South) acoustic biomass estimate in spring. This is the second year using the agreed procedure (benchmarked in 2018).

The assessment of Anchovy 9a West:

- carried out as expected (SALY) incorporating the new information from surveys, and commercial catch in the last year and total assumed catch until 30 June 2019.
- Given that the stock status relative to candidate reference points for stock size is unknown, a 0.8 PA buffer was applied in addition to the 0.2 uncertainty cap.
- Discards are generally considered negligible in this area (mean 0.02% of total catch). For the last semester of 2018, it was 0.01%.
- For the western component of the stock, ICES cannot assess the stock and exploitation status relative to MSY and precautionary approach (PA) reference points because the reference points are undefined.

For single stock summary sheet advice:

1. **Assessment type: SALY (benchmarked in 2018)**. The ICES framework for category 3 stocks was applied (ICES, 2012). The combined PELACUS and PELAGO acoustic biomass estimate was used as the index of stock development. The advice is calculated as the ratio between the last index value (index A) and the average of the two preceding values (index B) multiplied by the advised catch for 2018 (1 July 2018 to 30 June 2019).
2. **Forecast**: not presented/ Not required (this is like In year advice)
3. **Assessment model**: trend based assessment on a stock indicator as agreed during the last benchmark.
4. **Data issues:**

   Acoustic biomass estimates were fully used. All other biological information (length distribution, individual weights, ALKs) are documented but not used in the assessment. Cpue indices are not considered for this stock component.

5. **Consistency**: In 2018, the stock indicators were the same for the advice but a 1.2 uncertainty cap was applied and no precautionary buffer was applied because previous indicator ratio was far above the 1.5 limit.
6. **Stock status**: The western component of the stock has decreased significantly, and the application of the "1 versus 2" advice rule gave an indicator ratio of 0.1. An uncertainty Cap of 0.2 was applied in addition to the 0.8 PA value.
7. **Management Plan**: There is no management plan

8. **Basis of the advice**: A trend based advice, following the "one-over-two" ratio indexes from the combined PELACUS and PELAGO acoustic biomass estimates. This is like in-year advice as approved in the stock annex for this category 3 stock.

General comments

The assessment and report sections were well documented and explained in the report.

Technical comments

None.

Conclusions

- The assessment has been performed correctly SALY.
- The assessment shows a 90% decrease from 2018 to 2019, after a period of an increasing trend observed since 2014. The harvest rate in 2018 (0.19) was below the median (0.28) of the historical time-series.
- The advice follows the standard ICES guidelines for category 3 stocks advice.

Checklist for audit process

General aspects

- Has the EG answered those ToRs relevant to providing advice? Yes
- Is the assessment according to the stock annex description? Yes, except for the uncertainty cap.
- If a management plan is used as the basis of the advice, has it been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary? Not Applicable
- Have the data been used as specified in the stock annex? Yes
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex? Yes
- Is there any **major** reason to deviate from the standard procedure for this stock? No
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice? Yes

Audit of Southern Horse Mackerel (hom.27.9a)

Date: 06 of June 2019

Auditor: Laura Wise and Alexandra Silva

For single stock summary sheet advice:

The assessment and the forecast have been performed correctly and according to the stock annex.

1. Assessment type: SALY
2. Assessment: full analytical assessment
3. Forecast: presented
4. Assessment model: AMISH (Assessment Method for the Ibero-Atlantic Southern Horse mackerel) / ADMB tuned with the time-series of total catch, catch-at-age, biomass index of IBTS survey, abundance-at-age from IBTS survey and mean weight-at-age in the catch and stock
5. Data issues: Data available as in stock annex.
6. Consistency: The results of the assessment gives a historical perspective very consistent with the one produced last year.
7. Stock status: Fishing pressure on the stock is below F_{MSY}, F_{pa}, and F_{lim}, and spawning–stock size is above MSY $B_{trigger}$, B_{pa}, and B_{lim} as it was last year.
8. Management Plan: ICES was requested by the EU to evaluate a long-term management strategy for this stock. ICEs considered that the management plan was precautionary and that when the Harvest Control Rule (HCR) is applied, the stock is maintained at levels that can lead to catches around MSY. ICES advised that none of the elements of the HCR are in contradiction with ensuring that the stock is fished and maintained, in the future, at levels that can lead to MSY. However, ICES was requested by the EU to base the advice for 2020 on the ICES MSY approach.

Conclusions

The assessment has been performed correctly.

General and technical comments to the report were transmitted to the stock assessors on time to be incorporated in the final version of the report.

Audit of Sardine in 8abd (pil.27.8abd)

Date: 28/11/2019

Auditor: Margarita María Rincón Hidalgo

For single stock summary sheet advice:

1) **Assessment type:** Update. Inter-benchmarked in October 2019.
2) **Assessment**: full analytical assessment, Category 1 stock.
3) **Forecast**: Presented
4) **Assessment model**: SS3
5) **Data issues:**
   -Small changes in input data (French catches have been revisited downwards) for 2016.
   Stock status: Stock annex was followed Still some big difference between absolute values and survey estimates. Reference points have been recalculated. F is above F_{MSY} and between F_{pa} and F_{lim}; and spawning–stock size is above MSY $B_{trigger}$, B_{pa} and B_{lim}.
6) **Management Plan**: not applicable

Conclusions

The assessment has been performed correctly.

Checklist for audit process

General aspects

- Has the EG answered those ToRs relevant to providing advice? yes
- Is the assessment according to the stock annex description? yes
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary?
- Have the data been used as specified in the stock annex? yes
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex? yes
- Is there any **major** reason to deviate from the standard procedure for this stock? no
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice? yes

Audit of Sardine in 8c9a (pil.8c9a)

Date: 28/11/2019

Auditor: Erwan Duhamel

General

For single stock summary sheet advice:

1) **Assessment type: update**
2) **Assessment**: analytical
3) **Forecast**: presented
4) **Assessment model**: Stock Synthesis, version 3.30.11, NOAA (Methot and Wetzel, 2013).stock benchmarked in February 2017.
5) **Data issues:** probable useful data from new juvenile surveys (JUVESAR, JUVENA, ECO-CADIZ RECLUTAS) for on hypothetic future incorporation in the assessment. High correlation between ages for both spring acoustic surveys (PELAGO & PELACUS) from age 1 until age 7.
6) **Consistency**: abundance at age residuals similar to the 2018 assessment. Last assessment biomass similar as calculated this year (no retrospective pattern pointed out).
7) **Stock status**: The biomass of 1+ fish is less than half of B_{lim} since 2011. Fishing mortality is below F_{pa}
8) **Management Plan**: Regulation measures in both Spain and Portugal for purse-seine fishery include minimum landing sizes, specifications for design and use of gears, minimum mesh sizes for nets, closed seasons and, since 2013, the implementation of a Management Plan

General comments

This was well documented, well ordered and easy to follow.

Technical comments

The assessment is done as specified in the stock Annex.

Conclusions

The assessment has been performed correctly

The benchmark procedure was performed recently (February 2017).

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice? **YES**
- Is the assessment according to the stock annex description? **YES**
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary? **Not relevant**
- Have the data been used as specified in the stock annex? **YES**
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex? **YES**
- Is there any **major** reason to deviate from the standard procedure for this stock? **NO**
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice? **YES**

Audit of Sardine Subarea 7

Date: 03/12/2019

Auditor: Susana Garrido

General

The stock of sardine in Subarea 7 (data-limited) was separated from the sardine stock in divisions 8a,b and d (data-rich) after the WKPELA 2017 benchmark.
The landings data presently available to ICES are considered too uncertain for the purpose of providing advice. High oscillations of catches were observed over time including in the last decades, were landings ranged from nearly 5 000 to 19 000 tons with no clear trend, and no conceivable explanation to explain these oscillation.
Sardine in Subarea 7 is classified in category 5. The advice is based on trends in landings. The current advice for sardine in subarea 7 is based on the Category 5 precautionary approach, which calculates the catch advice as Cy+1 = Cy-1 and applies to that a -20% precautionary buffer.

The assessment of Sardine 7:

- The landings data presently available to ICES are considered too uncertain for the purpose of providing advice.
- The discard rate is unknown and is considered as quite variable.
- For these reasons it was concluded that ICES could not provide advice on the status of this stock, given the lack of reliable catch data.

For single stock summary sheet advice:

1) **Assessment type:** No assessment.
2) **Forecast**: not presented/ Not required
3) **Assessment model**: Category 5 precautionary approach, which calculates the catch advice as Cy+1 = Cy-1 and applies to that a -20% precautionary buffer.

- **Data issues:** The landings data presently available to ICES are considered too uncertain for the purpose of providing advice. The discard rate is unknown and is considered as quite variable. The only fishery-independent data available is an acoustic survey (PELTIC) carried out for 7 years. However the complete survey series (seven years) only covers 7.f and English waters 7.e, corresponding to one fourth of the total potential sardine habitat in that region. Its coverage was expanded in 2017 to the whole of Division 7.e and, in 2018 only, to Division 7.d, covering the bulk of the population in the region. Longer time-series of this survey and further analysis are required to be used as stock indicator. A self-sampling programme for the UK artisanal fishery that started in the autumn of 2017 is also expected to provide catch-at-age data.

4) **Consistency**: Prior to 2017 sardine in Subarea 7 was assessed as a single stock combining Subarea 7 (English Channel and Celtic Sea) and divisions 8.a, 8.b, and 8.d (Bay of Biscay). Following the benchmark WKPELA 2017 sardine started to be assessed separately in each area.
5) **Stock status**: Not defined.
6) **Management Plan**: There is no management plan
7) **Basis of the advice**: The lack of reliable catch data in the Celtic Sea and English Channel impairs the possibility of performing an assessment for this stock.

General comments

The assessment and report sections were well documented and explained in the report.

Technical comments

None

Conclusions

- The rationale for not providing assessment has been performed correctly.

- The advice follows the standard ICES guidelines for category 5 stocks advice.

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice? Yes
- Is the assessment according to the stock annex description? Yes.
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary? Not Applicable
- Have the data been used as specified in the stock annex? No reliable catch data available this year.
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex? Yes.
- Is there any **major** reason to deviate from the standard procedure for this stock? No
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice? Yes for the current available data. Efforts are being made (e.g. expansion of acoustic survey to the bulk of sardine habitat in the area) to be able to eventually upgrade the stock to category 3 in the future.

Annex 5: Update to the Sardine 8.abd stock assessment

An update of the stock assessment and short-term forecast was carried out after the working group following discussion regarding the use of an assumption in age structure during the interim year, as previously used for short-term forecast. During the inter-benchmark in 2019, it was advised those assumptions to be removed from the stock assessment, as they were considered as a potential source of problem for the retrospective bias. Short-term forecast during WGHANSA have been done keeping the interim age structure. It was later discussed between members of the group that interim age structures should have been completely removed. This implied a small changes in the data conversion from SS3 to FLR but changes (slightly) all the numbers in the stock assessment outputs, diagnostics and short-term forecasts. The overall status of the stock does not change in regards to its biological reference points.

This annex contains the updated assessment and short-term forecasts.

A.5.1 State of the stock

Summary of the assessment is shown in Table A.5.1 and in Figures A.5.1–A.5.3.

The spawning–stock biomass (SSB) is above MSY $B_{trigger}$. SSB has decreased from 2010 to 2012 to the lower value of the series and has been since then stable until 2016. Then it has been increasing in 2017. The decrease after 2012 is not clearly related to the increase in fishing mortality in recent years, as F went up above F_{MSY} just after the drop in biomass assessed for January 2012. Landings were above 30 kt between 2012 and 2014, dropping for two years, and then raising up again to 32 kt in 2018 for four consecutive years. Fishing mortality has been above 0.4 and above F_{MSY} since 2013 and below F_{pa}. Recruitment has been variable over time. Recruitment in 2018 is the highest of the time-series, well above the average.

Table A.5.1. Summary of the sardine 8abd stock assessment.

Year	Recruitment (millions)	SSB (tonnes)	Total Catch (tonnes)	F(2–5)
2000	4345.72	137381	15097	0.150
2001	5282.62	155884	15005	0.155
2002	3490.02	169031	18277	0.171
2003	3860.40	177717	16607	0.138
2004	7150.22	148534	14197	0.131
2005	2296.56	176853	16360	0.129
2006	3576.44	155241	16741	0.141
2007	7017.68	138975	17323	0.150
2008	8577.05	159785	21821	0.21
2009	3471.10	136808	20855	0.170
2010	2625.11	152925	20127	0.169
2011	4364.39	122800	23208	0.22
2012	7675.31	90069	30900	0.40
2013	5381.50	96849	32938	0.43
2014	7260.78	101466	35704	0.53
2015	2681.31	92320	28756	0.44
2016	7095.73	85645	29754	0.53
2017	5542.14	112304	30435	0.49
2018	9033.98	102182	32299	0.51
2019*	4899.95	100828		

***Geometric mean (2002–2018).**

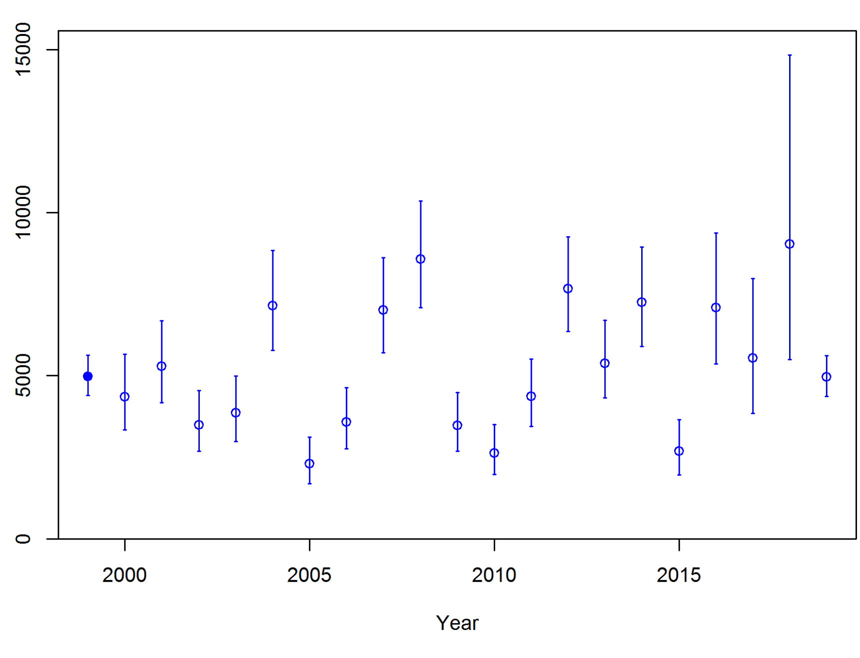


Figure A.5.1. Recruitment estimates (millions) from SS3 outputs for sardine 8abd. Last year's value is estimated from the model.

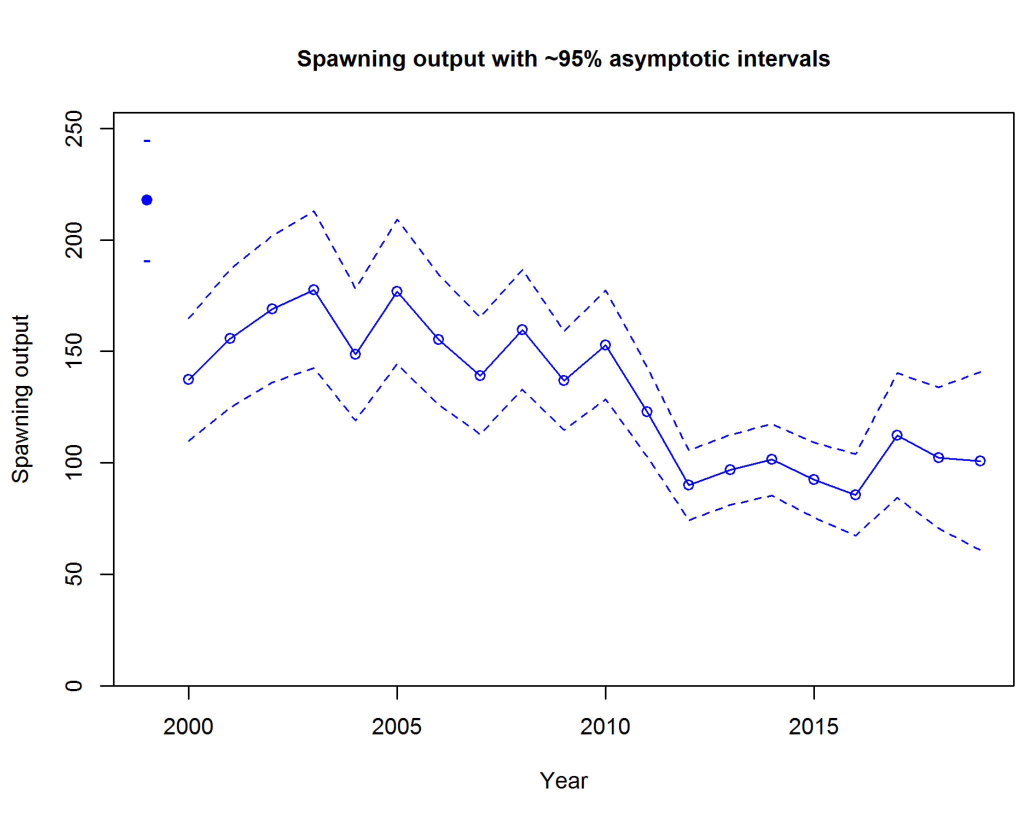


Figure A.5.2. Spawning–stock biomass (kt) from SS3 outputs for sardine 8abd. Last year's value is estimated from the model.

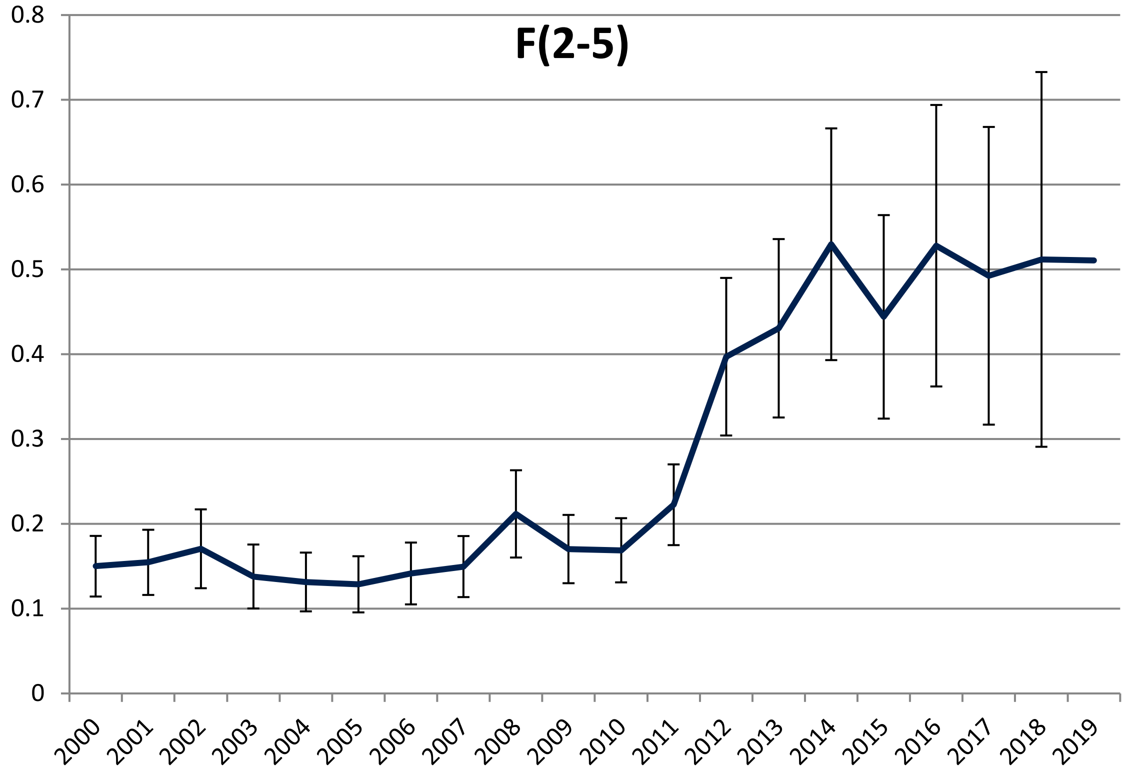


Figure A.5.3. Fishing mortality for ages 2 to 5 derived from SS3 outputs for sardine 8abd. Last year's point is an estimate of F *status quo* from the average fishing mortality of the three years before (2016–2018).

A.5.2 Diagnostics

Residuals (Figures A.5.4–A.5.5) and diagnostics do not highlight any problem regarding the input data and model fit. Some cohorts lead to some model over or underestimations. This phenomenon appears on some years for the Pelgas survey. For Pelgas, age 1 has positive residuals since 2011 and negative in earlier years.

For the commercial vessels, the cohort effect is less visible, but some years appear to have more residuals than other (e.g. 2009). The model fit to the survey indices is within the confidence intervals of those indices. There is no clear trend in recruitment estimates (Figure A.5.6).

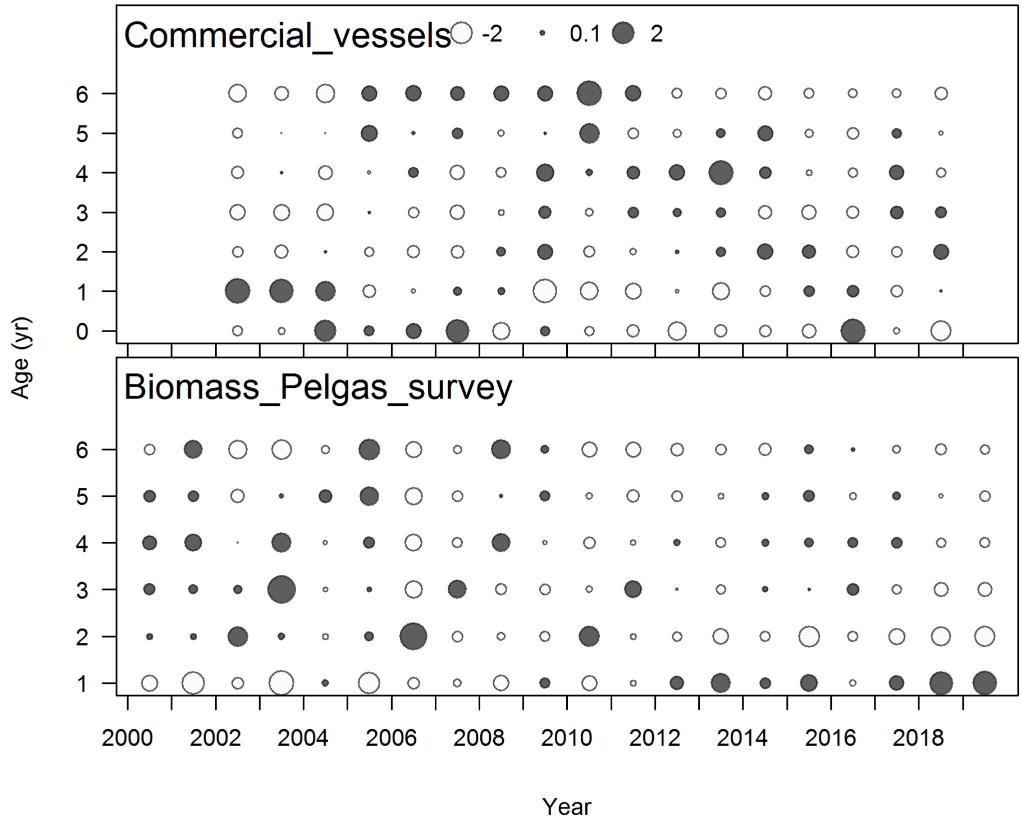


Figure A.5.4. Fit between model and age composition from the Pelgas survey and commercial vessels.

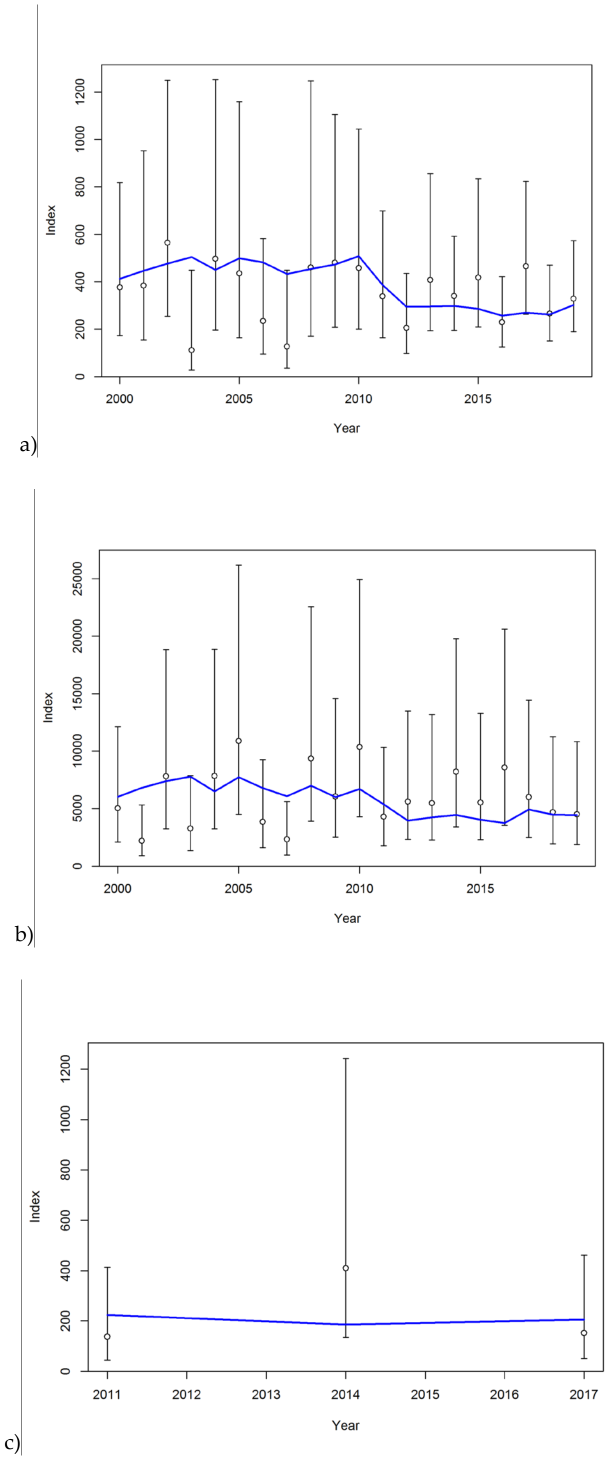


Figure A.5.5. Fit between model and survey indices: a - Acoustic (Pelgas), b - egg count (Bioman), c - DEPM.

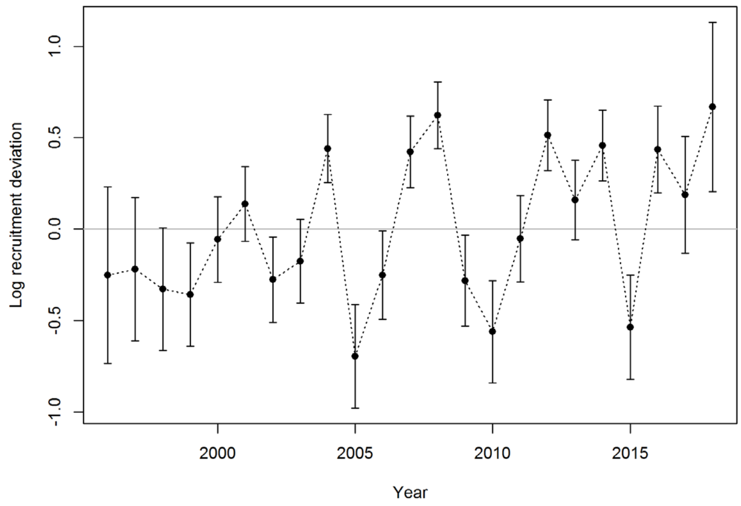


Figure A.5.6. Log recruitment deviation from the SS3 output.

A.5.3 Retrospective pattern

Retrospective patterns were considered in last year's assessment a problem, because strong bias over the time-series including some scaling effects. This required to recalculate biological reference points every year. The inter-benchmark that took place in 2019 aimed at reducing retrospective patterns by revisiting data and changing some of the model assumptions.

Retrospective patterns for SSB, F_{bar}(2–5), apical F and recruitment were computed for years 2014–2019 (Figure A.5.7) using the r4ss *do_retro()* function and Mohn's rho estimates were calculated using the same approach carried out during the inter-benchmark and therefore values can be compared to the work made during the inter-benchmark. For each run, assessment was performed including survey data until the last retrospective year and catch data until previous year, as done in the current assessment (2019).

Overall, SSB tends to be overestimated while F is underestimated. There is no clear pattern regarding recruits.

Absolute values of Mohn's rho estimates have increased in comparison to the assessment conducted during WGHANSA 2019 (see Section 6 of this report):

- Mohn's rho for SSB is 0.253 (previously 0.147).
- Mohn's rho for R is 0.313 (previously -0.133).
- Mohn's rho for F is -0.167 (previously -0.132).

Considering the assessment methodology this year has just been benchmarked, it is impossible to establish if the increase of retro bias is related to the added year of data or if this is a trend that will continue over the upcoming years. In both cases, this should be followed every year. On the other hand, it is worth noting that, previously, the SSB estimates were scaled down over the full time-series, meaning that the average SSB levels for each run was getting lower and lower when a year of data was added. With the current settings, while there are variations in the last years of the assessment, all retro runs tend to originate from the same levels at the beginning of the various time-series.

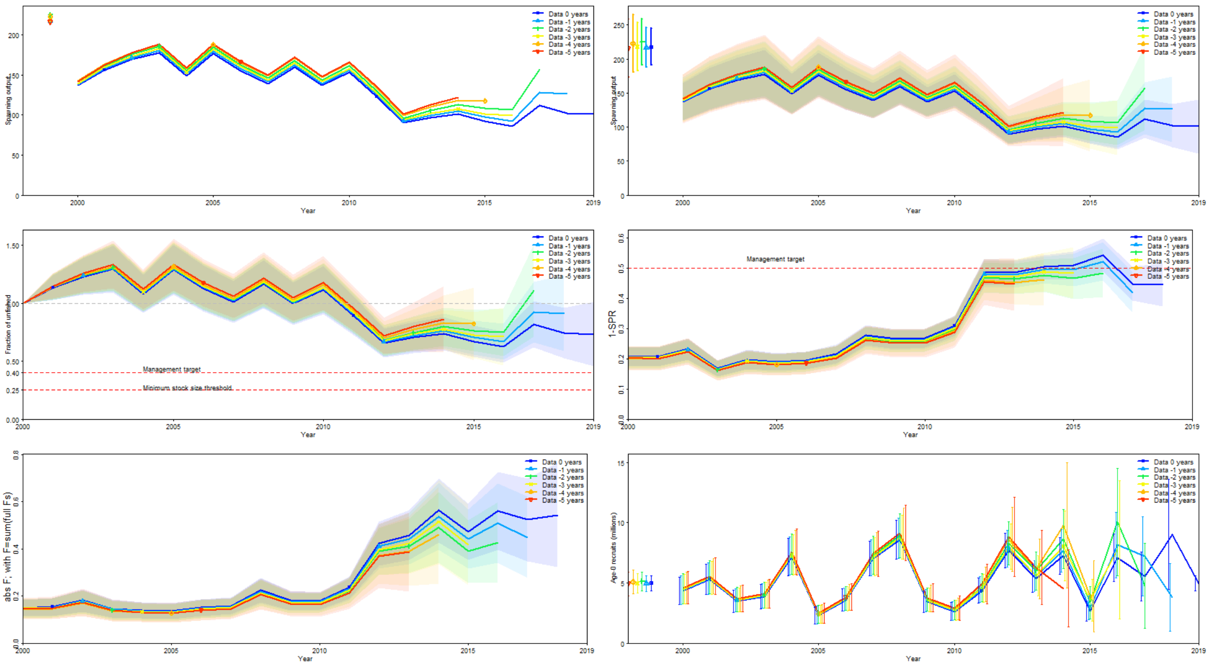


Figure A.5.7. Summary of retrospective plots.

A.5.4 Short-term projections

The recruitment of sardine for the intermediate year and forecast is assumed to be the geometric mean of the time-series of recruitment. Short-term projections were performed using FLR libraries using the *fwd* function.

The initial stock size corresponds to the assessment estimates for ages 1–6+ at the final year of the assessment. The maturity ogive is provided during the interim year by the PELGAS survey. F and M before spawning are zero, which correspond to the beginning of the year when the SSB is estimated by the model. Weights-at-age in the stock are provided during the interim year by the PELGAS survey. Weights-at-age in the catch are calculated as the arithmetic mean value of the last three years of the assessment. The exploitation pattern is equal to the last year of the assessment.

Preliminary catches are estimated and used as assumption for the interim year. The *fwd* function is set to use the preliminary catch estimates (instead of F estimates as done in previous years). Preliminary catch were available for quarter 1 to 3. Quarter 4 catches were estimated from the average proportion of Q4 catches over total catches for the last three previous years of the assessment.

Recruitment for 2019 was assumed to be 4900 million individuals. Assumption for the intermediate year are presented in Table A.5.2. The catch assumption was also included as preliminary catches in the stock assessment model this year. Input data for the short-term forecast are provided in Table A.5.3. Table A.5.4 provides the management options.

Table A.5.2. Assumptions for the intermediate year.

Variable	Value	Notes
F ages 2–5 (2019)	0.51	Based on estimated catches for 2019
SSB (2020)	125 498 tonnes	Short-term forecast
$R_{age\ 0}$ (2019/2020)	4900 million	Geometric mean (2000–2018)
Total catch (2019)	27 130 tonnes	Preliminary value based on reported catches for the first 3 quarters and predicted catches for quarter 4 assuming that they correspond to 44% of the annual catches (average percentage in 2016–2018).
Discards (2019)	0 tonnes	Negligible

Table A.5.3. Input data for the short-term forecast.

Year	Age	stock.n	stock.wt	catch.wt	mat	M	F
2019	0	4899.952	0.001	0.0243	0	1.071	0.01
	1	3071.388	0.0257	0.0386	0.7580	0.6912	0.19
	2	739.172	0.0433	0.0466	0.9977	0.5463	0.29
	3	365.307	0.0537	0.0569	0.9976	0.4752	0.41
	4	49.797	0.0624	0.0629	1.0000	0.4356	0.41
	5	52.187	0.0710	0.0725	0.9986	0.4122	0.41
	6+	27.954	0.0840	0.0778	1.0000	0.3978	0.41
2020	0		0.0003	0.0257	0	1.071	0.01
	1		0.0266	0.0386	0.8461	0.6912	0.19
	2		0.0432	0.0475	0.9985	0.5463	0.30
	3		0.0530	0.0572	0.9979	0.4752	0.42
	4		0.0620	0.0620	1.0000	0.4356	0.42
	5		0.0695	0.0709	0.9981	0.4122	0.42
	6+		0.0806	0.0746	1.0000	0.3978	0.42
2021	0		0.0003	0.0257	0	1.071	0.01
	1		0.0266	0.0386	0.8461	0.6912	0.19
	2		0.0432	0.0475	0.9985	0.5463	0.30
	3		0.0530	0.0572	0.9979	0.4752	0.42
	4		0.0620	0.0620	1.0000	0.4356	0.42
	5		0.0695	0.0709	0.9981	0.4122	0.42
	6+		0.0806	0.0746	1.0000	0.3978	0.42

Table A.5.4. Management option table.

Basis	Catch (2020)	F (2020)	SSB (2021)	% SSB change *	% Catch change **	% Advice change ***
ICES advice basis						
MSY approach: F_{MSY}	34 905	0.453	108 408	-14	8.1	56
Other scenarios						
F = 0	0	0	136 721	9	−100	−100
$F = F_{pa}$	40 368	0.54	104 089	-17	25	80
$F = F_{lim}$	52 866	0.76	94 352	-25	64	136
$SSB_{2021} = B_{lim}$	106 079	2.30	56 300	-55	228	373
$SSB_{2021} = B_{pa} = MSY\ B_{trigger}$	73 649	1.21	78 700	-37	128	229
$F = F_{2019}$	38 677	0.51	105 422	-16	20	73

*** SSB 2021 relative to SSB 2020.**

**** Catch in 2020 relative to catch in 2018 (32 299 t).**

*****Advised catch for 2020 relative to advised catch for 2019.**

Based on the GM recruitment and *catch assumption* in 2019 for all catch options, except for the SSB target of B_{lim} in 2021, the SSB will remain well above $B_{trigger}$. In all cases except no fishing, SSB in 2021 is expected to decrease compared with the one of 2020.

A.5.5 Comparison with WGHANSA 2019 assessment and forecasts (i.e. Section 6 of this report)

The revised assessment (i.e. this Annex 5) estimates a slight reduction in SSB and an increase in F compared to the previous assessment (i.e. Section 6 of this report). The correction results in a 2% downwards revision of the SSB value in 2019 and a 6% upwards revision of the F value in 2018 relative to the previous assessment results.

This however leads to a slightly higher catches applying the MSY approach that results in a 0.7% upwards revision of the catches for 2020. The reason for this is related to the 2018 recruitment estimate, the highest of the series. In the revised assessment, recruits in 2018 increase by 13%. As this increased recruitment is feed into the forecast, this results in slightly higher catch options.