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

VOLUME 2 | ISSUE 41

ICES SCIENTIFIC REPORTS

RAPPORTS
SCIENTIFIQUES DU CIEM

ICES INTERNATIONAL COUNCIL FOR THE EXPLORATION OF THE SEA
CIEM CONSEIL INTERNATIONAL POUR L'EXPLORATION DE LA MER

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 2 | Issue 41

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

Recommended format for purpose of citation:

ICES. 2020. Working Group on Southern Horse Mackerel, Anchovy and Sardine (WGHANSA). ICES Scientific Reports. 2:41. 655 pp. http://doi.org/10.17895/ices.pub.5977

Editors

Alexandra Silva

Authors

Manuela Azevedo • Leire Citores • Gersom Costas • Erwan Duhamel • Susana Garrido • Leire Ibaibarriaga • Hugo Mendes • Richard Nash • Rosana Ourens • Lionel Pawlowski • Fernando Ramos • Dália Reis • Margarita Rincón Hidalgo • Isabel Riveiro • Maria Santos • Andrés Uriarte • Laura Wise

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

Contents

i Executive summary

The main task of WGHANSA was to assess the status of 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 with modifications to mitigate the impact of missing surveys in 2020 due to the COVID19 disruption.

For sardine in 8c9a, the PELAGO index was raised by a linear regression model to accommodate the lack of the PELACUS estimation; the age composition of PELAGO was assumed to represent the whole stock. The biomass of sardine (age 1+) is above MSY $B_{trigger}$ for the first time since 2009. Fishing mortality is the lowest in the time-series but still above F_{MSY}. To answer a special request from Portugal and Spain catch scenarios for 2020 were revised.

For anchovy 9a.west, the PELAGO index was raised by a linear regression to accommodate the lack of the PELACUS2020 estimate. The stock size indicator increased from 4129 tonnes in 2019 to 56 526 tonnes in 2020. The harvest rate increased from 0.155 in management year 2018 to 0.63 in management year 2019.

The relative SSB of anchovy 9.a.south increased 26% from 2019 to 2020 being well above B_{pa}. Relative Fishing mortality (F) has fluctuated with no clear trend. From management year 2018 to 2019, relative F decreased 22%. The index ratio (1over2 rule) showed a 98% increase of the stock size indicator in 2020.

The assessment of horse mackerel in Division 9.a was modified due to the lack of the Portuguese demersal survey in autumn 2019. The SSB reached a historical maximum in 2020 of 1 102 627 tonnes. High recruitment since 2011 has contributed to the SSB increase. Fishing mortality, estimated to be 0.028 year -1 in 2019 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.

For both the Bay of Biscay anchovy and sardine, the sensitivity analyses indicated that the impact of missing data from the PELGAS 2020 survey on the assessments was not critical although the estimates of the last year were more uncertain.

For anchovy in 8, SSB shows an increasing trend and the harvest rate has fluctuated around 0.2 since the re-opening of the fishery in 2010. The SSB in 2020 is estimated to be 174 400 tonnes, which is the highest in the time-series and well above B_{lim}.

For sardine in 8abd, SSB decreased from 2010 to 2012 to the lower value of the series and has been stable since then. In 2020, SSB is estimated to be 103 915 tonnes, being above MSY $B_{trigger}$. Fishing mortality was above F_{MSY} and below F_{pa} from 2012 to 2019. In 2019, it is estimated to be below F_{MSY}. Recruitment has been variable over time and in 2019 is estimated to be around the time-series average.

Jack mackerel catches were 1231 tonnes in 2019, a level similar to those of recent years.

Finally, with respect to juvenile surveys for future incorporation in the assessment, the WG considered that the available time series is still short for anchovy in 9a. For sardine in 8c9a the work will proceed in the interim period to test the inclusion of juvenile survey data into the assessment model.

ii Expert group information

Expert group name	**Working Group on Southern Horse Mackerel, Anchovy and Sardine (WGHANSA)**
Expert group cycle	Annual
Year cycle started	2020
Reporting year in cycle	1/1
Chair	Alexandra (Xana) Silva, Portugal
Meeting venues and dates	25–29 May 2020, by correspondence (14 participants)
	23–26 November 2020, Online meeting (16 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 25–29 May 2020 (WGHANSA1) and at IPMA in Lisbon, Portugal, on 23–26 November 2020 (WGHANSA2) to (2019/2/FRSG13):

a) Address generic ToRs for Regional and Species Working Groups for relevant stocks (hom.27.9a, ane.27.9a and pil.27.8c9a in WGHANSA1 and pil.27.7, pil.27.8abd, ane.27.8 and jaa.27.10a2 in WGHANSA2);
b) In WGHANSA1, address the special request from Portugal-Spain on a revised advice on fishing opportunities for 2020 for pil.27.8c9a by updating the catch advice for 2020 based on the results of an updated stock assessment.

WGHANSA addressed ToR a) for pil.27.8c9a in WGHANSA1 according to the request of DGMARE and addressed ToR b) also in May, to answer the special request from Portugal and Spain. 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 meeting (Annex 4).

Stock	Stock code	Stock coordinator 1	Stock coordinator 2	Advice to be provided in 2020	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	18 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 2020–30 June 2021
Horse mackerel (*Trachurus trachurus*) in Division 9.a (Atlantic Iberian waters)	hom.27.9a	Gersom Costas	Hugo Mendes	X	1	18 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	18 December	1	Management strategy	Benchmarked in 2013
Sardine (*Sardina pilchardus*) in Subarea 7 (Southern Celtic Seas, and the English Channel)	pil.27.7	Rosana Ourens	Erwan Duhamel	-	2		5		Benchmark scheduled to 2021.

Stock	Stock code	Stock coordinator 1	Stock coordinator 2	Advice to be provided in 2020	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	18 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	18 June	1	MSY	Benchmarked in 2017; reference points changed in 2019, in the context of the evaluation of a management and recovery plan. A bilateral agreement between Portugal and Spain (Despacho 5713-A/2020; BOE-A-2020-4947) stating that they will manage the fishery in 2020 according to a harvest contrul rule, HCR12, evaluated as precautionary by ICES (ICES, 2019b). This rule has not been agreed by the EU thus ICES provides advice based on the MSY approach.

WGHANSA1 reported by 5 June 2019 for the attention of ACOM, on Anchovy in Division 9a (ane.27.9a), Horse mackerel in Division 9a (hom.27.9a) and Sardine in divisions 8c and 9a (pil.27.8c9a).

WGHANSA2 will meet at IPMA in Lisbon, Portugal, on 23–26 November 2020 and will report on 1 December to the attention of ACOM on Sardine in Subarea 7 (pil.27.7), Sardine in divisions 8a,b,d (pil.27.8abd), 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). Tor b) is addressed in Chapter 8.

Chapters 3, 6, 7 and 10 will be filled in the WGHANSA2 meeting.

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.

ToR b). The WG reviewed the catch advice for sardine 8c9a in 2020 based on the results of the stock assessment and 1 year short term forecast conducted during the meeting, taking the most recent data on catches (up to 2019) and surveys (up to 2020).

Preparatory work to address data limitations due to the COVID19 disruption: A WebEx was carried out by WGHANSA prior to the meeting to identify problems to the assessments due to missing surveys or other data (WGHANSA WebEx 29042020.pptx, Annex 2). The lack of PELACUS spring acoustic survey was identified as the main problem affecting the assessment of stocks in WGHANSA1, and a roadmap was set to perform sensitivity tests on the impact of the lack of this survey on ane.27.9a.west and on pil.27.8c9a, namely according to preliminary guideline from ACOM. While not related to the COVID19 disruption, the Portuguese demersal survey was not carried out and the WG also explored how this affected horse mackerel assessment.

In addition, the PELAGO2020 spring acoustic survey was performed in Miguel Oliver (RV from Spain), not the vessel that usually carries out the survey each year (RV Noruega, from Portugal). A joint WGACEGG-WGHANSA WebEx took place to discuss how the changes in the survey protocol could affect the comparability along the time-series and therefore the assessments. WGACEGG approved the use of the PELAGO2020 data for submission to WGHANSA (Annex 2, WGACEGG_15052020_meeting.pptx). The WG also outlined actions to explore the impact of the cancellation of PELACUS possible ways to mitigate using data from other surveys covering partially the area such as BIOMAN.

- Annex 1 - Participants list;
- Annex 2 - Working documents;
- Annex 3 - Stock Annexes;
- Annex 4 - Audits;

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

1.3.1 Timing of the meeting

WGHANSA continues to have two meetings per year, in June, by correspondence, to address General and specific ToRs: 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.

The participants recognise that two meetings per year (one of them by correspondence) is not an ideal situation and recommend that ICES evaluates the possibility to provide advice for Anchovy in 9.a and Horse mackerel in 9.a in November, together with the remaining WGHANSA stocks.

This year ICES was asked to provide advice for Sardine in 8c9a based on an assessment carried out in the correspondence meeting in May. Despite this additional work being feasible, it required extra effort from WGHANSA members, including the secretariat, and from all people involved in the preparation of survey and catch data for the stock. This extra effort was put on top of the disturbance created by the COVID19 pandemic situation. The WG considers that it is preferable to continue to have the sardine 8c9a assessment in November, to profit from the review of surveys by WGACEGG, in-year catch data and information from the autumn recruitment survey. The same advantages would apply to the assessment of horse mackerel and anchovy if these are moved to November.

Although it has not been possible to agree with WGACEGG a format for partly joint annual meetings, the two groups will improve interaction by creating dedicated time slots during their own meetings. WGHANSA members may participate in the discussion e.g. of surveys during WGACEGG meetings, by videoconference, and the same applies to WGACEGG members.

1.4 Quality of the fishery input

In 2020 (2019 catch data), the differences between the WG estimates and official data were minimal, and as is the usual procedure, estimates of the working group were used to perform the assessment in all cases.

1.5 Overview of the sampling activities on a national basis for 2019

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	5692	100%	179	7303	3170
Portugal	2618	100%	31	1238	1049
Total	8310	100%	210	8541	4219

Horse Mackerel 9a

Country	Official Catch	% of catch sampled	No. samples	No.measured	No. Aged
Portugal*	17 220	100	383	3679	351
Spain	19 317	100	201	11 605	778
Total	36 537	100	584	15 284	1129

Sardine 8c9a

Country	Official Catch	% of catch sampled	No. samples	No.measured	No. Aged
Portugal	9796	100%	87	6912	2277
Spain	3964	100%	61	36 057	2132
Total	13 760	100%	148	42 969	4409

Anchovy 8

Country	Official Catch	% of catch sampled	No. samples	No. measured	No. Aged
Spain	24807	100%	388	66018	3980
France	2048	100%	8	341	2023
Total	26857	100%	396	66359	6003

Sardine 8abd

Country	Official Catch	% of catch sampled	No. samples	No. measured	No. Aged
France	21 099	100%	76	3327	1596
Spain	3279	100%	185	19740	518
Total	24 378	100%	261	23 067	2114

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	1 044	100%	216	11 267	23
Total	1 044	100%	216	11 267	23

1.6 Benchmarks and inter-benchmarks

The WG discussed benchmarks or inter-benchmarks for most WGHANSA stocks.

The results are the following:

Sardine in 7 – benchmark for 2021 in preparation. The progress of the work was presented to WGHANSA2 and the group considered that substantial progress has been carried out and endorsed the work to the benchmark.

Anchovy in 8 – requested a benchmark for 2020 that was not carried out; potential benchmark in 2022 (prioritization score of 3).

Horse mackerel – Work is in progress to explore the fishery and survey selectivity models of the assessment; an inter-benchmark will be proposed pending on progress achieved inter-sessionally until WGHANSA in June 2021.

Anchovy 9a – may ask for benchmark in 2023 when the time-series of ECOCADIZ-RECLUTAS is sufficiently long to be explored within the assessment model.

Sardine 8c9a – work is in progress to incorporate data from autumn recruitment surveys in the assessment and discuss the results in the next WKTADSA meeting (January 2021). Following the joint discussion of these surveys with WGACEGG in November, it is expected that their use in the assessment is endorsed. An inter-benchmark will be proposed pending on progress achieved inter-sessionally until WGHANSA in June 2021.

1.7 Biological reference points: comments on terminology and estimation procedures

ICES adopted new reference points for pil27.8c9a in 2019 considering that the stock is in a state of low productivity regime.

In the same year, ICES evaluate several harvest control rules to be precautionary and, therefore, suitable for the management of the stock. One of these precautionary harvest control rules, HCR12, has a F_{target} higher than the adopted F_{MSY} for the stock. This as lead to misunderstandings between ICES client, managers and the general public. In WGHANSA-2, this issue was discussed and a proposal/suggestion to ACOM is made on Subsection 8.8.1.

2 Anchovy in northern areas

This section has not been updated, as there is no new information.

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 2020, the Council established the TAC in 2020 for the Bay of Biscay anchovy stock at 31 892 tonnes (Council Regulation No 123/2020), 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 2020 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 2019 and 2020

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 with decreasing catches along years).

The total number of fishing licences for anchovy in Spain in 2020 were 155. 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 has decreased progressively and some of them joined the north of the Bay of Biscay in the last seven years. The real target species of these vessels is sardine, and anchovy is more opportunistic in summer or 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 2019, 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. Particularly during August and September, purse-seiners caught a bit more than 1200 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 2019 were 26 857 tonnes, from which 24 809 corresponded to Spain and 2048 to France. From the Spanish catches, 7 tonnes corresponded to anchovy used as live-bait for tuna fishing and 33 tonnes to discards from Spanish bottom otter trawls directed to demersal fish. These discards are less than 0.15% 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 2019, 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 2019 are given in **Table 3.2.2.3**. Most of the catches took place in the second quarter (74%), followed by the third, first and fourth quarter (15%, 10% and 1% respectively). The major fishing activity of the Spanish fleet occurred in the second quarter (78%), whereas the French fleet operated mainly in the third quarter (64%). Regarding fishing areas, most of the Spanish catches in the first semester corresponded to ICES Division 8.cE. All 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. In 2019, only 86 tons have been declared in 25E5 and 25E4 and these catches have been reallocated to 8.a.

3.2.3 Catch numbers-at-age and length

Catch numbers-at-age by quarter in 2019 for Spain and France are given in **Table 3.2.3.1**. Age 2 individuals were predominant in the first and second quarters, whereas age 1 individuals were predominant in the third and fourth quarters. Age 0 individuals appeared in small amounts in the third quarter and represented 4% 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 2019, age 2 individuals dominated in the catches in the first semester (60%), while the larger group during the second half corresponded to the one-year old anchovies (51%).

Catch-at-length data (by 0.5 cm classes) by quarter in 2019 are given in **Table 3.2.3.3**. The length range was between 7.5 and 19 cm. The mean length was between 12.6 and 15.4 cm in the Spanish catches and between 14.3 and 14.7 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 2019, is shown in **Table 3.2.4.1**. See the stock annex for methodological issues.

3.2.5 Preliminary fishery data in 2020

The provisional catches during the first semester of 2020 were 14 819 t, from which 14 808 t corresponded to Spain and 11 t to France. 62% of the catches (in mass) during the first semester were age 1. In 2020, the French landings (still provisional) of anchovy drastically decreased because vessels found only small or medium-size individuals, and the price was very low, so vessels stopped targeting anchovy.

It must be emphasised that 2020 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, 2020 November and December catches were assumed to be 3% of the total annual catch (which is the average of the percentage of the catches in November and December in 2010–2019, after the reopening of the fishery). Therefore, the total catch in November and December was taken as 703 t, resulting in 11 116 t for the second semester 2020.

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	2,048	24,802	7			26,857
2020 (Up to end of Oct	137	25,095				25,232
AVERAGE (1960-2004)	6,394	26,337				32,824
AVERAGE (2010-2019)	3,548	16,989				20,658

** : 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
2019	7	8	2800	9743	8924	717	1863	1295	866	452	171	4	26850

Table 3.2.2.3. Bay of Biscay anchovy: Catches in the Bay of Biscay by country and divisions in 2019 (without live bait catches).

COUNTRIES	DIVISIONS	QUARTERS 1	2	3	4	CATCH (t) ANNUAL	%
SPAIN	8abd	409	4879	102	6	5396	21.8%
	8cE	2268	14501	1902	0	18671	75.3%
	8cW	138	4	594	0	735	3.0%
	TOTAL	2815	19384	2597	6	24802	100.0%
	%	11.4%	78.2%	10.5%	0.0%	100.0%	
FRANCE	8abd		561	1317	170	2048	100.0%
	8cE	0	0	0	0	0	0.0%
	8cW	0	0	0	0	0	0.0%
	TOTAL	0	561	1317	170	2048	100.0%
	%	0.0%	27.4%	64.3%	8.3%	100.0%	
INTERNATIONAL	8abd	409	5440	1419	175	7443	27.7%
	8cE	2268	14501	1902	0	18671	69.5%
	8cW	138	4	594	0	735	2.7%
	TOTAL	2815	19944	3914	175	26850	100.0%
	%	10.5%	74.3%	14.6%	0.7%	100.0%	

Table 3.2.3.1. Bay of Biscay anchovy: catch-at-age in thousands for 2019 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 Sub-area 8	0	0	0	74	299	373
	1	36,550	268,620	81,089	6,070	392,329
	2	63,411	480,004	75,657	1,698	620,770
	3	2,800	49,779	6,574	99	59,252
	4	0	440	0	0	440
	5	0	0	0	0	0
	TOTAL(n)	102,761	798,844	163,393	8,166	1,073,164
	W MED.	27.45	25.00	23.85	21.17	25.03
	CATCH. (t)	2815	19944	3914	175	26850
	SOP	2821	19972	3897	173	26863
	VAR. %	100.21%	100.14%	99.56%	98.57%	100.05%

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	1,001,551	440,134	794,055	611,047	494,610	355,663	522,361	189,081
2	157,665	13,534	92,621	13,334	123,683	10,771	59,482	75,999	310,620	12,581	193,137	31,446	439,655	91,977	493,437	54,867	282,301	21,771
3	31,362	1,664	9,954	596	18,096	1,986	8,175	4,999	29,179	61	16,960	1	5,336	0	61,667	1,325	76,525	90
4	14,831	58	1,356	0	54	0	0	0	0	0	0	0	0	0	0	0	4,096	7
5	8,920	0	99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total #	431,448	173,494	398,971	529,130	294,445	219,927	915,283	615,671	663,677	215,579	1,211,647	510,015	1,239,046	766,523	1,049,714	471,789	885,283	260,719

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

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

YEAR	2014		2015		2016		2017		2018		2019							
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						
0	0	37,068	0	443	0	74,571	0	23,725	0	1,770	0	373						
1	228,729	187,159	560,920	251,508	261,072	136,044	469,609	82,487	682,918	178,348	305,170	87,158						
2	336,224	12,181	357,044	128,579	363,465	58,740	425,906	48,549	399,932	37,574	543,415	77,355						
3	53,703	3,035	27,236	6,914	45,212	2,287	92,731	7,660	39,483	1,210	52,579	6,673						
4	4,271	0	173	0	231	0	2,339	0	292	0	440	0						
5	0	0	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	901,605	171,559						

Table 3.2.3.3. Bay of Biscay anchovy: Catch numbers-at-length by country and quarters in 2019.

	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						1		
8		17				1		
8.5		64		0		2		3
9		165		82		2		3
9.5		229		131		4		6
10		316		693		9		11
10.5		353	115	1,445	14	36	1	11
11		422	230	2,538	29	75	3	30
11.5		568	345	4,695	43	125	4	36
12		966	345	8,711	43	259	4	58
12.5		1,259	919	16,438	116	828	11	59
13		1,971	2052	34,462	924	2,454	111	46
13.5		2,633	3244	58,843	5506	6,497	705	43
14		5,245	5973	81,258	10061	12,648	1289	21
14.5		8,047	6190	96,938	18288	14,775	2365	21
15		15,911	4139	106,933	12711	16,915	1644	14
15.5		18,737	2619	110,949	7422	18,106	959	12
16		18,663	1137	98,854	3689	14,122	478	3
16.5		14,271	612	76,705	1629	9,314	210	3
17		8,178		41,683		4,535		0
17.5		3,348		19,779		1,658		0
18		968		6,783		685		
18.5		221		1,342		60		
19		6		18				
19.5								
20								
20.5								
21								
21.5								
22								
22.5								
23								
23.5								
24								
24.5								
25								
25.5								
26								
Total ('000)		102559	27921	769281	60475	103109	7784	382
Catch (t)		2815	561	19384	1317	2604	170	6
Mean Length(cm)		15.4	14.3	15.0	14.7	15.1	14.7	12.6

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

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		2019							
Sources:	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						
Age 0	na	16.1	0.0	9.4	na	14.3	na	8.5	na	12.5	na	11.9						
1	18.3	26.3	17.0	19.9	19.3	20.0	19.8	23.3	20.7	22.1	20.2	21.0						
2	25.1	33.3	25.5	28.1	24.5	24.1	25.1	26.8	25.0	28.3	27.4	26.0						
3	28.9	45.8	28.7	38.5	31.7	32.8	28.8	30.7	33.7	28.8	32.2	33.6						
4	26.0	na	25.5	na	32.6	na	29.9	0.0	27.8	na	27.7	na						
5	na	na	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	25.3	23.7						

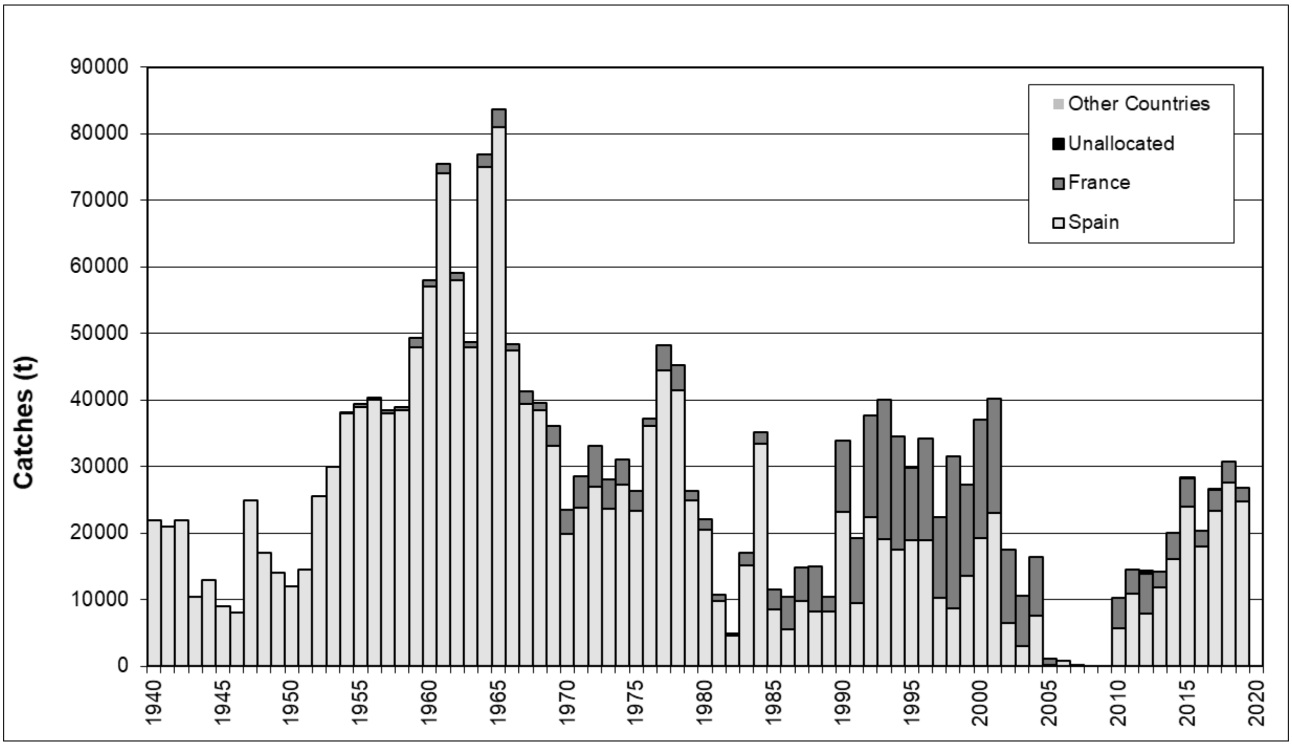


Figure 3.2.2.1. Bay of Biscay anchovy: Historical evolution of catches in Division 8 by countries.

3.3 Fishery-independent data

3.3.1 BIOMAN DEPM survey 2020

All the survey methodology and the estimation procedure are described in detail in the stock annex, Bay of Biscay Anchovy (Subarea 8). A detailed report of the survey and results 2020 is attached as a working document in ICES WGACEGG 2020 (**Santos. M *et al.*, BIOMAN 2020).**

3.3.1.1 Survey description

The 2020 anchovy DEPM survey was carried out in the Bay of Biscay from the 4th to the 27th 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 Vizconde de Eza 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 836. From those, 719 had anchovy eggs (86%) with an average of 480 eggs m^{-2} per station in the positive stations, and a maximum of 4690 eggs m^{-2} in a station. A total of 40 319 anchovy eggs were encountered and classified in the PairoVET stations. The number of CUFES samples (horizontal sampling) obtained was 1806. Frome those 1527 (85%) stations had anchovy eggs with an average of 50 eggs m^{-3} per station and a maximum of 569 eggs m^{-3} in a station.

This year 14.5% of the anchovy eggs were found in the Cantabrian Coast, in this coast the west limit of the spawning was found at 6ºW. There were eggs all over the French platform up to 48ºN (limit of the ICES area 8a). (**Figure 3.3.1.1.1**). The total area covered was 115 464 km^2 and the spawning area was 97 778 km^2.

In relation to the adult samples, 55 pelagic trawls were performed, from which 44 were selected for the analysis. This year, one additional anchovy adult sample was obtained from the Basque purse seines. In total, there were 45 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 were: 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, 15.8 was higher than last year (14.8ºC), the minimum was 12.8ºC and the maximum 19.7ºC. The mean SSS (34.6) was lower than last year (35) with a minimum of 29.9 and a maximum of 36. The weather conditions during the survey were good in general. The warmest waters were in the southeast of the Bay of Biscay, while the coldest were located around the mouth of the Garonne River and close to the French coast.

The lower saline waters were in a wide area along the French shelf, between the mouths of the Adour and Loire rivers. The lowest salinity peak was located at the mouth of the Garonne River and salinities above 35 UPS were located on the Cantabrian shelf and slope, and the outermost part of the French coast.

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 2020 was estimated at 2.32E+13 with a CV of 0.0636. This is the highest estimate 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 **334 283 t with a CV of 0.1158.** This is the largest biomass estimate in the time-series.

3.3.1.4 Population-at-age

Numbers-at-age were estimated from the age readings based on 3023 otoliths from the adult samples well distributed over the spawning area. Seven strata were defined based on the egg abundance, the adult distribution and the size and age of adult anchovy: Cantabric (Ca), South(S), Arcachon (A), Center (C), Garonne (G), Northeast (NE) and Northwest (NW) (**Figure 3.3.1.4.1**). 83% of the anchovy in numbers were estimated as individuals of age 1 (76% in mass), 15% of the individuals in numbers were of age 2 (21% in mass) and 2% of the individuals in numbers were of age 3 and older (4% in mass) (**Table 3.3.1.4.1**). This indicated the highest recruitment of the historical series. The anchovy age composition by haul 2020 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 is showed in **Figure 3.3.1.4.4.** The historical series of weight-at-age suggests a downwards trend in the last years.

Table 3.3.1.1.1. Bay of Biscay anchovy: Details of the DEPM survey BIOMAN 2020.

Parameters	Anchovy DEPM survey
Surveyed area	(43º18' to 48º00'N & 6º 43' to 1º13' W)
RV	Vizconde de Eza and Emma Bardán
Date	4-27/05/2020
Eggs	**RV VIZCONDE DE EZA**
Total egg stations	836
% st with anchovy eggs	85%
Anchovy egg average by st	480 eggs/m^2
Maximum anchovy eggs in a St	4690 eggs/m^2
Total ANE egg collected and staged	40 319 eggs
North spawning limit	48º'00'N
West spawning limit	6º00'W
Total area surveyed	115 464 Km^2
Spawning area	97 778 Km^2
CUFES stations	1806
Adults	**RV EMMA BARDAN and Purse-Seines**
Pelagic trawls	55
With anchovy	45
Selected for analysis	44
Hauls from purse-seines	1
Total adult samples for analysis	45

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 2020.

Parameter	Value	S.e.	CV
P_0	237.67	15.11	0.0636
z	0.30	0.035	0.1173
Ptot	2.32E+13	1.48E+12	0.0636

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 2020. Total egg production (P_{tot}) estimate is shown as well.

Parameter	estimate	S.e.	CV
P_{tot} (eggs)	2.32E+13	1.48E+12	0.0636
R'(% of females)	0.5214	0.0062	0.0119
S (% fem. spawning/day)	0.3552	0.0146	0.041
F (eggs/batch/mature fem.)	5,166	516	0.0999
W_f (g)	13.64	0.73	0.0537
DF (eggs/g/day)	70.16	6.79	0.0968
B (tons)	334283	38703	0.1158

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 2020.

Parameter	estimate	S.e.	CV
BIOMASS (tons)	334 283	38 703	0.1158
Total mean Weight (g)	12.22	0.514	0.0421
Population (millions)	27 486	3746	0.1363
Percentage-at-age 1	0.83	0.023	0.0274
Percentage-at-age 2	0.15	0.021	0.1364
Percentage-at-age 3+	0.02	0.005	0.2375
Numbers-at-age 1	22 758	3295	0.1448
Numbers-at-age 2	4 178	758	0.1813
Numbers-at-age 3+	549	111	0.2014
Percentage-at-age 1 in mass	0.76	0.032	0.0428
Percentage-at-age 2 in mass	0.21	0.028	0.1349
Percentage-at-age 3+ in mass	0.04	0.009	0.2325
Biomass-at-age 1 (tons)	252 547	32359	0.1281
Biomass-at-age 2 (tons)	69 010	12073	0.1749
Biomass-at-age 3+ (tons)	12 775	2845	0.2227
Weight-at-age 1 (g)	11.16	0.474	0.0425
Weight-at-age 2 (g)	16.57	0.853	0.0514
Weight-at-age 3 (g)	23.08	1.224	0.0530
Length-at-age 1 (mm)	123.13	1.140	0.0093
Length-at-age 2 (mm)	139.2	1.937	0.0139
Length-at-age 3 (mm)	152.28	3.473	0.0228

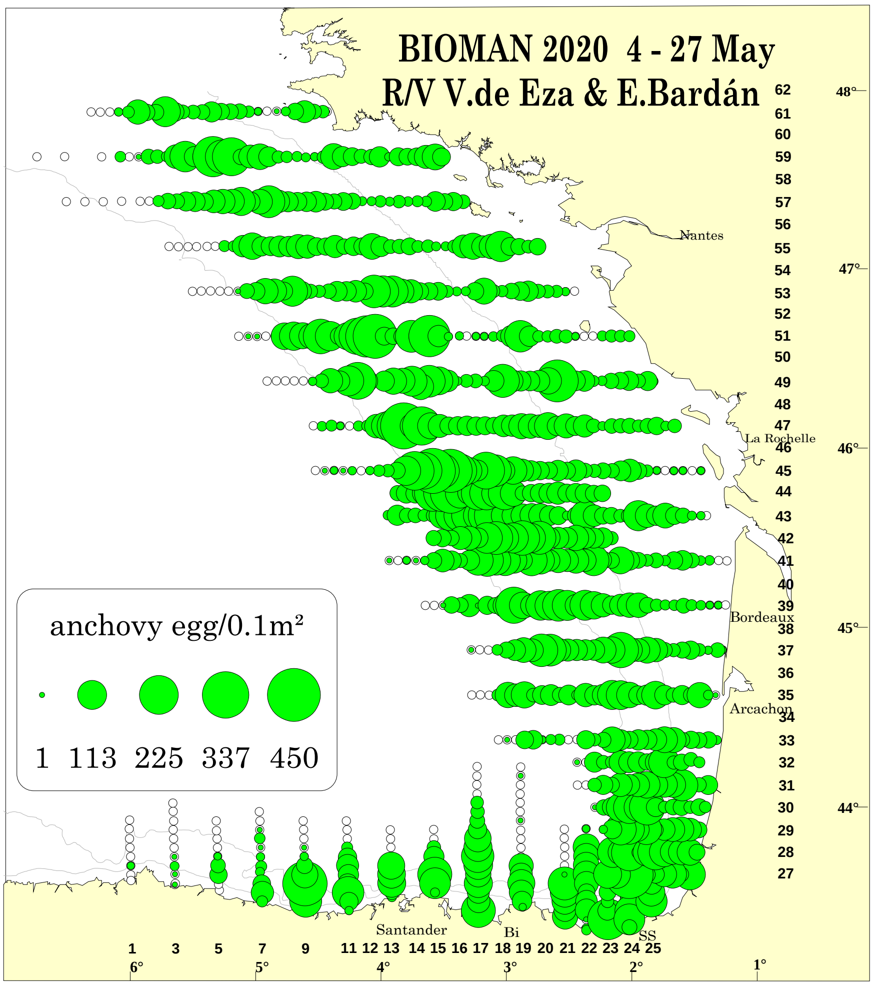


Figure 3.3.1.1.1. Bay of Biscay anchovy: Spatial distribution of anchovy egg abundance (eggs per 0.1 m²) from the DEPM survey BIOMAN2020 obtained with PairoVET (vertical sampling net).

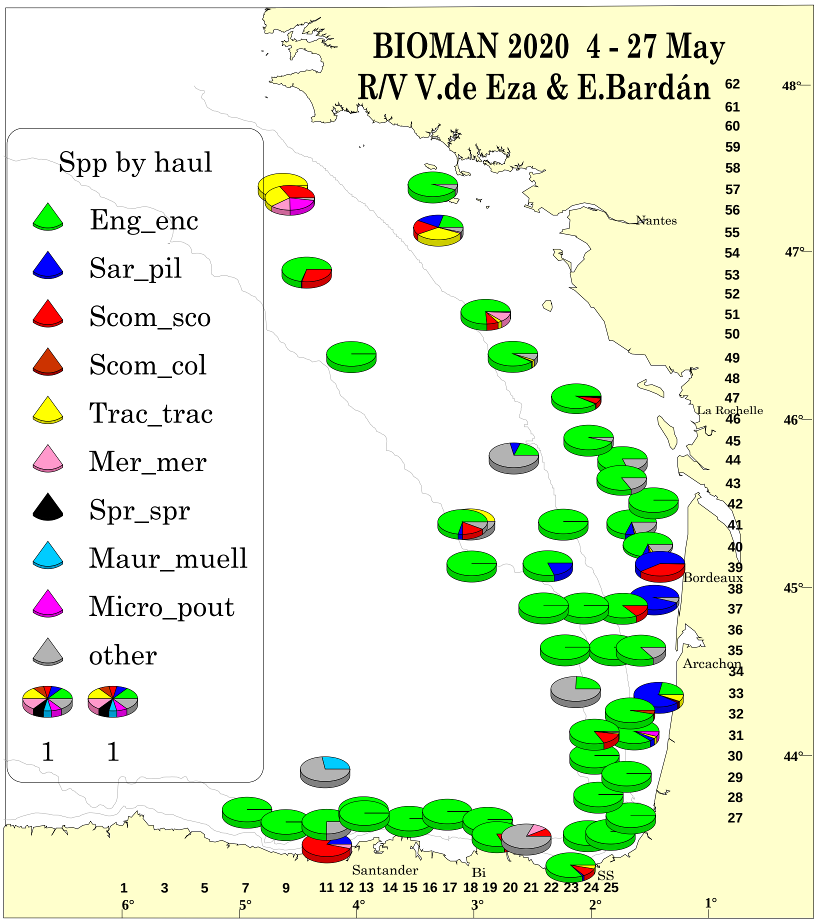


Figure 3.3.1.1.2. Bay of Biscay anchovy: Species composition of the 55 pelagic trawls from the RV Emma Bardán during BIOMAN2020.

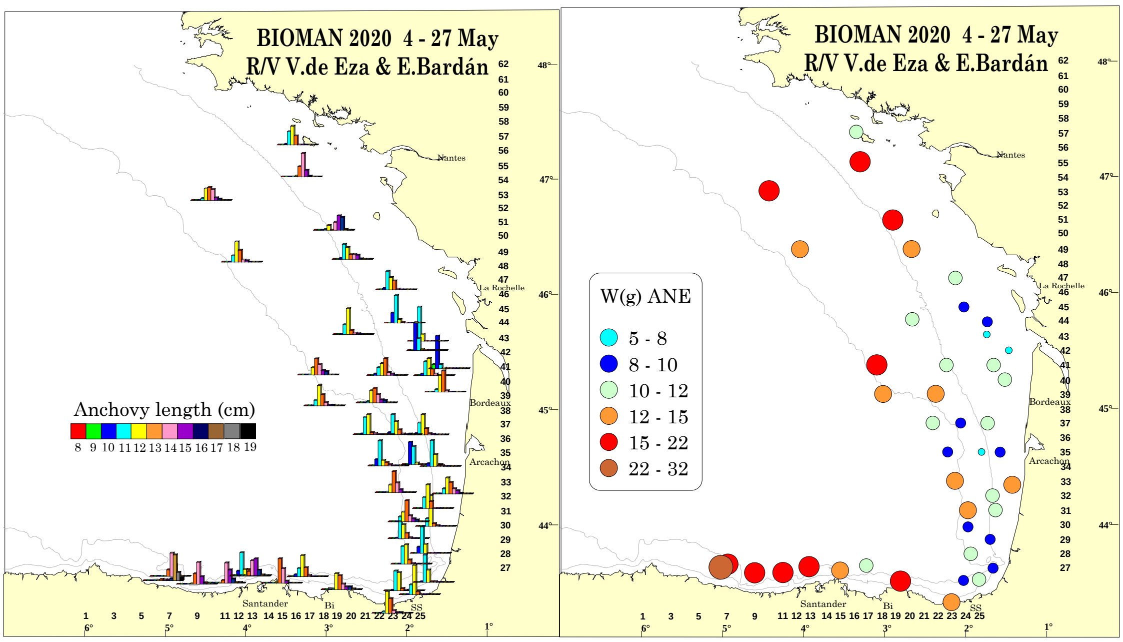


Figure 3.3.1.1.3. Bay of Biscay anchovy: Spatial distribution of anchovy size distribution by haul and mean weight during BIOMAN2019.

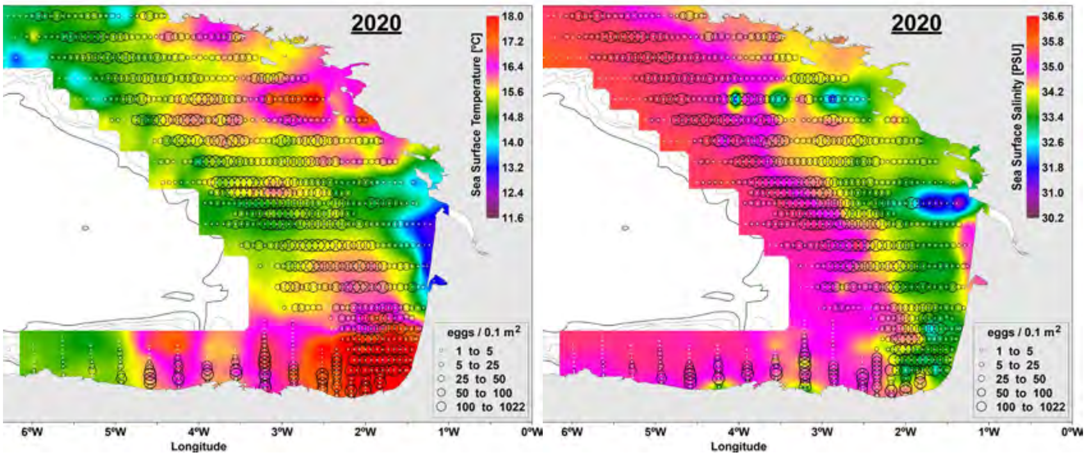


Figure 3.3.1.1.4. Bay of Biscay anchovy: From left to right spatial distribution of SST and SSS in BIOMAN 2020 and anchovy egg abundance (egg/0.1m²).

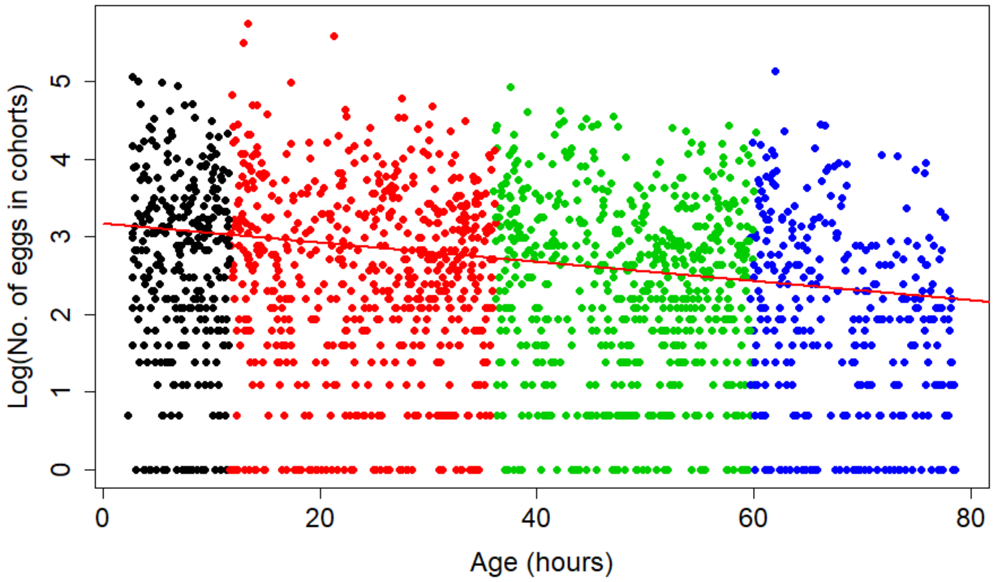


Figure 3.3.1.2.1. Bay of Biscay anchovy: Exponential mortality model in log scale adjusted applying a GLM to the data obtained in the Bayesian egg ageing (spawning peak at 23:00h GMT). The red line is the adjusted line. The coloured dots represent the different cohorts.

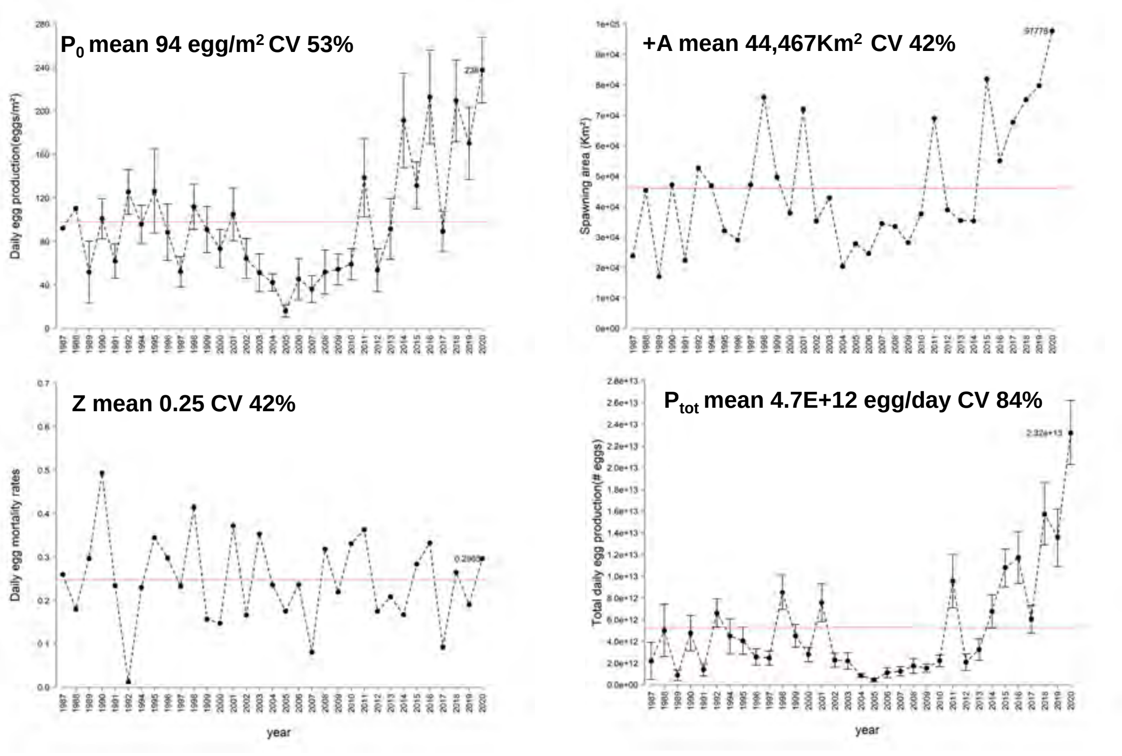


Figure 3.3.1.2.2. Bay of Biscay anchovy: Time-series of daily egg production (*P_0*), spawning area (*+A*). daily egg mortality rates (*z*) and total daily egg production (*P_{tot}*). The 2020 estimates are highlighted.

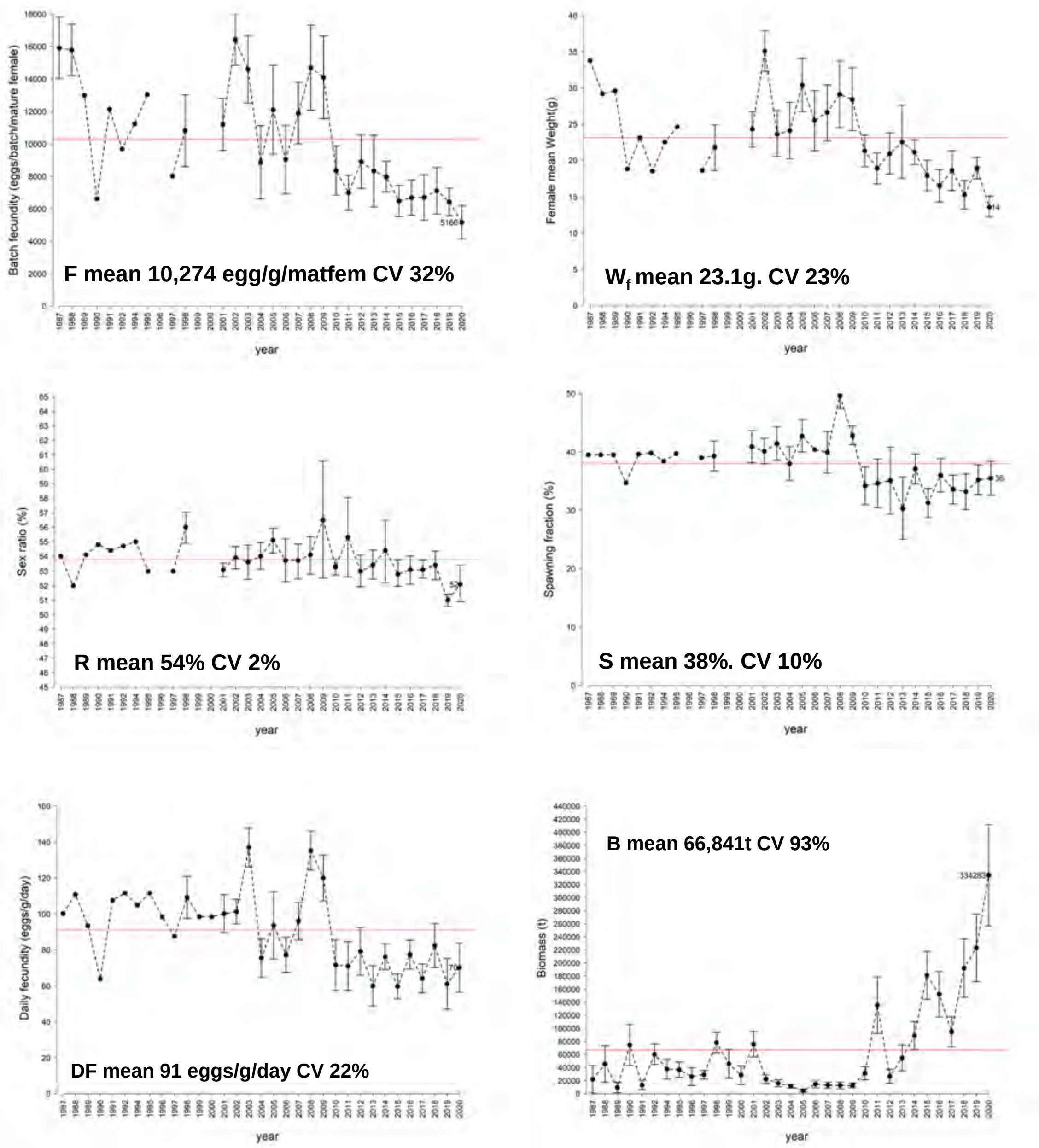


Figure 3.3.1.3.1. Bay of Biscay anchovy: Time-series of anchovy adult parameters: batch fecundity (F), female mean weight (Wf), sex ratio (R), spawning fraction (S), daily fecundity (DF) and total biomass (B) estimates (tonnes) obtained from the application of the DEPM. The 2020 estimates are highlighted.

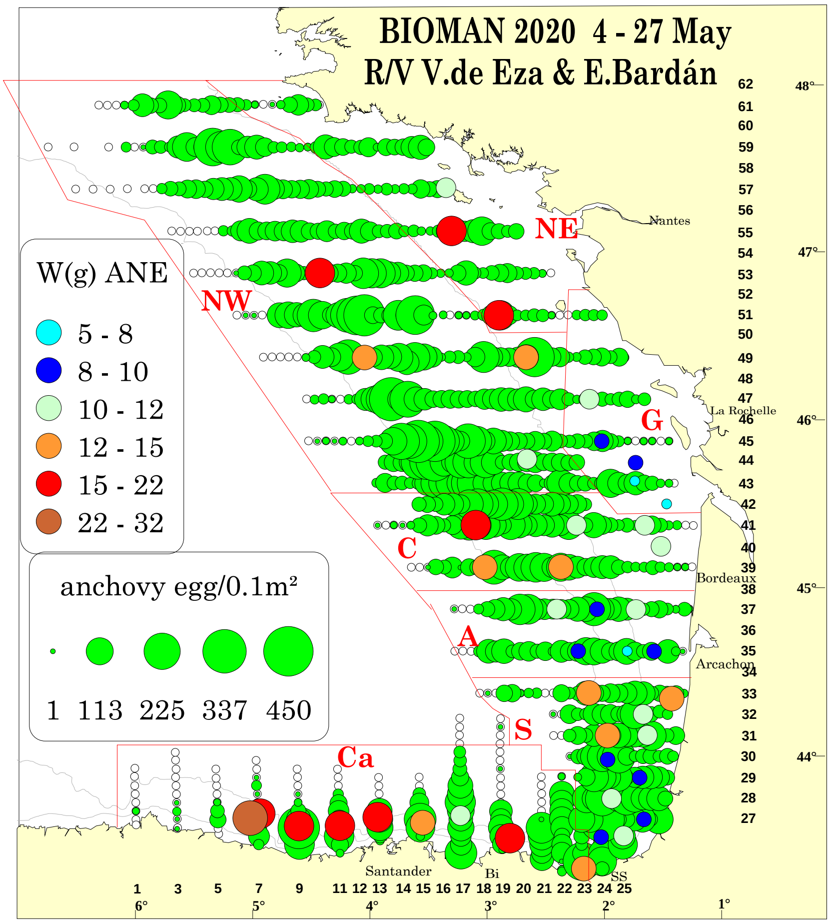


Figure 3.3.1.4.1. Bay of Biscay anchovy: seven regions defined to weight the adult samples to estimate anchovy numbers-at-age in 2020: Cantabric (Ca), Coastal South (CS), Coastal North (CN), Garonne (G), North (N) and West(W). The red lines represent the border of the regions, the green bubbles the abundance of anchovy eggs (egg/0.1m²) in each station and the small colour bubbles represent the mean weight (g) of individuals within each haul.

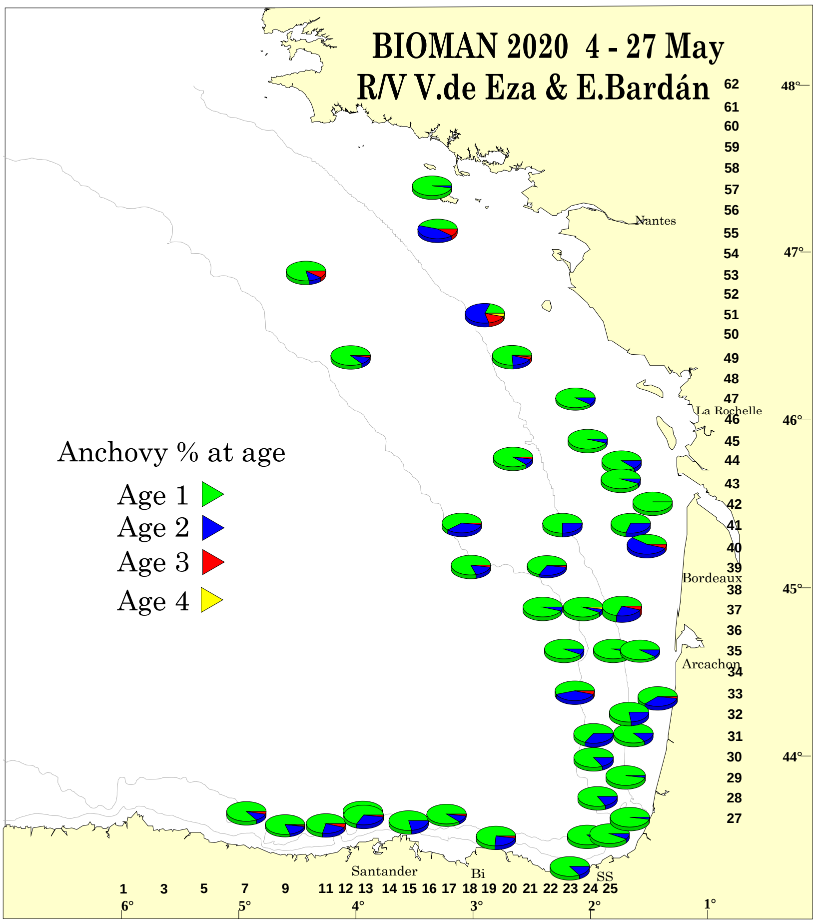


Figure 3.3.1.4.2. Bay of Biscay anchovy: Anchovy age composition by haul in BIOMAN2020.

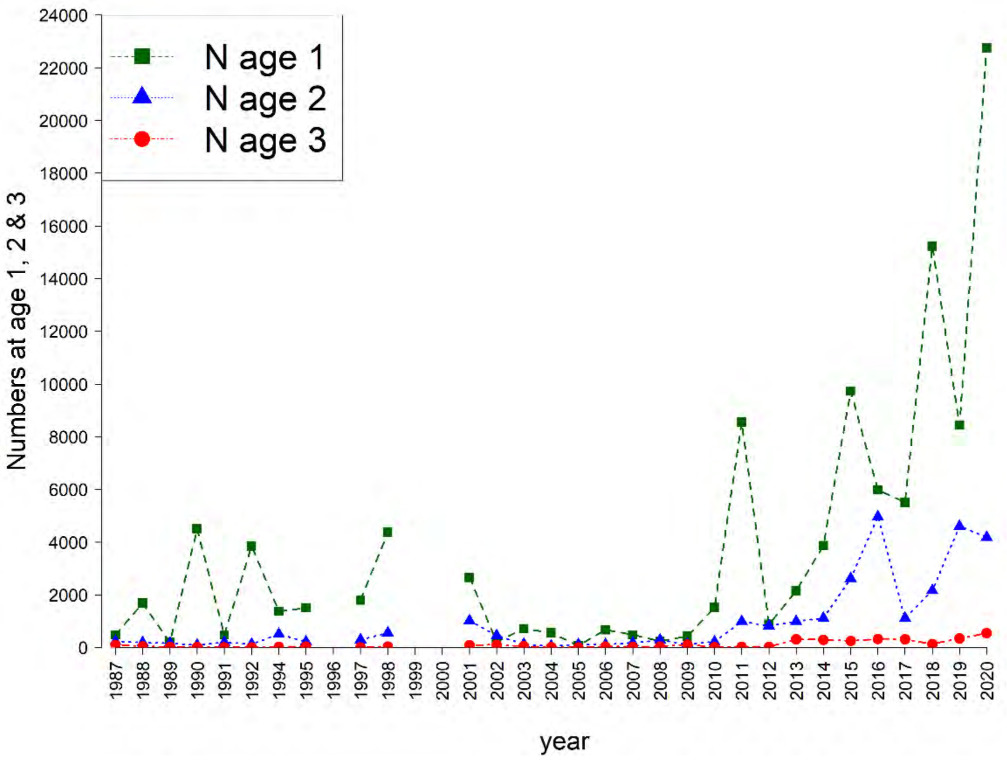


Figure 3.3.1.4.3. Bay of Biscay anchovy: Anchovy historical series of numbers-at-age from 1987 to 2020 from BIOMAN surveys.

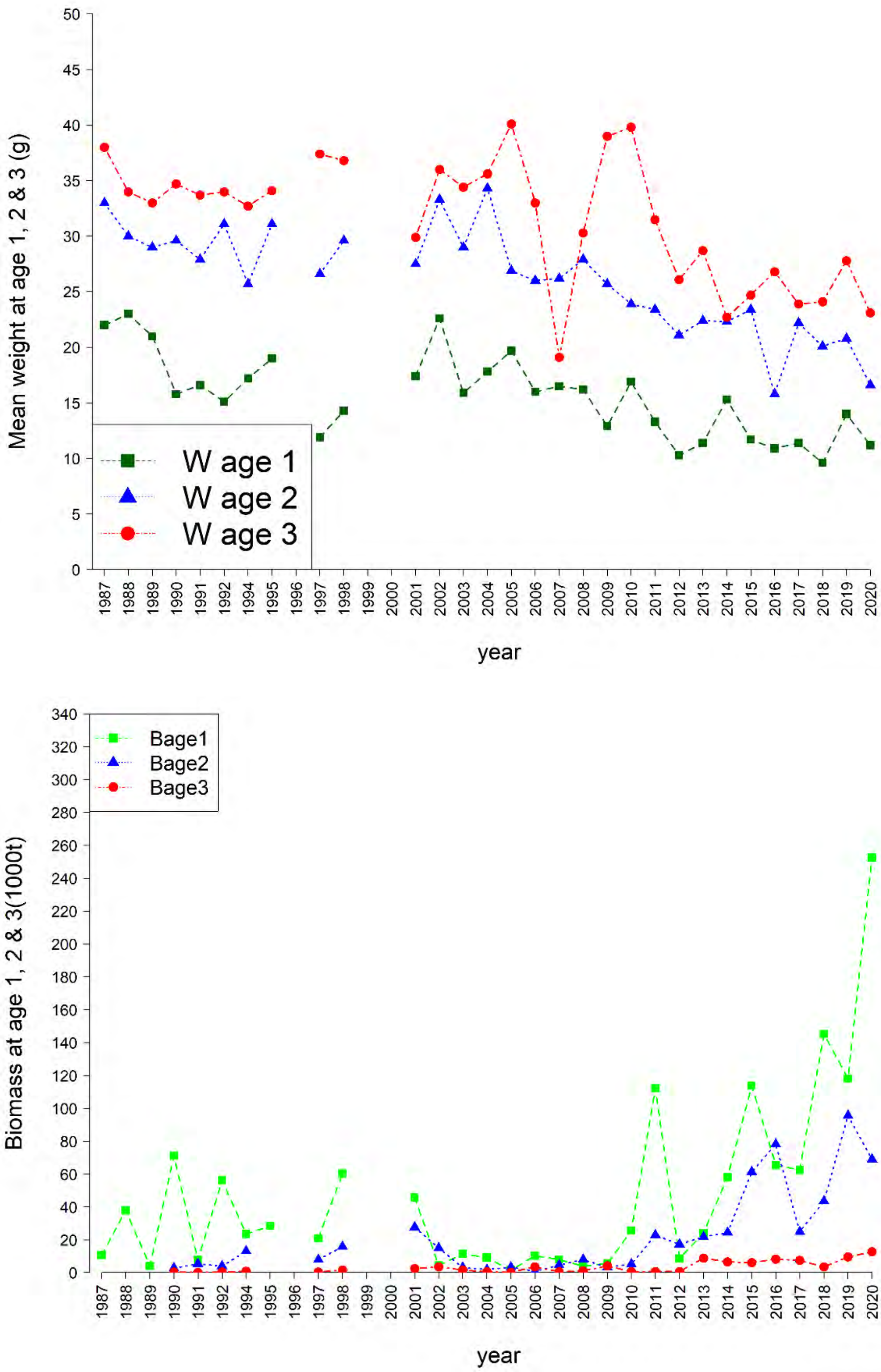


Figure 3.3.1.4.4. Bay of Biscay anchovy: Anchovy historical series (1987–2020) of mean weight-at-age and total biomass-at-age.

3.3.2 The PELGAS 2020 spring acoustic survey

All the methodology for the PELGAS survey is described in detail in the stock annex, Bay of Biscay Anchovy (Subarea 8). Due to the covid-19 disruption the PELGAS 2020 survey could not be carried out. This survey provides total biomass and age structure estimates for the stock assessment and the lack of survey implied a major deviation from the stock annex. The impact of the lack of this survey on the assessment is addressed in Section 3.8.

3.3.3 Autumn juvenile acoustic survey 2020 (JUVENA 2020)

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 2020 were reported and discussed in autumn 2020 in WGACEGG meeting (Boyra *et al.*, 2020, WD WGACEGG2020 (ICES, 2020)). Description of the survey and the estimates of anchovy juvenile abundance produced by this 2020 survey were already reported and discussed in WGACEGG report (ICES, 2020) 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 2020, 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 2020 took place between the 18th of August and 30th of September on board the chartered RV Angeles Alvariño and the RV Emma Bardán, both equipped with scientific echo sounders. (Boyra *et al.*, 2020; WD to WGACEGG). Following the standard transect design and acoustic methods as in previous years, the survey covered from 7º15′ W in the Cantabrian area to 47º50′ N in the French coast. A total of 100 hauls were done during the survey to identify the species detected by the acoustic equipment, 66 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, but small size and low density of the juvenile schools provided a comparatively 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 around 230 000 tonnes (**Table 3.3.3.1**). This value represents a medium value.

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
2020	29 849	6.1	228 879

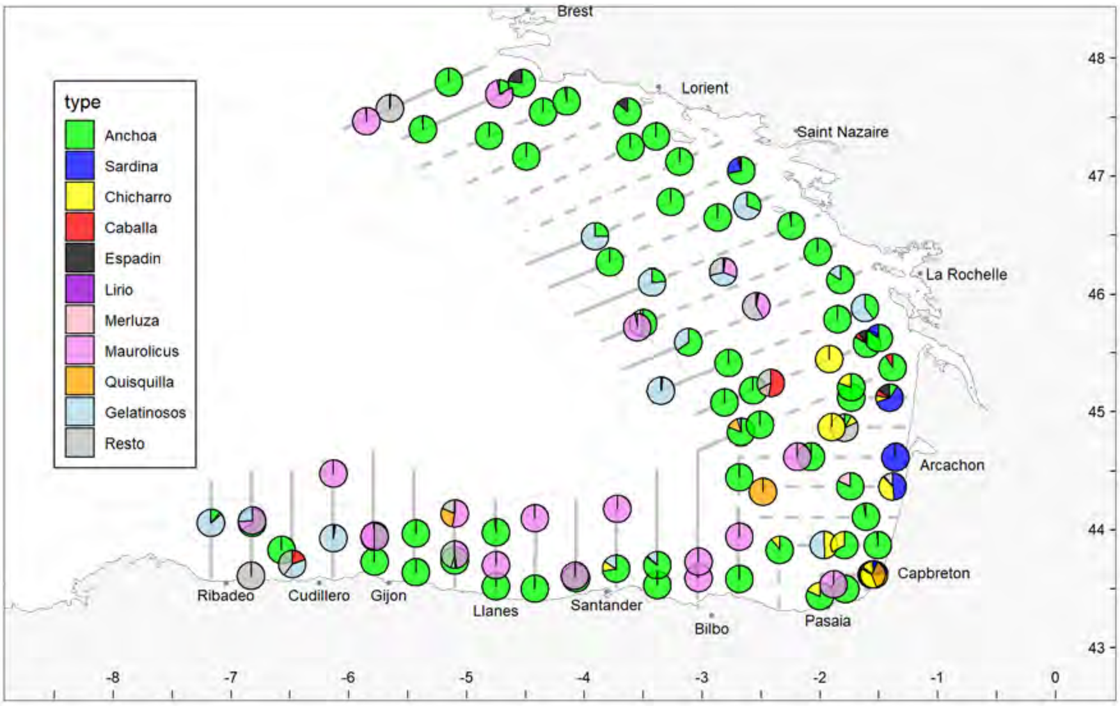


Figure 3.3.3.1. Bay of Biscay anchovy. Surveying transects and spatial distribution and species composition of the pelagic hauls in JUVENA 2020.

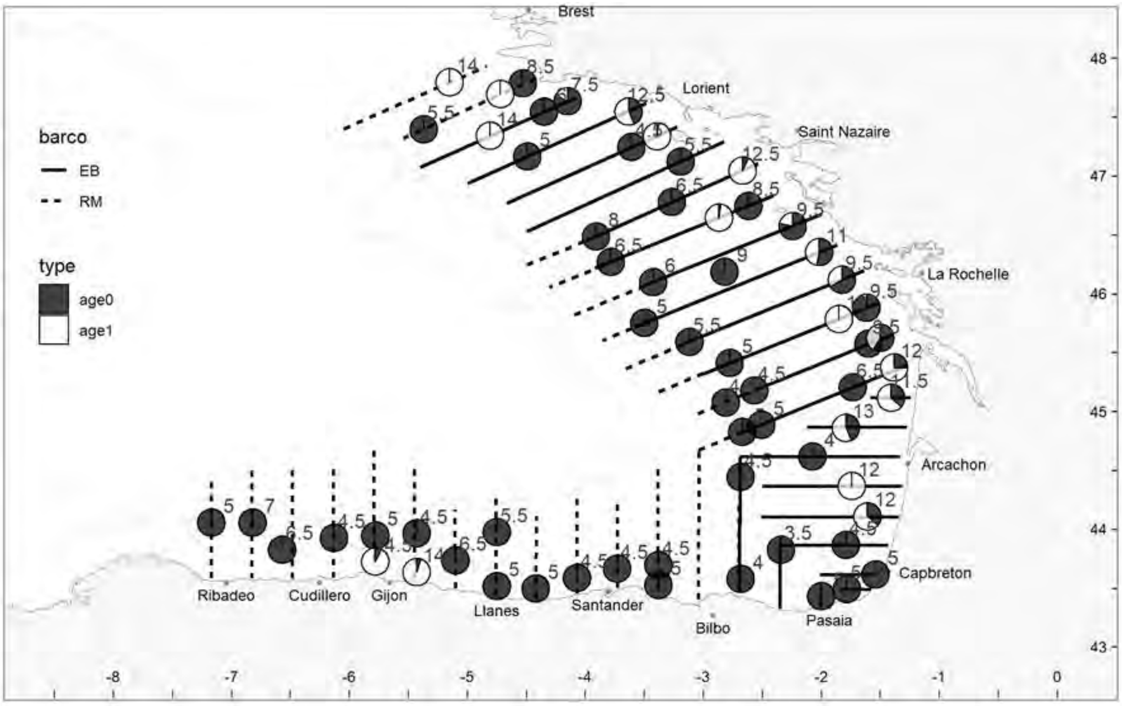
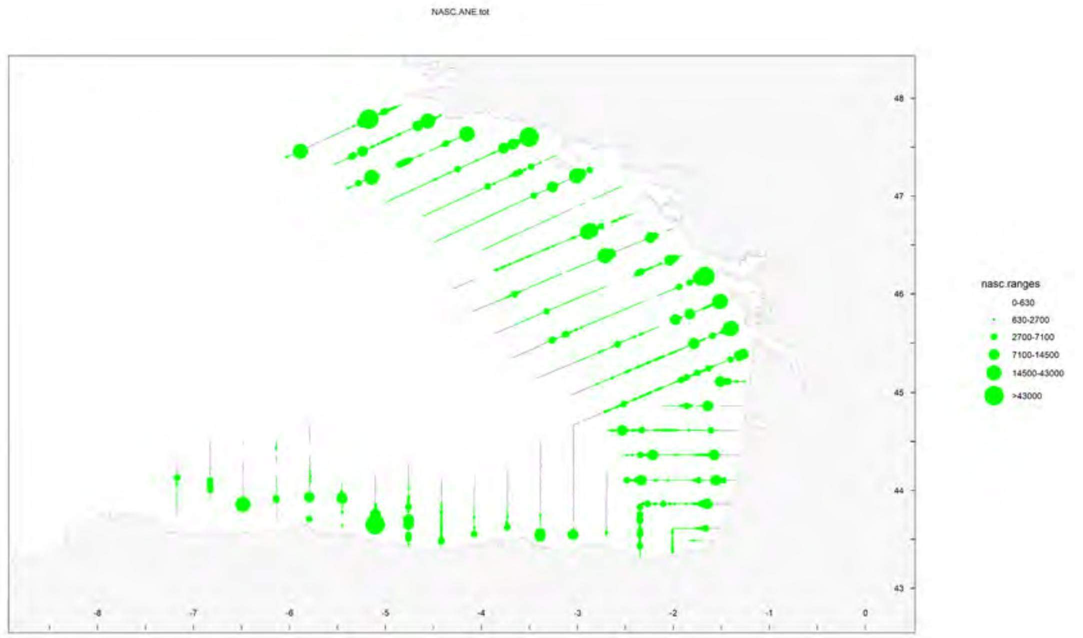


Figure 3.3.3.2. Bay of Biscay anchovy. Positive area of anchovy in JUVENA 2020. The pie charts show the percentage of juveniles (white) and adults (black) in the fishing hauls.



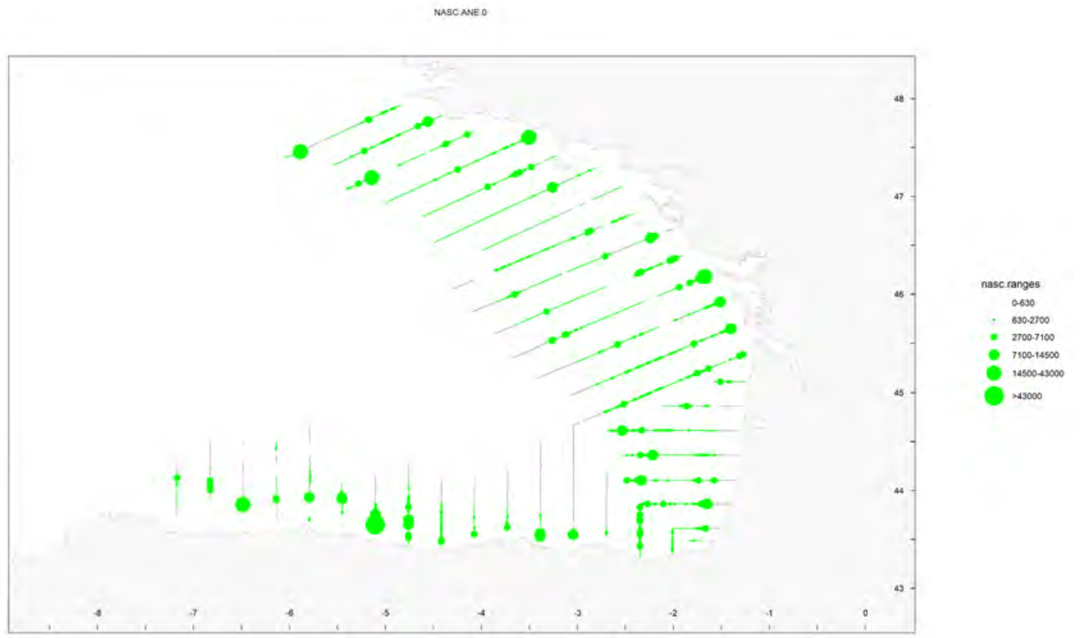


Figure 3.3.3.3. Bay of Biscay anchovy. Bubble maps representing acoustic backscattering by ESDU of 0.1 nm for total anchovy (top) and age 0 anchovy (bottom).

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 2020. Due to the Covid-19 disruption, the PELGAS 2020 survey, that is part of the input data for the stock assessment, could not be carried out. The assessment presented below follows the stock annex as in previous years, except for the lack of the PELGAS2020 biomass and age-structure estimates.

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 2020 only for the first semester);
- growth rates by age estimated from the weights-at-age of the stock.

In 2020 due to the Covid-19 disruption, the PELGAS acoustic survey could not be carried out. So, the total biomass and the proportion of biomass at-age 1 from the PELGAS acoustic survey are not available.

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 2020, the DEPM SSB estimate (around 334 300 t) was the largest of the historical time-series, well above the second highest value (223 200t) observed in 2019. 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. In 2020, the DEPM survey age 1 biomass proportion was around 0.76, indicating a large recruitment (Figure 3.5.1.2).

The historical series of the juvenile abundance index from the autumn acoustic survey JUVENA is shown in Figure 3.5.1.3. The 2020 survey index represents a medium value, slightly below the average of the temporal series.

Last year due to the bad weather conditions the JUVENA survey could not cover the region to the north of 46.6ºN and the 2019 juvenile abundance index was considered underestimated. This has been confirmed this year by the BIOMAN 2020 survey. Besides being the largest SSB estimate of the DEPM time series, the age 1 proportion was above the average indicating a large recruitment. In addition, an unusual high amount of anchovy has been observed during BIOMAN 2020 in the northern areas, which corresponds to the area that could not be covered by JUVENA last year.

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 2020, the preliminary total catch was around 14 800 t in the first half of the year and 11 116 t in the second half. The latter was under the assumption that the November and December catches represent 2.7% of the total catch (according to the average % of November and December catches in 2010–2019). Definitive 2020 catch estimates will be provided in WGHANSA 2021. Regarding the age structure of the catches, age 1 proportion in the catches in the first semester in 2020 was 0.62, which is above 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 2020 is approximately 174 400 t, which is the highest in the time-series, and the 90% probability interval is around 108 700 t and 274 700 t. This probability interval is amongst the widest in the time-series, accounting for the lack of PELGAS 2020 and the discrepancies observed in the surveys of the last years. The posterior median of recruitment in 2021 is around 53 600 t and the 90% probability interval is between 22 100 t and 129 500 t. The posterior distribution of recruitment is wider than the posterior distribution of previous recruitments because only the JUVENA 2020 survey provides direct information about 2020 recruitment. Assuming no fishing takes place in 2020, the SSB in 2021 is estimated around 135 400 t with a 90% probability interval around 84 800 t and 227 000 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 3.5.1.10) 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 2020 has been revised upwards significantly, whereas recruitment in 2019 is smaller in this assessment than in last year's assessment. Fishing mortality in the first semester of 2019 is slightly larger than in last year's assessment. As a result, biomass in 2019 is smaller than in last year's assessment. Fishing mortality in the second semester are slightly larger than estimated in last year's assessment. Overall, the harvest rates in the last three years are 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). The only exception is recruitment in 2019 that has been strongly revised upwards in this year's assessment.

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 -0.76 and 0.53 and the Mohn's rho was calculated at -0.073. The relative bias for SSB in the terminal year was always positive (Figure 3.5.2.2). The relative bias for SSB ranged between 0.09 and 0.18, and the Mohn's rho was 0.124. Mohn's rho for the fishing mortality by semester and annual harvest rate was -0.087, -0.189 and -0.109 respectively. The relative bias for the three time-series was negative in all the years (Figure 3.5.2.2).

3.5.3 Sensitivity analysis

In order to study the potential impact of the lack of PELGAS 2020 in this year's assessment a sensitivity analysis was carried out. The last three years' assessments (2017, 2018 and 2019) were repeated by removing PELGAS in the last year of the assessment. Overall, removing PELGAS in the terminal year increased the uncertainty in the last year's estimates (Figures 3.5.3.1, 3.5.3.3 and 3.5.3.5). The trends in the recruitment, SSB and fishing mortality by semester time-series were quite similar without and with PELGAS and the relative differences were usually small (<3%). However, the exact magnitude of the differences varied across the assessment years, depending on the level of agreement between the removed PELGAS estimates and the other assessment inputs (Figures 3.5.3.2, 3.5.3.4 and 3.5.3.6). The maximum absolute change for R, SSB and F was up to 2%, 3% and 10% in the 2017, 2018 and 2019 assessments, respectively. So, the largest effect of removing PELGAS corresponded to the 2019 assessment, where the last year's estimates changed substantially depending on the inclusion or not of PELGAS.

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.

This year the PELGAS acoustic survey could not be carried out due to the Covid-19 disruption. This is one of the spring surveys providing estimates of total biomass and age structure in the stock assessment model. So, the lack of the PELGAS 2020 data is expected to have an impact in the assessment results, but its exact extent cannot be quantified. The sensitivity analysis in which the last three stock assessments were repeated by removing the terminal year indices from PELGAS showed larger uncertainty in the last years' estimates. Although in general, the relative differences were small (<3%), the impact on the recruitment, SSB and fishing mortality estimates varied across the assessment years depending on the level of agreement between PELGAS and the other assessment inputs.

The catch data for 2020 are preliminary and the definite data will be available for WGHANSA 2021. As a result, the fishing mortality estimates in 2020 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. 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 (tonnes)**	**Total (tonnes)**	**cv**	**Age1 (tonnes)**	**Total (tonnes)**	**cv**	**Age0 previous year (tonnes)**	**Age1 (tonnes)**	**Total (tonnes)**	**Age1 (tonnes)**	**Total (tonnes)**	**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

Year	BIOMAN DEPM survey Age1 (tonnes)	BIOMAN DEPM survey Total (tonnes)	BIOMAN DEPM survey cv	PELGAS Acoustic survey Age1 (tonnes)	PELGAS Acoustic survey Total (tonnes)	PELGAS Acoustic survey cv	JUVENA Acoustic Age0 previous year (tonnes)	CATCH Semester1 Age1 (tonnes)	CATCH Semester1 Total (tonnes)	CATCH Semester2 Age1 (tonnes)	CATCH Semester2 Total (tonnes)	GROWTH G1 Age1	GROWTH G2+ Age2+
2007	7946	13060	0.178	26230	40876	0.1	78298	42	141	0	0	0.524	0.146
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	6164	22760	1842	4085	0.167	0.105
2020	252547	334283	0.116	NA	NA	NA	114072	9160	14819	NA	11116	NA	NA
2021	NA	NA	NA	NA	NA	NA	228879	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	0.644	0.782	0.952	Catchability of the DEPM B index
Qac	1.153	1.386	1.647	Catchability of the Acoustic B index
Qrobs	0.015	0.358	7.262	Parameter of the observation equation for the juvenile index
Krobs	0.925	1.214	1.511	Parameter of the observation equation for the juvenile index
Psidepm	2.391	4.209	7.497	Precision (inverse of variance) of the observation equation of DEPM B index
Psiac	4.658	8.361	14.431	Precision (inverse of variance) of the observation equation of Acoustic B index
psirobs	0.960	1.846	3.407	Precision (inverse of variance) of the observation equation of juvenile index
xidepm	3.292	3.960	4.686	Variance-related parameter for the observation equation of DEPM age 1 proportion
xiac	2.772	3.383	3.949	Variance-related parameter for the observation equation of Acoustic age 1 proportion
xicatch	2.289	2.647	2.991	Variance-related parameter for the observation equation of age 1 proportion in the catch
B0	16088	21020	27142	Initial biomass
mur	10.280	10.567	10.848	Median (in log scale) of the recruitment process
psir	0.769	1.174	1.726	Precision (in log scale) of the recruitment process
sage1sem1	0.392	0.462	0.547	Age 1 selectivity during the 1st semester
sage1sem2	0.842	1.029	1.247	Age 1 selectivity during the 2nd semester
G1	0.487	0.547	0.609	Intrinsic growth at age 1
G2	0.165	0.222	0.283	Intrinsic growth at age 2+
psig	18.951	27.043	37.041	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	12070	15953	21336	15799	20890	27277	0.958	1.246	1.621	0.262	0.370	0.534	0.527	0.689	0.910
1988	25742	31069	38025	23645	28883	36031	0.810	1.042	1.315	0.297	0.405	0.544	0.400	0.499	0.609
1989	6514	9155	12967	10951	15492	21623	0.710	0.972	1.332	0.135	0.199	0.303	0.381	0.532	0.752
1990	59002	67952	78879	45920	53711	63752	0.992	1.244	1.526	0.567	0.757	0.993	0.529	0.628	0.735
1991	17702	23409	30991	22564	30197	40042	0.869	1.146	1.496	0.202	0.289	0.418	0.452	0.600	0.803
1992	69108	86961	111393	54573	71862	95247	0.889	1.212	1.625	0.266	0.395	0.586	0.391	0.518	0.682
1993	50700	64687	80019	60498	73205	87770	0.685	0.877	1.110	0.454	0.595	0.793	0.448	0.537	0.650
1994	32986	41032	51022	38373	47513	58937	0.942	1.181	1.488	0.485	0.656	0.908	0.570	0.708	0.876
1995	34268	45430	59530	28826	40301	55044	1.160	1.578	2.153	0.258	0.388	0.614	0.529	0.722	1.010
1996	40361	50481	62617	38407	46913	58097	0.975	1.260	1.617	0.543	0.743	1.024	0.566	0.701	0.856
1997	30446	39547	52248	34174	44533	59203	0.492	0.666	0.885	0.429	0.616	0.901	0.345	0.459	0.598
1998	69525	90506	117546	68852	89921	117056	0.351	0.474	0.636	0.370	0.534	0.789	0.268	0.349	0.456
1999	30269	44815	64115	51077	67639	88308	0.410	0.546	0.739	0.312	0.441	0.635	0.294	0.384	0.509
2000	73595	90750	110612	75607	92431	111583	0.578	0.731	0.923	0.308	0.406	0.540	0.331	0.399	0.488
2001	62280	74259	88482	78169	90363	105210	0.557	0.673	0.810	0.415	0.523	0.654	0.382	0.444	0.513
2002	9318	13120	18254	31919	38628	47453	0.450	0.555	0.678	0.399	0.516	0.662	0.369	0.453	0.548
2003	15532	19670	24925	22306	27430	33916	0.304	0.386	0.487	0.499	0.666	0.886	0.309	0.382	0.470
2004	24542	30286	37943	24604	30661	39072	0.672	0.870	1.117	0.461	0.640	0.891	0.414	0.528	0.658
2005	2745	4225	6315	10402	14417	19748	0.113	0.158	0.221	0.000	0.000	0.000	0.057	0.078	0.108
2006	11724	16221	22018	14679	19781	26412	0.181	0.246	0.334	0.008	0.011	0.016	0.066	0.089	0.119
2007	15582	21472	29336	22626	29775	39036	0.010	0.014	0.018	0.000	0.000	0.000	0.004	0.005	0.006
2008	6281	9141	13129	18340	23806	30768	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	6939	9993	14151	15365	19916	25604	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2010	36309	47647	62250	37480	48541	62489	0.314	0.410	0.538	0.141	0.198	0.277	0.161	0.208	0.269
2011	88069	111700	141830	94124	117841	147008	0.235	0.300	0.387	0.052	0.071	0.096	0.099	0.123	0.154
2012	34692	45706	60227	78915	97697	120845	0.157	0.198	0.251	0.121	0.156	0.201	0.119	0.147	0.182
2013	28982	38403	50831	54598	68919	86340	0.288	0.365	0.465	0.091	0.119	0.159	0.163	0.204	0.258
2014	55943	73143	95928	67893	86898	110537	0.361	0.462	0.597	0.110	0.151	0.204	0.177	0.225	0.288
2015	89894	114105	146694	106353	131727	165676	0.337	0.427	0.540	0.124	0.165	0.219	0.171	0.214	0.266
2016	40521	53732	71684	80549	101320	129057	0.270	0.345	0.438	0.078	0.103	0.135	0.150	0.191	0.240
2017	53446	70145	92044	71770	92245	119551	0.483	0.628	0.810	0.066	0.090	0.122	0.218	0.282	0.362
2018	89457	118109	155944	100863	132518	174805	0.418	0.556	0.735	0.069	0.097	0.136	0.176	0.232	0.305
2019	54796	78828	112811	86321	121352	167789	0.333	0.457	0.638	0.060	0.087	0.127	0.160	0.221	0.311
2020	83314	142008	235452	108729	174428	274687	0.163	0.246	0.383	0.094	0.155	0.267	0.094	0.149	0.239
2021	22061	53601	129484	84784	135354	226998	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

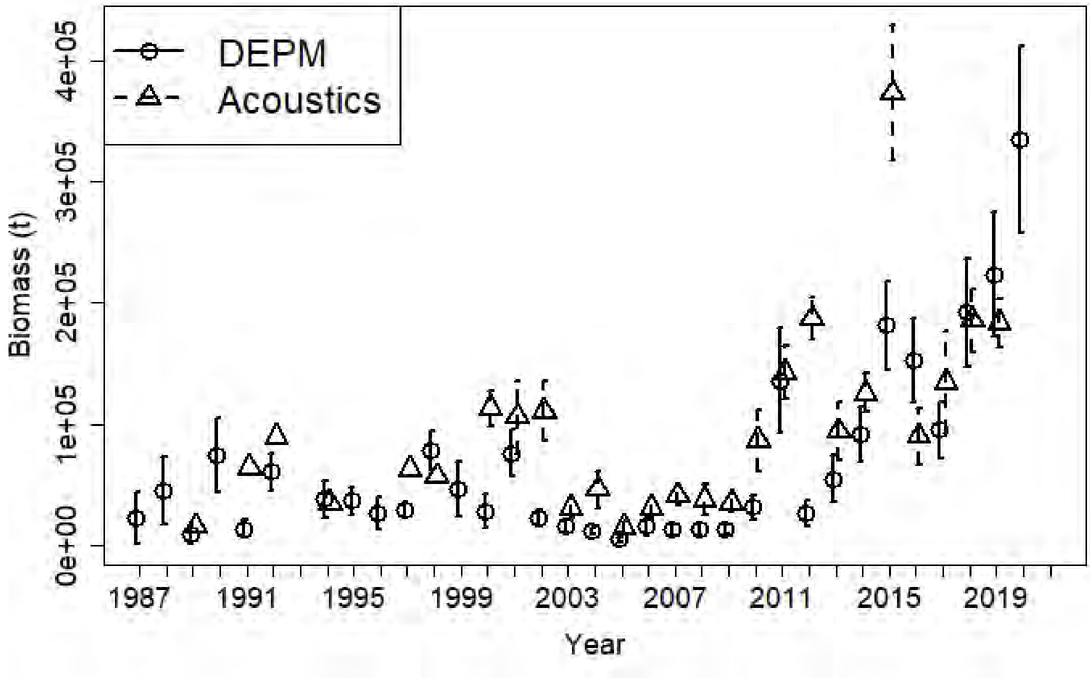


Figure 3.5.1.1. Bay of Biscay anchovy: Historical series of spawning–stock biomass estimates and the corresponding confidence intervals from DEPM (solid line and circles) and acoustics (dashed line and triangles).

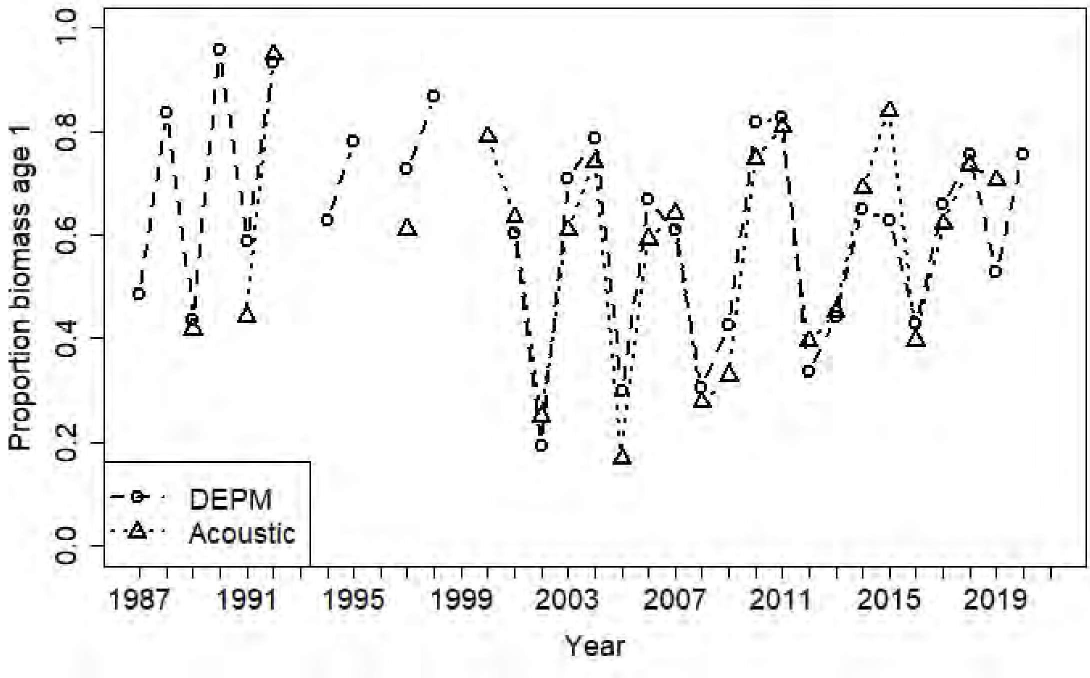


Figure 3.5.1.2. Bay of Biscay anchovy: Bay of Biscay anchovy: Historical series of age 1 biomass proportion estimates from DEPM (dashed line and circles) and acoustics (dotted line and triangles).

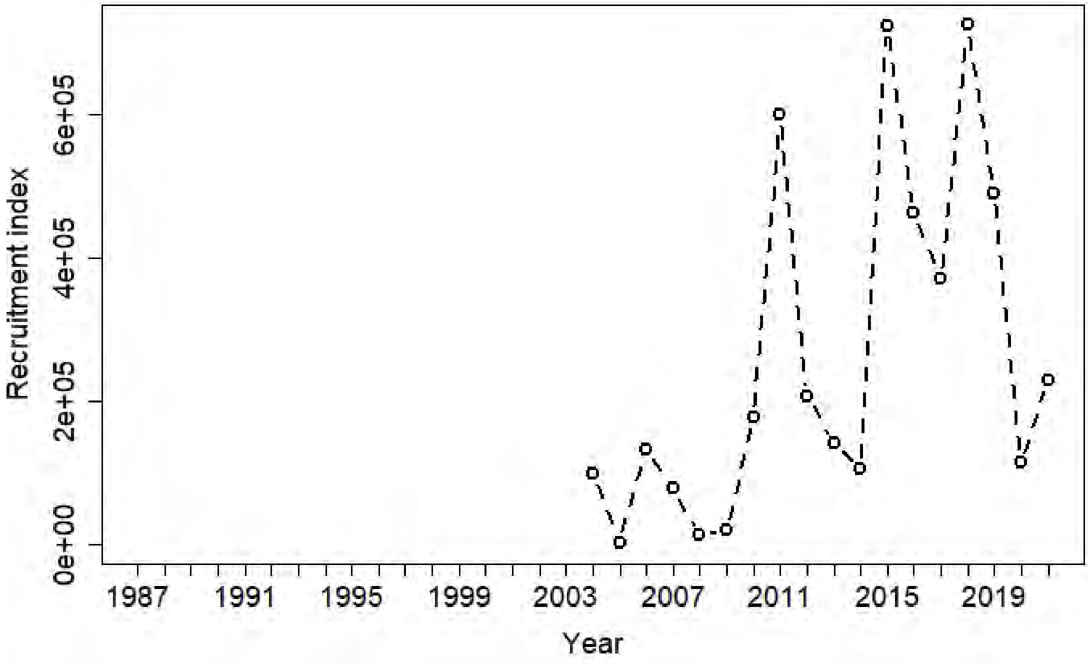


Figure 3.5.1.3. Bay of Biscay anchovy: Historical series of the juvenile abundance index from the autumn acoustic survey JUVENA that is related to recruitment (age 1) next year.

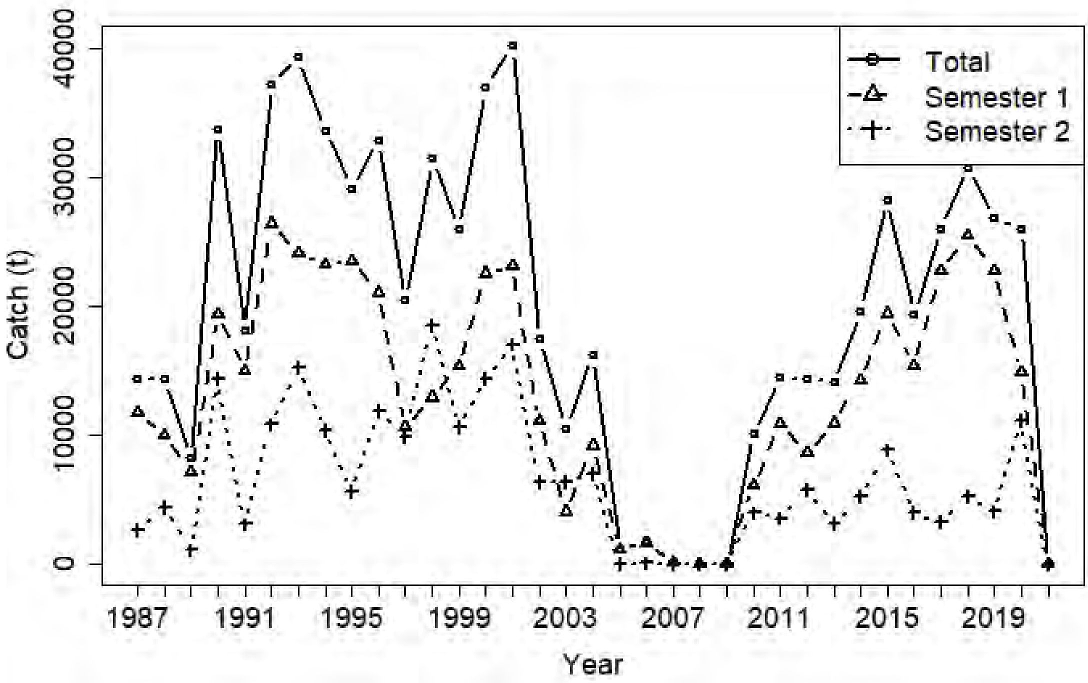


Figure 3.5.1.4. Bay of Biscay anchovy: Historical series of total catch (solid line) and catch by semesters (dashed and dotted lines for the first and second semester respectively). Note that the catch in 2020 is provisional and the catch in 2021 is set at zero.

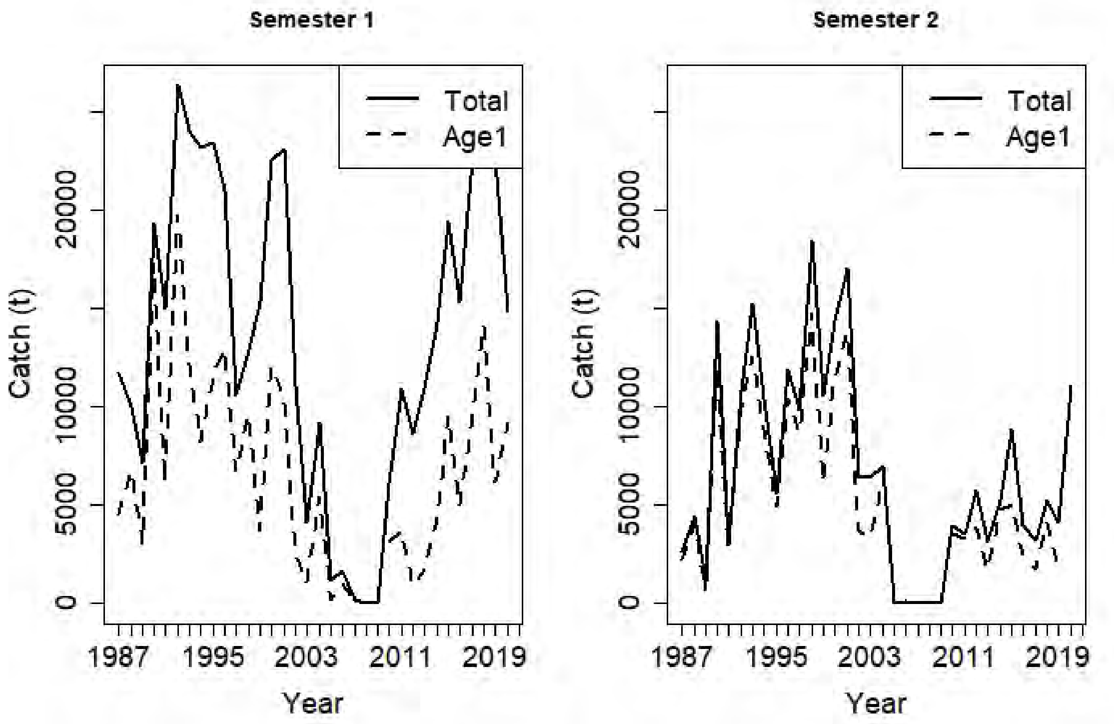


Figure 3.5.1.5. Bay of Biscay anchovy: Historical series of total (solid line) and age 1 (dashed line) catch (in tonnes). The left panel corresponds to the first semester and the right panel to the second semester. Note that the catch in 2020 is provisional.

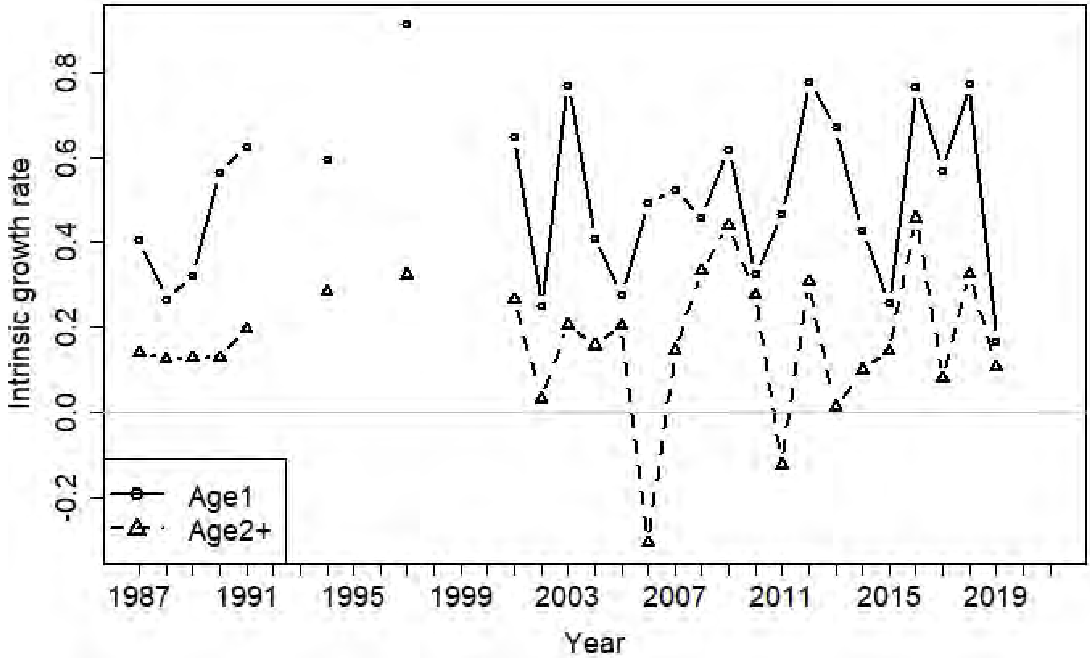


Figure 3.5.1.6. Bay of Biscay anchovy: Historical series of intrinsic growth rates by age as estimated from the mean weights-at-age of the stock.

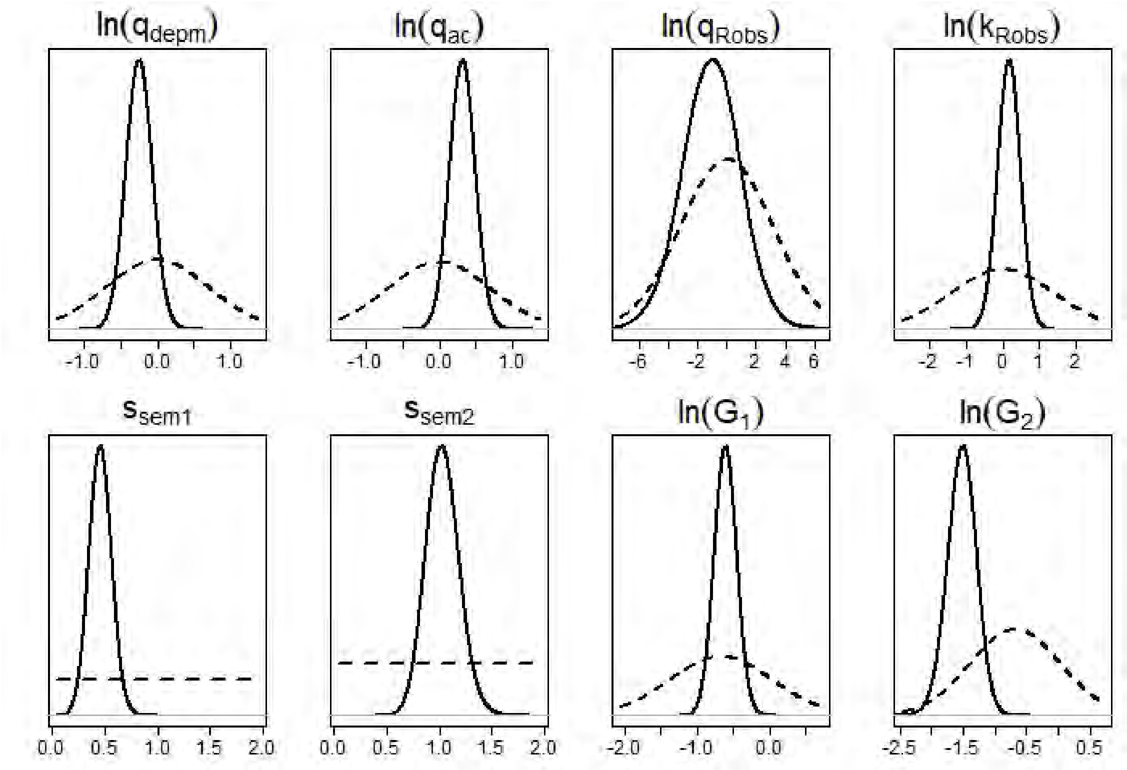
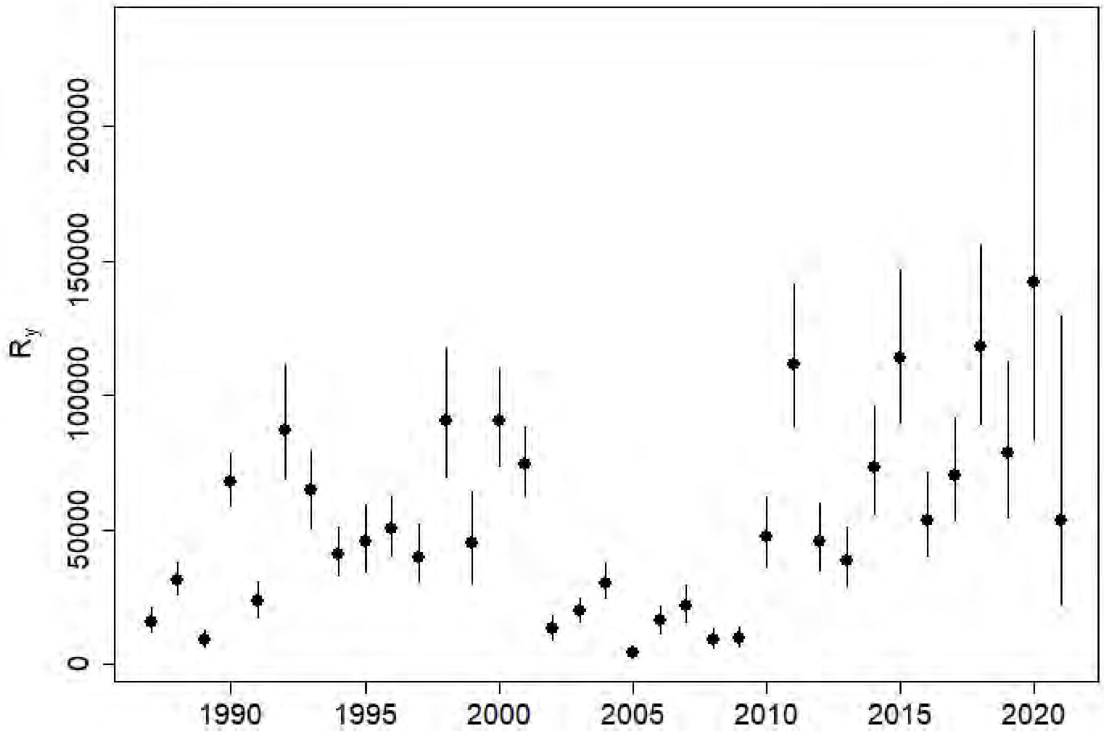
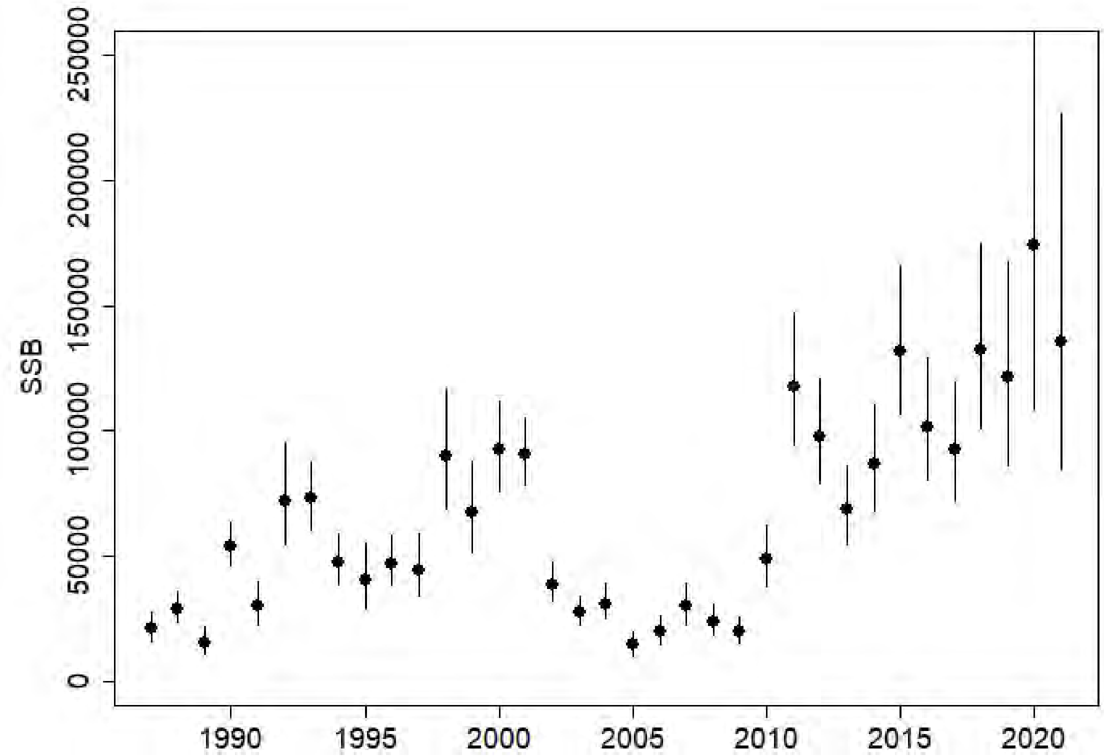


Figure 3.5.1.7. Bay of Biscay anchovy: Comparison between the prior (dotted line) and posterior distribution (solid line) for some of the parameters of CBBM.



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



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

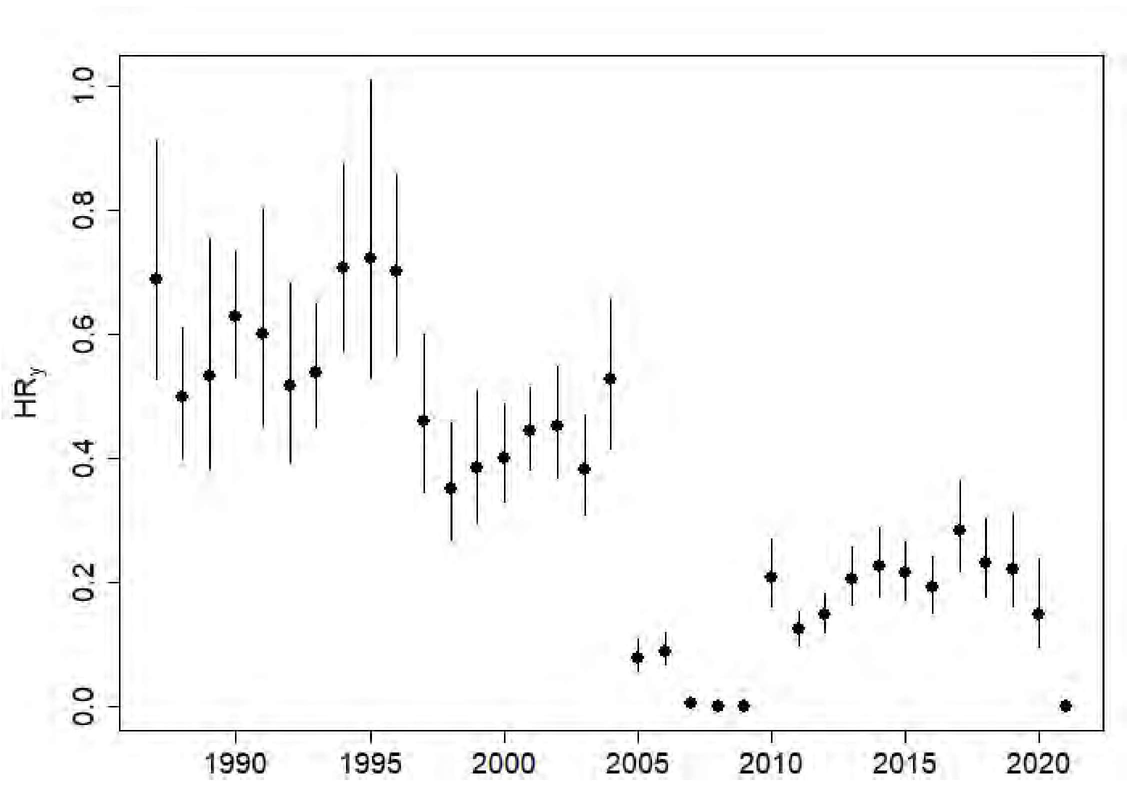


Figure 3.5.1.8. Bay of Biscay anchovy: Posterior median (bullet points) and 90% probability intervals (solid lines) for the recruitment (age 1 in mass in January), the spawning–stock biomass, the fishing mortality for the first and second semesters and the harvest rates (catch/biomass) from the CBBM. It must be taken into account that the fishing mortalities in 2021 are fixed at zero and SSB in 2021 results from no fishing in 2021.

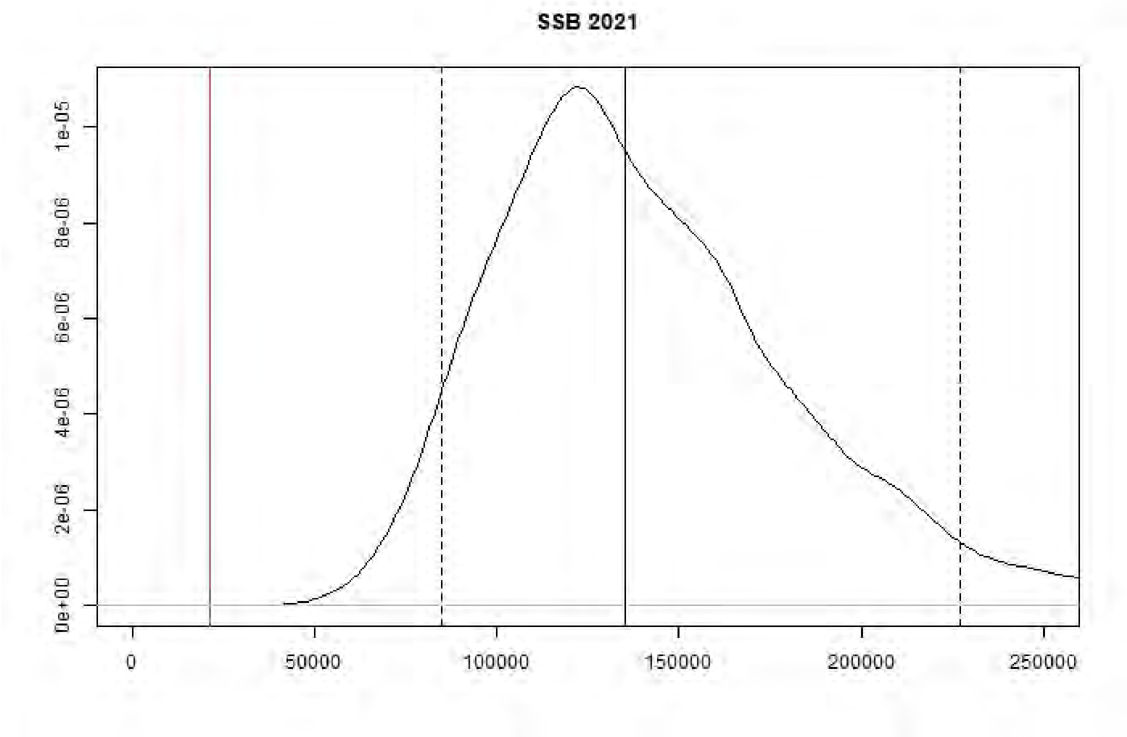


Figure 3.5.1.9. Bay of Biscay anchovy: Posterior distribution of SSB in 2021, under the assumption of no fishing during 2021. The red vertical line represents B_{lim} at 21 000 tonnes.

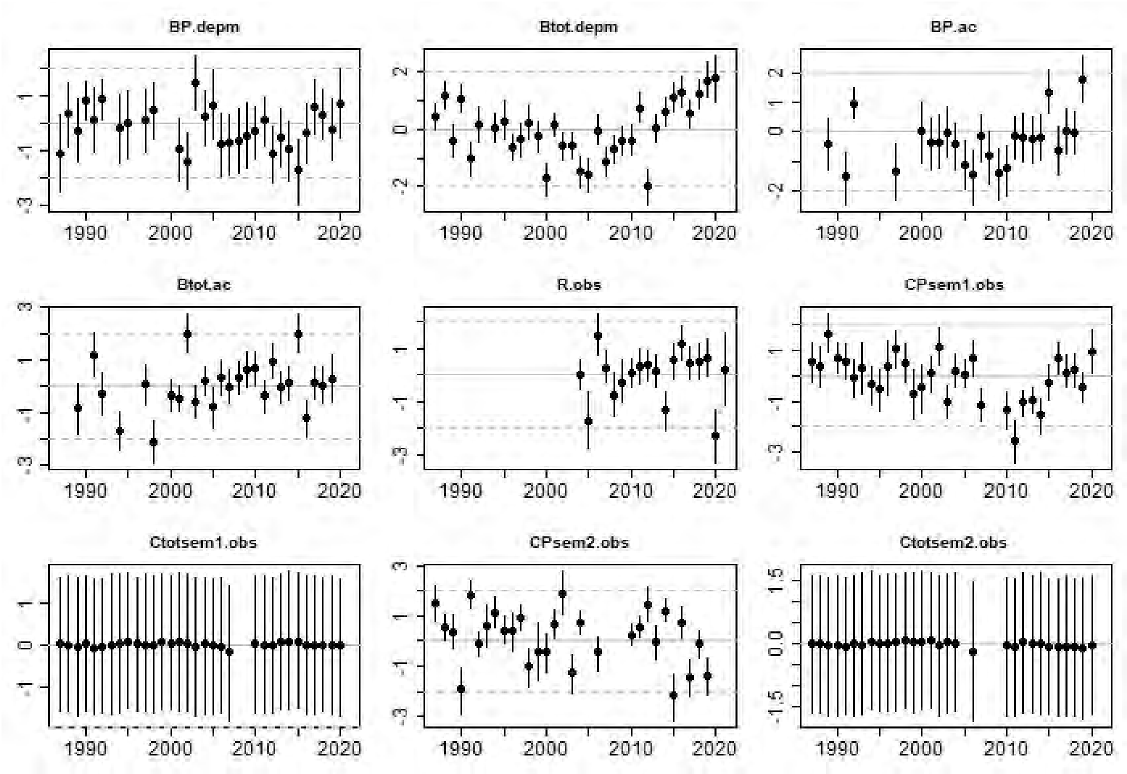
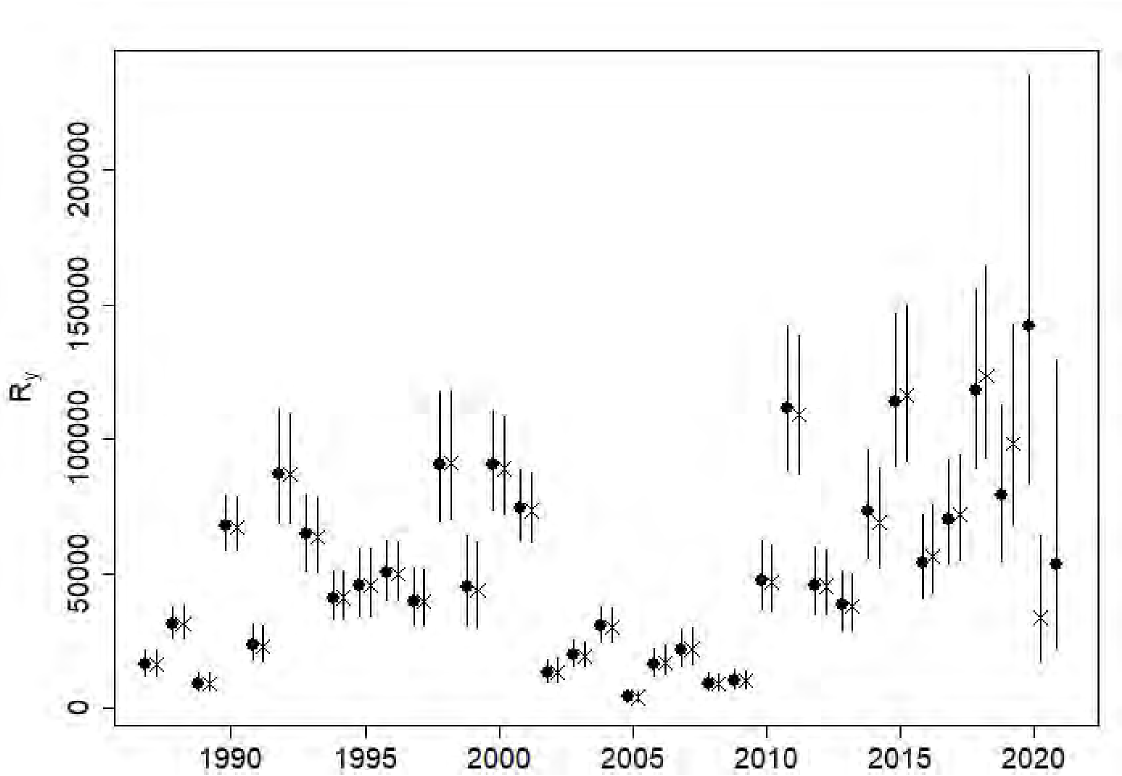
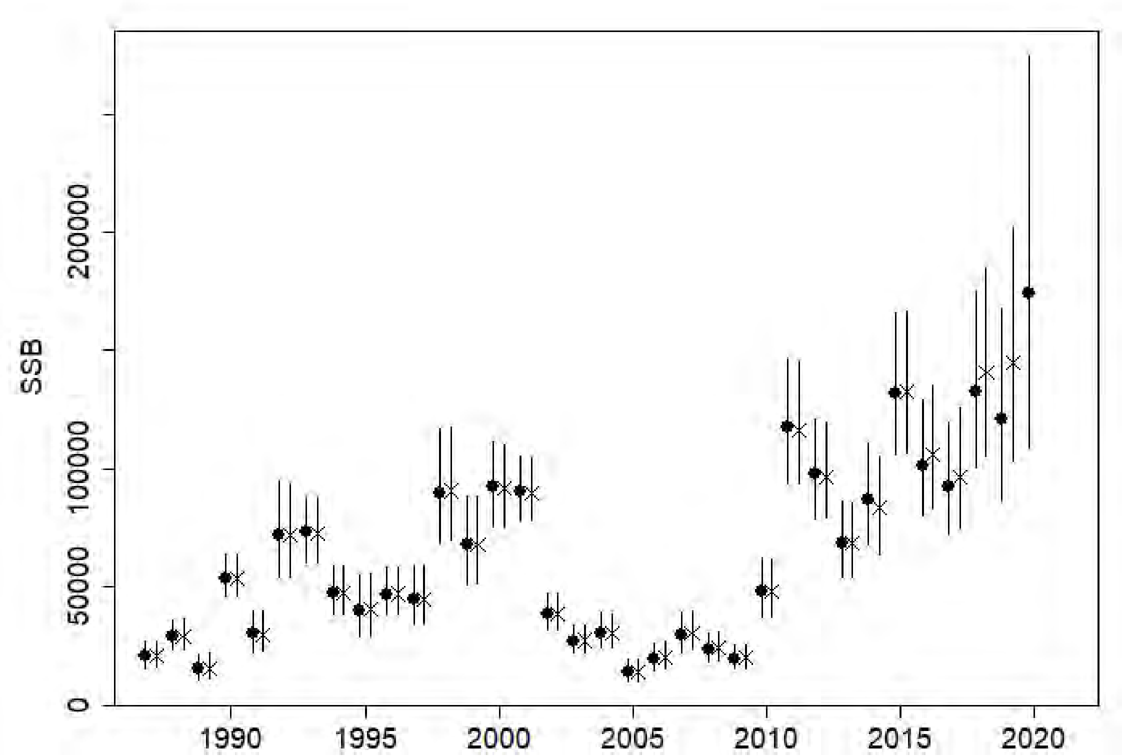


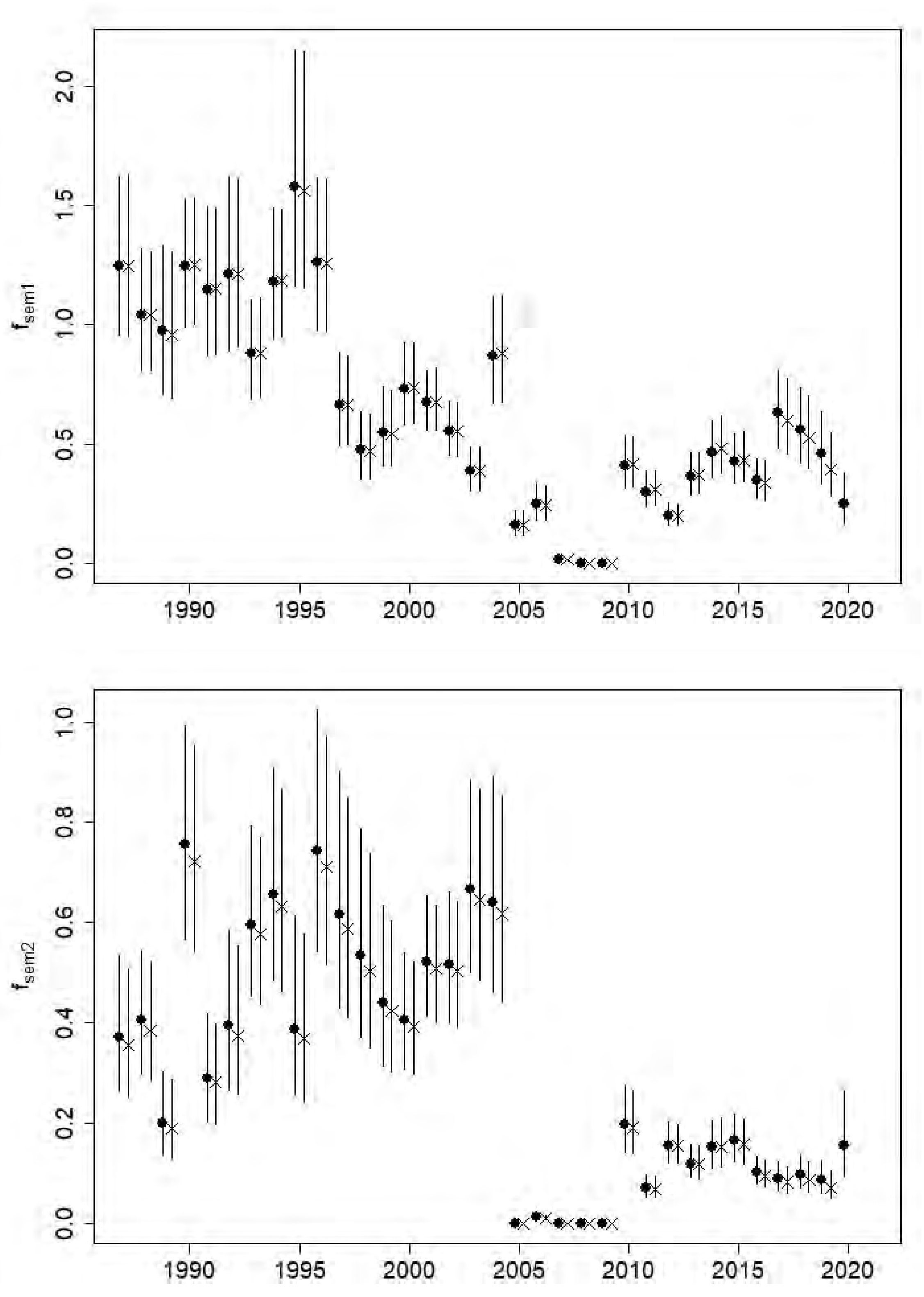
Figure 3.5.1.10. Bay of Biscay anchovy: Pearson residual medians and 90% probability intervals to the survey and catch observations used in the CBBM. From top to bottom and from left to right, residuals of the age 1 biomass proportion from the DEPM, total biomass from the DEPM, age 1 biomass proportion 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
200000
1990
1995
2000
2005
2010
2015
2020



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


fsem1
0.0
0.5
1.0
1.5
2.0
1990
1995
2000
2005
2010
2015
2020
fsem2
0.0
0.2
0.4
0.6
0.8
1.0

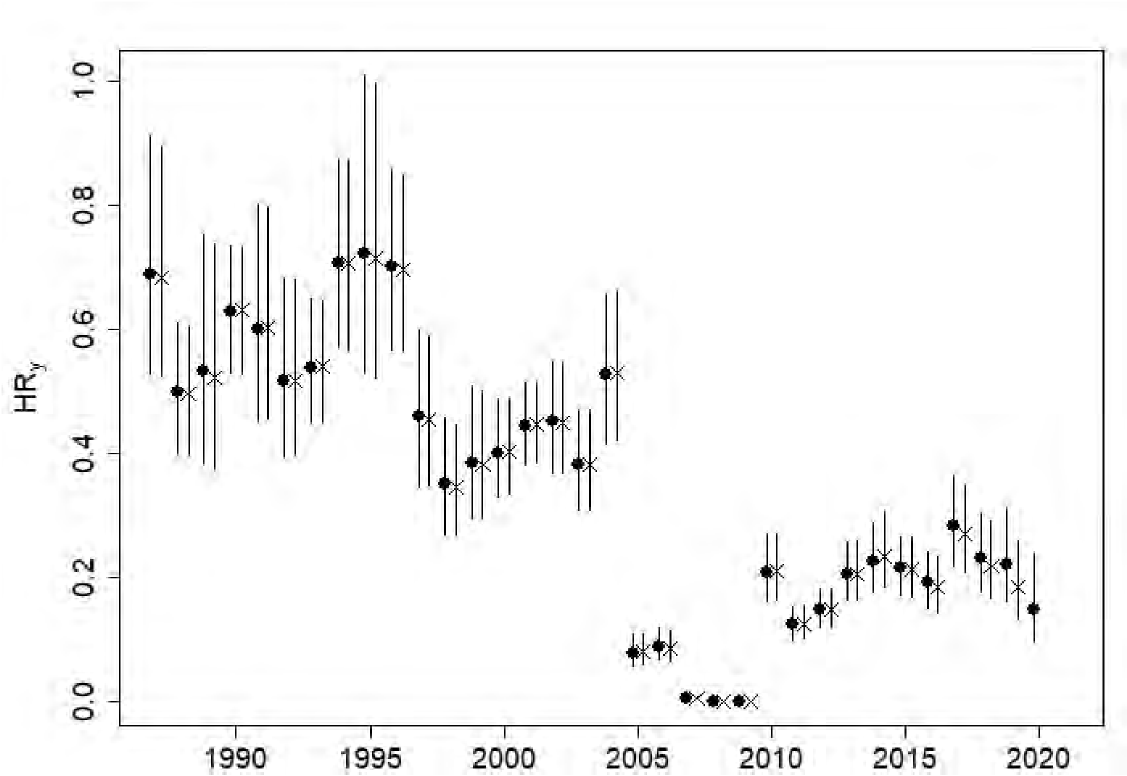
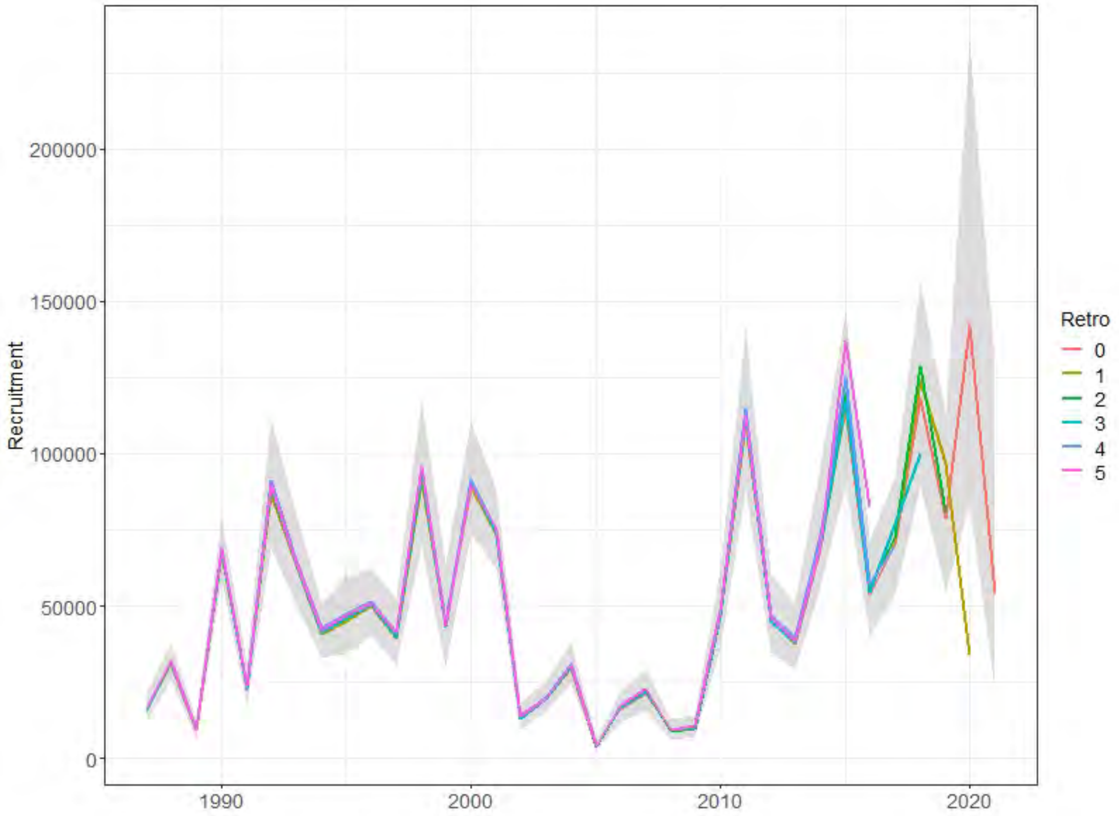
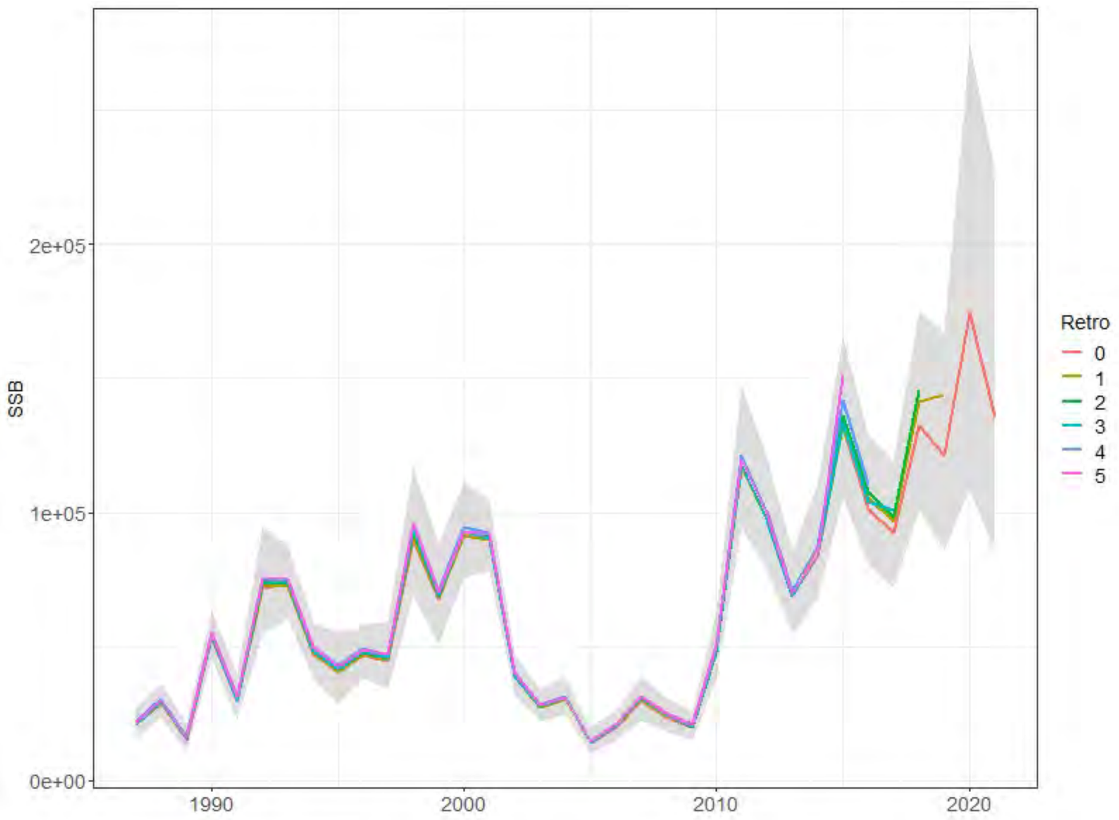
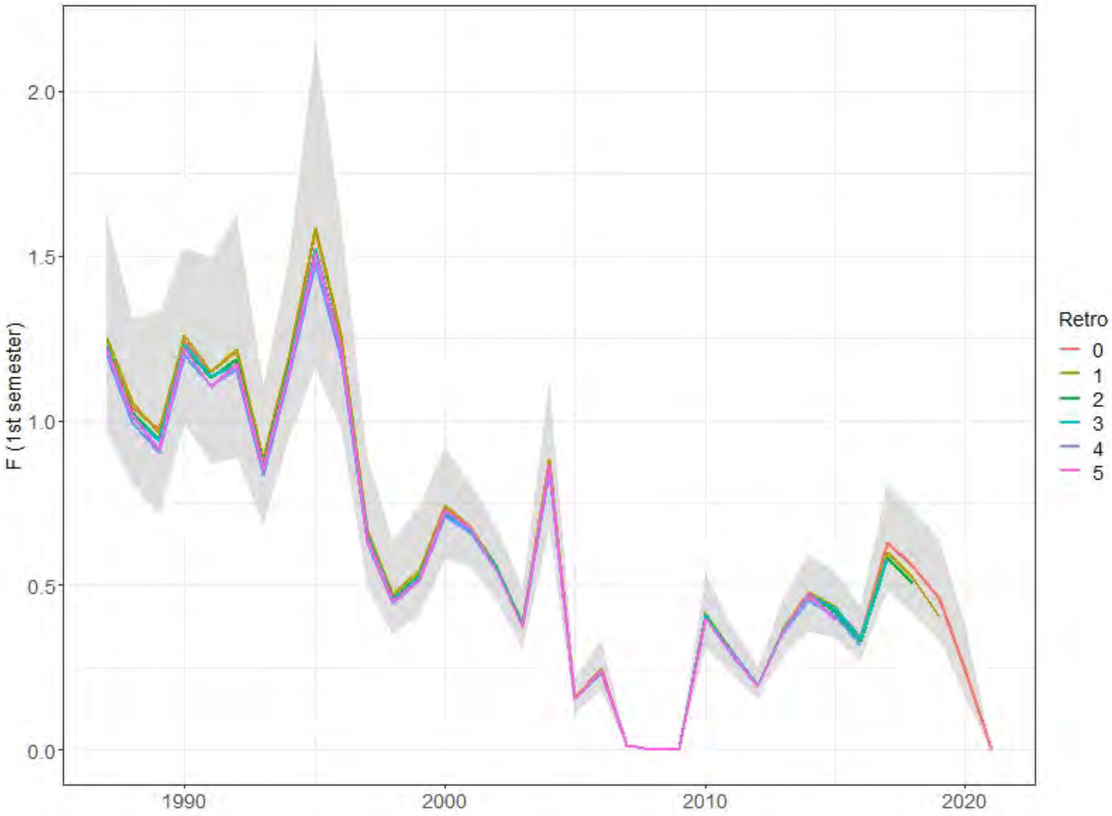


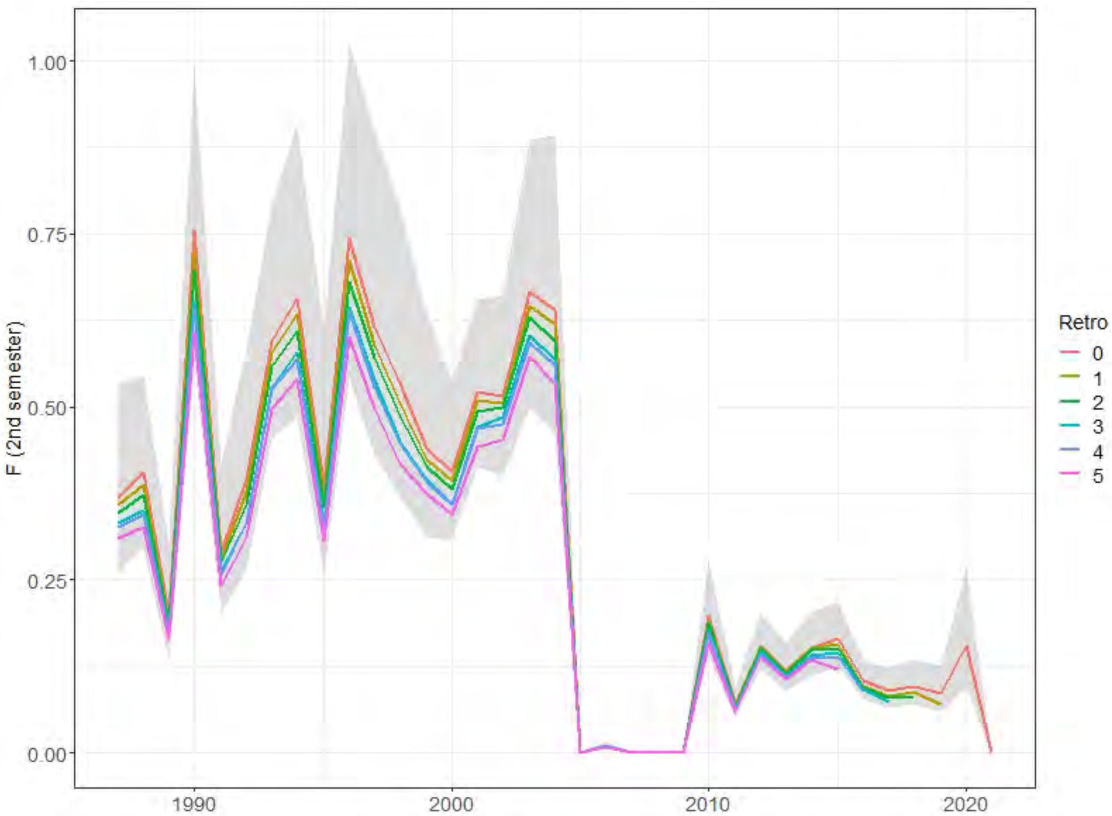
Figure 3.5.1.11. Bay of Biscay anchovy: From top to bottom comparison of the posterior median (points) and 90% probability intervals (solid lines) of the recruitment (age 1 in mass in January), the spawning–stock biomass, the fishing mortality in the first and in the second semester and the harvest rate assessed in WGHANSA 2019 (cross) and in November WGHANSA 2020 (bullet).


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


SSB
2e+05
1e+05
0e+00
1990
2000
2010
2020
Retro
0
1
2
3
4
5



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



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

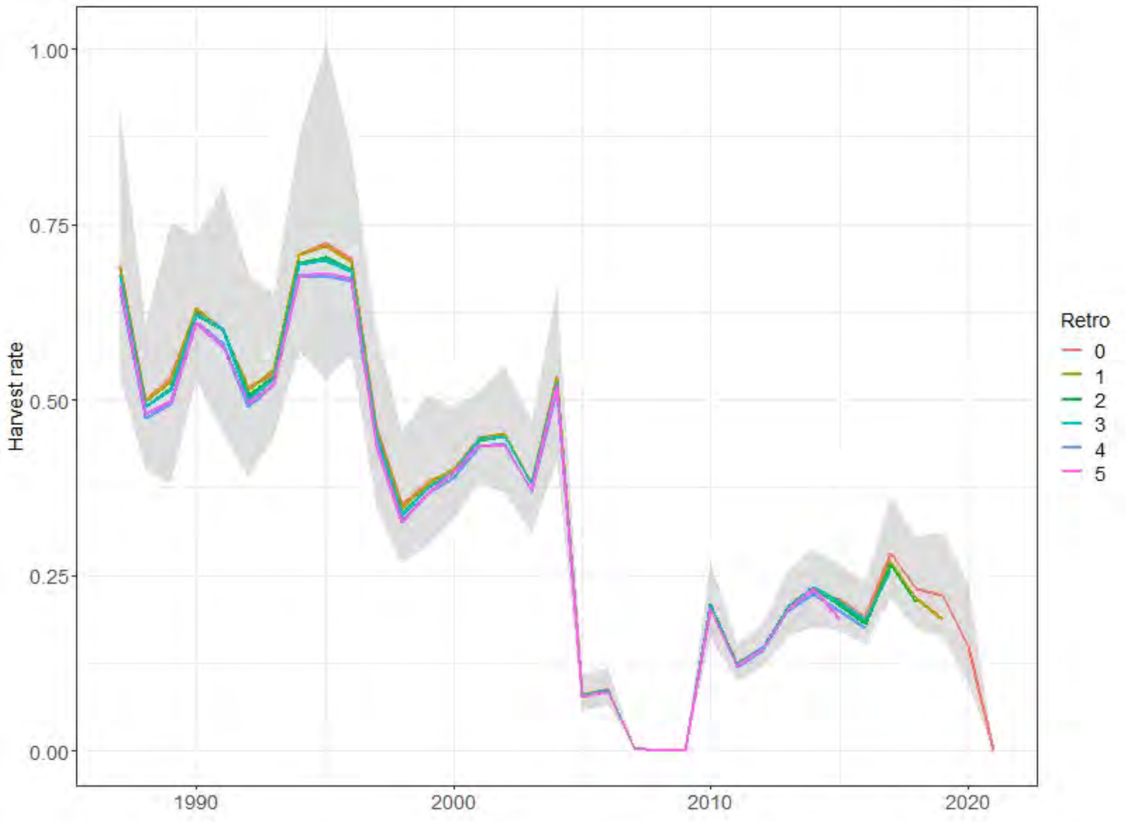
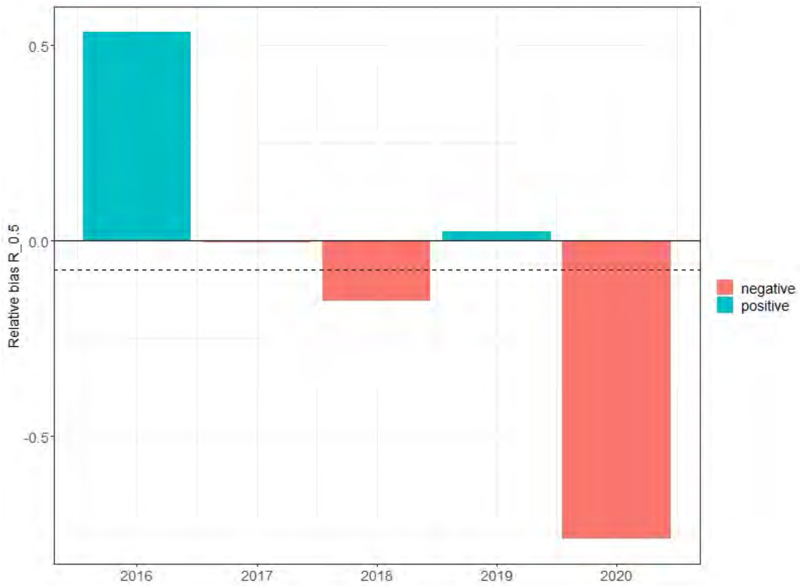
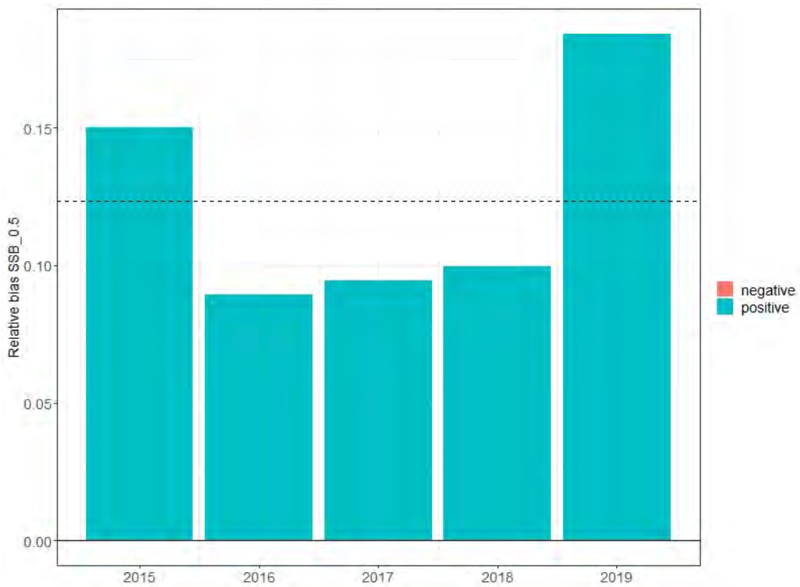
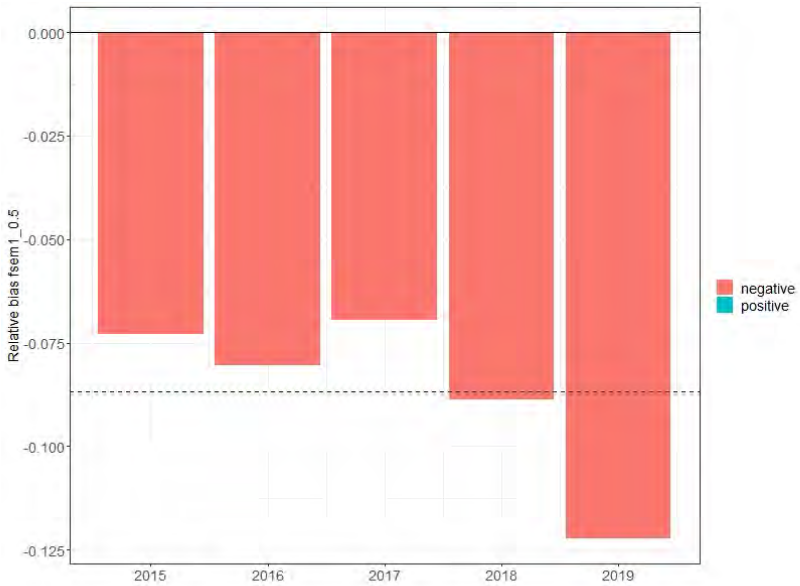
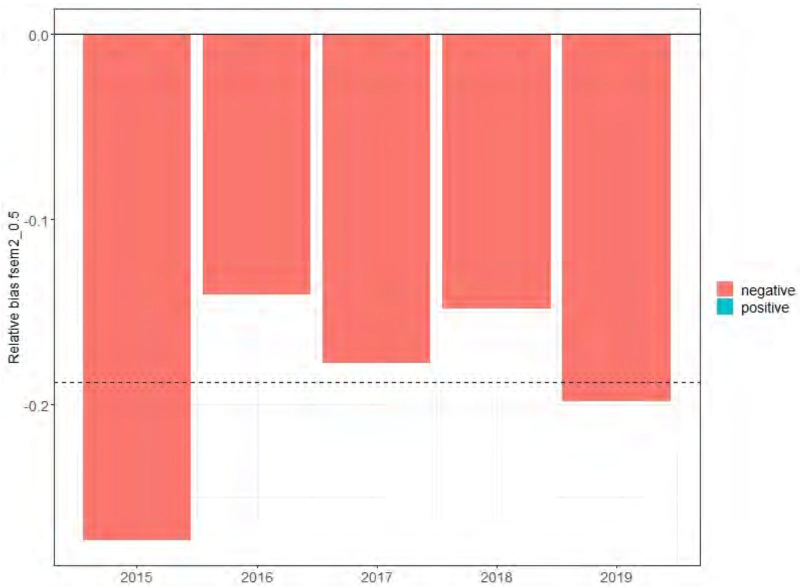


Figure 3.5.2.1. From top to bottom retrospective pattern of recruitment (age 1 in tonnes on 1st January), SSB, fishing mortality on 1st and 2nd semesters and harvest rate. The shaded are represents the 90% probability intervals from this year's assessment.


0.5
0.0
-0.5
Relative bias R_0.5
2016
2017
2018
2019
2020
negative
positive


0.15
0.10
0.05
0.00
Relative bias SSB_0.5
2015
2016
2017
2018
2019
negative
positive


0.000
-0.025
-0.050
-0.075
-0.100
-0.125
Relative bias fsem1_0.5
2015
2016
2017
2018
2019
negative
positive


0.0
-0.1
-0.2
Relative bias fsem2_0.5
2015
2016
2017
2018
2019
negative
positive

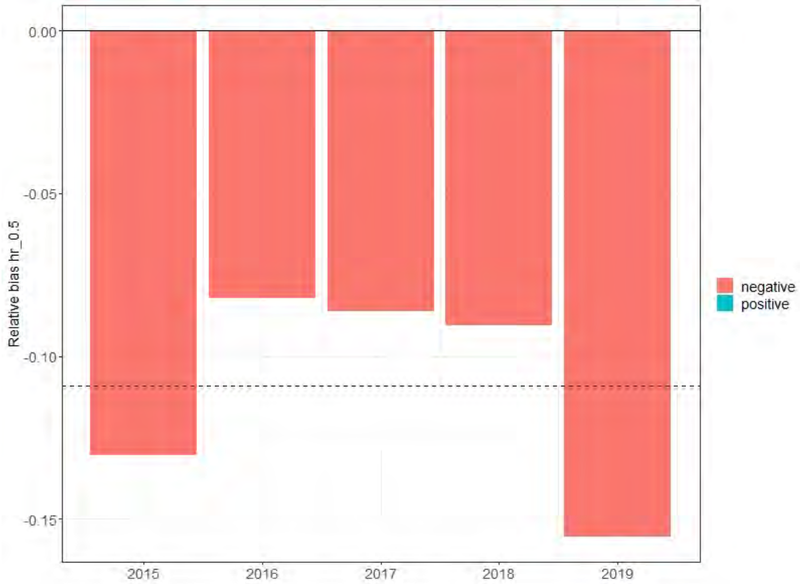
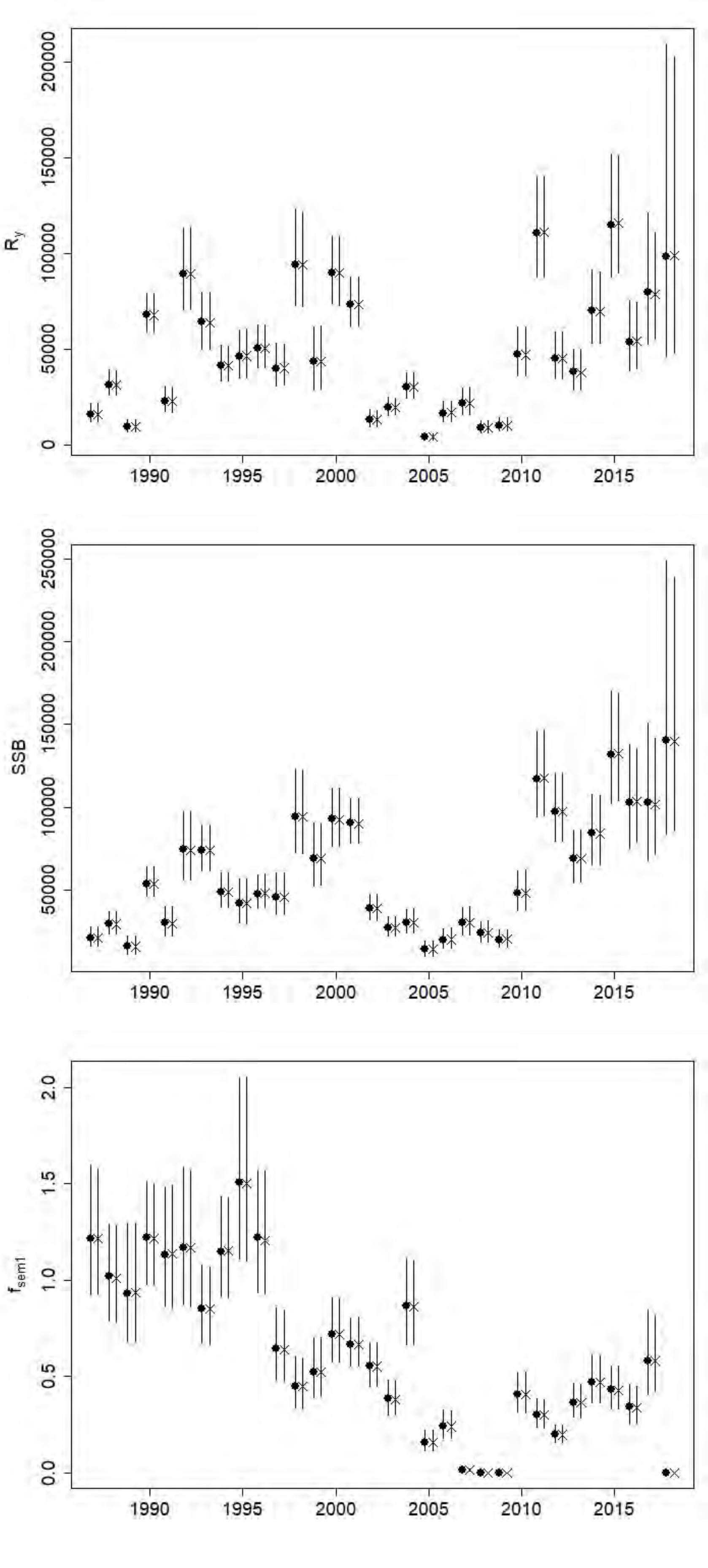


Figure 3.5.2.2. From top to bottom relative bias of recruitment (age 1 in tonnes on 1st January), SSB, fishing mortality on 1st and 2nd semesters and harvest rate. The horizontal dashed lines represent the Mohn's rho statistic for each time-series.



R_y
0
50000
100000
150000
200000
1990
1995
2000
2005
2010
2015
SSB
50000
100000
150000
200000
250000
1990
1995
2000
2005
2010
2015
f_sem1
0.0
0.5
1.0
1.5
2.0
1990
1995
2000
2005
2010
2015

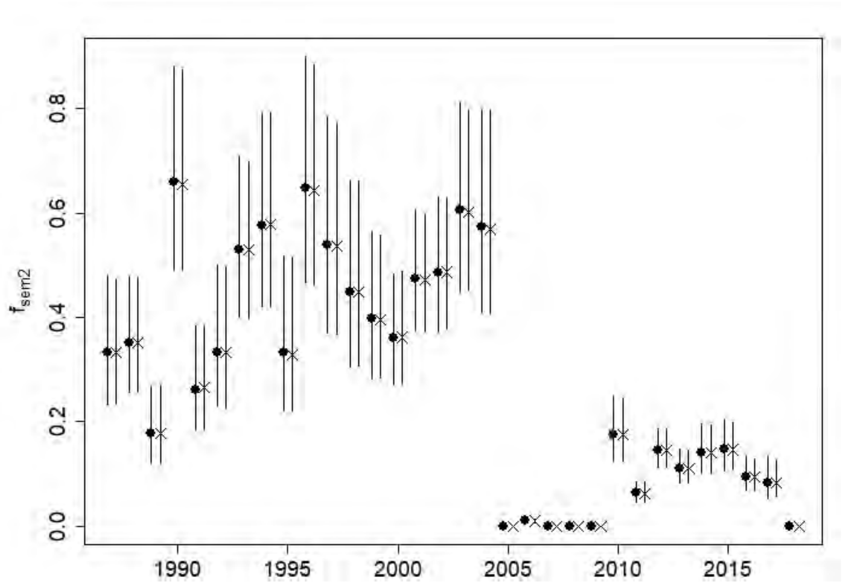


Figure 3.5.3.1. Bay of Biscay anchovy: From top to bottom comparison of the posterior median (points) and 90% probability intervals (solid lines) of the recruitment (age 1 in mass in January), the spawning–stock biomass and the fishing mortality in the first and in the second semester without (bullet) and with (cross) PELGAS biomass and age structure indices in the last year for the 2017 assessment.

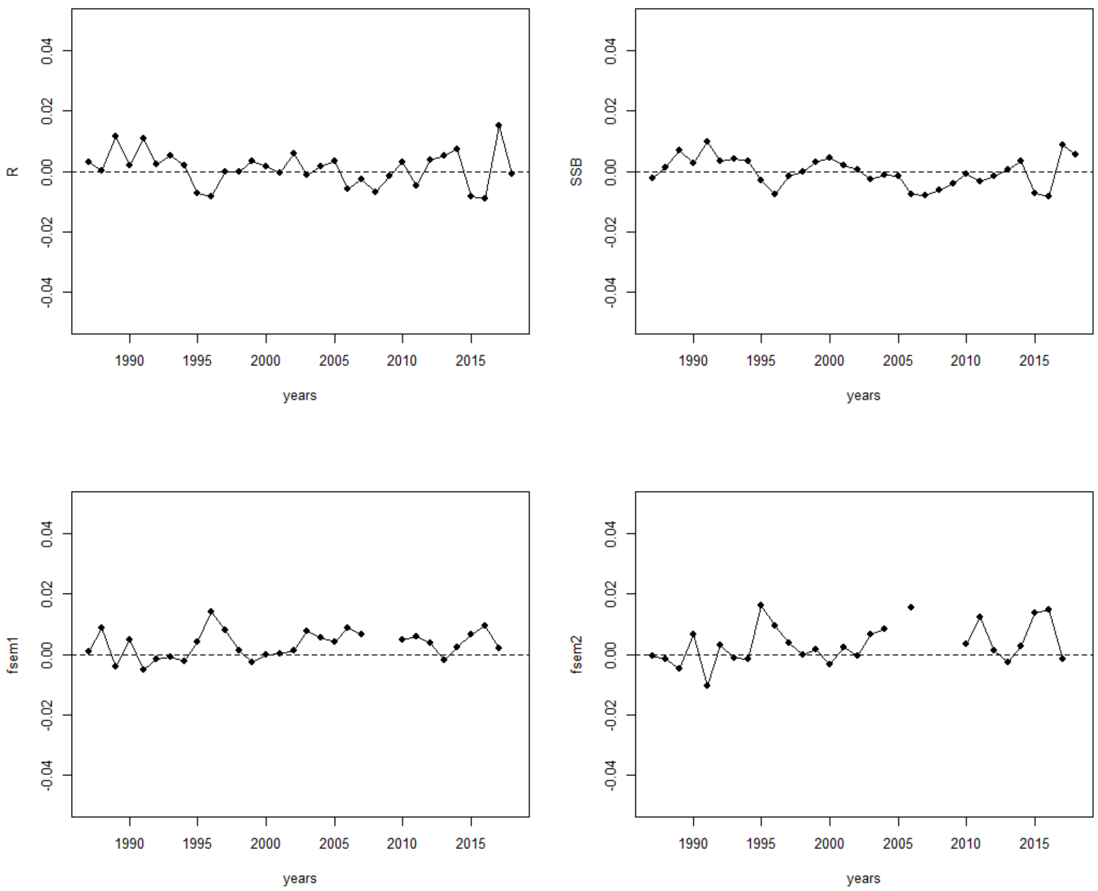
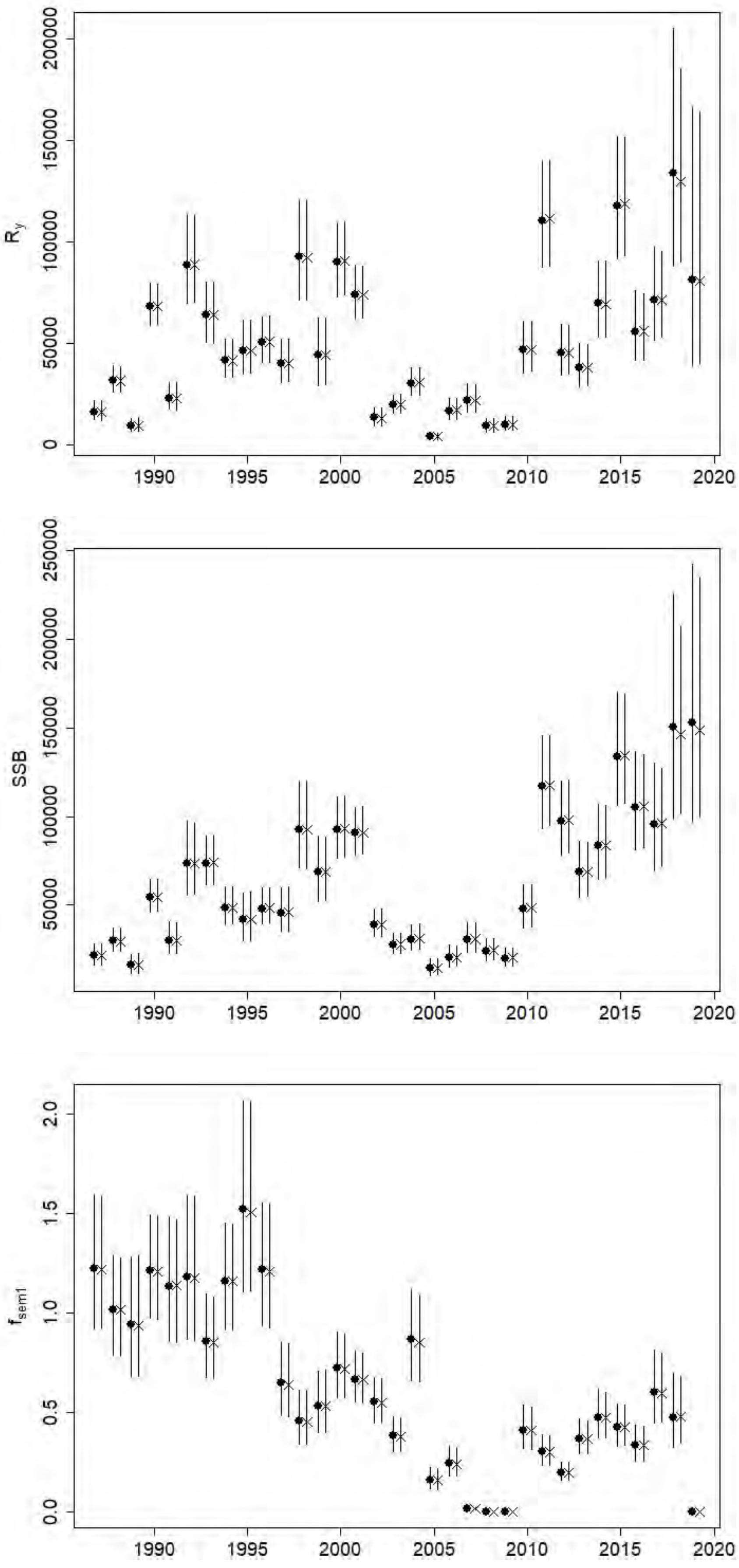


Figure 3.5.3.2. Bay of Biscay anchovy: From top to bottom and from left to right relative differences of the posterior median (points) of the recruitment (age 1 in mass in January), the spawning–stock biomass and the fishing mortality in the first and in the second semester when PELGAS biomass and age-structure indices in the last year are removed with respect to the final 2017 stock assessment including PELGAS.


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

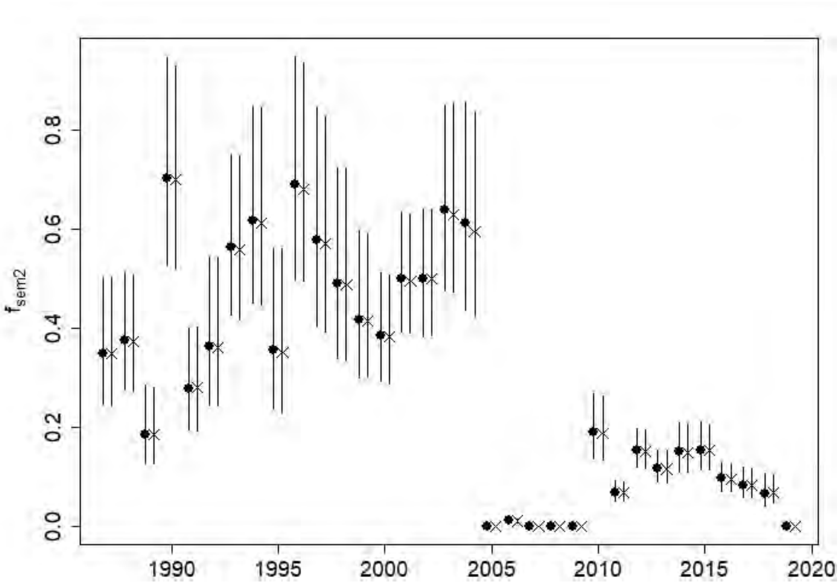


Figure 3.5.3.3. Bay of Biscay anchovy: From top to bottom comparison of the posterior median (points) and 90% probability intervals (solid lines) of the recruitment (age 1 in mass in January), the spawning–stock biomass and the fishing mortality in the first and in the second semester without (bullet) and with (cross) PELGAS biomass and age-structure indices in the last year for the 2018 assessment.

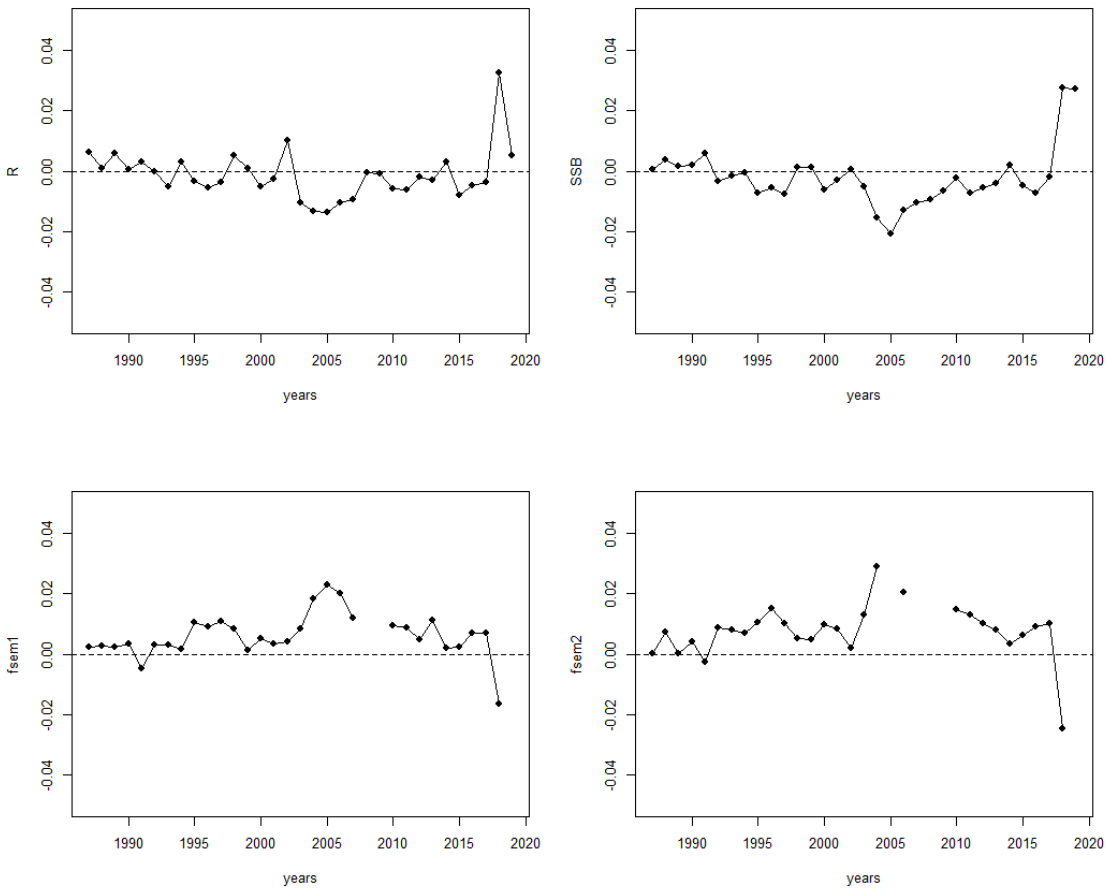
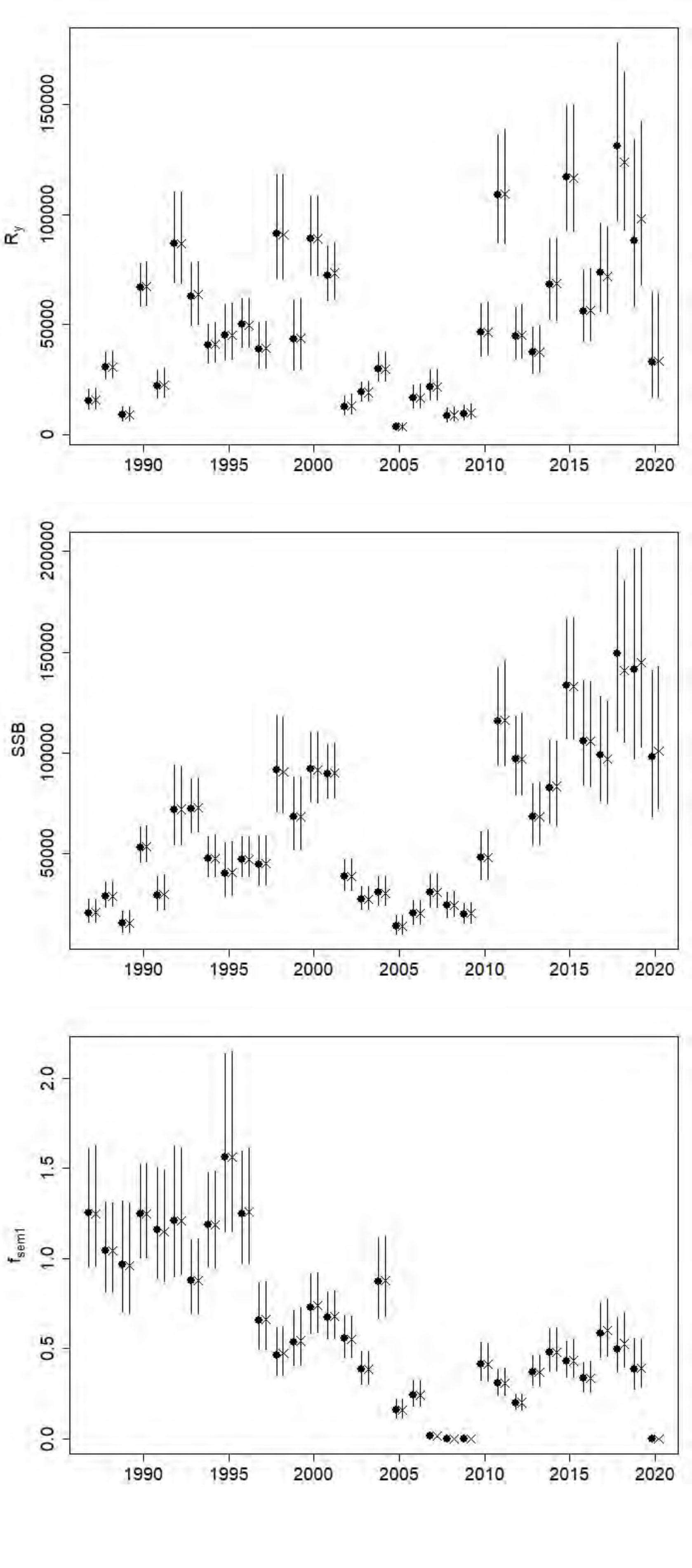


Figure 3.5.3.4. Bay of Biscay anchovy: From top to bottom and from left to right relative differences of the posterior median (points) of the recruitment (age 1 in mass in January), the spawning–stock biomass and the fishing mortality in the first and in the second semester when PELGAS biomass and age-structure indices in the last year are removed with respect to the final 2018 stock assessment including PELGAS.



R_y
0
50000
100000
150000
1990
1995
2000
2005
2010
2015
2020
SSB
50000
100000
150000
200000
f_{sem1}
0.0
0.5
1.0
1.5
2.0

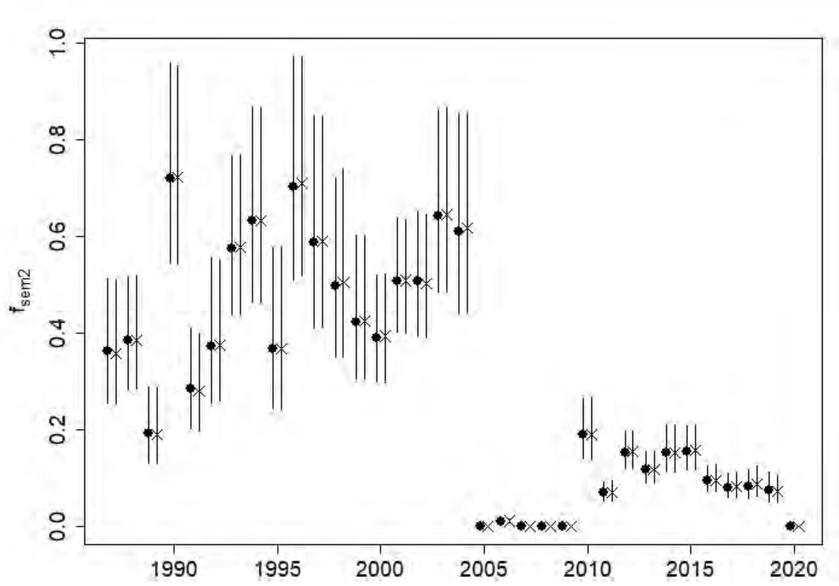


Figure 3.5.3.5. Bay of Biscay anchovy: From top to bottom comparison of the posterior median (points) and 90% probability intervals (solid lines) of the recruitment (age 1 in mass in January), the spawning–stock biomass and the fishing mortality in the first and in the second semester without (bullet) and with (cross) PELGAS biomass and age-structure indices in the last year for the 2019 assessment.

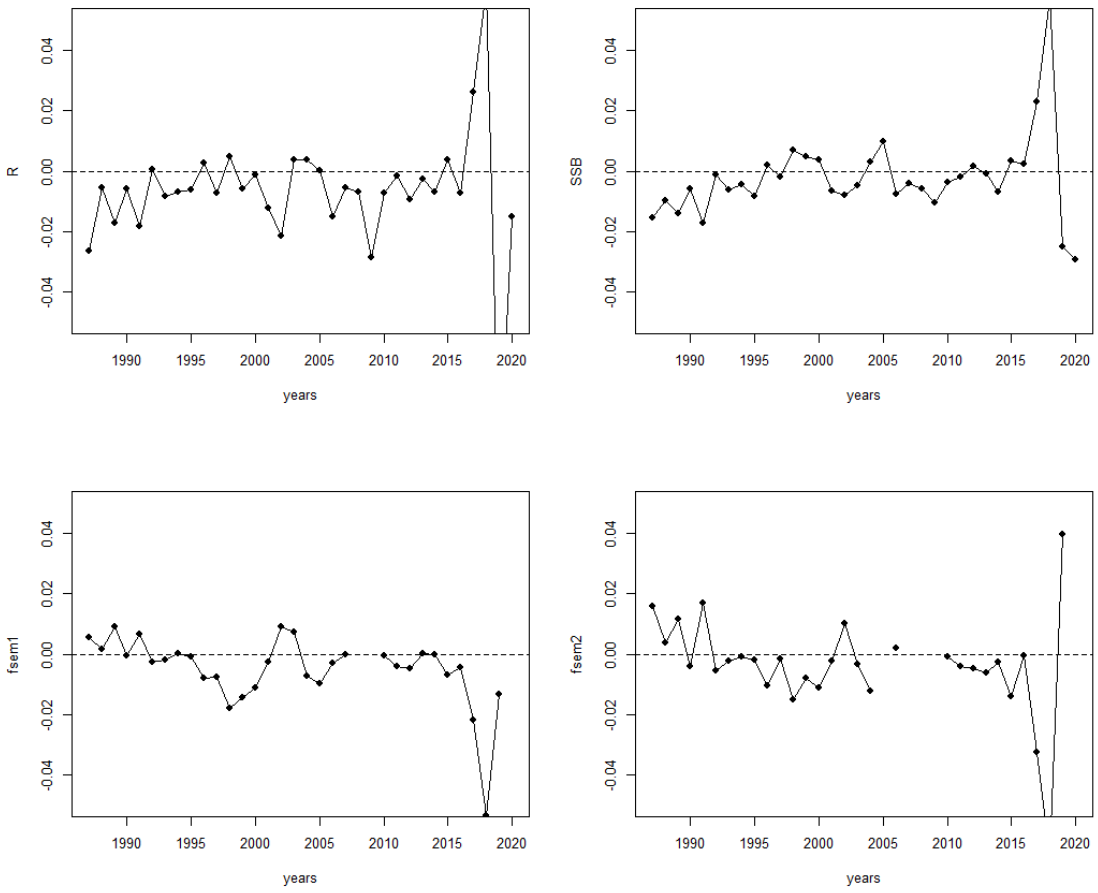


Figure 3.5.3.6. Bay of Biscay anchovy: From top to bottom and from left to right relative differences of the posterior median (points) of the recruitment (age 1 in mass in January), the spawning–stock biomass and the fishing mortality in the first and in the second semester when PELGAS biomass and age-structure indices in the last year are removed with respect to the final 2019 stock assessment including PELGAS.

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 2021 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 2021 from the assessment in November. The median recruitment (age 1 biomass on 1st January) in 2021 for the November projections is around 53 600 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 2021 should be established at 33 000 t. Under the assumption that 60% of the annual catches are taken in the first semester, the deterministic SSB in 2021 is 118 900 t (Table 3.6.3). When the projection is stochastic, the median SSB in 2021 is around 121 800 t with a 90% probability interval between 71 300 t and 213 600 t (Figure 3.6.3). The probability of SSB in 2021 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 0.02 (Table 3.6.1 and Figure 3.6.4) and the corresponding median SSB values in 2020 are above 85 700 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 2021 being below B_{lim} is lower than 0.05 for total catches up to 143 000 t (Table 3.6.1 and Figure 3.6.5). The harvest rate in 2020 was equal to 0.149. The same harvest rate in 2021 would lead to catches around 18 500 t and SSB around 124 800 t, with probability of SSB being below B_{lim} lower than 0.001.

The final catch options table for 2021 is given in Table 3.6.3.

Following the stock annex, the usual underlying assumption for the short-term projections is that 60% of the catches are taken in the first semester. This value corresponds to the average of the percentages of catches in the first semester from 1987 to 2004 before the fishery closure and it was also used in the evaluation of the management plan (STECF 2013; 2014). However, the percentage of the catches taken in the first semester since the re-opening of the fishery has been 0.75. To test the potential influence of this assumption, the short-term projections were repeated assuming that 75% of the catches corresponded to the first semester (Table 3.6.4). In general, given the current high level of biomass, the impact in the final catch option table was low.

Table 3.6.1. Bay of Biscay anchovy: Probability of SSB in 2021 of being below B_{lim} under different catch options for 2021 and alternative catch allocation by semesters.

P(SSB<B_{lim})			% CATCHES IN THE 1st SEMESTER 2021										
			0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
R estimated	TOTAL CATCH 2021	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00036	0.00000
		0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00055	0.00055	0.00000
		0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00036	0.00055	0.00164	0.00000
		0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00018	0.00055	0.00145	0.00309	0.00000
		0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00055	0.00145	0.00273	0.00582	0.00000
		0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00018	0.00055	0.00255	0.00527	0.00964	0.00000
		0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00055	0.00145	0.00364	0.00764	0.01529	0.00000

Table 3.6.2. Bay of Biscay anchovy: Median SSB in 2021 under different catch options for 2021 and alternative catch allocation by semesters.

SSB		% CATCHES IN THE 1st SEMESTER 2021										
		0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
R estimated	TOTAL CATCH 2021											
	0	135354	135354	135354	135354	135354	135354	135354	135354	135354	135354	135354
	5000	135354	135015	134676	134336	134000	133663	133325	132983	132640	132297	131954
	10000	135354	134676	134000	133325	132640	131954	131269	130588	129906	129223	128540
	15000	135354	134336	133325	132297	131269	130247	129223	128198	127173	126143	125112
	20000	135354	134000	132640	131269	129906	128540	127173	125802	124421	123049	121653
	25000	135354	133663	131954	130247	128540	126830	125112	123392	121653	119908	118165
	30000	135354	133325	131269	129223	127173	125112	123049	120953	118862	116768	114666
	35000	135354	132983	130588	128198	125802	123392	120953	118514	116069	113611	111164
	40000	135354	132640	129906	127173	124421	121653	118862	116069	113263	110462	107645
	45000	135354	132297	129223	126143	123049	119908	116768	113612	110462	107290	104070
	50000	135354	131954	128540	125112	121653	118165	114666	111164	107645	104070	100448
	55000	135354	131611	127857	124078	120257	116418	112564	108704	104789	100811	96824
	60000	135354	131269	127173	123049	118862	114666	110462	106220	101901	97549	93163
	65000	135354	130929	126486	122003	117467	112914	108351	103709	98994	94277	89481
	70000	135354	130588	125802	120953	116069	111164	106220	101176	96097	90954	85778

Table 3.6.3. Bay of Biscay anchovy: Catch options for 2021 under the assumption that 60% of the catches were taken in the first semester

		STOCHASTIC	DETERMINISTIC
Basis	Catch 2021	$P(SSB_{2021}<B_{lim})$	SSB_{2021}
G3 with hr=0.4	33000	<0.0001	118900
Zero catches	0	<0.0001	132368
Same deterministic harvest rate as 2020 (0.1486857)	18562	<0.0001	124840
P(SSB2020>Blim)=0.05	143500	0.0498	70370
Other options	5000	<0.0001	130352
	10000	<0.0001	128327
	15000	<0.0001	126293
	20000	<0.0001	124251
	25000	<0.0001	122201
	30000	<0.0001	120141
	35000	<0.0001	118070
	40000	<0.0001	115991
	45000	<0.0001	113902
	50000	<0.0001	111803
	55000	<0.0001	109694
	60000	<0.0001	107574
	65000	0.0002	105445
	70000	0.0005	103303

Table 3.6.4. Bay of Biscay anchovy: Catch options for 2021 under the assumption that 75% of the catches were taken in the first semester.

		STOCHASTIC	**DETERMINISTIC**
Basis	Catch 2021	$P(SSB_{2021}<B_{lim})$	SSB_{2021}
G3 with hr=0.4	33000	<0.0001	115471
Zero catches	0	<0.0001	132368
Same deterministic harvest rate as 2020 (0.1486857)	18299	<0.0001	123074
P(SSB2020>Blim)=0.05	115000	0.0499	70252
Other options	5000	<0.0001	129846
	10000	<0.0001	127311
	15000	<0.0001	124763
	20000	<0.0001	122201
	25000	<0.0001	119624
	30000	<0.0001	117032
	35000	<0.0001	114425
	40000	<0.0001	111803
	45000	<0.0001	109165
	50000	<0.0001	106512
	55000	0.0005	103840
	60000	0.0005	101151
	65000	0.0015	98444
	70000	0.0027	95719

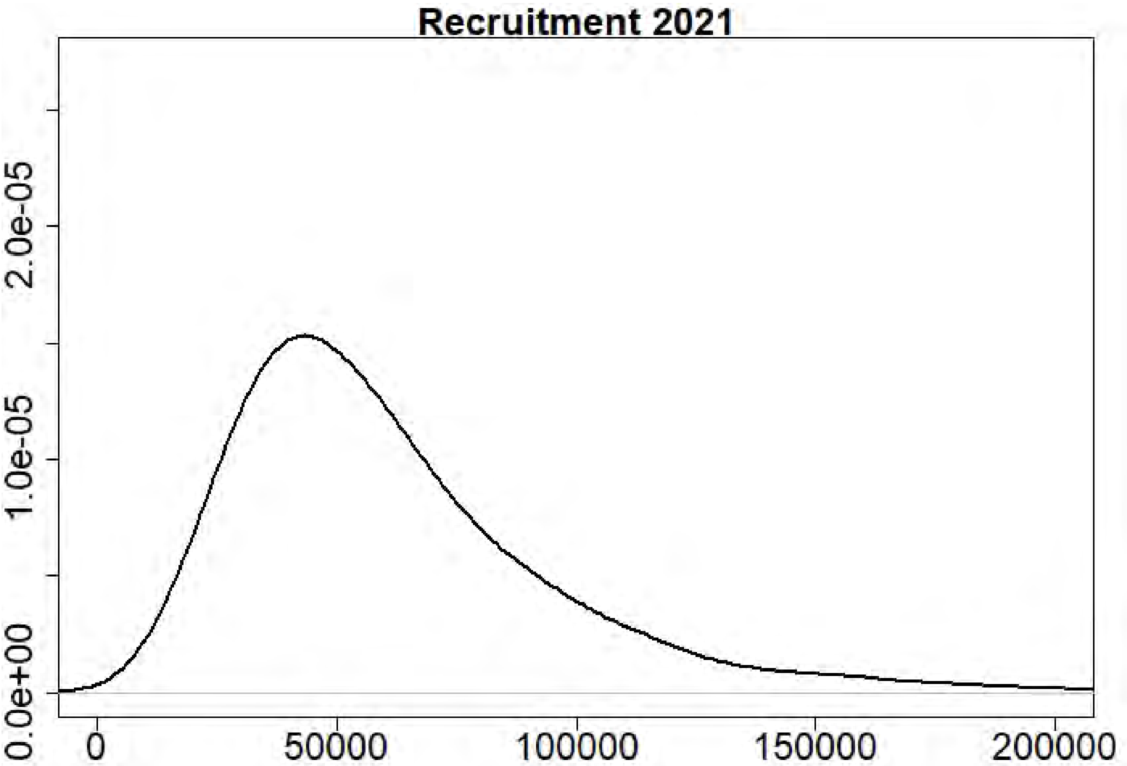


Figure 3.6.1. Bay of Biscay anchovy: Posterior distribution of recruitment (age 1 biomass at the beginning of the year) in 2021.

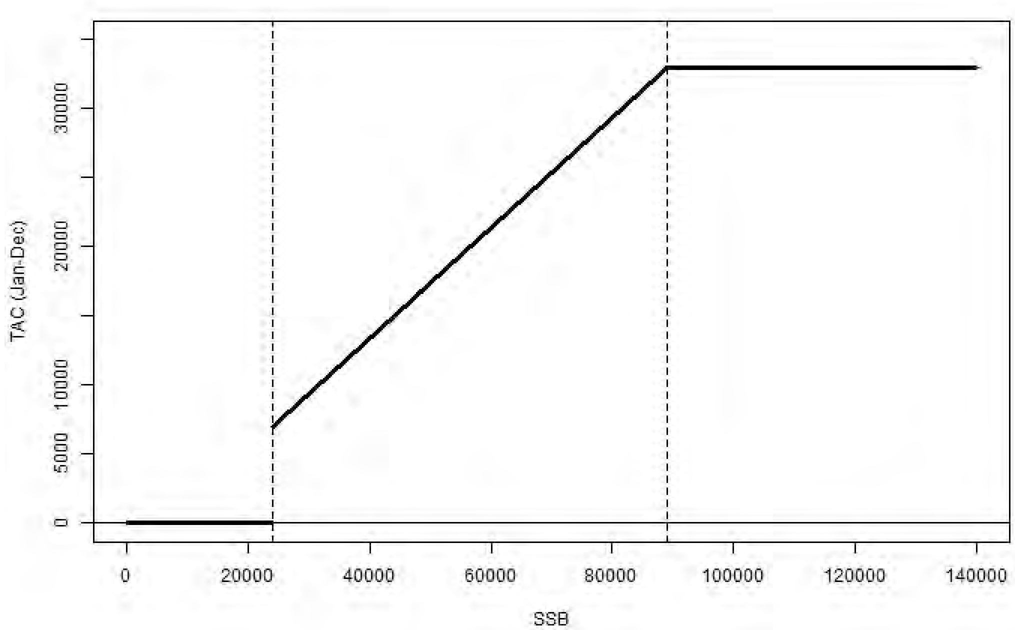


Figure 3.6.2. Bay of Biscay anchovy: Harvest control rule G3 with harvest rate of 0.4 according to which the TAC from January to December is set as a function of the expected spawning–stock biomass (on 15th May) in the management year.

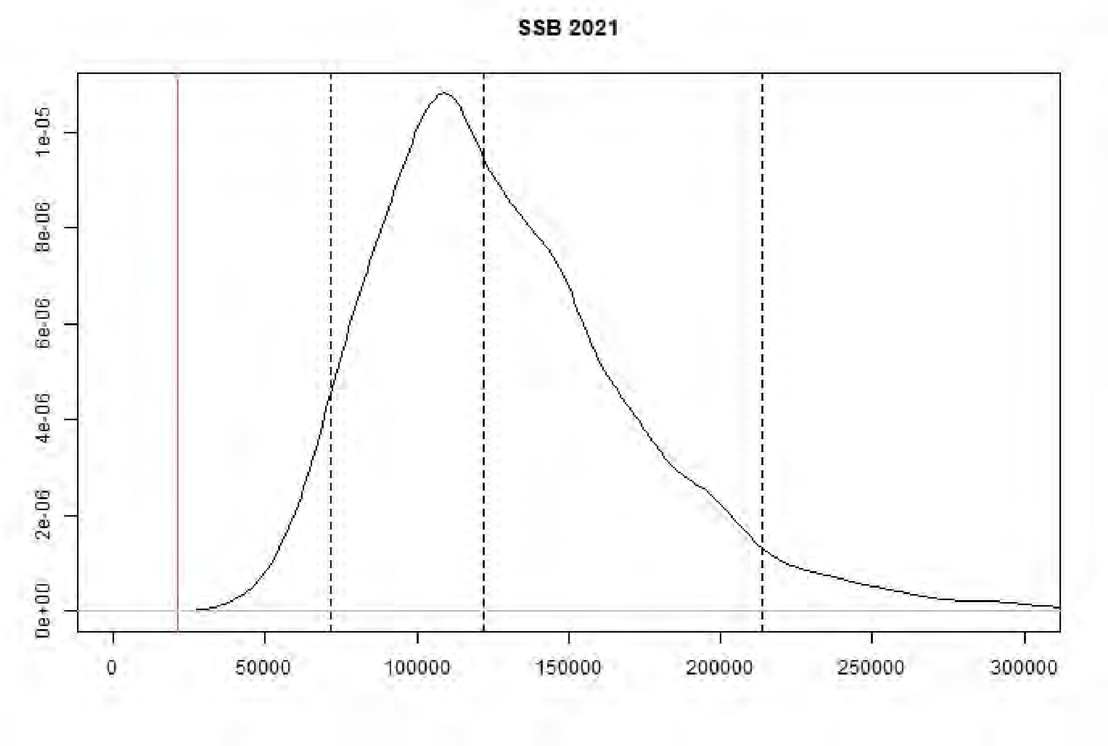


Figure 3.6.3. Bay of Biscay anchovy: Posterior distribution of SSB in 2021 if the annual catch is set according to the LTMP at 33 000 t and 60% of the catch is taken during the first semester. Vertical black dashed lines represent the 5, 50 and 95 posterior quantiles, whereas the red vertical line is B_{lim} (21 000 t).

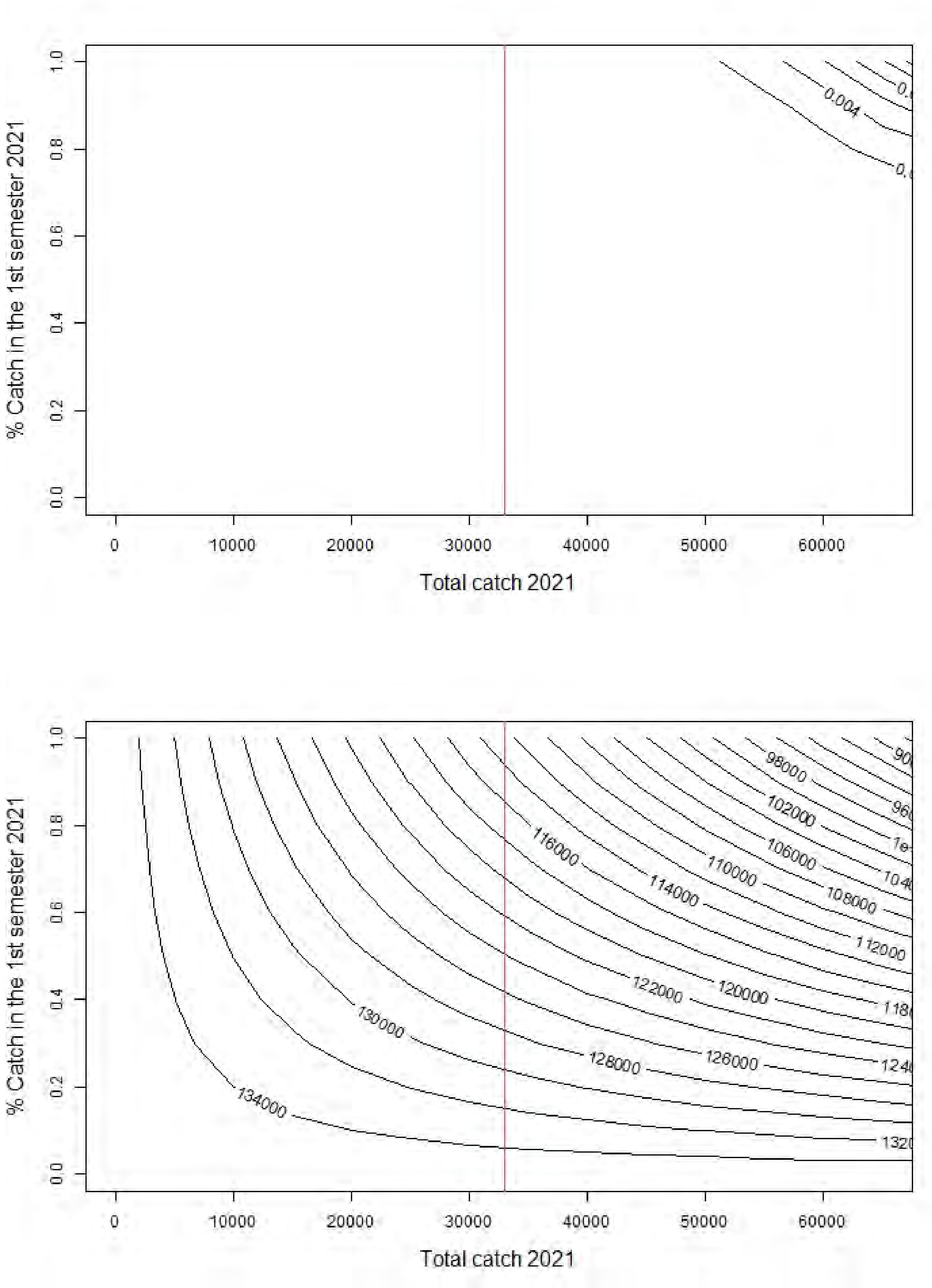


Figure 3.6.4. Bay of Biscay anchovy: Contour plots of probability of SSB in 2021 being below B_{lim} (on the top) and median SSB in 2021 (on the bottom) depending on the total catch in 2021 (x-axis) and the % of the catch in the first semester (y-axis). The vertical red line is set at 33 000 t.

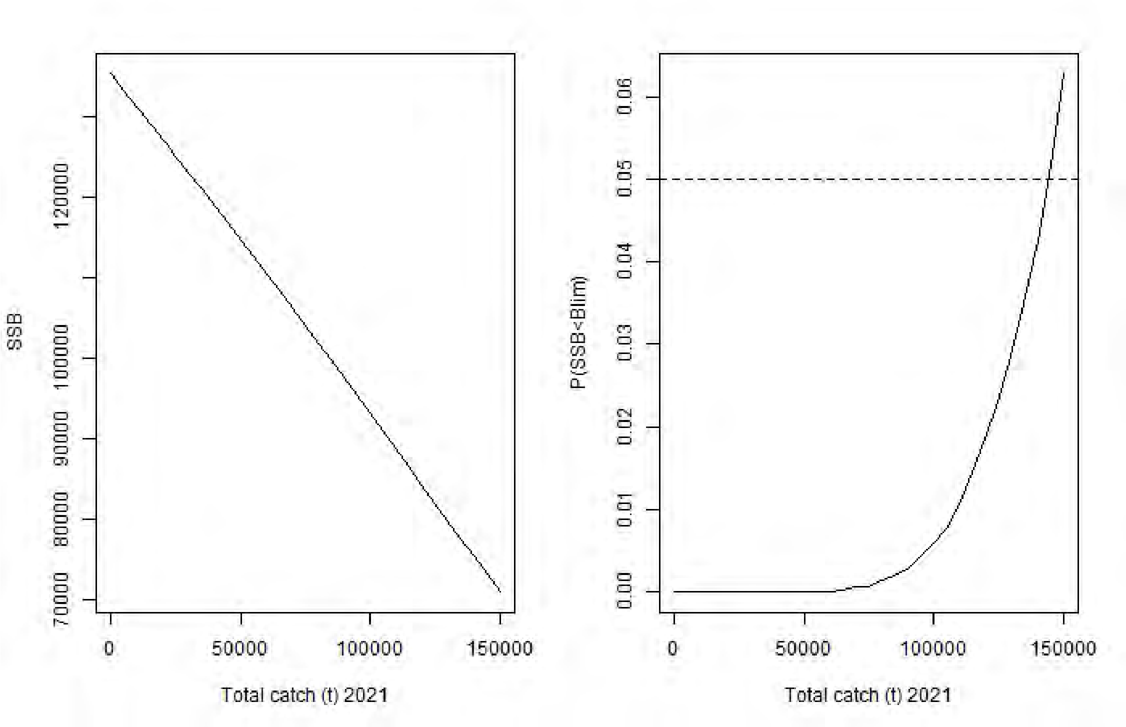


Figure 3.6.5. Bay of Biscay anchovy: SSB in 2021 (on the left) and probability of SSB in 2021 been below B_{lim} (on the right) depending on the total catch taken in 2021 when 60% of the catch is taken during the first semester.

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 2019, 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:

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

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:

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

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.

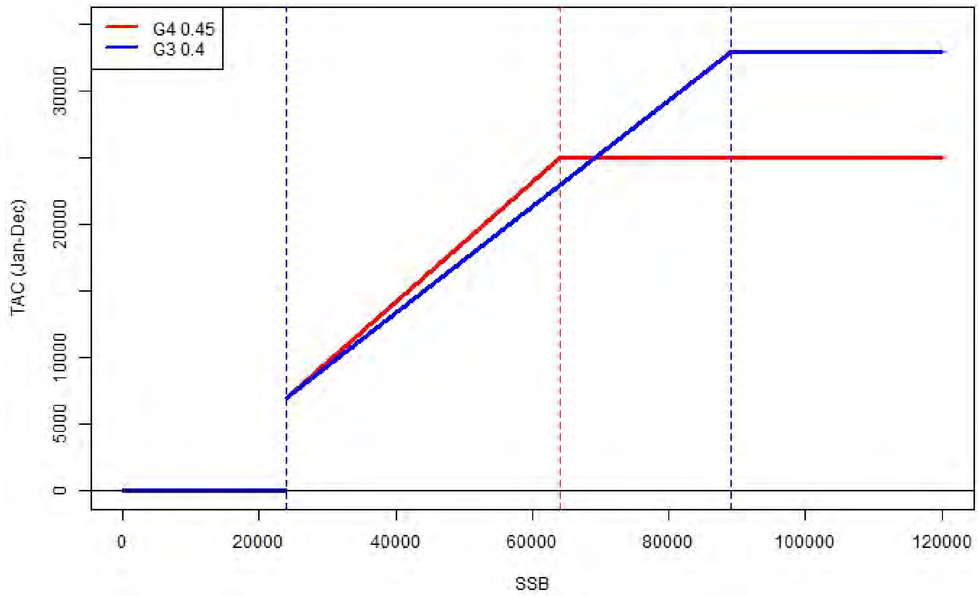


Figure 3.7.3.1. Bay of Biscay anchovy: Harvest control rules G4 with harvest rate of 0.45 (in red) and G3 with harvest rate of 0.4 (in blue) according to which the TAC from January to December is set as a function of the expected spawning–stock biomass (on 15th May) in the management year.

3.8 Deviations from stock annex caused by missing information from Covid-19 disruption

1. Stock

Anchovy (*Engraulis encrasicolus*) in Subarea 8 (Bay of Biscay) (ane.27.8)

2. Missing or deteriorated survey data

The French acoustic survey PELGAS 2020 could not be conducted due to the Covid-19 disruption. This survey is an important source of information for the anchovy stock assessment as it provides estimates of the total biomass and of the age structure of the stock in spring. The other surveys used for stock assessment (BIOMAN 2020 and JUVENA 2020) were carried out as usual following the standard methodologies described in the stock annex.

3. Missing or deteriorated catch data

2020 catch data used in the stock assessment are preliminary. Although it is expected that there might be a deterioration of the quality of the 2020 catch data, it is not possible to evaluate the extent of the effect of the Covid-19 disruption on these data until next year, when the official 2020 catch data (and corresponding sampling levels) will be reported.

4. Missing or deteriorated commercial *LPUE/CPUE* data

Not applicable.

5. Missing or deteriorated biological data: (e.g. maturity data)

There were no missing or deteriorated biological data due to the Covid-19 disruption.

6. Brief description of methods explored to remedy the challenge

It was not possible to remedy the lack of PELGAS 2020 survey and no method was explored.

7. Suggested solution to the challenge, including reason for this selecting this solution

The stock annex was applied as in previous years, except for the lack of the PELGAS 2020 data.

8. Was there an evaluation of the loss of certainty caused by the solution that was carried out?

The exact extent of the lack of PELGAS 2020 in the stock assessment cannot be quantified. However, we carried out a sensitivity analysis in which the last three stock assessments were repeated by removing the terminal year indices from PELGAS. The results showed that when the last year PELGAS indices were missing, the last years' stock assessment estimates were more uncertain. In addition, the last years' estimates of recruitment, SSB and F changed when the last year PELGAS indices were removed. However, the magnitude of the differences varied between the assessments, depending on the level of agreement between the removed PELGAS estimates and the other assessment inputs. The maximum absolute change for R, SSB and F was up to 2%, 3% and 10% in the 2017, 2018 and 2019 assessments, respectively.

4 Anchovy in Division 9.a

4.1 ACOM Advice Applicable to the management period July 2019–June 2020

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.

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.

From the above reasons, 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.

ICES advised for the period 1st July 2019 to 30th June 2020 that when the precautionary approach is applied, catches from the western component should be no more than 2662 t and catches from the southern component should be no more than 6290 t (no more than 8952 t for the whole stock). The TAC for this same management period was agreed in 10 240 t (Portugal: 5343 t; Spain: 4897 t).

Official anchovy landings in the division in 2019 were of 10 803 t. Estimated total catches were 11 014 t. Provisional estimated catches for the current management calendar are 8610 t (western component: 2618 t; southern component: 5992 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 potential connectivity of anchovy population of the 9a West subdivisions with the south Iberian population (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. The separation of the population from the GoC and the Alboran Sea (Spanish SW Mediterranean) is still unclear (Garrido *et al.*, 2018a). Morphometric and genetic studies indicate a differentiation of the western and Cantabrian populations, as well as a separation with those from the GoC.

The evidence summarised 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 presenting both the available evidence and the resulting new evidence from these undergoing studies to the ICES Stock Identification Methods Working Group for future consideration.

Given the poor cohort tracking of anchovy populations in the western component assessed by the acoustic surveys PELACUS and PELAGO, and new available information of age composition of surveys, a study is being developed to study the potential correlation between the western and the Cantabrian anchovy populations, whose preliminary results were presented during the WGHANSA meeting (ANE_2020_InputData_WesternComponent_27May.pptx).

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 2019

4.3.1 Fishing fleets

Anchovy harvesting throughout the Division 9.a was carried out in 2019 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 gillnets (GNS_DEF_60-79_0_0 accidental anchovy landings).

- Spanish bottom otter trawl directed to demersal and pelagic fish (OTB_MPD_>=55_0_0 anchovy discards).

Southern 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 bottom otter trawl directed to demersal fish in 9.a South (OTB_MCD_>=55_0_0 anchovy discards).

The Spanish fleet fishing anchovy in the Western component was composed in 2019 by a total of 77 vessels. From this total, 70 vessels (91%) were purse-seiners (**Table 4.3.1.1**). The Portuguese fleet targeting anchovy and operating in the Western component in 2019 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 2019, GoC anchovy fishing was practised by 56 purse-seiners, entailing a drastic reduction in comparison with the number of purse-seiners targeting anchovy in previous years (74–78 vessels for the period 2016–2018). 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 2019 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 2019 was estimated at 11 014 t, which represented a 20% decrease on the catches landed in the previous year (13 732 t), although is still among the most recent historical maxima recorded in the last years (since 1989; **Table 4.3.2.1.1**, **Figure 4.3.2.1.1**). The above estimate is the result from adding up 10 803 t of official landings and 211 t of discards (see **Section 4.3.3**).

As usual, the anchovy fishery in 2019 was almost exclusively harvested by purse-seine fleets (98.1% 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 2014–2019.

Provisional official landings during the first semester in 2020 amounted to 3477 t. Provisional catches during the current management period (July 2019–June 2020), as the result of summing up total catches from the second semester in 2019 and provisional official landings from the first semester in 2020, amounted to 8610 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 2019 catches by subdivision is shown in **Table 4.3.2.2.2**.

Western component

The total catch in 2019 for this stock component was estimated at 6200 t, which accounted for 32.8% decrease on the 2018 catch (9233 t) and represented 56% of the total catch in the division. This 2019 estimate is the fifth historic high since the one recorded in 1995 and is well above the historical mean (1843 t). The fractions composing this total catch in 2019 were: 6200 t of official landings and 0.6 t of discards.

Provisional official landings during the first semester in 2020 amounted to 269 t.

Provisional catches during the current management period (July 2019–June 2020) amounted to 2618 t.

The distribution of these catches by subdivision is as follows:

Subdivision 9a North

In this Spanish subdivision, a total of 991 t was caught in 2019, which represented similar catch levels than those estimated the previous year (992 t). These catches accounted for 16.0% of the total catch estimated for the Western component and 9.0% for the whole division. This estimated catch is the result of adding up 990 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 third and first semesters.

Provisional official landings during the first semester in 2020 amounted to 16 t (up to 18th May 2020). Those ones corresponding to the current management calendar amounted to 664 t.

Subdivision 9a Central-North

This subdivision concentrated a great part of the anchovy fishery in 2019, both in relation to the whole division (47.3%) and to the Western component (83.9%): a total catch of 5205 t was estimated (with all of these catches corresponding to official landings; neither unallocated nor discarded catches were reported). These catches represented a 34% decrease on the catches estimated the previous year (7871 t), but they still are among the successive historical maxima recorded since 2016 on. Purse-seiners practically harvested the whole fishery, mainly during the first and third semesters in the year.

Provisional official landings during the first semester in 2020 amounted to 253 t (up to end of April). Official landings during the current management calendar were 1954 t.

Subdivision 9a Central-South

Anchovy catches from this subdivision were only 4 t (all of them official landings), accounting for a strong 98.8% decrease in relation to the catches in 2018 (370 t) and staying this value close to its historical minima. Such catches accounted only for 0.1% of the total catch in the Western component and 0.04% 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 2020 (up to end of April) in this subdivision amounted to 0 t and to 0.3 t for the current management calendar.

Southern component

Subdivision 9a South

The total catch in 2019 of this stock component was estimated at 4814 t, which accounted for a 7% increase with respect to the 2018 catch (4499 t) and represented 43.7% of the total catch in the division. The fractions composing this total catch in 2019 were: 4603 t of official landings (Portugal: 113 t, Spain:

4490 t) and 211 t of (Spanish) discards. About ninety-six percent (95.7%) 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 third one.

Provisional official landings during the first semester in 2020 amounted to 3208 t (2 t from the Portuguese fishery, 3206 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 only recorded in the first quarter 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 2019 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 in 2019, was 0.050 (4.5%) and may be considered as a relatively very low ratio. Discards were recorded in the first three quarters in the year.

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 (1988–2019) 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 since 2017, 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 were 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 was 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. A higher sampling effort has been made in the port of Matosinhos (9.a Central-North) since 2018 to have monthly biological data of anchovy in that area that represents the bulk of catches in the western component.

Quarterly LFDs in 2019 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 0.1% and 4% of the catches occurred in the 9.a Central-South and 9.a South (Algarve) subdivisions, respectively.

Catch-at-age data in 2019 have been provided only for the Spanish fishery in subdivisions 9.a North and South and from the Portuguese fishery in Subdivision 9 .a Central North.

No age structure is available for 2019 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 2019 are shown in **Tables 4.3.5.1.1** to **4.3.5.1.6**. Size range in catches from the whole fishery varied between 12.0 and 19.0 cm size classes (mode at 16.0 cm size class), with an annual mean size and weight in catches being estimated at 16.0 cm and 29.3 g, respectively.

Subdivision 9.a Central-North

The available size compositions of 2019 anchovy catches from the Subdivision 9.a Central-North are shown in **Tables 4.3.5.1.7** to **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 >99% of all catches. Anchovy size composition in purse-seine catches (i.e. the main fishery) ranged between 10.5 and 18.5 cm size classes (mode at 15.0 cm size class), with an annual mean size and weight in catches being estimated at 15.4 cm and 22.6 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 2019 by métier/fraction and for the whole fishery are shown in **Tables 4.3.5.1.11** to **4.3.5.1.15**. Size range of the exploited stock (landings plus discards) in the whole fishery varied between 4.5 and 17.0 cm size classes, with the modal class at 12.0 cm size class. Anchovy mean length and weight in the Spanish 2019 annual catch (11.6 cm and 10.7 g) were lower 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 2019 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 2019 was of 33.8 million fish, composed by ages 1, 2 and 3 anchovies, with age- 1 and 2 olds accounting for 41% and 57% of the total catch, respectively.

Subdivision 9.a Central-North

Estimates from the fishery in this subdivision in 2019 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 2019 was of 222 million fish, composed by 0, 1, 2 and 3 year old anchovies, which accounted for 1%, 16%, 79%, and 4% of the total catch, respectively.

Subdivision 9.a Central-South

No estimate from this subdivision in 2019 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 2019. Total catches in the Spanish fishery in 2019 were estimated at 446 million fish, which accounted for a 23% increase in relation to the 362 million caught during the previous year. Such an increase was mainly caused by huge 314% and 168% increases of ages 0 and 2 respectively, whereas age 1 fish experienced a 16% decrease, although it is still the dominant age group (59% of the total catch in numbers). 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 low.

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 2019 are shown in **Tables 4.3.6.1** and **4.3.6.2**. Anchovy mean length and weight in the catches were 16.0 cm and 29.3 g. 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 2019, all the age groups but age 3 fish mean weight experienced a small increase 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 2019 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 15.4 cm and 22.6 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 2019 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 2019 annual catches were estimated at 11.6 cm and 10.3 g respectively, somewhat lower 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 from 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 has been 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 2019 and 2020 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 RV *Thalassa* from 1997 to 2012 and since then is routinely conducted on board the Spanish RV *Miguel Oliver*. An inter-calibration survey was done in April 2014 off Garonne mouth (i.e. 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 0320

PELACUS 0320 was not conducted in the spring of 2020 due to the Covid-19 disruption. In **Table 4.4.2.1** and **Figure 4.4.2.1** the time-series (1996–2019) of anchovy biomass estimates from *PELACUS* are shown.

PELAGO series

PELAGO 20

The *PELAGO 20* survey was conducted this year between 4th to 25th May on board RV Miguel Oliver. Seventy-one (71) transects were acoustically sampled between Caminha and Cape Trafalgar. A total of 26 pelagic trawl hauls were carried out by the research vessel. The distribution and species composition of all of these hauls are shown in **Figure 4.4.2.2**.

Regarding the mapping of acoustic energy, anchovy was found in both extremes of the distribution area (9aCN and 9aS(CAD)), with only few fish in both 9aCS and 9aS(ALG) (**Figure 4.4.2.3)**.

Anchovy acoustic estimates for the whole surveyed area were 8791 million fish and 100 078 t.

In 9a Central-North were estimated a total of 3152 million fish and 50 282 t, an estimate which represents the second highest peak of abundance of the time-series. The estimated population in this subdivision ranged between 10.5 and 18.5 cm size classes, with a main mode at 12 cm size class (**Figure 4.4.2.4**). The assessed population abundance from this subdivision was structured by Age-1, Age-2 and Age-3 fish, with the Age-1 being the dominant age (68%), followed by Age-2 fish (24%) and Age-3 (7%) fish (**Figure 4.4.2.5**).

Anchovy population in 9a Central-South was supported by 0.3 million fish and 9 t, showing a size range between 14.0 and 18.5 size classes, with a 16.5 cm modal size, and with a predominance of Age 2 individuals, followed by Age 3 and Age 1 (**Figures 4.4.2.4** and **4.4.2.5**).

In the Subdivision 9.a South, with values of 5639 million fish and 49 787 t (**Table 4.4.2.2**), the Spanish waters concentrated most of the population. In 9a South-Algarve were estimated a total of 89 million fish and 1798 t (**Figure 4.4.2.4**). The estimated population in Subdivision 9.a South-Algarve ranged between 11.5 and 16.5 cm size classes, with a main mode at 15.5 cm size class, and a dominance of Age 1 (45.9%) followed by Age 2 (42.0%) and last Age 3 (12%) individuals (Figure 4.4.2.5).

In 9a South-Cadiz were estimated a total of 5550 million fish and 47 998 t (Figure 4.4.2.4). The estimated population in this Subdivision 9.a South-Cadiz ranged between 7.5 and 16.5 cm size classes, with a main mode at 11.5 cm size class. The population was dominated by Age 1 individuals (89.6%) followed by Age 2 (10.3%) and Age 3 (0.1%) (**Figure 4.4.2.5**).

Table 4.4.2.2 and **Figure 4.4.2.6** 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. In 2020, the population has significantly increased to an abundance close to the maximum of 2018, representing the second highest peak of abundance, increasing 1218% since 2019. Anchovy in 9.a Central-South is still maintaining low abundances. Biomass levels in the Subdivision 9.a South are experiencing the increasing trend restarted in 2018, at a level above the historical average (**Figure 4.4.2.7**).

Figure 4.4.2.8 shows the age structure of the population estimates in the western component. Age 2 anchovies constitute the bulk of the population in spring, followed by age 1, and 3 are also present. Strong incoming recruitments seem to be inferred in 2019, 2018 and 2017, although the last two not detected during the 2019 survey.

Size composition and age structure of the population estimated in the southern component through the time-series was described in previous reports. In **Table 4.4.2.4** and **Figure 4.4.2.9**, 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 2019-07

The *ECOCADIZ 2019-07* survey was conducted by IEO between 31th July and 13rd August 2019 in the Portuguese and Spanish shelf waters (20–200 m isobaths) off the Gulf of Cadiz on board the Spanish RV *Miguel Oliver*. The survey design consisted in a systematic parallel grid with 21 transects equally spaced by 8 nm, normal to the shoreline. A total of 27 valid fishing hauls (between 42–183 m depth) for echotrace ground-truthing purposes were carried out (**Figure 4.4.2.10**). CUFES sampling (121 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 150 CTD (with coupled altimeter, oximeter, fluorometer and transmissometer sensors) - LADCP casts, and sub-superficial thermosalinograph-fluorometer and VMADCP continuous sampling were carried out to oceanographically characterise the surveyed area. Twenty six (26) *Manta trawl* hauls were also carried out to characterise the distribution pattern of micro-plastics over the shelf. A detailed description of the *ECOCADIZ 2018-07* survey methods and results are given in Ramos *et al*. (WD 2020a).

Chub mackerel (*Scomber colias*) was the most frequent species in the fishing hauls, followed by horse mackerel (*Trachurus trachurus*), anchovy, sardine, mackerel (*S. scombrus*), blue jack mackerel (*T. picturatus*), Atlantic pomfret (*Brama brama*) and bogue (*Boops boops*). Long-spine snipefish (*Macrorhamphosus scolopax*), boarfish (*Capros aper*) and transparent goby (*Aphia minuta*) showed a medium relative frequency of occurrence. Mediterranean horse-mackerel (*T. mediterraneus*) and pearlside (*Maurolicus muelleri*) showed a low occurrence. Pearlside was the most abundant species in these hauls, followed by sardine, chub mackerel, anchovy and long-spine snipefish, with the remaining species showing negligible relative contributions (**Figure 4.4.2.10**).

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, a situation which was repeated in the last year's survey. Such an increase is the result of the relatively high acoustic contributions of anchovy (29%), sardine (19%), chub mackerel (18%), and the unexpected high contributions of Atlantic pomfret (18%) and transparent goby (5%), species, which usually have showed an accidental occurrence or very low abundance through the time-series.

Anchovy was mainly distributed between Cape Santa Maria and Bay of Cadiz, although showing the highest densities in the Spanish shelf waters between El Rompido (RA10) and Bay of Cadiz (RA03). This distribution pattern differed from the exhibited one during the *PELAGO* spring survey, when anchovy was restricted to the Spanish waters only (**Figure 4.4.2.10**).

Anchovy eggs distribution resembled the adults' and, although overall egg density was higher than previous years, the spawning area showed a reduction as compared with the observed ones in previous years (**Figure 4.4.2.11)**.

Overall acoustic estimates in summer 2019 were of 5485 million fish and 57 700 tonnes. By geographical strata, the Spanish waters yielded 99% (5405 million) and 97% (56 139 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 80 million and 1560 t.

The size class range of the assessed population varied between the 8.5 and 17.5 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 waters and the smallest (and youngest) ones concentrated in the surroundings of the Guadalquivir river mouth and adjacent shallow waters (**Figures 4.4.2.12** and **4.4.2.13**).

The population was composed by fishes not older than two years. As it has been happening in the last years, during the 2019 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 42 and 30% of the total estimated abundance and biomass, respectively. Age 1 fish represented 55% and 66% of the total abundance and biomass (**Figure 4.4.2.13**).

The summer 2019 biomass estimate (57 700 t) becomes in the historical maximum within the time-series (2006: 35 539 t; 2016: 34 184 t; 2018: 34 908 t; **Table 4.4.2.3**, **Figure 4.4.2.14**) and denotes a strong increase in relation to the previous year, up to levels well above the historical average (ca. 24 kt), showing a recent increasing trend. Although the spring *PELAGO 19* survey also estimated increased population levels (29 876 t, 3398 million), but with all the anchovy located in the Spanish waters, such increase was not so pronounced as the estimated by its summer counterpart.

Table 4.4.2.4 shows the time-series of population estimates-at-age in the southern component estimated by *PELAGO* and *ECOCADIZ* surveys (see also **Figure 4.4.2.9**).

4.4.3 Recruitment surveys

SAR, JUVESAR and *IBERAS* 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 survey 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 estimates 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 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 (*ECOCADIZ-RECLUTAS*) were routinely prospected by RV *Ramón Margalef* and the northwest coast of Portugal (*JUVESAR*) by RV *Noruega* since 2013. The idea is to fill the gap between both *JUVENA* and *ECOCADIZ-RECLUTAS* surveys and incorporate the *JUVESAR* series, following the same radials in Subdivision 9.a Central-North. This new time-series is being conducted in the vessel RV *Ángeles Alvariño*, twin of RV *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 was planned in September, at the same time of *JUVENA* and before *ECOCADIZ-RECLUTAS* one (see **Table 4.4.3.2**).

The rationale 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 biomass 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 triggered by the strength of the recruitment.

IBERAS 0919

IBERAS 0919 was carried out on board RV *Ángeles Alvariño* from 5th to 27th September. Further details are shown in Amorím *et al*. (2019). The survey covered from Cape São Vicente (south Portugal, ICES Subdivision 9aCS) to Cape Fisterra (43ºN, 9aN). The survey area (from 20 to 100 m isobath) was covered using an adaptive grid with 73 tracks with random start and evenly distributed each 8 nmi on those areas out of the main expected recruitment areas and each 4 nmi on the main ones. Additionally 23 zig-zag transects were also conducted inside the Rías (**Figure 4.4.3.1**). Besides, in specific areas chosen on the core expected distribution area of juveniles, the very shallower waters (15–10 m) were prospected with the vessel's auxiliary dinghy equipped with a portable EK60 with a 120 kHz transducer. The standard tracks were extended towards the coast, which were prospected by the dinghy. Simultaneously, the vessel steamed the inter-track line. Results at 120 kHz recorded by both echosounders (EK80 on board *Ángeles Alvariño* and EK60 on board dinghy) were compared. The vessel's acoustic equipment consisted of a Simrad EK-80 scientific echosounder, operating at 18, 38, 70, 120 and 200 kHz, working in CW mode. All frequencies were calibrated according to the standard procedures (Demer *et al*., 2015) during the first two days. The EK60 on board the dinghy had an ES120 7CD. Due to the bad weather conditions, this transducer was not calibrated. The backscattering acoustic energy from marine organisms was measured continuously during daylight except in the northern area where some tracks were steamed at night.

A total of 16 pelagic fishing were done as shown in **Figure 4.4.3.2**. As in 2018, horse mackerel had the higher presence and was found in 71% of the trawl hauls, being also noticeable the presence of sardine (59%) and chub mackerel (47%). On the contrary, anchovy only occurred in 6% of the hauls, with a small contribution in the total catch (2%). Although long-spine snipe fish, *Macroramphosus scolopax*, only occurred in four fishing stations, catches have significantly increased since the last year, accounted for 69% of the total catch in weight, with this species being the dominant species at waters deeper than 50 m in the southern part.

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 referred to ESDU (1 nmi) were extracted, accounting 6 286 echotraces with a total NASC (sA) of 785 176 m^2 nmi^{-2}. On tracks, NASC values were 430 069 m^2 nmi^{-2}, which was similar to that recorded in 2018 (476 837, 10% lower). Bathymetric distribution of schools is significantly different from that recorded last year. The weighting average depth (weighting factor, sA) shifted from 30.22 m (c.v. 0.50) to 37.53 m (c.v. 0.38), with a mode located at 47.5 m (32.5 m in 2018). As in 2018, it seems the main school distribution area was covered, since only few schools were found in very shallow waters. In the area covered by the dinghy only few schools were recorded and even the inclusion of coastal inter-transects had little impact on the estimation of the mean NASC value.

Anchovy occurred in shallower waters, near Figueira da Foz, corroborated by both the purse-seiner and the fishing stations done by the research vessel. In the Cascais area, although no fishing stations were done (due to the presence of fishing gears), additional information from purse-seiner fleet was used to allocate some echotraces to anchovy (**Figure 4.4.3.3**).

The estimated biomass in 2019 had an important decrease in relation to the previous year, from $182*10^3$ t to only $4*10^3$ t (164 million). Almost no recruits were assessed, and age group 2 accounted for the 59% of the biomass (57% in number); this result partially agreed the 2018 assessment when the bulk of the biomass was composed by ages 1 and 2, with little contribution of YOY (**Table 4.4.3.2**; **Figures 4.4.3.4** and **4.4.3.5**).

ECOCADIZ-RECLUTAS survey series

ECOCADIZ-RECLUTAS 2019-10

ECOCADIZ-RECLUTAS 2019-10 survey was conducted by IEO between 10th and 30th October 2018 in the Portuguese and Spanish shelf waters (20–200 m isobaths) off the Gulf of Cadiz on board the RV *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 181 $CTDO_2$ 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 2020b).

The 21 foreseen acoustic transects were sampled. A total of 25 valid fishing hauls were carried out for echotrace ground-truthing purposes. From the pelagic fish species set, anchovy and chub mackerel were the most frequent species in those hauls, followed by horse mackerel, mackerel and sardine (**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. Anchovy accounted for 44% of the total back-scattered energy, followed by chub mackerel (23%), sardine (15%) and Mediterranean horse mackerel (10%), and the remaining species with relative contributions of acoustic energies lower than 5%.

The spatial pattern of distribution of anchovy acoustic density was characterised by a concentration of the bulk of the population practically all over the shelf between Alfanzinha (west of Cape Santa Maria) and Bay of Cadiz (**Figure 4.4.3.6**). The size composition of anchovy catches indicates that the smallest recruits occurred mainly in the Spanish coastal waters.

Gulf of Cadiz anchovy abundance and biomass in autumn 2019 were of 5518 million fish and 48 398 t. Spanish waters concentrated 78% (4301 million) and 67% (32 309 t) of the total estimated abundance and biomass respectively. Portuguese estimates amounted to 1217 million and 16 089 t (**Table 4.4.3.3**; **Figure 4.4.3.7**).

The size range recorded for the estimated population was between 8.0 and 19.0 cm size classes, with a marked mode at the 10.0 cm size class (**Table 4.4.3.3**; **Figure 4.4.3.7**).

The population was composed by the age groups 0 to 2. Age 0 was the dominant age group (88% of total abundance and 75% of the total biomass: 4845 million, 36 405 t), followed by 1-year olds. Juveniles were widely distributed in the coastal-inner shelf waters between the Guadiana river mouth and Chipiona-Rota area, with the coastal area comprised between Guadiana and Guadalquivir rivers 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 are 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.

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 correctly attributed 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 guidelines presented on ICES (2019), 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. For 2020 the PELACUS coverage was missed and PELAGO survey was available (the later represents, on average, 88% of the biomass of the stock component). PELAGO was used to infer the expected biomass for the PELACUS missing coverage, with a linear regression using the historical data (2007-2019) of PELAGO and PELACUS **(Figure 4.6.1.1.1)**.

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 2020 are described in Rincón *et al*. (WD 2020).

There are two remarkable model issues that were found this year regarding last year implementation. The first is that it was noticed that discards were included in the assessment for years 2014, 2015 and 2016, and the second, that length distribution for ECOCADIZ survey were including zero age individuals, even when the model specifications in the previous report were specifying that discards were not included and that age zero individuals were removed from all inputs for ECOCADIZ survey.

For this year, it was decided to include discards for the missing years and age zero information was removed from the ECOCADIZ length distribution.

Data input

Data input for optimization routines is summarised in **Table 4.6.2.1.1.1**. It corresponds to all the information of the fishery available until the end of June of 2020, together with data from *ECOCADIZ* and *PELAGO* survey series up to 2019 and 2020, respectively.

Catches (landings +discards, discards from 2014 onwards) 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 2020. For the first two quarters of year 2020, provisional catches estimations of Spanish (until May 18th) purse-seine fleet were used and catches for June were estimated as the 38% of January to May catches based on historical records from 2009 to 2019. There were not any catches for Portuguese purse-seine in these two quarters.

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 20 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 fluctuating or sharp patterns of some years of the surveys, like 2013 for the *ECOCADIZ* (**Figure 4.6.2.1.2.2**) survey and 2001, 2002, , 2009, 2013 and 2014 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.

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 2020 advice are those corresponding to years 2018, 2019 and 2020, with values of 1512, 5658 and 7101 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 1220 t (corresponding to a relative B_{lim} equal to 0.289) and a B_{pa} of 2001 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) was not obtained this year given that the PELACUS survey was not carried out due to the COVID19 pandemic. Nevertheless, the biomass estimated by the PELAGO shows a sharp increase of more than 1200% this year after a year of 93% decrease in 2019 that followed the historical maximum abundance registered in 2018 (**Figure 4.8.1.1**). The harvest rate in 2019 was above 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 2020 (56 526 t) and the average of the two preceding values of 2018 and 2019 (34 613 t), and the Advised Catch (July 2020 to June 2021, 4347 t). The index is estimated to have increased by 63% and thus the 80% uncertainty cap was not applied.

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 (7100 t) and the average of the two preceding values (3585 t), multiplied by the recent advised catches for 2019 (July 2019 to June 2020, 6290 t). Following the guidelines presented in ICES (2019) an uncertainty cap of 80% was applied. The index ratio is estimated to have increased 98%, i.e. more than 80% and thus the uncertainty cap was applied. Stock size has been above B_{pa} for the last 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 the 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 9 in its Annex 3 (ICES, 2019, page 100), whereby the one over two rules is constrained by an uncertainty cap of +/- 80% of the former catch advice.

The expert group considers that the current advice procedure for short-lived species category 3 stocks, based on the 1over2 ratio with uncertainty cap of 80%, is still not flexible enough to adapt to the highly fluctuating nature of this stock. In the last year, when the rule was applied for the second time to the western component, the -80% uncertainty cap was applied to account for the greater decrease of the population and led to an advice for catches implying a harvest rate of about 62% over the biomass acoustic estimate in 2019. This year (2020), a sharp increase of the population was observed (by more than 1000% compared to the 2019 estimate), restoring the biomass to a similar level as the one recorded two years ago. The advised catch, however, following the 1over2 rule indicated just an upward revision of a 63% of previous catch advice. This implies an advised harvest rate of 7% in 2020 compared to the estimate of biomass provided by the acoustic survey in this year. This implies a huge change in harvest rates between these two consecutive years (63% in 2019 to 7% in 2020).

The WG considers that the current Rule (1over2 with 80% UCap) cannot accommodate to the highly fluctuating biomass. To restore previous levels of catches (as the one in 2018) after the reduction by 80% adopted in 2019, it would be required an increase of about 500% (a result from 1/(1–0.8)). This would never be allowed by the 80% Uncertainty Cap. This catch diminishing property of this rule was already mentioned in the section of caveats of the guidelines for provision of advice for SLS Category 3 stocks adopted by ACOM. For the observed high interannual changes in abundances this may result in a too intense and fast reduction of catches in a very short period of years, damaging unnecessarily the fishing opportunities. This confirms that this approach can only be taken as an interim approach while a better formulation for providing advice can be established, either by allowing greater uncertainty caps (such as being capable of restoring catch levels when sharp increases of the population occurs) or simply by applying harvest rates to the most recent biomass estimates from surveys.

Another problem related to this formulation derives directly from the 1over2 trend based rule. This rule implies that the mean in the denominator, referring to the mean biomass of the two previous years, is presumed to be a good indicator of the previous status of the stock. However, for rapidly changing resources, the ratio between current biomass estimates and the mean of the two previous year may be misleading, compared with the trend between the current and previous year biomass estimates. This suggests that moving the rules from the 1over2 to the 1over1 might be necessary, which is equal to just applying a constant harvest rate in future years. This consideration again suggest that HCRs based on either fixed or gradually changing harvest rates might be preferable to the 1over2 to better accommodate the fluctuations in abundance of these populations.

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 for both surveys was very high. These issues need to be further investigated.

It has been also tested the effect of including ECOCADIZ survey information in the last year together with slight changes in the seed for optimization. **Figure 4.11.1** shows the estimated relative SSB time-series in the current model implementation (blue line) compared with the one used for last year assessment (purple line) and three other implementations removing the last year, two with the same seed (olive and dark green lines), one of them including ECOCADIZ 2019 (dark green line); and one with a different seed (pink line). It was observed that the retrospective pattern persist, even if the "seed" for optimization is the same, sometimes the pattern it is also reduced with a different seed (pink line). This suggests that further investigation is needed on the optimization uncertainty. However, relative SSB time-series trends are similar in most of the years.

In addition, two different trends in the last four years have been observed in **Figure 4.11.1**. One trend for those implementations without ECOCADIZ 2019 (olive green, pink and purple lines), where 2018 estimate is around 1, and one for those including it (blue and dark green lines), where 2018 estimate is around 0.5. This could be explained by the incorporation of new information on age composition provided by the ECOCADIZ survey performed in July 2019.

During the meeting, the group acknowledges, in particular, that the estimated SSB time-series for this year (blue line) had changed in comparison with the SSB time-series estimated last year (purple line). There were discrepancies for two points in the time-series, the estimates for 2019 and 2018. The discrepancy regarding 2019 estimate, was considered as expected considering that information for year 2019, in the assessment of 2019, was preliminary. However, for 2018, the estimates showed a big difference (being reduced to 35% of the level in the past assessment in WGHANSA 2019), which is, as showed before, produced mainly by new information provided on age composition by the ECOCADIZ survey performed in July 2019.

By using the former ICES advice for 2019 (6290 t) the resulting advice for 2020 is 11 322 tonnes in the advice sheet, But by using what might have been the ICES advice for 2019 in case of having perceived the population as done from the current assessment (the advice for 2019 would have been 8057 t), then the catch advice for 2020 would have been of 14 502 t.

This implies the fact that the rule assumes that past advice was unbiased, but as far as our new assessment updates the past series estimates of the indicator SSB, it is saying at the same time that the trend-based indicator for providing advice in 2019 was partially biased (as far as those biomass estimates SSB have now been changed). Therefore, the new application of the rule is incorporating a catch advise for the previous year which is now known to be not consistent with what would have been advised in case of perceiving the population as in the current (most recent) assessment. This is probably a general problem, which may affect others stock in category 3 with an indicator linked to an analytical assessment.

This situation was not considered when putting forward the guidelines for category 3 short-lived species. Certainly, the stability/variability of the assessment producing the stock trend indicators is something has to be incorporated when assessing the performance of these HCRs for category 3 stocks and it requires further investigation.

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 Deviations from stock annex caused by missing information from Covid-19 disruption

1. Stock: Anchovy 9.a
2. Missing or deteriorated survey data: PELACUS survey missing, used in combination with PELAGO survey as stock index for the western component of this stock. No missing data for the southern component of the stock.
3. Missing or deteriorated catch data: NO.
4. Missing or deteriorated commercial *lpue/cpue* data: NO
5. Missing or deteriorated biological data: NO
6. Brief description of methods explored to remedy the challenge: Anchovy biomass of the missing PELACUS survey was extrapolated from the relationship of PELACUS and PELAGO biomass in the period from 2007 to 2019 using a linear regression going through the origin.
7. Suggested solution to the challenge, including reason for this selecting this solution: The survey index of the western component of anchovy 9.a is the combination of the biomass estimated in the PELACUS survey (9a.N subdivision) and the PELAGO survey (9a.CN and 9a.CS subdivisions). In the period from 2007 to 2019, the biomass of anchovy estimated in the PELACUS survey represented between 0 and 18.7% and a median of 2.3% of the total survey index. The linear regression between the two surveys in the period from 2007 to 2019 is significant ($p<0.01$, $r2=0.60$) and has a negative intercept, implying that when the PELAGO survey biomass was zero the PELACUS would be negative. A linear regression forced through the origin was also significant ($p<0.05$, $r2=0.46$) and the ANOVA test showed no significant differences between the two regressions ($p=0.49$). It was then decided to select this regression forced through the origin to extrapolate to PELACUS biomass because there is no support to consider the intercept to be different from zero and it is likely that a biomass of zero in the PELAGO would correspond to zero biomass in the PELACUS.
8. Was there an evaluation of the loss of certainty caused by the solution that was carried out? The PELACUS survey represented from 0 to 18.7% of the total survey index in the historical data since 2007 and is significantly correlated to the PELAGO survey index. For these reasons, although it is not possible to ascertain the biomass of the PELACUS survey in 2020, it is assumed that the loss of certainty is not large.

4.14 References

Carrera, P., Díaz, P., Domínguez-Petit, R., González-Bueno, G., Riveiro, I. 2018. Pelagic ecosystem acoustic-trawl survey *PELACUS 0318*: Sardine, South Horse mackerel, Anchovy and Chub mackerel abundance estimates. Working document presented in the ICES Working Group on Southern Horse Mackerel, Sardine and Anchovy (WGHANSA). Lisbon, Portugal, 26–30 June 2018.

Garrido, S., Ramos, F., Silva, A., Angélico, M. M., Marques, V. 2018a. Population structure of the European anchovy (*Engraulis encrasicolus*) in ICES Division 9a: synopsis and updated information. Working document presented to the ICES Benchmark Workshop on Pelagic Stocks (WKPELA 2018). 12–16 February 2018. Copenhagen, Danmark.16 pp.

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

ICES. 2004. Report of the Study Group on Assessment Methods Applicable to Assessment of Norwegian Spring-Spawning Herring and Blue Whiting Stocks (SGAMHBW). 19–22 February 2004, Lisbon, Portugal. ICES CM 2014/ACFM 145. 166 pp.

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

ICES. 2008a. Report of the Working Group on Anchovy (WGANC), 13–16 June 2008, ICES Headquarters, Copenhagen. ICES CM 2008 ACOM:04. 226 pp.

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

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

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

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

ICES. 2012. ICES Implementation of Advice for Data-limited Stocks in 2012 in its 2012 Advice. ICES CM 2012/ACOM:68. 42 pp.

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

ICES. 2017a. Report of the Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas 7, 8, and 9. WGACEGG Report 2016 Capo, Granitola, Sicily, Italy. 14–18 November 2016. ICES CM 2016/SSGIEOM:31. 326 pp.

ICES. 2017b. Report of the Workshop to review the ICES advisory framework for short-lived species, including detailed exploration of the use of escapement strategies and forecast methods (WKMSYREF5), 11–15 September 2017, Capo Granitola, Sicily. ICES CM 2017/ACOM:46 A. 63 pp.

ICES. 2018a. Report of the Benchmark Workshop on Pelagic Stocks (WKPELA 2018), 12–16 February 2018, ICES HQ, Copenhagen, Denmark. ICES CM 2018/ACOM:32. 313 pp.

ICES. 2018b. Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas 7, 8 and 9 (WGACEGG). ICES WGACEGG REPORT 2017 3–17 November 2017. pp. 388.

ICES.2019. Ninth Workshop on the Development of Quantitative Assessment Methodologies based on LIFE-history traits, exploitation characteristics, and other relevant parameters for data-limited stocks (WKLIFE IX).ICES Scientific Reports. 1:77. 131 pp.

Jiménez, M.P., Tornero, J., Villaverde, A., Llevot, M.J., Solla, A., Ramos, F. 2018. Anchovy spawning stock biomass of the Gulf of Cadiz in 2017. Working document presented in the ICES Working Group on Southern Horse Mackerel, Sardine and Anchovy (WGHANSA). Lisbon, Portugal, 26–30 June 2018.

Massé, J., Uriarte, A., Angélico, M. M., and Carrera, P. (Eds.) 2018. Pelagic survey series for sardine and anchovy in ICES subareas 8 and 9 – Towards an ecosystem approach. *ICES Cooperative Research Report* No. 332. 268 pp. https://doi.org/10.17895/ices.pub.4599.

Payne, M. R., L. W. Clausen, H Mosegaard. 2009. Finding the signal in the noise: objective data-selection criteria improve the assessment of western Baltic spring-spawning herring. *ICES Journal of Marine Science*, 66: 1673–1680.

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

Ramos, F., Tornero, J., Oñate, D., Jiménez, M.P. 2018a. Acoustic assessment and distribution of the main pelagic fish species in ICES Subdivision 9a South during the *ECOCADIZ 2017-07* Spanish survey (July–August 2017). Working document presented in the ICES Working Group on Southern Horse Mackerel, Sardine and Anchovy (WGHANSA). Lisbon, Portugal, 26–30 June 2018.

Ramos, F., Tornero, J., Oñate, D., Córdoba, P. 2018b. Acoustic assessment and distribution of the main pelagic fish species in ICES Subdivision 9a South during the *ECOCADIZ-RECLUTAS 2017-10* Spanish survey (October 2017). Working document presented in the ICES Working Group on Southern Horse Mackerel, Sardine and Anchovy (WGHANSA). Lisbon, Portugal, 26–30 June 2018.

Rincón, M M., Ramos, F., Uriarte, A., Ibaibarriaga, L. Garrido, S., Silva, A. 2020. Gadget for anchovy 9a South: Model description and results to provide catch advice and reference points (WGHANSA 2020-1). Working Document presented to ICES WGHANSA 2020, 25–29 May 2020.

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 2019. 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						
2019	Vessels targeting anchovy					
	Engine (HP)					
Length (m)	0–50	51–100	101–200	201-500	>500	Total
≤10	5					5
11–15	2	14	7			23
16–20		1	6	6		13
>20			3	30	3	36
Total	7	15	16	36	3	77

Subdivision 9.a South						
2019	Vessels targeting anchovy					
	Engine (HP)					
Length (m)	0–50	51–100	101–200	201-500	>500	Total
≤10						
11–15	1	6	2	1		10
16–20		5	20	9		34
>20			2	9	1	12
Total	1	11	24	19	1	56

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 2019. 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						
2019	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						
2019	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						
2019	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 2020 first semester updated until 30th April (9a.CN, 9a.CS, 9a.S-ALG) –18th May (9a.N, 9a.S-CAD).

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

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
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	991	5205	4	6200	113	4701	4814	11014
2020*	16.0	252.6	0	268.6	2	3206	3208	3477

Table 4.3.2.2.1. Anchovy in Division 9.a. Catches (t) by gear and subdivision in 1989–2019. 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 polyva-lent	-	-	-	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	2019
9.a N	Demersal trawl	0	0	0	0	0	0.2	0	7	0.6	0.6
	Artisanal	4	0	1	6	0	21	6	6	0.4	0.1
	Purse-seine	175	541	37	63	581	152	217	1057	991	990
9.a C-N	Demersal Trawl	5	4	1	0.5	2	3	2	2	0,3	0.2
	P. seine polyvalent	45	1116	177	17	9	150	294	332	403	34
	Purse-seine	50	2119	342	175	668	2381	6613	8521	7468	5170
9.a C-S	Demersal Trawl	1	1	0.4	1	3	2	1	0.2	1	0.02
	P. seine polyvalent	0	0.1	17	4	1	0.4	4	13	14	1

Subarea	Gear	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
	Purse-seine	1	0.4	202	127	18	8	5	157	355	4
9.a S (PT)	Demersal Trawl	8	13	16	2	5	1	3	6	1	0
	P. seine polyvalent	4	33	0.1	2	0.04	0.02	0.04	0	0	0
	Purse-seine	17	33	41	63	113	1	16	20	65	113
9.a S (ES)	Demersal Trawl	0	0	2	0	99	33	118	204	90	209
	Artisanal	0	0	0	0	0	0.1	0.1	0.01	0	0
	Purse-seine	2901	6216	4752	5172	8835	6845	6463	4381	4343	4492

Table 4.3.2.2.2. Anchovy in Division 9.a. Quarterly anchovy catches (t) by subdivision in 2019.

SUBDIVISION/ COMPONENT	QUARTER 1		QUARTER 2		QUARTER 3		QUARTER 4		ANNUAL (2019)	
	C(t)	%	C(t)	%	C(t)	%	C(t)	%	C (t)	%
9.a North	266	26.8	77	7.8	520	52.4	128	13.0	991	9.0
9.a Central North	3405	65.4	98	1.9	1009	19.4	693	13.3	5205	47.3
9.a Central South	4	86.9	0.3	6.3	0	6.8	0	0.0	4	0.0
Western Comp.	3675	59.3	176	2.8	1528	24.7	821	13.2	6200	56.3
9.a South (PT)	0	0.0	0	0.0	4	3.7	108.9	96.3	113	1.0
9.a South (ES)	322	6.9	1621	34.5	1885	40.1	873	18.6	4701	42.7
Southern Comp.	322	6.7	1621	33.7	1889	39.2	981	20.4	4814	43.7
TOTAL	3997	36.3	1796	16.3	3418	31.0	1802	16.4	11014	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 (1988–2019). Increasing colour intensities denote increasing problems in sampling coverage of fishing effort.

Year	Landings	Effort	Lpue
1988	4263	4549	0.933
1989	5330	5727	0.920
1990	5726	6198	0.914
1991	5697	7651	0.736
1992	2995	5603	0.539
1993	1629	3003	0.477
1994	2883	3627	0.710
1995	495	1684	0.158
1996	1556	5588	0.224
1997	4376	4348	0.927
1998	7824	4958	1.474
1999	4594	6006	0.764
2000	2078	5911	0.351
2001	8180	6741	1.214
2002	7847	7543	1.040
2003	4754	6416	0.741
2004	5177	7099	0.728
2005	4386	5605	0.782
2006	4367	7245	0.603
2007	5575	6871	0.811
2008	3168	4543	0.697
2009	2922	4661	0.627
2010	2901	4346	0.668
2011	6196	6191	1.001
2012	4754	4754	1.000
2013	5172	6270	0.825
2014	6340	6363	0.996
2015	6701	5032	1.332
2016	6424	6017	1.068
2017	3636	3357	1.076
2018	4342	3513	1.208
2019	4490	3407	1.280

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 2019. Length–frequency distribution from Q2 landings was not available but it has been estimated by raising Q2 landings to the LFD from Q1.

2019	Q1	Q2	Q3	Q4	TOTAL
Length	9.a N	9.a N	9.a N	9.a N	9.a N
(cm)					
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	45	13	0	0	59
12.5	70	20	0	0	90
13	91	27	0	0	117
13.5	427	124	0	70	621
14	1010	294	961	348	2613
14.5	1340	390	990	417	3137
15	960	280	3343	696	5278
15.5	955	278	1584	1044	3860
16	1211	353	5050	974	7587
16.5	1143	333	792	557	2824
17	1552	452	2977	348	5329
17.5	499	145	99	70	813
18	78	23	984	0	1085
18.5	0	0	0	0	0

2019 Length (cm)	Q1 9.a N	Q2 9.a N	Q3 9.a N	Q4 9.a N	TOTAL 9.a N
19	0	0	332	0	332
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	9381	2732	17111	4523	33746
Catch (T)	265	77	520	128	990
L avg (cm)	15.8	15.8	16.2	15.8	16.0
W avg (g)	28.3	28.3	30.4	28.4	29.3

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 2019. 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.

2019 Length (cm)	Q1 9.a N	Q2 9.a N	Q3 9.a N	Q4 9.a N	TOTAL 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	0.002	0.002	0	0	0.003
12.5	0.003	0.003	0	0	0.01
13	0.003	0.003	0	0	0.01
13.5	0.02	0.02	0	0	0.03
14	0.04	0.04	0	0	0.1
14.5	0.1	0.1	0	0	0.1
15	0.04	0.04	0	0	0.1
15.5	0.04	0.04	0	0	0.1
16	0.05	0.05	0	0	0.1
16.5	0.04	0.04	0	0	0.1
17	0.1	0.1	0	0	0.1
17.5	0.02	0.02	0	0	0.04
18	0.003	0.003	0	0	0.01

2019 Length (cm)	Q1 9.a N	Q2 9.a N	Q3 9.a N	Q4 9.a N	TOTAL 9.a N
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	0.4	0.4	0	0	1
Catch (T)	0.01	0.01	0	0	0.02
L avg (cm)	15.8	15.8	-	-	15.8
W avg (g)	28.3	28.3	-	-	28.3

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 2019. 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.

2019 Length (cm)	Q1 9.a N	Q2 9.a N	Q3 9.a N	Q4 9.a N	TOTAL 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	0.01	0.02	0	0	0.02
12.5	0.01	0.02	0	0	0.03
13	0.01	0.03	0	0	0.04
13.5	0.06	0.15	0	0	0.2
14	0.15	0.34	0	0	0.5
14.5	0.20	0.45	0	0	1
15	0.14	0.33	0	0	0.5
15.5	0.14	0.32	0	0	0.5
16	0.18	0.41	0	0	1
16.5	0.17	0.39	0	0	1
17	0.23	0.53	0	0	1
17.5	0.08	0.17	0	0	0.2
18	0.01	0.03	0	0	0.04

2019 Length (cm)	Q1 9.a N	Q2 9.a N	Q3 9.a N	Q4 9.a N	TOTAL 9.a N
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	1	3	0	0	5
Catch (T)	0.04	0.1	0	0	0.1
L avg (cm)	15.8	15.8	-	-	15.8
W avg (g)	28.3	28.3	-	-	28.3

Table 4.3.5.1.4. 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 2019. Note that the raw LFDs were measured to the lower 1 cm size class.

2019 Length (cm)	Q1 9.a N	Q2 9.a N	Q3 9.a N	Q4 9.a N	TOTAL 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	0.1	0	0	0	0.1
13.5	0	0	0	0	0
14	0.4	0	0	0	0.4
14.5	0	0	0	0	0
15	6	0	0	0	6
15.5	0	0	0	0	0
16	13	0	0	0	13
16.5	0	0	0	0	0
17	1	0	0	0	1
17.5	0	0	0	0	0
18	0	0	0	0	0
18.5	0	0	0	0	0

2019 Length (cm)	Q1 9.a N	Q2 9.a N	Q3 9.a N	Q4 9.a N	TOTAL 9.a N
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	21	0	0	0	21
Catch (T)	0.6	0	0	0	0.6
L avg (cm)	15.9	-	-	-	15.9
W avg (g)	28.6	-	-	-	28.6

Table 4.3.5.1.5. 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 2019. Note that the raw LFDs of discards were measured to the lower 1 cm size class.

2019	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)	
Fraction	Landings	Discards	Landings	Discards	Landings	Discards	Landings	Discards	Landings	Dis-cards
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	0	0	0	0	0	0	0	0	0	0
11.5	0	0	0	0	0	0	0	0	0	0
12	46	0	13	0	0	0	0	0	59	0
12.5	70	0	20	0	0	0	0	0	90	0
13	91	0.1	27	0	0	0	0	0	118	0.1
13.5	427	0	125	0	0	0	70	0	621	0
14	1010	0.4	295	0	961	0	348	0	2614	0.4
14.5	1340	0	391	0	990	0	417	0	3138	0
15	960	6	280	0	3343	0	696	0	5278	6
15.5	955	0	278	0	1584	0	1044	0	3861	0
16	1211	13	353	0	5050	0	974	0	7588	13
16.5	1143	0	333	0	792	0	557	0	2825	0
17	1553	1	453	0	2977	0	348	0	5330	1
17.5	499	0	146	0	99	0	70	0	813	0
18	78	0	23	0	984	0	0	0	1085	0

2019	**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)	
Fraction	Landings	Discards	Landings	Discards	Landings	Discards	Landings	Discards	Landings	Dis-cards
18.5	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	332	0	0	0	332	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
21	0	0	0	0	0	0	0	0	0	0
21.5	0	0	0	0	0	0	0	0	0	0
Total N	9382	21	2736	0	17111	0	4523	0	33752	21
Catch (T)	265	0.6	77	0	520	0	128	0	990	0.6
L avg (cm)	15.8	15.9	15.8	-	16.2	-	15.8	-	16.0	15.9
W avg (g)	28.3	28.6	28.3	-	30.4	-	28.4	-	29.3	28.6

Table 4.3.5.1.6. 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 2019.

2019	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	46	13	0	0	59
12.5	70	20	0	0	90
13	91	27	0	0	118
13.5	427	125	0	70	621
14	1011	295	961	348	2614
14.5	1340	391	990	417	3138
15	966	280	3343	696	5285
15.5	955	278	1584	1044	3861
16	1224	353	5050	974	7601
16.5	1143	333	792	557	2825
17	1554	453	2977	348	5331
17.5	499	146	99	70	813
18	78	23	984	0	1085
18.5	0	0	0	0	0
19	0	0	332	0	332

2019	**Q1**	**Q2**	**Q3**	**Q4**	**TOTAL**
Length (cm)	9.a N	9.a N	9.a N	9.a N	9.a N
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	9403	2736	17111	4523	33772
Catch (T)	266	77	520	128	990
L avg (cm)	15.8	15.8	16.2	15.8	16.0
W avg (g)	28.3	28.3	30.4	28.4	29.3

Table 4.3.5.1.7. 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 2019. Discards are null, hence landings correspond to catches.

2019	**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	0	0	116	0	116
11	0	241	926	0	1167
11.5	0	341	1505	0	1846
12	1091	401	2316	0	3808
12.5	2546	401	2316	0	5263
13	10184	421	2432	2644	15681
13.5	11275	361	2316	2644	16596
14	12366	461	4748	2644	20219
14.5	15275	441	4864	2644	23224
15	16003	301	4864	2644	23811
15.5	15275	301	3474	2644	21694
16	16003	261	3358	2644	22266
16.5	15275	261	3474	2644	21654
17	16003	221	3358	2424	22005
17.5	6547	201	2548	2204	11498
18	6547	80	1505	1322	9454
18.5	0	20	116	220	356

2019	**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
19	0	0	0	0	0
19.5	0	0	0	0	0
20	0	0	0	0	0
Total N	144388	4714	44235	27324	220660
Catch (T)	3387	96	1002	685	5170
L avg (cm)	15.6	14.3	15.0	15.6	15.4
W avg (g)	22.8	18.3	21.5	23.6	22.6

Table 4.3.5.1.8. Anchovy in Division 9.a. Western Component. Subdivision 9.a Central-North. Portuguese multipurpose fleet (although fishing with artisanal purse-seines) (métier MIS_MIS_0_0_0_HC). Seasonal and annual length distributions ('000) of anchovy landings in 2019. 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. Discards are null, hence landings correspond to catches.

2019	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	0	0	1	0	1
11	0	6	6	0	12
11.5	0	9	9	0	18
12	6	11	14	0	30
12.5	14	11	14	0	38
13	54	11	14	31	111
13.5	60	10	14	31	114
14	66	12	28	31	137
14.5	81	12	29	31	153
15	85	8	29	31	153
15.5	81	8	21	31	141
16	85	7	20	31	143
16.5	81	7	21	31	140
17	85	6	20	28	139
17.5	35	5	15	26	81
18	35	2	9	15	61
18.5	0	1	1	3	4

2019	**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
19	0	0	0	0	0
19.5	0	0	0	0	0
20	0	0	0	0	0
Total N	767	126	263	318	1474
Catch (T)	18	3	6	8	34
L avg (cm)	15.6	14.3	15.0	15.6	15.4
W avg (g)	22.8	18.3	21.5	23.6	22.4

Table 4.3.5.1.9. Anchovy in Division 9.a. Western Component. Subdivision 9.a Central-North. Portuguese trawl fleet for demersal fish species (métier OTB_DEF_>=55_0_0). Seasonal and annual length distributions ('000) of anchovy landings in 2019. 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. Discards are null, hence landings correspond to catches.

2019 Length (cm)	**Q1** 9.a C-N	**Q2** 9.a C-N	**Q3** 9.a C-N	**Q4** 9.a C-N	**TOTAL** 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	0	0	0.02	0	0.02
11	0	0	0.2	0	0.2
11.5	0	0	0.3	0	0.3
12	0.02	0	0.4	0	0.4
12.5	0.04	0	0.4	0	0.5
13	0.1	0	0.4	0	1
13.5	0.2	0	0.4	0	1
14	0.2	0	1	0	1
14.5	0.2	0	1	0	1
15	0.2	0	1	0	1
15.5	0.2	0	1	0	1
16	0.2	0	1	0	1
16.5	0.2	0	1	0	1
17	0.2	0	1	0	1
17.5	0.1	0	0.5	0	1
18	0.1	0	0.3	0	0.4
18.5	0	0	0.0	0	0.02

2019	**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
19	0	0	0	0	0
19.5	0	0	0	0	0
20	0	0	0	0	0
Total N	2	0	8	0	10
Catch (T)	0.05	0	0.2	0	0.2
L avg (cm)	15.6	-	15.0	-	15.1
W avg (g)	22.8	-	21.5	-	21.8

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 2019. 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 >99% of catches from all quarters.

2019	**Q1**	**Q2**	**Q3**	**Q4**	**TOTAL**
Length (cm)	9.a CN	9.a CN	9.a CN	9.a CN	9.a CN
6	0	0	0	0	0
6.5	0	0	0	0	0
7	0	0	0	0	0
7.5	0	0	0	0	0
8	0	0	0	0	0
8.5	0	0	0	0	0
9	0	0	0	0	0
9.5	0	0	0	0	0
10	0	0	0	0	0
10.5	0	0	117	0	117
11	0	247	932	0	1179
11.5	0	350	1515	0	1865
12	1097	412	2330	0	3839
12.5	2559	412	2330	0	5302
13	10238	433	2447	2675	15792
13.5	11335	371	2330	2675	16711
14	12432	474	4777	2675	20357
14.5	15357	453	4893	2675	23378
15	16088	309	4893	2675	23965
15.5	15357	309	3495	2675	21836
16	16088	268	3379	2675	22409
16.5	15357	268	3495	2675	21795
17	16088	227	3379	2452	22145
17.5	6581	206	2563	2229	11580
18	6581	82	1515	1338	9516
18.5	0	21	117	223	360

2019	**Q1**	**Q2**	**Q3**	**Q4**	**TOTAL**
Length (cm)	9.a CN	9.a CN	9.a CN	9.a CN	9.a CN
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	145156	4841	44505	27642	222144
Catch (T)	3405	98	1009	693	5205
L avg (cm)	15.6	14.3	15.0	15.6	15.4
W avg (g)	22.8	18.3	21.5	23.6	22.6

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 2019. Length–frequency distribution from Q1 landings was not available but it has been estimated by raising Q1 landings to the LFD from Q2.

2019	**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	Land-ings	Dis-cards	Land-ings	Dis-cards	Land-ings	Dis-cards	Land-ings	Dis-cards	Land-ings	Dis-cards
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	8	0	53	0	0	0	0	0	61	0
8.5	90	0	596	0	0	0	2737	0	3423	0
9	389	0	2579	0	37	0	23945	0	26950	0
9.5	490	0	3243	0	243	0	33523	0	37498	0
10	922	0	6108	3	832	10	30791	0	38653	13
10.5	1884	0	12478	0	1906	20	8455	0	24723	20
11	3190	0	21126	0	18762	10	7801	0	50878	10
11.5	3828	0	25357	3	25979	0	7806	0	62971	3
12	3189	0	21122	0	36031	10	8500	0	68842	10
12.5	2532	0	16771	0	24504	29	3676	0	47482	29
13	1241	0	8219	0	13168	29	1838	0	24466	29
13.5	1080	0	7154	0	10092	0	230	0	18556	0
14	582	0	3855	0	4444	0	689	0	9571	0
14.5	316	0	2096	0	2545	0	0	0	4957	0
15	133	0	882	0	461	29	0	0	1477	29
15.5	153	0	1015	0	585	0	0	0	1753	0
16	54	0	356	0	304	0	0	0	714	0
16.5	77	0	507	0	24	0	0	0	607	0
17	38	0	254	0	0	0	0	0	292	0
17.5	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0

2019	**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	Land-ings	Dis-cards	Land-ings	Dis-cards	Land-ings	Dis-cards	Land-ings	Dis-cards	Land-ings	Dis-cards
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	20197	0	133772	7	139916	135	129990	0	423874	141
Catch (T)	239	0	1581	0.1	1798	2	873	0	4490	2
L avg (cm)	12.0	-	12.0		12.4		10.4	-	11.6	12.7
W avg (g)	11.9	-	11.8		12.9		6.7	-	10.6	14.2

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 2019. Length–frequency distribution from Q1 landings was not available but it has been estimated by raising Q1 landings to the LFD from Q2.

2019	**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	8	53	0	0	61
8.5	90	596	0	2737	3423
9	389	2579	37	23945	26950
9.5	490	3243	243	33523	37498
10	922	6112	841	30791	38667
10.5	1884	12478	1925	8455	24742
11	3190	21126	18771	7801	50888
11.5	3828	25361	25979	7806	62974
12	3189	21122	36041	8500	68852
12.5	2532	16771	24532	3676	47511
13	1241	8219	13196	1838	24494
13.5	1080	7154	10092	230	18556
14	582	3855	4444	689	9571
14.5	316	2096	2545	0	4957
15	133	882	490	0	1506
15.5	153	1015	585	0	1753
16	54	356	304	0	714
16.5	77	507	24	0	607
17	38	254	0	0	292
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

2019	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)
19.5	0	0	0	0	0
20	0	0	0	0	0
20.5	0	0	0	0	0
Total N	20197	133778	140051	129990	424015
Catch (T)	239	1581	1802	873	4494
L avg (cm)	12.0	12.0	12.4	10.4	11.6
W avg (g)	11.9	11.8	12.9	6.7	10.6

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 discards in 2019.

2019	**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)
4	0	0	0	0	0
4.5	0	5	0	0	5
5	0	5	0	0	5
5,5	0	0	0	0	0
6	6	14	0	0	20
6.5	0	35	0	0	35
7	6	78	0	0	84
7.5	17	158	0	0	175
8	20	182	0	0	202
8.5	103	296	0	0	399
9	1586	467	56	0	2108
9.5	1247	893	121	0	2260
10	982	721	241	0	1944
10.5	1004	724	1105	0	2833
11	464	621	1509	0	2595
11.5	512	538	1767	0	2817
12	585	300	1734	0	2619
12.5	498	102	950	0	1549
13	201	50	237	0	488
13.5	299	37	138	0	474
14	243	11	28	0	282
14.5	297	6	5	0	309
15	168	15	21	0	204
15.5	161	0	0	0	161
16	33	0	0	0	33
16.5	1	0	0	0	1
17	0	0	0	0	0

2019	**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)
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	8434	5258	7911	0	21603
Catch (T)	84	40	85	0	209
L avg (cm)	11.1	10.3	11.8	-	11.2
W avg (g)	9.9	7.6	10.8	-	9.7

Table 4.3.5.1.14. 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 2019.

2019	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	Land-ings	Dis-cards	Land-ings	Dis-cards	Land-ings	Dis-cards	Land-ings	Dis-cards	Land-ings	Dis-cards
4	0	0	0	0	0	0	0	0	0	0
4.5	0	0	0	5	0	0	0	0	0	5
5	0	0	0	5	0	0	0	0	0	5
5.5	0	0	0	0	0	0	0	0	0	0
6	0	6	0	14	0	0	0	0	0	20
6.5	0	0	0	35	0	0	0	0	0	35
7	0	6	0	78	0	0	0	0	0	84
7.5	0	17	0	158	0	0	0	0	0	175
8	8	20	53	182	0	0	0	0	61	202
8.5	90	103	596	296	0	0	2737	0	3423	399
9	389	1586	2579	467	37	56	23945	0	26950	2108
9.5	490	1247	3243	893	243	121	33523	0	37498	2260
10	922	982	6108	724	832	251	30791	0	38653	1957
10.5	1884	1004	12478	724	1906	1125	8455	0	24723	2853
11	3190	464	21126	621	18762	1519	7801	0	50878	2605
11.5	3828	512	25357	541	25979	1767	7806	0	62971	2820
12	3189	585	21122	300	36031	1744	8500	0	68842	2629
12.5	2532	498	16771	102	24504	978	3676	0	47482	1578
13	1241	201	8219	50	13168	266	1838	0	24466	516
13.5	1080	299	7154	37	10092	138	230	0	18556	474
14	582	243	3855	11	4444	28	689	0	9571	282
14.5	316	297	2096	6	2545	5	0	0	4957	309
15	133	168	882	15	461	50	0	0	1477	232
15.5	153	161	1015	0	585	0	0	0	1753	161
16	54	33	356	0	304	0	0	0	714	33
16.5	77	1	507	0	24	0	0	0	607	1

2019	**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	Land-ings	Dis-cards	Land-ings	Dis-cards	Land-ings	Dis-cards	Land-ings	Dis-cards	Land-ings	Dis-cards
17	38	0	254	0	0	0	0	0	292	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	20197	8434	133772	5264	139916	8046	129990	0	423874	21744
Catch (T)	239	84	1581	40	1798	87	873	0	4490	211
L avg (cm)	12.0	11.2	12.0	10.3	12.4	11.8	10.4	-	11.6	11.2
W avg (g)	11.9	9.9	11.8	7.6	12.9	10.8	6.7	-	10.6	9.7

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 catches in 2019.

2019 Length (cm	**Q1** 9.a S (ES)	**Q2** 9.a S (ES)	**Q3** 9.a S (ES)	**Q4** 9.a S (ES)	**TOTAL** 9.a S (ES)
4	0	0	0	0	0
4.5	0	5	0	0	5
5	0	5	0	0	5
5,5	0	0	0	0	0
6	6	14	0	0	20
6.5	0	35	0	0	35
7	6	78	0	0	84
7.5	17	158	0	0	175
8	28	235	0	0	263
8.5	193	892	0	2737	3822
9	1976	3045	93	23945	29059
9.5	1736	4135	364	33523	39758
10	1904	6833	1082	30791	40610
10.5	2888	13202	3030	8455	27575
11	3654	21747	20281	7801	53483
11.5	4341	25898	27746	7806	65791
12	3774	21422	37775	8500	71471
12.5	3030	16872	25482	3676	49060
13	1442	8269	13433	1838	24982
13.5	1379	7192	10230	230	19031
14	825	3867	4472	689	9853
14.5	614	2102	2550	0	5266
15	301	897	511	0	1709
15.5	315	1015	585	0	1914
16	87	356	304	0	747
16.5	78	507	24	0	609
17	38	254	0	0	292

2019 Length (cm	Q1 9.a S (ES)	Q2 9.a S (ES)	Q3 9.a S (ES)	Q4 9.a S (ES)	TOTAL 9.a S (ES)
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	28630	139036	147962	129990	445618
Catch (T)	406	1660	1972	873	4911
L avg (cm)	11.8	12.0	12.4	10.4	11.6
W avg (g)	11.3	11.7	12.7	6.7	10.6

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 2019 on a quarterly (Q), half-year (HY) and annual basis.

2019	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	0	0	0	0	0
	1	3274	953	7225	2291	4227	9516	13743
	2	5942	1726	9514	2189	7668	11703	19371
	3	196	57	372	43	253	415	668
	Total (n)	9412	2736	17111	4523	12148	21634	33782
	Catch (t)	266	77	520	128	343	648	991
	SOP	266	77	520	128	348	647	995
	VAR.%	99.9	100.0	100.0	100.1	98.5	100.2	99.6

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 2015–2019).

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
2019	0	3274	5942	196

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 2019 on a quarterly (Q), half-year (HY) and annual basis.

2019	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	2670	301	0	2970	2970
	1	15831	2544	14846	3146	18375	17992	36367
	2	123073	2249	26131	23028	125323	49159	174482
	3	6252	47	858	1167	6299	2026	8325
	Total (n)	145156	4841	44505	27642	149997	72147	222144
	Catch (t)	3405	98	1009	693	3504	1701	5205
	SOP	3316	89	956	654	3317	1609	4926
	VAR.%	102.7	110.9	105.5	106.0	105.6	105.7	105.7

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 2019 on a quarterly (Q), half-year (HY) and annual basis.

2019	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	38474	124742	0	163216	163216
	1	24019	131552	104295	5225	155571	109520	265091
	2	4611	7484	5193	23	12095	5216	17311
	3	0	0	0	0	0	0	0
	Total (n)	28630	139036	147962	129990	167666	277952	445618
	Catch (t)	322	1621	1885	873	1943	2758	4701
	SOP	322	1621	1885	873	1939.5	2646	4585
	VAR.%	99.4	99.9	99.9	99.9	100.2	104.2	102.5

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 (1995–2019).

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
2019	163216	265091	17311	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 2019 on a quarterly (Q), half-year (HY) and annual basis.

2019	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	0	0	0	0	0
	1	14.8	14.8	15.8	15.6	14.8	15.8	15.5
	2	16.3	16.3	16.5	16.0	16.3	16.4	16.4
	3	17.2	17.2	17.3	17.3	17.2	17.3	17.3
	Total	15.8	15.8	16.2	15.8	15.8	16.1	16.0

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 2019 on a quarterly (Q), half-year (HY) and annual basis.

2019	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	0	0	0	0	0
	1	0.024	0.024	0.028	0.027	0.024	0.028	0.027
	2	0.031	0.031	0.032	0.029	0.031	0.031	0.031
	3	0.036	0.036	0.036	0.036	0.036	0.036	0.036
	Total	0.028	0.028	0.030	0.028	0.029	0.030	0.029

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 2019 on a quarterly (Q), half-year (HY) and annual basis.

2019	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	13.3	15.7	0	13.5	13.5
	1	13.9	12.9	13.8	15.2	13.8	14.0	13.9
	2	15.8	15.9	15.9	15.6	15.8	15.7	15.8
	3	16.2	17.5	17.5	17.2	16.2	17.3	16.5
	Total	15.6	14.3	15.0	15.6	15.5	15.3	15.4

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 2019 on a quarterly (Q), half-year (HY) and annual basis.

2019	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	0.015	0.023	0	0.016	0.016
	1	0.016	0.013	0.016	0.021	0.016	0.017	0.017
	2	0.024	0.024	0.025	0.024	0.024	0.024	0.024
	3	0.025	0.032	0.032	0.031	0.025	0.032	0.027
	Total	0.023	0.018	0.021	0.024	0.023	0.022	0.023

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 2019 on a quarterly (Q), half-year (HY) and annual basis.

2019	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	11.6	10.3	0	10.6	10.6
	1	11.3	11.8	12.6	12.7	11.7	12.6	12.1
	2	13.9	14.8	13.5	14.3	14.5	13.5	14.2
	3	0	0	0	0	0	0	0
	Total	11.8	12.0	12.4	10.4	11.9	11.4	11.6

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 2019 on a quarterly (Q), half-year (HY) and annual basis.

2019	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	0.010	0.006	0	0.007	0.007
	1	0.010	0.011	0.013	0.013	0.011	0.013	0.012
	2	0.019	0.022	0.017	0.019	0.021	0.017	0.020
	3	0	0	0	0	0	0	0
	Total	0.011	0.012	0.013	0.007	0.012	0.010	0.010

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	Q3	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)				

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	Q3	Q4	Q2	Q3	Q4	Q2	Q3
2007			Apr(1,2)	Nov					Jul (2)			
2008	Apr(2)		Apr(1,2)	(Nov)							Jun(2)	
2009	Apr(2)		Apr(2)					Jun(2)	(Jul)(3)	(Oct)		
2010	Apr(2)		Apr(2)						(Jul)(2)			
2011	Apr(2)		Apr(2)									Jul(2)
2012	Apr(2)									Nov		
2013	Mar(2)		Apr(2)		(Nov)				Aug(2)			
2014	Mar(2)		Apr(2)		(Nov)				Jul(2)	Oct		Jul(2)
2015	Mar(2)		Apr(2)		Dec				Jul(2)	Oct		
2016	Mar(2)		Apr(2)		Dec				Jul(2)	Oct		
2017	Mar(2)		Apr(2)		Dec				Jul(2)	Oct		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	Q3	Q4	Q2	Q3	Q4	Q2	Q3
2018	Mar(2)		Apr(2)				Nov		Jul(2)	Oct		
2019	Mar(2)		Apr(2)			Sep			Jul(2)	Oct		
2020	No survey (Covid-19 disruption)		Mar(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). 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
March 2020	N	No survey (Covid-19 disruption)
	B	

Table 4.4.2.2. Anchovy in Division 9.a. *PELAGO* survey series (spring Portuguese acoustic survey in Subdivisions 9.a Central-North to 9.a South). Historical series of overall and regional acoustic estimates of anchovy abundance (N, millions) and biomass (B, tonnes).

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.**

******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.**

****Corrected estimates after detection of errors in the sA values attributed to the Cadiz area (Marques and Morais, 2003).**

Table 4.4.2.2. 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
Apr. 20	N	3152	0.3	89	3242	5550	5639	8791
	B	50282	9	1789	52080	47998	49787	100078

Table 4.4.2.3. Anchovy in Division 9.a. *ECOCADIZ* survey series (summer Spanish acoustic survey in Subdivision 9.a South). Historical series of overall and regional acoustic estimates of anchovy abundance (N, millions) and biomass (B, tonnes).

Survey	Estimate	Portugal S(A)	Spain S(C)	TOTAL 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
Jul. 19	N	80	5405	5485
	B	1561	56139	57670

*****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 4.4.2.4. Anchovy in Division 9.a. Southern component. Historical series of overall acoustic estimates of anchovy abundance (N, millions) by age group estimated by *PELAGO* and *ECOCADIZ* acoustic surveys.

PELAGO	**N (million)**	**N (million)**	**N (million)**	**N (million)**	**N (million)**	**N (million)**
Year	Age 0	Age 1	Age 2	Age 3	Age 4	TOTAL
1999	0	2025	54	0	0	2079
2000	-	-	-	-	-	-
2001	0	2635	65	0	0	2700
2002	0	3774	49	0	0	3823
2003	0	2077	237	0	0	2314
2004	-	-	-	-	-	-
2005	0	1245	61	0	0	1306
2006	0	2197	48	2	0	2246
2007	0	3060	85	0	0	3144
2008	0	1540	485	7	0	2032
2009	0	1735	295	38	0	2069
2010	0	951	12	0	0	963
2011	-	-	-	-	-	-
2012	-	-	-	-	-	-
2013	0	157	900	201	6	1264
2014	0	1501	1327	63	0	2890
2015	0	2999	311	0	0	3310
2016	0	6403	127	4	0	6535
2017	0	1142	117	0	0	1259
2018	0	2115	39	3	0	2157
2019	0	3105	289	0	0	3393
2020	0	5237	392	9	0	5639

PELAGO	**N (%)**	**N (%)**	**N (%)**	**N (%)**	**N (%)**	**N (%)**
Year	Age 0	Age 1	Age 2	Age 3	Age 4	TOTAL
1999	0	97.4	2.6	0	0	100
2000	-	-	-	-	-	-
2001	0	97.6	2.4	0	0	100
2002	0	98.7	1.3	0	0	100
2003	0	89.7	10.3	0	0	100
2004	-	-	-	-	-	-
2005	0	95.3	4.7	0	0	100
2006	0	97.8	2.1	0.1	0	100
2007	0	97.3	2.7	0	0	100
2008	0	75.8	23.9	0.3	0	100
2009	0	83.9	14.3	1.9	0	100
2010	0	98.7	1.3	0	0	100
2011	-	-	-	-	-	-
2012	-	-	-	-	-	-
2013	0	12.4	71.2	15.9	0.5	100
2014	0	51.9	45.9	2.2	0	100
2015	0	90.6	9.4	0	0	100
2016	0	98.0	1.9	0.1	0	100
2017	0	90.7	9.3	0	0	100
2018	0	98.1	1.8	0.1	0	100
2019	0	91.5	8.5	0	0	100
2020	0	92.9	7.0	0.2	0	100

Table 4.4.2.4. Anchovy in Division 9.a. Southern component. Cont'd.

ECOCADIZ	**N (million)**	**N (million)**	**N (million)**	**N (million)**	**N (million)**	**N (million)**
Year	Age 0	Age 1	Age 2	Age 3	Age 4	TOTAL
2004	0	1215	19	0	0	1235
2005	-	-	-	-	-	-
2006	0	3170	42	0.1	0	3211
2007	0	1619	167	5	0	1790
2008	-	-	-	-	-	-
2009	0	879	218	39	0	1137
2010	185	686	80	4	0	954
2011	-	-	-	-	-	-
2012	-	-	-	-	-	-
2013	169	394	33	0	0	596
2014	51	1873	36	0	0	1960
2015	1607	1053	13	0	0	2673
2016	1666	1665	354	0	0	3686
2017	892	447	149	0	0	1488
2018	1408	1609	46	0	0	3063
2019	2320	3031	134	0	0	5485

ECOCADIZ Year	**N (%)** Age 0	**N (%)** Age 1	**N (%)** Age 2	**N (%)** Age 3	**N (%)** Age 4	**N (%)** TOTAL
2004	0	98.5	1.5	0	0	100
2005	-	-	-	-	-	-
2006	0	98.7	1.3	0.004	0	100
2007	0	90.4	9.3	0.3	0	100
2008	-	-	-	-	-	-
2009	0	77.3	19.2	3.4	0.02	100
2010	19.4	71.8	8.4	0.4	0	100
2011	-	-	-	-	-	-
2012	-	-	-	-	-	-
2013	28.4	66.1	5.5	0	0	100
2014	2.6	95.6	1.8	0	0	100
2015	60.1	39.4	0.5	0	0	100
2016	45.2	45.2	9.6	0	0	100
2017	60.0	30.0	10.0	0	0	100
2018	46.0	52.5	1.5	0	0	100
2019	42.3	55.3	2.4	0	0	100

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)
Sep. 19	N	0 (0)	122 (0.3)	42 (0)	164 (0.3)	164 (0.3)
	B	0 (0)	2981 (3)	1232 (0)	4212 (3)	4212 (3)

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)
Oct. 19	N	1217 (763)	4301 (4082)	5518 (4845)
	B	16089 (6613)	32309 (29792)	48398 (36405)

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

*** Partial estimate: only the Spanish waters were 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	
2019	10.0	11.9	20.0	

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, 1989–2019
	Age–length key	All quarters, 1989–2019
ECOCADIZ acoustic survey	Biomass survey indexes	Second quarter 2004, 2006 third quarter 2007, 2009, 2010, 2013–2019
	Length distribution	Second quarter 2004, 2006 third quarter 2007, 2009, 2010, 2013–2019
	Age–length key	Second quarter 2004, 2006 third quarter 2007, 2009, 2010, 2013–2019
PELAGO acoustic survey	Biomass survey indexes	First quarter 1999, 2001–2003 second quarter 2005–2010 and 2013–2020
	Length distribution	First quarter 1999, 2001–2003 second quarter 2000, 2005–2010, 2013–2020
	Age–length key	second quarter 2014–2020

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_∞=28.7648 cm
k	Annual growth rate, k =0.0756389
β	Beta-binomial parameter, β = 5000
ν_a	Age factor, ν_1 = 180000, ν_2 = 0.0603, ν_3 = 8.72e − 07
μ	Recruitment mean length, μ = 10.0644cm
σ_t	Recruitment length standard deviation by quarter, σ_2 = 3.00346, σ_3 = 1.62947, σ_4 = 3.58913
$l_{50,T}$	Length with a 50% probability of predation during period T, seine: $l_{50,1}$= 11.6cm, $l_{50,2}$ = 11.1 cm, *ECOCADIZ* survey: l_{50}= 13 cm, *PELAGO* survey: l_{50}= 16.8 cm
α_T	Shape of selectivity function, purse-seine: α_1 = 0.315, α_2 = 0.769, *ECOCADIZ* survey: α_3 = 1.33, *PELAGO* survey: α_3 = 0.387

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.

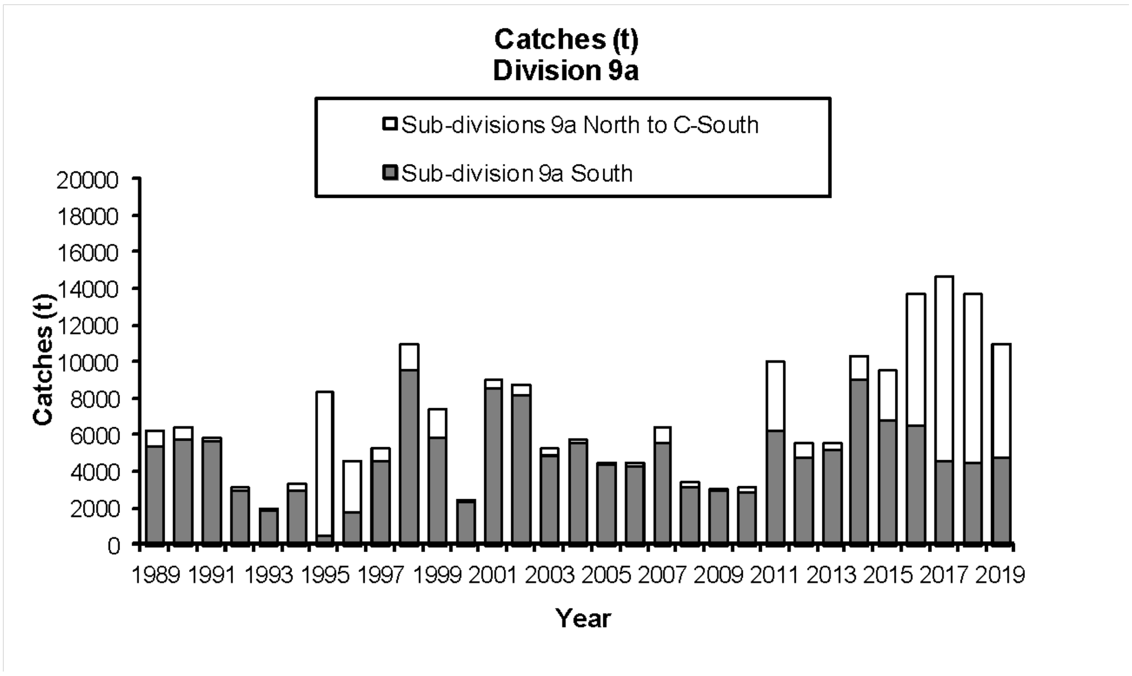


Figure 4.3.2.1.1. Anchovy in Division 9.a. Recent series of anchovy catches in Division 9.a (ICES estimates for 1989–2019, the period with data for all the subdivisions, all metiers are considered). Subdivisions are pooled in order to differentiate the anchovy fishery harvested throughout the Atlantic 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).

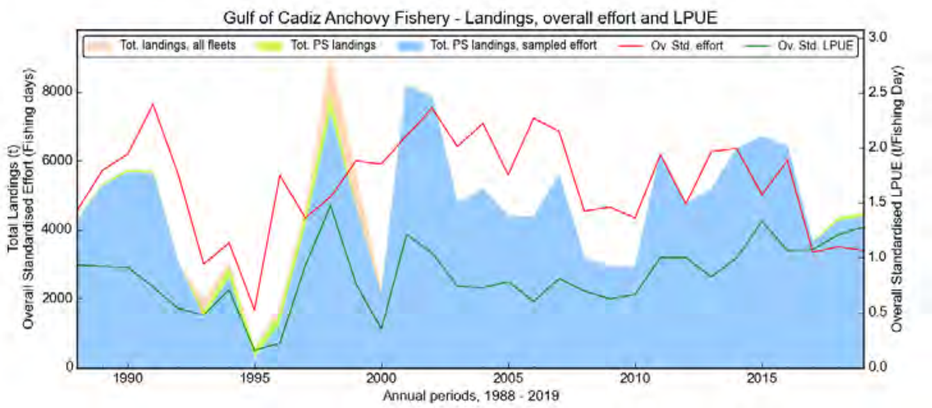


Figure 4.3.4.1. Anchovy in Division 9.a. Southern component. Subdivision 9.a South. Spanish purse-seine fishery (métier PS_SPF_0_0_0). Trends in Gulf of Cadiz anchovy annual landings, and purse-seine fleets' standardised overall effort and lpue (1988–2019).

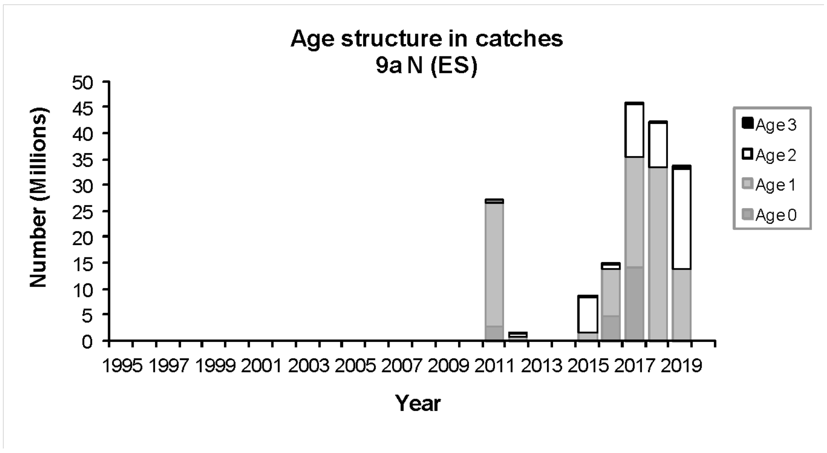


Figure 4.3.5.2.1. Anchovy in Division 9.a. Western component. Subdivision 9.a North. Spanish fishery (all métiers). Age composition in Spanish catches of SW Galician anchovy (available data provided to the WG). Although discards are still considered as negligible (hence landings are assumed as equal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

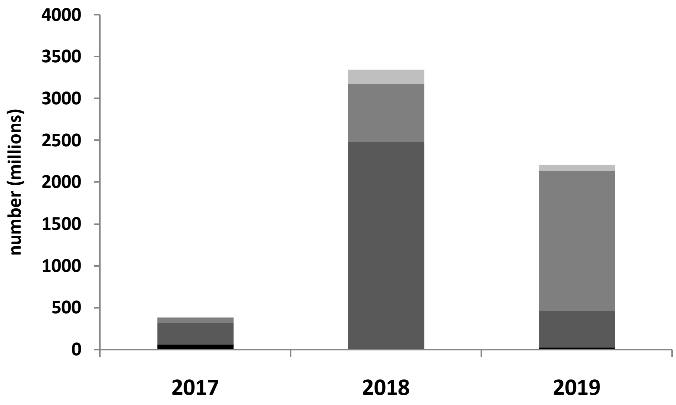


Figure 4.3.5.2.2. Anchovy in Division 9.a. Western component. Subdivision 9.a Central-North. Portuguese fishery (all métiers). Age composition in Portuguese anchovy catches (available data provided to the WG). Discards are negligible (hence landings are assumed as equal to catches).

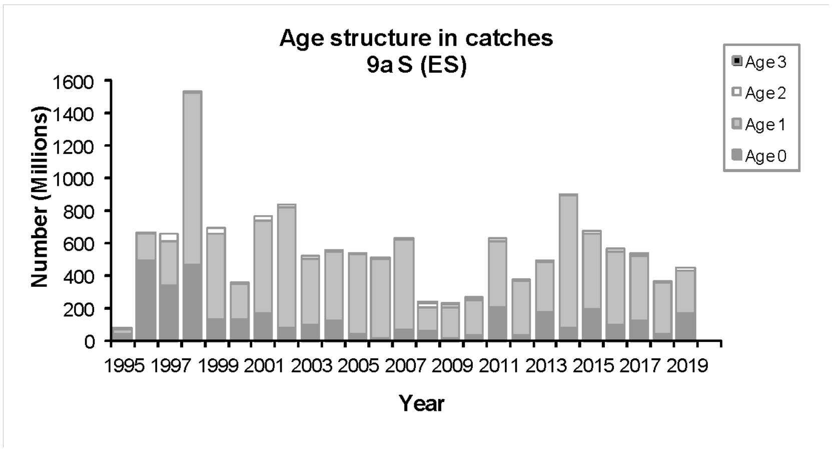
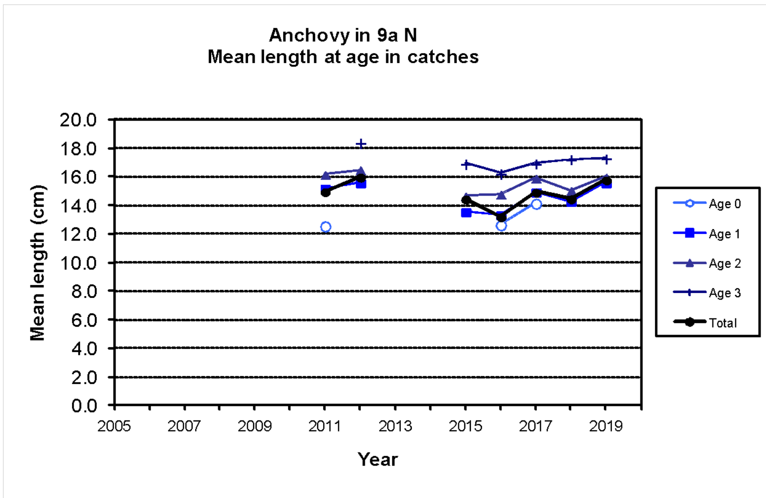


Figure 4.3.5.2.3. Anchovy in Division 9.a. Southern component. Subdivision 9.a-South. Spanish fishery (all métiers). Age composition in Spanish catches of Gulf of Cadiz anchovy (1995–2019). Discards are considered either very low or even negligible in this fishery, but since 2014 on estimates include the available discarded catches (see Section 4.3.3).



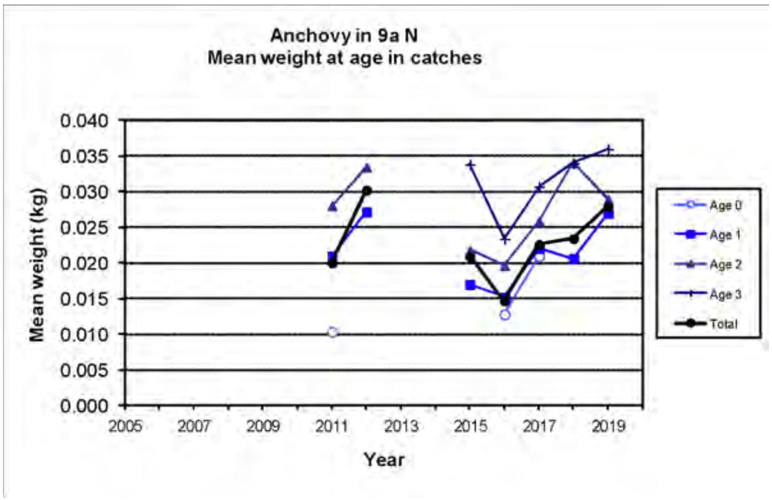


Figure 4.3.6.1. Anchovy in Division 9.a. Western component. Subdivision 9.a North. Spanish fishery (all métiers). Annual mean length (TL, in cm) and weight (kg) at-age in the Spanish catches of Western Galicia anchovy (2011–2019).

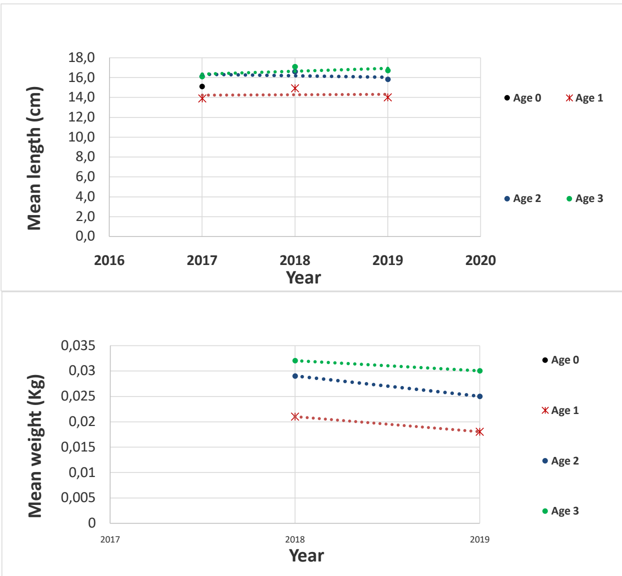
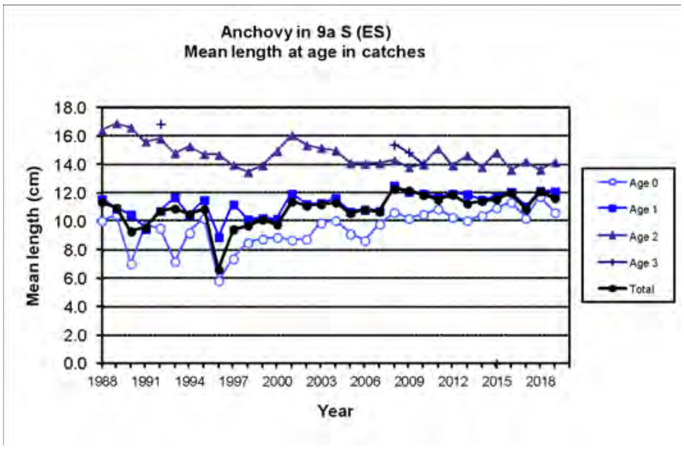


Figure 4.3.6.2. Anchovy in Division 9.a. Western component. Subdivision 9.a Central North. Spanish fishery (all métiers). Annual mean length (TL, in cm) and weight (kg) at-age in the Portuguese catches of North Western Portugal anchovy (2017–2019).



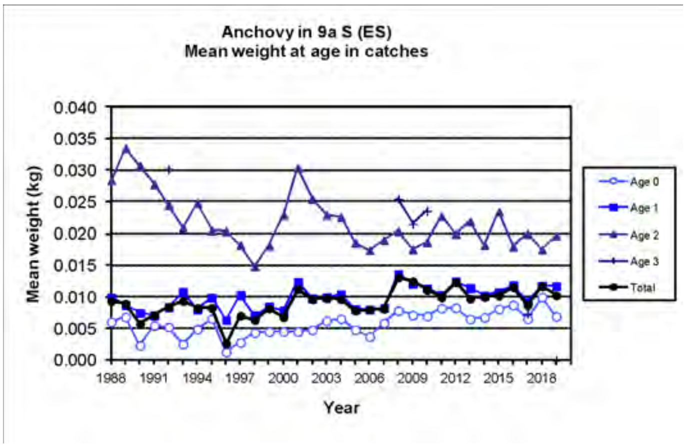


Figure 4.3.6.3. Anchovy in Division 9.a. Southern component. Subdivision 9.a-South. Spanish fishery (all métiers). Annual mean length (TL, in cm) and weight (kg) at-age in the Spanish catches of Gulf of Cadiz anchovy (1988–2019).

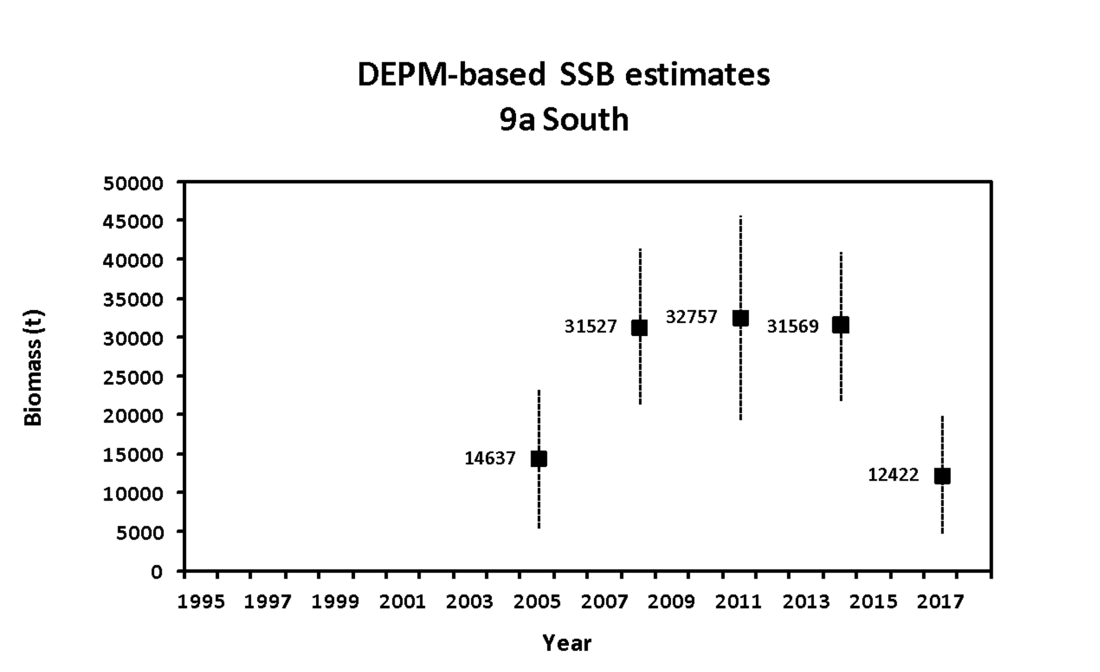


Figure 4.4.1.1. Anchovy in Division 9.a. Southern component. Subdivision 9.a South. *BOCADEVA* survey series (summer Spanish DEPM survey in Subdivision 9.a South). Series of SSB estimates (±SD) obtained from the survey series.

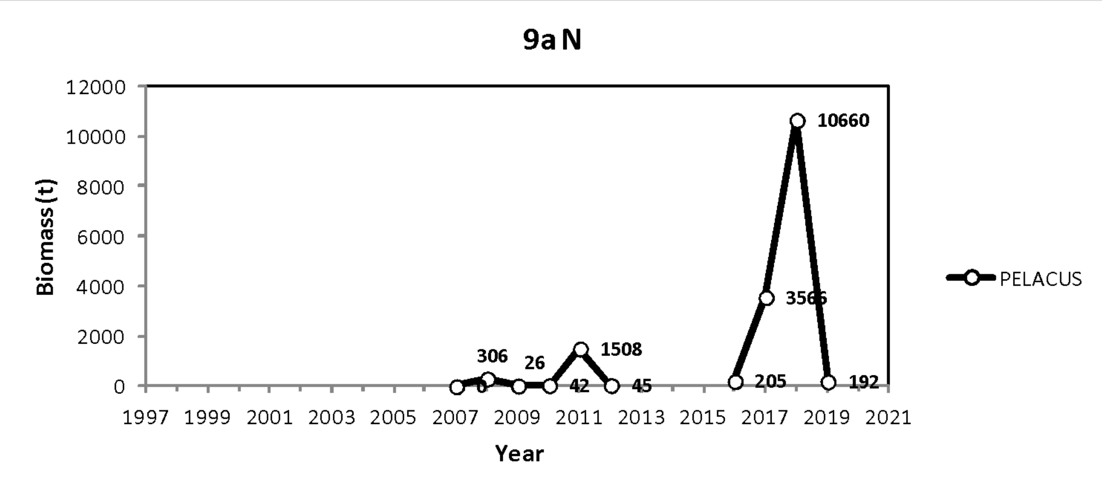


Figure 4.4.2.1. Anchovy in Division 9.a. Western component. Subdivision 9.a North. *PELACUS* survey series (spring Spanish acoustic survey in Subdivision 9.a North and Subarea 8c). Historical series of acoustic estimates of anchovy biomass (t) for the Subdivision 9.a North.

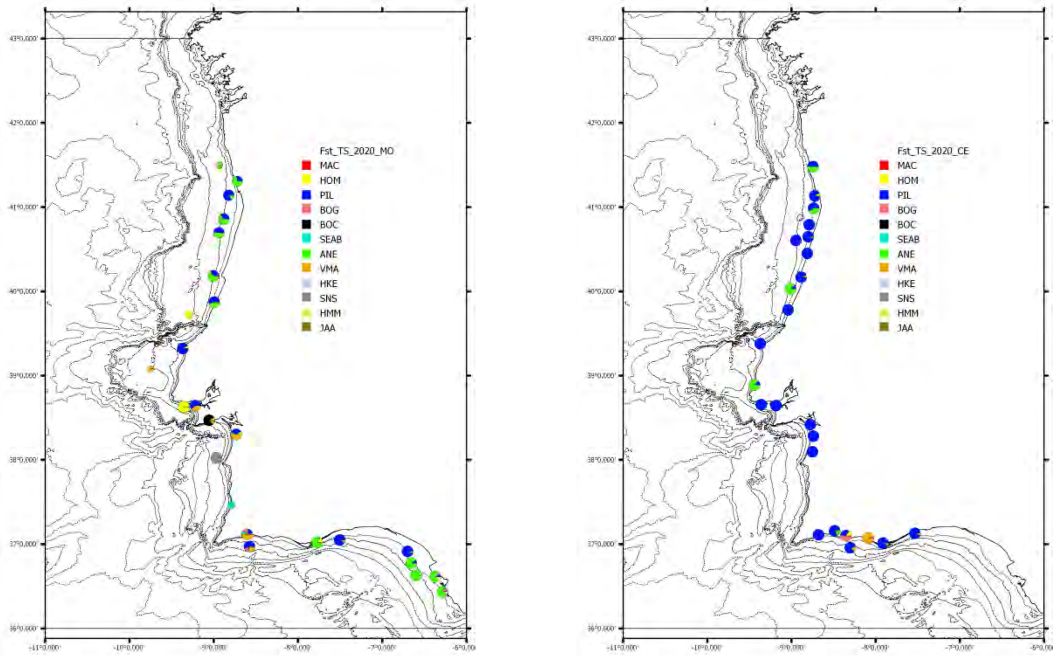


Figure 4.4.2.2. Anchovy in Division 9.a. Western and Southern components. Subdivisions 9.a Central-North to 9.a South. *PELAGO* survey series (spring Portuguese acoustic survey in Subdivisions 9.a Central-North to 9.a South). *PELAGO 20* survey. Location of valid fishing stations with indication of their species composition (percentages in number). Left panel shows results from RV Miguel Oliver and the right one from chartered purse seiners.

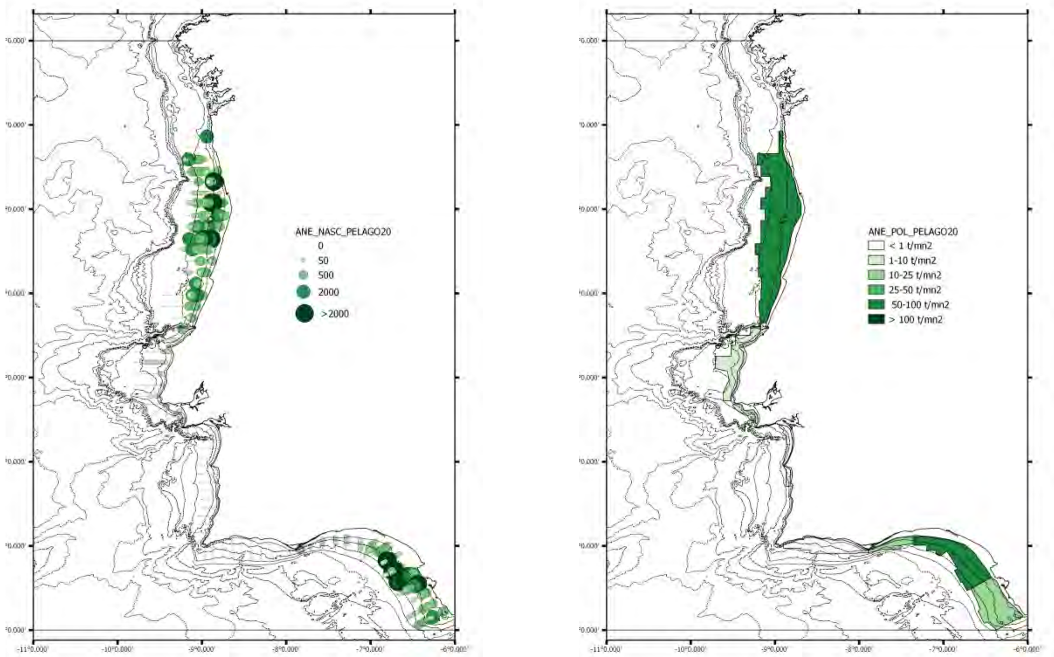


Figure 4.4.2.3. Anchovy in Division 9.a. Western and Southern components. Subdivisions 9.a Central-North to 9.a South. *PELAGO* survey series (spring Portuguese acoustic survey in subdivisions 9.a Central-North to 9.a South). *PELAGO 20* survey. Left: distribution of the NASC coefficients (m^2/mn^2) attributed to anchovy. Right: Anchovy density (t nmi^{-2}).

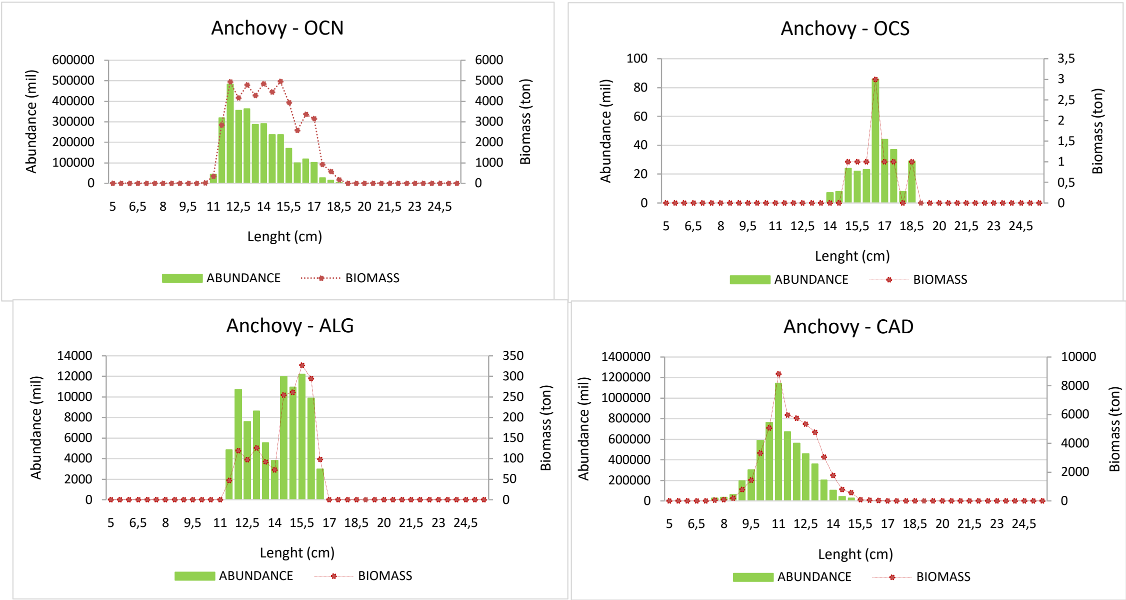


Figure 4.4.2.4. Anchovy in Division 9.a. Western and Southern components. Subdivisions 9.a Central-North to 9.a South. *PELAGO* survey series (spring Portuguese acoustic survey in Subdivisions 9.a Central-North to 9.a South). *PELAGO 20* survey. Estimated abundances and biomasses (number of fish in millions and tonnes, respectively) for the surveyed area by length class (cm).Note the different scales in the y-axis.

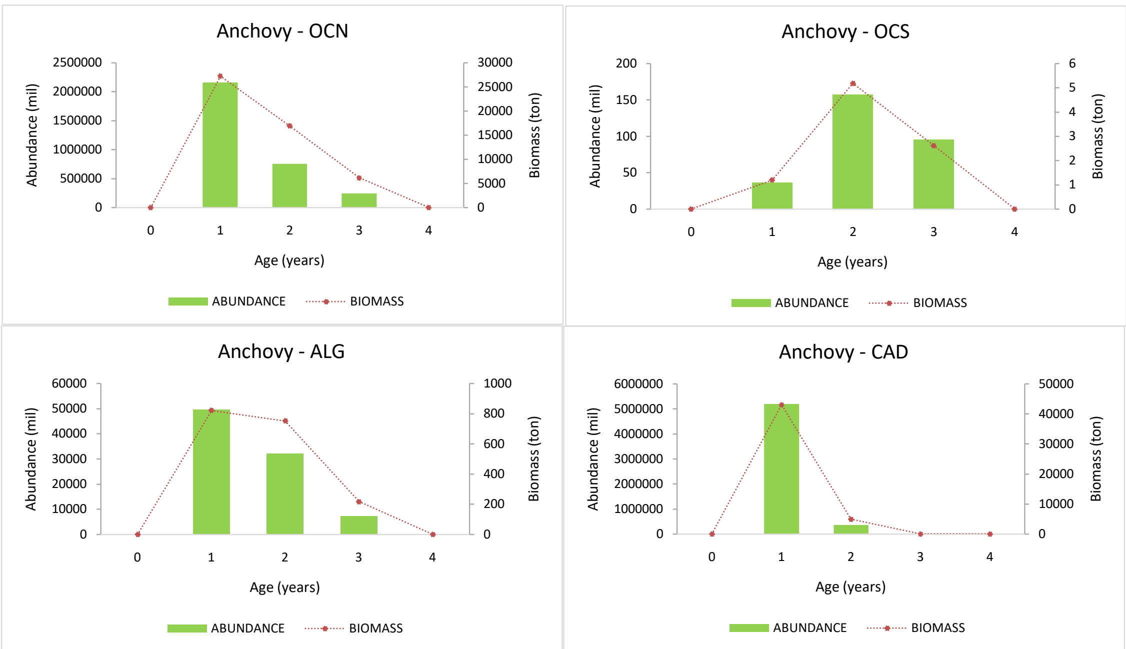


Figure 4.4.2.5. Anchovy in Division 9.a. Western and Southern components. Subdivisions 9.a Central-North to 9.a South. *PELAGO* survey series (spring Portuguese acoustic survey in Subdivisions 9.a Central-North to 9.a South). *PELAGO 20* survey. Estimated abundances and biomasses (number of fish in millions 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.

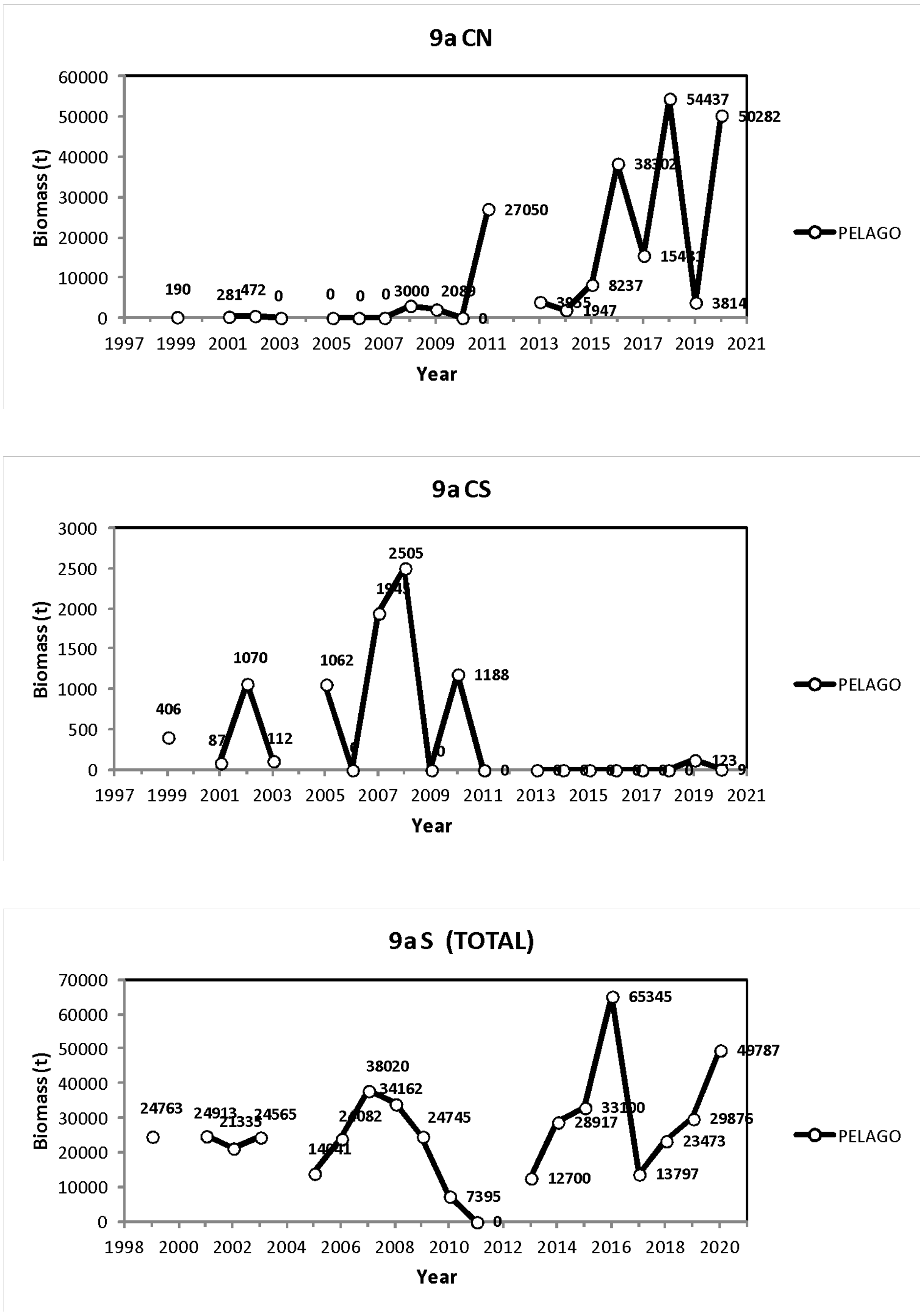
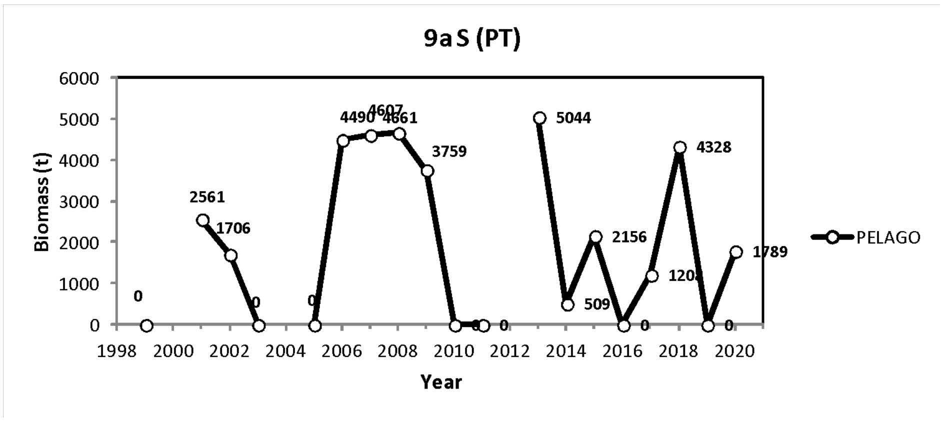


Figure 4.4.2.6. Anchovy in Division 9.a. Western and Southern components. Subdivisions 9.a Central-North to 9.a South. *PELAGO* survey series (spring Portuguese acoustic survey in Subdivisions 9.a Central-North to 9.a South). Historical series of regional acoustic estimates of anchovy biomass (t). Note the different scale of the y-axis.



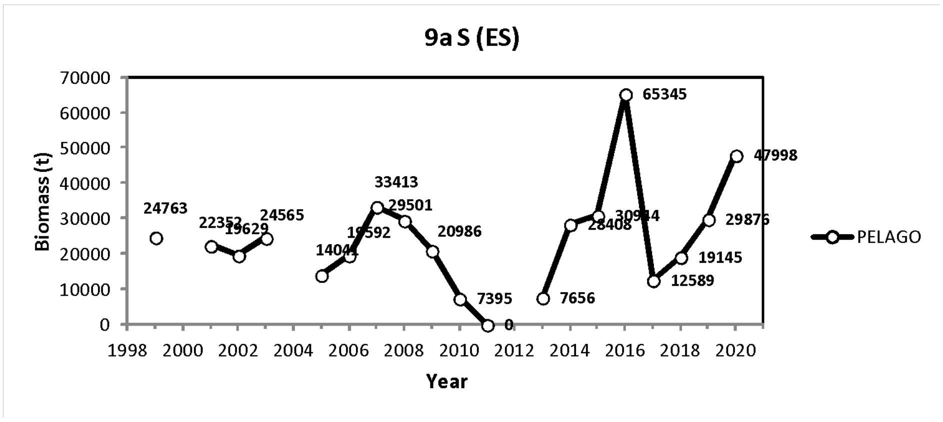


Figure 4.4.2.7. Continued. Acoustic estimates in the 9.a South differentiated by Portuguese (PT) and Spanish waters of the Gulf of Cadiz (ES). Note the different scale of the y-axis. Although estimates from Subdivision 9.a-South in 2010 and 2014 were not separately provided for Algarve and Cadiz to this WG, the total estimated for the subdivision was assigned to the Cadiz area (by assuming some overestimation) according to the observed acoustic energy distribution in the area.

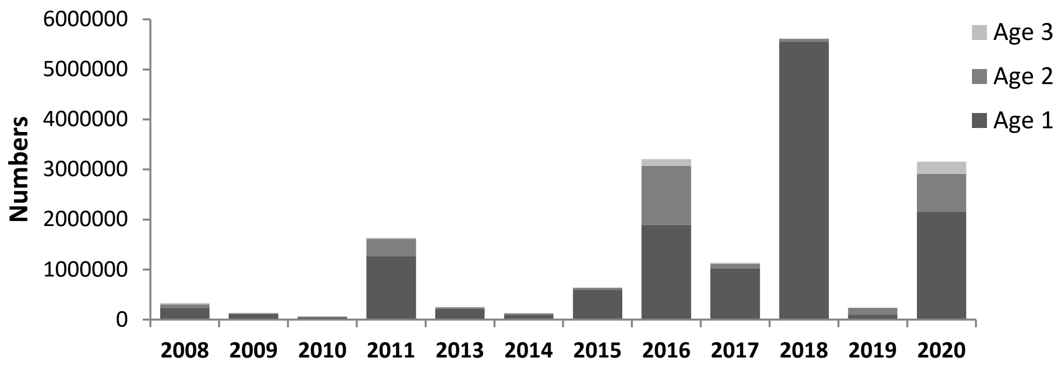
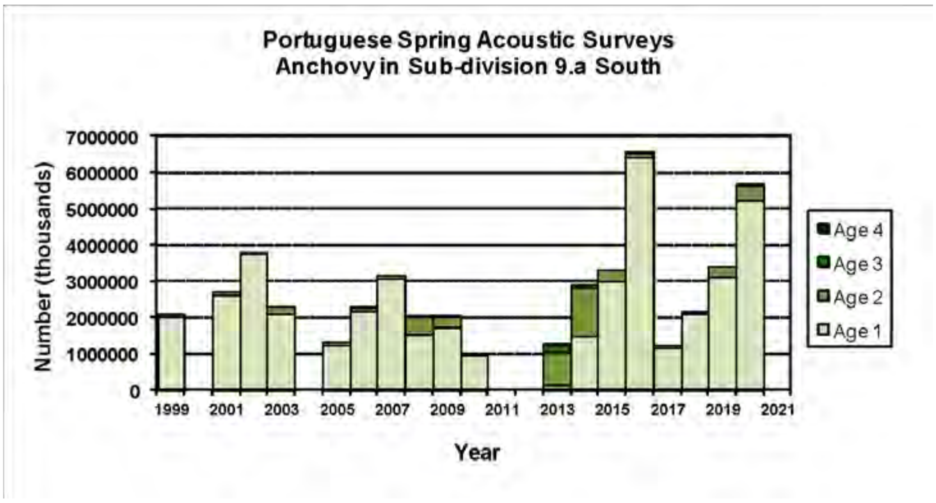


Figure 4.4.2.8. Anchovy in Division 9.a. Western component. Subdivisions 9.a North to Central-South. Annual trends of the estimated population by age class from the *PELACUS* (9a North)+*PELAGO* (9a Central-North and Central-South) Spring acoustic surveys. Age composition for 2020 only derived from the PELAGO survey given the PELACUS was not carried out.



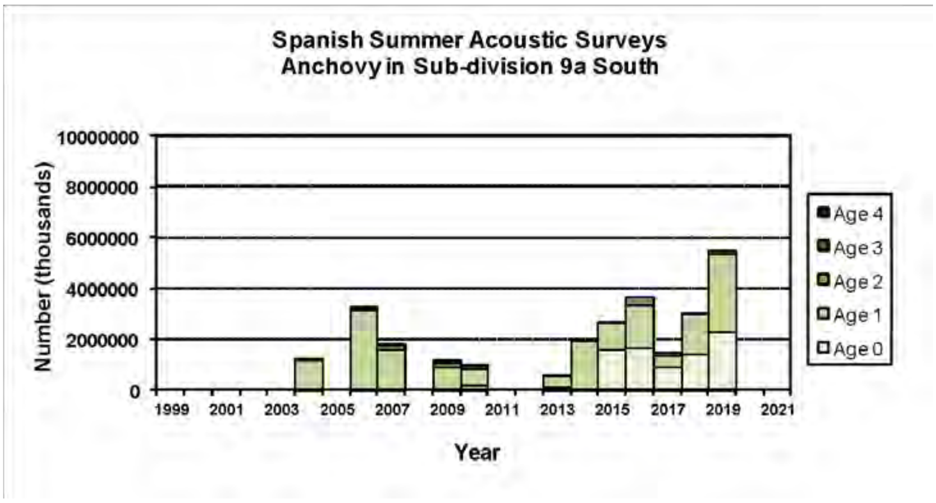


Figure 4.4.2.9. Anchovy in Division 9.a. Southern component. Subdivision 9.a-South. Annual trends of the estimated population by age class from the Algarve + Gulf of Cadiz areas by the Portuguese Spring (upper plot) and Spanish summer (lower plot) acoustic surveys. Portuguese estimates until 2012 have been age-structured using Spanish ALKs from the commercial fishery in the second quarter in the year.

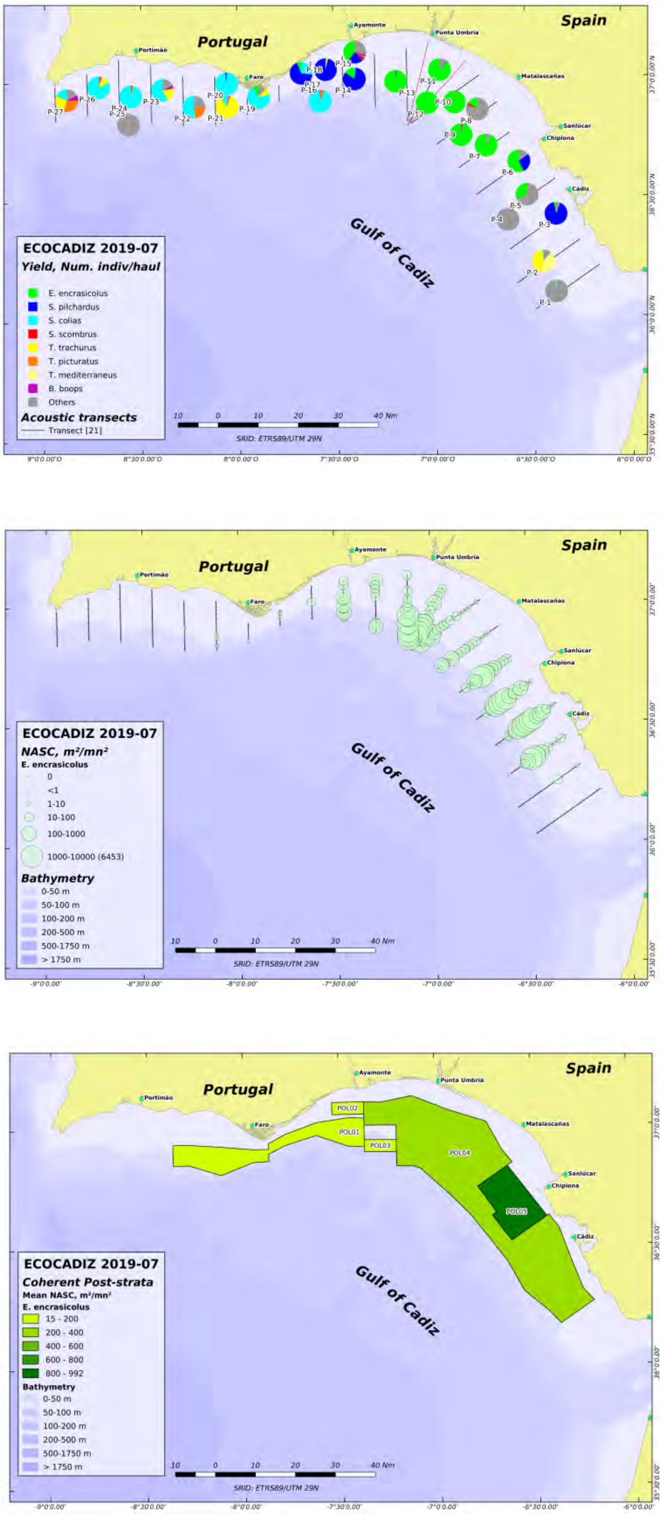


Figure 4.4.2.10. Anchovy in Division 9.a. Southern component. Subdivision 9.a South. *ECOCADIZ 2019-07* survey (summer Spanish acoustic survey in Subdivision 9.a South).Top: Location of valid fishing stations with indication of their species composition (percentages in number).Middle: Distribution of the backscattering energy (Nautical area scattering coefficient, NASC, in 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.

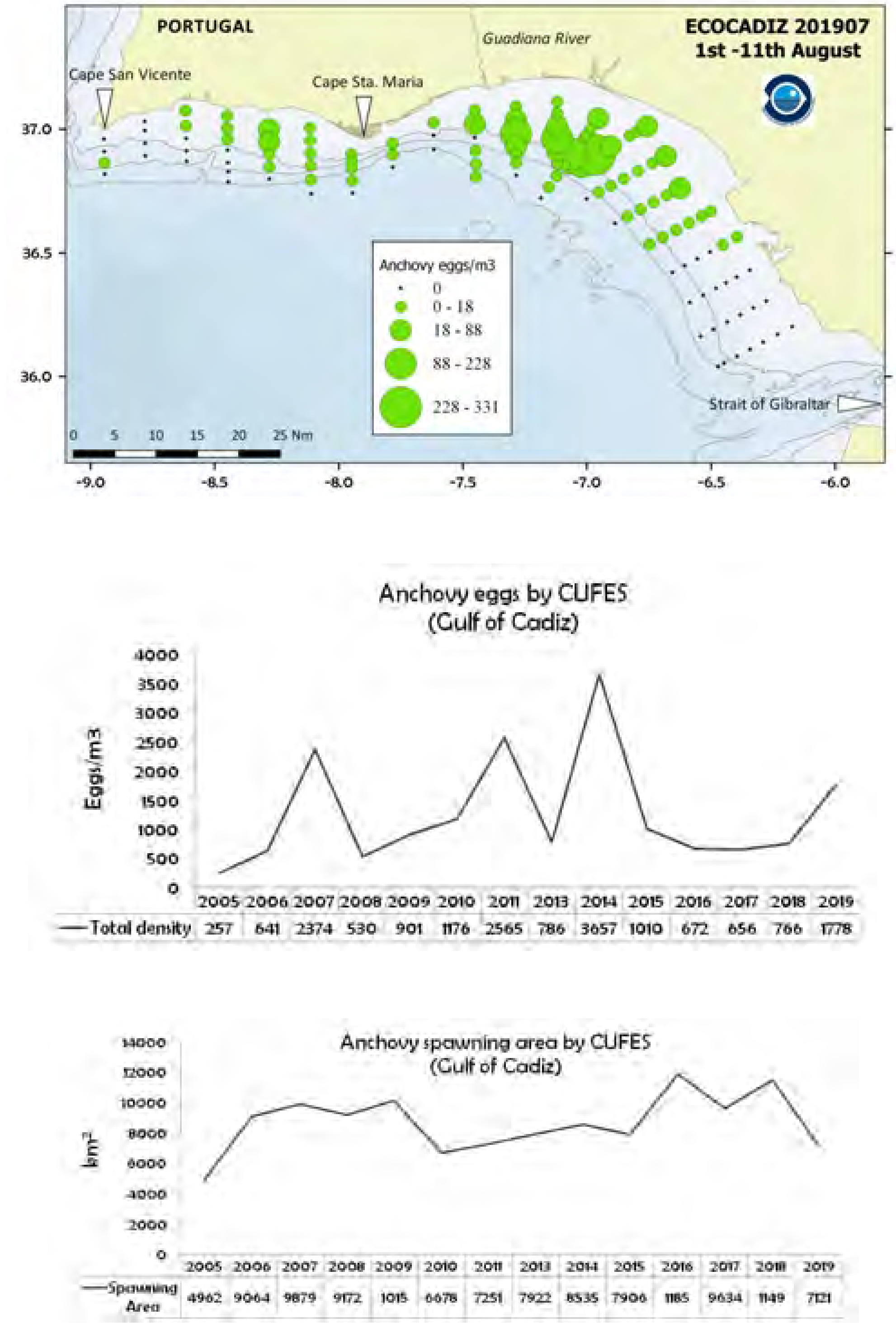


Figure 4.4.2.11. Anchovy in Division 9.a. Southern component. Subdivision 9.a South. *ECOCADIZ 2019-07* survey (summer Spanish acoustic survey in Subdivision 9.a South). Top: map of the distribution of anchovy egg density (eggs/m³) sampled by CUFES. Middle: time-series of CUFES total anchovy egg density estimates (eggs/m³). Bottom: time-series of CUFES anchovy spawning area (km²).

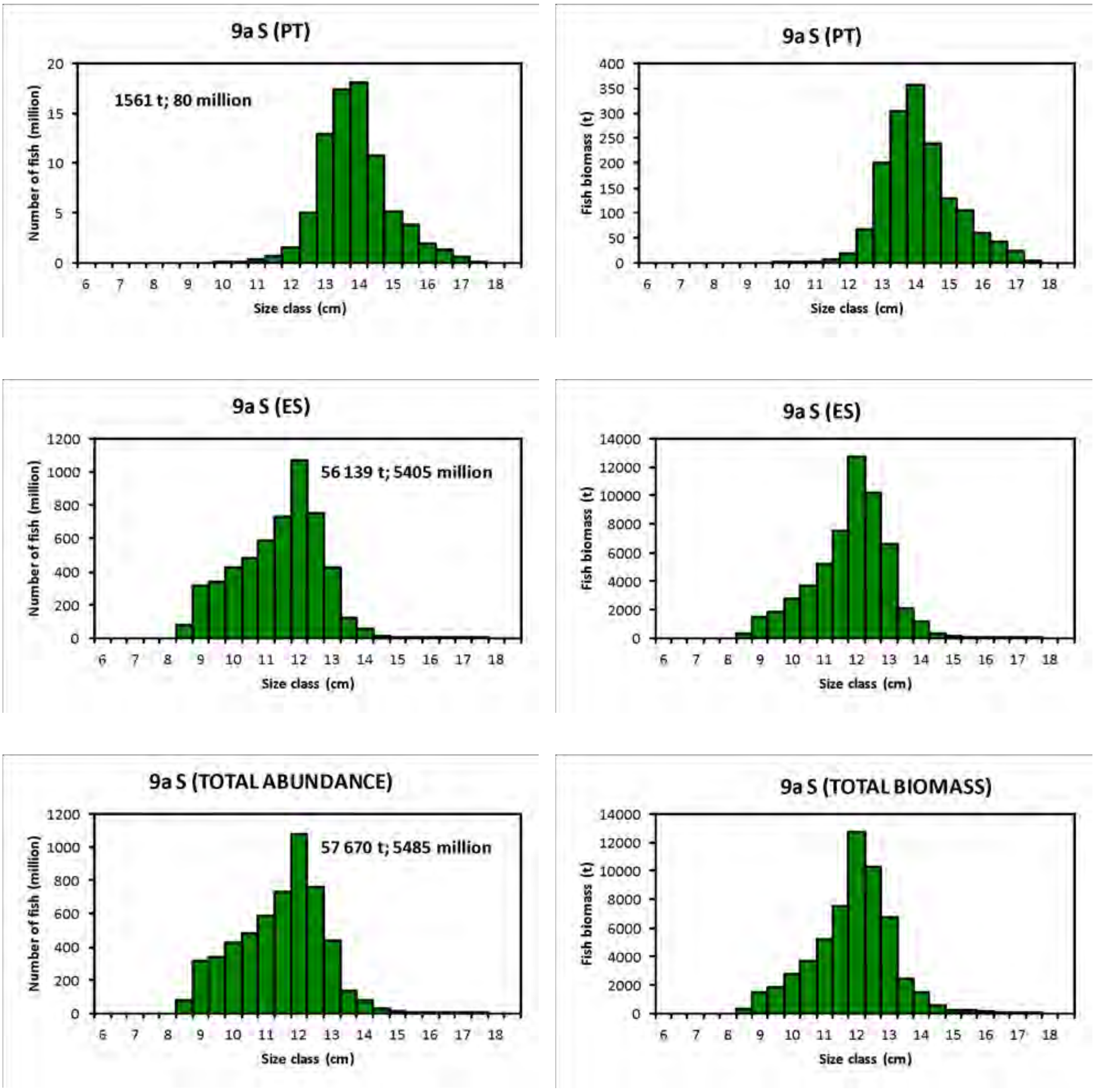


Figure 4.4.2.12. Anchovy in Division 9.a. Southern component. Sub-division 9.a South. *ECOCADIZ 2019-07* survey (summer Spanish acoustic survey in Subdivision 9.a South). Estimated abundances and biomasses (number of fish in millions and tonnes, respectively) for the surveyed area by length class (cm).Note the different scales in the y-axis.

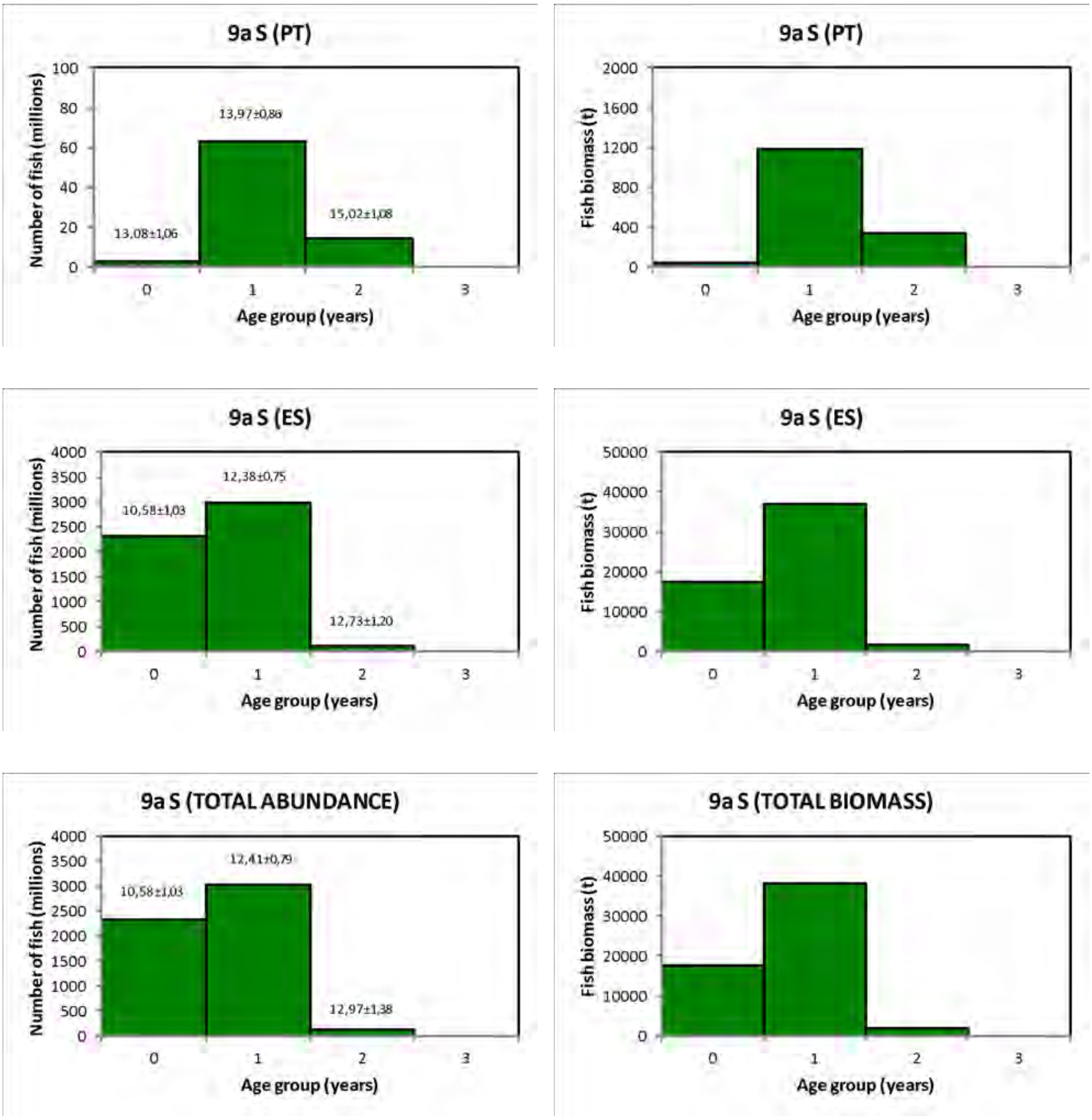


Figure 4.4.2.13. Anchovy in Division 9.a. Southern component. Subdivision 9.a South. *ECOCADIZ 2019-07* survey (summer Spanish acoustic survey in Subdivision 9.a South). Estimated abundances and biomasses (number of fish in millions and tonnes, respectively) for the surveyed area by age group, with indication of the mean size by age. Note the different scales in the y-axis.

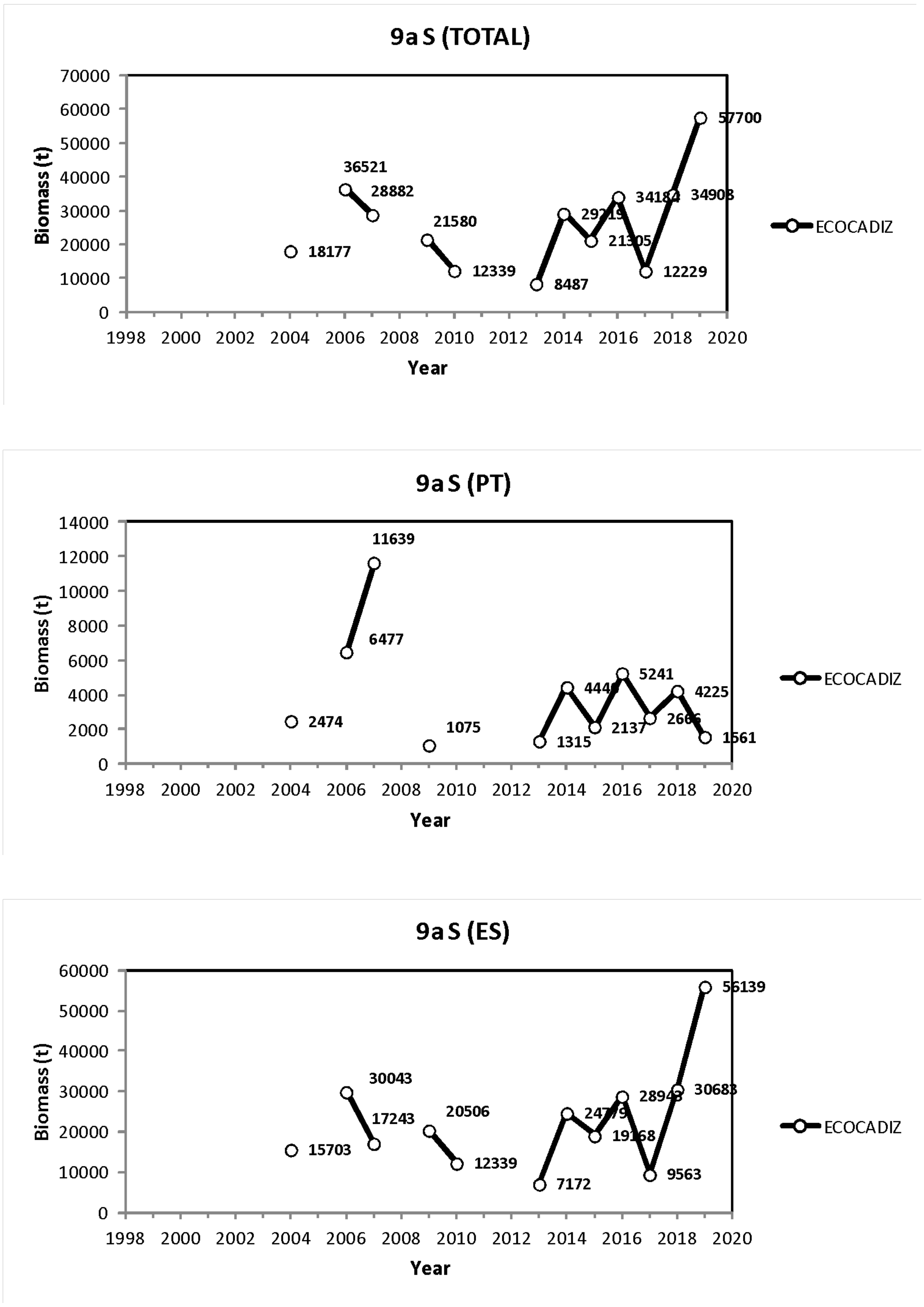


Figure 4.4.2.14. Anchovy in Division 9.a. Southern component. Subdivision 9.a South. *ECOCADIZ* survey series (summer Spanish acoustic survey in Subdivision 9.a South). Historical series of overall and regional (Portuguese, PT, and Spanish waters of the Gulf of Cadiz, ES) acoustic estimates of anchovy biomass (t). Note the different scale of the y-axis.

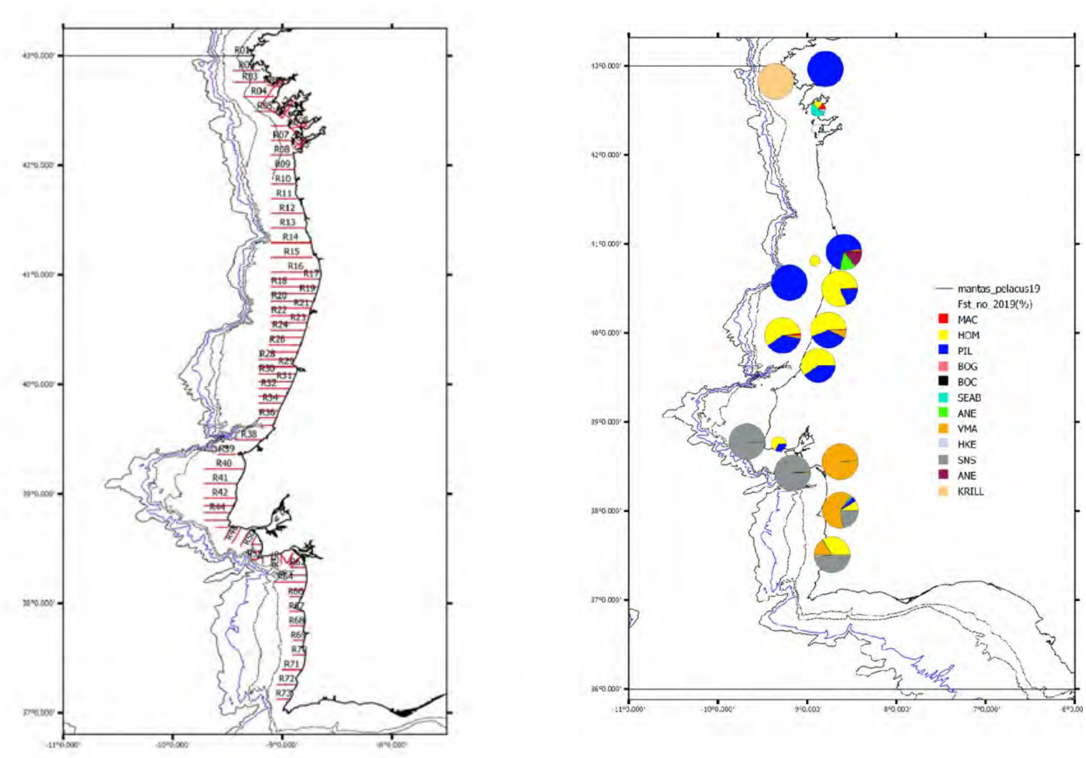


Figure 4.4.3.1. Anchovy in Division 9.a. Western component. Subdivisions 9.aNorth, 9.a Central-North and 9.a Central-South. *IBERAS 0919* survey (autumn Spanish-Portuguese acoustic survey in Subdivisions 9.aNorth to Central-South). Left: sampling grid. Right: location of valid fishing stations with indication of their species composition (percentages in number).

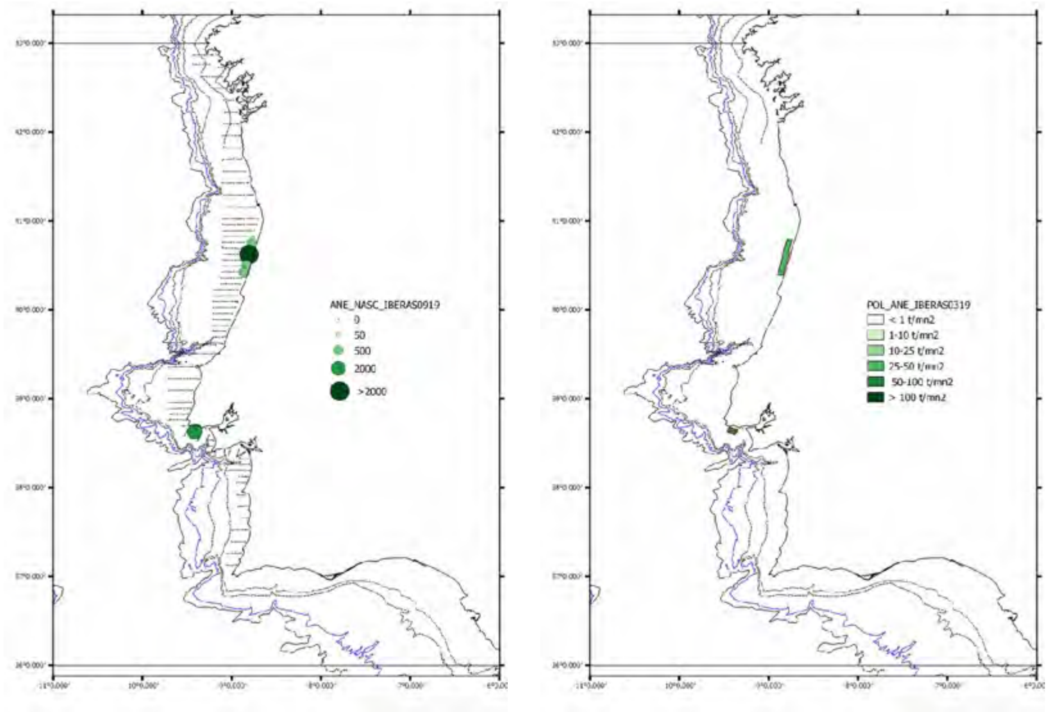


Figure 4.4.3.2. Anchovy in Division 9.a. Western component. Subdivisions 9.a North, 9.a Central-North and 9.a Central-South. *IBERAS 0919* survey (autumn Spanish-Portuguese acoustic survey in Subdivisions 9.a North to Central-South). Left: distribution of the backscattering energy (Nautical area scattering coefficient, NASC, in m^2 nmi^{-2}) attributed to the species. Right: distribution 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.

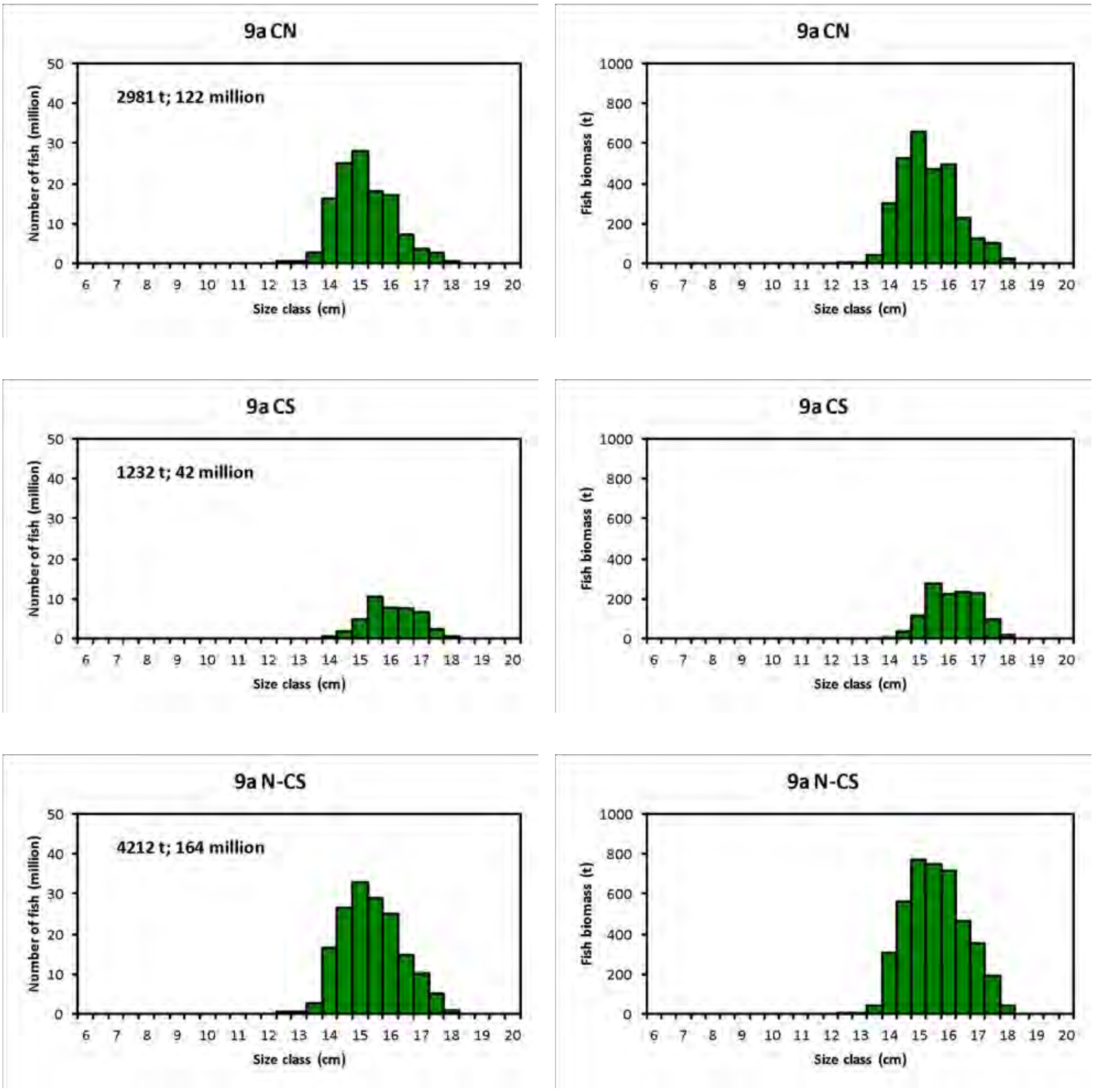


Figure 4.4.3.4. Anchovy in Division 9.a. Western component. Subdivisions 9.aNorth, 9.a Central-North and 9.a Central-South. *IBERAS 0919* survey (autumn Spanish-Portuguese acoustic survey in Subdivisions9.a North to Central-South). Estimated abundances and biomasses (number of fish in millions and tonnes, respectively) for the surveyed area by length class (cm).Note the different scales in the y-axis. No anchovy was acoustically recorded in 9.a North.

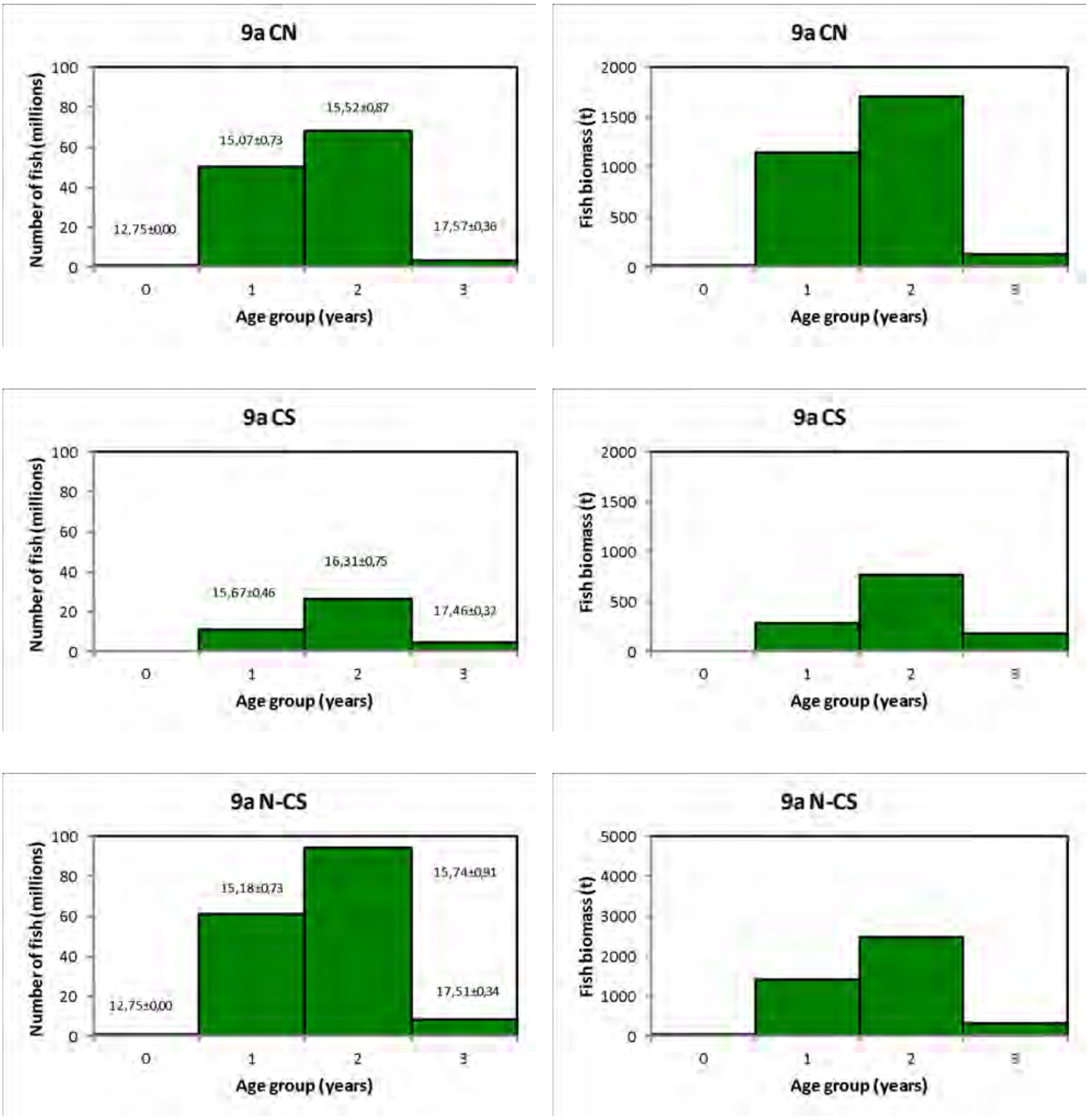


Figure 4.4.3.5. Anchovy in Division 9.a. Western component. Subdivisions 9.a North, 9.a Central-North and 9.a Central-South. *IBERAS 0919* survey (autumn Spanish-Portuguese acoustic survey in Subdivisions 9.a North to Central-South). Estimated abundances and biomasses (number of fish in millions and 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.

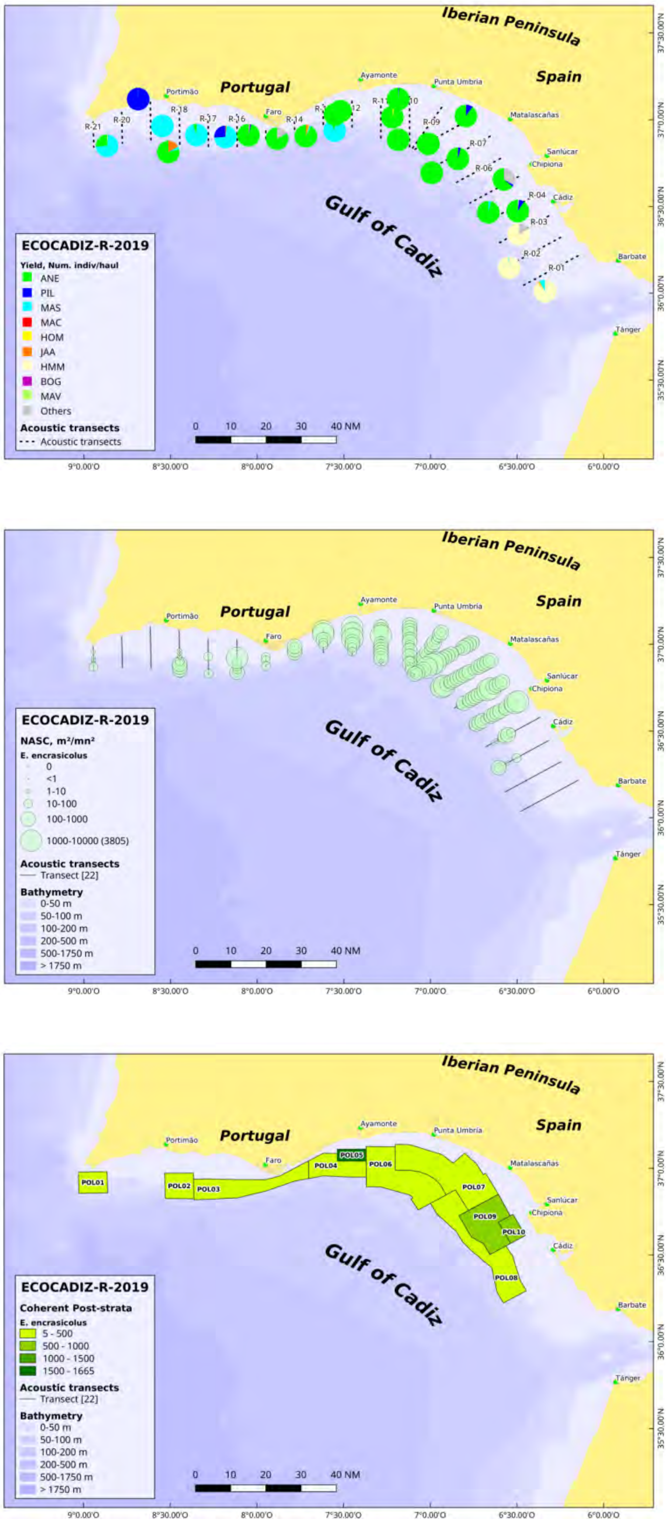


Figure 4.4.3.6. Anchovy in Division 9.a. Southern component. Subdivision 9.a South. *ECOCADIZ-RECLUTAS 2019-10* survey (autumn Spanish acoustic survey in Subdivision 9.a South). Top: Location of valid fishing stations with indication of their species composition (percentages in number).Middle: Distribution 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.

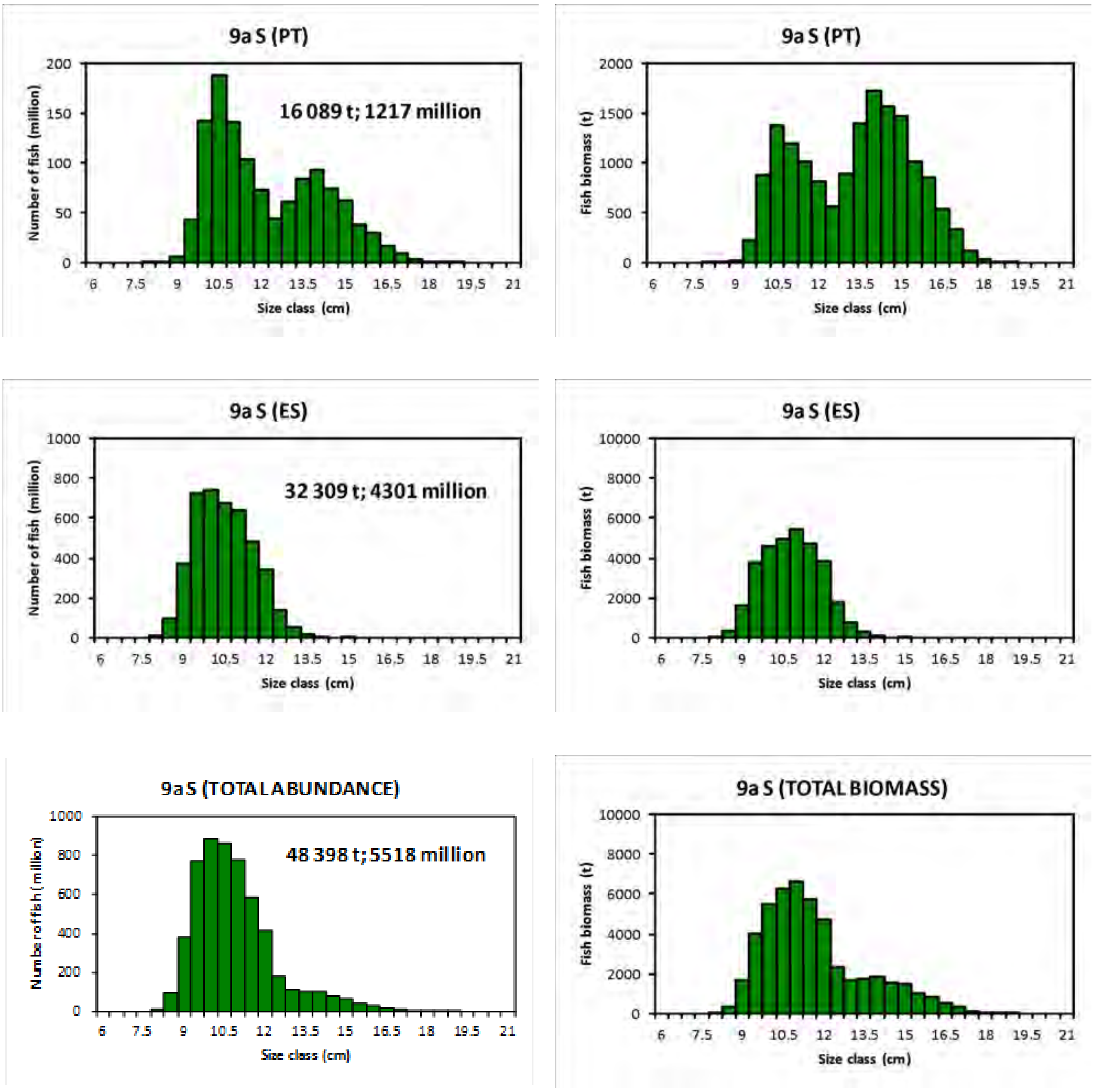


Figure 4.4.3.7. Anchovy in Division 9.a. Southern component. Subdivision 9.a South. *ECOCADIZ-RECLUTAS 2019-10* survey (autumn Spanish acoustic survey in Subdivision 9.a South). Estimated abundances and biomasses (number of fish in millions and tonnes, respectively) for the surveyed area by length class (cm).Note the different scales in the y-axis.

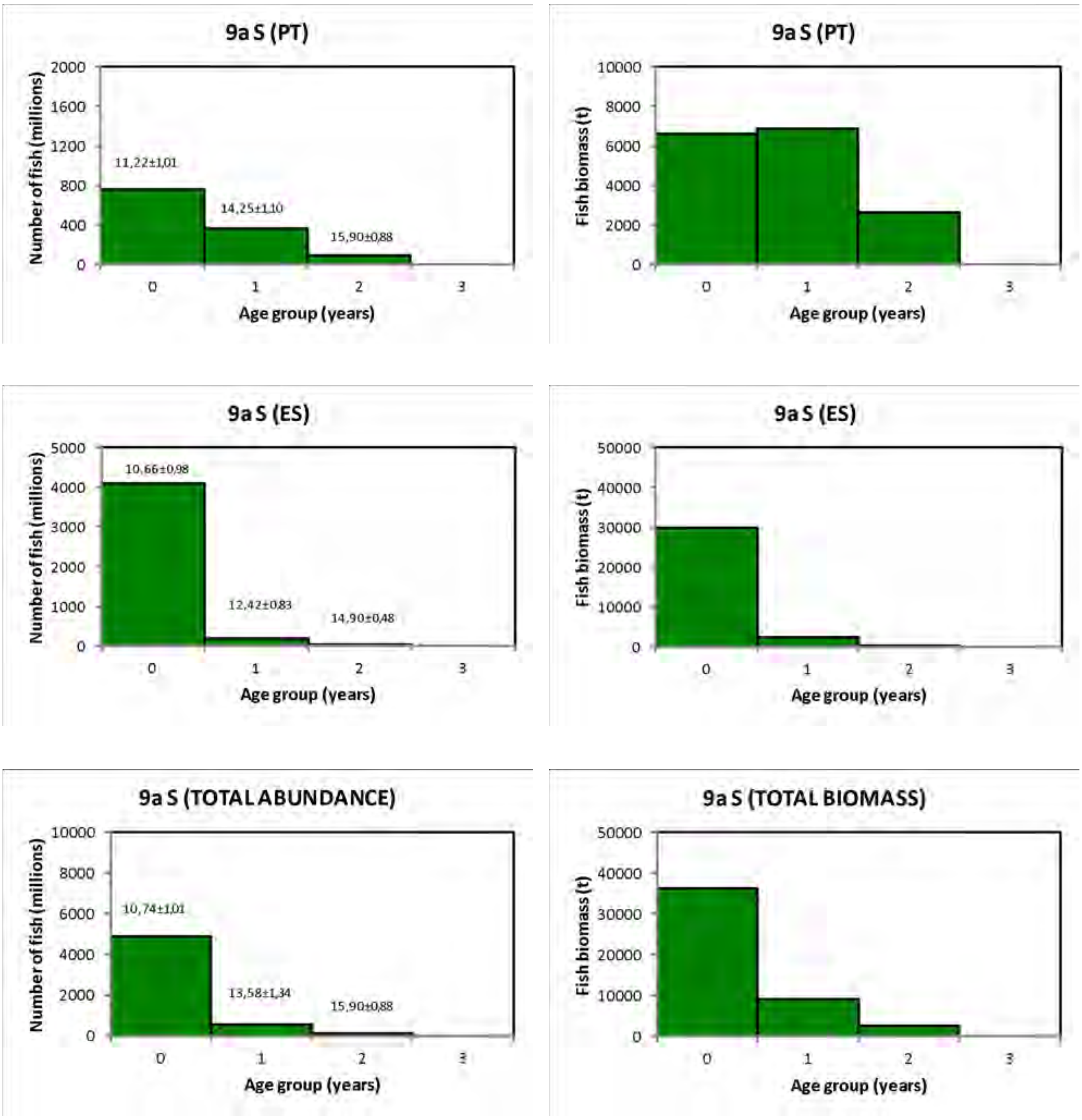
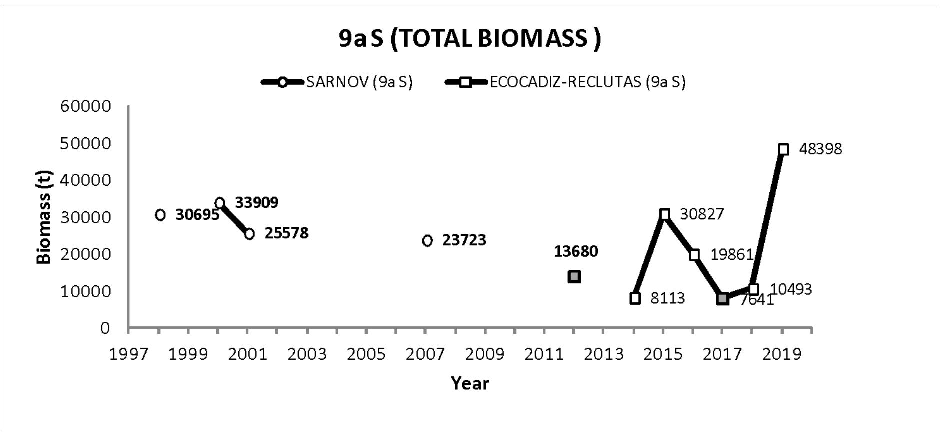
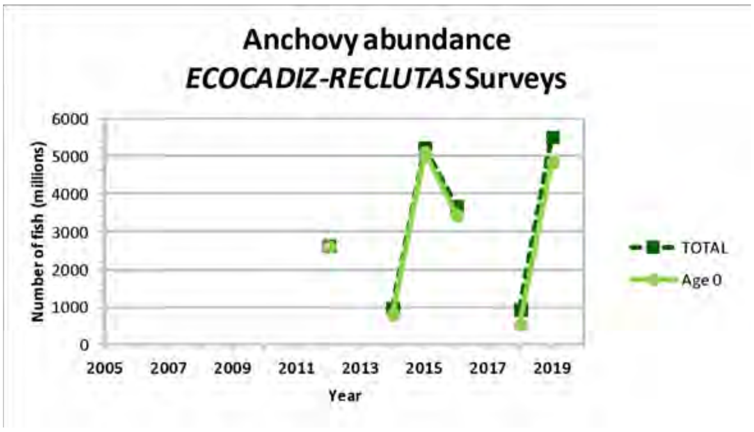


Figure 4.4.3.8. Anchovy in Division 9.a. Southern component. Subdivision 9.a South. *ECOCADIZ-RECLUTAS 2019-10* survey (autumn Spanish acoustic survey in Subdivision 9.a South). Estimated abundances and biomasses (number of fish in millions and tonnes, respectively) for the surveyed area by age group, with indication of the mean size by age. Note the different scales in the y-axis.





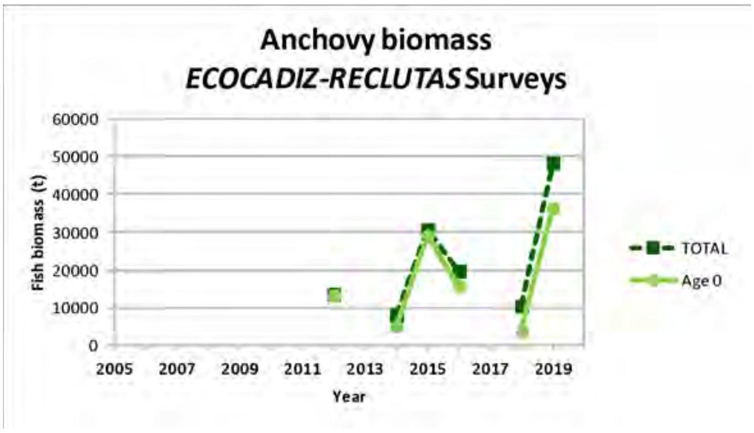


Figure 4.4.3.9. Anchovy in Division 9.a. Southern component. Subdivision 9.a South. *ECOCADIZ-RECLUTAS* survey series (autumn Spanish acoustic survey in Subdivision 9.a South). Top: historical series of overall acoustic estimates of anchovy biomass (t), (squares). The estimates from the older Portuguese *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.

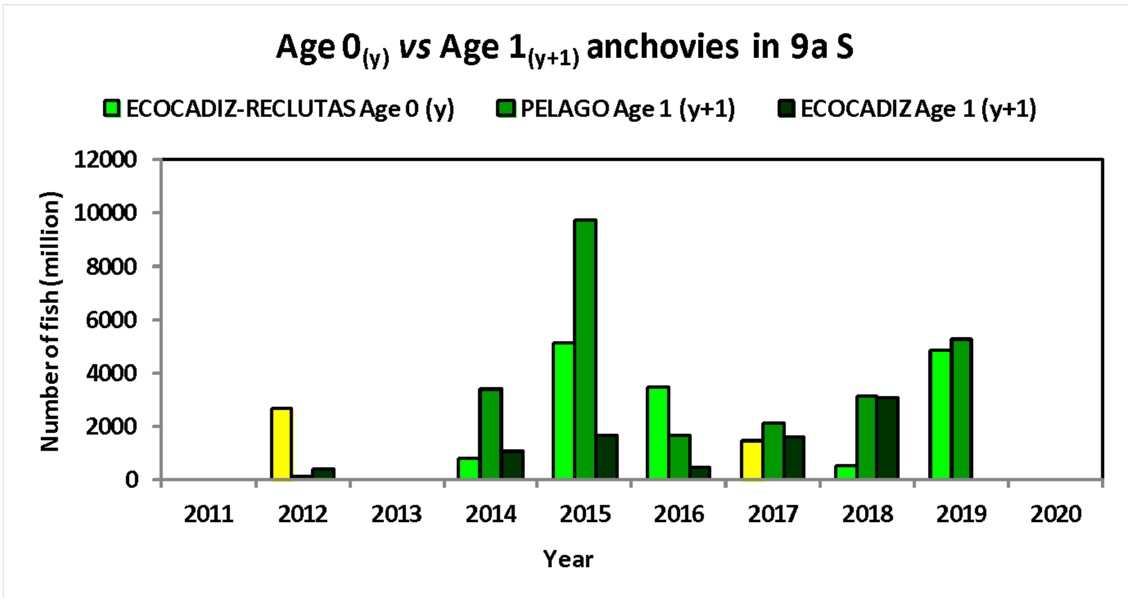


Figure 4.4.3.10. Anchovy in Division 9.a. Southern component. Subdivision 9.a South. *ECOCADIZ-RECLUTAS* survey series (autumn Spanish acoustic survey in Subdivision 9.a South). Correspondence between acoustic estimates of abundance of Age 0 anchovies from *ECOCADIZ-RECLUTAS* surveys in the autumn of 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* 2020 will be conducted after the WG.

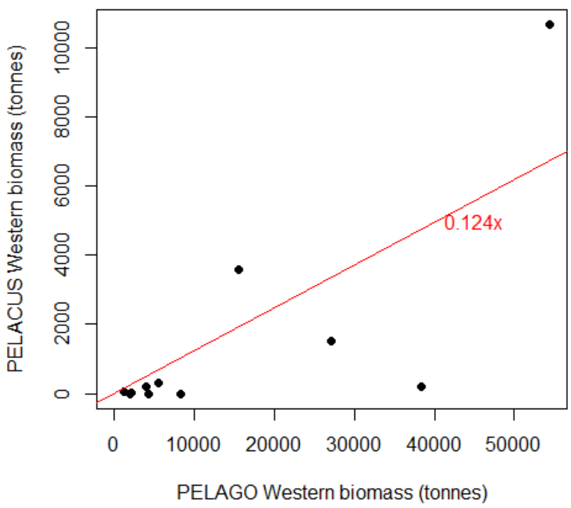


Figure 4.6.1.1.1 Anchovy in Division 9.a. Western component. Regression between the biomass estimated in the PELAGO and the PELACUS survey during the period 2007-2019.

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 1989–2019. Black lines represent estimated data while grey lines represent observed data.

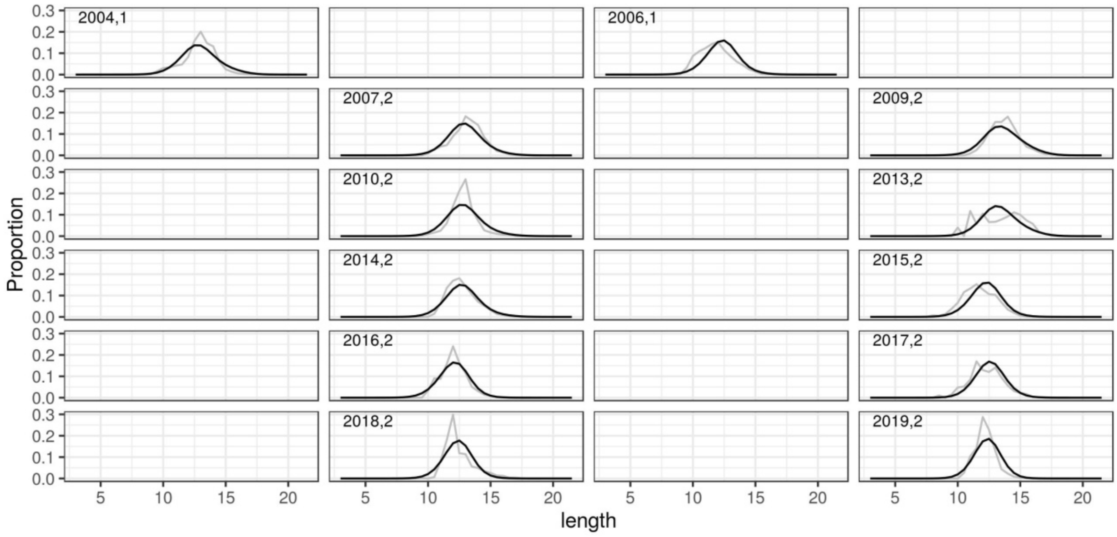


Figure 4.6.2.1.2.2. Anchovy in Division 9.a. Southern component. Comparison between observed and estimated catches length distribution for *ECOCADIZ* survey from 2004 to 2019. Black lines represent estimated data while grey lines represent observed data. The number next to the year indicates the quarter. 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.

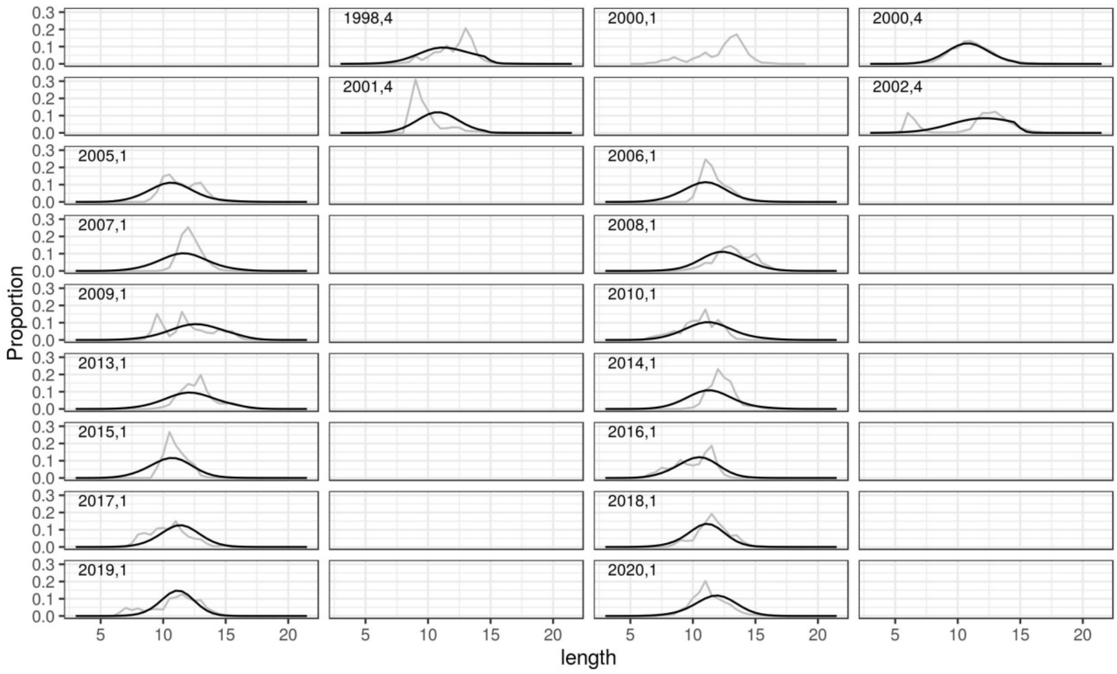


Figure 4.6.2.1.2.3. Anchovy in Division 9.a. Southern component. Comparison between observed and estimated catches length distribution for *PELAGO* survey from 1998 to 2020. Black lines represent estimated data while grey lines represent observed data. The number next to the year indicates the quarter. 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.

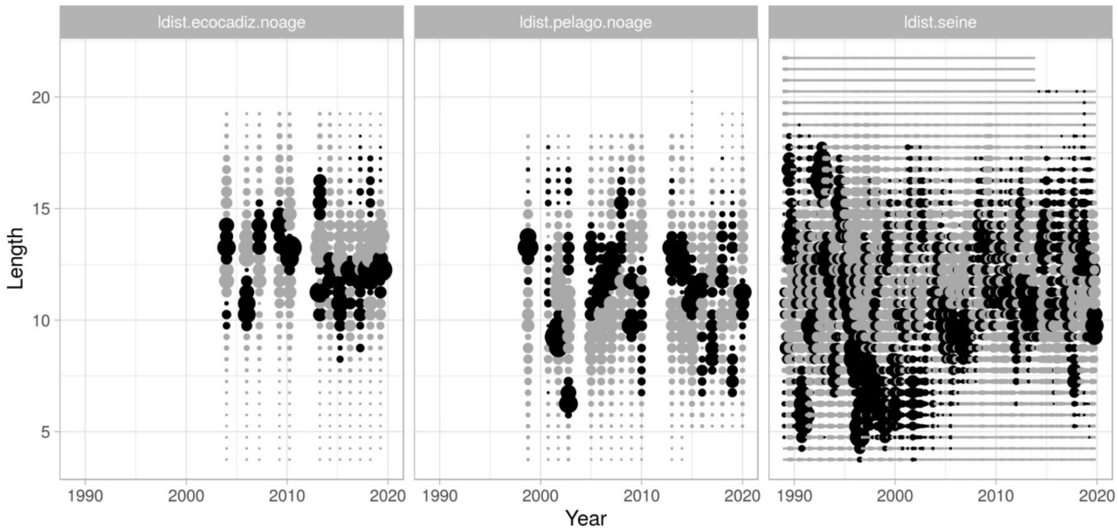


Figure 4.6.2.1.2.4. Anchovy in Division 9.a. Southern component. Standardised residual plots for the fitted length distribution from the *ECOCADIZ* survey, *PELAGO* survey and commercial fleet. Black points denote a model underestimate and grey points an overestimate. The size of the points denotes the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

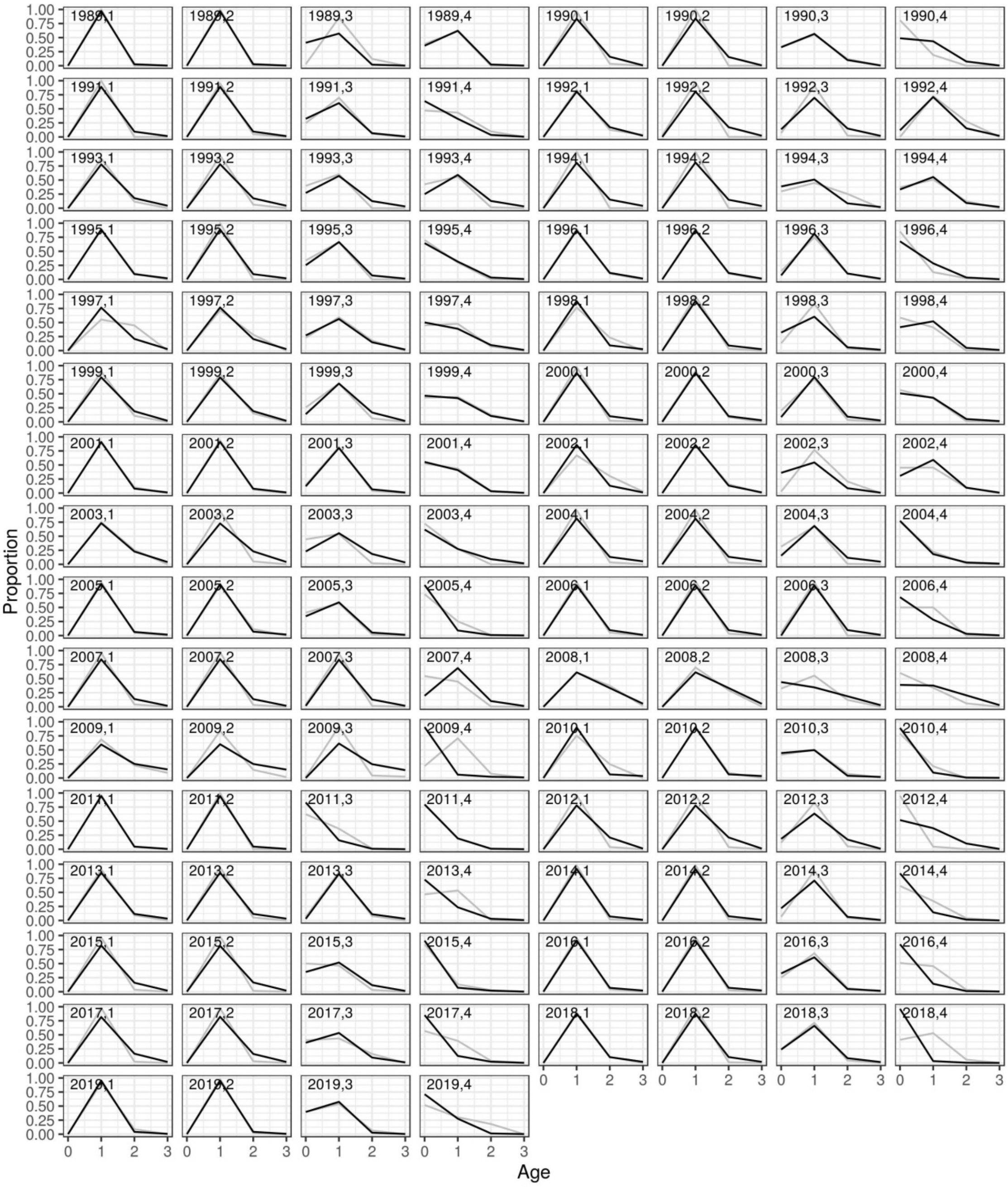


Figure 4.6.2.1.2.5. Anchovy in Division 9.a. Southern component. Comparison between observed and estimated quarterly catches age distribution from 1989 to 2019. Black lines represent estimated data while grey lines represent observed data. The number next to the year indicates the quarter.

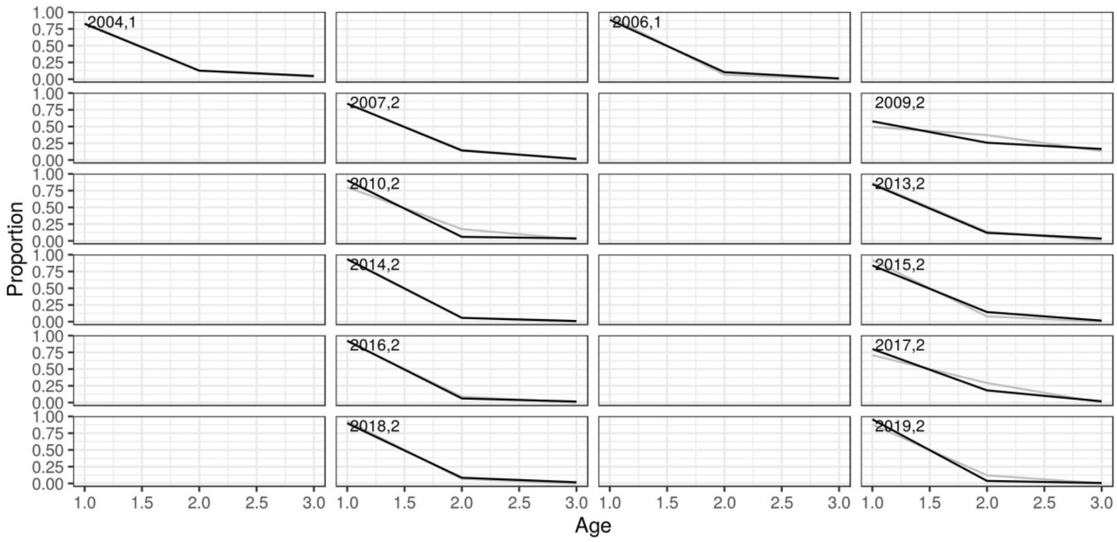


Figure 4.6.2.1.2.6. Anchovy in Division 9.a. Southern component. Comparison between observed and estimated *ECO-CADIZ* survey age distribution from 2004 to 2019. Black lines represent estimated data while grey lines represent observed data. The number next to the year indicates the quarter. Note that 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.

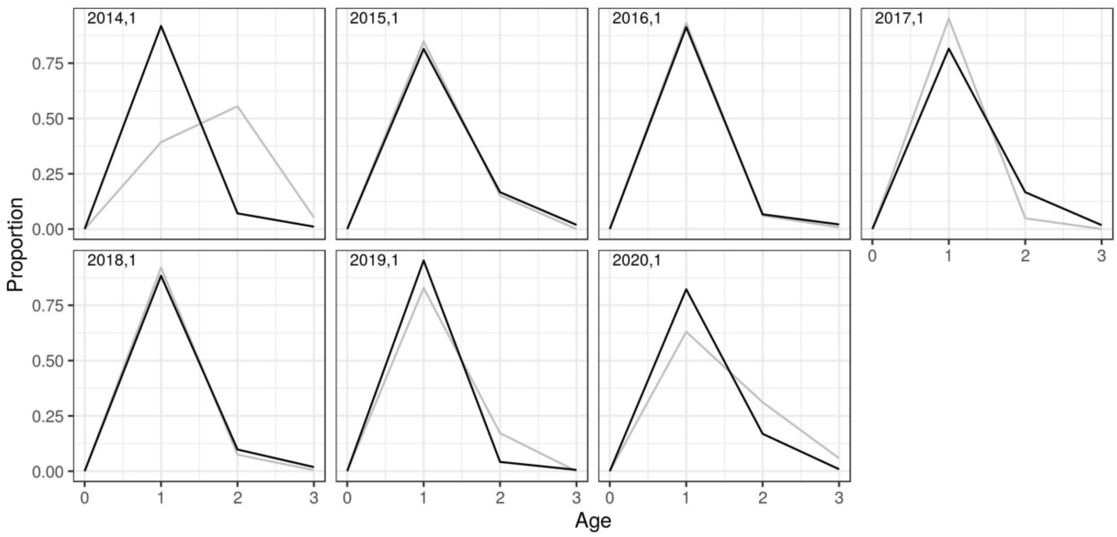


Figure 4.6.2.1.2.7. Anchovy in Division 9.a. Southern component. Comparison between observed and estimated *PELAGO* survey age distribution from 2014 to 2020. Black lines represent estimated data while grey lines represent observed data. The number next to the year indicates the quarter. Note that the 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.

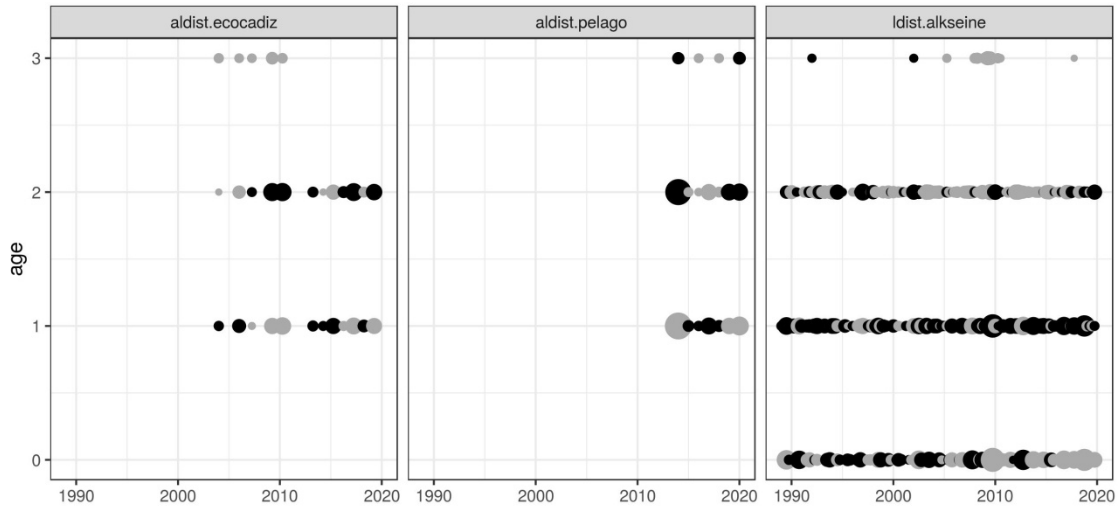


Figure 4.6.2.1.2.8. Anchovy in Division 9.a. Southern component. Standardised residual plots for the fitted age distribution from the *ECOCADIZ* survey, *PELAGO* survey and commercial fleet. Black points denote a model underestimate and grey points an overestimate. The size of the points denotes the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

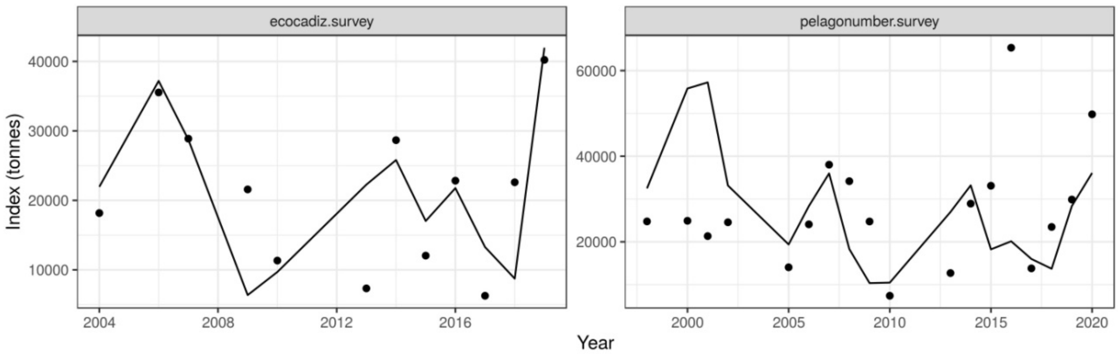


Figure 4.6.2.1.2.9. Anchovy in Division 9.a. Southern component. Comparison between observed and estimated survey biomass indices. Black points represent observed data while black line represents estimated data.

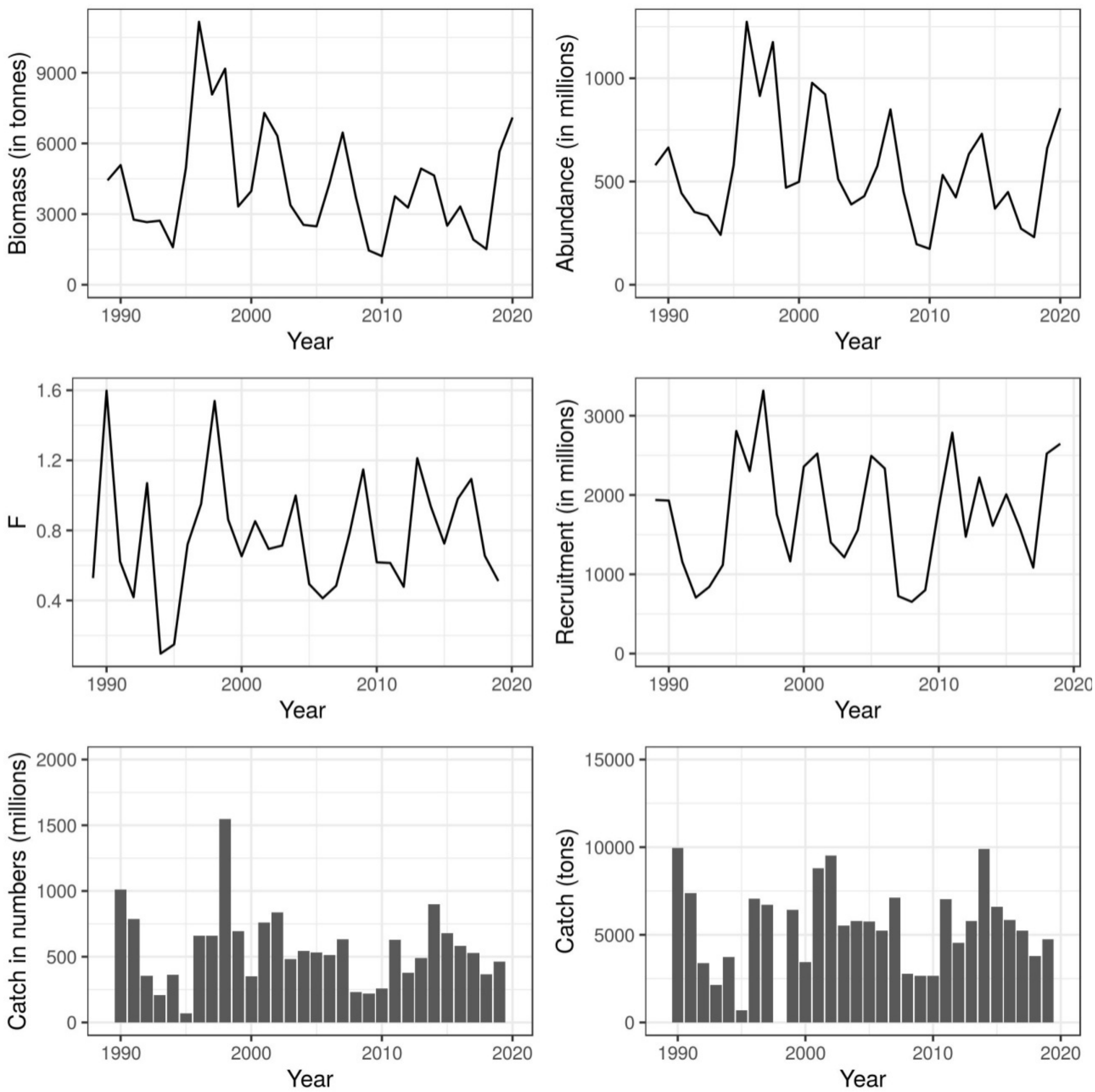


Figure 4.6.2.1.3.1. Anchovy in Division 9.a. Southern component. Annual model estimates for abundance with more than one year of age (in numbers and biomass), recruitment and fishing mortality compared with annual catch time-series (in numbers and biomass). Measures were summarised at the end of June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

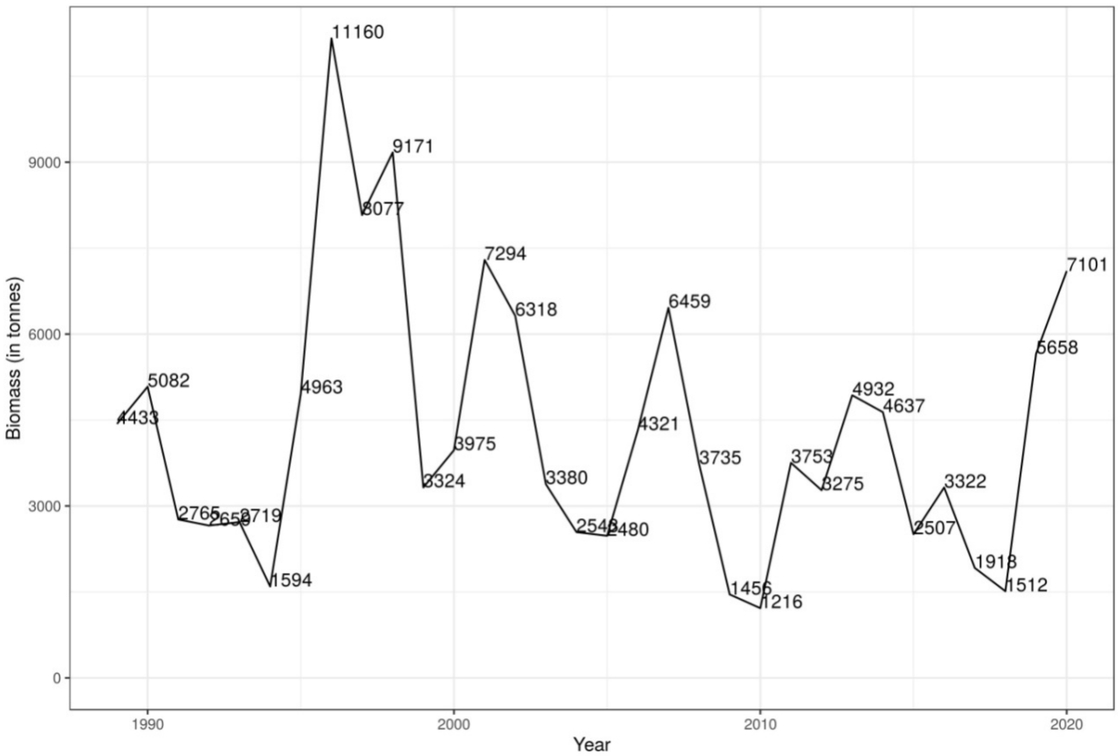


Figure 4.6.2.1.3.2. Anchovy in Division 9.a. Southern component. Time-series of estimated biomass at the end of June each year, assuming that a year starts in July and ends in June of the next year. For this stock, it is assumed that there are no individuals of age 0 at that time of the year, then this 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.

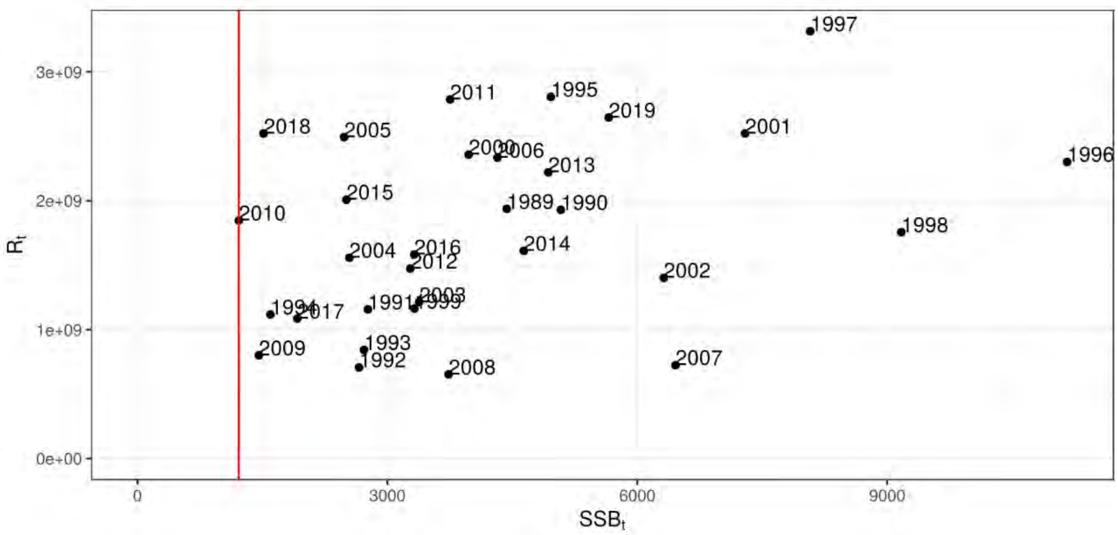


Figure 4.7.2.1. Anchovy in Division 9.a. Southern component. Estimated spawning–stock biomass vs. Recruitment plot. Red line indicates the B_{lim} value (B_{lim}=B_{loss}=SSB_{2010}=1220 t).

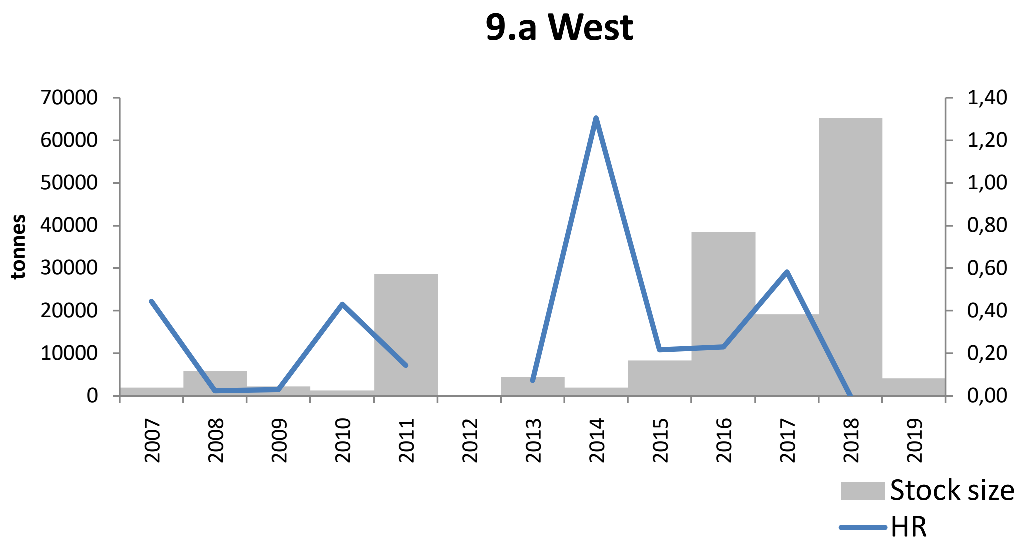


Figure 4.8.1.1. Anchovy in Division 9.a. Western Component. Stock biomass survey index and harvest rates. Harvest rates were estimated with the biomass of the surveys of a given year and the catches of the management period, i.e. 2007 corresponds to the period July 2007 to June 2008.

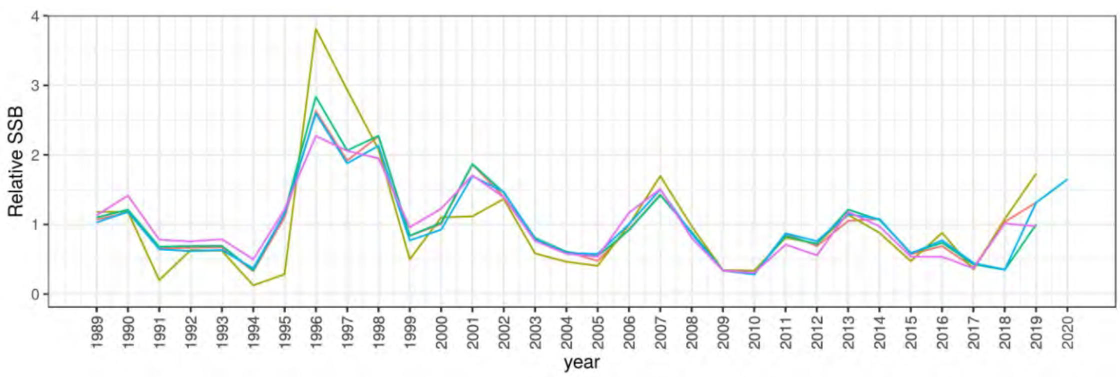


Figure 4.11.1. Anchovy in Division 9.a. Southern component. Estimated relative SSB for different model implementations testing the effect of including ECOCADIZ survey information in the last year together with slight changes in the seed for optimization. Estimated relative SSB time-series for the current and previous assessments (blue and purple lines, respectively), estimated relative SSB when removing the last year: two with the same seed (olive and dark green lines), one of them including ECOCADIZ 2019 (dark green line); and one with a different seed (pink line).

5 Sardine general

This section hasn't been updated as there is no new information.

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, e, h) 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. Working group estimates are provided in Table 6.2.1.2. Differences are generally related to unallocated catches. 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 2019 were 3 279 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. In 2019, 21 300 tonnes were landed. 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 and trawlers operate mainly in coastal areas (<10 nautical miles. 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 (1989–2019).

	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

year	8 a,b,d 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
2019	21099	3250	0	0	0	0	0	0	0	24349

Table 6.2.1.2. Sardine landings by France (1983–2019) and Spain (1996–2019) 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
2019	21300	3279	24579

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 and a new estimate was available for 2020. The survey took place from the 4th to the 27st 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 2020 in Annex 3 (Santos M. *et al*. BIOMAN 2020).

Total egg abundance for sardine was estimated as the sum of the numbers of eggs in each station multiplied by the area each station represents. This year sardine egg abundance estimate in Division 8abd was 3.75E+12, after removing part of the NorthWest area and the entire Division 8c, to be consistent with the historical series. This egg abundance in 2020 was below the time-series average (of 5.75E+12) (Figure 6.2.2.1.1, Table 6.2.2.1.1). Sardine eggs were encountered all along the Cantabric coast (Division 8c), from the coast to 200 m depth, between 2º and 6º00'W; the west spawning limit was not found in the Cantabric coast, although some reduction of the egg abundance was encountered in the last transect to the west. In the French platform, sardine eggs were encountered along the isobath of 100 m depth until 45ºN and also at deeper waters between 45º and 46ºN. And from there to 48ºN they were mainly restricted to the area between coast and 100 m depth. The eggs founds in the most northern radial at 48ºN were also taken into account for the estimation of the egg abundance (as in previous years) (Figure 6.2.2.1.2).

In the sampling of BIOMAN 2020 with the PairoVET net (vertical sampling) from 836 stations a total of 294 (35%) had sardine eggs, with a total number of eggs sorted of 3839. In the sampling with CUFES (horizontal sampling) a total of 1806 stations sardine appeared 679 stations (37%). 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. To provide an input on Spawning Biomass for the assessment of sardine in the 8abd, the stations from Division 8c were removed (Figure 6.2.2.1.2).

This year the coverage provided by BIOMAN was the only sampling taken into account for the DEPM estimates, i.e., total Daily egg production, adult parameters and spawning and total biomass and population estimates. In previous years the DEPM estimates were based on the joint estimates from two independent coverages, one in the until about 45ºN produced by the SAREVA survey in April and the other for the remaining northern area produced by BIOMAN survey in May (see previous reports). However, in this year, as SAREVA was not carried out due to the COVID disruption, the entire estimate was produced by BIOMAN survey in May.

BIOMAN survey has produced DEPM spawning Biomass, and also using the mean maturity (from the survey) total biomass and population in numbers estimates. These have been reported in WGACEGG 2020 (Santos M. *et al*. BIOMAN Survey 2020), and for the purpose of independent shelf documentation they are summarized in the Table 6.2.2.1.2. Spawning Biomass amounts to 99 376 t (CV=23%), and with a population maturity in mass of about 98%, total corresponding stock biomass is 102 563 t (CV=23%). This value reduces former DEPM estimates available in 2017 in about 33%, due to substantial decrease in the Egg production, which has been partly compensated by a strong reduction of the spawning frequency.

From the Total of 14 samples available (which have subsampling for age composition) (Figure Figure 6.2.2.1.2), the age composition of the stock was inferred as well (Table 6.2.2.1.2). This is not an official input for the assessment but in the absence of PELGAS it was worth considering such information as a potential way of covering the gap produced by the lack of PELGAS (see section 6.3.1).

Parallel, estimates of Total Biomass and population at age were produced from the BIOMAN survey in 2014 and 2017, but were not considered in the inter-benchmark of this stock (ICES 2019). Therefore they are not reported here, even though they were used in the sensitivity analysis for the assessment detailed in Section 6.3.1.

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
2020	3.75E+12
Mean	5.75.E+12
Std Dev	3.E+12
CV	46.3%

Table 6.2.2.1.2. Sardine Spawning Biomass (SSB) and Total Biomass in Division 8abd, with information on the mean weight and mean percentages by age at the population level (including mean weights and lengths by age).

Parameter	estimate	S.e.	CV		Biological Features	estimate	S.e.	CV
Ptot	1.97E+12	3.15E+11	0.1596		Weight at age 1 (g)	34.44	2.35	0.0684
R'	0.52	0.008	0.0147		Weight at age 2 (g)	43.79	1.63	0.0371
S	0.12	0.016	0.1372		Weight at age 3 (g)	48.40	1.03	0.0213
F	14,544	1,271	0.0874		Weight at age 4 (g)	50.22	1.49	0.0296
Wf	43.25	1.78	0.0412		Weight at age 5 (g)	60.04	0.00	0.0000
DF	20.38	3.40	0.1668		Weight at age 6+ (g)	62.37	3.42	0.0549
SSB	**99,376**	22,941	0.2308		Lenght at age 1 (mm)	164.52	3.02	0.0184
Mature population	0.97	0.0332	0.0343		Lenght at age 2 (mm)	178.38	1.55	0.0087
Biomass	**102,563**	24,106	0.2350		Lenght at age 3 (mm)	187.07	0.65	0.0035
Wt	40.13	2.21	0.0550		Lenght at age 4 (mm)	191.60	1.71	0.0089
Population (millions)	2,572	637	0.2477		Lenght at age 5 (mm)	201.93	0.00	0.0000
Percentage at age 1	0.50	0.119	0.2404		Lenght at age 6+ (mm)	210.08	2.69	0.0128
Percentage at age 2	0.33	0.076	0.2297					
Percentage at age 3	0.10	0.044	0.4304					
Percentage at age 4	0.06	0.025	0.4168					
Percentage at age 5	0.00	0.003	0.9325					
Percentage at age 6+	0.01	0.004	0.5396					

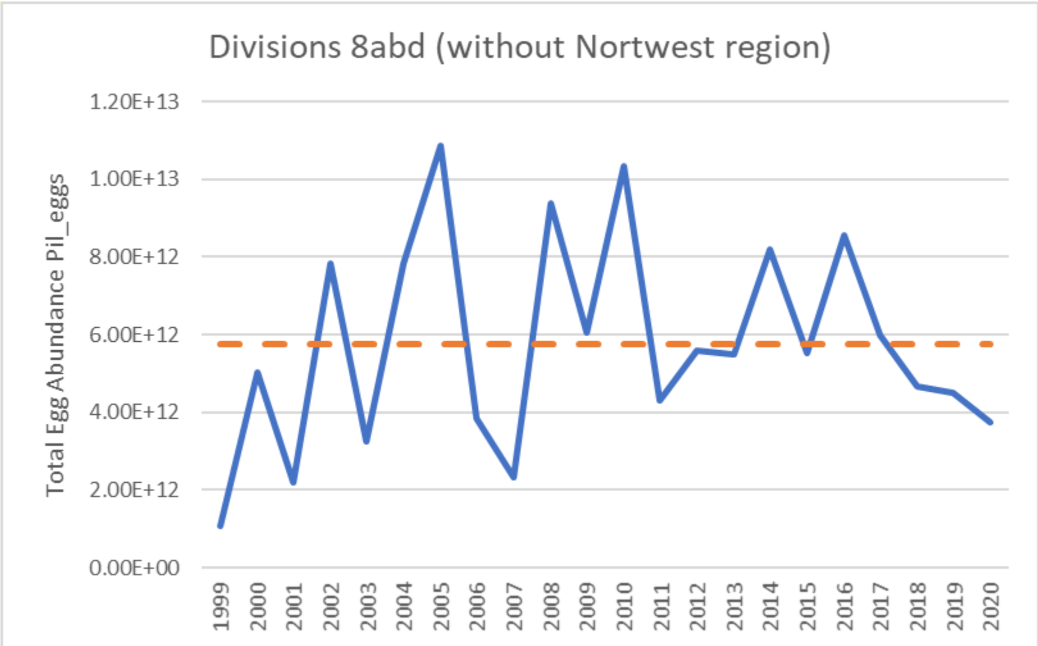


Figure 6.2.2.1.1. historical series and 2020 estimates of sardine total egg abundances (eggs)in 8abd without the north-west part (blue line), the one for assessment proposes to be consistent with the historical series. This year value (3.75E+12 eggs) is below the mean.

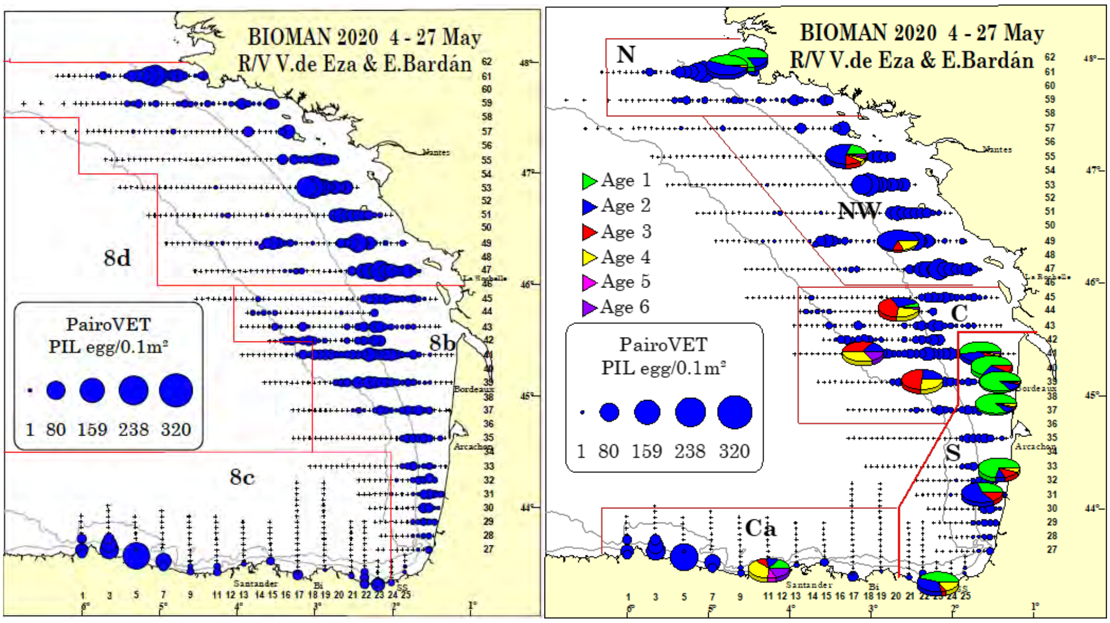


Figure 6.2.2.1.2. Distribution of sardine egg abundances (eggs per 0.1 m²) from the DEPM survey BIOMAN2020 obtained with PairoVET (Left graph) and distribution of adult samples informing on the percentages by age in the samples (Right graph).

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 2020, due to COVID-19, PELGAS was cancelled and therefore no new information was added this year.

The information below come from PELGAS 2019 and previous surveys. The survey is expected to resume in spring 2021.

Series of sardine abundances-at-age (2000–2019) is shown in Figure 6.2.2.2.1. In 2019, The population is still very young, with an age distribution largely dominated age 1 and 2 groups (sum about 92% in numbers). 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 6.2.2.2.2) 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 in 2019. 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 6.2.2.2.3). The fecundity appears low this year, corroborated by the youth of the sardine population (age 1 starting their maturation).

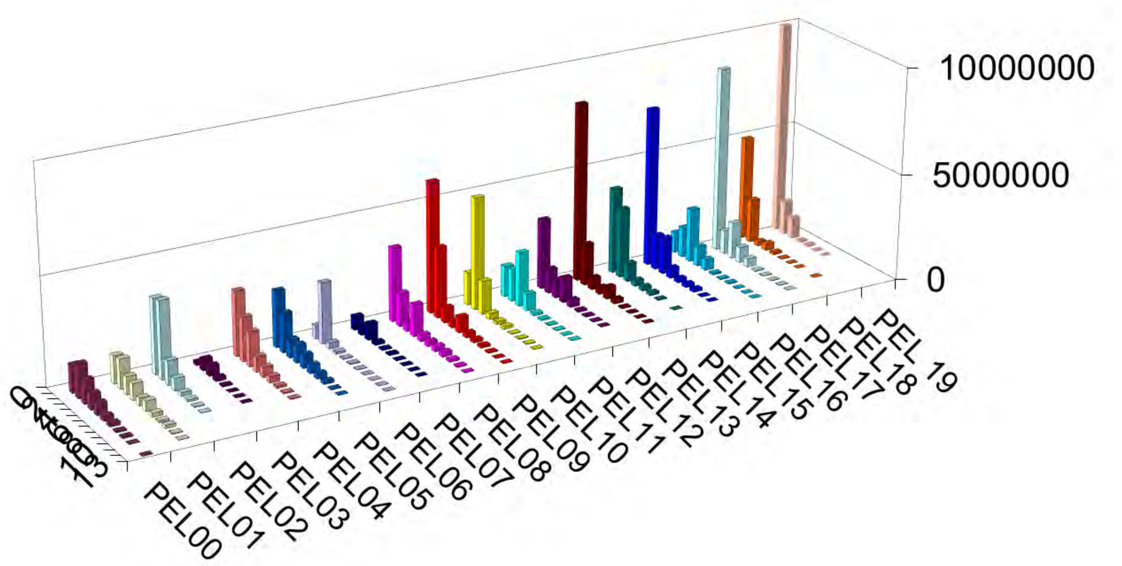


Figure 6.2.2.2.1. Age composition of sardine as estimated by acoustics since 2000.

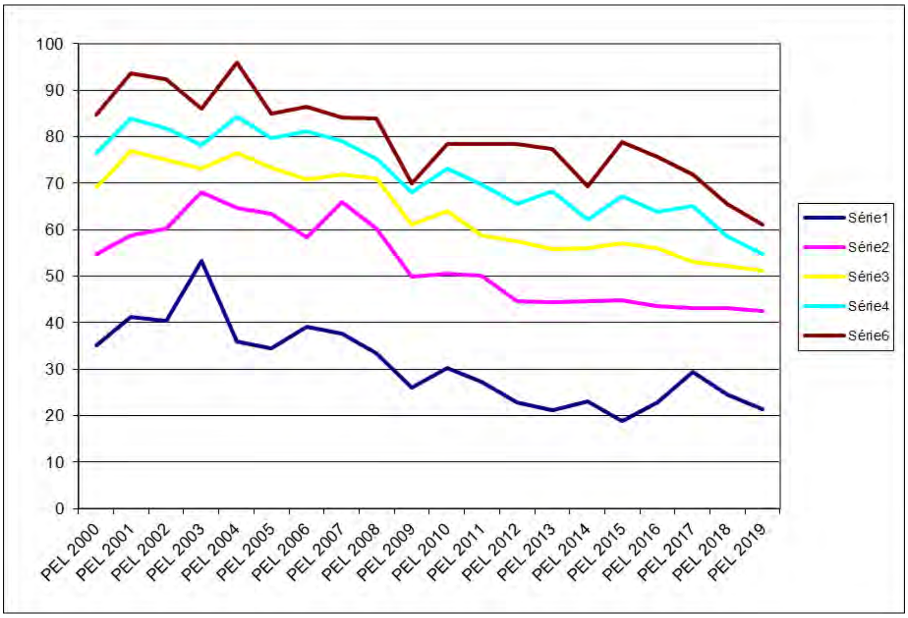


Figure 6.2.2.2.2. Sardine mean Weight-at-age along pelgas series (since 2000).

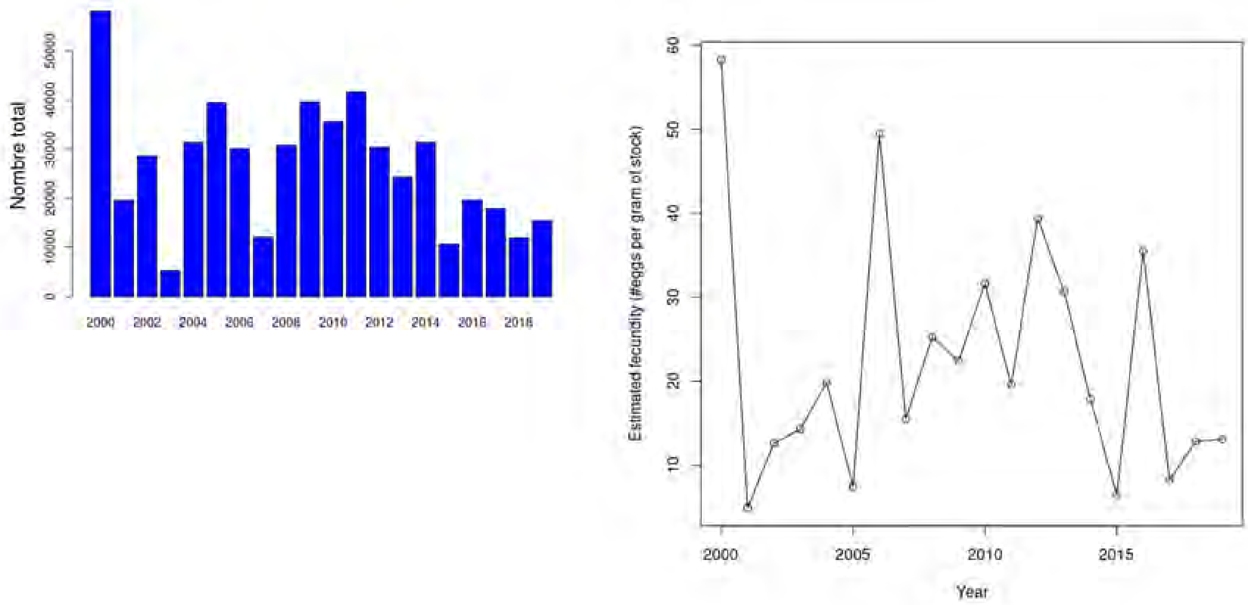


Figure 6.2.2.2.4. Number of eggs observed during PELGAS surveys from 2000 to 2019 counted in the CUFES system (left) and estimated fecundity acoustic biomass vs number of eggs corrected by the vertical model (Right).

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 11.5 to 23 cm. In 2019, 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 2019 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 2019 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 2019.

Length * (half cm)	**Quarter 1**	**Quarter 2**	**Quarter 3**	**Quarter 4**	**All year**
10					
10.5					
11					
11.5	102	242		24	368
12	102	242		24	368
12.5	205	484	373	24	1 086
13	614	1 453	1 118		3 186
13.5	205	484	1 864	310	2 863
14	512	1 211	3 728	991	6 442
14.5	307	727	2 982	1 407	5 423
15	307	727	3 355	2 372	6 761
15.5	102	242	6 337	3 342	10 024
16	614	1 453	21 249	4 255	27 571
16.5	1 637	3 876	24 977	4 706	35 195
17	4 502	10 658	14 911	5 062	35 134
17.5	6 344	15 018	11 929	3 789	37 080
18	9 618	22 769	19 385	4 024	55 797
18.5	8 186	19 378	14 539	3 295	45 397
19	7 265	17 198	13 793	2 727	40 984
19.5	6 446	15 260	9 692	2 465	33 865
20	5 014	11 869	5 965	1 864	24 712
20.5	2 763	6 540	2 610	1 039	12 952
21	819	1 938	2 237	1 101	6 094
21.5	512	1 211		558	2 280
22	102	242		186	530
22.5				124	124
23					
23.5					
24					
24.5					
25					
Total number	56 278	133 225	161 044	43 688	394 235
Official catch (t)	2 883	4 515	9 167	4 534	21 100

Table 6.2.3.1.2. Spanish sardine catch-at-length composition (thousands) in ICES Division 8b in 2019.

Length * (half cm)	Quarter 1	Quarter 2	Quarter 3	Quarter 4	All year
10					
10.5					
11					
11.5					
12					
12.5				17	17
13				21	21
13.5				2	2
14				15	15
14.5	22			16	38
15	20			33	53
15.5	67			302	368
16	133			928	1 061
16.5	686			2 156	2 842
17	1 445	40	8	2 776	4 270
17.5	2 143	121	38	3 506	5 809
18	2 675	242	83	3 721	6 721
18.5	3 208	444	214	4 595	8 461
19	2 201	686	307	4 718	7 912
19.5	1 772	525	363	4 884	7 544
20	1 035	404	272	4 188	5 900
20.5	882	161	192	3 353	4 589
21	408	161	109	2 250	2 928
21.5	246	40	38	1 311	1 636
22	88	40	26	504	658
22.5	15		4	141	159
23	4			32	36
23.5				3	3
24					
24.5					
25					
Total number	17 049	2 865	1 656	39 472	61 042
Official catch (t)	881	86	53	2 230	3 250

Table 6.2.3.1.3. Spanish 2019 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	0	538.845	538.845
1	895.604	3.95967	52.6973	9362.89	10315.2
2	6413.01	323.029	283.676	11837.1	18856.9
3	7197.93	798.884	410.067	14826.6	23233.5
4	863.689	116.468	54.7456	1916.41	2951.32
5	1207.41	179.071	43.8246	1659.55	3089.86
6	423.87	66.199	6.73934	209.824	706.632
7	105.196	13.6199	0	0	118.816
8	15.629	3.4731	0	0	19.1021
9	0	0	0	0	0

Table 6.2.3.1.4. French 2019 landings in ICES Division 8b: Catch in numbers (thousands) -at-age.

Age	First Quarter	Second Quarter	Third quarter	Fourth Quarter	Whole Year
0	0	0	24817.9	4034.86	28852.8
1	4890.63	37214.7	109512	24279.6	175897
2	20981.3	35164.1	45250	33446.9	134842
3	22059.8	24557.4	17008.5	14088.6	77714.3
4	3016.84	3130.98	5895.64	4694.68	16738.1
5	4022.81	3573.52	4154.85	3160.01	14911.2
6	1161.26	906.384	866.772	513.182	3447.6
7	117.304	60.69	0	0	177.994
8	28.0172	34.6039	0	0	62.6211
9	0	0	0	0	0

Table 6.2.3.2.1. Spanish 2019 landings in divisions 8a,b: Mean length (cm) -at-age.

	First Quarter	Second Quarter	Third quarter	Fourth Quarter	Whole Year
0				14.2627	14.2627
1	16.5823	17.4245	18.8631	17.4211	17.3556
2	18.0652	18.6454	19.4928	19.0738	18.7297
3	19.1249	19.4307	19.9378	19.8151	19.5902
4	19.8225	20.019	20.157	20.355	20.1822
5	20.3119	20.3689	20.8399	21.0242	20.7053
6	21.0438	21.0699	19.9804	20.4502	20.8598
7	20.9758	20.7683			20.952
8	21.682	21.7194			21.6888
9					

Table 6.2.3.2.2. Spanish 2019 landings in divisions 8a,b: Mean weight (kg) -at-age.

	First Quarter	Second Quarter	Third quarter	Fourth Quarter	Whole Year
0				0.02203	0.02203
1	0.0358	0.0411	0.05353	0.04156	0.04112
2	0.04581	0.0502	0.05915	0.05542	0.05212
3	0.05404	0.0565	0.06366	0.06263	0.05978
4	0.06011	0.06171	0.06608	0.06837	0.06565
5	0.06441	0.06483	0.07325	0.07536	0.07044
6	0.0712	0.07147	0.06403	0.06962	0.07069
7	0.07046	0.0684			0.07023
8	0.07743	0.07782			0.0775
9					

Table 6.2.3.2.3. Spanish 2019 landings in ICES Division 8,b: mean length (cm) -at-age.

Age	First Quarter	Second Quarter	Third quarter	Fourth Quarter	Whole Year
0			14.7701	14.1969	14.6899
1	15.1166	15.6971	16.7927	17.6069	16.6267
2	17.8716	17.5302	18.8287	19.0648	18.3997
3	18.9894	18.8075	19.4765	19.5409	19.1385
4	19.4701	19.2503	20.6677	20.506	20.1413
5	19.909	19.7397	20.9622	20.7646	20.3432
6	20.5578	20.4535	21.5413	21.2847	20.8858
7	21.0546	20.7851			20.9627
8	21.3043	21			21.1362
9					

Table 6.2.3.2.4. Sardine general: French 2019 landings in ICES Division 8b: mean weight (kg) -at-age.

Age	First Quarter	Second Quarter	Third quarter	Fourth Quarter	Whole Year
0			0.0256	0.02266	0.02519
1	0.0275	0.03089	0.03805	0.04403	0.03707
2	0.04611	0.04344	0.05417	0.05629	0.05064
3	0.05561	0.05398	0.06013	0.06074	0.05701
4	0.06007	0.058	0.07222	0.07049	0.06689
5	0.06435	0.06267	0.07545	0.07327	0.06893
6	0.07104	0.06994	0.08207	0.07909	0.07472
7	0.07648	0.0735			0.07546
8	0.07931	0.07587			0.07741
9					

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 IBPSardine inter-benchmark (ICES, 2019). The inter-benchmark took place in 2019 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 second one following the inter-benchmark in 2019.

6.3.1 Impact of the cancellation of PELGAS 2020 due to COVID-19

The COVID-19 pandemics in 2020 resulted in the cancellation of PELGAS 2020. This survey provides critical data for the assessment, namely stock number-at-age, weight-at-age, maturity and acoustic index. The working group was tasked to evaluate the impact of the lack of those data in 2020 and to provide, if possible, a fix to account for the missing values.

The approach to the exercise was iterative. As a first step, all PELGAS data (stock structure, maturity and acoustic index) were removed in the terminal year from previous assessments with times series for the survey ending from 2014 to 2019. No substitute data were provided at this stage. Those assessments were compared to reference past assessments (i.e. with no degradation to the original data). For most runs, it was found when PELGAS is missing in the terminal year, SSB is increased by around 30%. Except for the year 2017, the magnitude of this deviation was relatively stable every year (figure 6.3.1.1) for SSB. Because of higher SSB, F was downscaled by 4 to 31% depending the year (table 6.3.1) Recruitments estimates were unchanged except in the penultimate year.

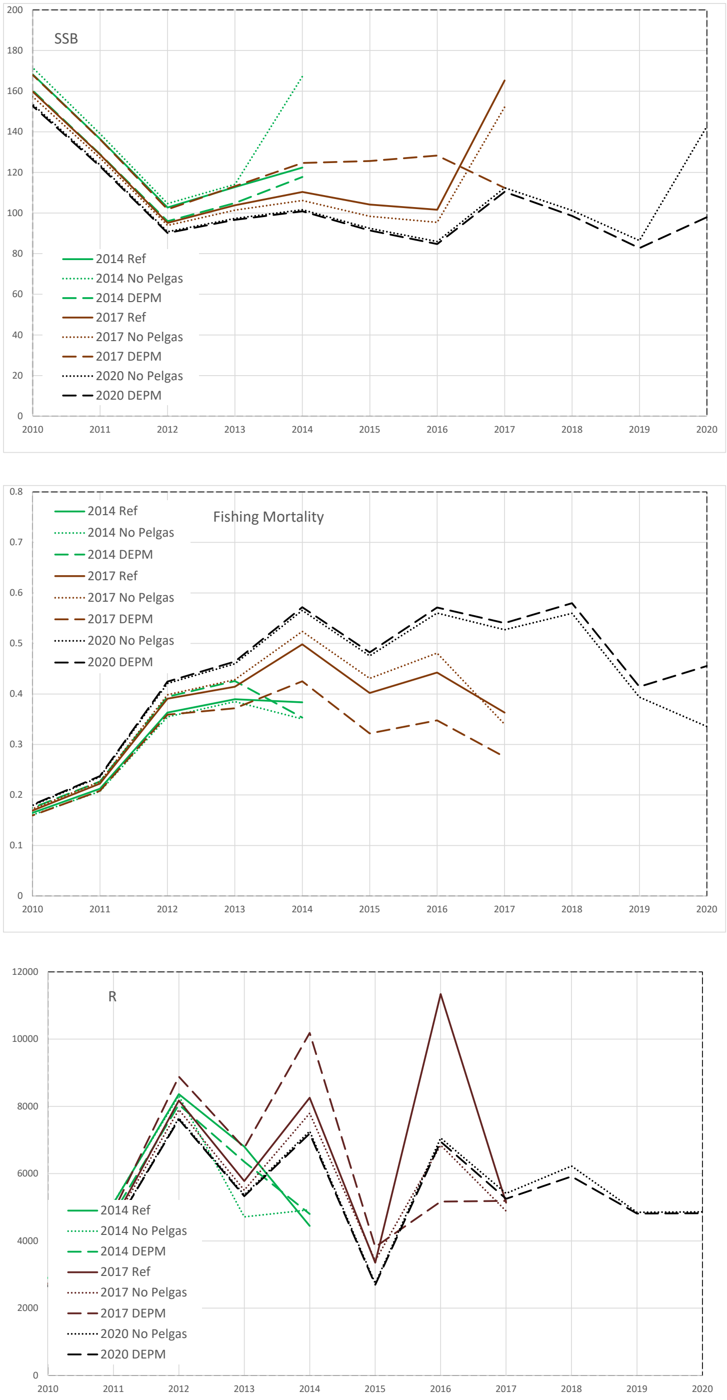


Figure 6.3.1.1. Trial assessment (SSB, F, R) without PELGAS in the terminal year (dashed line) and reference runs (continuous line).

Table 6.3.1. Relative difference between trial and reference runs, for SSB (upper), Fishing mortality F (middle) and Recruitment (bottom panel).

	% diff SSB rel to ref run	
Final year run	No pelgas	DEPM
2014	36.7	-3.7
2015	33.4	
2016	54.4	
2017	-7.9	-32.0
2018	31.1	
2019	38.0	

	% diff F rel to ref run	
Final year rur	No pelgas	DEPM
2014	-8.7	-7.9
2015	-4.2	
2016	-33.5	
2017	-6.4	-24.1
2018	-30.9	
2019	-15.9	

	% diff R rel to ref run	
Final year rur	No pelgas	DEPM
2014	10.7	7.9
2015	-4.8	
2016	1.2	
2017	-4.8	1.1
2018	1.2	
2019	-1.1	

It was subsequently found that the increase of SSB is related to the assumptions used by the model to replace the missing weight-at-age and maturity-at-age values. In the case of this assessment, SS3 was using substitutes value from the first active line of the time-series (2000).

This assumption could work in the case of the stock were weight-at-age and maturity had not substantially changed over the full times series. In the case of this sardine stock, there is a clear trends towards lower weight-at-age values during the whole time-series of PELGAS and commercial catches and maturity is not constant either.

Using the 2000 values causes an increase of SSB because SSB is the sum of products of weight-at-age by number-at-age by maturity-at-age. The now predominant proportion of age 1 individuals adds sensitivity of the SSB estimates to any change in age 1 values. This particular age group has exhibited the strongest decline in individual mean weight since 2000, actually the 2000 value is 63% higher than the PELGAS 2019 value.

Some attempts were made to feed the model with alternate default weight-at-age values for missing years. Those attempts failed and it was then seen as mandatory step to include 2020 substitute values for the missing PELGAS ones. With the aim of a minimal deviation from the benchmark procedure, two options were considered:

1) Using the DEPM mean weight (and perhaps population structure) at age as substitutes for the missing years.
2) Using average weight-at-age from PELGAS previous three years.

One additional challenge is to address the lack of number-at-age provided normally by PELGAS. DEPM is able to provide those numbers for option 1 while option 2 may require additional treatment for number-at-age.

In order to validate the use of DEPM data, age structure between PELGAS and BIOMAN were compared for 2014 and 2017 where both surveys were available (figure 6.3.1.2). While there are good agreement in terms of mean Weight-at-age between surveys, in terms of age structure the agreement is good in 2014 but not 2017. This resulted in different behaviors in additional exploratory runs (Figure 6.3.1.3) where the run using the DEPM is in good agreement with the reference run in 2014 but not in 2017.

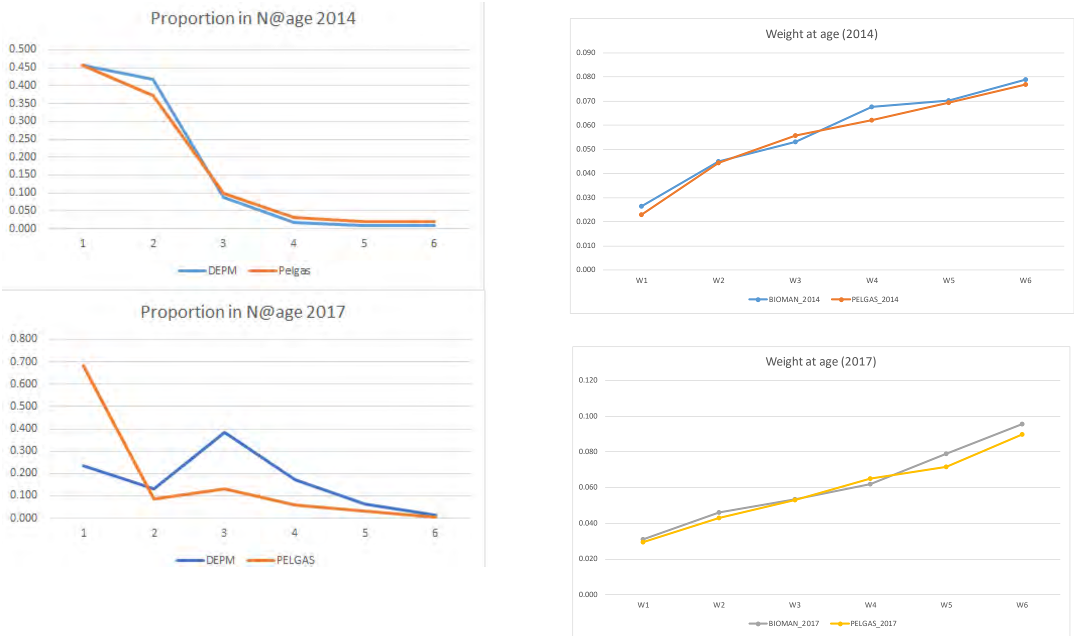


Figure 6.3.1.2. Comparisons of number-at-age and weight-at-age between DEPM and PELGAS surveys.

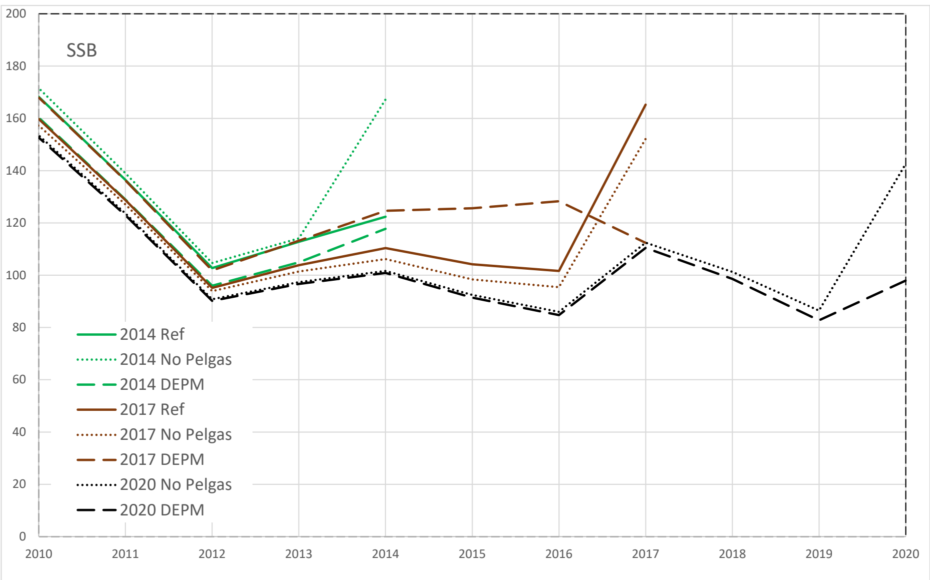


Figure 6.3.1.3. SSB estimates from trials assessment using DEPM age structure (dashed line).

This suggests the difference in number-at-age structure between surveys (in 2017) indicates the model is sensible to the provided numbers-at-age. In the case of 2020, there are no data available to compare the DEPM with, therefore the inclusion of this datasets adds potential uncertainties in regards of the validity of the model outputs.

One way to investigate the problem of the number-at-age was to check how runs would be impacted by the removal only of number-at-age in the terminal year (Figure 6.3.1.4).

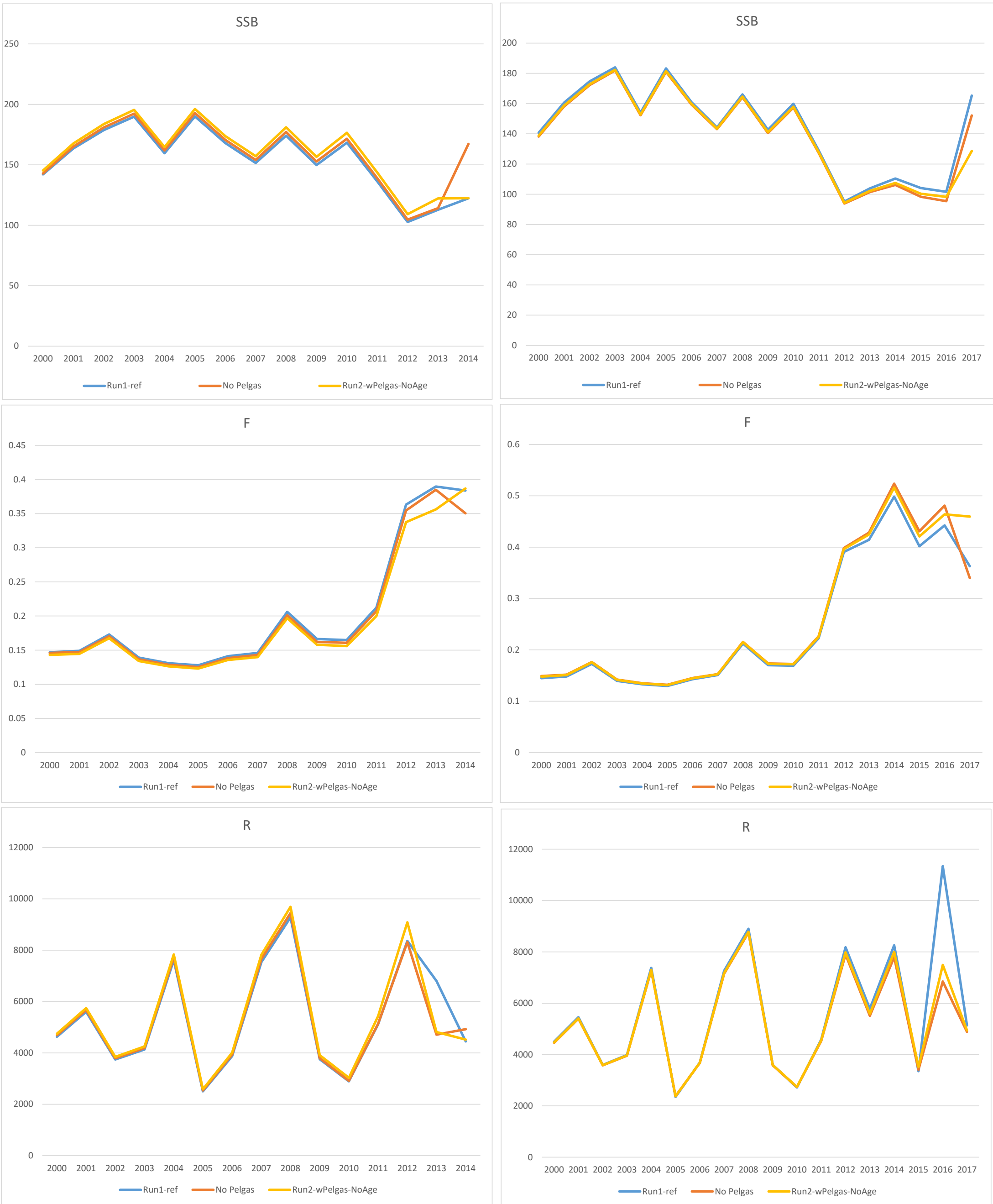


Figure 6.3.1.4. Trials assessment removing the number-at-age structure (yellow line) against full removal of PELGAS data in the terminal year (orange line) and reference run (blue line) with terminal year in 2014 (left) and in 2017 (right).

This set of runs show that the removal of number-at-age in the terminal year does not impact substantially the output of the model as long as some weight-at-age and maturity-at-age are provided. There is however an impact on the recruitment for the penultimate year. This is because the surveys provide information to the model to estimate recruits in the previous year.

A sensitivity analysis for 2020 (Figure 6.3.1.5) both with the mean Weight-at-age from PELGAS (2017-2019) but one using and the other not using the age structure from the DEPM showed that results were very consistent in terms of SSB trajectories and that recruitment estimates at age 0 for 2019 were as well coincident in both runs, though small deviation was evident in the 2018 recruitment (of about 6%). As such this proved that inclusion or not of the DEPM age structure was not going to affect the results for the current assessment and for the short term projections (notice that age 0 in 2018 will be age 3 in the advice year 2021). Thus the current assessment omitting the age structure from PELGAS is shown to be robust to the use, or not, of a substitute for the age structure from the DEPM BIOMAN survey. Then as the stock annex did not include the age structure from the DEPM as an input, it was decided to left it aside, not being included in the assessment. But the former sensitivity analysis shows that such decisions has no noticeable impact on the current assessment. Of course as usual the triennial DEPM SSB estimate in 2020 has been used as input for the current assessment.

From those sets of runs, the assessment can handle the lack of number-at-age in the final years. The final choice was to choose between using the Weight-at-age and maturity estimates from the DEPM estimates in 2020 or using the average values from PELGAS over the last 3 previous years (2017–2019).

Maturity-at-age from DEPM was 0.97 for age 1 and 0.81 for PELGAS (2017–2019). Those values were similar and in the possible recent trends from the existing time-series. After some discussions among the group, PELGAS values were considered as more reliable.

Weight-at-age are differing substantially between the two approaches with Weight-at-age 1 being higher for BIOMAN and then becomes gradually lower than the PELGAS average for older individuals. Some final runs were carried out using average maturity from PELGAS and weight-at-age from the DEPM (run2) or average weight from PELGAS (run5). Both runs provided very similar outputs in terms of fit, SSB, F, R (Figure 6.3.1.6). After some comparison with commercial weight-at-age for 2020 and previous years back to 2015 at quarter 2, it was still unclear which values to use. PELGAS was finally chosen to keep some consistency by having both average maturity and Weight-at-age originating from the same survey.

This year's final assessment is therefore not including any stock number-at-age data and use the average values from PELGAS 2017-2020. No Pelgas acoustic index is provided. This is seen as the minimal deviation from the usual assessment procedure as described in the stock annex. As such, and following the various conclusions from this exercise, the group felt there are no reason to suppose an unusual level of uncertainties in the various output including in the estimates of recruitment.

One promising aspect from this exercise is the progressive availability of the DEPM stock structure. Due to limited time and in order not to deviate from the stock annex, it was impossible to use and validate the use of those numbers as separate sets of number, weight and Maturity-at-age because of additional settings required as a pre-requisite (like setting survey selectivity at age) but it is definitely some addition to consider and test for the next benchmark of this stock.

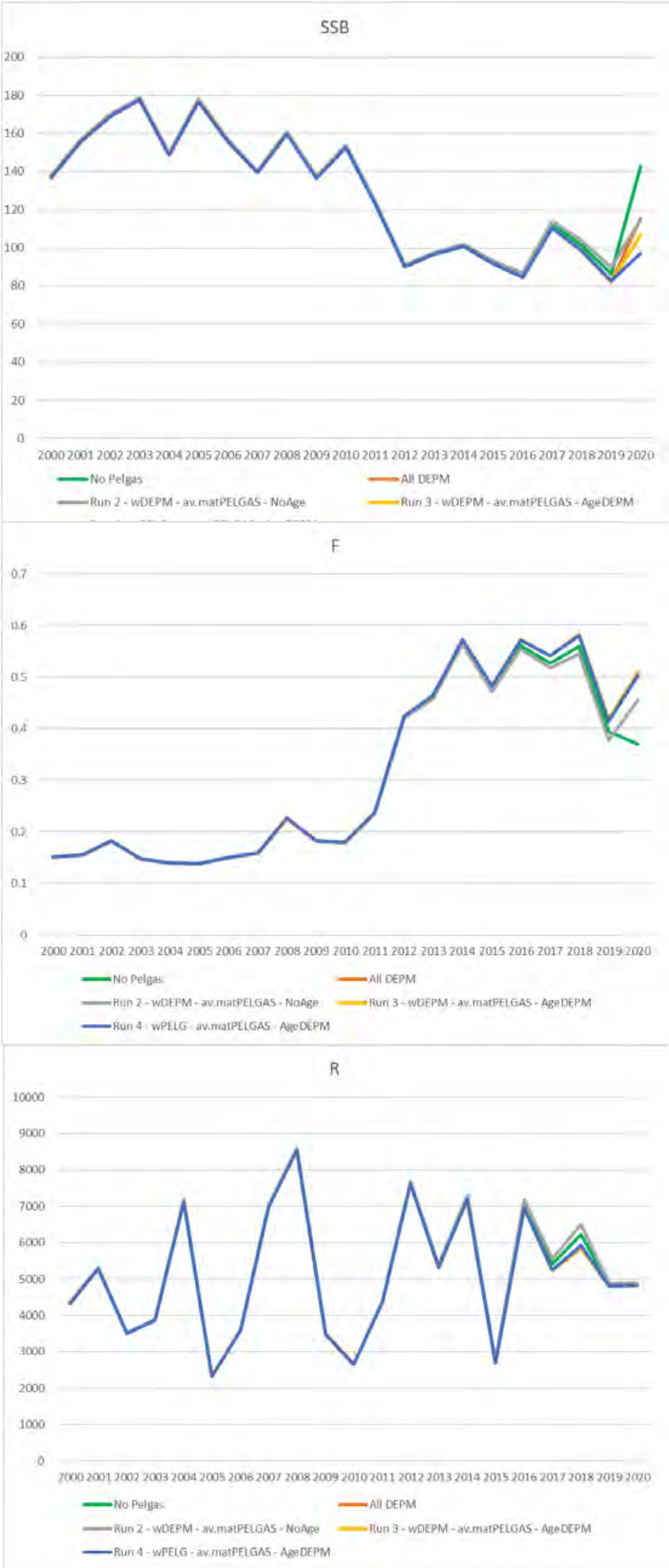


Figure 6.3.1.5. Sensitivity analysis in 2020. No age structure provided ("no pelgas" run – green), weight-at-age from PELGAS (run4 - blue) or DEPM (run 3 – yellow) with DEPM age structure, full DEPM structure including maturity (run "All Depm" – red) and no number-at-age from the DEPM (run 2 - grey) in 2020.

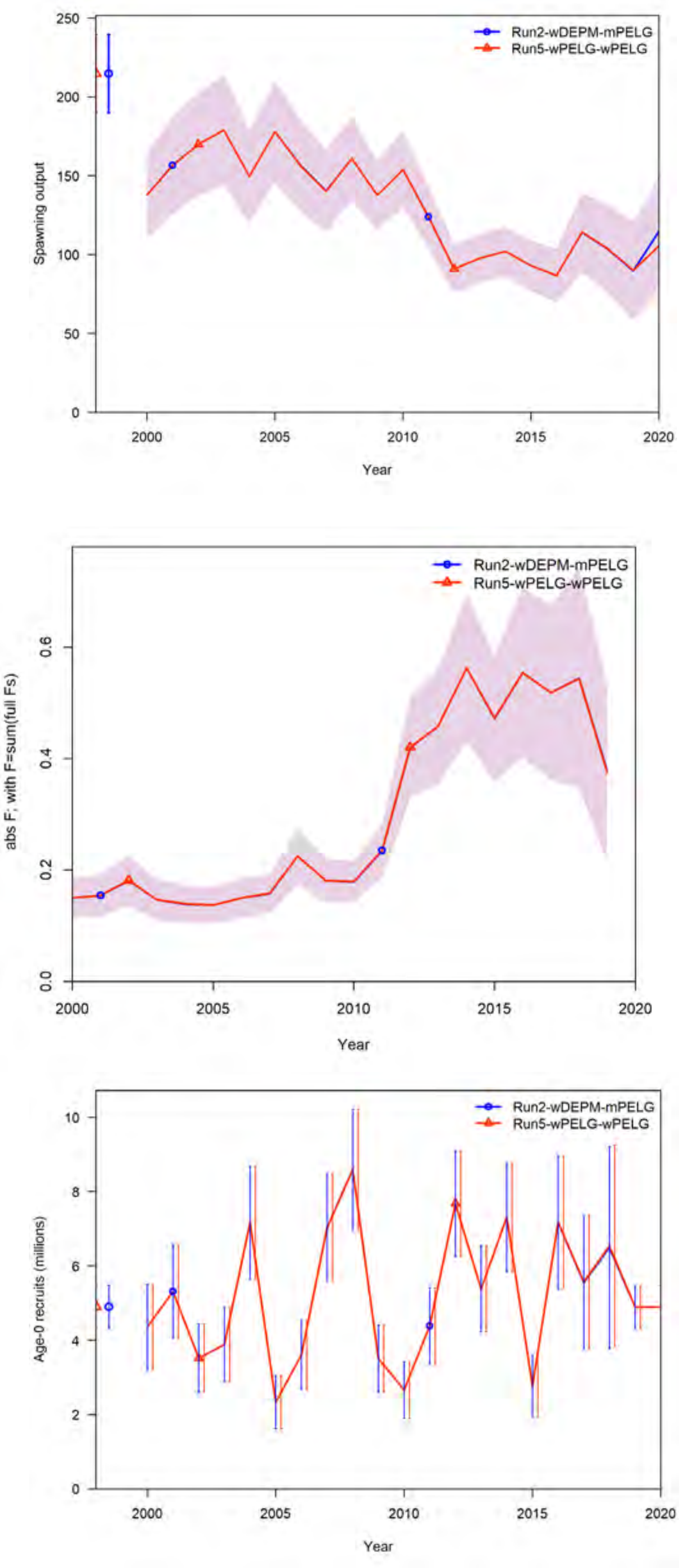


Figure 6.3.1.6. Final trial runs using weight-at-age from DEPM (run2) or from the average of the last 3 years of PELGAS (run5).

6.3.2 State of the stock

Summary of the assessment is shown in Table 6.3.2.1 and in Figures 6.3.2.1–6.3.2.2.

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. 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}. In 2019, it is now estimated to be below F_{MSY}. Recruitment has been variable over time. Recruitment in 2019 is around the time-series average.

Table 6.3.2.1. Summary of the sardine 8abd stock assessment.

Year	Recruitment (thousand)	SSB (tonnes)	Total Catch (tonnes)	F(2–5)
2000	4359590	138218	15097	0.150
2001	5308960	156793	15005	0.154
2002	3523640	170043	18277	0.181
2003	3892430	179117	16607	0.146
2004	7166540	149820	14197	0.139
2005	2344830	178001	16360	0.137
2006	3611960	156674	16741	0.150
2007	7018600	140479	17323	0.158
2008	8574730	160906	21821	0.22
2009	3509400	137472	20855	0.181
2010	2673380	153662	20127	0.179
2011	4384110	123831	23208	0.24
2012	7659010	90978.9	30900	0.42
2013	5381190	97534	32938	0.46
2014	7297240	101873	35704	0.56
2015	2769140	92801	28756	0.47
2016	7154450	86521.1	29754	0.56
2017	5547140	113857	30435	0.52
2018	6486180	103360	32299	0.55
2019	4785480	89396.6	24579	0.38
2020	4839000**	103915		

***Geometric mean (2002–2019).**

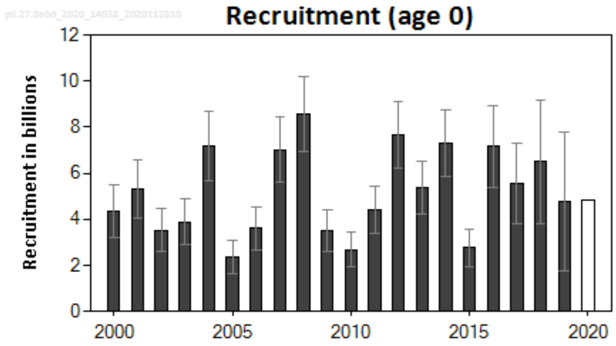


Figure 6.3.2.1. Recruitment estimates from SS3 outputs for sardine 8abd. Last year's value is estimated from the model.

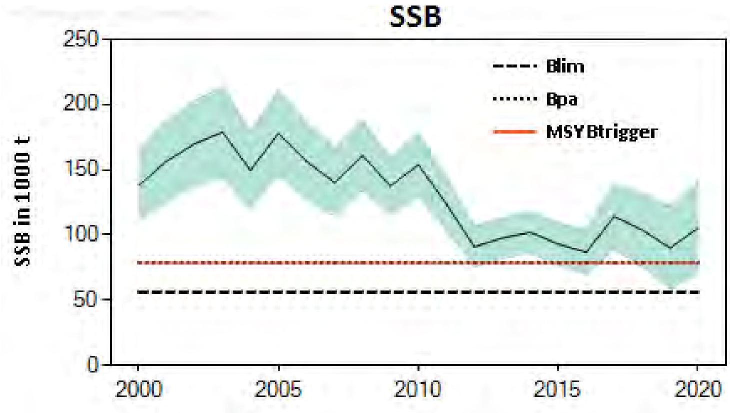


Figure 6.3.2.2. Spawning–stock biomass from SS3 outputs for sardine 8abd. Last year's value is estimated from the model.

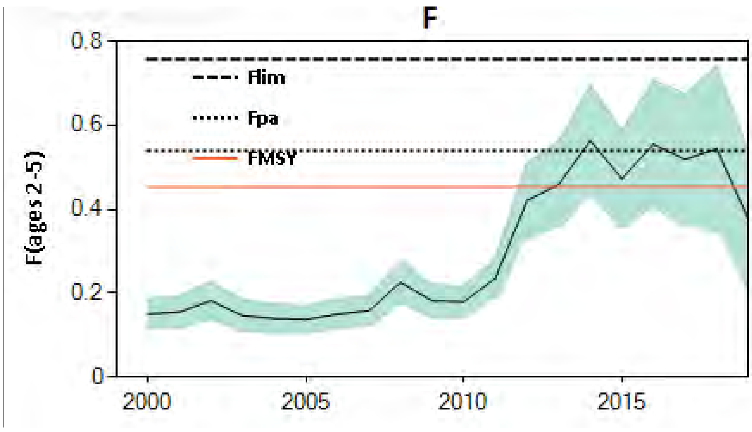


Figure 6.3.2.3. Fishing mortality for ages 2 to 5 derived from SS3 outputs for sardine 8abd. Last year's point is an estimate of F *status quo* from the average fishing mortality of the three years before (2017–2019).

6.3.3 Diagnostics

Residuals (Figures 6.3.3.1–6.3.3.2) 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.

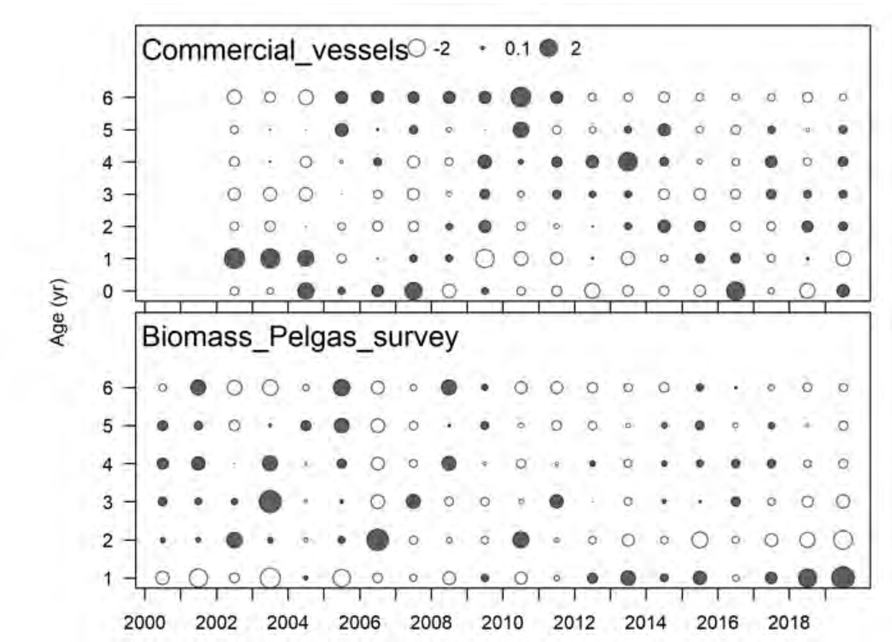
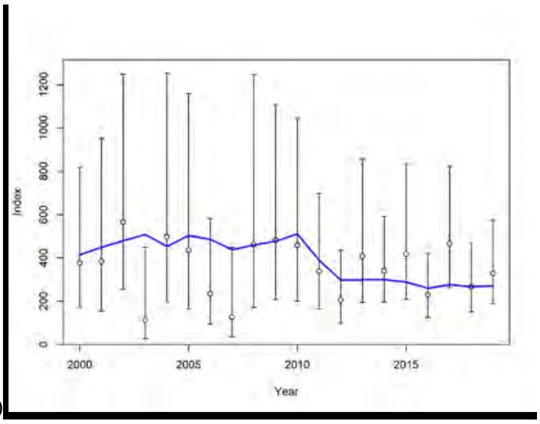
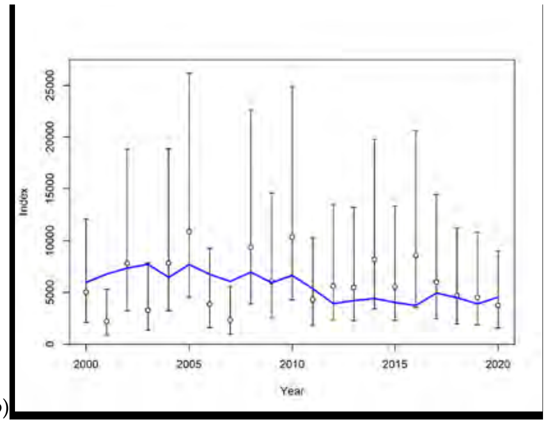


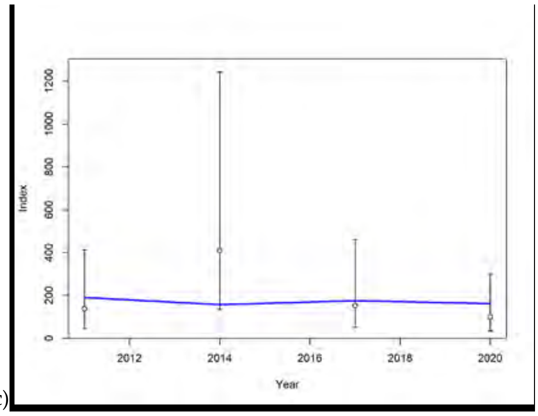
Figure 6.3.3.1. Fit between model and age composition from the Pelgas survey and commercial vessels (up to 2019).



a)



b)



c)

Figure 6.3.3.2. Fit between model and survey indices: a - Acoustic (Pelgas), b - egg count (Bioman), c - DEPM.

6.3.4 Retrospective pattern

Retrospective patterns were considered as 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 2015–2020 (Figure 6.3.4.1) 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 (2020).

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 slightly decreased in comparison to previous assessment (especially for R):

- Mohn's rho for SSB is 0.214 (previously 0.231).
- Mohn's rho for F is -0.203 (previously 0.264).
- Mohn's rho for R is 0.009 (previously -0.152).

Considering the assessment methodology this year has been benchmarked in 2019, 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 prior the 2019 , 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. The relatively high value observed for SSB and F seems related to the assessment with final year 2017. That year, egg count and acoustic index were having opposite trends which may have brought some conflicting signals into the model.

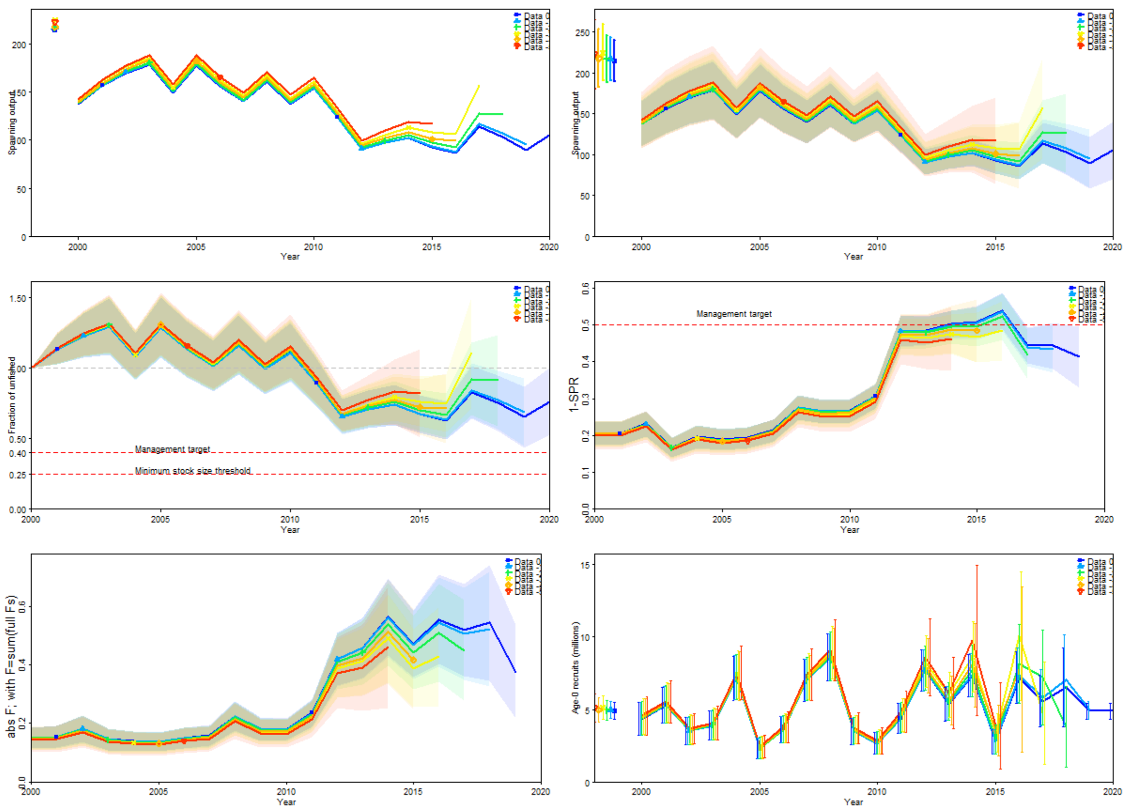


Figure 6.3.4.1. Summary of retrospective plots.

6.3.5 Comparison with previous assessment

The comparison is done with the run carried out during the Inter-benchmark (Figures 6.3.5.1–6.3.5.3). 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 2019 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 2019 value. The opposite is observed for the fishing mortality. There is no clear pattern for recruits.

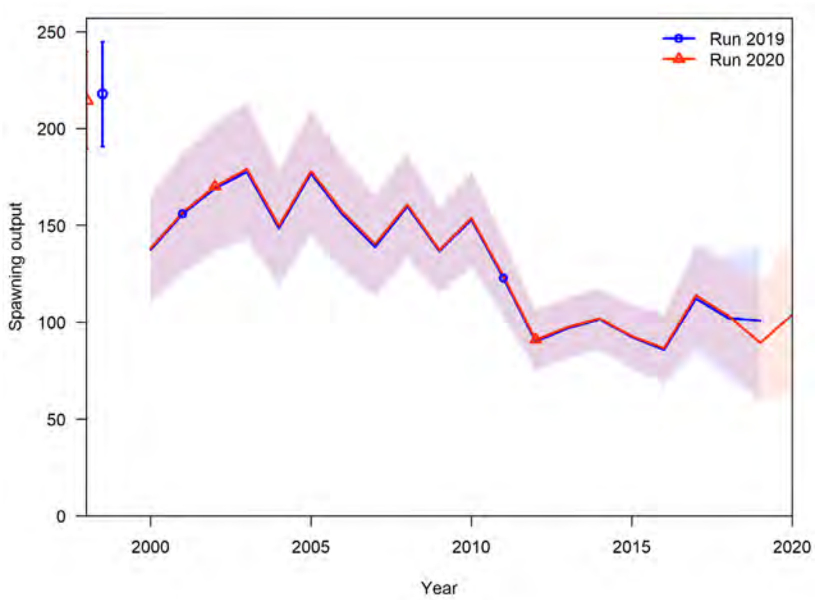


Figure 6.3.5.1. Comparison of SSB estimates between this year and the 2019 inter-benchmark run.

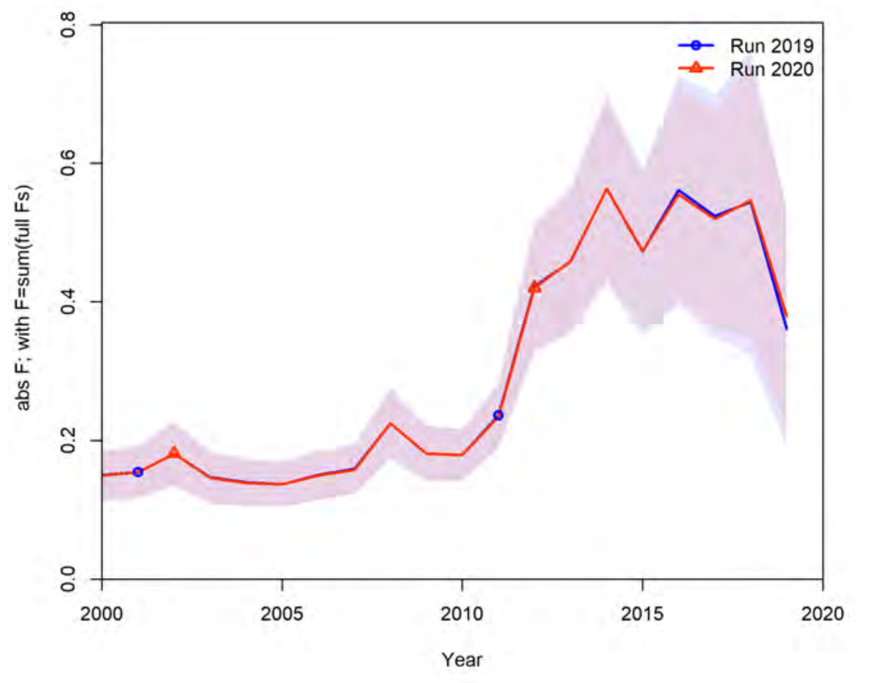


Figure 6.3.5.2. Comparison of F estimates between this year and last year's runs.

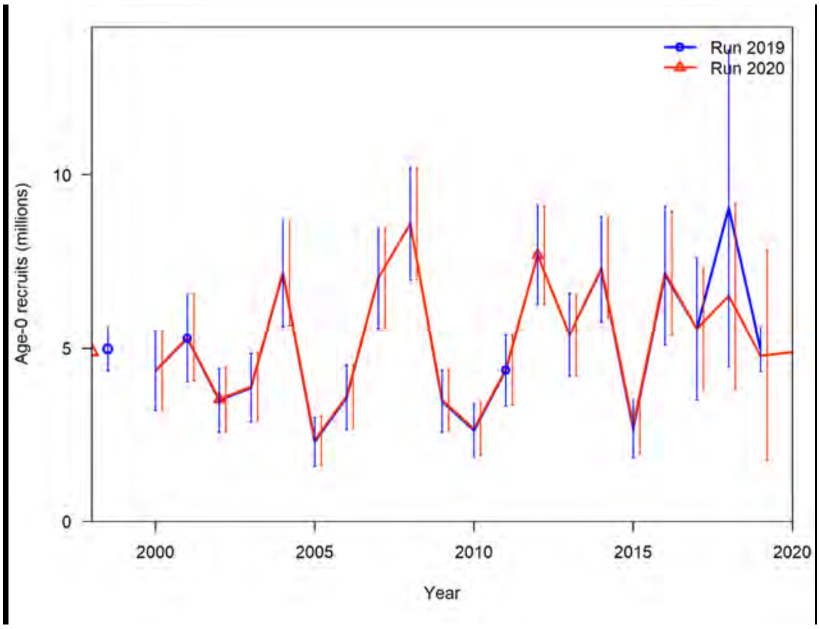


Figure 6.3.5.3. Comparison of Recruitment estimates between this year's and last year's runs.

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 in 2020 by the average of PELGAS survey for the period (2017-2019). 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 in 2020 by the average of the PELGAS survey for 2017-2019. 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). Preliminary catch were available for quarter 1 to 3.

The assumption for the catch in 2020 relies on preliminary catch statistics available from January to mid-November. The catches from mid-November and December were assumed to be equal to those already reported in Q4 by mid-November 2020. This deviates from the stock annex as the standard procedure would results in projected catches for Q4 that would considered too high to be achievable by the fishery by the end of the year (17 143t in Q4 leading to a total of 38 862t for 2020, above highest historical catches of the series).

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

Recruitment for 2020 was assumed to be 4839 million 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 (2020)	0.451	Based on estimated catches for 2020
SSB (2021)	90 558 tonnes	Short-term forecast
$R_{age\ 0}$ (2020/2021)	4839 million	Geometric mean (2000–2019)
Total catch (2020)	31 158 tonnes	Preliminary value based on reported catches until mid-November and predicted catches for Quarter 4.
Discards (2020)	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
2020	0	4838.712	0.001	0.0262	0	1.071	0.008
	1	1630.191	0.0252	0.0378	0.8089	0.6912	0.219
	2	934.482	0.0429	0.0484	0.9992	0.5463	0.378
	3	322.530	0.0521	0.0571	0.9987	0.4752	0.498
	4	157.669	0.0594	0.0635	0.9987	0.4356	0.498
	5	22.994	0.0661	0.0699	1.0000	0.4122	0.498
	6+	37.069	0.0777	0.0739	0.9986	0.3978	0.498
2021	0		0.0000	0.0246	0	1.071	0.007
	1		0.0238	0.0379	0.7792	0.6912	0.209
	2		0.0429	0.0484	0.9990	0.5463	0.360
	3		0.0518	0.0573	0.9996	0.4752	0.474
	4		0.0576	0.0633	0.9979	0.4356	0.474
	5		0.0642	0.0697	1.0000	0.4122	0.474
	6+		0.0736	0.0739	0.9995	0.3978	0.474
2022	0		0.0000	0.0246	0	1.071	0.007
	1		0.0238	0.0379	0.7792	0.6912	0.209
	2		0.0429	0.0484	0.9990	0.5463	0.360
	3		0.0518	0.0573	0.9996	0.4752	0.474
	4		0.0576	0.0633	0.9979	0.4356	0.474
	5		0.0642	0.0697	1.0000	0.4122	0.474
	6+		0.0736	0.0739	0.9995	0.3978	0.474

Table 6.4.3. Management option table.

Basis	Catch (2021)	F (2021)	SSB (2022)	% SSB change *	% Catch change **	% Advice change ***
ICES advice basis						
MSY approach: FMSY	27 858	0.453	86 609	-4	13	-20
Other scenarios						
F = 0	0	0	108 239	19.5	-100	-100
F = Fpa	32 217	0.539	83 306	-8	31	-8
F = Flim	42 192	0.757	75 849	-16	71	21
SSB2022 = Blim	69 659	1.589	56 300	-38	183	100
SSB2022 =Bpa= MSY Btrigger	38 353	0.669	78 700	-13	56	10
F = F2020	27 832	0.4525	86 629	-4	13	14

*** SSB 2022 relative to SSB 2021.**

**** Catch in 2021 relative to catch in 2010 (24 579 t).**

*****Advised catch for 2021 relative to advised catch for 2020.**

Based on the GM recruitment and *catch assumption* in 2020, for all catch options except for the SSB target of B_{lim} in 2022, the SSB will remain well above $B_{trigger}$. In all cases except no fishing, SSB in 2022 is expected to decrease compared with the one of 2021.

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). Bpa 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.

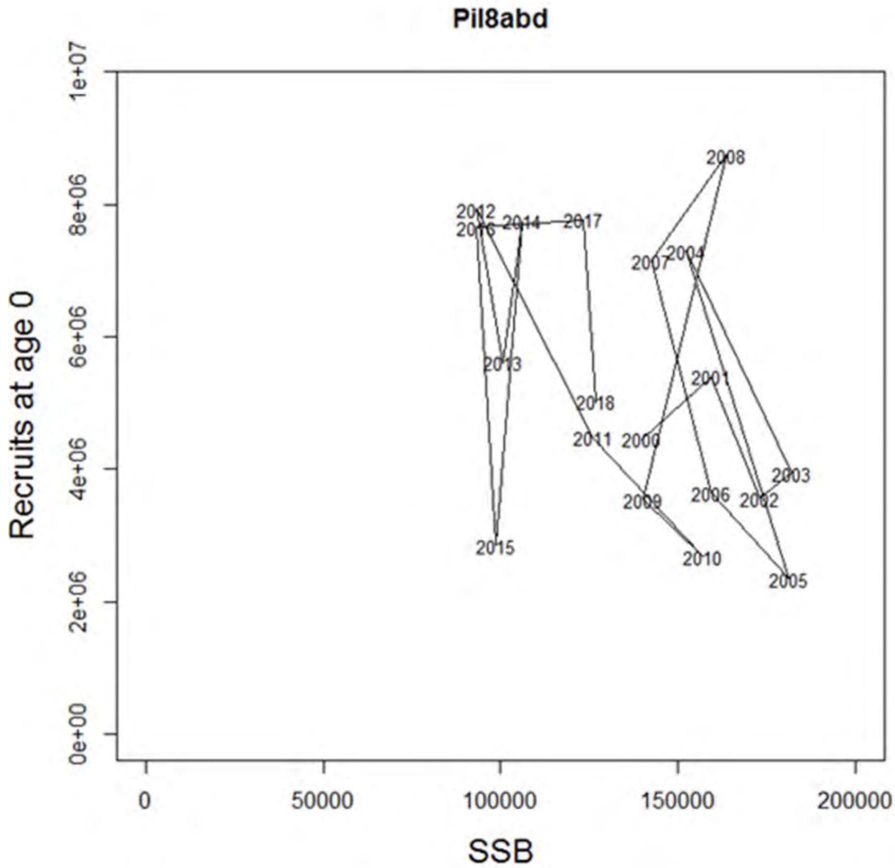


Figure 6.6.1. Stock–recruitment relationship for sardine in 8abd.

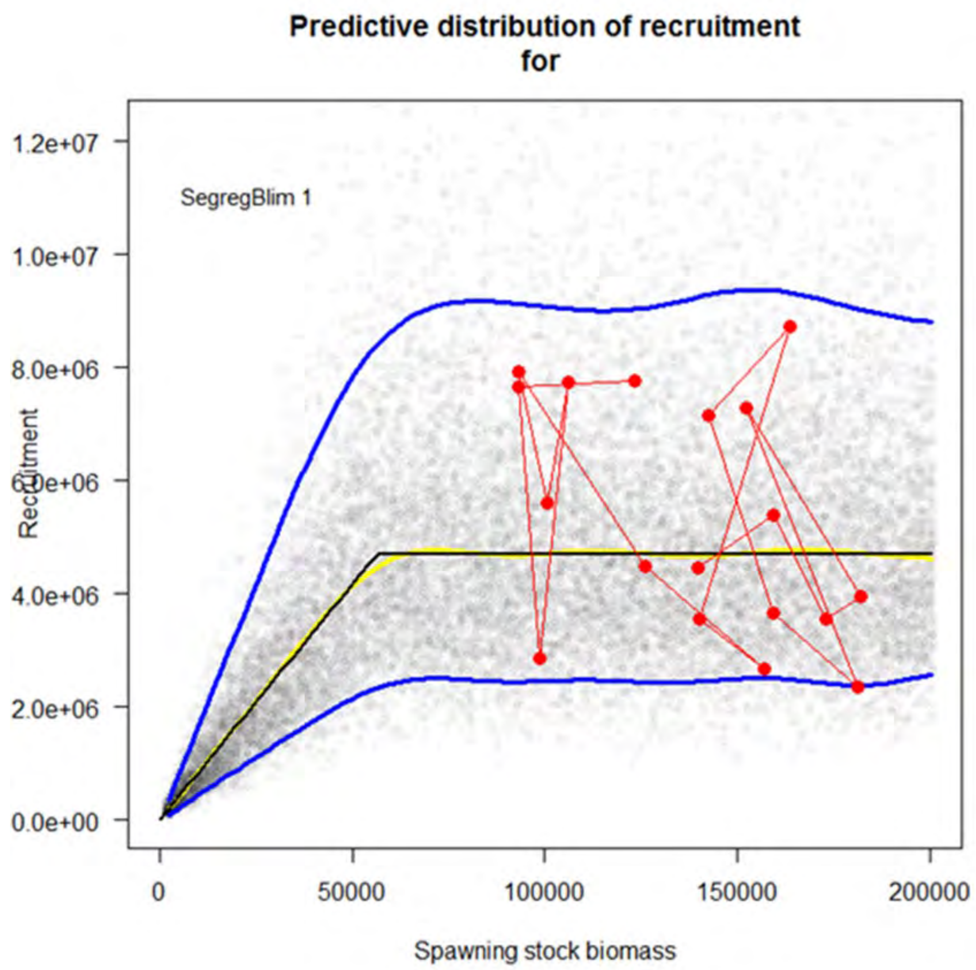


Figure 6.6.2. Segmented regression model with the breakpoint fixed at B_{lim} for sardine in 8abd.

6.6.1 References

Beddington, J.R. and Cooke, J. 1983. The potential yield of previously unexploited stocks. FAO Fisheries Technical Paper No. 242, 63 pp.

Horbowy, J., and Luzeńczyk, A. 2012. The estimation and robustness of FMSY and alternative fishing mortality reference points associated with high long-term yield. Canadian Journal of Fisheries and Aquatic Sciences, 69: 1468–1480.

ICES. 2018. Report of the Working Group on Southern Horse Mackerel, Anchovy and Sardine (WGHANSA), 26–30 June 2018, Lisbon, Portugal. ICES CM 2018/ACOM:17. 639 pp.

ICES. 2019. Inter-benchmark process on sardine (*Sardina pilchardus*) in the Bay of Biscay (IBPSardine). ICES Scientific Reports. 1:80. 34 pp. http://doi.org/10.17895/ices.pub.5552

Mace, P.M. 1994. Relationships between common biological reference points used as thresholds and targets of fisheries management strategies. Can. J. Fish. Aquat. Sci. 51(1): 110–122. doi:10.1139/f94-013.

Mace, P.M. and Sissenwine, M.P. 1993. How much spawning per recruit is enough? Risk Evaluation and Biological Reference Points for Fisheries Management (eds S.J. Smith, J.J. Hunt and D. Rivard). Canadian Special Publication in Fisheries and Aquatic Sciences No. 120, National Research Council of Canada, Ottawa, 101–118.

Myers, R.A., Bowen, K.G., and Barrowman, N.J. 1999. Maximum reproductive rate of fish at low population sizes. Can. J. Fish. Aquat. Sci. 56: 2404–2419. doi:10.1139/f99-201.

Zhou, S., Yin, S., Thorson, James T., Smith, Anthony D. M., Fuller, M., and Walters, C. J. 2012. Linking fishing mortality reference points to life history traits: an empirical study. Canadian Journal of Fisheries and Aquatic Sciences, 69: 1292–1301.

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

Buckland S.T., Burnham K.P., Augustin N.H. 1997. Model selection: an integral part of inference. Biometrics 53:603–618.

ICES. 2017. ICES Advice technical guidelines. ICES Advice, Book 12.

ICES. 2016. Report of the Workshop to consider FMSY ranges for stocks in ICES categories 1 and 2 in western waters (WKMSYREF4), 13–16 October 2015, Brest, France. ICES CM 1025/ACOM:58.187 pp.

ICES. 2019. Inter-benchmark process on sardine (*Sardina pilchardus*) in the Bay of Biscay (IBPSardine). ICES Scientific Reports. 1:80. 34 pp. http://doi.org/10.17895/ices.pub.5552.

6.11 Deviations from stock annex caused by missing information from Covid-19 disruption.

1. **Stock:** Pil-8abd
2. Missing or deteriorated survey data:

PELGAS 2020 cancelled

- Acoustic index (not critical for the assessment as others surveys provide indices)
- Stock number-at-age (not critical - based on sensitivity analysis)
- Stock weight-at-age (critical – no other source of data)
- Stock maturity-at-age (not critical - can be duplicated from previous years)

3. Missing or deteriorated catch data:

None

4. Missing or deteriorated commercial *LPUE/CPUE* data

None.

5. Missing or deteriorated biological data: (e.g. maturity data)

- Stock number-at-age
- Stock weight-at-age
- Stock maturity-at-age

6. Brief description of methods explored to remedy the challenge:

- Sensitivity analysis carried out on previous "historical run" by removing last year of PELGAS data and by comparing the resulting outputs to regular assessments using full series (exercise done back in time with terminal years from 2014 to 2019)
- Sensitivity analysis of runs where missing data were replaced by DEPM stock structure estimates and/or last three years average from PELGAS.

7. Suggested solution to the challenge, including reason for this selecting this solution: (clearly document changes from the normal procedures in the stock annex)

- The assessment follows the stock annex procedure except no number-at-age data are provided for Pelgas in 2020.
- Stock weight-at-age and maturity weight-at-age are assumed in 2020 to be the average from PELGAS for the period 2017–2019.

8. Was there an evaluation of the loss of certainty caused by the solution that was carried out?

None but assessment uncertainties in the output are in the same range of magnitude than in previous years.

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.

Landings from England represent on average 59% of the total landings since 2011, increasing its contribution up to 85% in the last two years. 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.

The size composition of the landings was stable over time, although fishers consistently measured a higher proportion of big individuals than the processors (Figure 7.3.1). The difference in the mean size over the three years between data sources was 1 cm (19.3 cm for the processors' data and 20.3 cm for the fishers' data). The multiple peaks in the distributions from the processors are due to part of their staff measuring the samples with 1 cm precision instead of 0.5 cm. Although these discrepancies in the data must be further explored, the self-sampling initiative is considered a success by both scientists and industry and will continue 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 quantify 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 (Figure 7.4.1.1). In 2017, a higher resolution of 5 nmi between parallel transects was used in Lyme Bay (7.e).

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. On average, 33% of the stock has been found in French waters of 7e since the survey area was extended in 2017.

The time-series of biomass estimated from the PELTIC in the Core area (area surveyed since 2013, without the French part of Division 7.e) has significantly increased in the last three years, reaching the highest biomass in 2019 with 273 708 tonnes of sardine (Figure 7.4.1.3). Although the biomass in 2020 dropped up to 178 781 tonnes (0.31% coefficient of variation), it is still the second highest value of the time-series. The temporal series of the biomass in the total area (including French side of Division 7.e) was very similar, although it showed a slight drop in 2018 compared to 2017 that was not found in the Core Area (Figure 7.4.1.3). The biomass in the total area in 2020 was 332 098 (0.20% coefficient of variation) tonnes.

Biological analyses from trawl catches carried out during the PELTIC acoustic survey identified age classes from 0 to 9, although individuals older than 7 were only found in 2015. The abundance of the youngest classes (0–3) has increased since 2017 (Figure 7.4.1.4), and it was particularly high for age 0 in 2019, both in the core area (9 573 063 individuals) and total area (13 125 340 individuals). Whereas this high recruitment of age 0 decreased in the core area in 2020 (443 517 individuals), it remains in French waters of 7e (11 286 904 individuals in total area).

7.5 Stock assessment

This stock is considered a category 5 stock, and the status is therefore evaluated based on trends in landings only.

The status of the stock is unknown but there are no signals of over-exploitation. The length composition of the landings has been stable over the three years of data, and although the biomass estimated from the PELTIC acoustic survey dropped in 2020, it is still higher than prior 2018. The PELTIC also found high recruitment levels in the last two years, and therefore high abundance are expected in the following years.

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.

Additionally, the harvest rate (estimated as the proportion of the landings in relation to the biomass estimated from the PELTIC) has never exceeded 20% since the starting of the PELTIC time-series, which is usually considered a safe level of exploitation.

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.

There is a benchmark in 2021 to compile the data available for this stock, assess their quality, and identify the most appropriate method to assess this stock. Depending on the results, this stock might be upgraded to category 3.

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 this fishery and there is no international TAC. Following the ICES framework for category 5 stocks, ICES aim to provide catch advice for sardine in Sub-area 7 based on landing trends every two years. However, quantitative advice has never been provided due to high uncertain of the landing data.

The landing data, as well as the PELTIC time-series, will be evaluated in the benchmark in 2021. The stock might be upgraded to category 3.

7.9 References

ICES. 2015. Manual for International Pelagic Surveys (IPS). Series of ICES Surcvey Protocols SISP 9 – IPS. 92 pp.

ICES. 2017. Report of the Benchmark Workshop for Pelagic Stocks (WKPELA). 6–10 February 2017, Lisbon, Portugal. ICES CM 2017/ACOM:35. 278 pp.

Table 7.2.1.1. Official landings (tonnes) by country reported to ICES (1970–2019) in ICES Subarea 7.

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

	France	United Kingdom	Netherlands	Ireland	Germany	Denmark	Lithuania	Belgium	Spain	Poland
1996	1563	7304	48	0	0	1396	0	0	0	0
1997	3346	7280	411	0	13	1124	0	0	0	0
1998	1974	6873	1647	192	100	14316	0	0	0	0
1999	119	4815	5166	2375	146	3490	0	0	8	0
2000	4074	4353	6586	354	436	1682	0	0	0	0
2001	8589	10375	6609	1060	454	0	0	0	0	0
2002	5324	7858	1905	2652	224	0	0	0	10	0
2003	6594	4358	6897	2580	25	0	0	0	0	0
2004	6681	2681	2187	6195	109	742	0	0	0	0
2005	11113	3631	2231	2083	274	0	0	0	5	0
2006	12965	1925	2287	698	481	0	17	0	2	0
2007	8865	2654	1106	14	0	4	0	0	0	0
2008	8665	3470	2073	875	42	54	0	0	0	0
2009	4135	2541	3406	33	0	0	0	0	0	0
2010	850	2521	6645	25	106	13	0	0	0	0
2011	507	3604	513	983	22	3	0	0	0	0
2012	444	4423	1439	8	0	0	0	0	0	0
2013	1768	3722	1804	236	214	40	0	0	0	0
2014	1202	3889	249	0	18	953	0	0	0	0
2015	1040	4293	1137	380	1551	1011	1	0	0	0
2016	863	9389	4697	232	1941	2286	0	1	0	0
2017	726	7623	1349	140	1095	2459	0	0	0	0
2018	663	8141	0	44	490	263	0	0	0	0
2019	873	6430	90	33	53	0	40	0.47	0	0.42

Figure 7.2.1.1. Official landings (tonnes) by country reported (1970–2019) in Subarea 7.

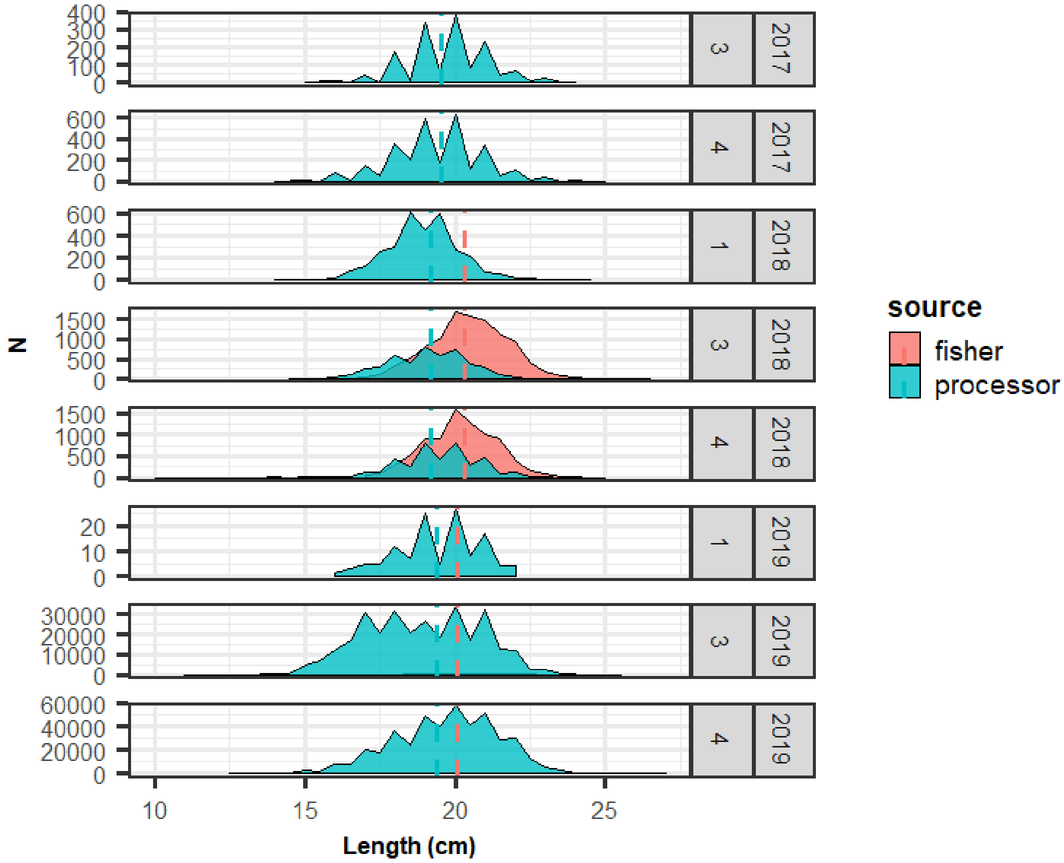


Figure 7.3.1. Length–frequency distribution of landings from the Cornish ringnetters by year and quarter. Distributions were estimated with the data provided by fishers and processors

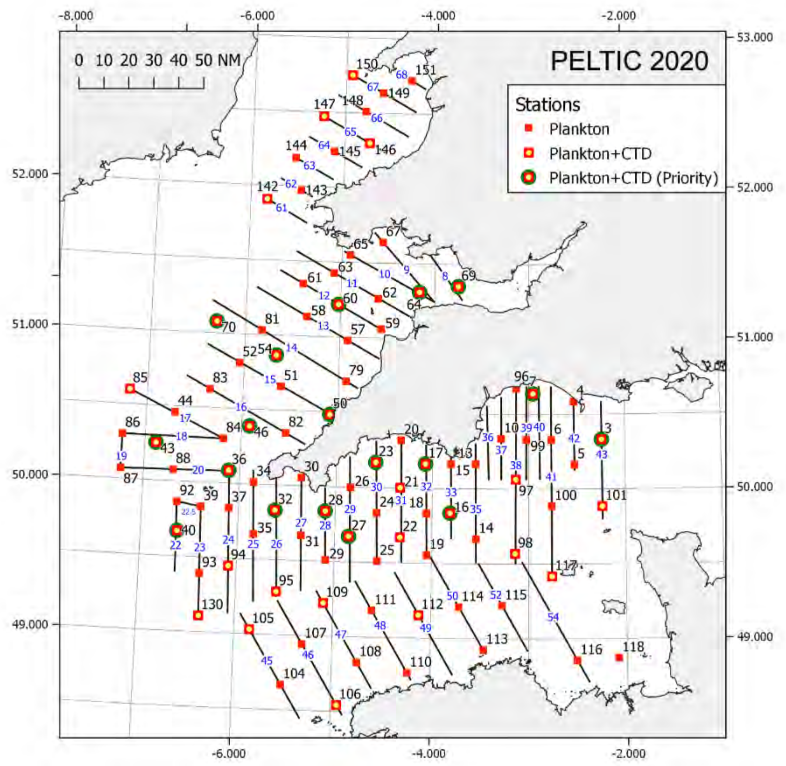


Figure 7.4.1.1. Survey area in 2020, showing the acoustic transects (blue lines), plankton stations (red squares) and hydrographic stations (Yellow circles).

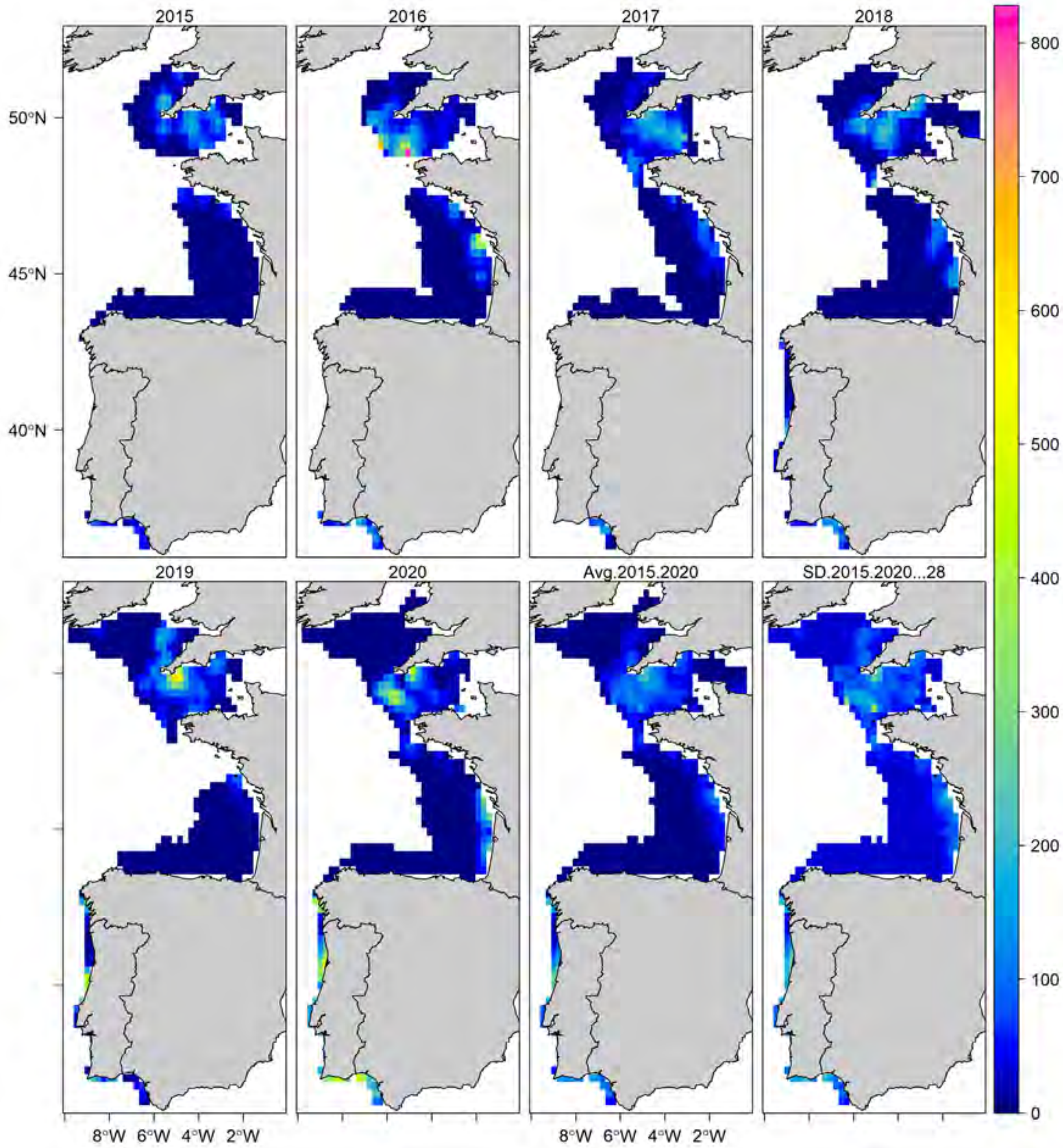


Figure 7.4.1.2. Annual autumn acoustically derived sardine distribution in the Northeast Atlantic Ocean, shown separately for the years 2015–2019, and for all years averaged (including the standard deviation). Note that in 2015 and 2016 spatial coverage of the combined PELTIC and JUVENA surveys was incomplete,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

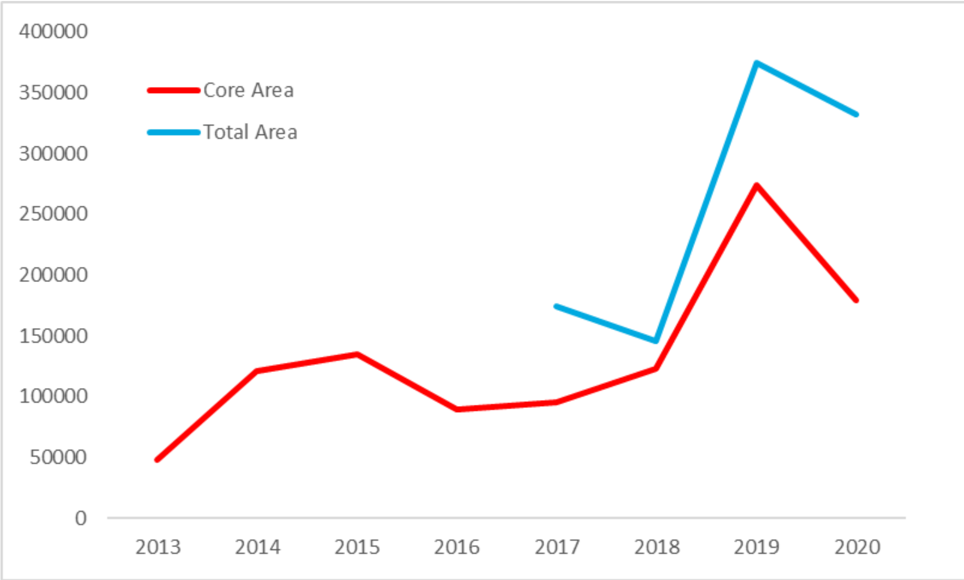
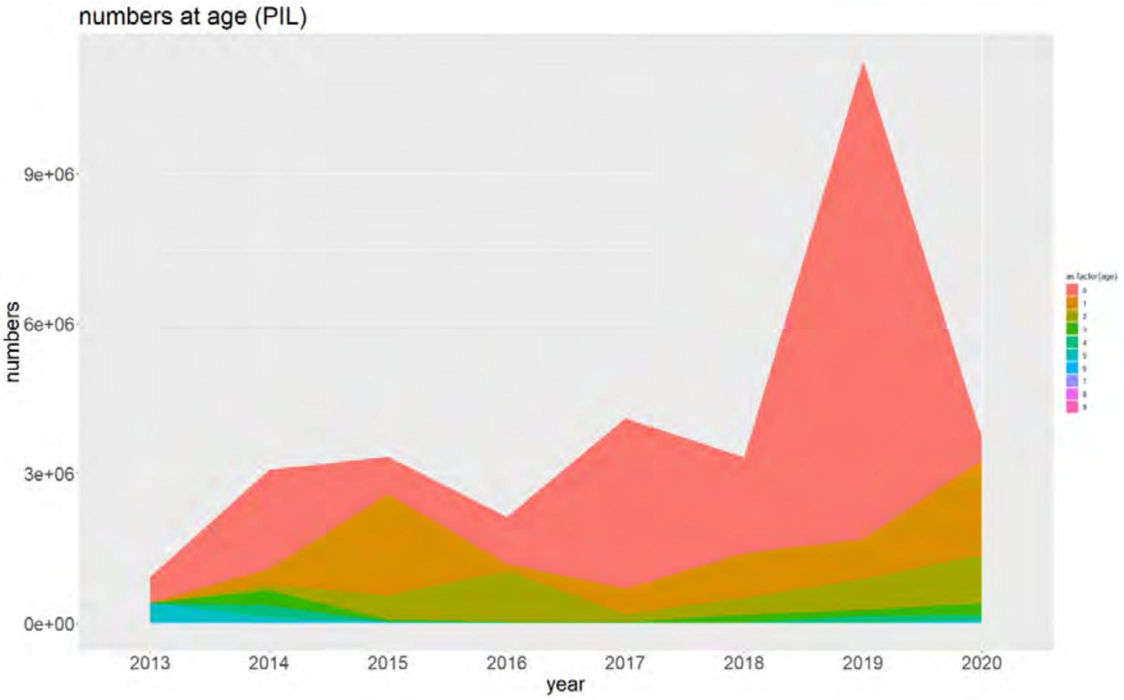


Figure 7.4.1.3. Sardine biomass in tonnes estimated from PELTIC survey in the core area (red line), covering Division 7.f and English waters of 7.e, and in the total area (blue line), covering Division 7.f and 7.e (also French side).

a)



b)

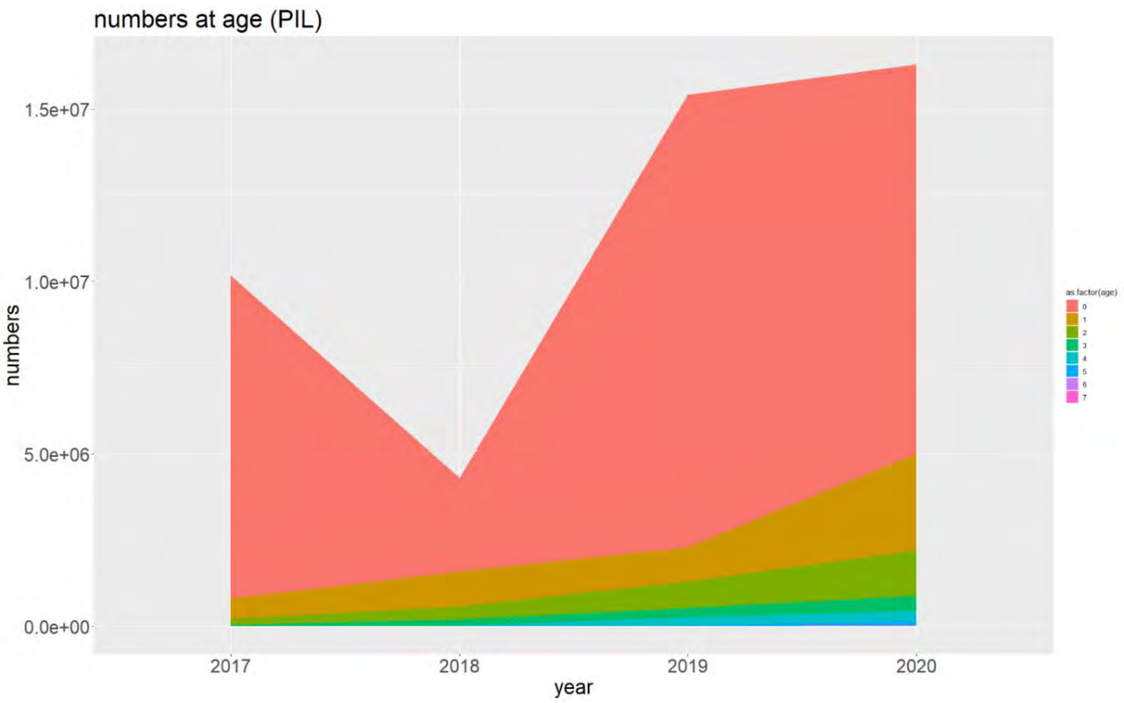


Figure 7.4.1.4. Numbers-at-age estimated from the fish samples collected during the PELTIC survey: a) Core area, covering Division 7.f and English waters of 7.e; b) Total area, covering Division 7.f and 7.e (also French side).

8 Sardine in 8c and 9a

8.1 ICES Advice Applicable to 2020 and stock management

In Portugal, sardine catches were not allowed with any fishing gear from the 12th of October 2019 to the 31st of May 2020 (Despacho n.º 9004-A/2019, Diário da República, 2.ª série - N.º 193 - 8 de Outubro de 2019; Despacho n.º 5713-A/2020, Diário da República, 2.ª série - N.º 100 - 12 de Maio de 2020). From the 3st of June to the 31st of July, a catch limit of 6300 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 5713-A/2020, Diário da República, 2.ª série - N.º 100 - 12 de Maio de 2020). In 2020, there was a bilateral agreement between Portugal and Spain on setting a provisional catch quota until the end of July of 9500 t, from which 3182.500 kg corresponded to Spain. The purse-seine fishery for sardine in Spain remained closed since 31st October 2019, and was reopened on 4th May 2020 (BOE-A-2020-4947), with maximum catches allowable during May of 1000 kg by day/vessel and 1500 kg until the end of July. Likewise, as in Portugal, landings of sardines smaller than 15 cm are limited and onboard observer programme continues.

8.2 The fishery in 2019

8.2.1 Fishing fleets in 2019

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 2019 indicate that the number of purse-seiners taking sardine were 430, with mean power of 231Kw.

In Portuguese waters, fleet data indicate that 176 vessels landed sardine with mean vessel tonnage of 69.9 GT and engine power category of 359 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 2019 are shown in Tables 8.2.2.1, 8.2.2.2 and Figure 8.2.2.1. Total 2019 landings in divisions 8c and 9a were of 13 760 t, which represents a decrease by 8.6% with respect to 2018 landings (15 062 tonnes). The bulk of the landings (99%) were made by purse-seiners.

In Spain, sardine landings, 3964 tonnes, represent a 26% decrease in relation to values from 2018 (5323 tonnes). All ICES subdivisions, except 9aN where catches increased by 26%, showed a significant decrease in catches (42% in 8c and 25% in 9aS-Cadiz).

In Portugal, sardine landings remain stable (9796 tonnes in 2019 vs 9738 tonnes in 2018), but with an uneven contribution by area to that of the previous year. Catches in the 9aS-Algarve subdivision increased by 42% compared to 2018, and in the western areas 9aCN and 9aCS decreased by 2% and 10%, respectively.

Table 8.2.2.1 summarises the quarterly landings and their relative distribution by ICES subdivision. In 2019, as in 2018, due to management regulations implemented in Spain and Portugal (see Section 8.1. of the report), the sardine fishery opened later in the yea. The catch agreed for both countries was reached in October and the fishery remained closed in November and December in both Spain and Portugal. For that reason, the sums of the second and third quarter landings represent more than 90% of the annual catches.

The relative contribution of the different areas for the total catch is similar in relation with 2018, with area 9aS-Cadiz loosing importance.

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 2019 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

Annual length distributions (Table 8.2.4.1a) show that, as usual, smaller individuals were caught in 9aS-Cádiz subdivision. Length distributions were unimodal in Spain in 9aS-Cadiz and 8cE (with modes at 14.5 cm and 19.5 cm, respectively). In western areas, subdivision 9aN and 8cW, distributions were bimodal, with a smaller mode at 14.5 cm and another at 19.5 cm and 21 cm respectively.

Tables 8.2.4.1b,c,d,e show the quarterly length distributions of landings from each subdivision.

For Portugal, sardine annual length distributions were unimodal in 9aS-Algarve and 9aCS, with a mode at 17 cm and 18.5 cm, respectively. For 9aCN subdivision, length distribution is bimodal, with a bigger mode at 18.5 cm and another at 14 cm.

Table 8.2.4.2 shows the catch-at-age in numbers for each quarter and subdivision for the year 2019, 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 1 had the higher contribution, 34% of the total biomass in catches, followed by age 2, with 20% of the catches. Age 0 was mainly caught in the main recruitment areas of this stock: 9aS-Cadiz (56%), and in the northern areas of 9a division (9aN and 9aCN subdivisions). Age-3, strong 2016 year class, was still dominant in the Cantabrian (8c division).

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 WGACEGG (e.g. WGACEGG 2019), where final results were presented and fully discussed (ICES, 2020).

In 2020, IPMA DEPM survey was carried out in R/V Vizconde de Eza between the 3rd and 29th of February. This survey covers subdivisions 9aCN, 9aCS and 9aS while the Spanish DEPM survey (SAREVA0320) samples traditionally the spawning sardine population in the 9aN and 8c subdivisions (Figure 8.3.1.1). In 2020, due to the Coronavirus COVID-19 health crisis and the subsequent 'state of alarm' lockdown in Spain, the survey SAREVA0320 was cancelled.

Samples from the Portuguese DEPM survey are being processed, and data from the survey will be presented to WGACEGG in November 2020. During the Working Group, it will be discussed if these data can be used, and how, as an input for the next assessment (2021).

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 divisions 8c and 9a. The Iberian acoustic survey is planned and discussed within WGACEGG (e.g. WGACEGG 2019). As described in the Stock Annex, the total numbers of individuals and 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 8c and 9a using acoustic methods. The Portuguese survey (PELAGO20) took place, for the first time, onboard the RV "Miguel Oliver". The Spanish survey (PELACUS0320), normally carried out on the RV "Miguel Oliver", was canceled due to the coronavirus (COVID-19) pandemic, a few days before its planned start in March.

The methodology applied in both surveys is agreed and revised at the WGACEGG.

8.3.2.1 Portuguese spring acoustic survey

The PELAGO acoustic surveys have sampled the Portuguese and Bay of Cadiz continental shelves, since 1995 with the R/V Noruega, a 49 m trawl vessel. In 2020, PELAGO was carried out on-board of the RV Miguel Oliver, an acoustic trawler of 70 m length, 2x1000 kW diesel-electric, the same vessel used since 2013 for the Spanish spring acoustic surveys.

PELAGO20 survey started on the 4th of March in the Gulf of Cadiz (sampled westwards), the calibration took place in Vigo on the 12th of March and the western area was sampled from the 13th to the 24th of March (southwards).

26 pelagic fishing stations, 25 being positive, and 25 fishing hauls done by chartered commercial purse-seiners were used to characterize the pelagic fish community. 15 thousand tonnes of fish were caught by RV Miguel Oliver, corresponding to 736 thousand fish. Sardine accounted for 38% of the total catch in weight (30% in number) and was present in 72% of the trawl hauls. In addition, 25 fishing operations were carried out by commercial purse-seiners, and sardine was caught in more or less in the same proportion on average in the research trawl hauls.

Figure 8.3.2.1.1 shows the acoustic transect along the surveyed area and Figure 8.3.2.1.2 shows the fishing operations conducted during the survey and the proportion of species in each fishing station.

Sardine and anchovy occurred in the northern part of the surveyed area in schools evenly distributed. Sardine schools were thicker and denser than the anchovy schools. Figure 8.3.2.1.3 shows the NASC values allocated to sardine. Highest values of NASC were found in the northern area. Yet, in almost all strata few dense schools have a significant contribution to total NASC, giving a highly skewed distribution, where few values have a great contribution to both mean and variance.

Figure 8.3.2.1.4 and Table 8.3.2.1.1 show the abundance in number and biomass by length and age class, respectively. In 9aCN the bulk of the fish are smaller than 16 cm and represent 99% of age 1 individuals, reflecting the strength of the 2019 year class already detected last year during the IBERAS survey. In 9aCS, the length distribution is bimodal with a main mode at 16.5 cm of age 1 individuals. The second mode of larger individuals includes mainly four year old sardines of the 2016 cohort. In 9aS-Algarve larger fish dominate and the modal age class is the age 2 sardines. For the 9aS-Cadiz it should be highlighted a first mode located at 7 cm, that belongs to an early offspring of the 2020 cohort, i.e. age 0 individuals; a second and a third modes are also observed at 13.5 cm and 17.5 cm. In this area, most sardines belong to age classes 0, 1 and 2.

In relation to 2019, total abundance of sardine (18 939 million individuals) showed an increase of 316%. Abundance of 1+ individuals, 16 581 million, represents an increment of 350%.

The sardine B1+ was estimated to be 385 thousand tonnes for the whole area, representing a significant increase of 153% in relation to the PELAGO19 survey.

In April and after the survey, results of PELAGO20 were discussed during an extraordinary meeting of the WGACEGG in order to assess the validity of the estimation due to the change of methodology. The aspects analysed were the following:

1. Different vessel:

Although an inter-calibration was not carried out before the survey (the change of vessel was made shortly before the survey and the calendar of the boat did not allow it), historic inter-calibration exercise between RV Miguel Oliver and RV Thalassa suggested very little difference in acoustic data. The number of fishing stations was more significant in affecting results of historic comparison. During PELAGO20 high number of stations was achieved, with support from purse-seiners.

2. Earlier timing:

WGACEGG considers that it was not expected to affect results, as survey still captured the population in same seasonal cycle as time-series.

3. Post-processing methodology:

In 2020, results were presented comparing two different approaches:

- IPMA: traditional PELAGO approach (historic series) using two frequencies (38 and 120 kHz), no plankton filters, Movies software + IPMA routines;
- IEO: Vigo (PELACUS) approach, multi-frequency (18, 38, 70, 120 & 200 kHz), EchoView software, plankton filters + QGIS, IEO routines.

Post-processing approach showed very little difference apart for one or two strata (15% difference). Data presented to WGHANSA are those based on the traditional method.

As a result of WGACEGG meeting, PELAGO20 data were approved for submission to WGHANSA (see Annex 2).

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 (especially for age-0 individuals), although they have interannual differences (Figure 8.3.3.1).

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 this 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 (Figure 8.3.3.2).

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. In 2018, the survey was carried out in November and in 2019, the date was advanced to September. 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 was confirmed with the estimates of age 1 of PELAGO20.

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. Deviations from the stock annex caused by missing information due to the COVID-19 disruption are described in detail in Section 8.9. Deviations were in the input data from the joint acoustic survey abundace index. Additional details on the input data used in the stock assessment model can be found in the stock annex (See Annex 3).

Input data	WGHANSA 2020
Catch	Catch biomass 1978–2019 (tonnes)
	Catch-at-age 1978–2019 (thousands of individuals)
Acoustic survey (Joint SP+PT) *	Total numbers 1996–2020 (thousands of individuals)
	Numbers-at-age 1996–2020 (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 1978–2019 (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, 2017–2019), kg

Input data	WGHANSA 2020
Maturity-at-age	From DEPM surveys in DEPM years, linear interpolation for years in-between (constant 1978–1998, 2017–2019), proportions
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 2006–2019. 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 8.4.1.1 shows the parameters estimated by the assessment model. Fishing mortality-at-age and numbers-at-age are presented in Tables 8.4.1.2 and 8.4.1.3. Parameters estimated in the 2020

assessment are also comparable to those from the 2019 assessment, virgin recruitment ($R_{0,2020}$ = 14 901 700 vs $R_{0,2019}$ = 14 513 300, CV = 3%) and the initial F ($initF_{2020}$ = 0.75 year^{-1} versus $initF_{2019}$ = 0.79 year^{-1}, CV = XXX%). Catchability parameters are close to 1 for both the acoustic (Q = 1.29, RMSE = 0.30) and the DEPM (Q=1.17, RMSE=0.31) surveys. Correlations between the assessment parameters range from -0.87 to 0.42 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 (four cases) and one case in the last period.

The assumed standard error for both surveys, all years = 0.25, is consistent with the residual mean square errors estimated by the model, 0.30 for the acoustic index and 0.31 for the DEPM index. The harmonic mean of the fishery age composition sample size, 76, 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 20).

Figures 8.4.1.1 and 8.4.1.2 show the fit of the model to the acoustic survey and DEPM indices of abundance. Both are similar to the fit of the 2019 assessment model but, in the case of the acoustic survey index the model shows a sligthly worse fit in the last three years. The assessment of 2020 shows a poor fit to the 2020 point estimate of the acoustic survey index. It is observed that in previous years, high values of the point estimate of the acoustic surveys have poorer fits, i.e. positive residuals for the recruitment estimates in the surveys.

Figure 8.4.1.3 shows the model residuals from the fit to the catch-at-age composition (top panel) and the acoustic survey age composition (bottom panel). Catch-at-age residuals in the last year (2019) are higher than in the last couple of years, positive for ages 1, 2 and 3 and negative for all the other ages. Residuals for age zero class are the highest. The acoustic survey residuals in 2020 are positive for age one and negative for all other ages. Residuals for this index are also higher than in the last couple of years.

The fishery selectivity patterns estimated in the present assessment show less abrupt changes over time and through ages (particularly at the age-6+ group) (Figure 8.4.1.4). The patterns over age are dome-shaped in the three periods with the early (1978–1987) and recent periods (2006–2019) 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 2020 assessment results is shown in Table 8.4.1.4 and Figure 8.4.1.5 (in the figure compared the 2019 assessment model results). The estimate of B1+ in 2020 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. Zero catches were assumed for 2020 since the fishery was closed until the 4th of May, i.e. there were no catches before the survey took place. 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 2020 is predicted to be 344 114 t (CV = 15.8%), assuming that the stock weights are equal to the mean of the last six years. This represents an increase of 66% when compared with B1+ in 2019 = 207 412 t (CV = 13.8%). B1+ is above B_{lim} = 196 334 t, Bpa = 252 523 t and MSY $B_{trigger}$ = 252 523 t of the current low productivity regime of the stock (see Section 8.7). $F_{bar\ 2–5}$ in 2019 is estimated to be 0.058 year^{-1} (CV = 14.4%) 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, has been fluctuating around historically low values. The 2019 recruitment estimate (R_{2019} = 16 760 900, CV = 21%) constitutes the highest value since 2004 and is above the long-term geometric mean (geometric mean 1978–2018 = 13 752 797). This constitutes an increase of 127% when compared with recruitment in 2018 (R_{2018} = 7 391 850, CV = 18.9%). The increase in recruitment was first observed by the IBERAS 2019 juvenile survey and was later confirmed by the 2020 acoustic survey PELAGO (Section 8.3.3).

8.4.2 Reliability of the assessment

Data from the Spanish (PELACUS) and Portuguese (PELAGO) acoustic surveys are a joint index in the assessment model. 2020 PELACUS survey could not be carried out due to the Coronavirus (COVID-19) pandemic. A sensitivity analysis was carried out to evaluate the possible impact of the lack of PELACUS data in both the assessment estimates and the quality of the assessment (see Section 8.9 for details). Results show that estimates are within the confidence intervals of the estimates from the 'true' assessment with few exceptions. The biggest changes were found for recruitment estimates within the runs without any acoustic data in the terminal year. Trends including the PELAGO acoustic data are more stable and with less deviation from the 'true' assessment.

Considering that PELAGO represents the majority of the population in numbers (mean = 91%) and that there is a significant correlation between sardine abundance of the two surveys, the PELAGO index was raised by a linear regression model to accommodate the lack of the PELACUS estimation (see Section 8.9).

Other parameters, such as sample size and cv of the acoustic index that are fixed throughout the time-series, have not been modified in the assessment settings because the disturbance in CV and sample size are expected to be minimum. Analyses carried out during the Working Group show that this was the case, and estimates for the main variables of the stock development are similar between different model parametrization of sample size and cv of the acoustic survey.

Without PELACUS age composition data there is a bias in the population age composition assumed for the acoustic abundance index in 2020 (PELACUS usually has a higher percentage of the older individuals). The causes of the poor fit to the 2020 acoustic index are not fully understood and will be investigated.

8.5 Retrospective pattern

Retrospective patterns for Biomass 1+, $F_{ages2\text{-}5}$ and recruitment were computed for years 2014–2020. 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 (2020). 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 8.5.1). The model slightly underestimates Biomass 1+ (Mohn's rho of -0.112) and recruitment (Mohn's rho of -0.24) while it overestimates $F_{ages2\text{–}5}$ (Mohn's rho of 0.059). Differences in the estimation of these parameters between runs are more pronounced for recruitment 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 (2020) and forecast year (2021) were set to the geometric mean of the last five years (2015–2019), $R_{2020–2021}$ = 7 584 483 thousand individuals. This changes the population number-at-age structure and it is therefore necessary to adjust fishing mortality in the interim year (2020). Fishing mortality in the interim year is the fishing mortality that corresponds to a catch constrain. The catch assumption for 2020 was assumed to be 19 106 tonnes based on the official documents published in Portugal and Spain prior to the WGHANSA (Despacho n.º 5713-A/2020, Diário da República, 2.ª série - N.º 100 - 12 de Maio de 2020, BOE-A-2020-4947). With the structure of the population used for the short-term forecast, this corresponds to a $F_{ages2–5,\ 2020}$ = 0.064.

For 2021, predictions were carried out with an $F_{multiplier}$ assuming an F_{sq}= 0.092, the average estimate of the last three years in the assessment (i.e. $F_{ages2–5}$ mean 2017–2019), as indicated in the Stock Annex.

Table 8.6.1 shows input data of the short-term forecast. Table 8.6.2 shows the results of the short-term forecast. The complete set of results for fine steps of $F_{multiplier}$ scenarios is stored in file pil.27.8c9a_stf_scenarios2020_HCR12.xls in the WGHANSA SharePoint.

8.7 Reference points

Biological Reference Points (BRPs) for this stock were re-evaluated 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	2006–2017	Technical basis
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, 2018).**

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}).

In 2019, ICES published two advices (ICES, 2019c) where 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, HCR4 and HCR12 (Figure 8.8.1), 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, and are consistent with the ICES precautionary approach with no more than 5% probability of the spawning–stock biomass (SSB) falling below B_{lim}.

A bilateral agreement between Portugal and Spain (Despacho 5713-A/2020; BOE-A-2020-4947) stating that they will manage the fishery in 2020 according to a harvest control rule, HCR12, evaluated as precautionary by ICES (ICES, 2019b). This management plan has not been adopted by the EU thus ICES provides advice based on the MSY approach.

8.8.1 Biological reference points: comments on terminology and estimation procedures

8.8.1.1 Communication of management based on MSY

Managers, stakeholders, and the general public have raised questions that underline difficulties to understand the 2020 Advice sheet for pil.27.8c9a. The EU Member States struggled to pass the message to ICES clients and the general public that if they manage the stock with HCR12 (HCR considered by ICES as precautionary in 2019) this is precautionary in the long term even if the F_{target} of HCR12 is above F_{MSY}. This is related to the fact that there might be as many target Fs as HCRs devised to manage sustainably a given stock. In summary, there might be other precautionary HCRs besides the ICES advice rule and this is difficult to acknowledge from the table of catch options in the advice sheet.

In this particular case, F_{MSY} = $F_{p.05}$ using the ICES MSY AR. This means that F_{MSY} had to be constrained so that the combination of $B_{trigger}$ and the ICES MSY AR comply with the precautionary criteria. We think it might be useful to somehow reflect that information in the Table of catch scenarios.

We suggest that the Table of catch scenarios should be reformulated so that it is easier to understand that the current ICES advice basis is a precautionary approach equivalent to HCR12. Moreover, from both scenarios only one (HCR12) provides the maximum precautionary fishing target that leads to higher yields.

Basis	Catch (2021)	F (2021)	Biomass 1+ (2022)	% Biomass 1+ change *	% Catch change **
ICES advice basis					
ICES MSY Advice Rule	10871	0.032	357223	2	-21
Other precautionary Advice Rules^					
F_{HCR3}	10871	0.032	357223	2	-21
F_{HCR4}	10871	0.032	357223	2	-21
F_{HCR12}	21472	0.064	349386	-1	56
Other Catch options					
F = F_{MSY}	10871	0.032	357223	2	-21
F_{y+1}= F_y (F_{2021} = F_{2020})	21472	0.064	349386	-1	56
F_{pa}	38767	0.118	336640	-4	182
F_{lim}	50506	0.156	328016	-7	267
B1+ (2022) = B_{lim} (196334)	235355	0.97	196334	-44	1611
B1+(2022) = B_{pa} (252523)	154932	0.554	252523	-28	1026
B1+ (2022) = MSY $B_{trigger}$ (252523)	154932	0.554	252523	-28	1026

^ Precautionary harvest control rule (ICES, 2019a, b).

8.8.1.2 Estimation Procedures

Within ICES different tools are used to estimate reference points. If we use the EqSim short cut approach we derive different reference points from those estimated within a full MSE approach. In the specific case of pil.27.8c9a, the large difference between the $F_{MSY} = F_{p.05}$ value obtained obtained for the ICES Advice rule with EqSim and the maximum precautionary F_{target} obtained for HCR12 in a full MSE (Figure 8.8.1), needs to be closely examined. Possible causes might be: estimated risk (risk type 1/3), different uncertainty levels for assessment and management, different uncertainty sources, time frame considered and different types of HCRs.

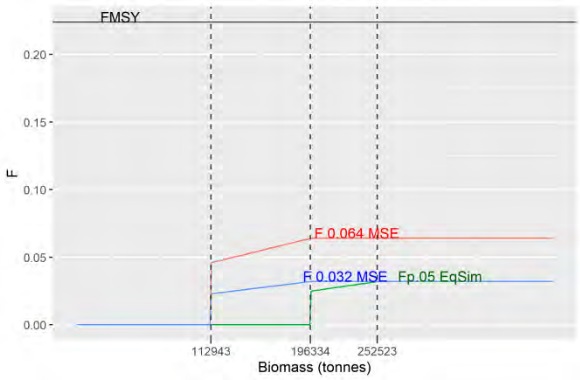


Figure 8.8.1. Sardine in 8c and 9ª: Different harvest control rules tested with EqSim (green line) and with MSE within WKSARMP.

8.9 Deviations from stock annex caused by missing information from Covid-19 disruption

1. **Stock:** pil.27.8c9a.
2. Missing or deteriorated survey data:

Two independent indexes (from acoustic and DEPM surveys) are used in the sardine 8c9a assessment. IPMA (Portugal) and IEO (Spain) carry out annually spring acoustic surveys and triennial DEPM surveys. For each type of survey, the results of both countries are added in a joint index. Results of the 2020 DEPM survey are not included in 2020 assessment because sample analysis is a process that takes several months. Results are going to be presented and discussed in the WGACEGG in November 2020 to evaluate if they can be included in the next assessment.

In 2020, the Spanish acoustic (PELACUS03020) and DEPM (SAREVA0320) surveys were cancelled due to the state of alarm lockdown in Spain. Portuguese surveys, which started earlier, could be carried out successfully this year.

3. Missing or deteriorated catch data:

No problem associated with catch data in this years' assessment due to the COVID disruption. Only the 2019 catch data are used in this years' assessment.

4. Missing or deteriorated commercial lpue/cpue data:

Not applicable.

5. Missing or deteriorated biological data: (e.g. maturity data)

No problem associated with biological data in 2020 assessment due to the COVID disruption.

6. Brief description of methods explored to remedy the challenge:

In the absence of the Spanish acoustic survey in 2020, the first analysis carried out during WGHANSA was to study the relative contribution of PELACUS to the total abundance of individuals and age structure (Figures 8.9.1 and 8.9.2). The PELAGO survey has the higher contribution to the total abundance and biomass of the combined survey index. Along the time-series, the total number of individuals observed in the stock area covered by the spring acoustic survey PELAGO represent 91% of the total number of individuals. Proportion-at-age largely differs between surveys, the younger individuals (age 1 and 2) predominate in the stock area covered by the PELAGO survey (75% or more) and older individuals have a higher proportion in the stock area covered by the PELACUS survey.

The correlation between the proportion that each age in each survey represents in the total number of individuals per year was also inspected (Figure 8.9.3) and there is no any apparent correlation within ages and between surveys. However, from 1996 onwards (years included in the assessment model), abundance in spring acoustic surveys shows a significant correlation between surveys (Figure 8.9.4).

A sensitivity analysis was carried out to evaluate the possible impact of the lack of PELACUS data in both the assessment estimates and the quality of the assessment. This analysis was done in a retrospective way, where previous assessments (2019, 2018, 2017, 2010 and 2005), including the combined index in the terminal year as described in the stock annex, were compared (e.g. CVs, summaries) with runs that mimick the same assessment but i) without the data from the PELACUS survey (number of individuals and numbers-at-age) in the terminal year, and ii) without the acoustic abundance index in the terminal year.

Ways to 'fill-in' the index for this year where the PELACUS survey is missing were discussed in a WebEx meeting prior to WGHANSA1. The VAST model-based approach (Thorson, 2019) is complex and the WG considered it would be difficult to have expertise and time to apply it for WGHANSA1 stocks. Other ways forward were mentioned, such as reviewing the possible use of opportunistic acoustic data recorded during BIOMAN in eastern part of Cantabrian and extrapolate information from PELAGO 9aCN to the 9aN, or use a model of the spatial and temporal progress of cohorts (Silva *et al.*, 2019). None of these approaches were feasible for the WGHANSA1 meeting but will be taken into account in the future as ways to 'fill-in' the survey index series in future assessments.

7. Suggested solution to the challenge, including reason for selecting this solution:

The group decision was to use as index in the terminal year the age proportion derived from PELAGO and the total abundance estimated as the sum of PELAGO abundance and the calculation of PELACUS abundance from the regression model between surveys in the time-series (Figure 8.9.4). The results from the sensitivity analysis showed estimates of all runs are within the confidence intervals of the estimates from the 'true' assessment with few exceptions. The biggest changes were found for recruitment estimates within the runs without any acoustic index. Also, trends without the PELACUS acoustic data are more stable (always seem to follow the same trend within estimates) and with less deviation from the 'true' assessment (change in proportion are lower) than without any acoustic index in the terminal year (Figure 8.9.5 and Table 8.9.1).

No further deviations were applied to the settings of the assessment model, considering the low effect on results and the arbitrariness of the selection. This decision was based on the complementary sensitivity analysis comparing the following different runs: i) updated assessment with no acoustic index on the terminal year; ii) updated assessment with total abundance and age proportion derived from PELAGO as index in the terminal year; iii) updated assessment with the age proportion derived from PELAGO but total abundance estimated as the sum of PELAGO abundance and the calculation of PELACUS abundance from the correlation between surveys in the time-series; iv) the previous run settings plus change in the **CV** of the acoustic index (CV was increased from 25 to 35%); v and vi) the same setting as run iii) but with change in the **sample size** from 25 to **20 (PELACUS20)** and from 25 to **15 (PELACUS15).** The objective of these two last runs was to reduce the weight of the acoustic index to the objective function, to take into account the lower level of sampling within the distribution area of the stock caused by the lack of PELACUS.

Differences between runs are small (around 5%; Figure 8.9.6 and Table 8.9.2). The raising the total numbers of individuals, the reduction of sample size and increase of CV of the acoustic abundance index in the terminal year also do not affect much to the quality of the assessment. The group considered that there were not enough arguments to modify CV and sample size, given that those settings had never been modified in previous years in the model despite the existence of problems related to the survey coverage, bad weather, etc. and the effect of the change on the assessment results hasn't been quantified. However, the group decided to raise the total numbers of individuals to take into the account the individuals in the stock area covered by the PELACUS spring acoustic survey. If one only used the total number of individuals from the PELAGO survey one would be underestimating the total number of individuals in the stock area.

8. Was there an evaluation of the loss of certainty caused by the solution that was carried out?

Yes, please see points 6 and 7 above.

8.10 Portugal and Spain request for updated advice on catch opportunities for 2020 for sardine (*Sardina pilchardus*) in divisions 8.c and 9.a (Cantabrian Sea and Atlantic Iberian waters)

ICES received a special request from Portugal and Spain (Annex 6) to review the catch advice for 2020 based on the most recent available data. ICES will responded to this request by updating the advice based on the results of the stock assessment conducted in 2020 (section 8). The WG reviewed the catch scenarios for 2020 based on the results of the stock assessment and a one year short term forecast conducted during the meeting (see Tables below). The most recent data on catches (up to 2019) and surveys (up to 2020) were used.

Catch scenarios for 2020 were revised upwards as a consequence of updating the assessment with the most recent information. This results in an estimate of the 2019 Recruitment higher than the assumption made for the interim year in the previous advice. Consequently, there is an upward revision of the 2020 biomass of fish of age one and older at the beginning of the year from 184137 to 344114 tonnes and the geometric mean of Recruitment (2015-2019) used as an assumption for 2020 is also revised upwards. Catches corresponding to Fmsy were revised from 4124 tonnes to 9660 tonnes.

Table 2. Sardine in divisions 8.c and 9.a. The basis for the revised catch options for 2020. Weights are in tonnes. Recruitment in millions.

Variable	Value	Notes
B1+ (2020)	344 114	Estimated in the 2020 assessment
$R_{age\ 0}$ (2020)	7584	Geometric mean (2015–2019)

Table 3. Sardine in divisions 8.c and 9.a. Annual catch scenarios for the revised catch advice for 2020. All weights are in tonnes.

Basis	Catch (2020)	F (2020)	Biomass 1+ (2021)
MSY approach: F_{MSY}	9660	0.032	358010
$F = F_{MSY}$	9660	0.032	358010
$F_{2020} = F_{2019}$	17381	0.058	352409
F_{HCR12}	19106	0.064	351159
F_{pa}	34577	0.118	339968
F_{lim}	45122	0.156	332363
B1 + (2021) = B_{lim} (196334)	239853	1.12	196334
B1 + (2021) = B_{pa} (252523)	157708	0.64	252523
B1 + (2021) = MSY $B_{trigger}$ (252523)	157708	0.64	252523

8.11 New references

ICES. 2016. Report of the Workshop to consider FMSY ranges for stocks in ICES categories 1 and 2 in Western Waters (WKMSYREF4), 13–16 October 2015, Brest, France. ICES CM 2015/ACOM:58. 187 pp.

ICES. 2017a. ICES fisheries management reference points for category 1 and 2 stocks. ICES Advice, Book 12, Section 12.4.3.1.

ICES. 2017b. Report of the Benchmark Workshop on Pelagic Stocks, 6–10 February 2017, Lisbon, Portugal. ICES CM 2017/ACOM:35. 294 pp.

ICES. 2018. Report of the Working Group on Southern Horse Mackerel, Anchovy and Sardine (WGHANSA), 26–30 June 2018, Lisbon, Portugal. ICES CM 2018/ACOM:17. 639 pp.

ICES. 2020. Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES areas 7, 8 and 9 (WGACEGG; outputs from 2019 meeting). ICES Scientific Reports. 2:44. 490 pp.

ICES. 2019b. Workshop on the Iberian Sardine Management and Recovery Plan (WKSARMP). ICES Scientific Reports. 1:18. 125 pp. http://doi.org/ 10.17895/ices.pub.5251.

ICES. 2019c. Request from Portugal and Spain to evaluate additional harvest control rules for the Iberian sardine stock in divisions 8.c and 9.a. In Report of the ICES Advisory Committee, 2019. ICES Advice 2019,sr.2019.26, https://doi.org/10.17895/ices.advice.5755.

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.

Silva A, Garrido S, Ibaibarriaga L, Pawlowski L, Riveiro I, Marques V, Ramos F, Duhamel E, Iglesias M, Bryère P, Mangin A, Citores L, Carrera P, Uriarte A. 2019. Adult-mediated connectivity and spatial population structure of sardine in the Bay of Biscay and Iberian coast, Deep-Sea Research Part II, https://doi.org/10.1016/j.dsr2.2018.10.010.

Table 8.2.2.1. Sardine in 8c and 9a: Quarterly distribution of sardine landings (t) in 2019 by ICES subdivision. Above absolute values; below, relative numbers.

Sub-Div	1st	2nd	3rd	4th	Total
8cE	15	181	19	138	**353**
8cW	0	1072	156	27	**1255**
9aN	4	694	302	76	**1076**
9aCN	0	751	2392	376	**3520**
9aCS	0	1380	2572	338	**4290**
9aS-Algarve	0	630	1244	112	**1986**
9aS-Cadiz	0	219	828	233	**1280**
Total	**19**	**4928**	**7513**	**1300**	**13760**

Sub-Div	1st	2nd	3rd	4th	Total
8cE	0.11	1.32	0.14	1.01	**2.57**
8cW	0.00	7.79	1.14	0.19	**9.12**
9aN	0.03	5.05	2.20	0.55	**7.82**
9aCN	0.00	5.46	17.38	2.73	**25.58**
9aCS	0.00	10.03	18.69	2.46	**31.18**
9aS-Algarve	0.00	4.58	9.04	0.82	**14.43**
9aS-Cadiz	0.00	1.59	6.02	1.69	**9.30**
Total	**0.14**	**35.81**	**54.60**	**9.45**	

Table 8.2.2.2. Sardine in 8c and 9a: Iberian Sardine Landings (tonnes) by subarea and total for the period 1940–2019.

			Subarea			
Year	8c	9aNorth	9a Central	9a Central	9a South	9a South
			North	South	Algarve	Cadiz
1940	66816		42132	33275	23724	
1941	27801		26599	34423	9391	
1942	47208		40969	31957	8739	
1943	46348		85692	31362	15871	
1944	76147		88643	31135	8450	
1945	67998		64313	37289	7426	
1946	32280		68787	26430	12237	
1947	43459	21855	55407	25003	15667	
1948	10945	17320	50288	17060	10674	
1949	11519	19504	37868	12077	8952	
1950	13201	27121	47388	17025	17963	
1951	12713	27959	43906	15056	19269	
1952	7765	30485	40938	22687	25331	
1953	4969	27569	68145	16969	12051	
1954	8836	28816	62467	25736	24084	
1955	6851	30804	55618	15191	21150	
1956	12074	29614	58128	24069	14475	
1957	15624	37170	75896	20231	15010	
1958	29743	41143	92790	33937	12554	
1959	42005	36055	87845	23754	11680	
1960	38244	60713	83331	24384	24062	
1961	51212	59570	96105	22872	16528	
1962	28891	46381	77701	29643	23528	
1963	33796	51979	86859	17595	12397	
1964	36390	40897	108065	27636	22035	
1965	31732	47036	82354	35003	18797	
1966	32196	44154	66929	34153	20855	
1967	23480	45595	64210	31576	16635	
1968	24690	51828	46215	16671	14993	
1969	38254	40732	37782	13852	9350	
1970	28934	32306	37608	12989	14257	
1971	41691	48637	36728	16917	16534	
1972	33800	45275	34889	18007	19200	
1973	44768	18523	46984	27688	19570	
1974	34536	13894	36339	18717	14244	
1975	50260	12236	54819	19295	16714	

			Subarea			
Year	8c	9aNorth	9a Central	9a Central	9a South	9a South
			North	South	Algarve	Cadiz
1976	51901	10140	43435	16548	12538	
1977	36149	9782	37064	17496	20745	
1978	43522	12915	34246	25974	23333	5619
1979	18271	43876	39651	27532	24111	3800
1980	35787	49593	59290	29433	17579	3120
1981	35550	65330	61150	37054	15048	2384
1982	31756	71889	45865	38082	16912	2442
1983	32374	62843	33163	31163	21607	2688
1984	27970	79606	42798	35032	17280	3319
1985	25907	66491	61755	31535	18418	4333
1986	39195	37960	57360	31737	14354	6757
1987	36377	42234	44806	27795	17613	8870
1988	40944	24005	52779	27420	13393	2990
1989	29856	16179	52585	26783	11723	3835
1990	27500	19253	52212	24723	19238	6503
1991	20735	14383	44379	26150	22106	4834
1992	26160	16579	41681	29968	11666	4196
1993	24486	23905	47284	29995	13160	3664
1994	22181	16151	49136	30390	14942	3782
1995	19538	13928	41444	27270	19104	3996

Table 8.2.2.2 Continued. Sardine in 8c and 9a: Iberian Sardine Landings (tonnes) by subarea and total for the period 1940–2019.

			Sub-area			
Year	8c	9aNorth	9a Central	9a Central	9a South	9a South
			North	South	Algarve	Cadiz
1996	14423	11251	34761	31117	19880	5304
1997	15587	12291	34156	25863	21137	6780
1998	16177	3263	32584	29564	20743	6594
1999	11862	2563	31574	21747	18499	7846
2000	11697	2866	23311	23701	19129	5081
2001	16798	8398	32726	25619	13350	5066
2002	15885	4562	33585	22969	10982	11689
2003	16436	6383	33293	24635	8600	8484
2004	18306	8573	29488	24370	8107	9176
2005	19800	11663	25696	24619	7175	8391
2006	15377	10856	30152	19061	5798	5779
2007	13380	12402	41090	19142	4266	6188
2008	13636	9409	45210	20858	4928	7423
2009	11963	7226	36212	20838	4785	6716
2010	13772	7409	40923	17623	5181	4662
2011	8536	5621	37152	13685	6387	9023
2012	13090	4154	19647	9045	2891	6031
2013	5272	2128	15065	9084	4112	10157
2014	4344	1924	6889	6747	2398	5635
2015	1916	1946	7117	4848	1812	2956
2016	2886	2887	7695	4031	1972	3233
2017	2251	2225	5182	6676	2836	2742
2018	2764	856	3579	4759	1400	1704
2019	1608	1076	3520	4290	1986	1280

Table 8.2.4.1. Sardine in 8c and 9a: Sardine length composition (thousands), mean length (cm) and catch (t) by ICES sub-division in 2019.

				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							2	2
9								
9.5							15	15
10							73	73
10.5							98	98
11							113	113
11.5				45			187	232
12				220			309	529
12.5	1			1 264		313	1 117	2 695
13		77	151	2 876		1 096	420	4 619
13.5	1	107	249	3 496		939	1 018	5 810
14	1	609	1 393	4 161		792	5 271	12 227
14.5	1	957	2 115	2 320		75	5 937	11 406
15	13	759	1 701	1 311		1 614	5 312	10 709
15.5	34	523	1 157	300	31	1 838	4 118	8 001
16	56	199	571	241		8 122	4 603	13 791
16.5	184	225	695	218	83	7 179	3 282	11 865
17	217	272	757	1 287	396	9 947	2 193	15 068
17.5	314	63	616	3 460	2 480	4 092	1 731	12 755
18	594	198	617	7 839	5 784	2 746	834	18 613
18.5	740	645	917	9 471	9 707	2 392	718	24 591
19	834	696	1 168	8 931	9 079	1 342	372	22 422
19.5	891	667	2 659	4 639	9 237	924	164	19 182
20	591	1 481	2 449	4 734	7 901	600	30	17 785
20.5	404	2 260	1 464	3 360	5 160	416	30	13 093
21	324	2 872	791	2 360	3 844	210		10 401
21.5	136	2 377	413	1 184	1 864	131		6 105
22	56	1 116	169	473	1 415	37		3 265
22.5	11	886	126	124	1 234	37		2 419
23	3	361	3	66	1 072			1 505
23.5		2	2	41	230			276
24		2	11		115			129
24.5					16			16
25								
25.5								
26								
26.5								
27								
27.5								
28								
28.5								
29								
Total	5 404	17 355	20 194	64 422	59 648	44 843	37 946	249 812
Mean L	19.3	19.8	17.9	18.0	19.8	17.0	15.6	18.0
sd	1.31	2.62	2.50	2.52	1.30	1.49	1.50	2.43
Catch	**353**	**1255**	**1076**	**3520**	**4290**	**1986**	**1280**	**13760**

Table 8.2.4.1a. Sardine in 8c and 9a: Sardine length composition (thousands), mean length (cm) and catch (t) by ICES subdivision in the first quarter 2019.

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								
14.5								
15								
15.5								
16								
16.5	1							1
17	10							10
17.5	17							17
18	28							28
18.5	48							48
19	35							35

First Quarter								
Length	**8c E**	**8c W**	**9a N**	**9a CN**	**9a CS**	**9a S**	**9a S (Ca)**	**Total**
19.5	49							49
20	21							21
20.5	16							16
21	12							12
21.5	7							7
22	1							1
22.5								
23								
23.5								
24								
24.5								
25								
25.5								
26								
26.5								
27								
27.5								
28								
28.5								
29								
Total	246							246
Mean L	19.3							19.3
sd	1.11							1.11
Catch	**15**							**15**

Table 8.2.4.1b. Sardine in 8c and 9a: Sardine length composition (thousands), mean length (cm) and catch (t) by ICES subdivision in the second quarter 2019.

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								2	2
9								
9.5							15	15
10							73	73
10.5							98	98
11							113	113
11.5							187	187
12							301	301
12.5				11			116	127
13				167			117	283
13.5				248			136	384
14			20	93			144	256
14.5				15		37	42	94
15	13		21			55	173	262
15.5	32		42		31	37	305	446
16	44		166	68		515	289	1 083
16.5	141		257	17	83	663	473	1 633
17	147	90	404	196	156	2 429	448	3 869
17.5	204		494	758	890	2 890	699	5 934
18	418	143	510	2 008	2 024	2 044	641	7 788
18.5	448	623	875	2 808	2 282	1 952	718	9 708
19	489	654	1 086	1 899	3 239	829	372	8 567
19.5	475	591	2 511	942	3 927	626	164	9 237

Second Quarter								
Length	**8c E**	**8c W**	**9a N**	**9a CN**	**9a CS**	**9a S**	**9a S-C**	**Total**
20	260	1 307	2 112	1 039	2 806	276	30	7 830
20.5	131	2 046	1 049	696	1 968	239	30	6 159
21	169	2 765	581	452	966	37		4 970
21.5	63	2 323	306	231	512	74		3 509
22	18	1 080	96	43	462	37		1 737
22.5	6	874	100	77	291	37		1 385
23		360		11	182			553
23.5		1			125			126
24		1	9		55			66
24.5								
25								
25.5								
26								
26.5								
27								
27.5								
28								
28.5								
29								
Total	3 059	12 859	10 640	11 779	20 000	12 777	5 685	76 798
Mean L	19.	21.	19.6	18.9	19.7	18.1	16.5	19.3
sd	1.32	1.15	1.31	1.57	1.25	1.10	2.56	1.85
Catch	**181**	**1 072**	**694**	**751**	**1 380**	**630**	**219**	**4 928**

Table 8.2.4.1c. Sardine in 8c and 9a: Sardine length composition (thousands), mean length (cm) and catch (t) by ICES subdivision in the third quarter 2019.

Third 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				45				45
12				220			8	228
12.5	1			1 253		313	8	1 575
13		74	142	2 710		1 096	103	4 125
13.5	1	68	131	3 248		939	286	4 674
14	1	425	821	4 068		792	958	7 065
14.5	1	708	1 368	2 305		38	3 910	8 331
15		559	1 079	1 311		1 534	4 145	8 627
15.5		425	821	300		1 801	3 614	6 961
16	1	179	345	173		7 581	4 314	12 593
16.5	4	223	430	187		6 312	2 809	9 964
17	10	179	345	1 028	240	7 262	1 745	10 809
17.5	12	63	122	2 628	1 590	946	1 033	6 393
18	24	56	108	5 448	3 393	523	193	9 745
18.5	54	22	42	6 164	6 005	210		12 497
19	52	42	82	6 170	4 252	258		10 857
19.5	41	75	145	3 188	3 995	42		7 488

Third Quarter								
Length	**8c E**	**8c W**	**9a N**	**9a CN**	**9a CS**	**9a S**	**9a S-C**	**Total**
20	33	173	334	2 932	4 741	222		8 435
20.5	19	212	410	2 042	3 176	74		5 934
21	14	103	199	1 267	2 771	148		4 502
21.5	6	50	97	608	1 351	32		2 146
22	2	33	64	219	953			1 272
22.5	2	10	20	25	944			1 000
23	2			3	890			894
23.5				2	105			107
24					60			60
24.5					16			16
25								
25.5								
26								
26.5								
27								
27.5								
28								
28.5								
29								
Total	281	3 680	7 106	47 545	34 482	30 122	23 126	146 343
Mean L	19.3	16.4	16.4	17.5	19.9	16.4	15.8	17.5
sd	1.34	2.32	2.32	2.61	1.39	1.30	0.98	2.38
				2391.76				2 392
Catch	**19**	**156**	**302**	**2 392**	**2 572**	**1 244**	**828**	**7 513**

Table 8.2.4.1d. Sardine in 8c and 9a: Sardine length composition (thousands) by ICES subdivision in the fourth quarter 2019.

Fourth 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								
11.5								
12								
12.5							993	993
13		3	9				199	211
13.5		39	118				595	752
14		184	552				4 169	4 906
14.5		249	747				1 985	2 981
15		200	601			26	993	1 820
15.5	2	98	294				199	593
16	10	20	59			26		114
16.5	38	2	7	14		205		266
17	50	3	9	63		256		380
17.5	81			74		256		411
18	124			383	366	179		1 052
18.5	189			499	1 420	230		2 338
19	259			861	1 587	256		2 964

Fourth Quarter								
Length	**8c E**	**8c W**	**9a N**	**9a CN**	**9a CS**	**9a S**	**9a S-C**	**Total**
19.5	325	1	3	509	1 314	256		2 408
20	277	1	3	763	354	102		1 500
20.5	238	1	4	623	16	102		984
21	129	4	11	641	108	26		917
21.5	59	3	10	345		26		442
22	33	3	8	211				255
22.5	3	2	6	23				34
23	2	1	3	52				58
23.5		1	2	40				43
24		1	2					3
24.5								
25								
25.5								
26								
26.5								
27								
27.5								
28								
28.5								
29								
Total	1 818	816	2 449	5 098	5 166	1 944	9 134	26 425
Mean L	19.7	15.	15.	20.1	19.3	18.5	14.3	17.2
sd	1.23	1.19	1.19	1.27	.6	1.33	.7	2.74
Catch	**138**	**27**	**76**	**376**	**338**	**112**	**233**	**1 300**

Table 8.2.4.2. Sardine in 8c and 9a: Catch in numbers- (thousands) at-age by quarter and by subdivision in 2019.

							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

Year	Age0	Age1	Age2	Age3	Age4	Age5	Age6+
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
2019	53515	85035	49870	40297	13422	4307	3429

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	0%	22%	40%	26%	0%	9%	56%	21%
1	16%	4%	13%	39%	25%	59%	36%	34%
2	34%	12%	21%	18%	30%	22%	5%	20%
3	38%	38%	19%	10%	28%	9%	2%	16%
4	7%	16%	6%	5%	9%	1%	1%	5%
5	5%	4%	0%	1%	4%	0%	0%	2%
6+	1%	3%	0%	1%	4%	0%	0%	1%
	100%	100%	100%	100%	100%	100%	100%	100%
Age	**8c-E**	**8c-W**	**9a-N**	**9a-CN**	**9a-CS**	**9a-S**	**9a-S-C**	**Total**
0	0%	7%	15%	31%	0%	7%	40%	100%
1	1%	1%	3%	30%	18%	31%	16%	100%
2	4%	4%	9%	24%	36%	20%	4%	100%
3	5%	16%	10%	16%	41%	10%	2%	100%
4	3%	21%	9%	22%	40%	3%	2%	100%
5	6%	17%	2%	13%	59%	2%	1%	100%
6+	1%	16%	1%	13%	64%	4%	0%	100%

Table 8.2.5.1. Sardine 8c and 9a: Sardine Mean length (cm) at age by quarter and by subdivision in 2019.

							First Quarter
Age	**8c-E**	**8c-W**	**9a-N**	**9a-CN**	**9a-CS**	**9a-S**	**9a-S-C**
0							
1	16.9		18.2				
2	18.3		19.3				
3	19.1		20.4				
4	20.0		20.8				
5	20.4		22.0				
6	21.2		22.9				
7	20.9						
8							
9							
10							
11							
12							

							Second Quarter
Age	**8c-E**	**8c-W**	**9a-N**	**9a-CN**	**9a-CS**	**9a-S**	**9a-S-C**
0							11.0
1	17.5	19.3	18.2	14.8		16.2	15.5
2	18.8	20.0	19.3	18.7	18.4	17.6	17.6
3	19.7	21.0	20.4	20.1	19.6	19.0	18.7
4	20.7	21.6	20.8	20.8	20.4	19.9	19.0
5	20.6	22.1	22.0	21.1	21.2	21.5	20.0
6	21.3	22.2	22.9	21.0	22.2	21.7	
7	21.1			21.7	21.7	22.0	
8				21.8	22.4	22.7	
9				22.3		17.4	
10							
11							
12							

							Third Quarter
Age	**8c-E**	**8c-W**	**9a-N**	**9a-CN**	**9a-CS**	**9a-S**	**9a-S-C**
0	13.9	15.4	15.4	14.2		13.9	15.3
1	18.0	19.8	19.8	18.7	18.4	16.7	16.4
2	19.1	20.6	20.6	19.8	19.2	18.0	17.8
3	19.7	21.0	21.0	20.7	20.1	20.2	18.3
4	19.8	21.3	21.3	21.4	21.1		
5	20.8	22.0	22.0	21.4	22.3		
6	19.8	22.4	22.4	20.3	22.5		
7					22.4		
8					23.0		
9							
10							
11							
12							

							Fourth Quarter
Age	**8c-E**	**8c-W**	**9a-N**	**9a-CN**	**9a-CS**	**9a-S**	**9a-S-C**
0		14.9	14.9	18.2	18.3	16.2	14.2
1	18.0	20.2	20.2	19.3	19.0	18.2	15.3
2	19.3	21.1	21.1	20.5	19.8	19.9	
3	20.0	21.8	21.8	20.8	19.6		
4	20.1	22.4	22.4	21.9	21.2		
5	20.8	23.0	23.0	22.8	20.3		
6	19.8	23.4	23.4	22.8			
7					21.3		
8							
9							
10							
11							
12							

							Whole Year
Age	**8c-E**	**8c-W**	**9a-N**	**9a-CN**	**9a-CS**	**9a-S**	**9a-S-C**
0	13.9	15.3	15.2	14.3	18.3	13.9	14.8
1	17.6	19.4	18.5	18.6	18.6	16.8	16.2
2	19.0	20.1	19.4	19.1	18.9	17.8	17.6
3	19.8	21.0	20.4	20.6	19.9	19.2	18.7
4	20.4	21.6	20.9	21.3	20.8	19.9	19.0
5	20.7	22.1	22.1	21.5	22.0	21.5	20.0
6	21.0	22.2	22.9	20.9	22.3	21.7	
7	21.1			21.7	22.0	22.0	
8				21.8	22.8	22.7	
9				22.3		17.4	
10							
11							
12							

Table 8.2.5.2. Sardine 8c and 9a: Sardine Mean weight (kg) at age by quarter and by subdivision in 2019.

						First Quarter	
Age	8c-E	8c-W	9a-N	9a-CN	9a-CS	9a-S	9a-S-C
0							
1	0.037		0.049				
2	0.049		0.058				
3	0.056		0.070				
4	0.066		0.076				
5	0.071		0.093				
6	0.081		0.105				
7	0.078						
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
1	0.043	0.061	0.051	0.030		0.036	0.030
2	0.056	0.070	0.061	0.060	0.057	0.046	0.045
3	0.066	0.083	0.074	0.075	0.067	0.056	0.055
4	0.078	0.091	0.080	0.085	0.075	0.064	0.058
5	0.076	0.097	0.097	0.088	0.082	0.078	0.069
6	0.086	0.100	0.111	0.088	0.094	0.080	
7	0.084			0.097	0.088	0.083	
8				0.098	0.096	0.090	
9				0.105		0.046	
10							
11							
12							

						Third Quarter	
Age	8c-E	8c-W	9a-N	9a-CN	9a-CS	9a-S	9a-S-C
0	0.023	0.033	0.033	0.024	0.059	0.024	0.032
1	0.054	0.072	0.072	0.058	0.067	0.043	0.040
2	0.065	0.082	0.082	0.070	0.076	0.055	0.051
3	0.072	0.088	0.088	0.080	0.087	0.079	0.056
4	0.073	0.091	0.091	0.090	0.102		
5	0.085	0.102	0.102	0.090	0.104		
6	0.071	0.107	0.107	0.075	0.104		
7					0.110		
8							
9							
10							
11							
12							

						Fourth Quarter	
Age	8c-E	8c-W	9a-N	9a-CN	9a-CS	9a-S	9a-S-C
0		0.029	0.029	0.053	0.055	0.041	0.025
1	0.057	0.083	0.083	0.064	0.063	0.055	0.032
2	0.072	0.095	0.095	0.078	0.071	0.069	
3	0.081	0.107	0.107	0.081	0.069		
4	0.081	0.118	0.118	0.096	0.087		
5	0.092	0.128	0.128	0.110	0.075		
6	0.076	0.136	0.136	0.109			
7					0.087		
8							
9							
10							
11							
12							

						Whole Year	
Age	8c-E	8c-W	9a-N	9a-CN	9a-CS	9a-S	9a-S-C
0	0.023	0.032	0.032	0.025	0.055	0.024	0.029
1	0.047	0.065	0.055	0.058	0.063	0.043	0.038
2	0.061	0.071	0.063	0.063	0.071	0.047	0.046
3	0.072	0.083	0.075	0.080	0.069	0.060	0.055
4	0.078	0.091	0.081	0.090	0.087	0.064	0.058
5	0.082	0.098	0.100	0.093	0.075	0.078	0.069
6	0.083	0.100	0.112	0.085		0.080	
7	0.082			0.097	0.087	0.083	
8				0.098		0.090	
9				0.105		0.046	
10							
11							
12							

Table 8.3.2.2. Sardine in 8c and 9a: sardine abundance in number (millions of fish) and biomass (tons) by age groups and ICES subdivision in PELAGO2020. MW (mean weight) in grams and ML (mean length) in cm.

AREA 9aCN												
AGE	0	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (ton)	1893	196762	160	-	-	-	-	-	-	-	-	198815
%Biomass	0.95	98.97	0.08	-	-	-	-	-	-	-	-	100
Abundance (N in 10^3)	165846	11379979	4621	-	-	-	-	-	-	-	-	11550446
%Abundance	1.44	98.52	0.04	-	-	-	-	-	-	-	-	100
Mean Weight (gr)	11.41414	17.29019	34.62454	-	-	-	-	-	-	-	-	
Mean Length (cm)	11.8	13.5	17.0	-	-	-	-	-	-	-	-	
AREA 9aCS												
AGE	0	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (ton)	-	10582	12076	3687	10999	2109	376	474	494	81	-	40878
%Biomass	-	25.89	29.54	9.02	26.91	5.16	0.92	1.16	1.21	0.20	-	100
Abundance (N in 10^3)	-	286905	254074	67723	183012	31741	4665	6042	6306	913	-	841381
%Abundance	-	34.10	30.20	8.05	21.75	3.77	0.55	0.72	0.75	0.11	-	100
Mean Weight (gr)	-	36.88473	47.52859	54.44091	60.09951	66.44396	80.52479	78.4888	78.32382	88.93479	-	
Mean Length (cm)	-	16.6	18.2	19.2	19.9	20.7	22.2	22.0	21.98944	23.1	-	
AREA 9aS-ALG												
AGE	0	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (ton)	-	9292	22990	6041	7292	1413	136	127	109	7	9	47415
%Biomass	-	19.60	48.49	12.74	15.38	2.98	0.29	0.27	0.23	0.02	0.02	100
Abundance (N in 10^3)	-	286253	476989	110416	121628	23562	1770	1642	1427	86	121	1023895
%Abundance	-	27.96	46.59	10.78	11.88	2.30	0.17	0.16	0.14	0.01	0.01	100
Mean Weight (gr)	-	32.45912	48.19894	54.71	59.95284	59.95169	76.94659	77.15051	76.14136	83.83234	73.83314	
Mean Length (cm)	-	15.8	18.3	19.2	19.9	19.9	21.8	21.8	21.7	22.5	21.5	
AREA 9aS-CAD												
AGE	0	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (ton)	7615.033	41442	46375	3583	6819	1409.171	358.6	-	-	-	-	107602
%Biomass	7.077	38.515	43.099	3.330	6.337	1.310	0.333	-	-	-	-	100
Abundance (N in 10^3)	2192809	1930434	1187280	66476.72	116505.7	23327.8	6642.8	-	-	-	-	5523476
%Abundance	39.70	34.95	21.50	1.20	2.11	0.42	0.12	-	-	-	-	100
Mean Weight (gr)	0.034727	0.214679	0.390601	0.538958	0.585266	0.604074	0.539833	-	-	-	-	
Mean Length (cm)	7.6	14.1	17.1	19.0	19.5	19.7	19.0	-	-	-	-	
AREA PELAGO												
AGE	0	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (ton)	9508	258078	81601	13311	25110	4931	870	601	603	88	9	394710
%Biomass	2.41	65.38	20.67	3.37	6.36	1.25	0.22	0.15	0.15	0.02	0.00	100
Abundance (N in 10^3)	2358655	13883572	1922964	244616	421145	78631	13078	7684	7733	999	121	18939198
%Abundance	12.45	73.31	10.15	1.29	2.22	0.42	0.07	0.04	0.04	0.01	0.00	100
Mean Weight (gr)	4.031119	18.58876	42.43526	54.41425	59.62201	62.70762	66.5593	78.20277	77.92114	88.49464	73.83314	
Mean Length (cm)	7.9	13.7	17.5	19.1	19.8	20.1	20.5	22.0	21.9	23.0	21.5	

Table 8.4.1a. Sardine in 8c and 9a: Mean weights-at-age (kg) in the catch. Weights-at-age in 1978–1990 and 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
2019	0.028	0.05	0.059	0.074	0.084	0.094	0.097

Table 8.4.1b. Mean weights-at-age (Kg) in the stock. Weights-at-age in 1978–1998 are fixed. Weights-at-age in 2018–2019 are assumed to be equal to weights-at-age in 2017, the last DEPM survey (see Stock Annex).

Year	Age1	Age2	Age3	Age4	Age5	Age6+
1998	0.027	0.041	0.050	0.059	0.060	0.063
1999	0.030	0.043	0.050	0.054	0.059	0.062
2000	0.027	0.041	0.050	0.059	0.060	0.063
2001	0.024	0.039	0.051	0.064	0.061	0.064
2002	0.022	0.037	0.052	0.069	0.062	0.066
2003	0.021	0.041	0.054	0.068	0.065	0.072
2004	0.020	0.045	0.056	0.067	0.068	0.079
2005	0.019	0.049	0.058	0.066	0.072	0.086
2006	0.024	0.052	0.060	0.067	0.072	0.084
2007	0.029	0.054	0.062	0.069	0.072	0.081
2008	0.033	0.057	0.064	0.070	0.072	0.079
2009	0.030	0.054	0.063	0.070	0.069	0.075
2010	0.027	0.051	0.062	0.070	0.067	0.072
2011	0.024	0.048	0.061	0.070	0.064	0.068
2012	0.027	0.048	0.062	0.068	0.068	0.073
2013	0.030	0.049	0.063	0.067	0.073	0.077
2014	0.032	0.049	0.065	0.066	0.077	0.081
2015	0.030	0.048	0.063	0.066	0.073	0.077
2016	0.029	0.046	0.062	0.065	0.070	0.072
2017	0.027	0.045	0.060	0.065	0.066	0.068
2018	0.027	0.045	0.060	0.065	0.066	0.068
2019	0.027	0.045	0.060	0.065	0.066	0.068

Table 8.4.1.1. Sardine in 8c and 9a: Parameters and asymptotic standard deviations estimated in the 2020 assessment model.

Label	Value	Parm_StDev	Phase	Min	Max	Init
SR_LN(R0)	16.517	0.031	1	1	20	16
Early_InitAge_4	0.533	0.590	2	-5	5	0
Early_InitAge_3	0.529	0.466	2	-5	5	0
Early_InitAge_2	0.510	0.283	2	-5	5	0
Early_InitAge_1	0.781	0.188	2	-5	5	0
Main_RecrDev_1978	0.921	0.158	2	-5	5	0
Main_RecrDev_1979	1.044	0.154	2	-5	5	0
Main_RecrDev_1980	1.155	0.145	2	-5	5	0
Main_RecrDev_1981	0.660	0.170	2	-5	5	0
Main_RecrDev_1982	0.041	0.232	2	-5	5	0
Main_RecrDev_1983	1.552	0.108	2	-5	5	0
Main_RecrDev_1984	0.310	0.182	2	-5	5	0
Main_RecrDev_1985	0.184	0.177	2	-5	5	0
Main_RecrDev_1986	0.038	0.188	2	-5	5	0
Main_RecrDev_1987	0.837	0.123	2	-5	5	0
Main_RecrDev_1988	0.218	0.157	2	-5	5	0
Main_RecrDev_1989	0.182	0.155	2	-5	5	0
Main_RecrDev_1990	0.239	0.152	2	-5	5	0
Main_RecrDev_1991	1.325	0.087	2	-5	5	0
Main_RecrDev_1992	0.893	0.098	2	-5	5	0
Main_RecrDev_1993	0.056	0.140	2	-5	5	0
Main_RecrDev_1994	-0.072	0.133	2	-5	5	0
Main_RecrDev_1995	-0.299	0.135	2	-5	5	0
Main_RecrDev_1996	0.082	0.108	2	-5	5	0
Main_RecrDev_1997	-0.297	0.130	2	-5	5	0
Main_RecrDev_1998	-0.025	0.114	2	-5	5	0
Main_RecrDev_1999	-0.281	0.135	2	-5	5	0
Main_RecrDev_2000	0.878	0.086	2	-5	5	0
Main_RecrDev_2001	0.349	0.108	2	-5	5	0
Main_RecrDev_2002	-0.233	0.141	2	-5	5	0
Main_RecrDev_2003	-0.479	0.166	2	-5	5	0
Main_RecrDev_2004	0.983	0.075	2	-5	5	0
Main_RecrDev_2005	-0.092	0.113	2	-5	5	0
Main_RecrDev_2006	-1.257	0.175	2	-5	5	0
Main_RecrDev_2007	-0.920	0.137	2	-5	5	0
Main_RecrDev_2008	-0.631	0.114	2	-5	5	0
Main_RecrDev_2009	-0.445	0.098	2	-5	5	0
Main_RecrDev_2010	-0.971	0.120	2	-5	5	0

Label	Value	Parm_StDev	Phase	Min	Max	Init
Main_RecrDev_2011	-1.078	0.126	2	-5	5	0
Main_RecrDev_2012	-0.905	0.112	2	-5	5	0
Main_RecrDev_2013	-0.778	0.109	2	-5	5	0
Main_RecrDev_2014	-1.077	0.129	2	-5	5	0
Main_RecrDev_2015	-0.477	0.114	2	-5	5	0
Main_RecrDev_2016	-0.256	0.113	2	-5	5	0
Main_RecrDev_2017	-1.204	0.174	2	-5	5	0
Main_RecrDev_2018	-0.472	0.165	2	-5	5	0
Main_RecrDev_2019	0.302	0.194	2	-5	5	0
InitF_seas_1_flt_1purse_seine	0.749	0.127	1	-1	2	0.3
LnQ_base_Acoustic_survey(2)	0.258	0.080	1	-3	3	0
LnQ_base_DEPM_survey(3)	0.157	0.108	1	-3	3	0
AgeSel_P2_purse_seine(1)	1.655	0.152	2	-3	3	0.9
AgeSel_P3_purse_seine(1)	0.766	0.136	2	-4	4	0.4
AgeSel_P4_purse_seine(1)	-0.173	0.167	2	-4	4	0.1
AgeSel_P7_purse_seine(1)	-0.195	0.514	2	-4	4	-0.5
AgeSel_P2_purse_seine(1)_BLK1delta_1988	-0.351	0.183	2	-4	4	0.9
AgeSel_P2_purse_seine(1)_BLK1delta_2006	0.022	0.142	2	-4	4	0.9
AgeSel_P3_purse_seine(1)_BLK1delta_1988	-0.033	0.167	2	-4	4	0.4
AgeSel_P3_purse_seine(1)_BLK1delta_2006	-0.210	0.138	2	-4	4	0.4
AgeSel_P4_purse_seine(1)_BLK1delta_1988	0.811	0.190	2	-4	4	0.1
AgeSel_P4_purse_seine(1)_BLK1delta_2006	-0.562	0.140	2	-4	4	0.1
AgeSel_P7_purse_seine(1)_BLK1delta_1988	-0.537	0.526	2	-4	4	-0.5
AgeSel_P7_purse_seine(1)_BLK1delta_2006	0.515	0.375	2	-4	4	-0.5

Table 8.4.1.2. Sardine in 8c and 9a: Fishing mortality-at-age estimated in the assessment. RefF is equal to F(2–5), the reference fishing mortality, corresponding to the average F of ages 2 to 5 years.

Year	age0	age1	age2	age3	age4	age5	age6+	refF
1978	0.036	0.188	0.405	0.34	0.34	0.34	0.28	0.356
1979	0.029	0.149	0.322	0.271	0.271	0.271	0.223	0.283
1980	0.028	0.147	0.317	0.267	0.267	0.267	0.22	0.279
1981	0.027	0.141	0.304	0.256	0.256	0.256	0.211	0.268
1982	0.026	0.137	0.295	0.248	0.248	0.248	0.204	0.26
1983	0.026	0.135	0.291	0.245	0.245	0.245	0.202	0.257
1984	0.025	0.133	0.286	0.241	0.241	0.241	0.198	0.252
1985	0.023	0.121	0.261	0.219	0.219	0.219	0.181	0.23
1986	0.028	0.149	0.321	0.27	0.27	0.27	0.222	0.283
1987	0.033	0.172	0.369	0.311	0.311	0.311	0.256	0.325
1988	0.031	0.115	0.239	0.453	0.453	0.453	0.218	0.399
1989	0.03	0.11	0.229	0.433	0.433	0.433	0.208	0.382
1990	0.033	0.12	0.249	0.472	0.472	0.472	0.227	0.416
1991	0.03	0.11	0.23	0.435	0.435	0.435	0.209	0.384
1992	0.022	0.082	0.17	0.322	0.322	0.322	0.155	0.284
1993	0.021	0.079	0.164	0.311	0.311	0.311	0.15	0.274
1994	0.018	0.067	0.139	0.262	0.262	0.262	0.126	0.231
1995	0.018	0.066	0.138	0.262	0.262	0.262	0.126	0.231
1996	0.024	0.09	0.187	0.353	0.353	0.353	0.17	0.311
1997	0.032	0.119	0.249	0.471	0.471	0.471	0.227	0.415
1998	0.036	0.133	0.278	0.526	0.526	0.526	0.253	0.464
1999	0.033	0.121	0.252	0.477	0.477	0.477	0.23	0.421
2000	0.029	0.107	0.224	0.423	0.423	0.423	0.204	0.373
2001	0.028	0.102	0.212	0.401	0.401	0.401	0.193	0.354
2002	0.023	0.085	0.177	0.335	0.335	0.335	0.161	0.296
2003	0.021	0.076	0.158	0.299	0.299	0.299	0.144	0.264
2004	0.023	0.084	0.174	0.33	0.33	0.33	0.159	0.291
2005	0.023	0.083	0.174	0.329	0.329	0.329	0.158	0.29

Year	age0	age1	age2	age3	age4	age5	age6+	refF
2006	0.026	0.098	0.165	0.178	0.178	0.178	0.143	0.175
2007	0.031	0.118	0.199	0.214	0.214	0.214	0.173	0.211
2008	0.05	0.187	0.316	0.341	0.341	0.341	0.274	0.334
2009	0.057	0.213	0.36	0.388	0.388	0.388	0.313	0.381
2010	0.071	0.269	0.453	0.489	0.489	0.489	0.394	0.48
2011	0.086	0.323	0.545	0.588	0.588	0.588	0.473	0.577
2012	0.068	0.257	0.434	0.468	0.468	0.468	0.377	0.46
2013	0.065	0.244	0.412	0.444	0.444	0.444	0.358	0.436
2014	0.042	0.157	0.264	0.285	0.285	0.285	0.23	0.28
2015	0.026	0.096	0.162	0.175	0.175	0.175	0.141	0.172
2016	0.025	0.095	0.161	0.173	0.173	0.173	0.139	0.17
2017	0.021	0.079	0.134	0.145	0.145	0.145	0.116	0.142
2018	0.011	0.043	0.073	0.079	0.079	0.079	0.063	0.077
2019	0.009	0.033	0.055	0.059	0.059	0.059	0.048	0.058

Table 8.4.1.3. Sardine in 8c and 9a: Numbers-at-age, in thousands at the beginning of the year, estimated in the assessment. Estimates of survivors in 2020 are also shown. Age 0 in 2020 is the estimated of recruitment using the S–R model fitted within the assessment.

Year	Age0	Age1	Age2	Age3	Age4	Age5	Age6+
1978	36335400	11425700	3344190	1007080	361169	78727	52054
1979	42353800	13155700	5143700	1394570	480304	179282	68034
1980	48342900	15448200	6155560	2330660	713220	255665	135929
1981	29883600	17639600	7243030	2801440	1196380	381053	217205
1982	16032600	10916700	8320920	3339780	1453960	646268	335677
1983	71372800	5861760	5172190	3873050	1747130	791646	554162
1984	21226100	26102500	2781430	2415310	2031660	953881	765412
1985	18567800	7766310	12415000	1305480	1272400	1113970	984087
1986	15784900	6809190	3738210	5978620	702755	712904	1226960
1987	34409600	5757870	3187380	1695370	3059980	374364	1097100
1988	18648100	12497600	2635060	1376990	832972	1564790	810246
1989	17802900	6784010	6053920	1296640	586993	369576	1174490
1990	18636600	6485140	3302340	3009480	563505	265511	861230
1991	54591300	6770740	3125980	1608380	1258190	245203	615033
1992	37160500	19883700	3294340	1552460	697701	568066	474072
1993	16281000	13641200	9957380	1737270	754460	352905	585132
1994	14176800	5980990	6849820	5280740	853344	385715	548108
1995	11111600	5225410	3040490	3726980	2722820	457952	559889
1996	15882600	4095740	2656650	1654680	1922440	1461790	606753
1997	10681400	5817680	2034720	1377820	779162	942194	1095390
1998	13608800	3880860	2805000	991553	576647	339403	1048700
1999	10498300	4925810	1845270	1327840	392810	237765	732647
2000	32421200	3812710	2371220	896262	552256	170039	526833
2001	20078900	11818500	1860780	1185160	393513	252369	390595
2002	11308600	7330300	5799800	940740	531749	183765	352860
2003	8846560	4147390	3658270	3036680	451021	265342	310699
2004	37483400	3252530	2088870	1952330	1509450	233340	334045
2005	13038500	13752000	1625400	1096770	941001	757231	325213

Year	Age0	Age1	Age2	Age3	Age4	Age5	Age6+
2006	4218910	4784020	6874660	854030	529336	472690	585837
2007	5792920	1542810	2357270	3643120	479131	309090	647402
2008	7465130	2107170	745134	1207700	1970730	269761	571349
2009	8552260	2665910	949584	339630	575888	978086	450630
2010	4882040	3032880	1170200	414030	154381	272457	706746
2011	4035500	1706110	1259780	464834	170206	66055.4	463967
2012	4362330	1390050	671171	456546	173083	65963.5	235738
2013	4806300	1529130	584029	271801	191631	75615.2	146541
2014	3616920	1690650	650966	241818	116850	85746.4	108595
2015	6428580	1302120	785365	312305	121862	61288.6	108101
2016	8705750	2351800	642577	417257	175694	71354.1	104417
2017	3619580	3185840	1161910	342052	235225	103088	108244
2018	7391850	1330110	1598890	635118	198424	142023	132834
2019	16760900	2742590	692158	929041	393531	127965	183051
2020	13801600	6236440	1442520	409506	586968	258780	211732

Table 8.4.1.4. Sardine in 8c and 9a: Summary table of the WGHANSA 2020 assessment. CVs are presented for SSB, recruitment and Apical F (maximum F-at-age by year); biomass and landings in tonnes, recruits in thousand 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	525270	476223	0.157	36335400	0.169	0.356	0.405	0.199	145609
1979	679205	621439	0.157	42353800	0.163	0.283	0.322	0.188	157241
1980	851997	784048	0.150	48342900	0.152	0.279	0.317	0.175	194802
1981	1020440	942637	0.142	29883600	0.176	0.268	0.304	0.165	216517
1982	948606	896618	0.143	16032600	0.238	0.260	0.295	0.155	206946
1983	749471	720852	0.153	71372800	0.107	0.257	0.291	0.149	183837
1984	1164890	1057700	0.105	21226100	0.184	0.252	0.286	0.143	206005
1985	987886	944406	0.102	18567800	0.177	0.230	0.261	0.110	208439
1986	797581	766606	0.102	15784900	0.188	0.283	0.321	0.143	187363
1987	643032	616813	0.105	34409600	0.121	0.325	0.369	0.146	177696
1988	708401	655775	0.093	18648100	0.159	0.399	0.453	0.123	161531
1989	627011	593821	0.095	17802900	0.157	0.382	0.433	0.121	140961
1990	564403	535160	0.096	18636600	0.155	0.416	0.472	0.120	149429
1991	519087	488878	0.102	54591300	0.088	0.384	0.435	0.122	132587
1992	854665	771836	0.080	37160500	0.099	0.284	0.322	0.112	130250
1993	965980	901457	0.070	16281000	0.142	0.274	0.311	0.106	142495
1994	814387	783614	0.071	14176800	0.134	0.231	0.262	0.091	136582
1995	675491	651549	0.071	11111600	0.137	0.231	0.262	0.084	125280
1996	541599	522559	0.074	15882600	0.109	0.311	0.353	0.089	116736
1997	480904	455598	0.074	10681400	0.132	0.415	0.471	0.091	115814
1998	389821	371492	0.079	13608800	0.116	0.464	0.526	0.099	108924
1999	374177	362480	0.081	10498300	0.138	0.421	0.477	0.104	94091
2000	320952	303330	0.089	32421200	0.087	0.373	0.423	0.107	85786
2001	482236	409464	0.077	20078900	0.109	0.354	0.401	0.105	101957
2002	496151	431708	0.076	11308600	0.142	0.296	0.335	0.106	99673
2003	471352	434515	0.079	8846560	0.167	0.264	0.299	0.097	97831
2004	411770	383661	0.085	37483400	0.071	0.291	0.330	0.096	98020
2005	549140	437499	0.073	13038500	0.110	0.290	0.329	0.092	97345

Year	Biomass 1+	SSB	CV SSB	Recruits	CV Recruits	F (2-5)	F Apical	CV F Apical	Landings
2006	642250	590229	0.063	4218910	0.176	0.175	0.178	0.100	87023
2007	505661	494047	0.064	5792920	0.135	0.211	0.214	0.076	96469
2008	391812	384746	0.066	7465130	0.110	0.334	0.341	0.076	101464
2009	294249	287968	0.068	8552260	0.093	0.381	0.388	0.088	87740
2010	247185	244152	0.065	4882040	0.118	0.480	0.489	0.099	89571
2011	177463	175756	0.073	4035500	0.125	0.577	0.588	0.108	80403
2012	131517	130127	0.090	4362330	0.116	0.460	0.468	0.118	54857
2013	121258	119728	0.100	4806300	0.121	0.436	0.444	0.133	45818
2014	124827	124827	0.111	3616920	0.145	0.280	0.285	0.144	27937
2015	117277	116492	0.121	6428580	0.135	0.172	0.175	0.146	20595
2016	147564	147564	0.120	8705750	0.138	0.170	0.173	0.144	22704
2017	188281	187119	0.123	3619580	0.195	0.142	0.145	0.148	21911
2018	177274	175675	0.132	7391850	0.189	0.077	0.079	0.147	15062
2019	207412	206720	0.138	16760900	0.215	0.058	0.059	0.144	13760
2020	344114	346826	0.158						

Table 8.6.1. Sardine in 8c and 9a: Input data for short-term catch predictions. Number-at-age for 2020 and recruitment for 2021. Input values for stock weight, catch weight, natural mortality (M) and fishing mortality- (F) at-age. Input units are thousands and kg.

2020						
Age	Number	Stock Weights	Catch Weights	Maturity	M	F
0	7584483	0,000	0,027	0	0,980	0,010
1	6236460	0,029	0,045	1	0,610	0,036
2	1442522	0,046	0,060	0,985	0,470	0,060
3	409506	0,062	0,075	1	0,400	0,065
4	586969	0,065	0,085	1	0,360	0,065
5	258780	0,070	0,091	1	0,350	0,065
6+	211732	0,072	0,097	1	0,320	0,052
2021						
Age	Number	Stock Weights	Catch Weights	Maturity	M	F
0	7584483	0,000	0,027	0	0,980	
1		0,029	0,045	1	0,610	
2		0,046	0,060	0,985	0,470	
3		0,062	0,075	1	0,400	
4		0,065	0,085	1	0,360	
5		0,070	0,091	1	0,350	
6+		0,072	0,097	1	0,320	

Table 8.6.2. Sardine in 8.c and 9.a: Output data for short-term catch predictions.

B1+_2020	F2020	Catch 2020	B1+ 2021	Fsq	Fmult	F	Catch 2021	B1+ 2022	Catch 2022	Change B1+ 2021-2022(%)	Change Catch 2019 2021(%)
344115	0.064	19106	351159	0.092	0	0	0	365277	0	4.0	-100
				0.092	0.1	0.0092	3168	362928	3297	3.4	-77
				0.092	0.2	0.0185	6312	360598	6526	2.7	-54
				0.092	0.3	0.028	9434	358286	9689	2.0	-31
				0.092	0.4	0.037	12533	355993	12787	1.4	-9
				0.092	0.5	0.046	15610	353717	15822	0.7	13
				0.092	0.6	0.055	18664	351459	18794	0.1	36
				0.092	0.7	0.065	21697	349220	21704	-0.6	58
				0.092	0.8	0.074	24707	346998	24555	-1.2	80
				0.092	0.9	0.083	27696	344793	27346	-1.8	101
				0.092	1	0.092	30663	342606	30080	-2.4	123
				0.092	1.1	0.102	33608	340436	32756	-3.1	144
				0.092	1.2	0.111	36532	338283	35377	-3.7	166
				0.092	1.3	0.120	39436	336147	37943	-4.3	187
				0.092	1.4	0.129	42318	334028	40456	-4.9	208
				0.092	1.5	0.139	45180	331926	42915	-5.5	228
				0.092	1.6	0.148	48021	329840	45323	-6.1	249
				0.092	1.7	0.157	50841	327770	47680	-6.7	270
				0.092	1.8	0.166	53642	325717	49987	-7.2	290
				0.092	1.9	0.176	56422	323680	52246	-7.8	310
				0.092	2	0.185	59183	321659	54456	-8.4	330

Table 8.9.1. Sardine in 8.c and 9.a: Comparison of the main parameters from the different runs with the 'true' assessment of the corresponding year.

	2019			2018			2017			2010		
	Advice	PELACUS	Acoustic	Advice	PELACUS	Acoustic	Advice	PELACUS	Acoustic	Advice	PELACUS	Acoustic
npars	61	61	61	60	60	60	59	59	59	52	52	52
maxgrad	1.30E-05	1.08E-05	7.16E-05	4.83E-05	2.95E-05	4.31E-05	5.69E-05	7.31E-05	5.30E-06	5.89E-05	5.80E-06	1.79E-05
Likelihood												
TOTAL	1.25E+02	1.26E+02	1.26E+02	1.23E+02	1.24E+02	1.23E+02	1.17E+02	1.20E+02	1.13E+02	8.13E+01	8.25E+01	7.94E+01
Catch	8.91E-10	9.72E-10	8.63E-10	1.26E-09	1.35E-09	1.30E-09	1.69E-09	1.74E-09	1.46E-09	2.12E-10	2.42E-10	1.34E-10
Equil_catch	5.90E-01	6.38E-01	6.06E-01	5.71E-01	6.69E-01	5.27E-01	3.42E-01	3.90E-01	1.93E-01	3.98E-03	3.34E-03	7.12E-03
Survey	-2.31E+01	-2.36E+01	-2.20E+01	-2.35E+01	-2.39E+01	-2.22E+01	-2.34E+01	-2.21E+01	-2.34E+01	-1.69E+01	-1.64E+01	-1.63E+01
Age_comp	1.22E+02	1.23E+02	1.22E+02	1.20E+02	1.20E+02	1.20E+02	1.17E+02	1.18E+02	1.15E+02	8.53E+01	8.58E+01	8.37E+01
Recruitment	2.51E+01	2.55E+01	2.52E+01	2.57E+01	2.67E+01	2.49E+01	2.30E+01	2.36E+01	2.12E+01	1.29E+01	1.31E+01	1.20E+01
Parm_softbounds	5.15E-04	5.15E-04	5.16E-04	5.13E-04	5.13E-04	5.12E-04	5.10E-04	5.10E-04	5.07E-04	5.67E-04	5.66E-04	5.70E-04
Correlation stats												
min	1.88E-06	2.80E-05	2.04E-05	3.30E-06	5.42E-06	9.76E-06	3.32E-05	1.35E-05	4.63E-06	2.11E-05	3.54E-05	1.36E-05
high	0.87093	0.87090	0.87086	0.87107	0.87087	0.87122	0.87202	0.87187	0.87261	0.86999	0.87072	0.86680

Table 8.9.2. Sardine in 8.c and 9.a: Comparison of the main parameters from the different assessment update.

	Advice	Pelacus	PelacusRSize20	PelacusRSize15	PelacusR	PelacusRCV
npars	43	43	43	43	43	43
maxgrad	1.12E-05	1.80E-05	7.47E-06	2.96E-05	2.79E-05	1.19E-05
Likelihood						
TOTAL	6.94E+01	6.97E+01	69.2818	69.391	69.8882	69.4074
Catch	6.62E-11	6.48E-11	6.3181E-11	4.72197E-11	7.30099E-11	6.61356E-11
Equil_catch	1.15E-02	1.15E-02	0.0114342	0.011136	0.011595	0.0115149
Survey	-1.38E+01	-1.36E+01	-13.8131	-12.7288	-13.6811	-13.8794
Age_comp	7.46E+01	7.46E+01	74.5855	73.7275	74.932	74.6721
Recruitment	8.61E+00	8.64E+00	8.49748	8.38063	8.62513	8.6027
Parm_softbounds	5.32E-04	5.33E-04	0.000531672	0.000536887	0.000530237	0.000532193
Correlation stats						
min	8.38E-06	6.30E-06	6.30E-06	0.000198813	2.06E-05	9.78E-05
high	0.8572	0.8544	0.8544	0.8598	0.8586	0.8535
HarMean(effN)						
Purse seine	73	73	73	73	73	73
Acoustic survey	22	22	22	22	22	22
ESTIMATES						
SSB	7.19E+05	6.97E+05	697386	710513	7.28E+05	7.47E+05

	Advice	Pelacus	PelacusRSize20	PelacusRSize15	PelacusR	PelacusRCV
SSB Upper	341428.8	331013.9	331013.9	334778.1	345147.4	339994.2
SSB Lower	1097469	1063758	1063758	1086248	1110545	1154034
Recruitment	60824400	59162800	59162800	57846100	61414500	63734300
Recruitment Upper	92920378	90289576	90289576	88655754	93911095	99995986
Recruitment Lower	28728422	28036024	28036024	27036446	28917905	27472614
F	0.217	0.224	0.224	0.218	0.216	0.211
F Upper	0.335	0.346	0.346	0.337	0.333	0.329
F Lower	0.100	0.103	0.103	0.098	0.098	0.094

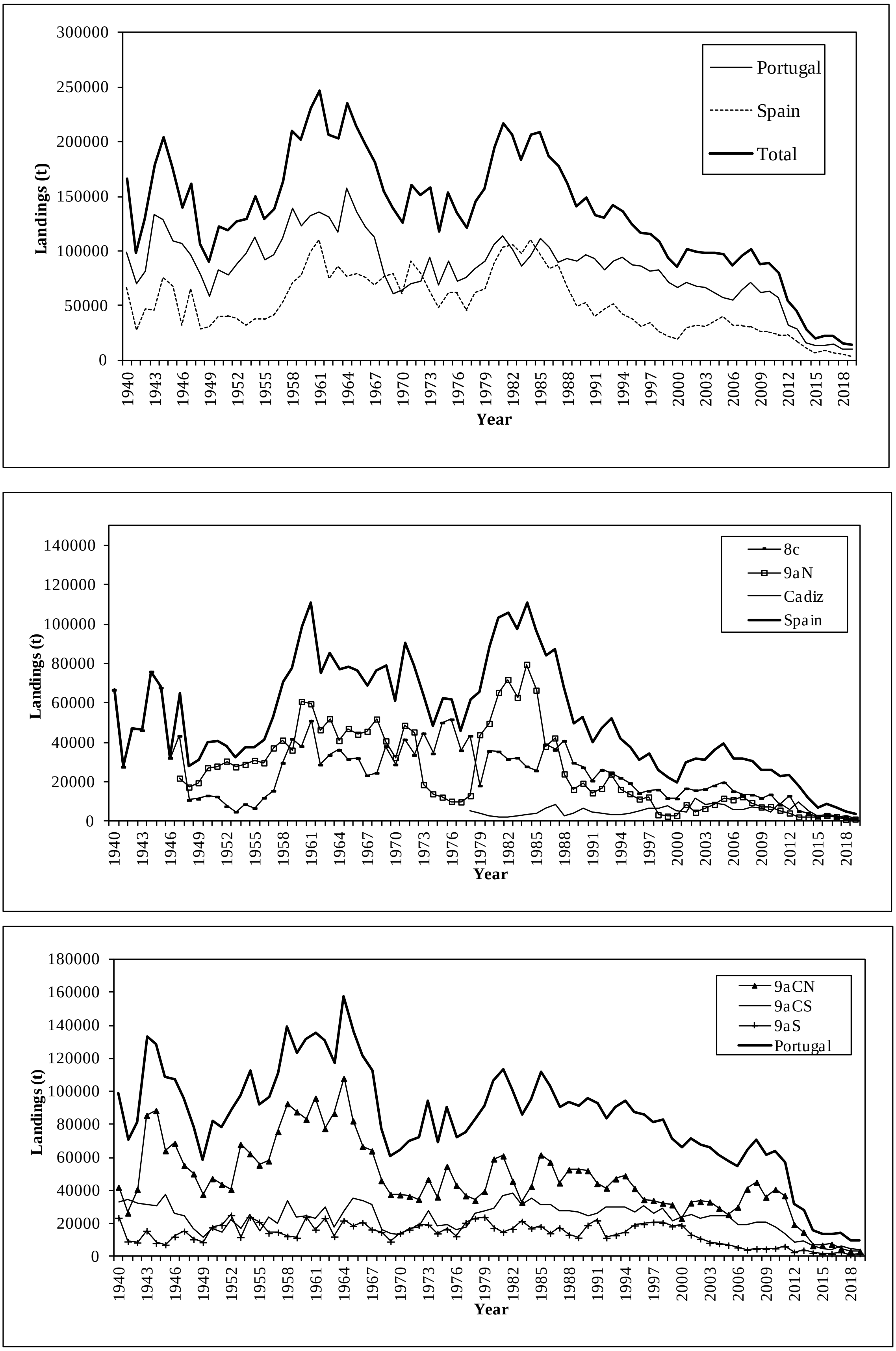


Figure 8.2.2.1. Sardine in 8c and 9a: WG estimates of annual landings of sardine, by country (upper panel) and by ICES subdivision and country.

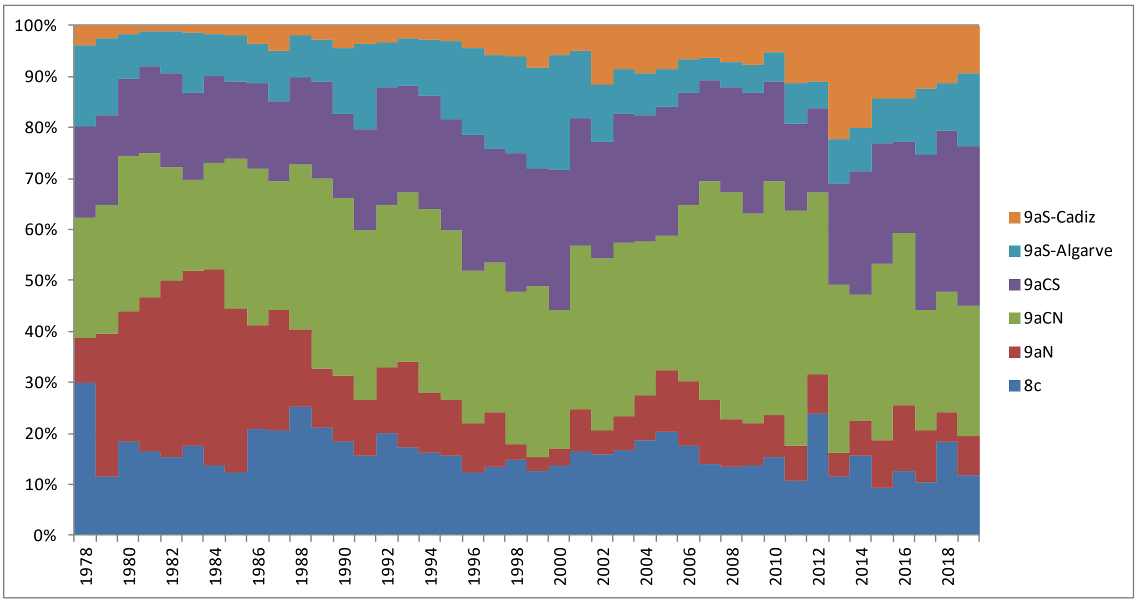


Figure 8.2.2.2. Sardine in 8c and 9a: Historical relative contribution of the different subareas to the total catches (1978–2019).

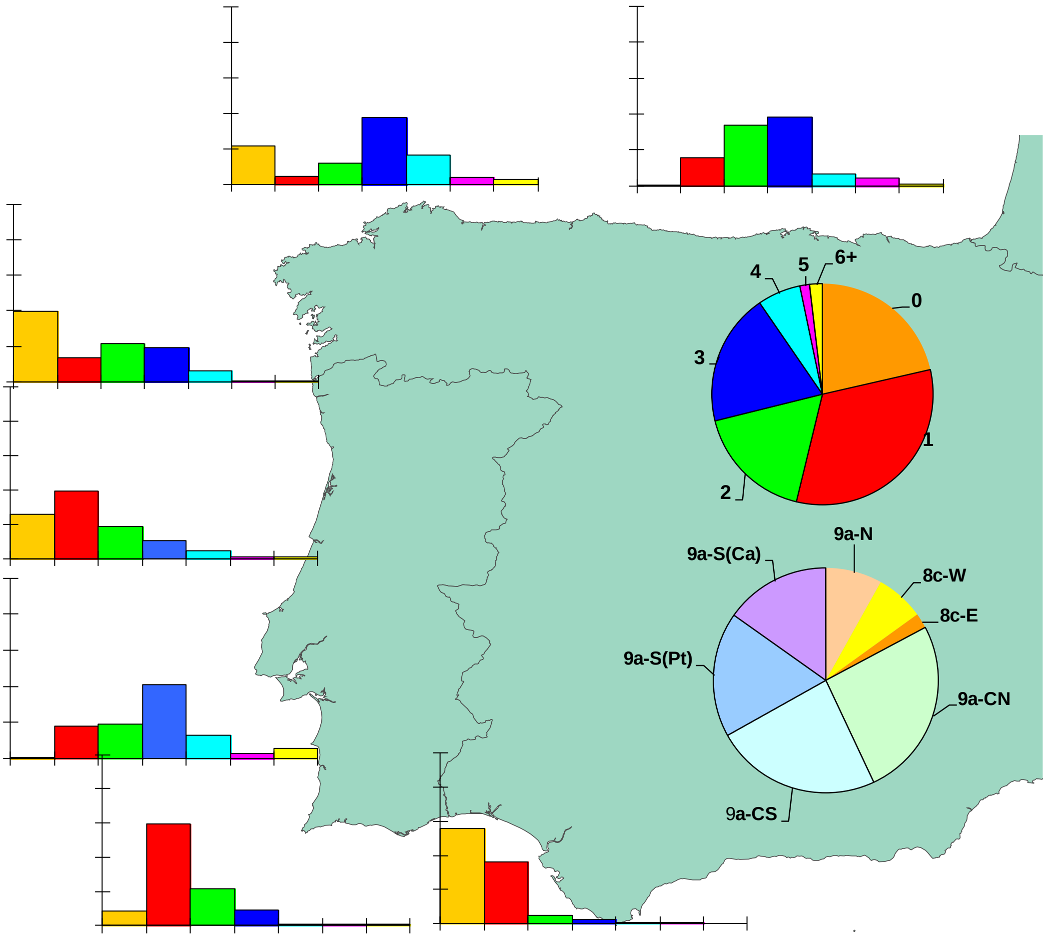


Figure 8.2.4.1. Sardine in 8c and 9a: Relative contribution of each age-class by areas as well as their relative contribution to the 2019 catches (pie-chart).

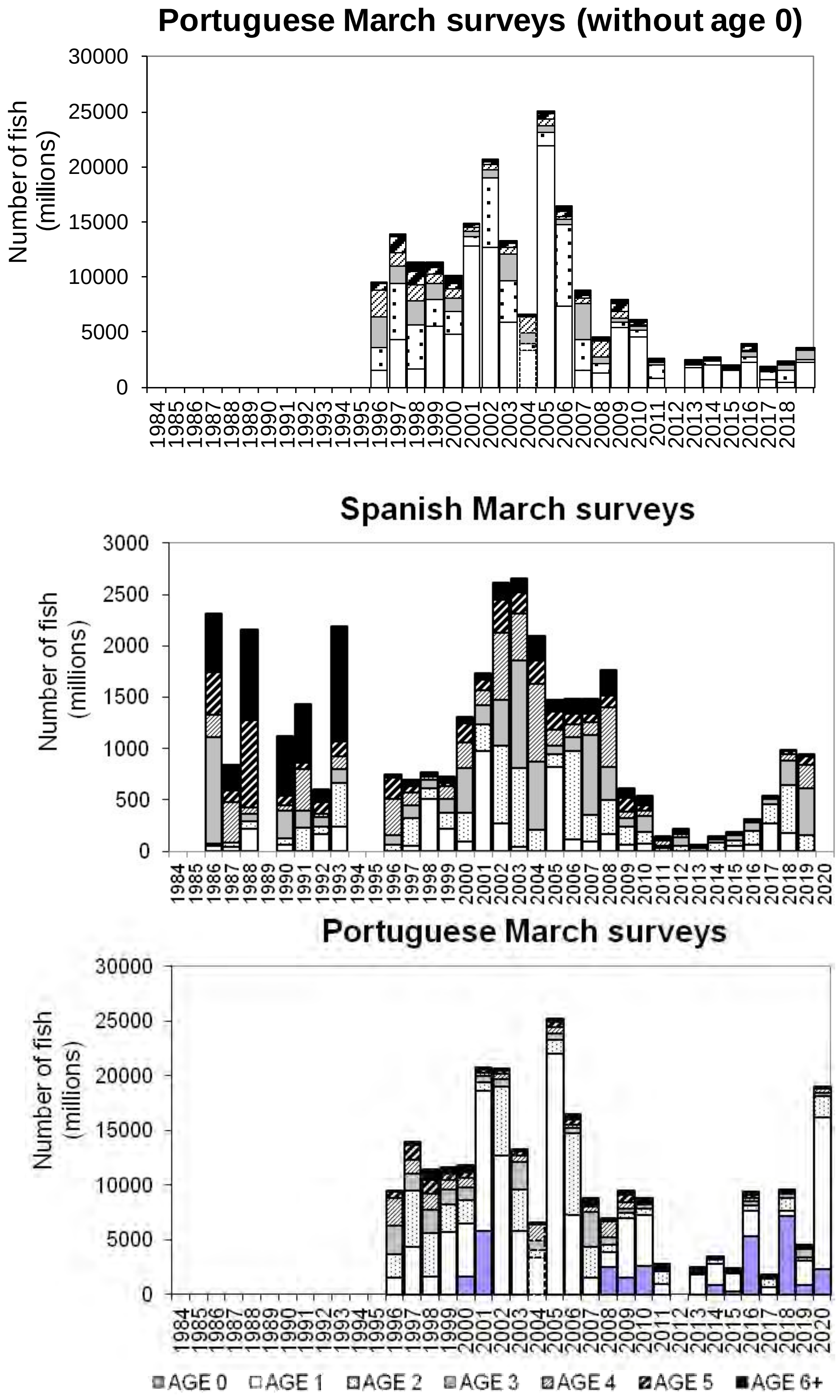


Figure 8.3.1. Sardine in 8c and 9a: Total abundance and age structure (numbers) of sardine estimated in the acoustic surveys. a) The Spanish March survey series covers area 8c and 9a-N (Galicia) and b) the Portuguese March surveys covers the Portuguese area and the Gulf of Cadiz (Subdivisions 9-CN, 9a-CS, 9a-S-Algarve and 9a-S-Cadiz). Portuguese acoustic survey in June 2004 was only considered as indications of the population abundance and is not included in assessment. Estimates from Portuguese acoustic surveys are not available for 2012 (year without survey).

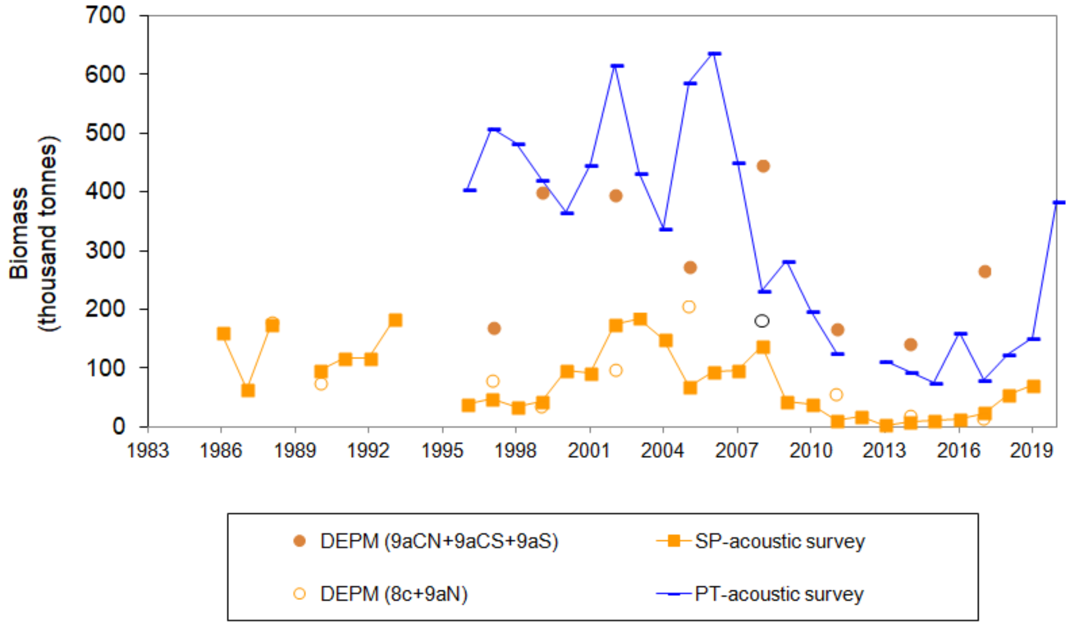


Figure 8.3.2. Sardine in 8c and 9a: Total sardine biomass (thousand tonnes) estimated in the different series of acoustic surveys and SSB estimates from the DEPM series covering the northern area and the west and southern area of the stock.

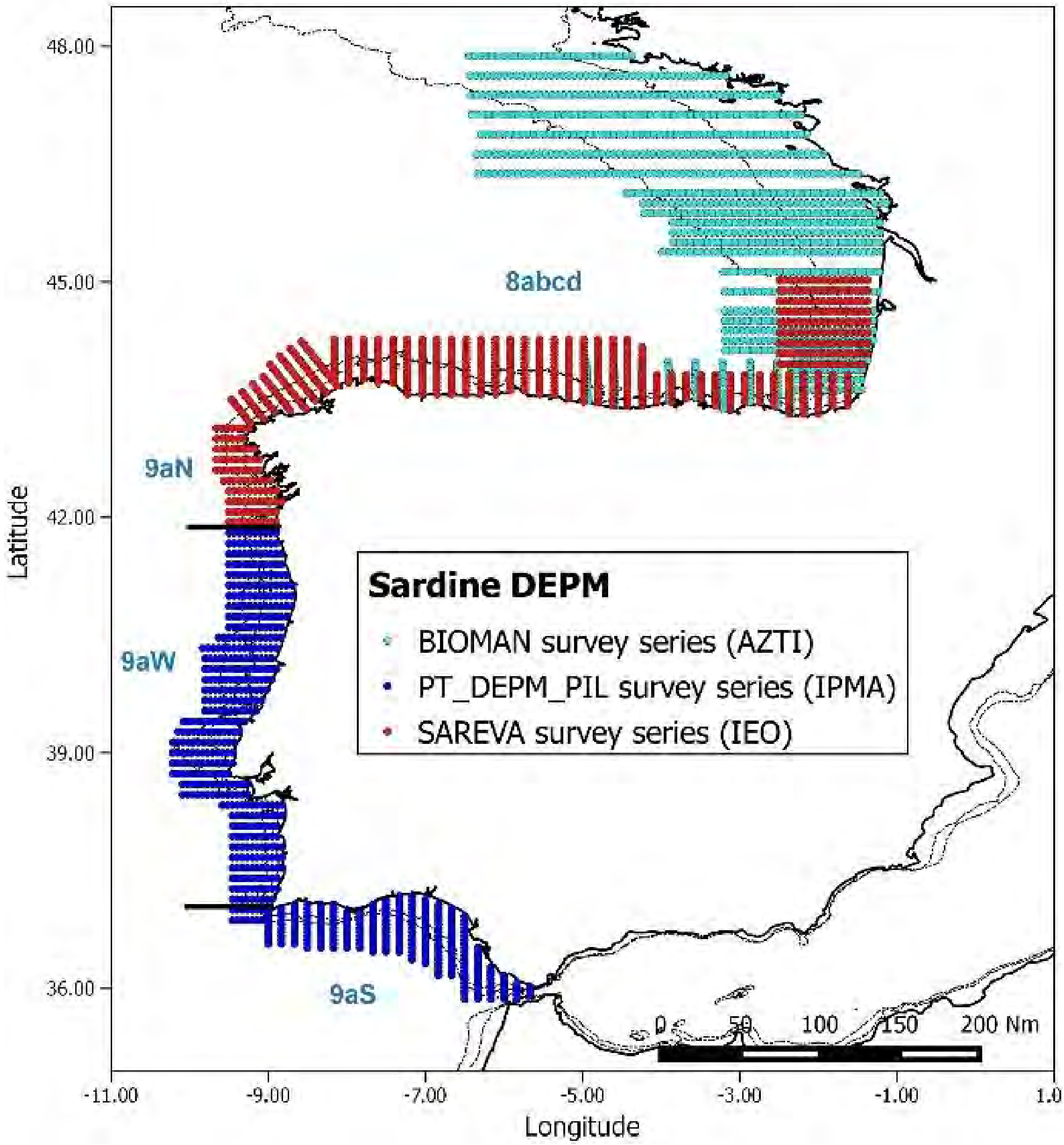


Figure 8.3.3.1. Sardine in 8c and 9a: DEPM surveys carried out by IPMA, IEO and AZTI in the Iberian Peninsula.

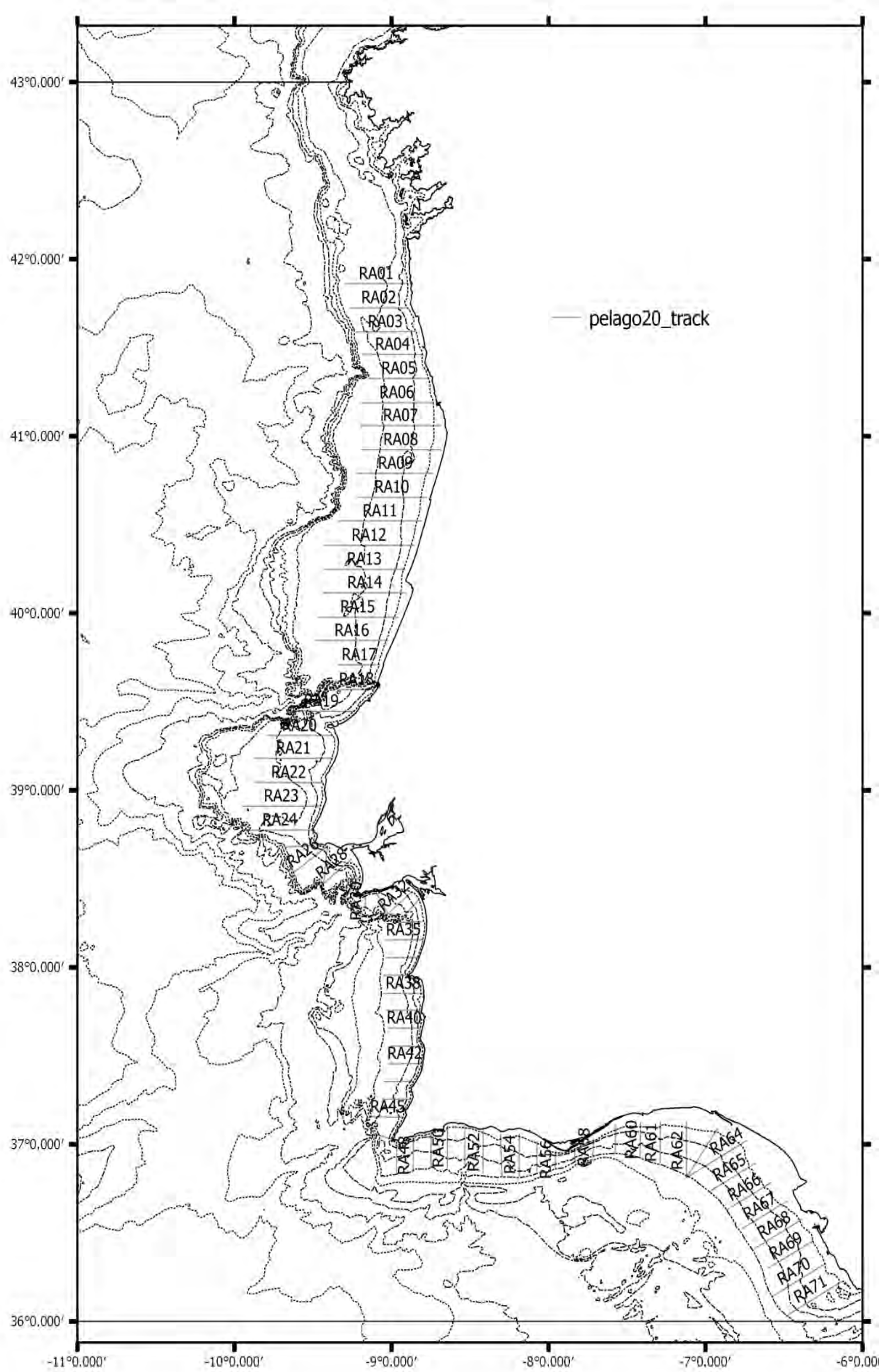


Figure 8.3.2.1.1. Sardine in 8c and 9a: acoustic transects during PELAGO 2020 survey.

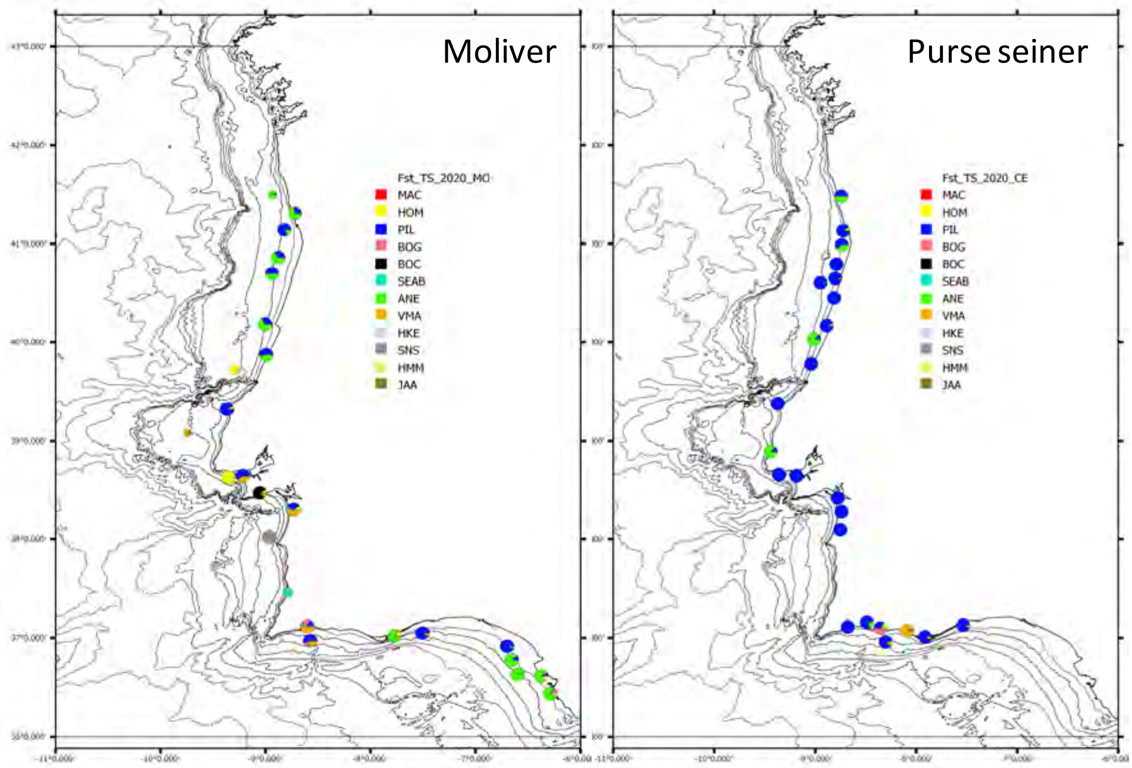


Figure 8.3.2.1.2. Sardine in 8c and 9a: Fishing haul operations during PELAGO 2020 survey.

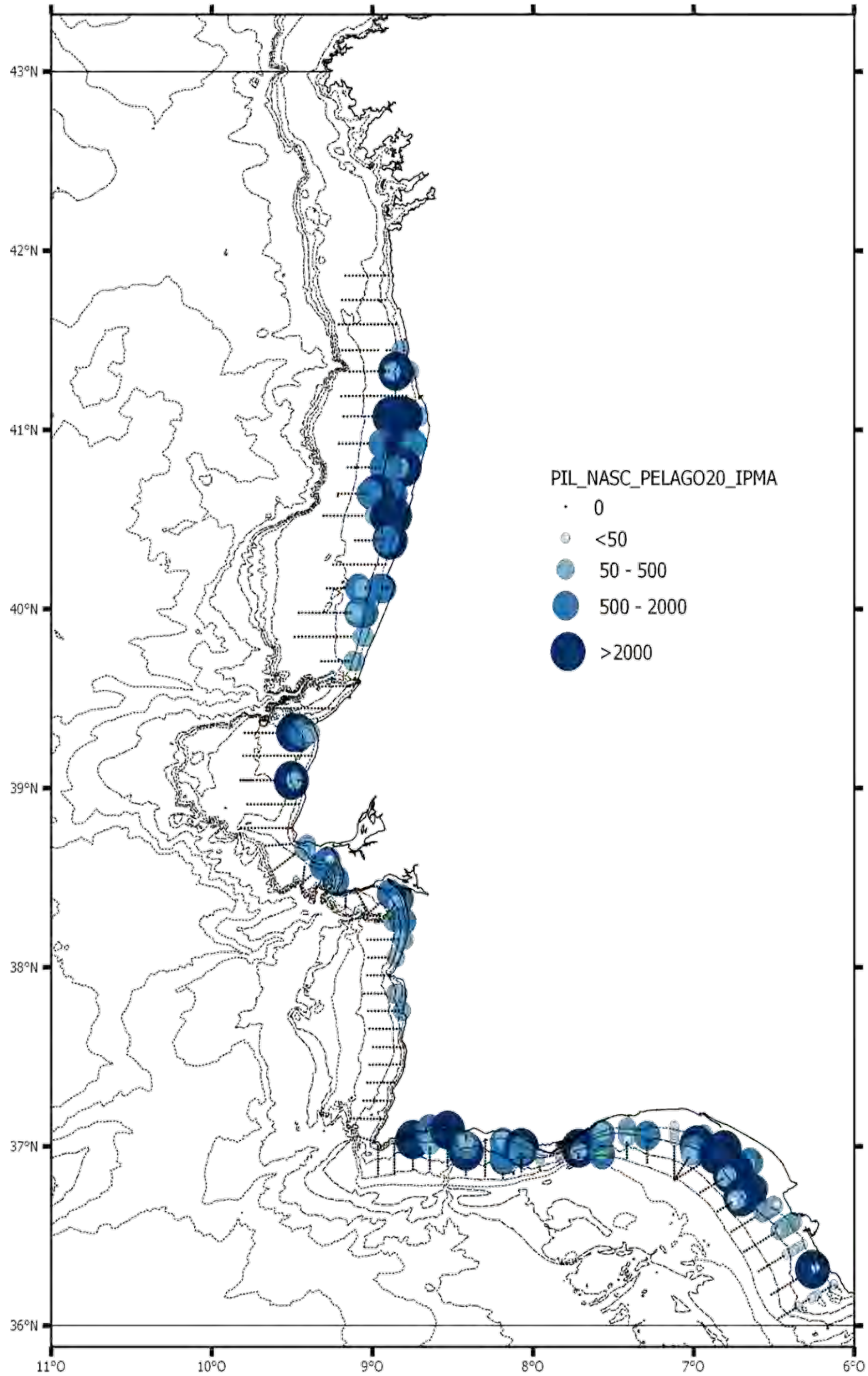


Figure 8.3.2.1.3. Sardine in 8c and 9a: Acoustic energy during PELAGO20.

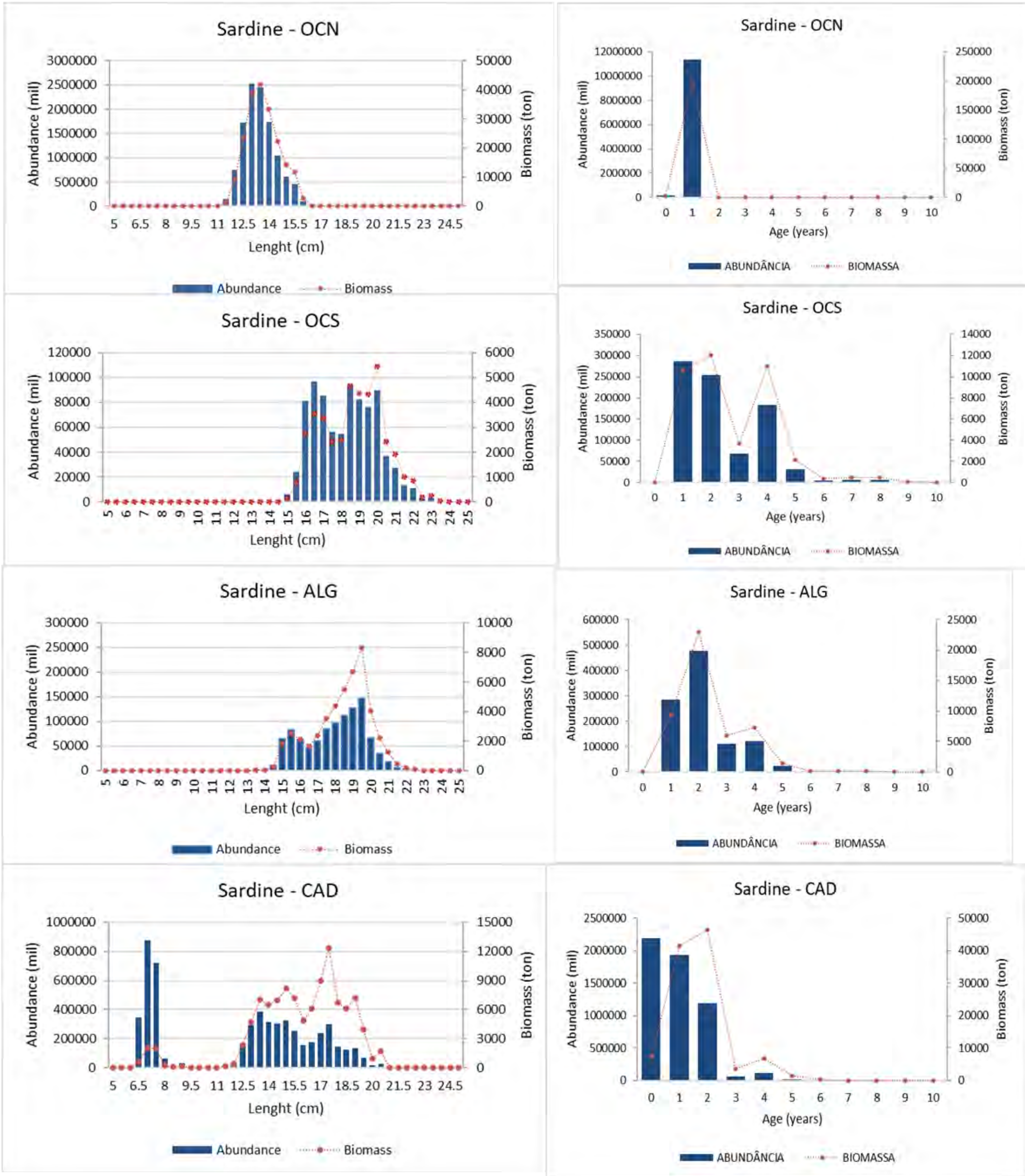
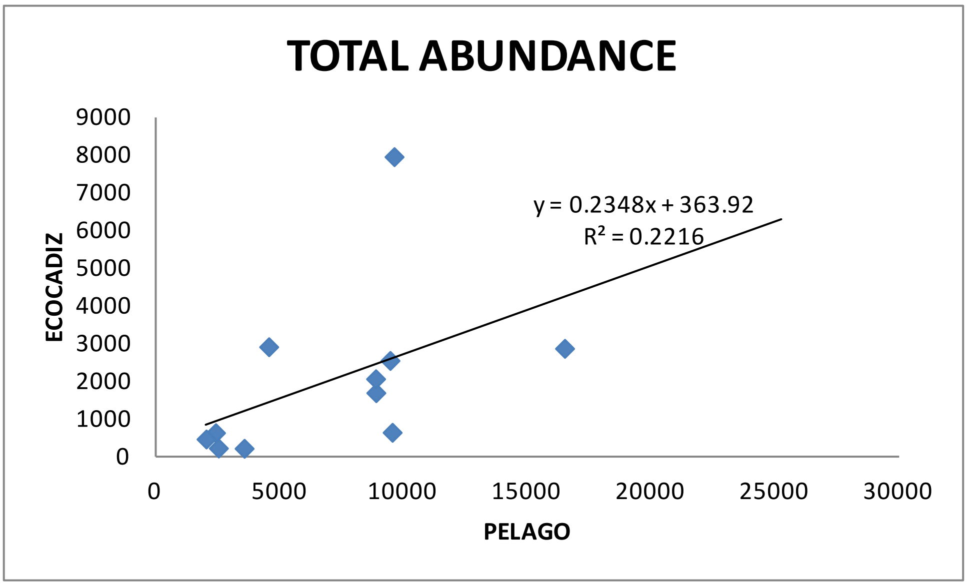


Figure 8.3.2.1.4. Sardine in 8c and 9a: Size (left panel) and age (right panel) composition during PELAGO20.



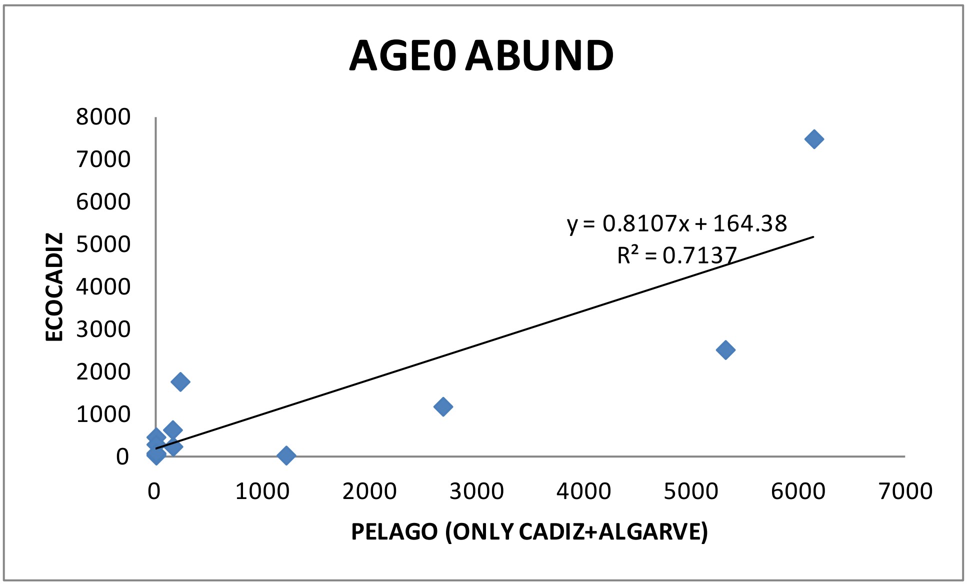


Figure 8.3.3.1. Sardine in 8c and 9a: Time-series of sardine estimation in PELAGO and ECOCADIZ surveys. Upper panel: correlation between total abundance in PELAGO and ECOCADIZ. Bottom panel: Age0 abundance correlation in the common area covered.

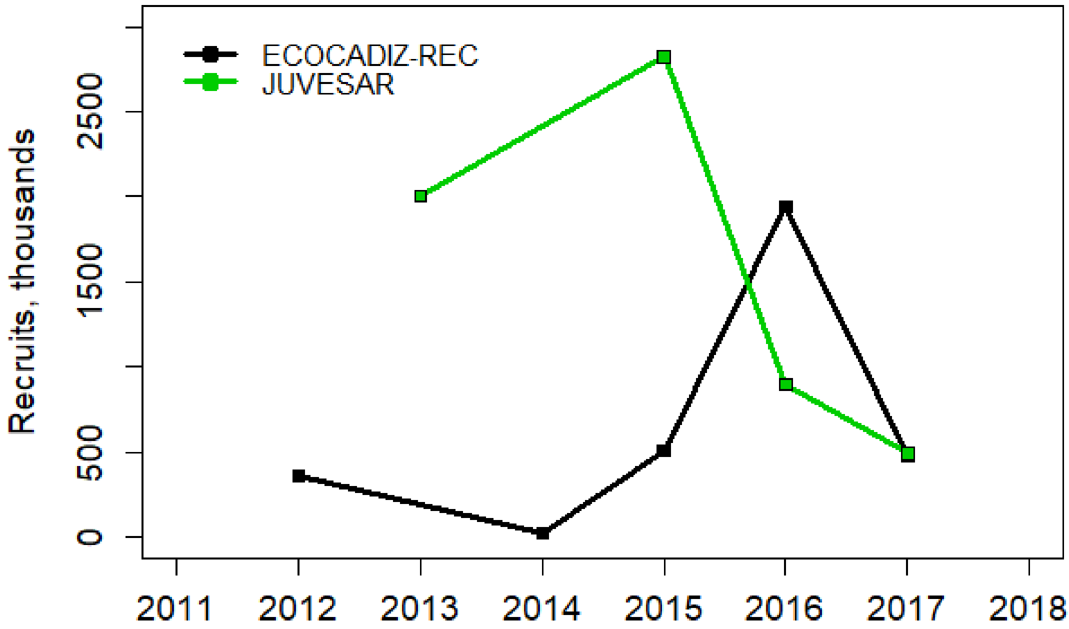


Figure 8.3.3.2. Sardine in 8c and 9a: Time-series of juvenile estimation in ECOCADIZ-RECLUTAS and JUVESAR surveys.

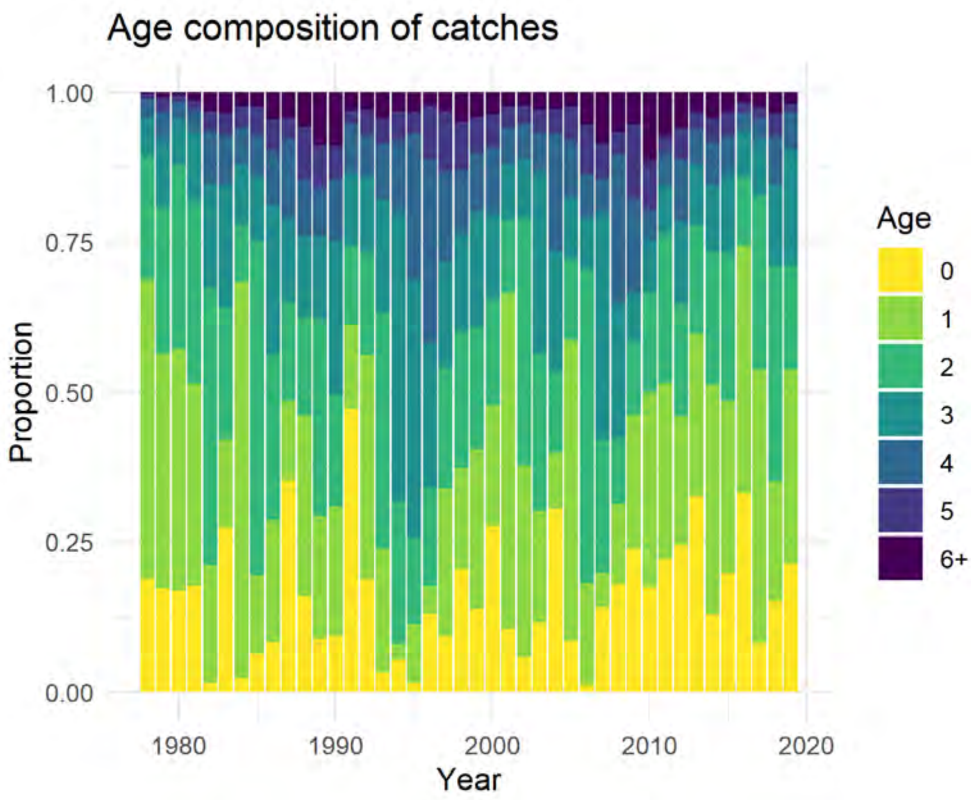


Figure 8.3.7.1. Sardine in 8c and 9a: Catches-at-age for 1978–2019.

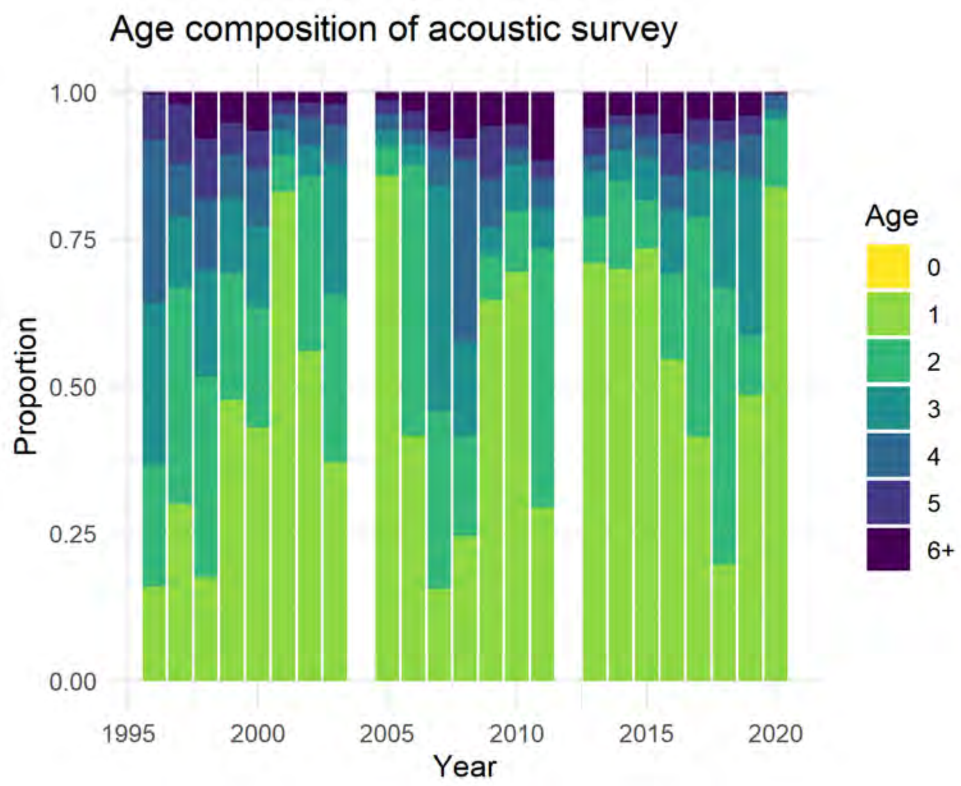


Figure 8.3.7.2. Sardine in 8c and 9a: Abundance-at-age in the joint Spanish-Portuguese spring acoustic survey 1996–2020. For 2020 abundance-at-age represents only the Portuguese spring acoustic survey that usually represents 91% of the total numbers of individuals.

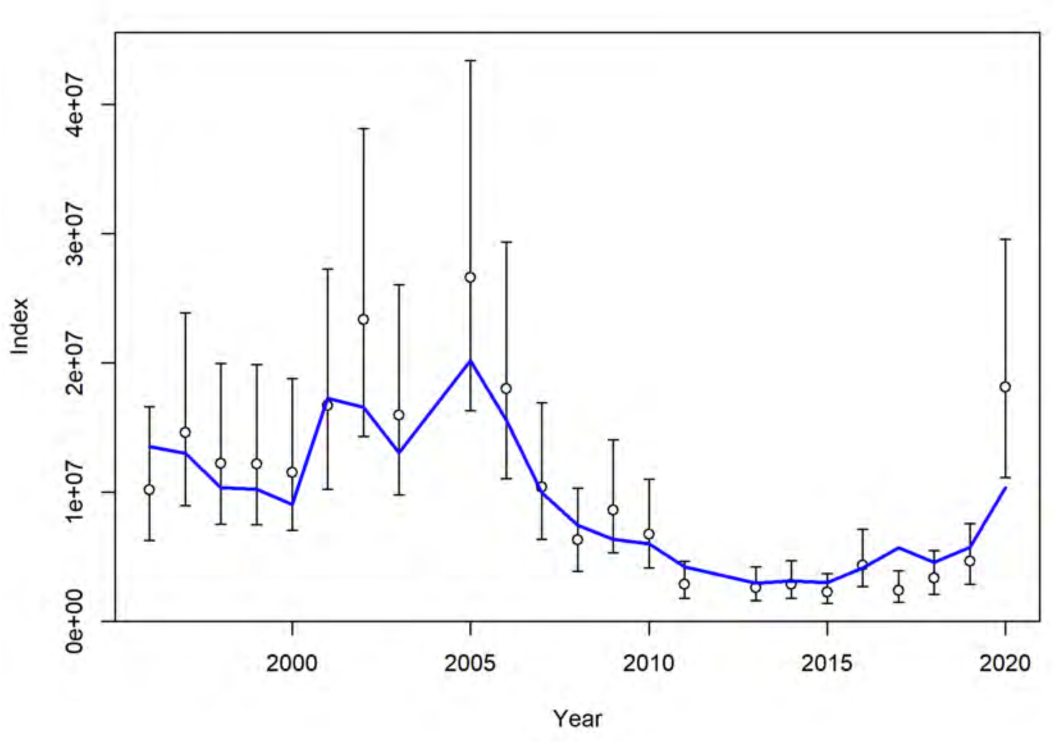


Figure 8.4.1.1. Sardine in 8c and 9a: Model fit to the acoustic survey series. The index is total abundance (in thousands of individuals). Bars are standard errors re-transformed from the log scale.

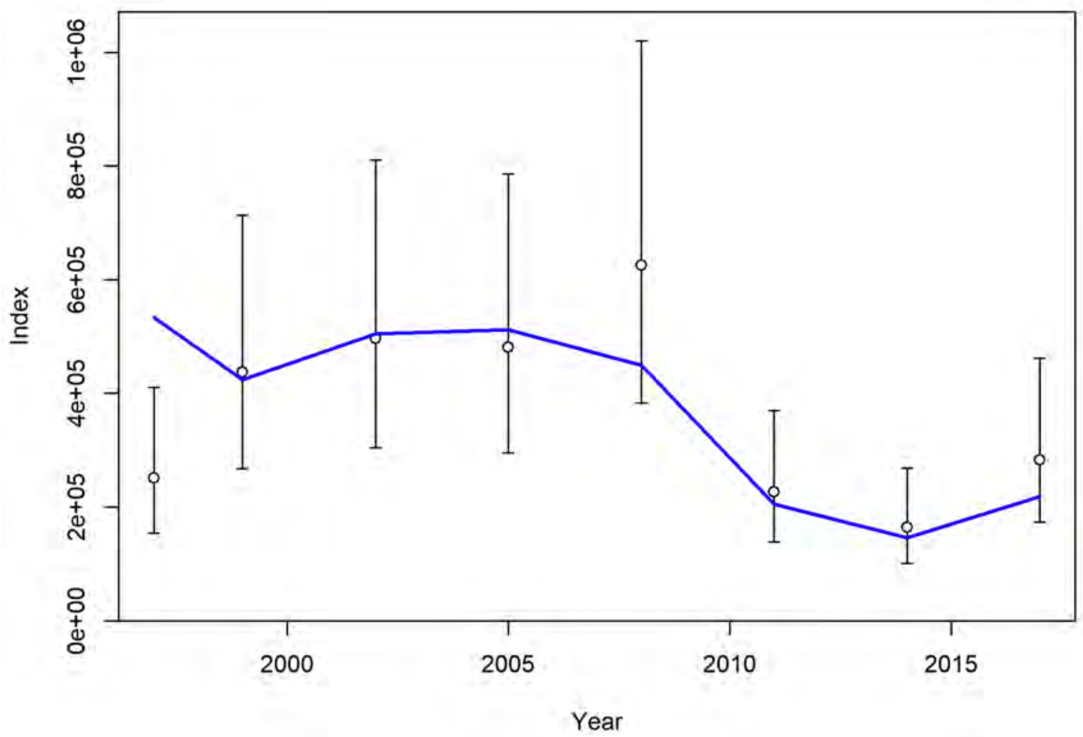
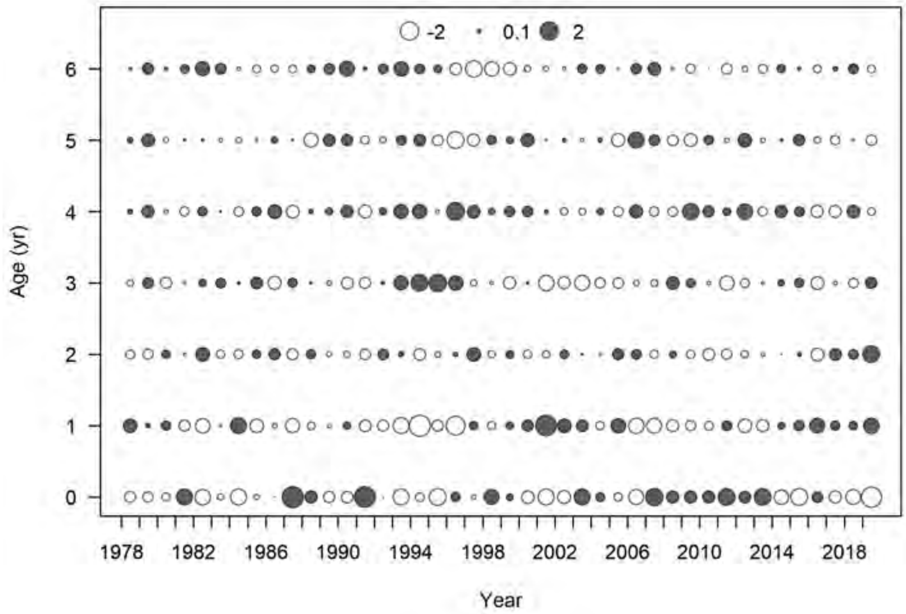


Figure 8.4.1.2. Sardine in 8c and 9a: Model fit to the DEPM survey series. The index is SSB (in thousand tonnes). Bars are standard errors re-transformed from the log scale.



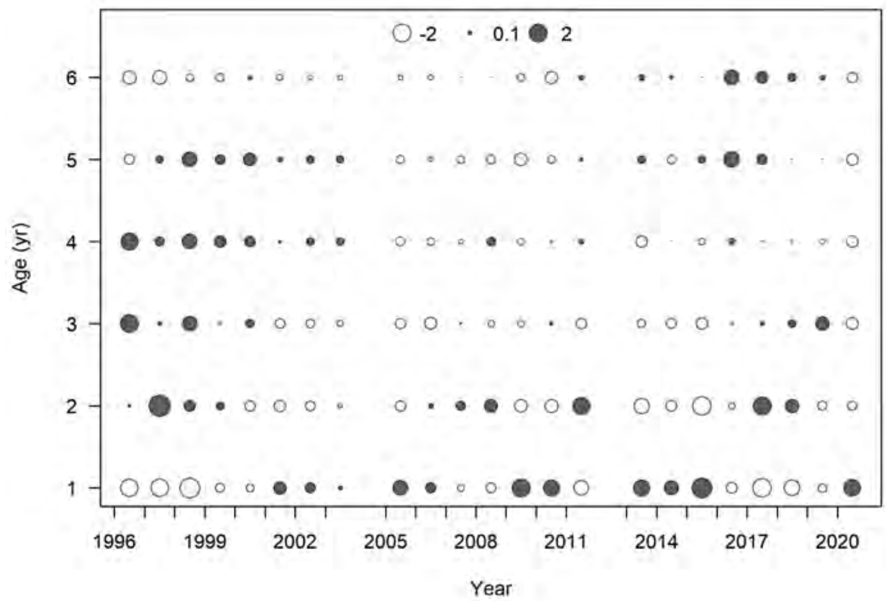


Figure 8.4.1.3. Sardine in 8c and 9a: Model residuals from the fit to the catch-at-age composition (top) and the acoustic survey age composition (bottom).

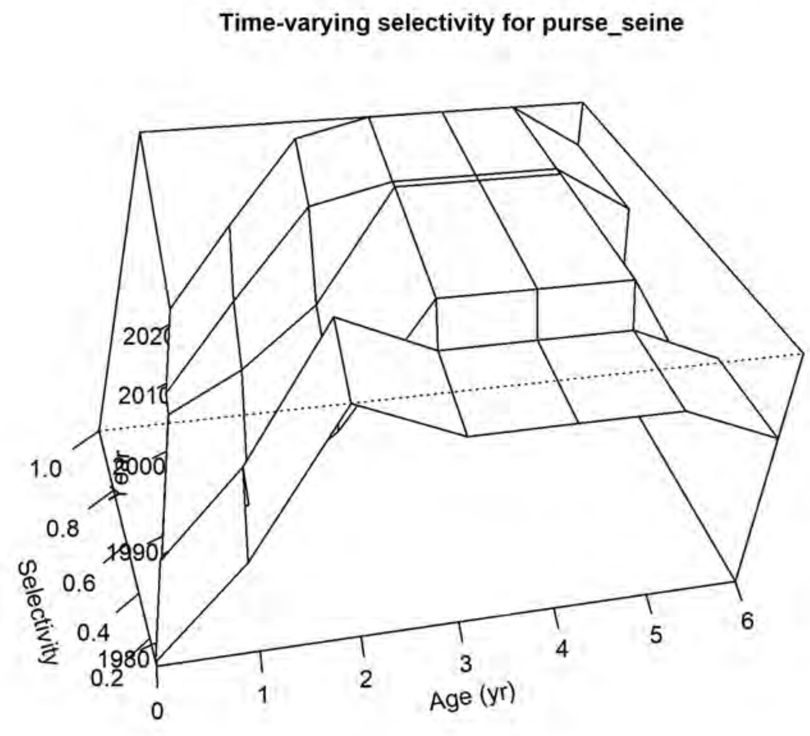


Figure 8.4.1.4. Sardine in 8c and 9a: Selectivity-at-age in the fishery showing the three blocks of fixed selectivity, 1978–1987, 1988–2005 and 2006–2019.

Figure 8.4.1.5. Sardine in 8c and 9a: Historical B1+ (top), $F_{bar(2–5)}$ (middle) and recruitment (bottom) trajectories in the period 1978–2019 (B1+ is estimated up to 2020). The WG 2019 assessment is shown for comparison (red line).

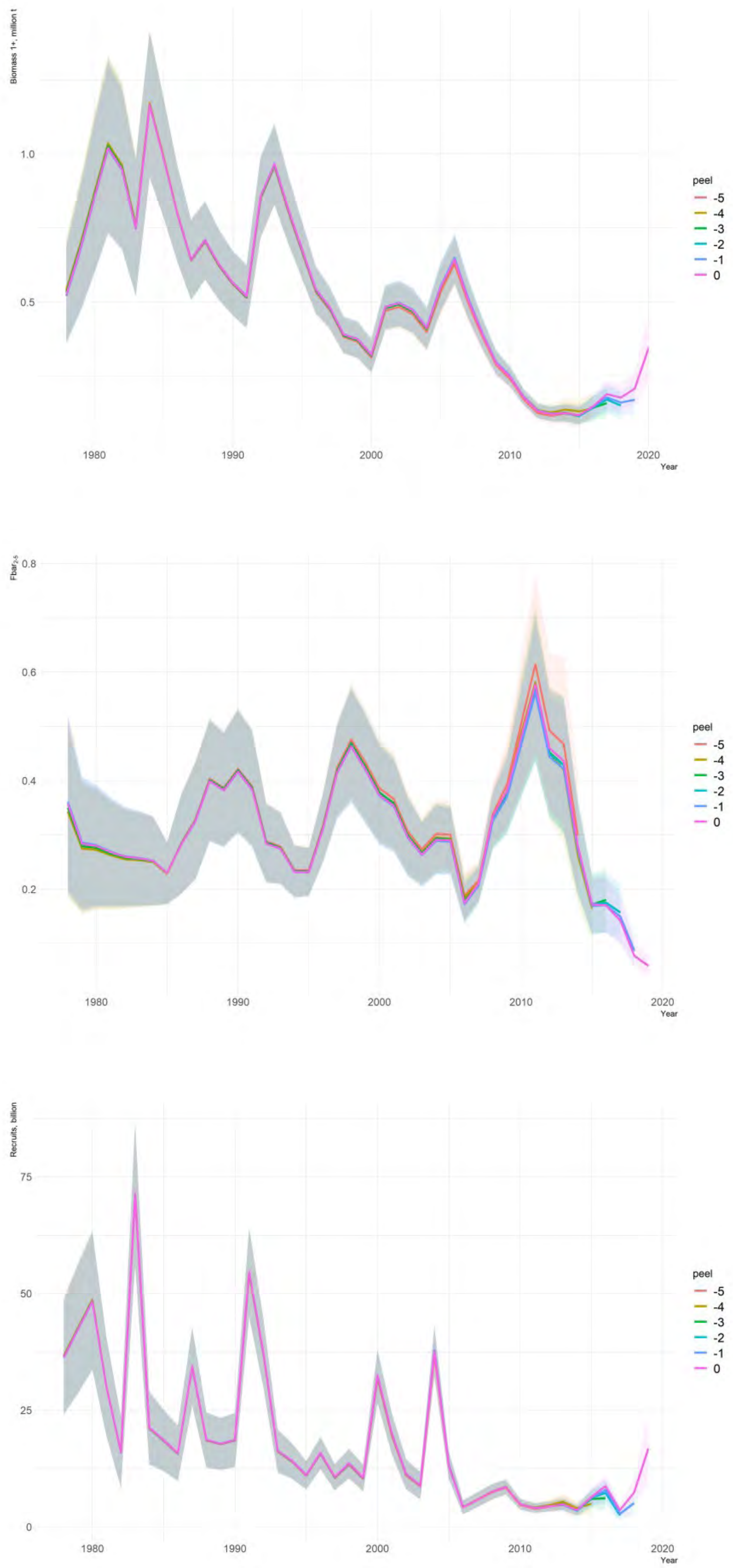
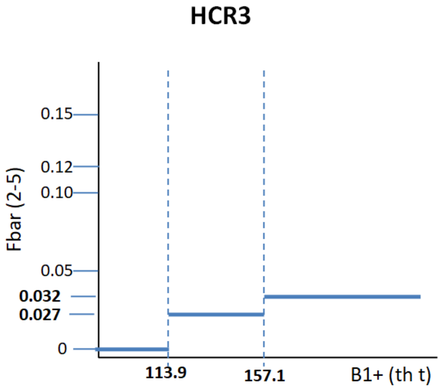
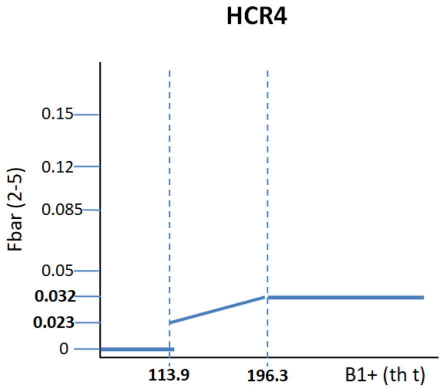


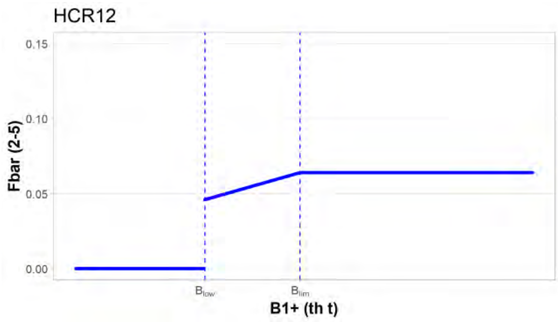
Figure 8.5.1. Sardine in 8c and 9a: Retrospective error for B1+ (top), $F_{bar(2–5)}$ (middle) and recruitment (bottom) in the assessment (B1+ is estimated up to 2020).





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

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



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 a value consistent with F increasing linearly from F=0.046 to F=0.064

iii) B1+ > 196.3 th t then F=0.064

Figure 8.8.1. Sardine in 8c and 9a: Harvest Control Rules HCR3, HCR4 and HCR12 with fishing mortality and biomass of fish age 1 and older (B1+) reference levels.

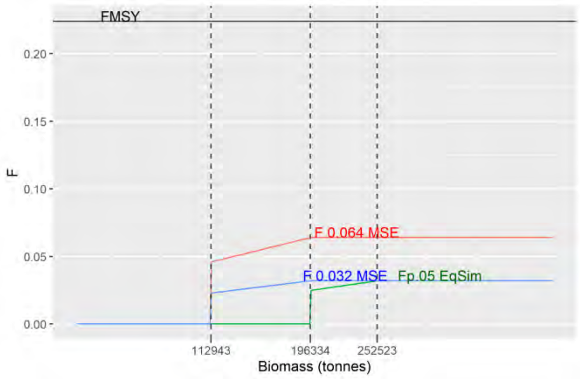


Figure 8.8.2. - Different harvest control rules tested with EqSim (green line) and with MSE within WKSARMP 2019.

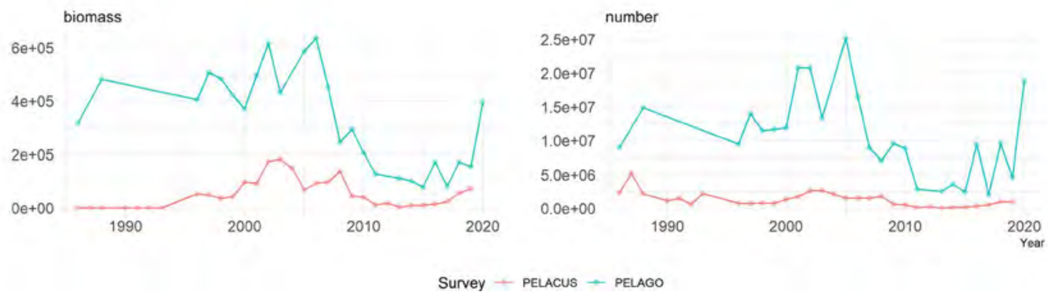


Figure 8.9.1. Sardine in 8c and 9a: Total biomass (left panel) and numbers (right panel) observed in the spring acoustic surveys PELACUS (red line) and PELAGO (blue line) between 1986–2020.

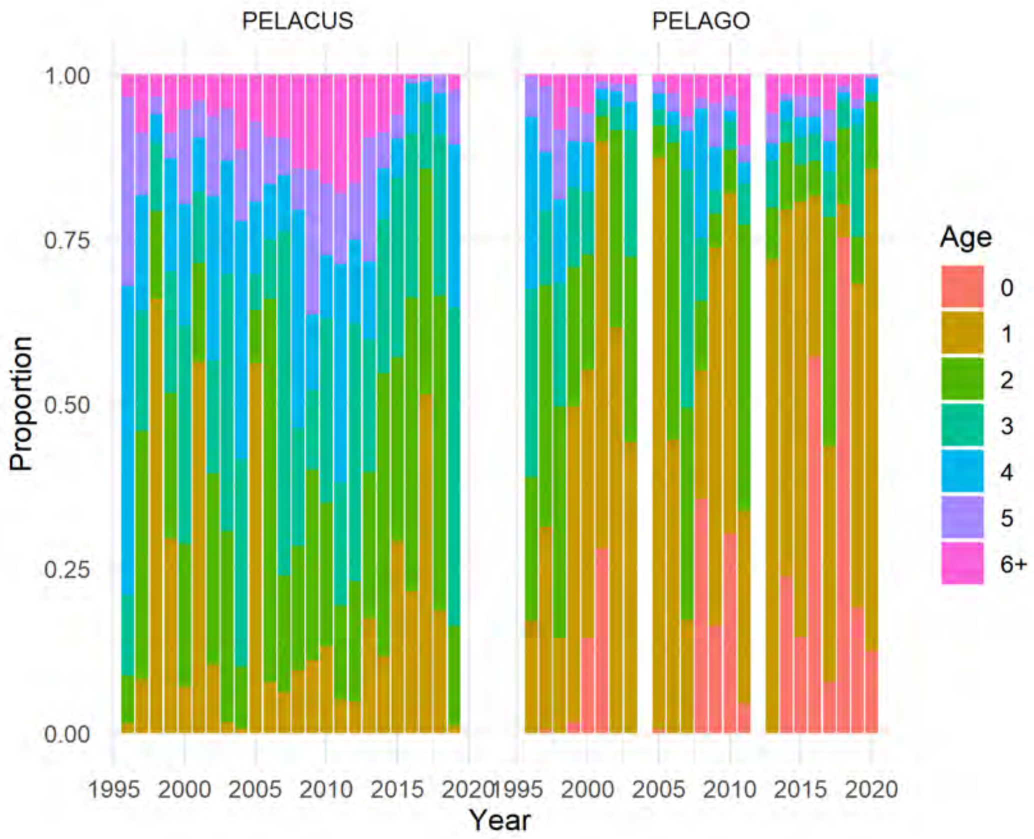


Figure 8.9.2. Sardine in 8c and 9a: Abundance at age in the spring acoustic surveys PELACUS (left panel) and PELAGO (right panel).

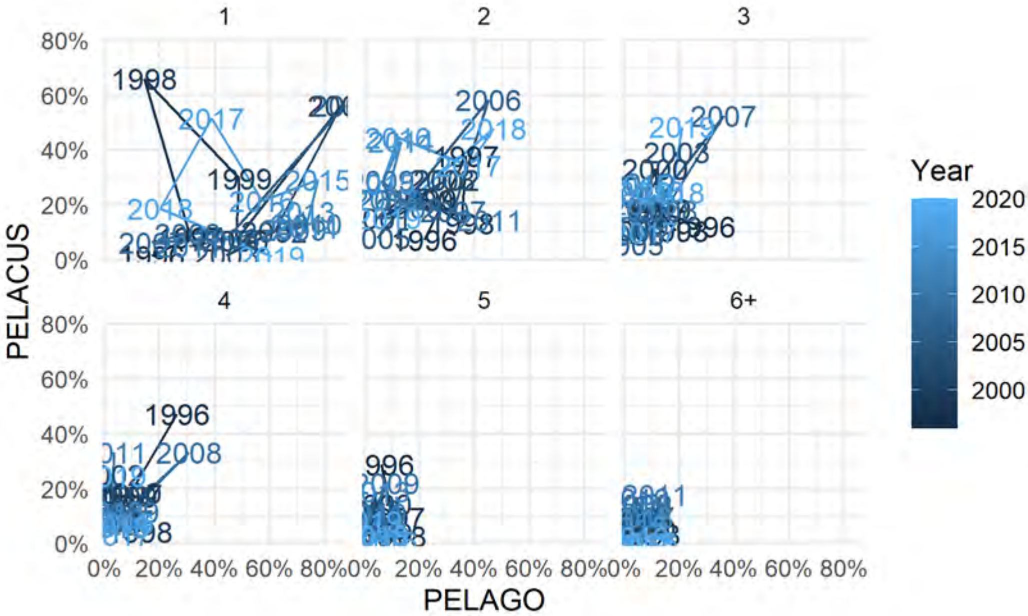


Figure 8.9.3. Sardine in 8c and 9a: Proportion at age in the spring acoustic surveys PELACUS (y-axis) and PELAGO (x-axis).

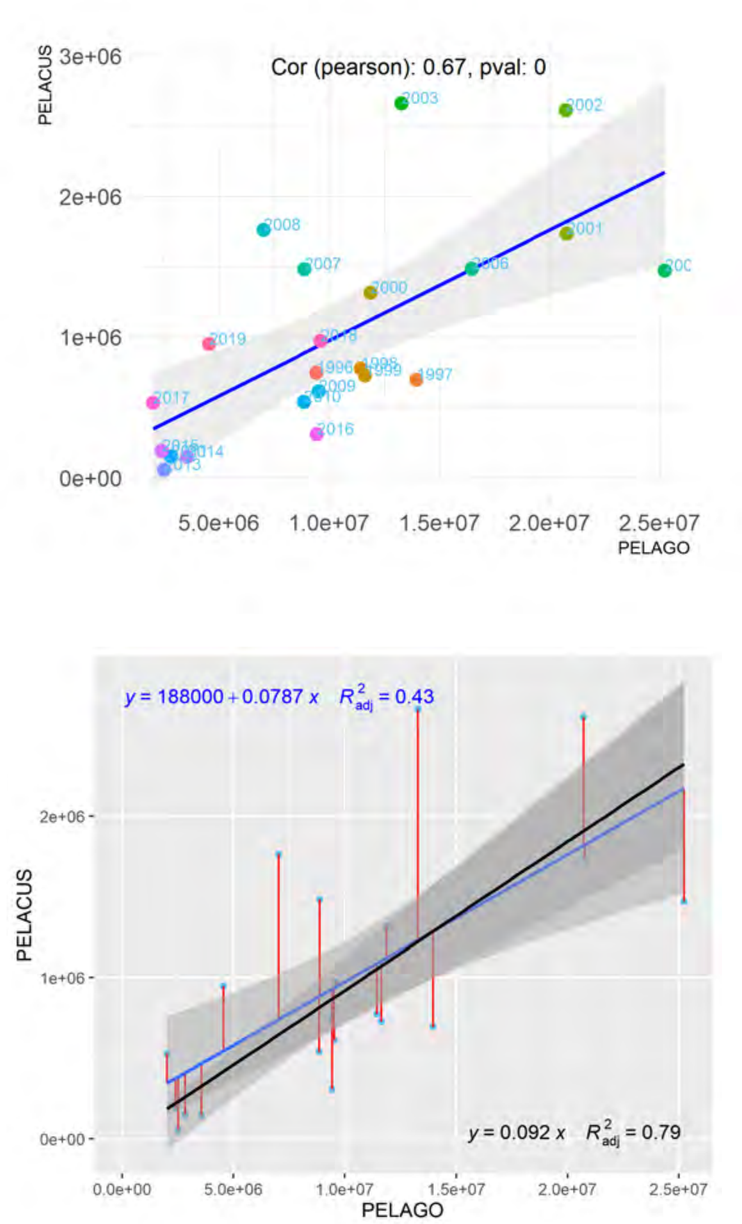
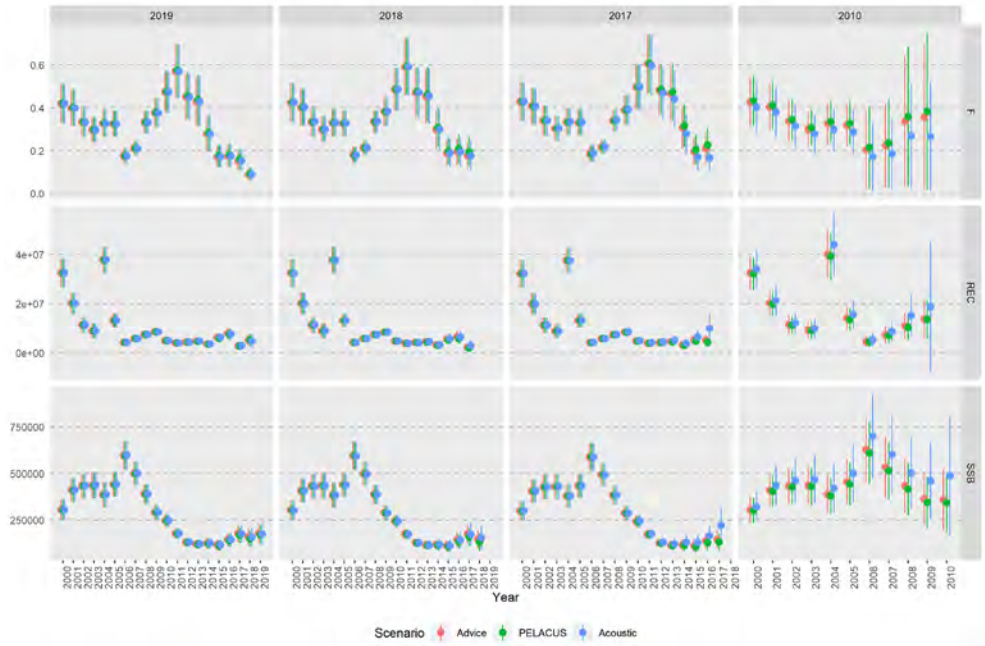


Figure 8.9.4. Sardine in 8c and 9a: Correlation between the abundance (number) of the two spring acoustic surveys. The model without an intercept (black line in bottom panel) was chosen since it had a lower AIC than the model with an intercept (blue line in both panels).



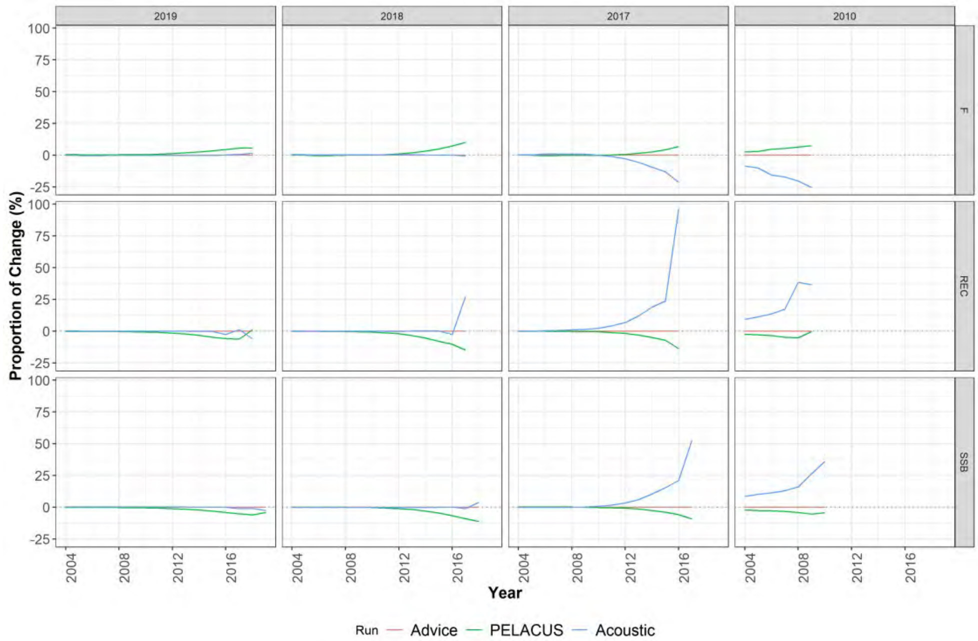


Figure 8.9.5. Sardine in 8c and 9a: Top panel: Point estimates and 95% confidence intervals of the three main variables, fishing mortality (F), recruitment (REC) ans spawning stock biomass (SSB) for the three runs (Advice, PELACUS and Acoustic) for four different assessment years (2019, 2018, 2017 and 2010). Bottom panel: Proportion of change between runs (PELACUS in green, Acoustic in blue) and the 'true' assessment (Advice in red).

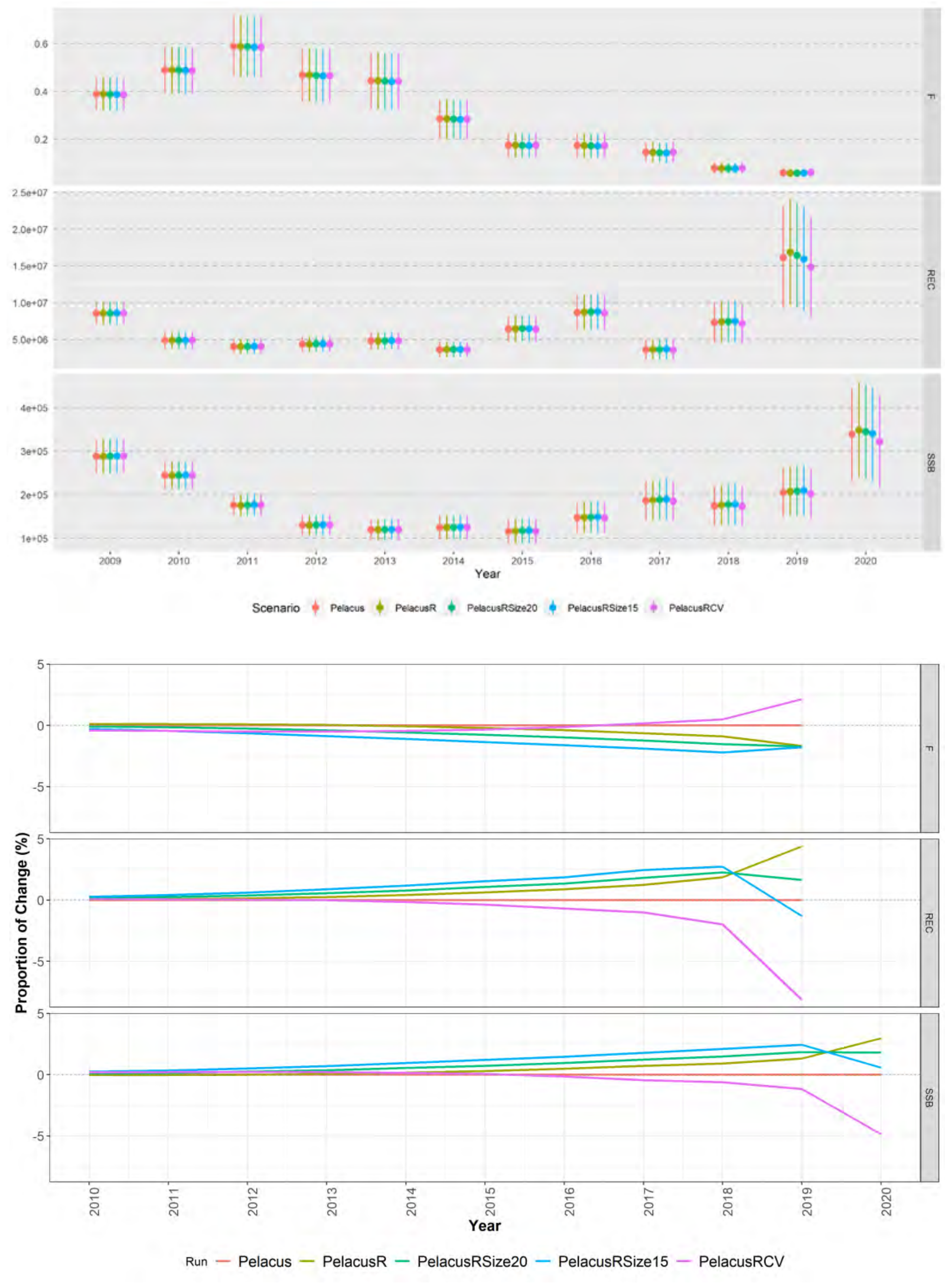


Figure 8.9.6. Sardine in 8c and 9a: Top panel: Point estimates and 95% confidence intervals of the three main variables, fishing mortality (F), recruitment (REC) and spawning–stock biomass (SSB) for the five runs (PELACUS, PELACUSR, PELACUSRSize20, PELACUSRSize15 and PELACUSRCV) of the updated assessment. Bottom panel: Proportion of change between runs (PELACUSR in brown, PELACUSRSize20 in green, PELACUSRSize15in blue and PELACUSRCV purple) and the run PELACUS (in red).

9 Southern Horse Mackerel (hom.27.9a)

9.1 ACOM Advice Applicable to 2020, 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 2011–2018 has been above the time-series average. The ICES advice was based on the MSY approach. ICES therefore recommended that catches in 2020 should not exceed 116 871 t. ICES also recommended that the TAC for this stock should only apply to *Trachurus trachurus*. A TAC of 116 871 t in 2020 has been set for *Trachurus* spp.

9.2 The fishery in 2019

9.2.1 Fishing fleets in 2019

The southern horse mackerel fisheries in Division 9.a are 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 and purse-seine fleets and Spanish purse-seine fleet show a similar exploitation pattern with a great presence of juveniles and lower abundance of adults. In the last few years the Spanish purse-seine fleet had a significant increase of individuals from ages 1 and 2 in the catches. Portuguese purse-seiners also increased the catches of these younger individuals in 2019. 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 have showed a significant decrease in the last few years. Horse mackerel is the main target species in the Portuguese bottom trawl fleet, in 2019 accounted for 46% of the Portuguese catches, while in Spain main catches are from the Purse-seine fleet (89%). Spanish artisanal fishery is negligible (3%). 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 fleet 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 (Figure 9.2.2.1). Spanish catches from the Gulf of Cádiz (Subdivision 9.a.s) are available since 2002 but they are scarce, representing less than the 1% of the total catch 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 (1992–2019) shows a peak in 1998, of 41 564 t, a steady increase since 2011 to 2016 and an increase was observed in 2019 with catches of 35 520 t (Table 9.2.2.1, Figure 9.2.2.2). 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 and increased from last year (+18%). Catches from the Spanish bottom trawl are relatively low despite the increase in 17% from 2018 to 2019 and the catches from the Portuguese purse-seine increased 24% from 2018 to 2019. The contribution of the artisanal fleet from both Portugal and Spain is very small, respectively representing 4% and 1% of the total catches in 2019.

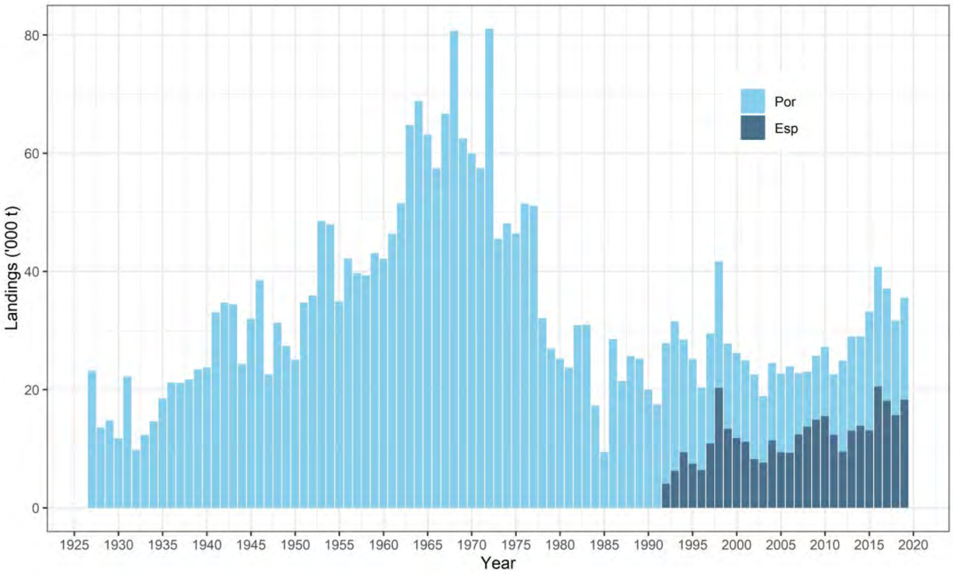


Figure 9.2.2.1. Historical time-series of landings (1927–2019) for southern horse mackerel (Division 27.9.a). Light blue bars are Portuguese landings and dark blue bars are Spanish landings.

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// (22575)*
2012	24,868//(25316)*
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)*
2019	35,520///(36,536)*

(*) 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 until the rest of the time-series is completed.

([1]) These figures have been revised in 2008.

Table 9.2.2.2. Southern horse mackerel landings by gear in the period 1992–2017 (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%
2006	15,019	5,430	3,445

Year	Bottom trawl	Purse-seine	Artisanal
	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%
2019	9,542	24,190	1,788
	26.86%	68.10%	5.03%

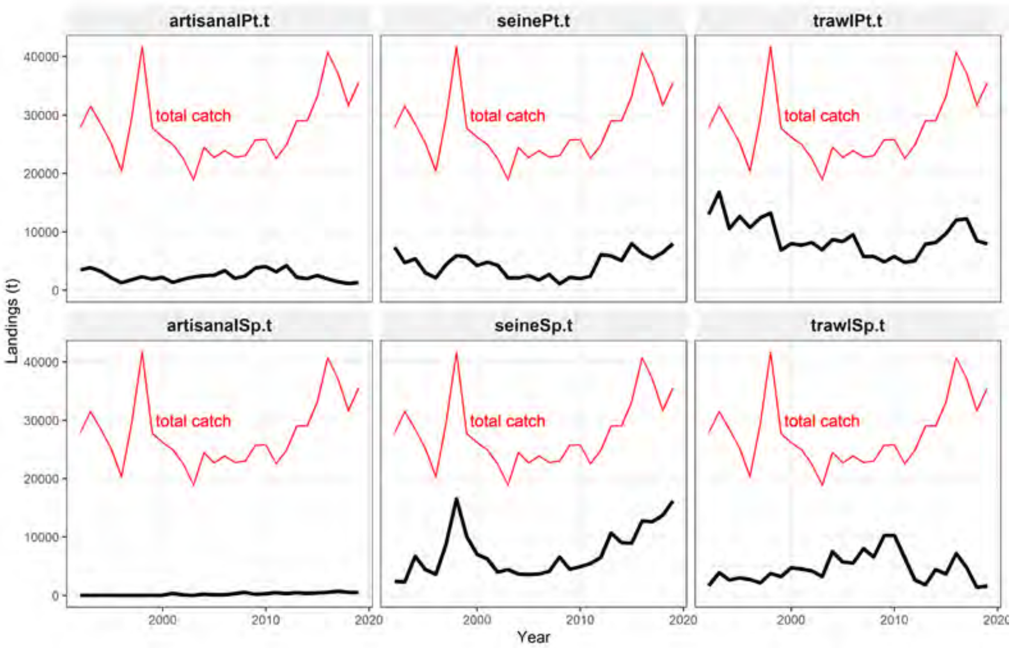


Figure 9.2.2.2. Time-series (1992–2019) of southern horse mackerel catches (in tonnes) by country (Pt – Portugal; Sp – Spain) and gear (artisanal; purse-seine, trawl).

Discards are estimated by both countries (Portugal since 2014, Spain since 2003) from national at-sea sampling programme (DCF) on board commercial vessels operating in ICES Division 9a. Discards are usually very low and not frequent thus being considered negligible. The horse mackerel Spanish discards come mainly from the bottom trawl fleet. Spanish discards in 2019 at Subdivision 9a were estimated to be around 319 tonnes, mainly from the trawl fleet (Table 9.2.2.3). The frequency of occurrence of horse mackerel discards from the Portuguese fleets in 2019 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 2019 by country (SP – Spain, PT - Portugal), fleet/métier, ICES subdivision and quarter.

Country	Fleet	Metier	Fishing Area	Quarter_1	Quarter_2	Quarter_3	Quarter_4	Total
SP	artisanal	GNS_DEF_80-99_0_0	27.9.a.n	0.00	0.02	0.00	0.00	0.0
SP	trawl	OTB_DEF_>=55_0_0	27.9.a.n	1.27	3.60	0.00	1.15	6.0
SP	trawl	OTB_MPD_>=55_0_0	27.9.a.n	0.06	3.18	0.00	0.00	3.2
SP	trawl	PTB_MPD_>=55_0_0	27.9.a.n	0.00	14.67	0.00	0.00	14.7
SP	trawl	OTB_MCD_>=55_0_0	27.9.a.s	98.02	160.56	28.01	0.00	286.6
SP	purse seine	PS_SPF_0_0_0	27.9.a.s	0.00	8.08	0.10	0.00	8.2
PT	trawl	OTB_CRU_>=55_0_0 (Loa >=12m)	27.9.a	0	0	0	0	0.0
PT	trawl	OTB_DEF_>=55_0_0 (Loa >=24m)	27.9.a	0	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 combined Portuguese and Spanish catch-at-age from 1992–2019, with age range 0–11+.

In general, catches are dominated by juveniles and young adults. Catches at age-2 showed a sharp increase in 2019 (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 1992–2019 (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
2019	27706	146270	116225	48796	20638	25280	11293	9325	7943	4022	5208	4361

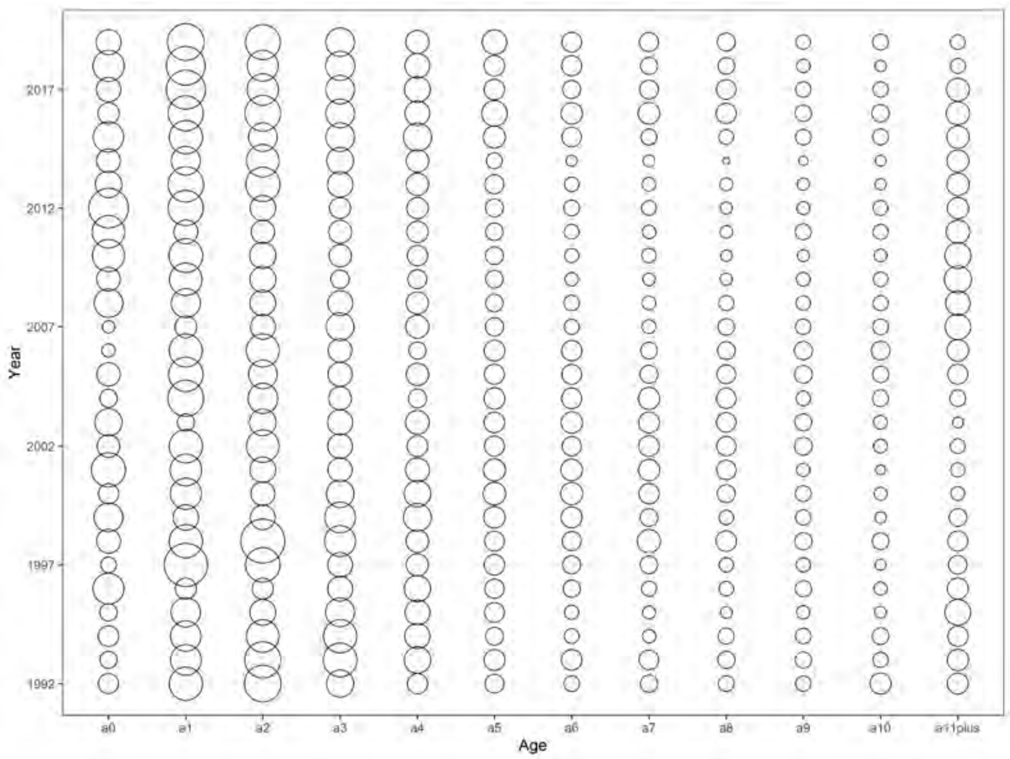


Figure 9.2.4.1. Bubble plot of proportions of southern horse mackerel catch in numbers-at-age in each year (1992–2019).

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 1992–2019. In 2019, the Portuguese and Spanish purse-seine fleet and the Portuguese trawl and artisanal fleets caught mainly juveniles and young adults. While the Spanish trawl and artisanal fleets catch larger, adult horse mackerel. In 2019, the Spanish purse-seine fleet showed an increase at catches at age-2–3 and the Portuguese artisanal fleet showed an increase in catches at ages 1–2.

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 1992–2019.

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
2019	494	6704	24021	18825	5382	8234	4354	3588	3030	1533	2064	2593

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
2019	22771	130029	88205	28013	14267	15732	6347	5175	4360	2087	2655	1407

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
2019	4441	9536	3999	1959	989	1314	591	562	553	402	488	361

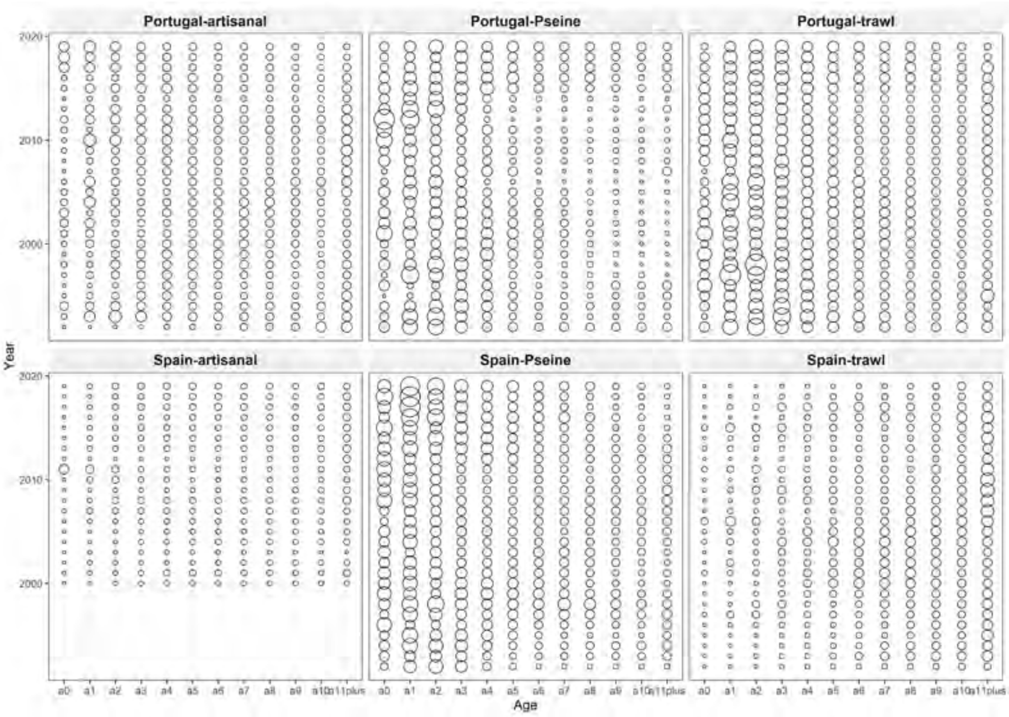


Figure 9.2.4.2. Bubble plot of proportions of southern horse mackerel catch in numbers-at-age by country and fleet in each year (1992–2019).

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 2019.

The mean weight-at-age is of a similar magnitude to previous years in all ages (Figure 9.2.5.1, Table 9.2.5.1) and the variations of mean length-at-age are of a similar scale along temporal series (Table 9.2.5.2). Otoliths from older fish became thicker with time and thus presenting more difficulties for age determination at 11+. In 2019, samples of ages 14–15 were only available from area 9.aNorth.

Table 9.2.5.1. Southern horse mackerel mean weight-at-age (kg) in the catch (1992–2017).

	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
2019	0.02	0.04	0.06	0.08	0.12	0.14	0.17	0.22	0.24	0.34	0.37	0.46

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
2019	13.4	16.3	19.2	21.3	24.2	25.4	27.3	29.8	30.7	34.0	35.1	37.0	38.3	40.3	41.8	39.8

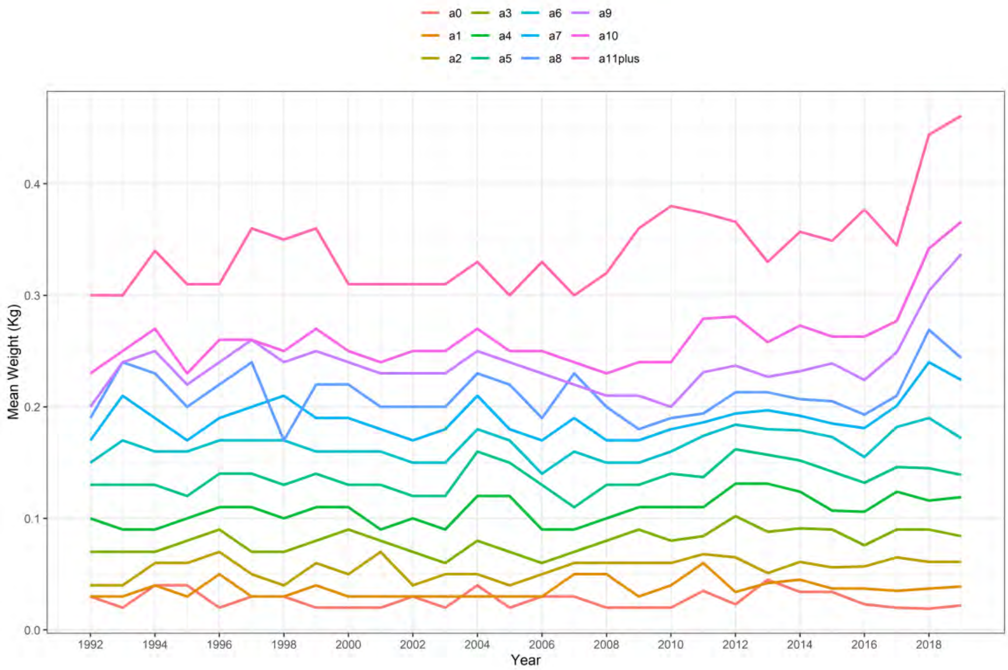


Figure 9.2.5.1. Southern horse mackerel mean weight-at-age (kg) in the catch (age range: 0 to 11+, plus group) (1992–2019).

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 Portuguese 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. Acoustic estimates require further analysis to be used as auxiliary information for recruitment strength.

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 combined survey abundance-at-age for tuning the assessment excluding age 0 is presented in Table 9.3.1.2.

The Portuguese IBTS was not conducted in 2019. Because this survey traverse the majority of the stock area, the combined survey abundance-at-age index could not be estimated for 2019.

Table 9.3.1.1.Southern horse mackerel. Cpue-at-age (number/hour) by survey, in the period 1992–2019. The Portuguese IBTS (October) survey were not conducted in 2012 and 2019.

Portuguese October Survey

	AGES															
YEAR	**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
2019	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Spanish October Survey (only Subdivision IXa North)

	AGES															
YEAR	**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
2019	0.6	0.3	0.1	0.1	0.4	2.1	0.3	0.1	0.1	0.0	0.5	0.2	0.2	0.0	0.0	0.1

***** 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 1992–2017. There were no Portuguese surveys in 2012 and 2019 and therefore the combined survey indices for 2012 and 2019 are 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
2019	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

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 (1992–2019).

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 1992–2019 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+. In 2012 and 2019, the Portuguese survey was not carried and, hence, the combined survey indices for 2012 and 2019 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, 2012, 2015 and subsequent years, 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 Portuguese and Spanish purse-seine fleets.

Table 9.4.1.1. Input data type, model assumptions and settings for the assessment of southern horse mackerel with data series 1992–2019.

Name	Year range	Age range	Assumptions/settings
Catch in weight	1992–2019		Variable in time
Catch-at-age	1992–2019	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)	1992–2019	0–11+	Variable by age and time
Proportion of F and M before spawning	1992–2019	0–11+	Fixed at 0.04 (mid-January)
Natural Mortality	1992–2019	0–11+	Age-dependent; time invariant
Catch-at-age selectivity	1992–2019	0–11+	Dome-shaped; constant at age 7+ Three blocks 1992–1997; 1998–2011; 2012–2019
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 1992–2019 (no survey index in 2012 and 2019)
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	1992–2019	0–11+	Multinomial distribution; log-normal with a constant CV of 5%
Proportion-at-age in the survey	1992–2019	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 presents the estimated selectivity in the survey (age range 1–11+) and in the catch-at-age (age range 0–11+) for the period 1992–2019.

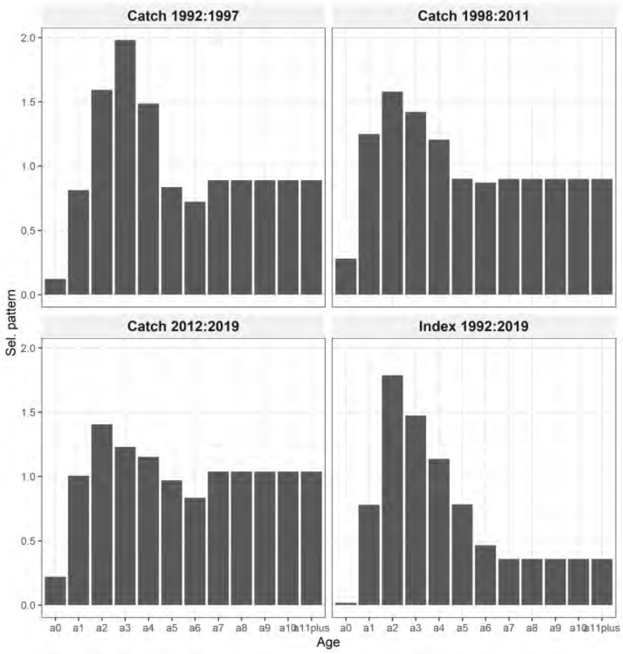


Figure 9.4.1.1. Southern horse mackerel. Estimated selectivity for the catch-at-age (three time blocks) and for the IBTS combined stratified mean abundance-at-age (one time block).

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 (1992–2019). Stock summary table (SSB at spawning time).

Year	Recruits (10*3)	SD	CV	SSB (t)	SD	CV	mean F_{2-10}	SD	CV	Catch (t)
1992	4386350	866378	0.20	295376	72442	0.25	0.087	0.020	0.23	27858
1993	3071000	639616	0.21	317063	80362	0.25	0.092	0.022	0.24	31521
1994	3030910	637637	0.21	338414	89355	0.26	0.075	0.019	0.25	28441
1995	4152710	848249	0.20	323479	88386	0.27	0.072	0.019	0.26	25147
1996	11171200	2068830	0.19	344567	96966	0.28	0.052	0.014	0.26	20400
1997	3675310	747686	0.20	362576	102320	0.28	0.072	0.019	0.26	29491
1998	2356190	513262	0.22	366600	102197	0.28	0.096	0.025	0.26	41564
1999	3591840	744639	0.21	417440	119940	0.29	0.059	0.016	0.27	27733
2000	3275730	697633	0.21	403472	118173	0.29	0.061	0.016	0.27	26160
2001	3872940	820319	0.21	387355	116231	0.30	0.060	0.016	0.27	24910
2002	2191290	505531	0.23	374790	114132	0.30	0.058	0.016	0.28	22506
2003	4347940	934400	0.21	375185	115313	0.31	0.049	0.013	0.27	18887
2004	4793460	1030380	0.21	425933	132003	0.31	0.053	0.014	0.27	23252
2005	3015470	683723	0.23	389795	121565	0.31	0.055	0.015	0.28	22695
2006	1573420	396655	0.25	377885	118255	0.31	0.060	0.017	0.28	23902
2007	2334770	568540	0.24	381525	121014	0.32	0.057	0.017	0.29	22790
2008	3706150	890618	0.24	375688	121473	0.32	0.059	0.017	0.29	22993
2009	3468690	876103	0.25	376114	124447	0.33	0.067	0.020	0.3	25737
2010	4330660	1121010	0.26	377443	127674	0.34	0.067	0.021	0.31	26556
2011	10955800	2730340	0.25	380175	131097	0.34	0.042	0.013	0.31	21875
2012	12987600	3230170	0.25	403738	138718	0.34	0.045	0.014	0.32	24868
2013	7132010	1881660	0.26	411265	138576	0.34	0.044	0.014	0.32	28993
2014	9746380	2577120	0.26	521876	170112	0.33	0.039	0.012	0.32	29017
2015	10498300	2905280	0.28	576836	184236	0.32	0.043	0.014	0.32	32723
2016	11726200	3446650	0.29	614174	194967	0.32	0.051	0.016	0.32	40741
2017	15021300	4746360	0.32	728804	232265	0.32	0.040	0.013	0.32	36946
2018	16394600	5784730	0.35	891175	282717	0.32	0.028	0.009	0.32	31661
2019	6410320	3382340	0.53	992092	311706	0.31	0.028	0.009	0.32	35520
Average	6186376	1652709	0.25	447530	138094	0.31	0.058	0.016	0.29	27675

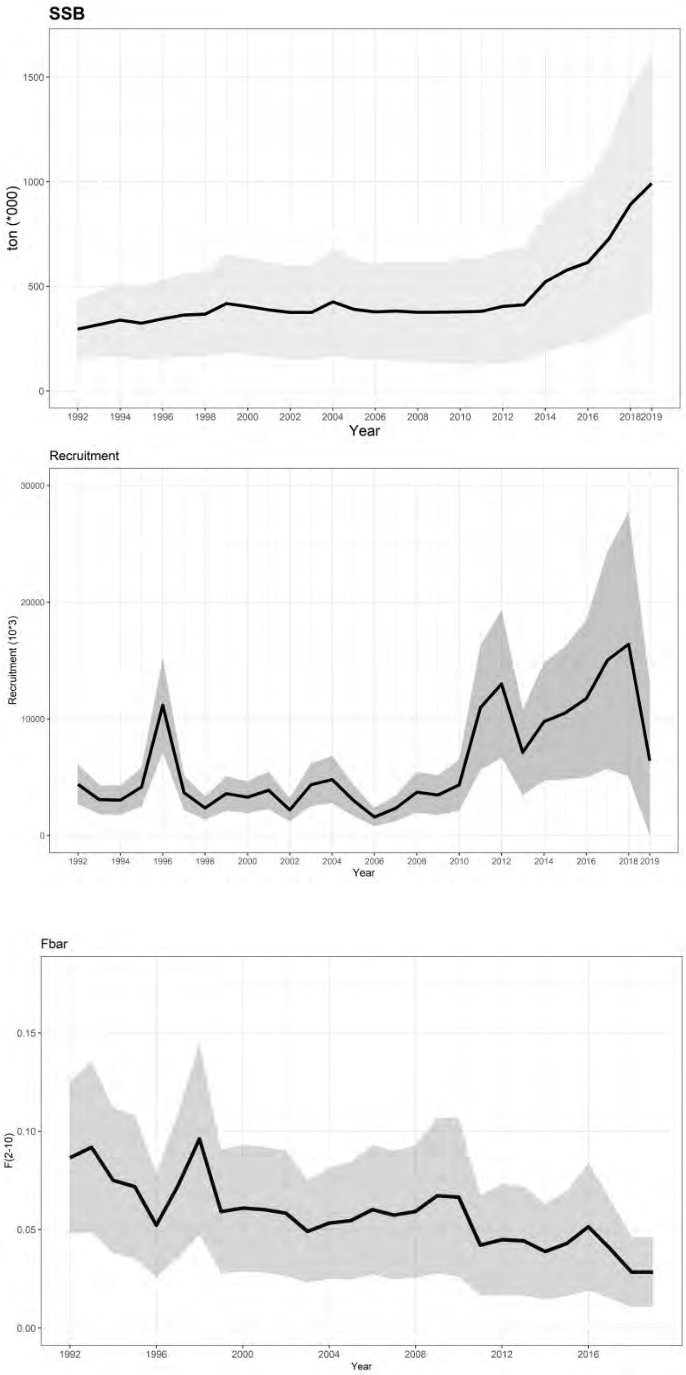


Figure 9.4.1.2. Southern horse mackerel final assessment (1992–2019). Plots of SSB (top), Recruitment (middle) and Fishing mortality (bottom, mean $F_{2–10}$). Grey shaded area shows 95% confidence bounds and average CV is 31% for SSB and 29% for $F_{2–10}$. SSB are in thousand tonnes and recruitment in thousands.

The estimated SSB shows a significant increase from 2013 to 2019 from 403 thousand tonnes to 992 thousand tonnes. Confidence intervals of SSB are in the range 25–34%. The fishing mortality has been below F_{MSY} over the whole time-series and after the slight increase in 2016, showed a decrease in 2017–2018. F in 2019 was estimated at 0.028 similar to the observed value in 2018. Confidence intervals of F are in the range 23–32%. The stock showed a strong recruitment in 1996 and above average recruitments in the most recent years, with high values in 2011, 2012 and

2016–2018. Although recruitment in 2018 is estimated as the highest recruitment, this estimate presents a high uncertainty due to lack of the 2019 survey tuning index (notably, estimates of age-1) in this year assessment. The latest recruitment in 2019 (6410 million) is estimated to be below average, but with high uncertainty.

Figure 9.4.1.3 shows the scatterplot of the estimated spawning–stock biomass and recruitment in the period 1992–2019.

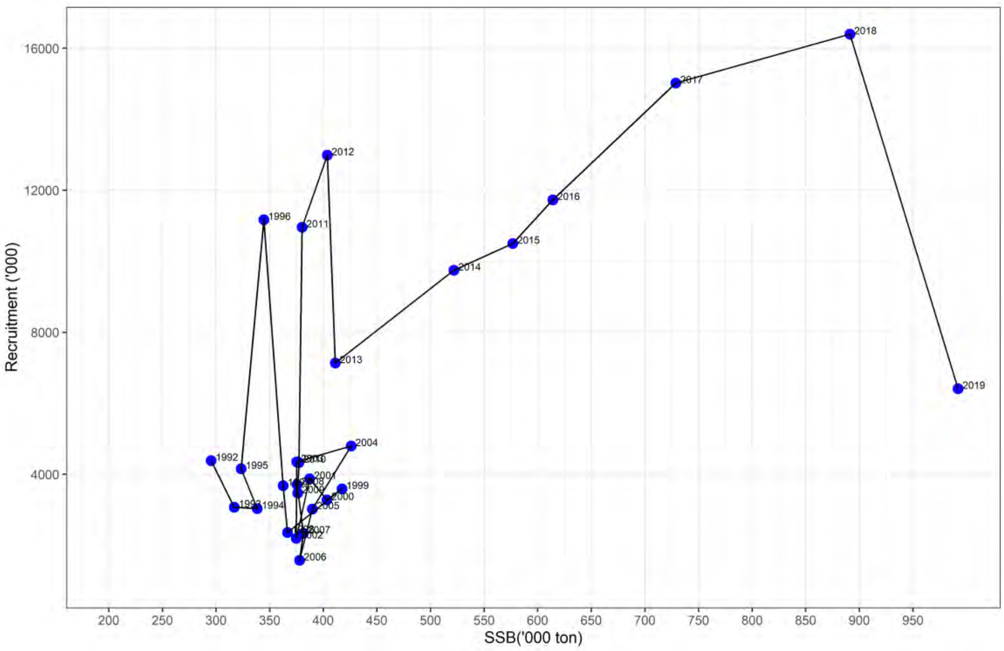
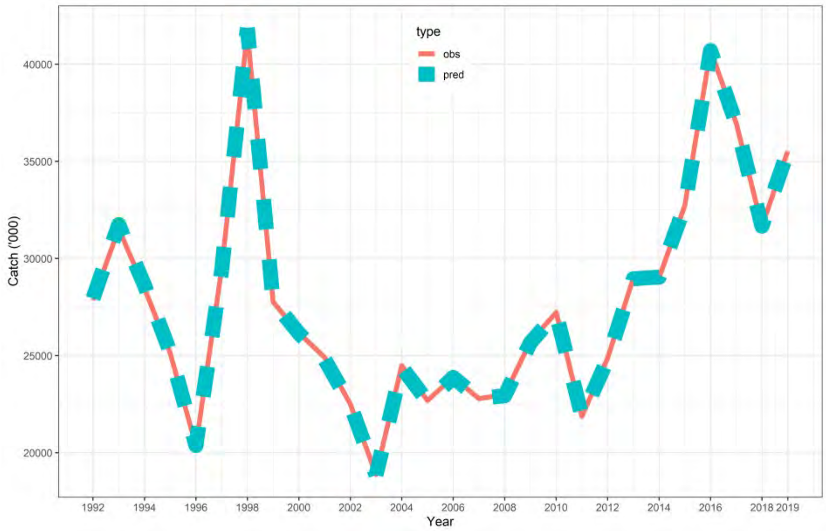


Figure 9.4.1.3. Stock–recruitment data for southern horse mackerel (1992-2019).

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 model down-weighted the high biomass observed in 2005. However, the 2013 and 2017 survey index were the highest in the time-series, which contributed for a steady increase of the fitted survey biomass index from 2013 to 2018, reaching values two times above the average (Figure 9.4.2.1). The 2019 combined survey index could not be estimated, due to the Portuguese survey not being carried out, and current assessment has been performed without 2019 tuning index this year. As a result of lacking 2019 index, a high uncertainty is observed in 2018 and 2019 recruitments.



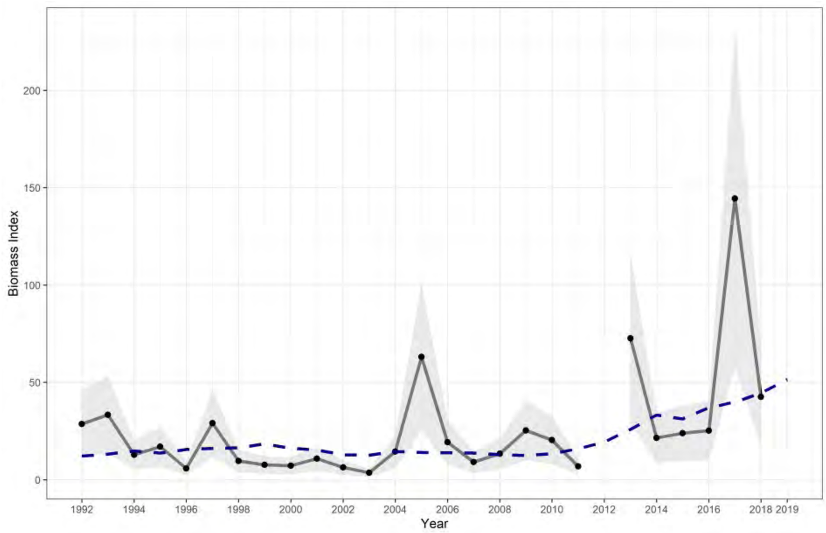


Figure 9.4.2.1. Southern horse mackerel (1992–2019). Catch biomass (top) and survey biomass index (bottom): observed (solid black line) and estimated values (dashed blue line). (Grey shaded area shows 95% confidence bounds of survey biomass index).

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 bubble plots of the residuals corresponding to the fitting of those data, are shown in Figure 9.4.2.4.

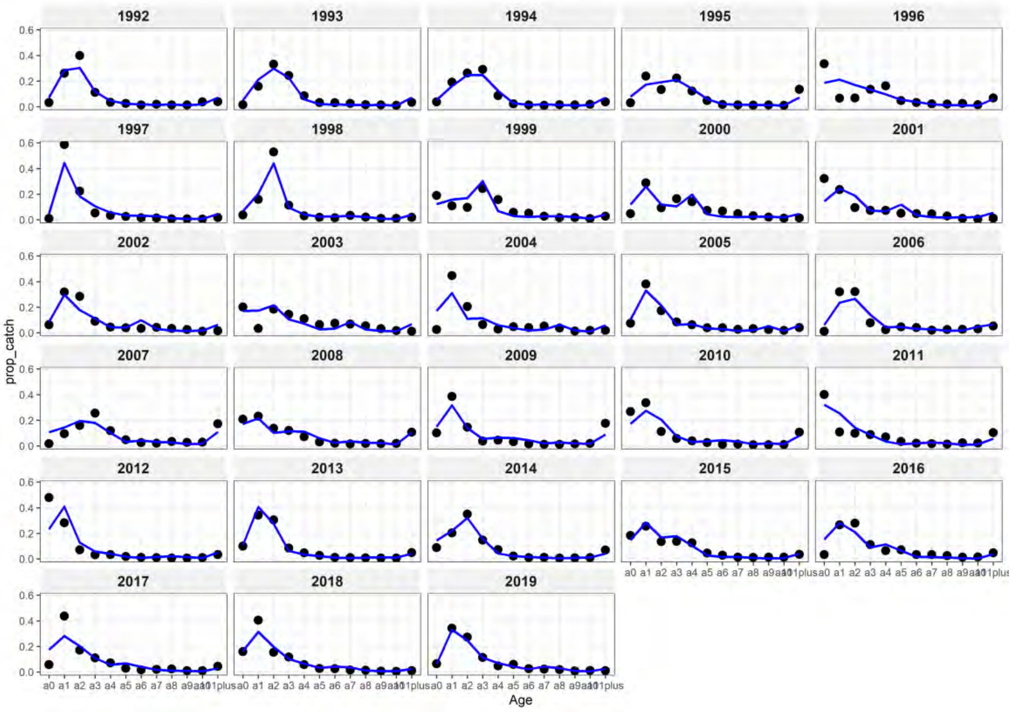


Figure 9.4.2.2. Southern horse mackerel (1992–2019). Comparison of proportions-at-age of the observed and fitted catch data (observed values=dots; fitted values=solid lines).

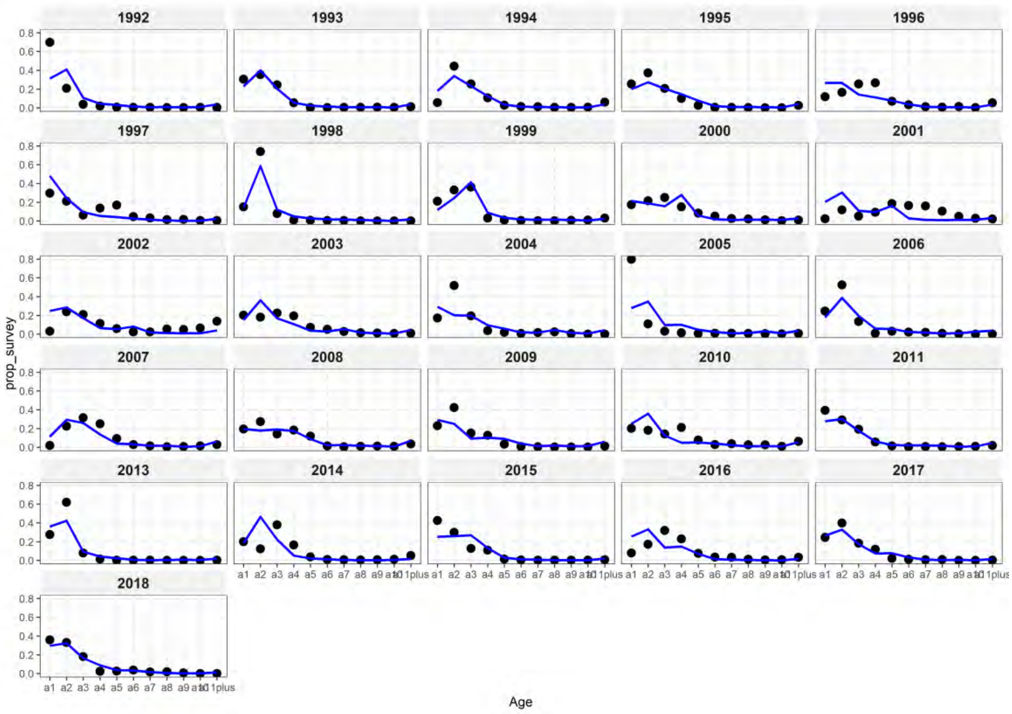


Figure 9.4.2.3. Southern horse mackerel 1992–2018). Comparison of proportions-at-age of the observed and fitted survey data (observed values=dots; fitted values=solid lines).

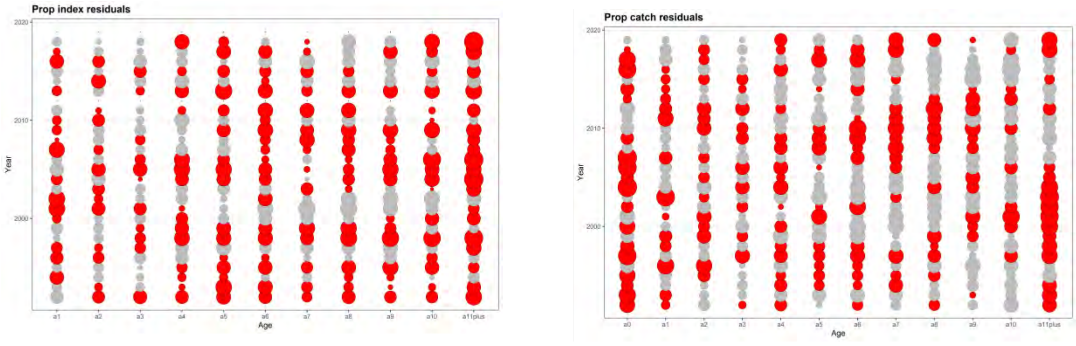


Figure 9.4.2.4. Southern horse mackerel (1992–2019). Bubble plot of catch (left, age range 0–11+) and survey (right, age range: 1–11+) proportion-at-age residuals (negative residuals=red bubbles).

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 32% (coefficient of variance). The relatively stable catches observed in 2019 and the continuous increase in stock abundance resulted in the same F_{bar} in 2019 that in the previous year. The uncertainty in the estimated F_{bar} is of similar magnitude around 32% (coefficient of variance). Because there was no available survey index for 2019, the stock assessment was performed without a tuning index in 2020, and therefore recruitments in last two years are highly uncertain (CV: 35% and 53%). Following the recommendation of last year ADGHANSA, the recruitments for 2018 and 2019 were replaced by the geometric mean of the last ten years (2008–2017) in the STF to reflect the estimated high values observed in the last years.

The retrospective analysis on SSB, recruitment and F_{bar} (mean F ages 2–10) was performed for a five-year period, from 1992–2014 to 1992–2019 time-series. The average Mohr´s rho are shown in Figure 9.4.2.5, which indicate an underestimation of the SSB (-0.14) and R estimates (-0.33) and overestimation of F (0.23). 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 of SSB and F are below or around the critical value (± 20) and the observed retrospectives are mostly inside the confidence bounds of the last assessment estimates.

Based on the results of the sensitivity analysis performed on the missing 2019 survey tuning index (see following Section 9.4.3), WGHANSA argued that the update assessment gives a valid basis for advice. It is noted, however, that there has been a continued and significant shift in relative catch contribution from bottom trawls to purse-seines in recent years (particularly in the last two years) which has led to a change in the age composition of catches, with an increase in the proportion of 1–2 year old fish (juveniles and young immature fish). This may violate the assumption of constant selectivity on the last period of the assessment (since 2011) and should be further investigated.

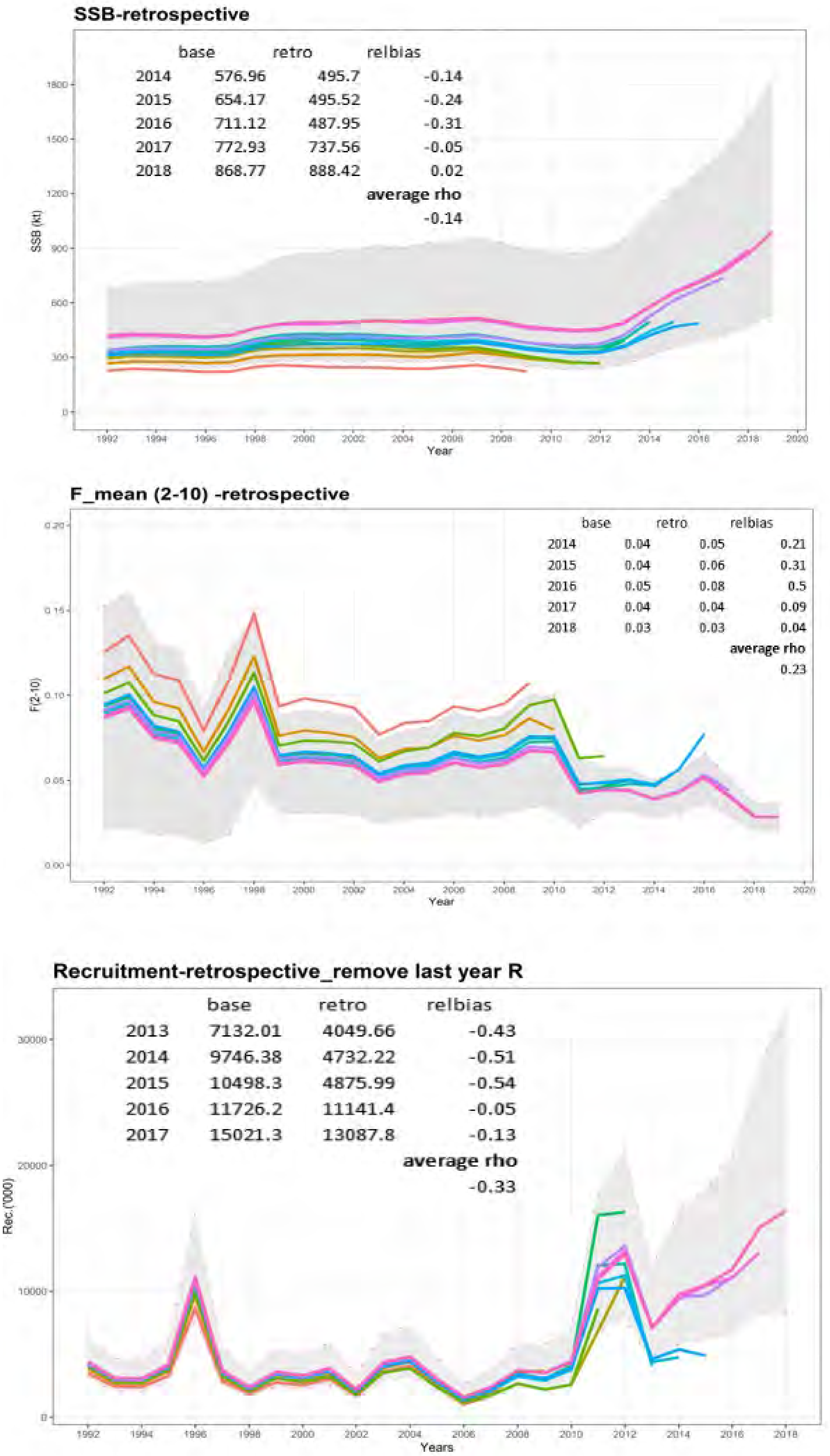


Figure 9.4.2.5. Retrospective analysis results. Trajectories of SSB, Recruitment and Fbar (grey=95% confidence intervals for the current assessment). The table in each graph shows the last assessment estimates (base) compared to each retrospective assessment (retro) and the relative bias in each year (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) 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.

Purse-seine catches in 2019 were about 2.5 times higher than catches from the trawl fleet and there has been a significant increase in the catch proportion of ages-1–2 in the last few years (Figures 9.2.4.2 and 9.4.2.3). WGHANSA 2018 performed exploratory assessment trial runs in the catch selectivity which showed an improvement in the model fit to proportions-at-age when an extra time block 2017–2018 in the catch selectivity was added to the model. The large increase of purse-seine catches when compared to the trawl fleet should be further analysed to assess for potential changes in the selectivity pattern that could accommodate the changes in the catch-at-age composition.

Some exploratory assessment trial runs were performed removing the last year survey index (Figure 9.4.3.1) or the second last year index (Figure 9.4.3.2) to compare results of the 2017, 2018 and 2019 assessments with and without these indices. It was noted that the magnitude of the impact of lacking a survey index is related with the estimate of the biomass index values, for example, the very high survey index values in 2017 caused a significant underestimation of SSB and an overestimation of F (top panels - Figure 9.4.3.2). However, the other trial runs showed no significant changes and WGHANSA decided that the update assessment without the 2019 year survey index could give a valid basis for advice.

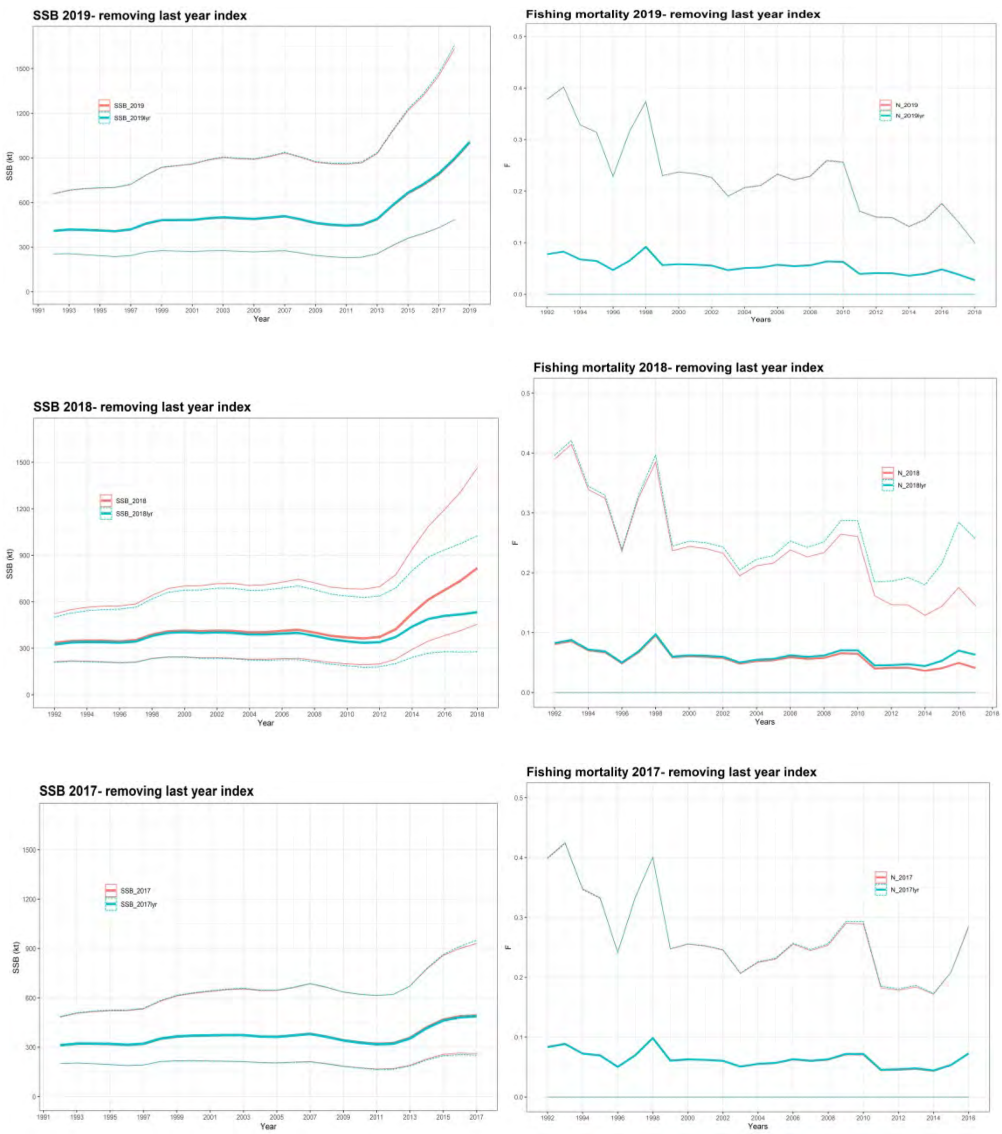


Figure 9.4.3.1. Sensitivity analysis results. Comparative trajectories of SSB and F_{bar} when last year index is removed (blue line) of stock assessment model in 2017, 2018 and 2019 assessments (dotted line=95% confidence intervals).

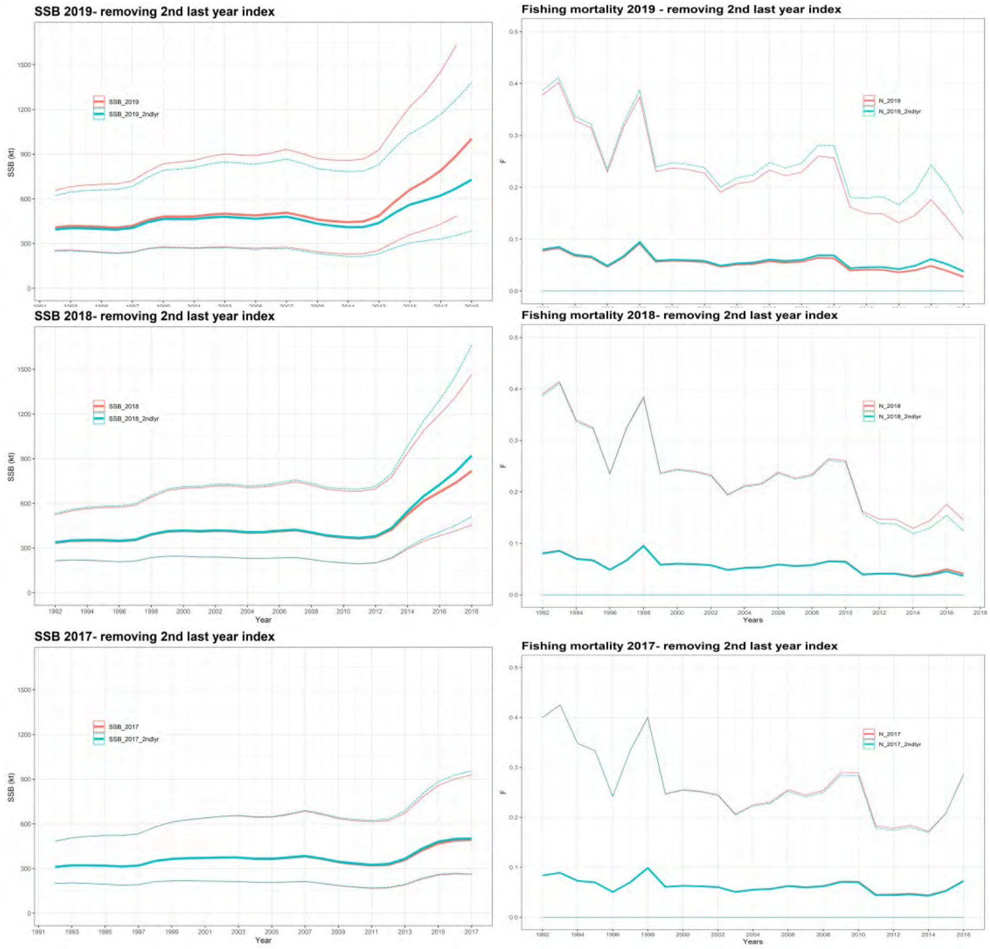


Figure 9.4.3.2. Sensitivity analysis results. Comparative trajectories of SSB and F_{bar} when second last year index is removed (blue line) of stock assessment model in 2017, 2018 and 2019 assessments (dotted line=95% confidence intervals).

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. Due to high uncertainty in recruitment for 2018, it is assumed a constant recruitment corresponding to the geometric mean recruitment of the last ten years period 2008–2017 (7.958 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 and age 2 in 2020 are the survivors of the geometric mean recruitment assumed for 2019 and 2018, respectively. 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 0.028), SSB in 2020 is estimated to be 1 102 627 tonnes. Predicted SSB levels for 2021 are 1 189 558 tonnes. The management options table also include the F based on the management plan (F = MP) and the $F_{p.05}$ as the maximum value of F applied when SSB > MSY $B_{trigger}$ that will result in SSB ≥ B_{lim} with a 95% probability in a stochastic long-term simulation.

The forecasts are deterministic and, therefore, no estimates of uncertainty are calculated. Sources of uncertainty in the outcomes is the recruitment assumed for 2018, 2019 and 2020, the assumptions on a stable mean fishing mortality and the likely changes in the fishery selection pattern in most recent years.

Table 9.5.1. Southern horse mackerel. Input for the short-term forecast (2020–2022). N – number of fish;(in thousands) SWt and CWt – mean weight in the stock and in the catch (in kg).

2020								
Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	7957662	0.9	0	0.04	0.04	0.022	0.006	0.022
1	3216796	0.6	0	0.04	0.04	0.039	0.026	0.039
2	1719565	0.4	0.36	0.04	0.04	0.061	0.037	0.061
3	2091959	0.3	0.82	0.04	0.04	0.084	0.032	0.084
4	1155897	0.2	0.95	0.04	0.04	0.119	0.030	0.119
5	802475	0.15	0.97	0.04	0.04	0.139	0.025	0.139
6	613217	0.15	0.99	0.04	0.04	0.172	0.022	0.172
7	373520	0.15	1	0.04	0.04	0.224	0.027	0.224
8	562550	0.15	1	0.04	0.04	0.244	0.027	0.244
9	391556	0.15	1	0.04	0.04	0.337	0.027	0.337
10	125922	0.15	1	0.04	0.04	0.366	0.027	0.366
11	408394	0.15	1	0.04	0.04	0.461	0.027	0.461
2021								
Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	7957662	0.9	0	0.04	0.04	0.022	0.006	0.022
1		0.6	0	0.04	0.04	0.039	0.026	0.039
2		0.4	0.36	0.04	0.04	0.061	0.037	0.061
3		0.3	0.82	0.04	0.04	0.084	0.032	0.084
4		0.2	0.95	0.04	0.04	0.119	0.030	0.119
5		0.15	0.97	0.04	0.04	0.139	0.025	0.139
6		0.15	0.99	0.04	0.04	0.172	0.022	0.172
7		0.15	1	0.04	0.04	0.224	0.027	0.224
8		0.15	1	0.04	0.04	0.244	0.027	0.244
9		0.15	1	0.04	0.04	0.337	0.027	0.337
10		0.15	1	0.04	0.04	0.366	0.027	0.366
11		0.15	1	0.04	0.04	0.461	0.027	0.461

2022								
Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	7957662	0.9	0	0.04	0.04	0.022	0.006	0.022
1		0.6	0	0.04	0.04	0.039	0.026	0.039
2		0.4	0.36	0.04	0.04	0.061	0.037	0.061
3		0.3	0.82	0.04	0.04	0.084	0.032	0.084
4		0.2	0.95	0.04	0.04	0.119	0.030	0.119
5		0.15	0.97	0.04	0.04	0.139	0.025	0.139
6		0.15	0.99	0.04	0.04	0.172	0.022	0.172
7		0.15	1	0.04	0.04	0.224	0.027	0.224
8		0.15	1	0.04	0.04	0.244	0.027	0.244
9		0.15	1	0.04	0.04	0.337	0.027	0.337
10		0.15	1	0.04	0.04	0.366	0.027	0.366
11		0.15	1	0.04	0.04	0.461	0.027	0.461

Table 9.5.2. Short-term forecast (2020–2022) for southern horse mackerel. Catch and SSB (at spawning time) in tonnes.

			2020			2021			2022
	Fmult	Fbar	SSB	Catch		SSB	Catch		SSB
F=0	0.00	0.00				1190922	0		1287501
$F_{sq} = F_{2019}$	1.00	0.03	1102627	34080		1189558	35751		1250868
F_{sq}*1.2	1.20	0.03				1189286	42787		1243669
F_MP	1.58	0.04				1188772	55938		1229421
F_{sq}*1.6	1.60	0.05				1188741	56747		1229397
F_{sq}*2.0	2.00	0.06				1188196	70559		1215291
F_{MSY}; F_{pa}	3.73	0.11				1185843	128627		1156148
$F_{p.05}$	5.20	0.15				1183847	175909		1108191
F_{lim}	6.70	0.19				1181814	222289		1061333
SSB_{2022}=MSY $B_{trigger}$=B_{pa}	68.80	1.95				1100677	1160543		181000
SSB_{2022}=B_{lim}	89.10	2.52				1075518	1263330		103000

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 Pelagic Advisory Council (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}= $B_{pa} \times e^{-1.645\sigma}$; $\sigma = 0.34$)	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}= $F_{lim} \times e^{-1.645\sigma}$; $\sigma = 0.32$)	ICES, 2016a

9.7 Management considerations

The traditional fishery across several fleets has for a long time targeted juvenile age classes. This exploitation pattern combined with a fishing mortality well below F_{MSY} over the whole time-series does not seem to have been detrimental to the dynamics of the stock. 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 2021 of 128 627 tonnes. The catch advice for 2021 under the MSY approach, represents an increase of 262% in comparison with catches observed in 2019 (Figure 9.7.1). If the advice would be based on the MP, then the increase of catches advised for 2021 in relation to actual catches in 2019 would be of 52%. The management strategy includes a +/- 15% stability clause which is only implemented after the first year of the plan being applied. Since the plan has not previously been applied, the 2020 TAC is not based on the plan and the stability clause would not apply in 2021.

TAC for this species was not limiting in the last years due to low market value and opportunities. Observed catches were always below the advised TAC in the available time-series. (Figure 9.7.1)

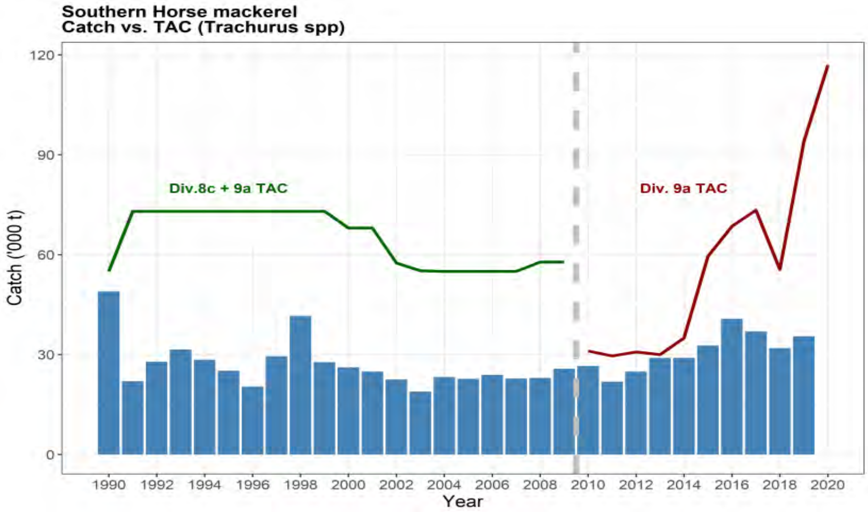


Figure 9.7.1. Catch and TAC for southern horse mackerel. Blue bars show catches for southern horse mackerel, green line shows combined TAC for horse mackerel in divisions 8c and 9a and red line shows TAC for horse mackerel in division 9a

9.8 Deviation from stock annex caused by missing information

1. **Stock:** hom.27.9a.
2. **Missing or deteriorated survey data**:

   One independent index (autumn IBTS surveys) is used in the hom.27.9a. assessment. IPMA (Portugal) and IEO (Spain) carry out annually bottom trawl surveys. The abundance indices from both surveys are combined (Table 9.3.1.1) and used for tuning the stock assessment. Not directly related to COVID disruption, but in 2019 the Portuguese IBTS survey was not carried out.

3. **Missing or deteriorated catch data:**

   The COVID disruption did not affect catch data because interim year data are not used in the assessment.

4. **Missing or deteriorated commercial lpue/cpue data:**

   Not applicable.

5. **Missing or deteriorated biological data: (e.g. maturity data)**

   The COVID disruption did not affect biological data because interim year data are not used in the assessment.

6. **Brief description of methods explored to remedy the challenge:**

   Exploratory analysis were performed to assess if the IBTS Spanish survey could be used as a 2019 tuning index in the assessment. The catch-at-age pattern in the areas covered by both surveys are very different and because the Portuguese survey represents 87% of the total coverage and traverse the majority of the stock area (Mendes *et al.*, 2017), the Spanish IBTS survey index was considered not adequate for tuning the assessment.

   Exploratory assessment trial runs were performed removing the last year survey index (Section 9.4.3, Figure 9.4.3.1) or the second last year index (Figure 9.4.3.2) to compare results of the 2017, 2018 and 2019 assessments with and without these indices.

7. **Suggested solution to the challenge, including reason for selecting this solution:**

   The assessment trial runs revealed that the magnitude of the impact on the assessment of lacking a survey index is related with the estimate of the biomass index values, for example, the very high survey index values in 2017 caused a significant underestimation of SSB and an overestimation of F (Section 9.4.3, top panels - Figure 9.4.3.2). However, the other trial runs showed no significant changes in the stock key parameters and WGHANSA decided that the update assessment without the 2019 combined survey index, could give a valid basis for advice.

8. **Was there an evaluation of the loss of certainty caused by the solution that was carried out?**

   There was an added uncertainty related to not having the 2019 biomass tuning index. Notably, there was a significant increase in the uncertainty of the 2018 recruitment estimates. Due to high uncertainty in recruitment for 2018, it was replaced in the short-term forecast by a constant recruitment, corresponding to the geometric mean recruitment of the last ten years period 2008–2017 (7.958 million fish). The abundance-at-age 1 and age 2 in 2020 where then the survivors of the geometric mean recruitment assumed for 2019 and 2018, respectively. Additionally, the assumption for this cohort, contributed for 6% of the total estimated SSB in the advice year 2021.

9.9 New references

Mendes, H., Azevedo, M., Chaves, C., Costas, G., Velasco, F. 2017. Characterization of Southern horse mackerel survey indices and implications for stock assessment. WD to the ICES WKPELA, 6–10 February, Lisbon, 27 pp.

10 Blue Jack Mackerel (*Trachurus picturatus*) in Subdivision 10.a.2 (Azores grounds)

The blue jack mackerel, *Trachurus picturatus* Bowdich, 1825 (*Carangidae*), 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 the islands shelf and offshore areas. The island shelf areas seem 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 islands' coast.

The *T. picturatus* landings were considerably high during the 1980s. However, changes in the local markets lead to a substantial reduction in the catches afterward. 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 later (since 2014) limited by local regulations with conditioned daily catch limits. Despite this reduction in the landings, this fishery still has a strong impact on some fishermen communities, which directly depends on this fishery's income.

10.1 Blue Jack Mackerel in ICES areas

The blue jack mackerel has a broad geographical distribution within the Eastern Atlantic waters and can be found from the southern Bay of Biscay to south 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 whose 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 the Canaries and Portuguese continental waters.

So far, no studies explicitly addressing the existence of distinct populations in this species' distribution range have been attempted. 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 in 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*, they are usually considered of reduced utility for the identification of stock units.

Several 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 some protozoan and helminth parasites showing differences in prevalence. The myxosporean *Kudoa nova* was found in samples from Western Sahara but not seen in the Azores archipelago banks. Similarly, some digeneans (Platyhelminths: *Digenea*) found in the Azores banks were not observed in the samples from Western Sahara and vice-versa. The apicomplexan, *Goussia cruciata,* which is common in *T. picturatus* from the Mediterranean (Kalfa-Papaioannou & Athanassopoulou-Raptopoulou, 1984) and more recently from Madeira waters (Gonçalves, 1996), was not found in the Azores or Western Sahara. These variations in the occurrence of parasites could indicate the existence of different populations of *T. picturatus*. Further studies concentrating on helminth parasites' occurrence show some differences in species diversity and parasitic infection levels (Costa *et al*. 2000, 2003).

The blue jack mackerel is an economically vital resource, especially in the Macaronesian islands of Azores and Madeira, where it is the main pelagic fish species being caught by the local (artisanal) fisheries. 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 observing fluctuations in the abundance indices obtained from demersal research surveys.

10.2 Catch scenarios for 2021 and 2022

The advice for this stock is biennial, and so the 2020 advice is valid for 2021 and 2022: *based on the precautionary approach catches should be no more than 878 tonnes in each of the years 2021 and 2022. This stock is an ICES category 5 stock (stocks for which only landings or a short series of catches are available) and since the precautionary buffer (20% reduction in catches) was applied in 2018 it has not been applied again in 2020.*

10.3 The fishery in 2019

Official landings for 2019 includes commercial landings from small purse-seiners (and other surrounding nets), landings from hooks and lines *métiers*, and unsold purse-seine landings withdrawn at the port (daily catch limits) and used as bait on longline and handline fisheries.

Other catches include longline bait, tuna (live) bait, and recreational catches. In 2019, estimates of recreational catches are available for boat recreational fishing only and estimates for shore anglers are not available).

10.3.1 Fishing Fleets

Trachurus picturatus is mostly landed by the artisanal fleet, using purse-seines and other surrounding nets, targeting juveniles. In 2019, these fleet landings represented around 90% of total blue jack mackerel (official) landings in the Azores.

The artisanal purse-seines fleet comprises small open deck vessels, mostly with less than 12 meters of overall length targeting juveniles of *T. picturatus*. This fleet's composition presents a regular decrease in recent years, with a reduction from 120 vessels in 2013 to around 30 active vessels in 2019 in the small pelagic fishery. The number of small purse-seine vessels of each size category for the last forty years is shown in Figure 1.

The longline and handline fleets catch less than 10% of the total official landings of *T. picturatus*. These fleets catch the adult stock mainly to use it as bait to catch other demersal species with high economic value. Only the excedent is landed.

10.3.2 Catches

Catches of blue jack mackerel, including landings (purse-seine catches, longline and handline catches) and other catches (longline bait plus discards from the longline fishery, tuna live bait, and recreational catches) from 1978 to 2019, are presented in Table 1. Purse-seine catches over daily sales limits are withdrawn from the human consumption market but are recorded as fish for bait. These catches are included in official landings only since 2018.

Total average yearly catches of blue jack mackerel in the Azores, for the period 2000–2019 are shown in Figure 2 and are around 1700 tonnes, while landings, in the same period, are on average 1000 tonnes.

A critical 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 bait boats fleet. Low recruitment in 2016 is apparently the cause of this reduction. In 2018 and 2019, an increasing number of catches of age 0 fish suggest strong recruitment. This situation has periodically been observed in the past. In the tuna fleet, catches of bait (*Trachurus picturatus*) are related to 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 are mostly related to the use of the blue jack mackerel for bait (as the quality as bait is high) and not for landings (as the market price for the adults is low).

10.3.3 Effort

The fishing effort in number of days at sea for the purse-seine fishery is presented by year in Figure 3. Since 2005, and with the continuous reduction of this fleet that started in the 1990s, the threshold of 5000 fishing days per year has never been exceeded.

10.3.4 Catches by length

Size frequencies for the blue jack mackerel caught in the Azores are available since 1980. Figure 4 and Figure 5 presented the size distribution of the landings (catch at size) for several years between 2011 and 2019. The two main fisheries target different size categories. The purse-seine fleets catch the juvenile fraction of the population while the longliners target the adult stock.

10.3.5 Basis of the advice

In 2018, the stock category of *Trachurus picturatus* in 10.a.2 changed from category 3 to category 5, and a precautionary buffer of 20% was applied to the advised catches. The reasons pointed out were that:

(i) different length-based reference points were explored, but where not found appropriate since catches from the different fisheries do not represent the full length composition of the stock;

(ii) stock size indicators previously 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;

(iv) and no data available from tuna bait, recreational fishery, and longline (bait) fisheries were available in the previous assessment for 2016 and 2017.

In 2019, the Working Group discussed different (or complementary) approaches that could have been taken into account for the 2020 assessment and proposed additional inter-sessional work:

- Continue track of (Catch, effort) CPUE indexes of different fleets (even if they are not good indicators of the full stock dynamics);
- Monitor catch length distributions (for any purpose, including landings or catches for live bait, bait for hooks, or discards) of different fleets;
- To assess growth (von Bertalanffy) parameters of blue Jack mackerel in the Azores;
- Track in time the length distribution series for the main fisheries;
- Try length-based methods, but with some changes from what has been done in the past: for example, (i) using the longline 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.

However, due to the disruption caused by the COVID-19, for the 2020 assessment, it was not possible to implement most of the planned approaches. Currently, there are no indices available that would reflect the development of the stock.

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 and for human consumption, mostly to regulate markets. This measure allows only 200 kg or 300 kg of catch per vessel, per day, depending on the island. It also states that fishing and consequent landings shall also be forbidden on weekends and set quantities for unsold purse-seine landings withdrawn at the port.

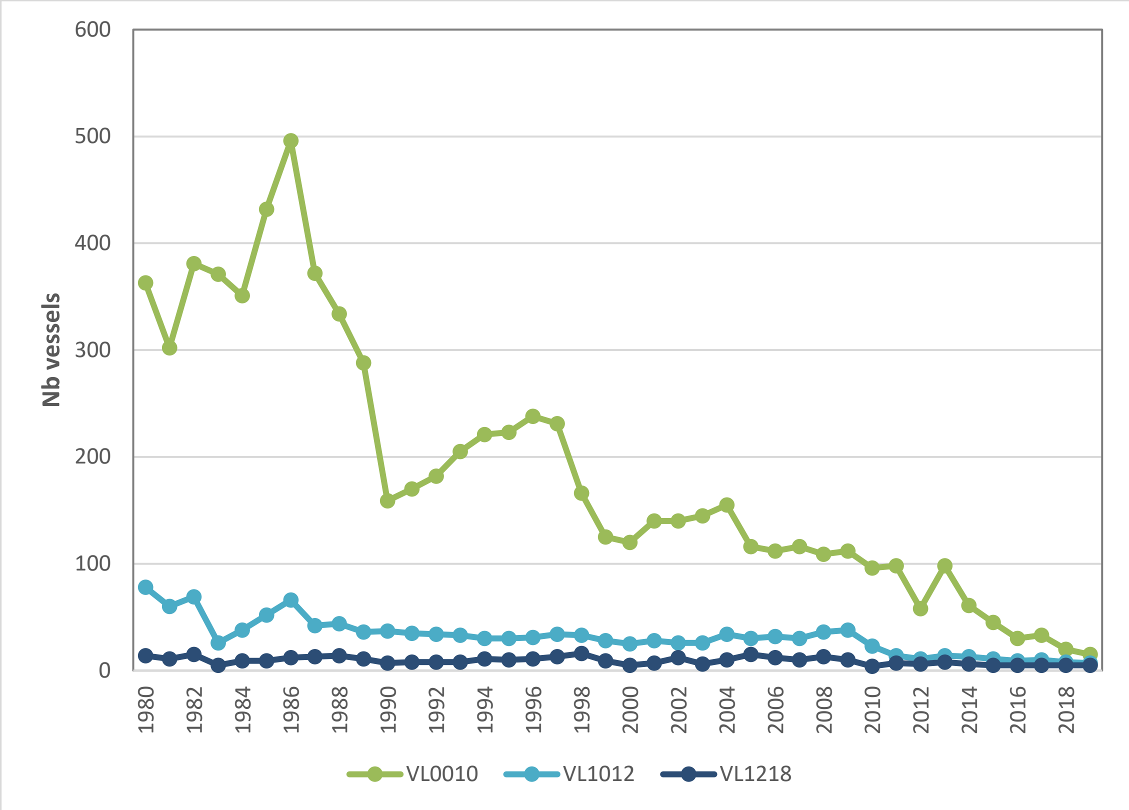


Figure 1. Number of small purse-seine vessels, by length category, of the blue jack mackerel (*T. picturatus*) fishery in the Azores (ICES Subdivision 10.a2) from 1980 to 2019.

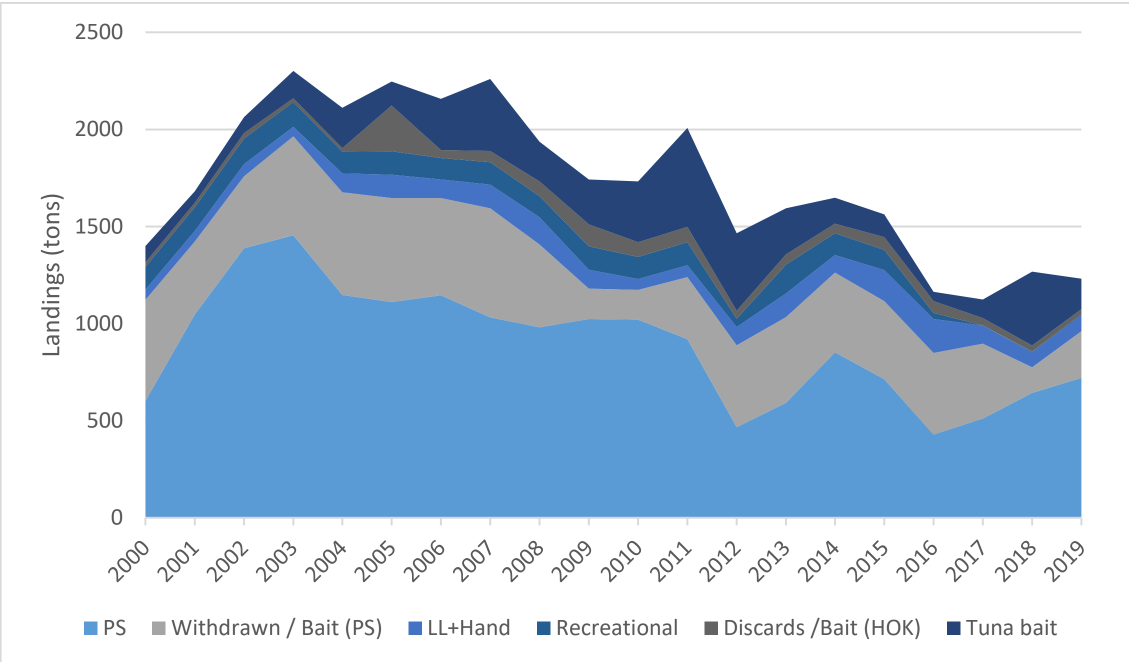


Figure 2. Estimated catches of blue jack mackerel (*T. picturatus*) in the Azores (ICES Subdivision 10.a2) from 1978 to 2019.

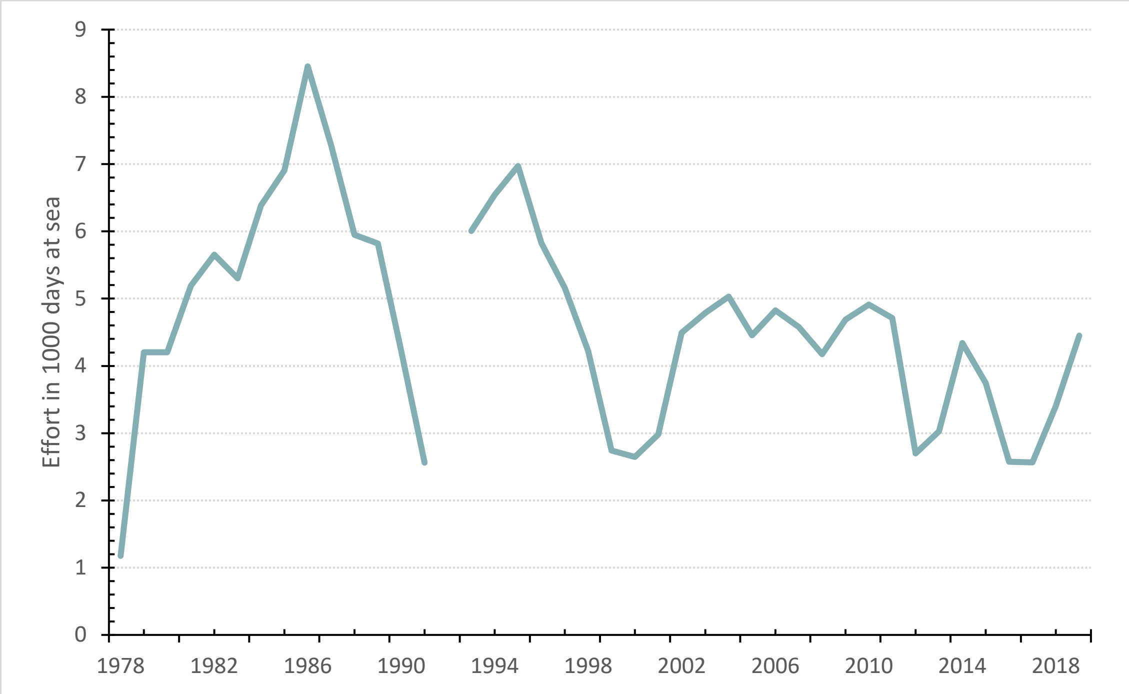


Figure 3. Nominal effort (number of days at sea) of the purse-seine fleet for the period 1978–2019.

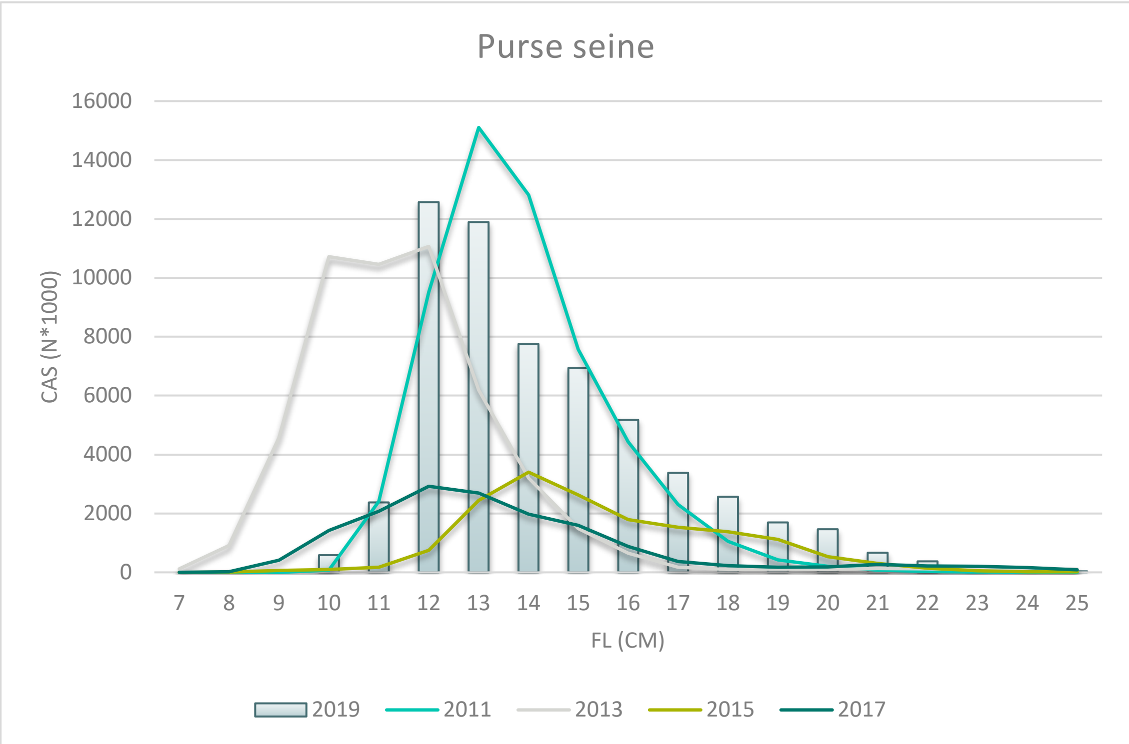


Figure 4. Annual size frequencies of the catches of blue jack mackerel (*T. picturatus*) in the Azores, from several years between 2011 and 2019, from the purse-seine fisheries (targeting juvelines).

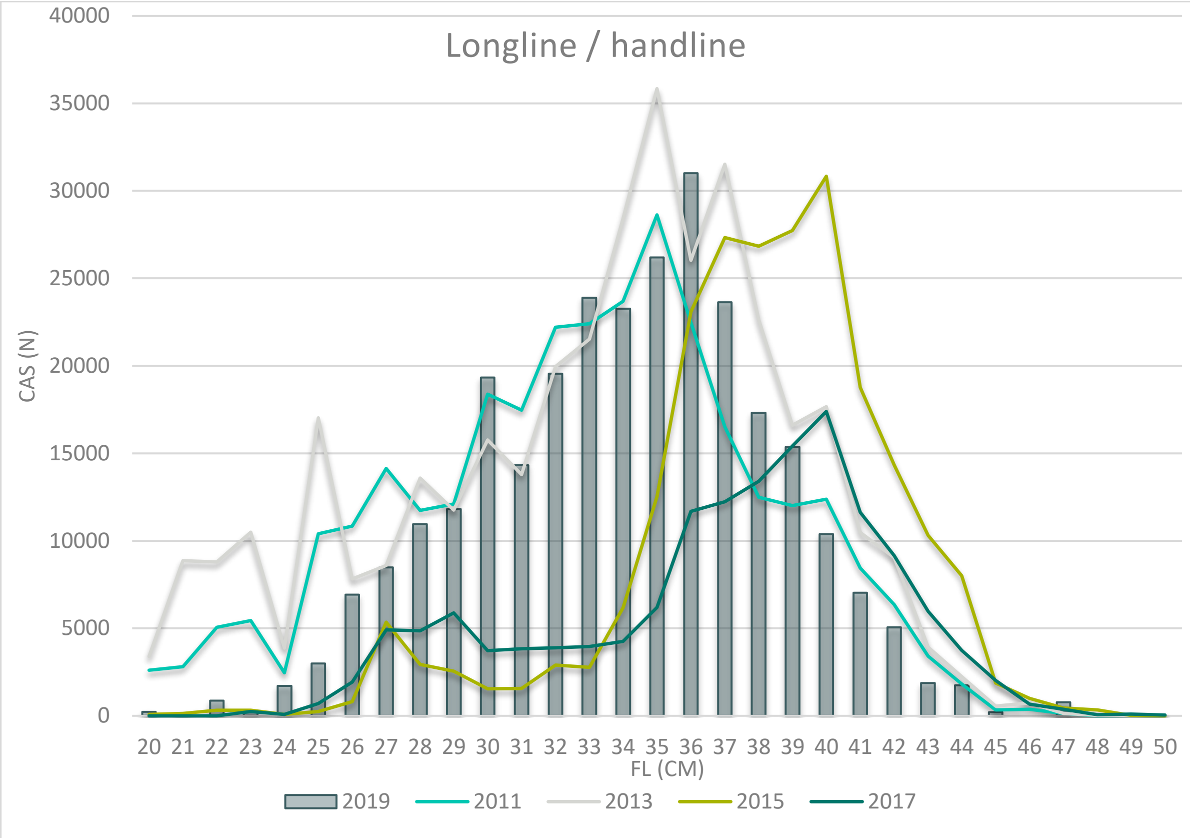


Figure 5. - Annual size frequencies of the catches of blue jack mackerel *(T. picturatus)* in the Azores, from several years between 2011 and 2019, from the longline and handline fisheries (targeting adults).

Table 1. History of catches (in tonnes) of blue jack mackerel (*Trachurus picturatus*) in Subdivision 10.a.2.

	Official landings			Additional catches				Total
Year	Purse-seine (human consumption)	Purse-seine (withdrawn at the port and used for bait)[1]	Longline + handline	Recreational	Longline (discards and used for bait)	Tuna bait	Purse-seine (withdrawn at the port and used for bait)[1]	ICES catches
1978	2657		78	129	15	115	0	2995
1979	4114		61	130	15	118	0	4439
1980	2920		70	132	22	210	0	3354
1981	2104		39	135	9	229	0	2516
1982	2429		43	142	10	239	0	2862
1983	3711		67	142	21	231	0	4172
1984	3180		62	135	17	295	0	3689
1985	3442		60	136	11	303	0	3952
1986	3282		58	135	9	433	0	3918
1987	2974		53	139	8	491	0	3666
1988	3032		55	143	8	586	0	3824
1989	2824		50	138	9	352	0	3373
1990	2472		48	117	11	345	584	3577
1991	1247		33	115	6	242	421	2064
1992	1226		35	121	6	249	486	2123
1993	1684		70	130	22	375	742	3023
1994	1745		59	125	18	264	636	2847
1995	1769		79	119	24	474	688	3153
1996	1642		123	110	38	351	656	2920
1997	1849		72	110	31	259	599	2920
1998	1387		120	111	52	308	606	2584
1999	609		84	119	37	141	565	1555

[1] PURSE-SEINE CATCHES IN EXCESS OF DAILY SALES LIMITS ARE WITHDRAWN FROM THE HUMAN CONSUMPTION MARKET BUT ARE RECORDED AS FISH FOR BAIT. STARTING IN 2018, THESE CATCHES ARE INCLUDED IN OFFICIAL LANDINGS.

	Official landings			Additional catches				Total
Year	Purse-seine (human consumption)	Purse-seine (withdrawn at the port and used for bait)[1]	Longline + handline	Recreational	Longline (discards and used for bait)	Tuna bait	Purse-seine (withdrawn at the port and used for bait)[1]	ICES catches
2000	602		53	117	23	83	521	1399
2001	1046		55	121	24	59	376	1681
2002	1387		63	132	28	82	371	2063
2003	1455		47	128	21	140	510	2301
2004	1148		98	111	19	208	528	2112
2005	1111		120	120	236	124	536	2247
2006	1145		96	111	40	264	501	2157
2007	1032		122	115	58	370	562	2259
2008	980		139	110	75	205	428	1937
2009	1023		98	119	115	230	157	1742
2010	1021		57	114	75	313	152	1732
2011	920		62	118	79	510	319	2008
2012	467		94	42	41	399	422	1465
2013	592		123	147	54	237	441	1594
2014	852		91	112	49	134	410	1648
2015	714		160	103	67	116	402	1562
2016	428		174	32	61	48	421	1164
2017	511		95	N/A	37	96	385	1124
2018	643	132	77	4	31	381		1268
2019	720	241	83	5	26	156		1231

11 ToR b Exploration of juvenile surveys

An update to the work carried out to evaluate the consistency of juvenile surveys was done and presented to the WGACEGG (see WD Garrido *et al*., 2020), to test for its potential for future incorporation in the assessment of southern sardine (8c9a) and the western and south components of the anchovy stock (9a). In the case of anchovy, no significant correlation of recruitment surveys and spring acoustic surveys was found for both for the west and south components, and the available data of recruitment survey in the south (ECOCADIZ-reclutas) is still low. For this reason, some more years should be included in the analysis so that the potential of juvenile surveys is evaluated again.

For the sardine, a high and significant correlation was found between the abundance of juvenile sardines estimated in the recruitment surveys carried out in the main recruitment area for the stock (subdivision 9aCN, survey series SAR+JUVESAR+IBERAS) and the abundance of age 1 sardine estimated in the spring acoustic surveys that are used in the assessment (PELAGO & PELACUS) during the following year. This high correlation (r^2= 0.86, <0.001, Figure 11 supports the progress of this work and testing the inclusion of the western recruitment survey series in the assessment.

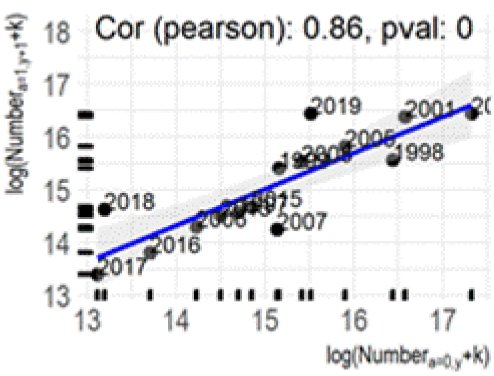


Figure 11. Relationship between the number of recruits at age 0 estimated in the subdivision 9aCN in the fall recruitment surveys (SAR, JUVESAR and IBERAS) and the number of age 1 individuals estimated in the spring acoustic surveys of the following year (PELACUS+PELAGO).

The present analysis was presented in WGACEGG to ask for their expert opinion on whether the differences between the autumn acoustic surveys are sufficient to prevent their use as recruitment index in the current assessment model.

Main concerns were related to vessels used and survey time. While SAR and JUVESAR surveys were carried out in RV "Noruega", IBERAS surveys have been carried out in RV "Angeles Alvariño" and "Ramón Margalef". On the other hand, while SAR have been carried out in November, JUVESAR in November and December, IBERAS has been carried out in November and recently (and in the future) in September. A vessel inter-calibration will no longer be possible with "Noruega" but considering the characteristics of all vessels (acoustic equipment, fishing gears, etc.) it is expected that no major differences exist.

Pooling all juvenile surveys, the number of age 0 individuals has a good correlation with the number of age 1 individuals in the following spring acoustic surveys (Figure 11), so it was assumed that survey time would also have no major impact on the estimation of the in-year recruitment.

However, it is expected that WGACEGG will provide some advice on this matter in this year's report.

12 References

Carrera, P., Díaz, P., Domínguez-Petit, R., González-Bueno, G., Riveiro, I. 2018. Pelagic ecosystem acoustic-trawl survey *PELACUS 0318*: Sardine, South Horse mackerel, Anchovy and Chub mackerel abundance estimates. Working document presented in the ICES Working Group on Southern Horse Mackerel, Sardine and Anchovy (WGHANSA). Lisbon, Portugal, 26–30 June 2018.

Garrido, S., Ramos, F., Silva, A., Angélico, M. M., Marques, V. 2018a. Population structure of the European anchovy (*Engraulis encrasicolus*) in ICES Division 9a: synopsis and updated information. Working document presented to the ICES Benchmark Workshop on Pelagic Stocks (WKPELA 2018). 12–16 February 2018. Copenhagen, Danmark.16 pp.

Garrido, S., Wise, L., Rincón, M., Riveiro, I., Moreno, A., Carrera, P., Ramos, F. Amorim, P. Investigation of consistency of juvenile surveys (e.g. JUVESAR, JUVENA, ECOCADIZ RECLUTAS) for potential future incorporation in the assessments. Working document presented to the ICES Working Group on Acoustic and Egg Surveys (WGACEGG). 16–20 November 2020.

ICES. 2017a. ICES fisheries management reference points for category 1 and 2 stocks. ICES Advice, Book 12, Section 12.4.3.1.

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

ICES. 2004. Report of the Study Group on Assessment Methods Applicable to Assessment of Norwegian Spring-Spawning Herring and Blue Whiting Stocks (SGAMHBW). 19–22 February 2004, Lisbon, Portugal. ICES CM 2014/ACFM 145. 166 pp.

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

ICES. 2008a. Report of the Working Group on Anchovy (WGANC), 13–16 June 2008, ICES Headquarters, Copenhagen. ICES CM 2008 ACOM:04. 226 pp.

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

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

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

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

ICES. 2012. ICES Implementation of Advice for Data-limited Stocks in 2012 in its 2012 Advice. ICES CM 2012/ACOM:68. 42 pp.

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

ICES. 2016. Report of the Workshop to consider FMSY ranges for stocks in ICES categories 1 and 2 in Western Waters (WKMSYREF4), 13–16 October 2015, Brest, France. ICES CM 2015/ACOM:58. 187 pp.

ICES. 2017a. Report of the Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas 7, 8, and 9. WGACEGG Report 2016 Capo, Granitola, Sicily, Italy. 14–18 November 2016. ICES CM 2016/SSGIEOM:31. 326 pp.

ICES. 2017b. Report of the Benchmark Workshop on Pelagic Stocks, 6–10 February 2017, Lisbon, Portugal. ICES CM 2017/ACOM:35. 294 pp.

ICES. 2017b. Report of the Workshop to review the ICES advisory framework for short-lived species, including detailed exploration of the use of escapement strategies and forecast methods (WKMSYREF5), 11–15 September 2017, Capo Granitola, Sicily. ICES CM 2017/ACOM:46 A. 63 pp.

ICES. 2018. Report of the Working Group on Southern Horse Mackerel, Anchovy and Sardine (WGHANSA), 26–30 June 2018, Lisbon, Portugal. ICES CM 2018/ACOM:17. 639 pp.

ICES. 2018a. Report of the Benchmark Workshop on Pelagic Stocks (WKPELA 2018), 12–16 February 2018, ICES HQ, Copenhagen, Denmark. ICES CM 2018/ACOM:32. 313 pp.

ICES. 2018b. Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas 7, 8 and 9 (WGACEGG). ICES WGACEGG REPORT 2017 3–17 November 2017. pp. 388.

ICES. 2019c. Request from Portugal and Spain to evaluate additional harvest control rules for the Iberian sardine stock in divisions 8.c and 9.a. In Report of the ICES Advisory Committee, 2019. ICES Advice 2019,sr.2019.26, https://doi.org/10.17895/ices.advice.5755.

ICES. 2020. Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES areas 7, 8 and 9 (WGACEGG; outputs from 2019 meeting). ICES Scientific Reports. 2:44. 490 pp. ICES. 2019b. Workshop on the Iberian Sardine Management and Recovery Plan (WKSARMP). ICES Scientific Reports. 1:18. 125 pp. http://doi.org/ 10.17895/ices.pub.5251.

ICES. 2019. Nineth Workshop on the Development of Quantitative Assessment Methodologies based on LIFE-history traits, exploitation characteristics, and other relevant parameters for data-limited stocks (WKLIFE IX).ICES Scientific Reports. 1:77. 131 pp.

Jiménez, M.P., Tornero, J., Villaverde, A., Llevot, M.J., Solla, A., Ramos, F. 2018. Anchovy spawning stock biomass of the Gulf of Cadiz in 2017. Working document presented in the ICES Working Group on Southern Horse Mackerel, Sardine and Anchovy (WGHANSA). Lisbon, Portugal, 26–30 June 2018.

Massé, J., Uriarte, A., Angélico, M. M., and Carrera, P. (Eds.) 2018. Pelagic survey series for sardine and anchovy in ICES subareas 8 and 9 – Towards an ecosystem approach. *ICES Cooperative Research Report* No. 332. 268 pp. https://doi.org/10.17895/ices.pub.4599.

Mendes, H., Azevedo, M. Chaves, C., Costas, G., Velasco, F. 2017. Characterization of Southern horse mackerel survey indices and implications for stock assessment. WD to the ICES WKPELA, 6–10 February, Lisbon, 27pp.

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.

Payne, M. R., L. W. Clausen, H Mosegaard. 2009. Finding the signal in the noise: objective data-selection criteria improve the assessment of western Baltic spring-spawning herring. *ICES Journal of Marine Science*, 66: 1673–1680.

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

Ramos, F., Tornero, J., Oñate, D., Córdoba, P. 2018b. Acoustic assessment and distribution of the main pelagic fish species in ICES Subdivision 9a South during the *ECOCADIZ-RECLUTAS 2017-10* Spanish survey (October 2017). Working document presented in the ICES Working Group on Southern Horse Mackerel, Sardine and Anchovy (WGHANSA). Lisbon, Portugal, 26–30 June 2018.

Ramos, F., Tornero, J., Oñate, D., Jiménez, M.P. 2018a. Acoustic assessment and distribution of the main pelagic fish species in ICES Subdivision 9a South during the *ECOCADIZ 2017-07* Spanish survey (July–August 2017). Working document presented in the ICES Working Group on Southern Horse Mackerel, Sardine and Anchovy (WGHANSA). Lisbon, Portugal, 26–30 June 2018.

Rincón, M M., Ramos, F., Uriarte, A., Ibaibarriaga, L. Garrido, S., Silva, A. 2020. Gadget for anchovy 9a South: Model description and results to provide catch advice and reference points (WGHANSA 2020-1). Working Document presented to ICES WGHANSA 2020, 25–29 May.

Silva A, Garrido S, Ibaibarriaga L, Pawlowski L, Riveiro I, Marques V, Ramos F, Duhamel E, Iglesias M, Bryère P, Mangin A, Citores L, Carrera P, Uriarte A. 2019. Adult-mediated connectivity and spatial population structure of sardine in the Bay of Biscay and Iberian coast, Deep-Sea Research Part II, https://doi.org/10.1016/j.dsr2.2018.10.010.

Annex 1: List of participants

Name	Address	Country	E-mail
Manuela Azevedo	Portuguese Institute for the Sea and the Atmosphere-IPMA	Portugal	mazevedo@ipma.pt
Leire Cirores	AZTI Sukarrieta	Spain	lcirores@azti.es
Gersom Costas	Instituto Español de Oceanografía Centro Oceanográfico de Vigo	Spain	gersom.costas@ieo.es
Erwan Duhamel	Ifremer-Lorient Station	France	Erwan.duhamel@ifremer.fr
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 25/5	DGMare	Belgium	Ursula.Krampe@ec.europa.eu
Hugo Mendes	Portuguese Institute for the Sea and the Atmosphere-IPMA	Portugal	hmendes@ipma.pt
Richard Nash	Cefas	UK	Richard.nash@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 Hi-dalgo	Institut de Ciències del Mar-CSIC	Spain	mmrinconh@gmail.com margarita.rincon@csic.es
Isabel Riveiro	IEO	Spain	isabel.riveiro@ieo.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 2020 and are presented in full in Annex 2:

WD1: WGACEGG 15 May 2020 *Ad hoc* WebEx meeting. Participants: WGACEGG members plus WGHANSA invitees.

WD2: WGHANSA WebEx 29 April 2020 – Missing survey data in the assessments. WGHANSA Pre-meeting by WebEx.

WD3: Characterization of Southern horse mackerel survey indices and implications for stock assessment. Hugo Mendes, Manuela Azevedo, Corina Chaves, Gersom Costas and Francisco Velasco.

WD4: Gadget for anchovy 9a South: Model description and results to provide catch advice and reference points. Margarita María Rincón, Fernando Ramos, Andrés Uriarte, Leire Ibaibarriaga, Susana Garrido, Alexandra Silva.

WD5: Acoustic assessment and distribution of the main pelagic fish species in ICES Subdivision 9a South during the *ECOCADIZ 2019-07* Spanish survey (July–August 2019). Fernando Ramos, Jorge Tornero, Paz Jiménez, Paz Díaz.

WD6: Acoustic assessment and distribution of the main pelagic fish species in ICES Subdivision 9a South during the *ECOCADIZ-RECLUTAS 2019-10* Spanish survey (October 2019). Fernando Ramos, Jorge Tornero, Pilar Córdoba, Pablo Carrera.

WGACEGG

15/05/2020 *ad hoc* webex meeting

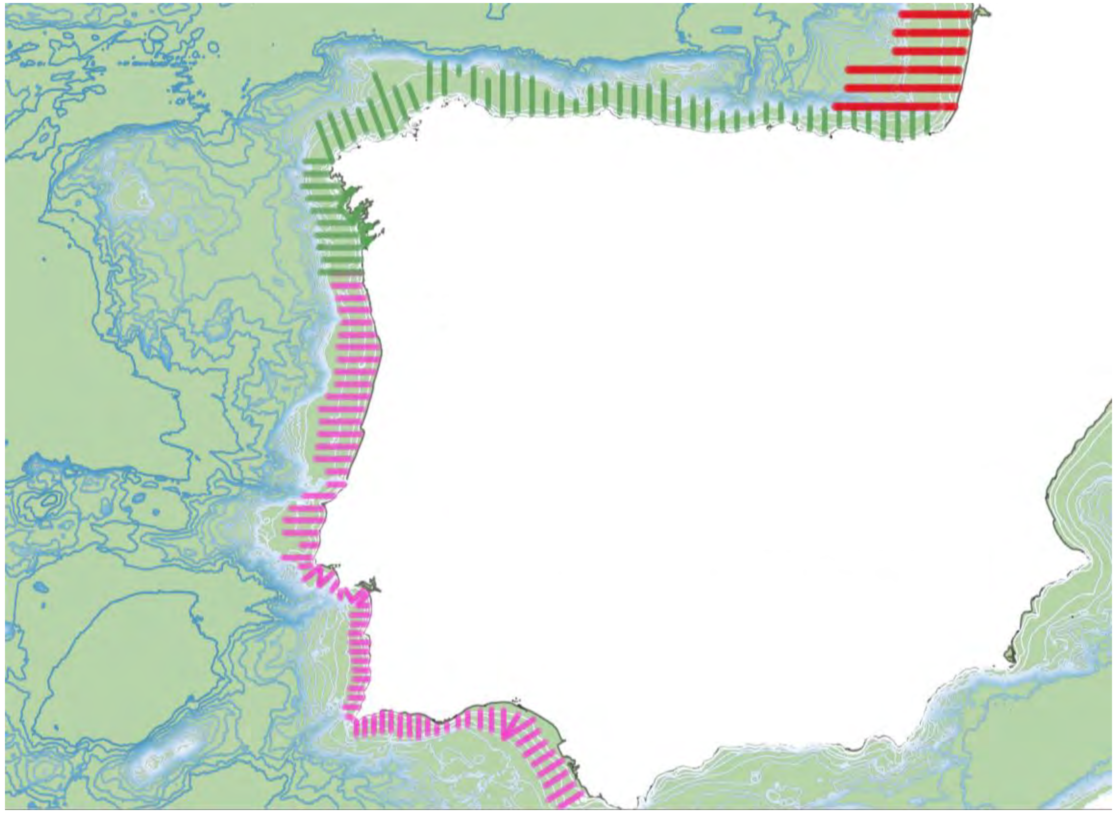
Participants: WGACEGG members plus WGHANSA-invited

Objective: Present and discuss PELAGO20 results and assess possible effects of changes to standard survey protocol to anchovy and sardine in area 9a+8c

Changes :

i. PELAGO20 (pink) was conducted on different vessel (RV Miguel Oliver instead of RV Noruega); slightly earlier; new post-processing approach considered and compared with IPMAs traditional approach

ii. PELACUS20 (green) was cancelled



PELAGO20: possible effects

Results – PELAGO20 data were approved for submission to WGHANSA

Possible effects of changes in survey protocol

1. Different vessel – unknown effect
   a. No inter-vessel calibration was conducted between regular and new vessel at the time of survey (although still planned for later)
   b. Historic inter-calibration exercise between RV Miguel Oliver and Thalassa suggested very little difference in acoustic data
   c. Number of fishing stations was more significant in affecting results of historic comparison; high number of stations were achieved in 2020 with support from purse seiners
2. Earlier timing was not expected to affect results as survey still captured the population in same seasonal cycle as time series
3. Post-processing was presented comparing 2 different approaches:
   i. IPMA: traditional PELAGO approach (historic series) using two frequencies (38 and 120kHz), no plankton filters, Movies software + IPMA routines;
   ii. IEO, Vigo (PELACUS) approach, multi-frequency (18, 38, 70, 120 & 200kHz) , EchoView software, plankton filters + QGIS, IEO routines.
   - Post-processing approach showed very little difference apart from in one or two strata (15% difference) which will be looked at closer.
   - Data presented to WGHANSA are those based on traditional method

PELACUS20 cancelation: effects

- No acoustic data for the area usually surveyed by PELACUS (9a north and 8c)
- No agreement about possible future solution for lack of data (exclude region vs interpolate and use info from BIOMAN)
- **ACTION** (WGACEGG): review possible use of opportunistic acoustic data recorded during BIOMAN in eastern part of Cantabrian. For 9aN and W Cantabrian no data is at all available, extrapolation for the W coast considered using PELAGO info to be discussed.
- **ACTION** (WGACEGG): review possible use of data and samples from BIOMAN in Cantabrian waters. Review possible analyses using info from adjacent areas vs. no data for W Catabrian and Galicia. (size/age structure major concern). Analyses to be undertaken in the coming months and be discussed at WGACEGG meeting in November2020.

9a+8c sardine DEPM 2020 surveys:

>> **PT-DEPM20-PIL** (IPMA, in blue): successfully conducted (3-29 Feb)
>> **SAREVA20** (IEO, in red): cancelled due to COVID19

- Information from both surveys are usually analysed jointly as a single set of data.

<u>Implications of the cancelation of SAREVA20:</u>

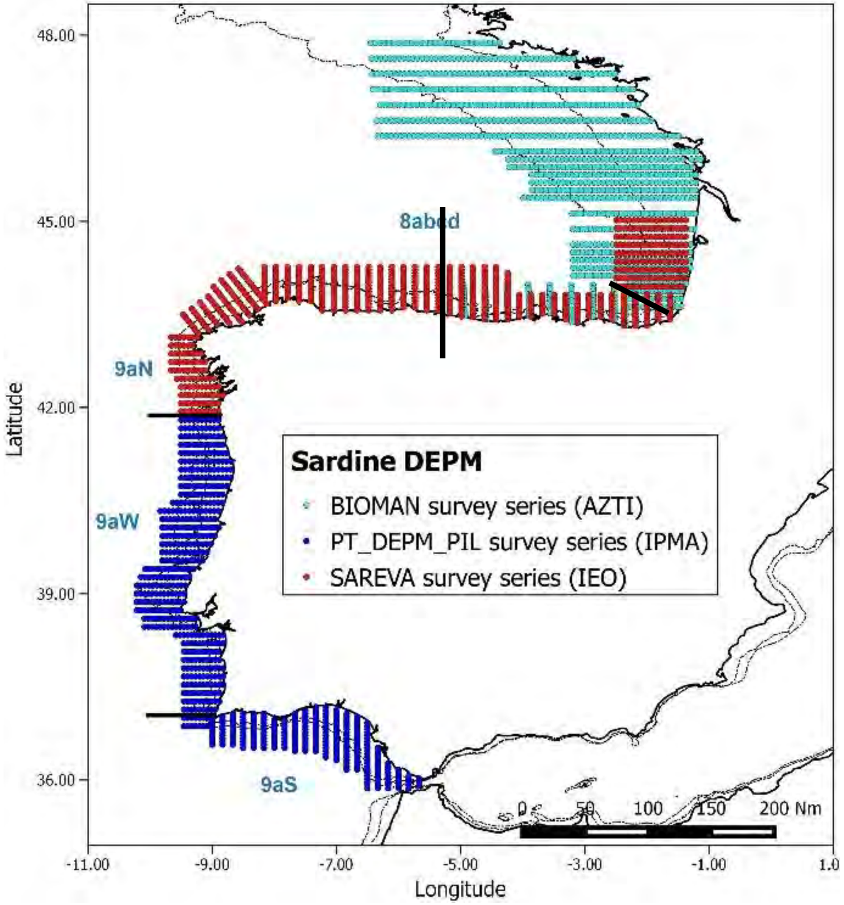
- No data for area 9aN and 8c
- However BIOMAN (AZTI DEPM survey for anchovy) was carried out, in May, and covered part of the SAREVA survey area in E Cantabrian (in green).

Possible utilization of information from this survey to be considered (potential difficulties: partial coverage, differences in survey protocol, late survey for PIL spawning, few adult samples)

<u>**ACTION** (WGACEGG):</u>

- ✓ Review possible use of data and samples collected during BIOMAN in eastern part of Cantabrian.
- ✓ For 9aN and W Cantabrian no data is at all available. Review possible analyses using info from adjacent areas vs. no data for W Cantabrian and Galicia. Extrapolation for the W coast considered using PT-DEPM20-PIL info, to be discussed.

- Analyses to be undertaken in the coming months and be discussed at WGACEGG meeting in November2020.



WGACEGG surveys in 2020 cancelled due to COVID19 lockdown:

- SAREVA (IEO)
- PELACUS (IEO)
- PELGAS (IFREMER)

Adjustments (delays, time/coverage reduction) possible for other surveys but not known yet

WGHANSA webex 29/04/2020

Missing survey data in the assessments

Agenda

1. Existing or possible problems for each stock (Wghansa1 and wghansa2)

- Southern horse mackerel – only 1 combined índex, PT demersal 2019 survey did not take place, sensitivity analysis started, previous similar problem showed large uncertainty in R estimates
- 9.a Anchovy south-all surveys used in Gadget available- PELAGO carried out in a diferent vessel, uncertain if ECOCADIZ surveys will be carried out
- 9.a anchovy west-PELACUS missing for the combined survey índex PELAGO+PELACUS , PELAGO carried out in a diferent vessel
- 8c9a Sardine -PELACUS missing for the combined survey índex PELAGO+PELACUS , PELAGO carried out in a diferent vessel, DEPM Spain missing as well for the combined index
- 8abd Sardine-BIOMAN is going to be carried out (start Saturday), PELGAS still uncertain (should start tomorrow), sample adults for fecundity and maturity
- 8ab anchovy- BIOMAN is going to be carried out (start Saturday), PELGAS still uncertain (should start tomorrow), JUVENA september (problems not anticipated, sample adults for fecundity
- 7 sardine (?)- PELTIC still scheduled for october

2. PELAGO carried out in a different vessel-acoustics similar, avoidance may be different, fishing performance (net VO of 15 m vs 6m in noruega); compare LFD between PS -MO and PS-Noruega; to be discussed in WGACEGG 2020; WD prepared by Pablo&Pedro&Ana submited to WGACEGG by correspondence before the meeting (?)

2. Evaluation of the impact of missing surveys

- Some ideas (Andres, others) and trials (Laura, others)
- Horse mackerel-using 2019 assessment, remove the survey last point, compare with and without; previously saw that the impact of a missing survey point was on recruitment
- Impact on the assessment and short term forecast
- Leave-one survey out (2017) do the assessment, compare with the full 2018 assessment
- Impact may be larger in R estimate than in SSB or F
- Design MSE to evaluate the lack of the survey (??)
- Look at CVs from diferente runs for the retrospective analysis and compare with the most recent assessment estimates

3. Agree on workplan

- Come in one week and decide

Benchmark Workshop on Pelagic Stocks (WKPELA 2017. Lisbon, 6-10 February 2017)

Characterization of Southern horse mackerel survey indices and implications for stock assessment

Hugo Mendes[1], Manuela Azevedo[1],Corina Chaves[1], Gersom Costas[2], Francisco Velasco[2]

[1]IPMA, [2]IEO-Vigo

Summary

This study analyses southern horse mackerel distribution in the stock area (Div. 9.a) based on bottom trawl survey data, aiming to improve the precision of the abundance-at-age survey index, the diagnostics of stock assessment model fit, the uncertainty in the estimates of the parameters fishing mortality (F ages 2-10), recruitment (R) and spawning stock biomass (SSB) as well as to evaluate the stock trends. Abundance of horse mackerel shows patchiness in the distribution across the entire time series with occasional high values that seem to be consistent across all the stock areas. The bulk of the horse mackerel surveyed individuals are from younger ages and mostly distributed in the shallow northwestern area of the stock. All ages can be found in the surveyed area suggesting that the survey sampling scheme covers the whole area and within the current stock area definition. No signs of migration outside the current geographic stock unit were found. From exploratory and modeling techniques we show a clear age distribution pattern by depth, with a strong stratification of younger individuals onshore that gradually go offshore as they grow. Based on this post-stratification we evaluated alternative methods for calculating indices of abundance-at-age and assess the implication for stock assessment. Despite higher uncertainty in the stock parameters using the mean abundance-at-age with post-stratification, the historical perspective of the stock trends is maintained as well as the signal for strong year classes in 1996, 2011 and 2012 and above average recruitment in most recent years. Moreover, the analysis of juvenile and adult survey indices from pre- (1983-1991) and assessment (1992-2015) periods, show a similar historical perspective of the stock.

1. Survey data

1.1. Portuguese IBTS sampling design (PTGFS WIBTS Q4)

The Portuguese groundfish surveys have been conducted since 1979, continuously in Autumn and partially in Winter and Summer, with R/V "Noruega" and, in its absence, with R/V “Capricórnio”. The surveys are conducted along the Portuguese continental waters (ICES Division 9a) and the area surveyed extends from 41º 50' N to 36º 41' N and from 20 to 500 meters depth.

The R/V Noruega is a stern trawler of 47.5 m length, 1500 horse power and 495 G.T.R. The fishing gear used is a bottom trawl (type Norwegian Campell Trawl 1800/96 NCT) with a 20 mm codend mesh size. The main characteristic of this gear is the groundrope with bobbins. The mean vertical opening is 4.6 m and the mean horizontal opening between wings and doors is 15.1 m and 45.7 m, respectively. The polyvalent trawl doors used are rectangular (2,7 m x 1,58 m) with an area of 3,75 m2 and weighting 650 Kg. In 1996, 1999, 2003 and 2004 those surveys were performed with the R/V Capricórnio because the main vessel was in repairing. The bottom trawl gear used (type FGAV019) had 25 mm codend mesh size and no rollers in the groundrope. The mean vertical opening of the net is 2.2 m and the mean horizontal opening between wings is 25.3 m (Table 1.1).

The main objectives of the surveys are to estimate indices of abundance and biomass of the most important commercial species; study the distribution pattern and estimate indices of abundance for recruits; estimate biological parameters, maturity evolution, sex-ratio, weight, food habits; build length and/or age compositions for the target species. Horse mackerel (*Trachurus trachurus*) is one of the survey main target species.

A stratified random sampling design was adopted during 1979-1989. The number of strata changed during this period: from 1979 to 1980 the surveyed area was divided into 15 strata and from 1981 onwards into 36 strata. Based on the statistical analysis of the previous surveys the design was revised in order to decrease the variance within stratum. The new strata are smaller than the previous ones and can be combined to get the previous ones. The aim of increasing the number of strata was to increase the probability of spreading the random sampled units in order to decrease the total variance of the species' mean abundance indices. The stratification is based on depth and geographical areas. The depth ranges used during 1979-1988 were 20-100m, 101-200m and 201-500m. Each stratum was divided into units of approximately 25 nm^2, sequentially numbered. During 1979-1980 the number of random hauls per stratum was based on the previous information of the relative abundance of the target species in each geographical area and on the ship time available. During 1981-1989, when the number of strata was 36, two random units were sampled by stratum whenever possible, to achieve an estimate of the standard error of the stratified mean by stratum. The tow duration was 60 minutes during 1979-1985 at a trawling speed of 3.5 knots, changing to 30 minutes during 1986-1988, and changed back again to 60 minutes in 1989 as it was observed that the large adults of horse mackerel were not caught in 30 minutes tows at this trawling speed (Table 1.1).

From 1990 to 2004, the sampling design was based on fixed stations. A total of 97 fixed stations were planned, spread over 12 sectors. Each sector was subdivided into 4 depth ranges: 20-100m, 101-200m, 201-500m and 501-750 m, with a total of 48 strata. The positions of the 97 fixed stations were selected based on common stations made during 1981-1989 surveys and taking into account that at least two stations per stratum should be sampled. A maximum of 30 supplementary stations were planned, fixed in each season, to be carried out if ship time is available or to replace positions that due to particular factors are not possible to sample. The duration of each tow was 60 minutes but changed in Autumn 2002 to 30 minutes in order to increase the number of hauls, with the rationale that large adults could escape the net since the survey was aimed at recruit. Fishing operations are carried out during daylight at a towing mean speed of 3.5 knots (Table 1.1).

In 2005 a new sampling scheme was implemented, based on a systematic and stratified random sampling, to facilitate the use of geostatistical models and to overcome the difficulties in the estimation of the variance. Additionally, it allows performing the calculations with the former 48 strata. The new sampling scheme includes depths from 20 to 500 m (instead of 750 m) once the main objective of the survey is to estimate recruitment indices for hake and horse mackerel and a mixed sampling scheme composed by 66 trawl positions distributed over a fixed grid with 5' per 5' miles, corresponding to trawl positions already done, and 30 random trawl positions, with a tow duration of 30 minutes (WKPGFS, 2004).

Table 1.1.Summary of sampling methodology in the Portuguese IBTS Q4 survey.

TIME PERIOD	SHIPS / GEAR	SAMPLING DESIGN	STRATA	TOW DURATION (MIN)	SURVEYED AREA (KM^2)
1979-1980	Noruega /NCT	Stratified random (~59 hauls)	15 (5 zones, 3 depth: 20-100; 101-200;201-500)	60	NA
1981-1985*	Noruega /NCT	Stratified random (~124 hauls)	36 (12 sectors, 3 depth: 20-100; 101-200; 201-500)	60	27182
1986-1988	Noruega /NCT	Stratified random (~124 hauls)	36 (12 sectors, 3 depth: 20-100; 101-200; 201-500)	30	27182
1989-1995, 1997-1998, 2000-2002	Noruega /NCT	Fixed (97 hauls)	48 (12 sectors, 4 depth: 20-100; 101-200; 201-500; 501-750)	60	34213
1996, 1999,	Capricórnio /CAR	Fixed (97 hauls)	48 (12 sectors, 4 depth: 20-100; 101-200; 201-500; 501-750)	60	34213
2003-2004	Capricórnio /CAR	Fixed (97 hauls)	48 (12 sectors, 4 depth: 20-100; 101-200; 201-500; 501-750)	30	34213
2005-2016*	Noruega /NCT	Mixed: Fixed (66 hauls) + Stratified random (30)	36(12 sectors, 3 depth: 20-100;101-200;200-500)	30	26883

* in 1984 and 2012 there was no PTGFS WIBTS Q4 survey

1.2. Spanish IBTS sampling design (SPGFS WIBTS Q4)

The Spanish groundfish survey time series covering the Northern Spanish Shelf started in 1983 and have been mainly carried out with R/V Cornide de Saavedra, but in 1989 with R/V Francisco de Paula Navarro. Since 2013 the Spanish surveys have been carried out with R/V Miguel Olivier. . Initially 1 hour hauls were tested, but in 1985 it was decided that 30 minutes tows provided enough information regarding species and length distribution of the species sampled, so from 1985 to today, 30 minutes hauls were performed except for the special deep waters hauls, where 40 minutes were performed to account for the time taken for the gear to reach ground contact deeper than 500m. These special deep hauls have not been taken into account when estimating standard abundances since they are not considered representative for the deep areas on the Cantabrian Sea and Galician shelves, whereas the shallower ones (<70 m) have been considered only between 1983 and 1996, although there were not shallower hauls in 9a.

In Spanish surveys a random stratified sampling design is adopted. A total of 20 random stations are planned over 3 sectors. Regarding the area surveyed, the area within Division 9a has not changed at all, also because in spite of the change of depth stratification done in 1997 after the SESITS project and the findings regarding species groupings, the shallowest strata (below 70m) has never been sampled due to the lack of trawlable grounds in this strata, as stated before (Table 1.2).

A CTD cast is performed after each haul in order to get temperature and salinity data by depth to be used in biological studies.

The catch from each haul is sorted, counted and weighed by species. For the target species and for some other commercial species (fishes, cephalopods and crustaceans) length measurements, as well as other biological information from selected samples, e.g. individual weights, sex, maturity stages, stomach contents, are undertaken. Furthermore, complete species list is provided and information on the length distribution of other commercial species are available. The estimation of mean abundance/biomass or stratified mean abundance/biomass by species follows the methodology presented by Cochran (1960).

Table 1.2. Summary of sampling methodology in the Spanish WIBTS Q4 survey.

TIME PERIOD	SHIPS / GEAR	SAMPLING DESIGN	STRATA	TOW DURATION (MIN)	SURVEYED AREA (KM²) TOTAL/9A
1983-1984	Cornide de Saavedra / Baka 44/60	Random stratified	30-100, 101-200,201-500	30 or 60	21039/4139
1985-1986,1988	Cornide de Saavedra / Baka 44/60	Random stratified	30-100, 101-200,201-500	30	21039/4139
1989	Fco. de Paula Navarro/ Baka 44/60	Random stratified	30-100, 101-200,201-500	30	21039/4139
1990-1996	Cornide de Saavedra / Baka 44/60	Random stratified	30-100, 101-200,201-500	30	21039/4139
1997-2012	Cornide de Saavedra / Baka 44/60	Random stratified	70-120,121-200,201-500	30	21039/4139
2013	Miguel Oliver / Baka 44/60	Random stratified	70-120,121-200,201-500	30	21039/4139

	Double wrapped ground-rope				
2014-2016	Miguel Oliver / Baka 44/60	Random stratified	70-120,121-200,201-500	30	21039/4139

The Portuguese and Spanish IBTS surveys cover contiguous areas in the same quarter (usually in October-November) and the majority of the distribution of the southern horse mackerel stock, excluding 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 not analyzed in this study.
As suggested in previous reviews of the assessment of this stock, the Spanish survey from Subdivision 9a North and the Portuguese survey are treated as a single survey, although they are carried out with different vessels and slightly different bottom-trawls. The catchability of "Cornide de Saavedra" and "Noruega" and fishing gears were compared for different fish species during project SESITS (EU Study Contract 96-029) and no significant differences were found for horse mackerel (ICES, 2011). Inter-calibrations between fishing gears of the Portuguese R/V´s and more recently Spanish R/V Miguel Oliver and Cornide also showed similar catchability and proportion of bentho-demersal species. Thus, the raw data (number per hour and age in each haul, including zeros) of the two datasets were merged and treated as a single dataset.

1.3. Sampling effort (Fishing stations by area and depth)

The Portuguese and Spanish surveys were analyzed from 1992 to 2015 corresponding to the assessment period, both surveys covers the bulk of the geographical distribution of the southern horse mackerel stock. Figure 1.1 shows the areas defined in this study: N, northernmost distribution of the stock and western Spanish area; NW, northwestern Portuguese area; SW, southwestern Portuguese area and S, southern Portuguese area.

The areas used in this study were delimited based on their geographic and physical characteristics. In fact, there are features that make those distinctions quite clear, such as the geographic orientation which corresponds to different oceanographic conditions, the extent of the continental shelf and separation by deep canyons or promontories (e.g. Cape Finisterre and Nazare canyon). The area covered in each of the geographic sectors is detailed in Table 1.3.

Furthermore, following analysis of the horse mackerel size spatial distribution in Portuguese waters from commercial catches, presented during the Data Evaluation Workshop, DEWKshom (Azevedo, M. and Silva, C., 2016) survey data was also stratified by three depth strata: D1, 20-100m; D2, 101-200m and the deeper D3 strata, above 200m. The different physical characteristics of the combined area/depth strata are reflected in the distribution of fishing stations across these strata, for example the wider continental shelf in the NW area is clearly reflected in the larger number of fishing station for D1, opposing the South area with the majority of fishing station in D3 (Fig. 1.2 and Table 1.3).

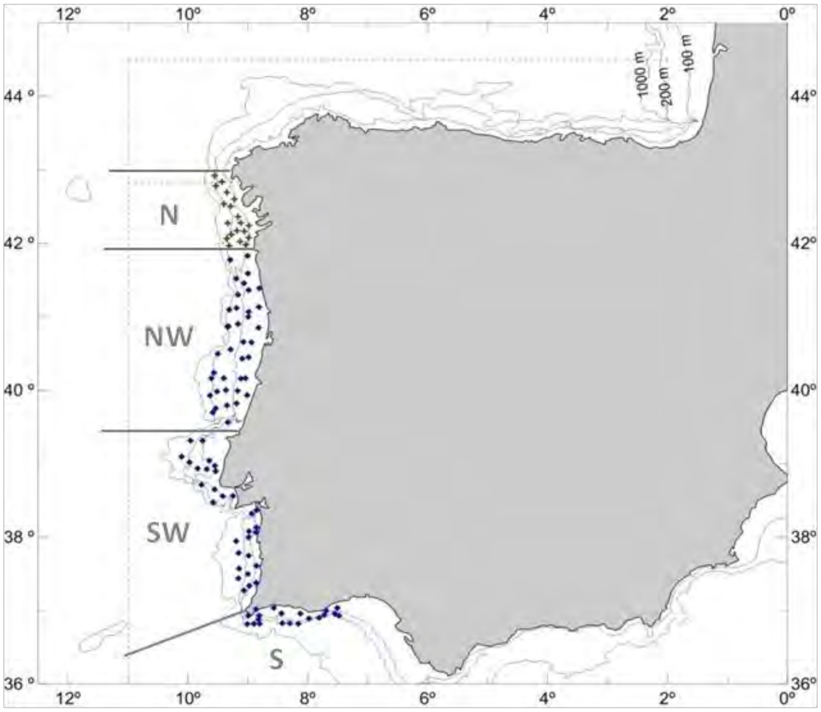


Figure 1.1. Survey areas for the southern horse mackerel stock distribution. The 100m, 200m and 1000m depth isobaths are showed.

While in Portuguese waters the number of hauls carried out in waters shallower than 100m is high, the sampling effort in Spanish waters (North area) below 100m is very scarce due to the massive presence of rocky grounds in the western Spanish inner shelf (Table 1.3). For this area, the D1 and D2 depth strata are 70-120m and 120-200m, respectively, reproducing the specific survey design for this area (see Table 1.2).

Table 1.3. – Number of fishing hauls by stock areas (see fig 1.3) and depth strata and total surveyed area in each zone. * Spanish surveys with a different stratification in D1, 70 – 120m and D2, 121-200m to reflect the geographic traits and survey stratification design for this area (see text for details).

AREA	D1(20-100)	D2(101-200)	D3>200	TOTAL
N	98*	252*	121	471 4 139 km²
NW	351	321	89	761 13 241 km²
SW	107	297	220	624 9 927 km²
S	111	138	198	447 3 715 km²
Total	667	1008	628	2281 31022 km²

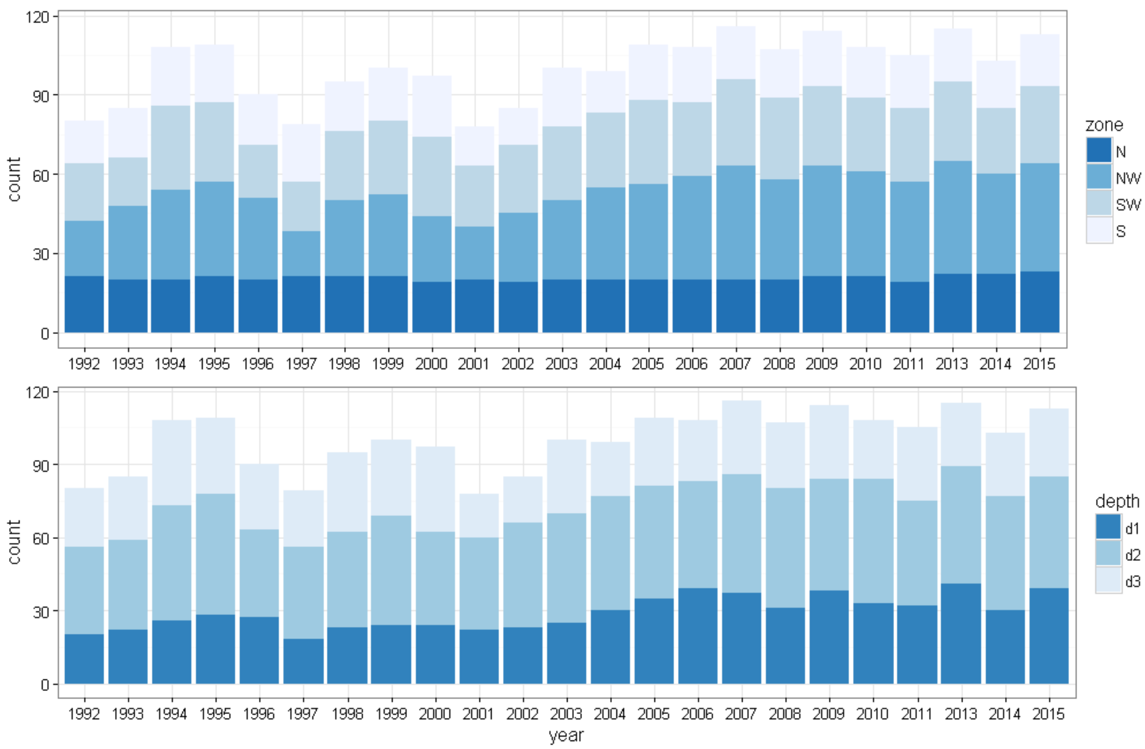


Figure 1.2. Fishing stations by zone and depth strata for the assessment years 1992-2015.

2. Total Abundance and Presence/Absence

2.1. Total abundance

From each haul the total number of individuals is estimated and survey abundance data was standardized to number per hour. The time series of abundance has a strong variability with some years of much higher abundance than others. This pattern is also clearly reflected across the analyzed areas. The majority of individuals are distributed in the NW area but with some high abundance years in other regions. Despite some significant correlations there are no clear trends across contiguous areas (Fig. 2.1).

The bulk of surveyed individuals are distributed shallower than 100m and occasionally in D2 (100-200m) as younger individuals are more abundant in these strata and have a greater aggregation tendency in dense shoals. A small relationship was found between abundance from D1 and D2. The extremely high abundance observed in 2005 was common in all areas but is mostly explained by some very large shoals that were caught in D1 in the N and NW areas (Fig. 2.1).

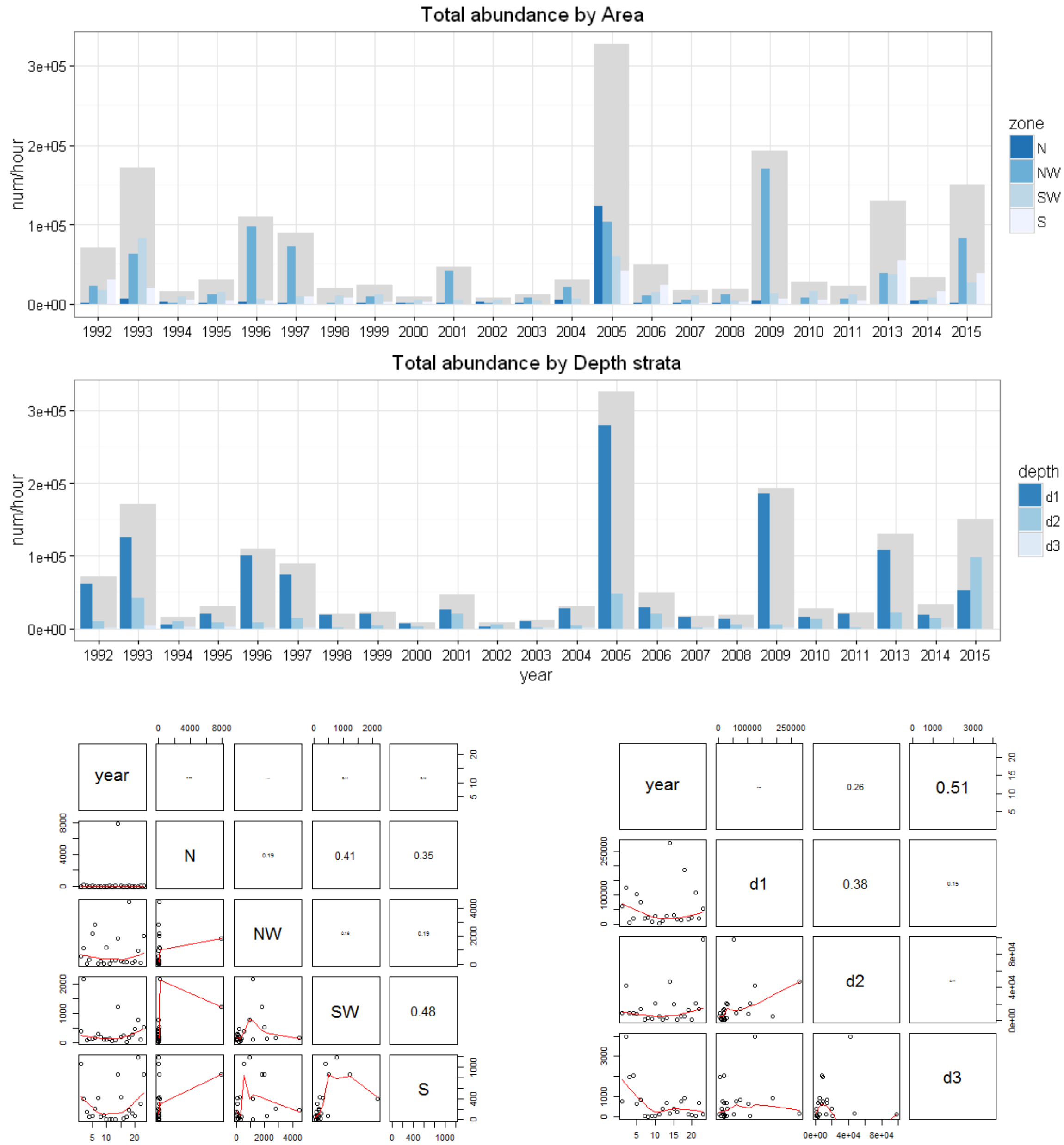


Figure 2.1. Total abundance (number per hour) (upper panels) and yearly correlations of abundance (lower panels) by area and depth strata.

The abundance data by age and year do not follow a Normal distribution, having a big proportion of zeros and a few extreme values. This is explained by the patchiness in the distribution of horse mackerel and by its characteristic of forming large shoals (ICES, 2011). The proportion of hauls containing no horse mackerel (*Prob.0*) was estimated across areas and depth strata from 1992-2015. An additional index, *Prob.*Q_3, was defined as the proportion of hauls with horse mackerel individuals above the estimated 3rd percentile, Q_3, of the abundance distribution data, after removing the 0´s. Despite not following a normal distribution this *Prob.*Q_3 cutpoint could provide some insight to the presence of these large shoals in survey data.

From 1992 to 2015 these two indices have no significant differences across area strata but have marked differences by depth strata. Most hauls (84%) in D1 have horse mackerel and the probability of hauls with no horse mackerel gradually increases with depth (Table 2.1). Concurrently the *Prob.Q₃* index has a contrasting behavior, in fact, there is a significant negative relationship between these two indices suggesting that the appearance of these large shoals is not only the result of chance but the two combined indicate years with high abundance (Fig. 2.2). As many other stocks, in high abundance years horse mackerel expands its distribution which is reflected by the reduced number of 0´s hauls coupled with increased occurrences of large shoals.

Table 2.1. – Proportion of hauls with a zero catch (Prob. 0) and big shoals (Prob. Q3) by stock areas and depth strata. The two indices are considerable different across depth strata but no clear distinction is shown across areas. The computed correlation coefficient is presented for 1992-2015 survey data.

STRATA/ INDICES.	N	NW	SW	S	DEPTH 1	DEPTH 2	DEPTH 3
Prob. 0	0.28	0.42	0.32	0.50	0.16	0.34	0.69
Prob. Q_3	0.04	0.17	0.21	0.17	0.34	0.12	0.01
r	-0.32	-0.69	-0.65	-0.75	-0.52	-0.49	-0.24

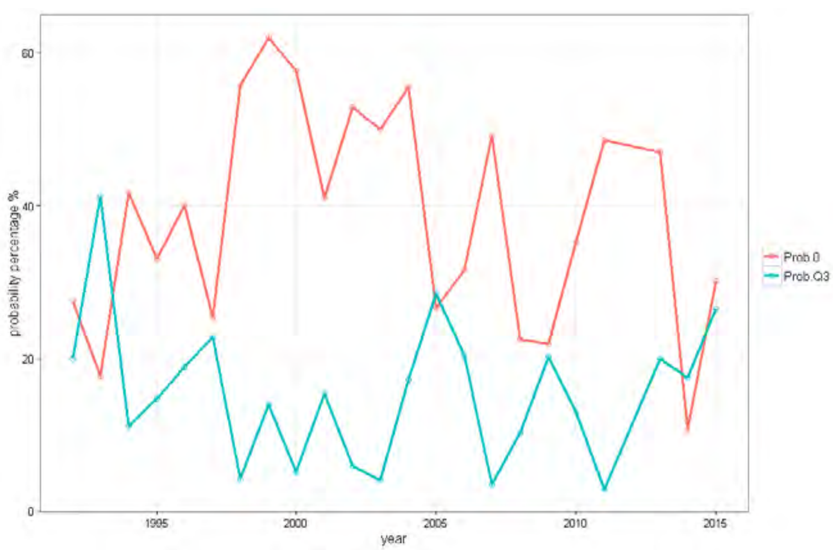


Figure2.2. Proportion of hauls with a zero catch (Prob.0) and big shoals (Prob.Q_3) from 1992-2015. Time series showing a clear negative relationship between the two indices.

2.2. Total Abundance-at-age

From each haul, a length frequency distribution is estimated for the total catch. These length distributions are then transformed into age composition, using the age-length keys obtained from otholiths reading of the fish sampled in each area (Portuguese and Spanish) during the 4th quarter.

The frequency of age class a in a given haul is then given by , where n_l is the frequency of length class l in that haul and $p_{a|l}$ is the proportion of fish in age class a within length class l. The estimates of abundance-at-age by area and depth are detailed in Figures 2.2-2.3.

Another useful indicator from bottom trawl survey data is the presence/absence by fishing hauls. Horse mackerel abundance-at-age and occurrence-at-age were analyzed to identify patterns by area or depth (Figs 2.2-2.3).

The bulk of number per hour abundance is from younger ages (0-2). The greater aggregation tendency of these small fish in dense shoals contributes to a high abundance estimates for these age classes. Recruits (age 0) are mostly distributed in the NW area (Fig 2.3).

Age occurrences analysis shows that all ages can be found in the surveyed area suggesting that the sampling scheme covers the whole area and within the current stock area definition. No signs of migration outside the current geographic stock unit were found. Whereas in the Portuguese areas, no apparent inward migration occurs from neighboring populations, the reasons for the occurrence pattern observed in the N area (large occurrence of age 0 and ages 6+, scarce occurrences of intermediate ages) is not clear from the data.

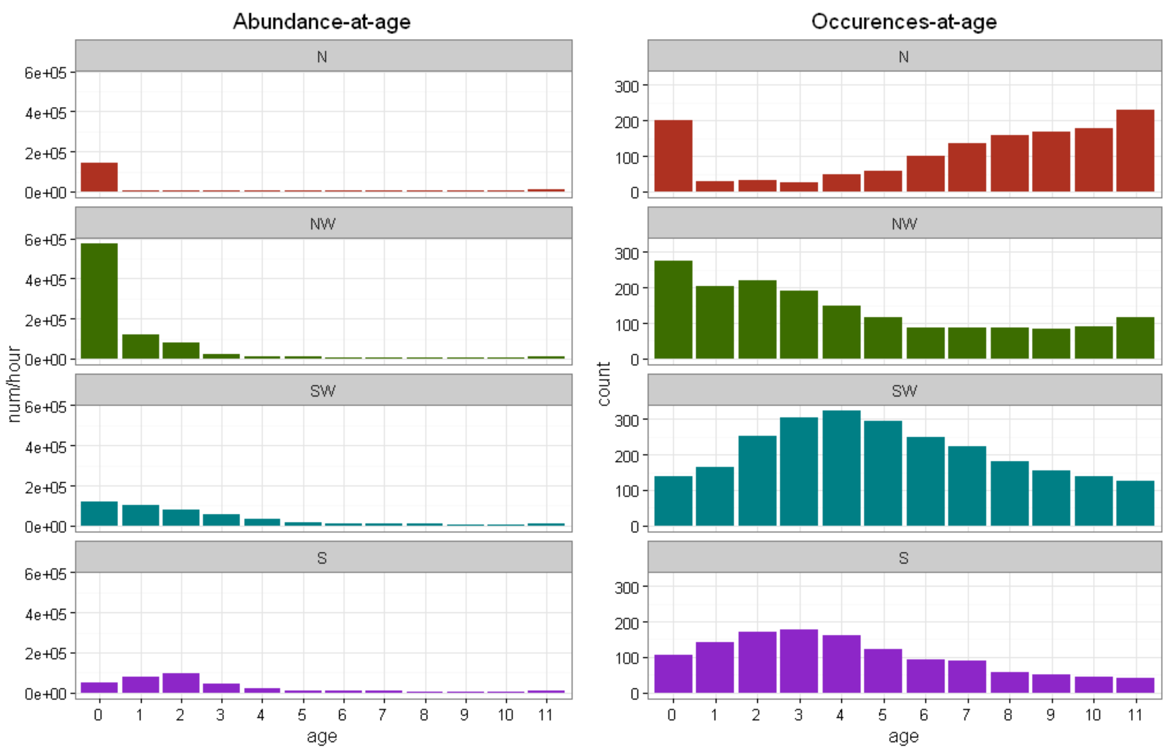


Figure 2.3. Total abundance-at-age and occurrences-at-age (0-11+) by area.

Horse-mackerel was observed in grounds up to 530m. The greater aggregation tendency of younger fish in dense shoals contributes to a higher 0-2 age abundance in the shallower strata (Fig. 2.4).

Depth strata have the most pronounced age distribution occurrences pattern: younger individuals in D1, all ages in D2 and predominance of older individual in the deeper D3 strata.

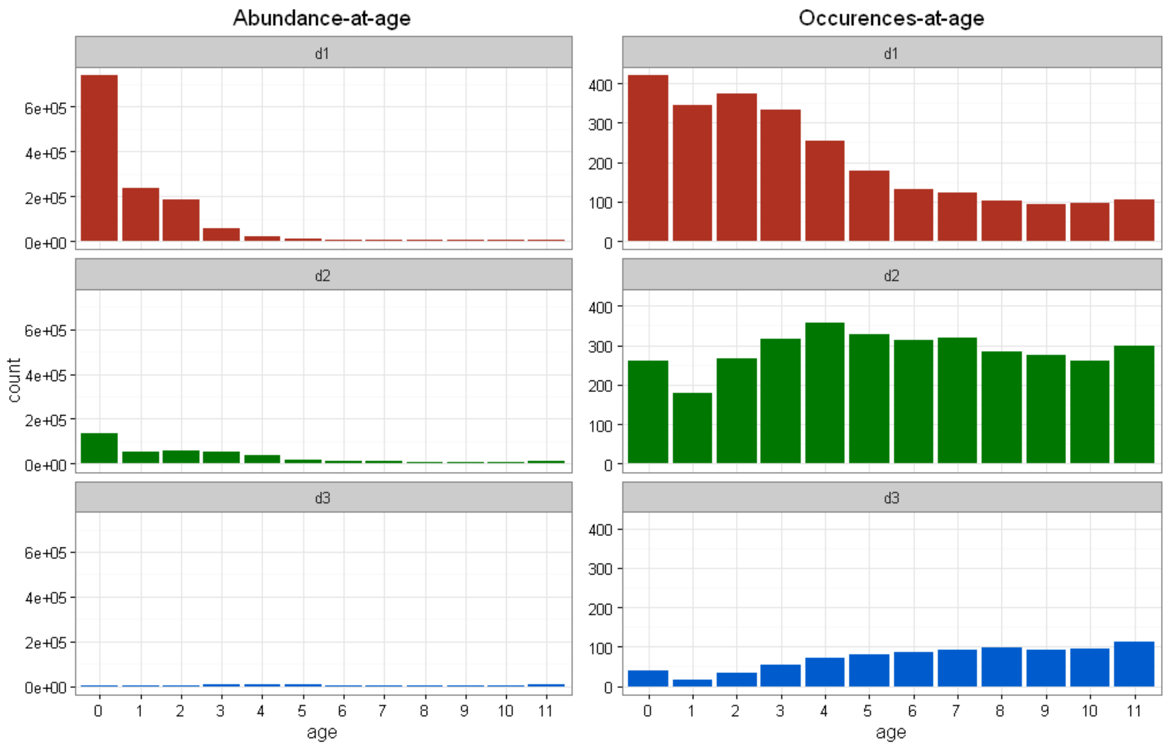


Figure 2.4. Total abundance-at-age and occurrences-at-age (0-11+) by depth strata.

In summary, the results of the abundance and occurrence analysis indicates a strong stratification of younger individuals onshore that gradually go offshore as they grow as was observed by Murta et al. (2008), that juveniles abundance is higher in northernmost distribution of the stock (in autumn), that all age groups are found within the stock boundaries with no apparent inward migration from neighboring populations, also suggesting that the stock is not heavily exploited.

2.3 Modelling age abundance

Horse mackerel survey data (1992-2015) was modeled using two approaches: i) Generalized Additive Models (GAM) fit to age abundance and, ii) Random forests classification analysis on presence/absence and on abundance-at-age to investigate relationships between survey predictors and horse mackerel abundance and occurrences.

Trying to obtain a clearer understanding of the effect of depth on the age distribution and due to the large number of zero observations across all ages and the need for a single depth effect model to make predictions for a large number of age groups, data smoothing was tried with Generalized Additive Models (GAM) using the package *mgcv* (v1.7-29) in the R statistical computing language

(R Core Development Team, 2010). Data smoothing was tried with one GAM by age with depth as a continuous covariate. Exploratory data analysis showed that abundance variance exceeds the mean. Therefore, the model fit was made assuming a log link function with a binomial negative since this distribution is found adequate to model overdispersed data. Moreover, the model fit also allows for the iterative estimation of the optimal dispersion parameter. The best model fit was obtained for younger ages (ages 0-3, Fig 2.5) but the residuals showed undesirable patterns (e.g. non-normality, autocorrelation). Other distributions and transformations of the data were tried, but with worse model fitting.

Despite the problematic residuals in the modelled abundance-at-age by depth, the results are shown in Figure 2.5. A contrasting behavior of abundance is shown between three different age groups; ages 0-3, 4-8 and 9-11+. Ages 0-3 are mostly distributed below 150m and the fitted abundance of ages 4+ seems to be driven by the sampling intensity of fishing station across depths.

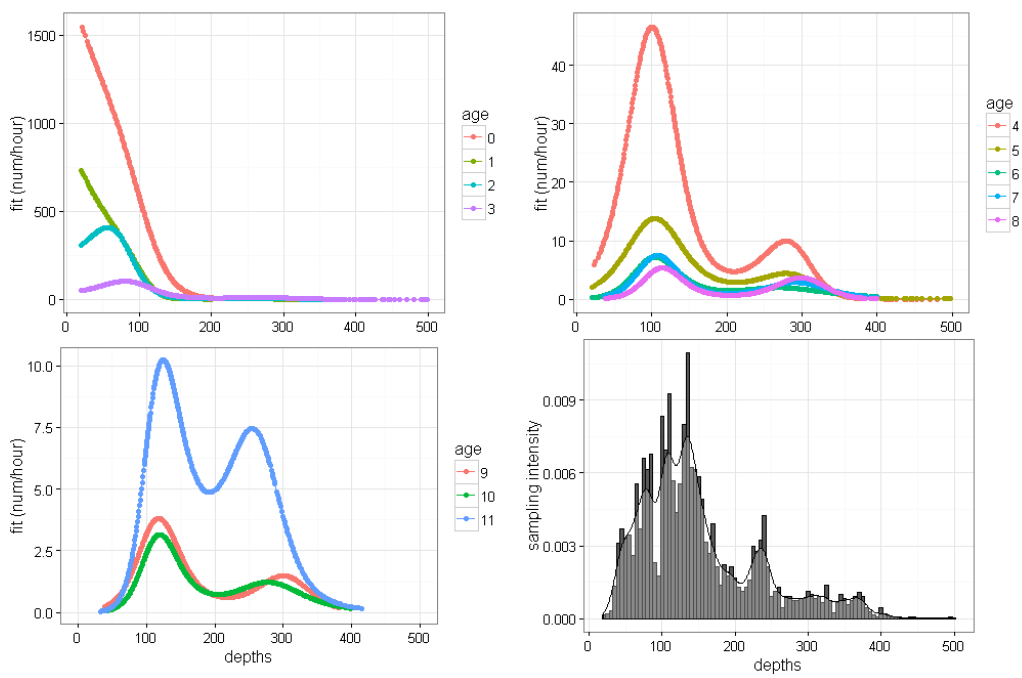


Figure2.5. Predicted total abundance-at-age by depth from the GAM fit. Lower right panel shows the distribution of fishing station by depth.

Random forests models (RF) are based on a large number of classification trees, which use recursive partitioning of data to group observations into predefined classes (Breiman, 2001; Cutler *et al*., 2007).

Once the classification tree is built, predictor data from the OOB (out of bag) observations are passed through the tree, generating predicted classifications for each observation in the OOB dataset. These predictions are compared with the true classification of the OOB data to generate a misclassification rate for the tree, and this process is repeated to generate a large number of trees. Misclassification rates of individual trees are averaged across all trees to produce an overall model error rate. Random forest models also measure variable importance directly in terms of predictive accuracy.

Random forests classification analysis was applied to investigate depth categorical predictor (depth strata 0-100, 101-200 and >200) against presence/absence by ages 0 to 15+, zone and year.

Analysis were carried out with the R package *randomForest* (v 4.6-12) and model fit diagnostics were analysed based on the mean decrease accuracy (MDA, which measures the model fit with variable dropping) and model overall explanatory power of the variables through the mean decrease of GINI index (contribution of each variable to the tree homogeneity).

Results from RF gave a high OOB estimate of error, of 35%, with classification error for depth strata ranging from 28-40%, being lower for D1 (Table 2.2). The analysis indicated that zone (MDA of 73.2) and ages 0-4 (MDA between 30-57) are the most significant variables for data classification while zone, year and ages 0-3 factors have much greater explanatory value, GINI index of 131.1, 125.3 and between 32-78, respectively (Fig. 2.6, Table 2.3).

Table 2.2. OOB (classification error) for Random Forest fit by depth strata.

	D1	D2	D3	OOB
D1	418	132	34	28.4%
D2	177	649	250	39.7%
D3	25	182	414	33.3%

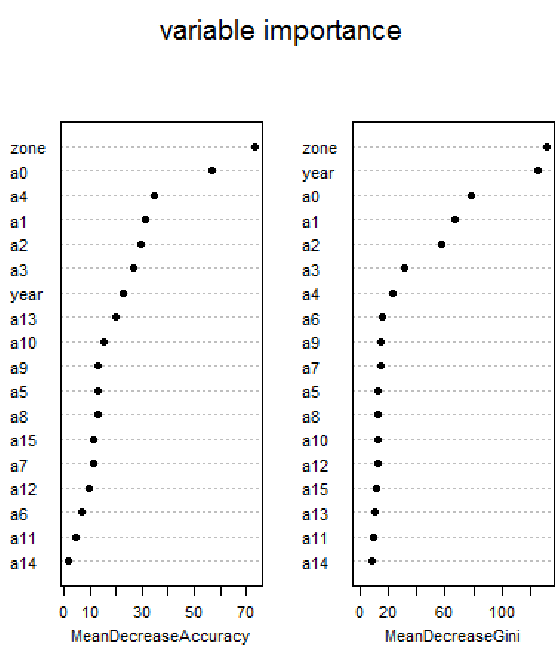


Figure 2.6. Plot of mean decrease accuracy (left) and GINI index (right) for Random Forest model.

Table 2.3. Mean decrease accuracy (MDA) and GINI index values for Random Forest (a0, a1, ..., a15: ages 0 to 15).

	D1	D2	D3	MDA	GINI
a0	34.57	14.21	49.02	56.66	77.71
a1	20.14	8.64	27.51	31.32	67.28
a2	27.43	6.55	22.53	29.33	57.09
a3	1.20	8.80	31.22	26.95	31.67
a4	-16.41	15.41	40.17	34.72	23.32
a5	1.64	1.38	16.70	12.95	13.21
a6	8.55	-5.50	12.97	6.63	15.99
a7	9.74	-6.35	18.47	11.17	14.44
a8	10.32	4.80	7.11	12.83	12.92
a9	15.23	-7.55	19.26	13.07	15.01
a10	10.89	3.40	10.37	15.25	12.81
a11	11.69	-5.94	9.70	4.61	10.07
a12	17.88	-5.15	11.78	9.74	12.54
a13	6.20	7.75	14.82	19.78	10.93
a14	12.11	-9.01	10.61	1.54	8.99
a15	18.26	-1.70	7.92	11.55	11.95
zone	48.93	50.91	49.74	73.22	131.13
year	15.66	16.81	5.03	23.00	125.26

Total abundance of horse mackerel shows a patchiness in the distribution across the entire time series with occasional high values that seem to be consistent across all the areas; also showing significant correlations in some areas but with no clear relationship among contiguous areas. The bulk of the horse mackerel surveyed individuals are in the larger NW and SW areas and shallower than 100m with some abundance in the intermediate layer. Age abundance data shows that the most of the surveyed individuals are from the younger ages (0-3) and are mostly distributed northward. Horse mackerel has clear and different occurrence distribution patterns across the three depth strata, showing a strong stratification of younger individuals onshore that gradually go offshore as they grow. Modeling analysis also indicated depth strata as the main factor associated to horse mackerel occurrences/abundance-at-age.

The analysis in this section revealed patterns in the age distribution that suggest exploring different survey post-stratifications to estimate horse mackerel abundance-at-age for stock assessment.

3. Abundance-at-age for stock assessment

From the distribution patterns showed in the previous sections and as the abundance data by age and year does not follow a Normal distribution, it is questionable whether the current simple average over all hauls of the number-per-hour, by age and year, is an adequate abundance index for tuning the stock assessment. Two alternative methods of obtaining an abundance index by age and year are explored in this section, one based in a simple average of the number-per-hour but, depending on the age, considering different depth strata and, another by fitting a smooth curve to abundance.

In a closed population, each year class is expected to decrease from one age to the other, at a rate that is proportional to the different causes of mortality. Therefore, a good indicator for the suitability of alternative methods for estimating age abundance from survey data is the survey signal by cohort. *Internal consistency* (IC) is defined by Berg et al. (2014) as the correlation between $\log I_{y,a}$ and $\log I_{y+1,a+1}$, where I, y and a denotes abundance index, year and age, respectively. Under the assumption of constant mortality by cohort, positive IC values give indication that cohorts can be followed in surveys abundance indices.

Following the analysis from section 2, several post-stratifications were tested to estimate an alternative abundance-at-age index. This alternative index was derived as an average of the number-per-hour over the hauls of different depth strata conditional on age. This abundance-at-age with post-stratification is different from computing a "stratified mean abundance-at-age" as the latter requires weighting the mean by the total number of units in each stratum. The best post-stratification for each age, using IC as the goodness-of-fit statistics, is detailed in Table 3.1.

Table 3.1. – Internal consistencies at each age and averaged over age groups between abundance-at-age (WGHANSA 2016, left), abundance-at-age with post-stratification (middle) and smoothed abundance-at-age (right). Improved consistencies in relation to current method are shown in bold. IC at age was computed in all methods from all pairwise values from 1992-2014 year classes.

	MEAN IC	AGE GROUP IC	POST-STRATIFICATION	STRATA IC	AGE GROUP IC	LOESS SMOOTH IC
0			D1-D2			
1	0.1		D1-D2	0.1		**0.86**
2	0.35	0.31	D1-D2	**0.36**	0.31	**0.78**
3	0.49		D1-D2	0.48		**0.84**
4	0.35		D1–D2 –D3*	0.31		**0.92**
5	0.18		D1–D2 –D3*	0.13		**0.56**
6	-0.05	0.16	D1–D2 –D3*	-0.07	0.12	**0.63**
7	0.25		D1–D2 –D3*	**0.26**		**0.84**
8	0.05		D1–D2 –D3*	-0.05		**0.93**
9	0.20		D2-D3	0.20		**0.93**
10	-0.1	0.05	D2-D3	**0.05**	**0.13**	**0.93**
11+	*-0.41*		D2-D3	*-0.33*		**0.94**
mean		0.17			0.17	0.83

***D3 in these ages group limited to 300m.**

IC values do not show a significant improvement in abundance index estimates with post-stratification (Table 3.1). Our previous analysis suggested that post-stratification on age abundance data would reduce data noise and provide more accurate estimates, but there were no significant different between the two averaging methods (Fig. 3.1). We consider that a stratified mean abundance index, using an adequate post-stratification, should be further investigated and evaluated in terms of IC criterion and precision of the estimates.

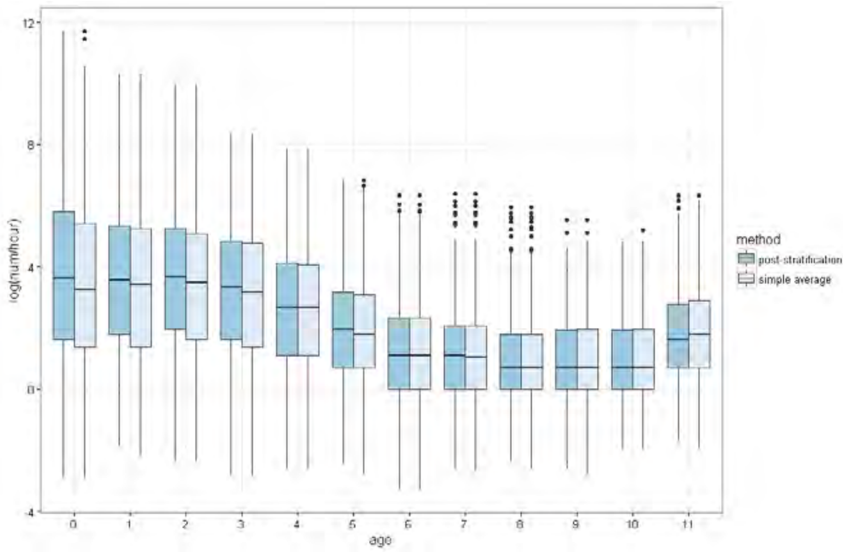


Figure3.1. Estimated mean abundance-at-age (log number/hour) and mean abundance-at-age with post-stratification.

Figure 3.2 shows the mean abundance-at-age by cohort (1992-2003) for age ranges 0-11+. Despite some noisy values, the underlying decreasing trend is noticeable among cohorts. We fitted a lowess smoother by cohort which reduced the variability and emphasize the underlying trend. The smoother was fitted to log-transformed data with the *loess* function in R (R Development Core Team, 2010). A smoothing span of α=1 (all ages are used for the local fits, weighted by their distance) was adopted which down-weighted the influence of a few extreme values observed in some cohorts. The underlying decreasing trend already observed in cohorts became more noticeable and, as expected, IC goodness-of-fit statistics achieved very high values (Table 3.1).

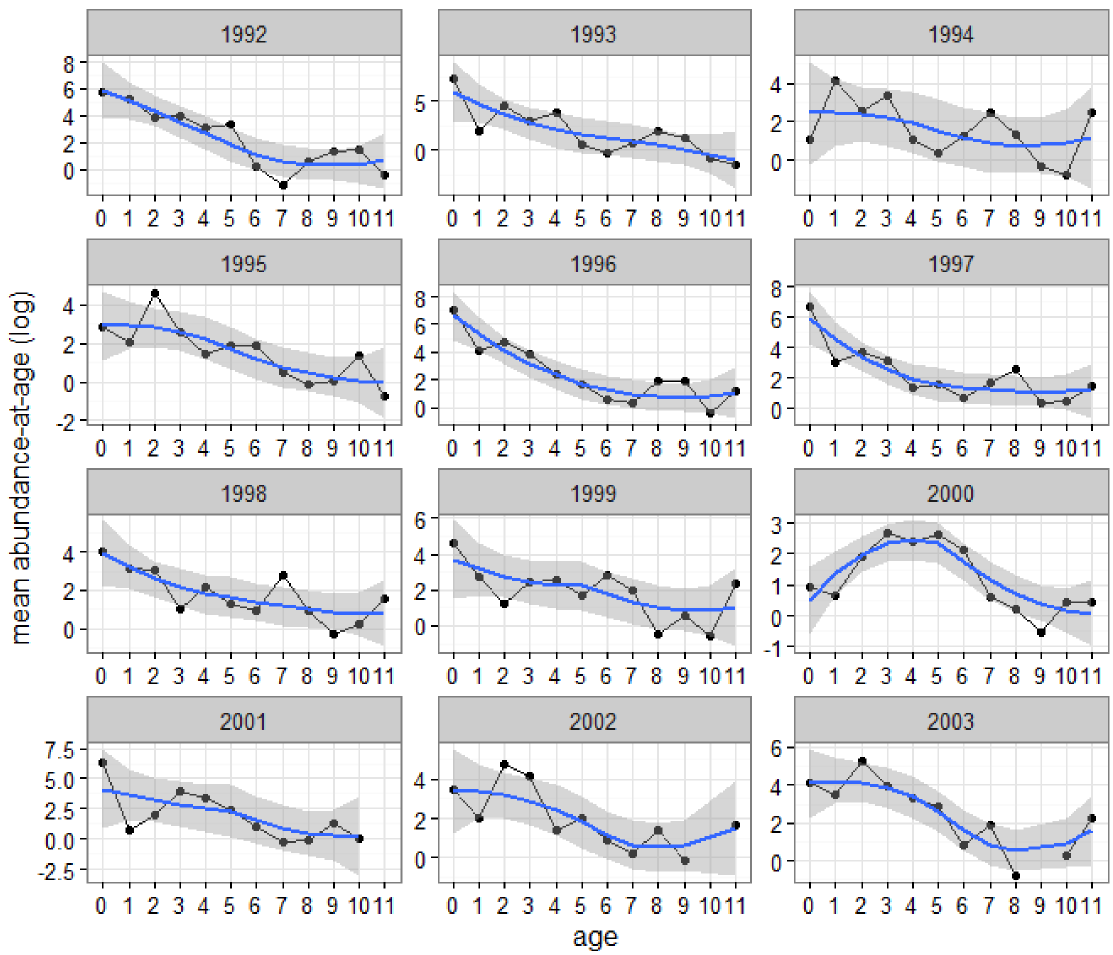


Figure 3.2. 1992-2003 cohorts as estimated by the mean abundance (in log number/hour) and by a lowess weighted smoothing with α=1 (blue lines).

The estimates and precision of the survey abundance indices are shown by method in Figure 3.3. Although the resulting abundance from the averaging methods is quite similar, some abundance peaks seems to be under estimated using the simple average. This smoothing technique requires a little guesswork and it is difficult to obtain a comprehensive equation that describes the abundance-at-age data but the promising results could be further improved by calibrating the smoothing parameter to the variability of each cohort by cross validation (e.g. Hastie et al., 2001) producing estimates even more robust to outliers. Nevertheless, we should not disregard the observed abundance peaks at survey data as they may provide some valuable information for example on the inflow of new recruits to the stock.

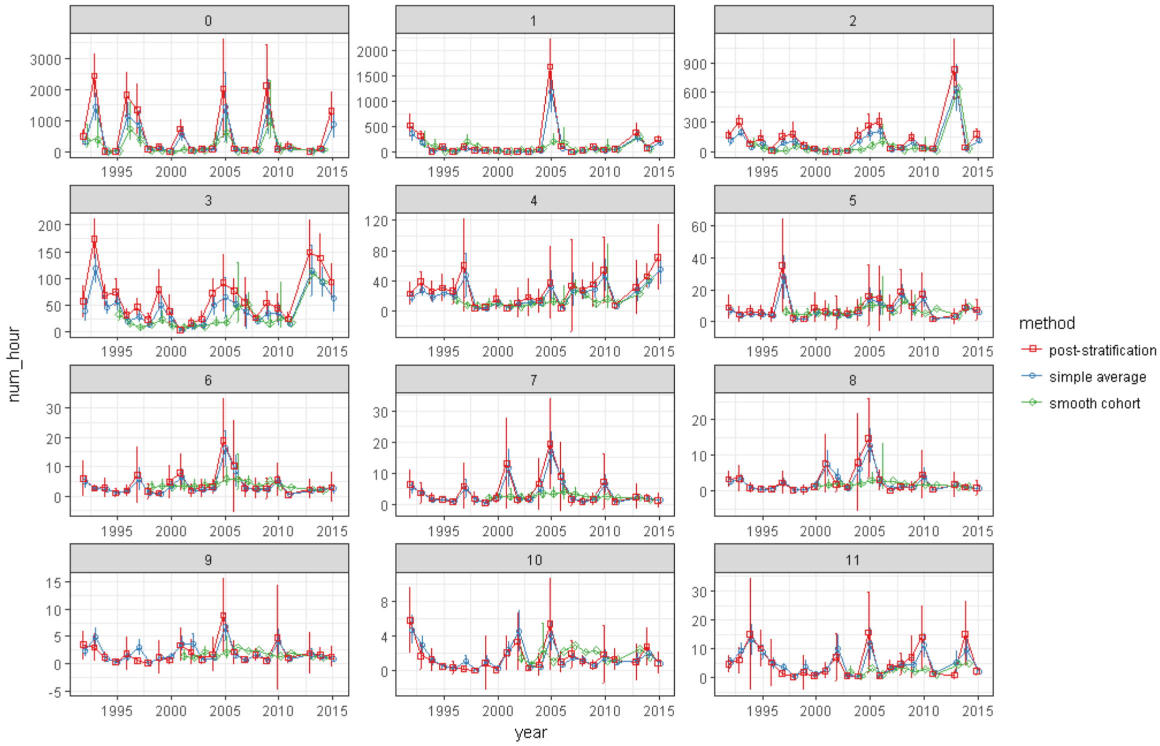


Figure 3.3. Estimated survey abundance-at-age by method. Standard error bars are shown. Standard error bars are symmetrical for both averaging methods but not for the back transformed log data from the smoothed method.

Although the IC provides useful guidance to test alternative estimates of abundance-at-age for stock assessment it is noted that IC is based on assumptions of constant total mortality by cohort, which is why a stock assessment tuned with the abundance indices gives better criteria to evaluate the precision of the indices (e.g. Berg et al., 2014).

Following the discussions and analysis conducted during the benchmark on the revision of the survey abundance-at-age obtained from the several estimation approaches, there were conflicting evidences, of which estimator to use to determine abundance from surveys. From the different methods of obtaining an abundance index by age and year, the expert group decided that the "standard" stratified mean following the methodology by Cochran (1960) was the most appropriate to deal with the stratified IBTS survey design as well as to deal with the variability in the data, thus replacing the current simple average method as the abundance index for tuning the assessment (ICES WKPELA, 2017). The survey abundance index is then based on a stratified mean abundance-at-age, y_{st}, by taking the mean catch (excluding age 0) per strata, including a combination of 3 depth strata, from 20 to 500m and 13 sectors, from Cape Finisterre to Guadiana River (Table 3.1) over the total strata in the surveyed area, following the methodology presented by Cochran (1960):

$$\bar{y}_{st} = \sum_{h=1}^{L} N_h \bar{y}_h \Big/ N$$

Where, N is the total number of units in all strata, N_h is the total number of units in stratum h and $\bar{y}_h$ is the age sample mean of abundance in number in stratum h. The description of the number of sampling units per strata and the estimated abundance-at-age are shown in Tables 3.1 and 3.2.

Table 3.1. Portuguese and Spanish IBTS strata description. Sampling units: rectangles of 5x5 nautical miles.

Strata	sampling units	zone	depth	Strata	sampling units	zone	depth
1A	14	N	1	SIN1	7	SW	1
1B	26	N	2	SIN2	14	SW	2
1C	11	N	3	SIN3	8	SW	3
CAM1	17	NW	1	MIL1	3	SW	1
CAM2	11	NW	2	MIL2	5	SW	2
CAM3	2	NW	3	MIL3	7	SW	3
MAT1	16	NW	1	ARR1	6	SW	1
MAT2	12	NW	2	ARR2	6	SW	2
MAT3	2	NW	3	ARR3	6	SW	3
AVE1	17	NW	1	SAG1	2	S	1
AVE2	15	NW	2	SAG2	3	S	2
AVE3	3	NW	3	SAG3	3	S	3
FIG1	14	NW	1	POR1	12	S	1
FIG2	23	NW	2	POR2	6	S	2
FIG3	5	NW	3	POR3	4	S	3
BER1	10	NW	1	VSA1	6	S	1
BER2	13	NW	2	VSA2	2	S	2
BER3	3	NW	3	VSA3	3	S	3
LIS1	18	SW	1				
LIS2	21	SW	2				
LIS3	12	SW	3				

Table 3.2. Stratified mean abundance-at-age (number/hour) by year.

year/age	0	1	2	3	4	5	6	7	8	9	10	11+
1992	454.53	488.16	145.83	26.84	13.21	5.89	4.05	4.39	2.44	2.29	4.02	3.42
1993	1678.91	184.25	213.34	148.82	32.63	1.99	2.14	3.20	3.07	4.30	2.63	7.27
1994	3.79	8.01	63.04	36.14	15.20	4.17	2.02	1.72	0.90	0.78	0.93	8.70
1995	15.82	61.24	89.70	49.70	23.86	6.51	1.42	1.24	0.62	0.27	0.41	6.23
1996	1222.48	6.29	8.73	13.47	14.03	3.65	1.73	0.65	0.40	0.77	0.19	2.80
1997	2095.29	97.43	68.96	20.40	45.02	55.43	15.00	11.20	4.82	5.77	2.05	1.71
1998	86.63	33.22	161.72	17.36	2.21	1.44	0.98	1.19	0.28	0.09	0.05	0.14
1999	159.52	20.18	31.79	34.79	2.85	0.96	0.58	0.23	0.22	0.69	0.87	3.03
2000	2.50	13.69	17.11	19.77	11.92	6.57	4.07	2.09	1.70	1.02	0.30	0.85
2001	1296.13	1.84	8.76	3.87	6.89	13.80	12.33	11.86	7.81	3.67	2.09	1.58
2002	21.23	1.51	11.40	10.00	5.50	2.76	1.15	1.10	2.58	2.31	3.10	6.57
2003	58.87	9.09	8.23	10.16	8.80	3.26	2.35	1.26	0.71	0.60	0.36	0.48
2004	82.70	37.42	112.43	42.35	8.13	4.24	1.86	3.83	5.15	0.97	0.40	0.18
2005	1289.99	1188.57	162.24	45.20	21.82	10.50	13.79	14.49	11.79	6.72	4.10	11.26
2006	72.63	84.60	181.81	46.63	3.40	10.36	7.39	6.65	2.71	1.41	0.49	0.30
2007	36.58	1.98	22.59	31.52	25.08	9.22	2.74	1.57	0.57	0.65	1.42	2.88
2008	52.57	28.24	39.69	20.64	26.75	17.34	2.22	0.81	1.30	1.90	1.42	4.98
2009	1268.32	79.50	147.03	52.39	44.70	11.61	2.82	1.69	1.38	0.91	0.72	4.63
2010	83.42	36.81	32.82	25.64	38.27	14.12	5.23	6.97	4.68	4.58	1.76	11.58
2011	133.20	33.09	24.54	16.23	4.71	1.20	0.42	0.55	0.36	0.68	0.81	1.59
2012	-	-	-	-	-	-	-	-	-	-	-	-
2013	12.62	363.78	820.02	105.41	18.92	3.02	2.47	2.73	2.17	2.23	1.45	2.87
2014	53.92	40.83	25.38	77.70	33.62	7.83	2.07	1.73	1.15	1.44	2.36	10.48
2015	906.80	160.33	112.58	48.47	40.85	5.51	2.37	1.18	0.89	0.95	0.85	2.59

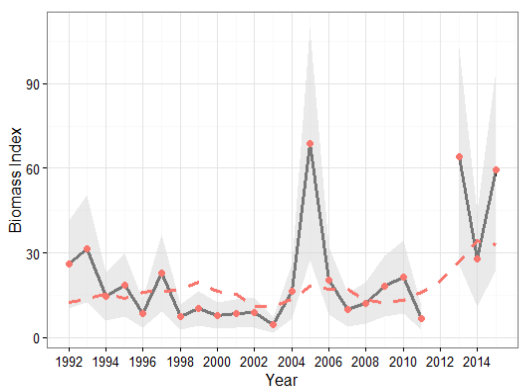
4. Assessment comparison

A stock assessment was performed with AMISH using the same model settings as in WGHANSA 2016 but tuning the stock assessment with the combined (Portuguese and Spanish data) bottom-trawl survey abundance-at-age index for ages 0-11+, computed as the mean abundance-at-age from the post-stratification derived in this study (Table 3.1., Fig.3.3), referred to as trial assessment. Model fit diagnostics and key-parameter estimates are presented in the following sections being compared with those obtained in the last year´s assessment using the combined bottom-trawl survey abundance-at-age index for ages 1-11+, computed as a simple average of the number-per-hour (WGHANSA 2016).

4.1. Model fit diagnostics

Diagnostics focus on the model fit to the time series of the biomass index (Figure 4.1.1), to the proportions-at-age of the survey abundance indices (Figure 4.1.2) and on the residuals of the abundance-at-age index and of the catch-at-age (Figures 4.1.3-4.1.4).

The estimated biomass index with the trial assessment shows slight improvements in 1998-2001 with the estimated biomass closer to the upper 95%CI (Figure 4.1.1) but better fit to the proportions-at-age in the age ranges 1-5 in years 1992, 1996, 2005-2006, 2011 and 2015 (Figure 4.1.2) noting that in this assessment the abundance-at-age 0 is included.



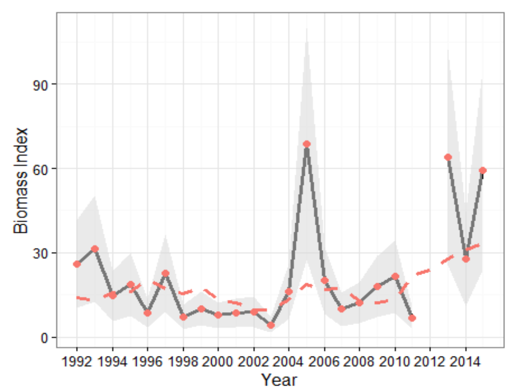


Figure 4.1.1. Historical series of biomass index estimates from the combined bottom-trawl survey (solid black line) and by the assessment model (dashed red line) with 95% confidence intervals (grey), using mean abundance-at-age (WGHANSA 2016, left) and mean abundance-at-age with post-stratification (right).

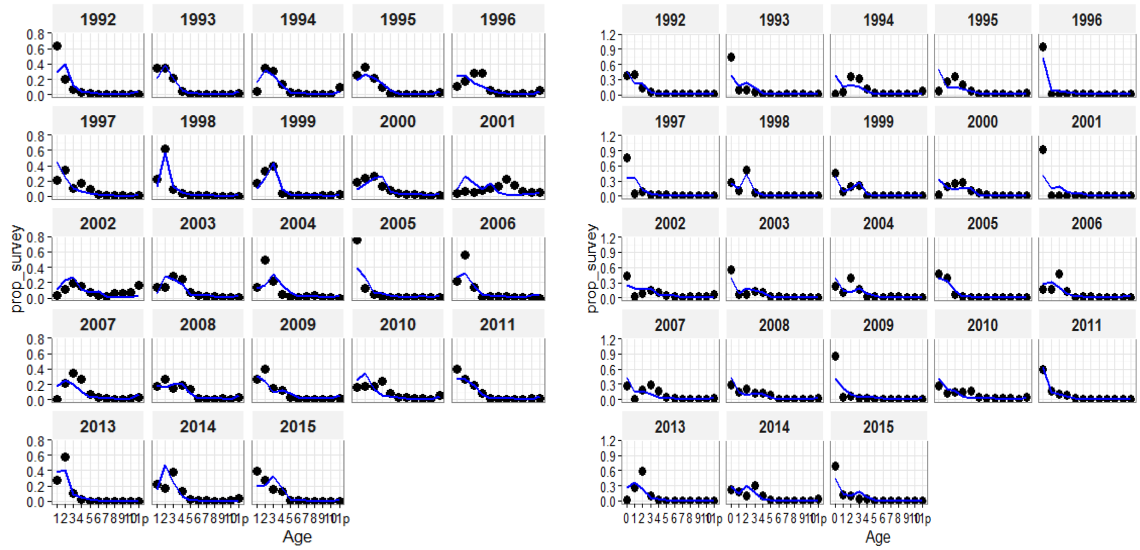


Figure 4.1.2. Comparison of proportions at-age of the abundance indices observed in survey data and those fitted by the assessment model (observed values =dots; fitted values = solid lines) using mean abundance-at-age (WGHANSA 2016, left, ages 1-11+, yscale: 0-0.8) and mean abundance-at-age with post-stratification (right, ages: 0-11+, yscale: 0-1.2).

Residuals of the abundance-at-age are generally slightly lower in the trial assessment , although the year effect in 1996 is not removed. Residuals at age 0 are small with the exception of year-classes 1993-1994, 2000 and 2014, where observed abundance-at-age 0 is lower than the estimated by the model fit (Figure 4.1.3). However, the residuals of the catch-at-age 0 are higher with the trial assessment despite similar pattern (Figure 4.1.4).

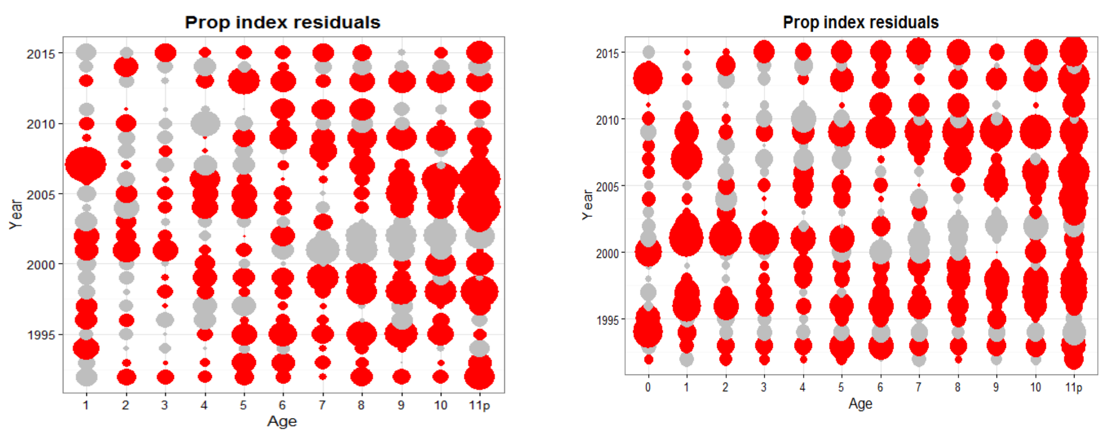


Figure 4.1.3. Bubble plot of survey abundance-at-age residuals from the assessment model (negative residuals – red bubbles) using mean abundance-at-age (WGHANSA 2016, left, ages: 1-11+) and mean abundance-at-age with post-stratification (right, ages: 0-11+).

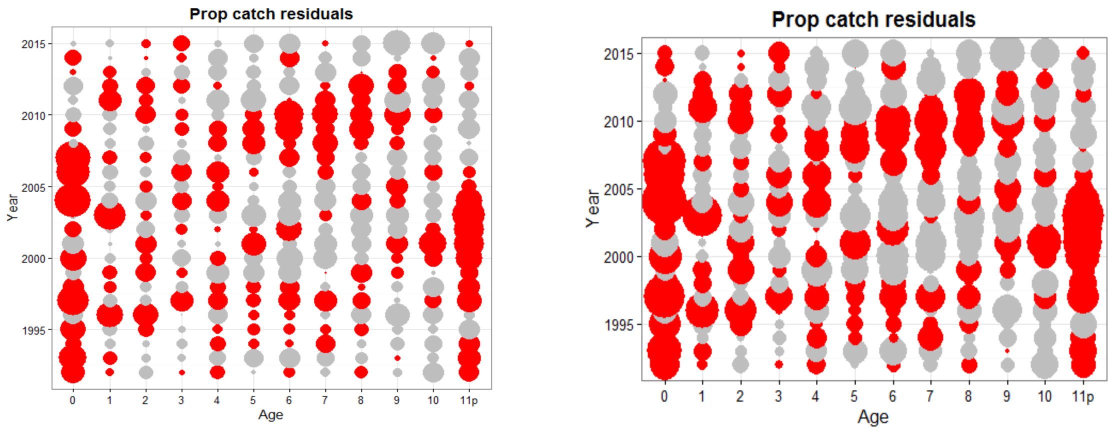


Figure 4.1.4. Bubble plot of catch-at-age residuals from the assessment model (negative residuals – red bubbles) using mean abundance-at-age (WGHANSA 2016, left) and mean abundance-at-age with post-stratification (right).

4.2. Stock key-parameter estimates

Figure 4.2.1 shows the estimated fishing mortality (mean F ages 2-10), spawning stock biomass (SSB) and recruitment (R), with 95% confidence intervals. Table 4.2.1 presents the point estimates of the parameters, the corresponding coefficient of variance (CV) and relative differences between assessment runs.

Results show that despite similar trajectories in the main parameters (Fbar, R and SSB) the trial assessment estimates slightly higher Fbar (relative differences around 24%) and higher R and SSB over the entire time series (relative differences in SSB of 15-23%). The recruitment is higher mainly in the period 1992-2005 and in 2009 (relative differences in the range 10-18%) and in 2015 (relative difference of 26%). While the strong year-class of 1996 is estimated to be 15% higher there are small differences between runs in the 2011-2012 recruitment estimates (Table 4.2.1).

Uncertainties in R, SSB and Fbar are higher in the trial assessment, being in the range 29-43%, 35-50% and 34-47%, respectively, while uncertainties in last year´s assessment were in the range of 20-40% for R, 24-36% for SSB and 24-34% for Fbar (Table 4.2.1). Since the trial assessment was carried out with the same model settings of last year´s assessment an exploratory run was performed by adopting three periods for the survey selection pattern-at-age (1992-1997, 1998-2008, 2009-2015) instead of the five periods (1992-1999, 2000-2001, 2002-2004, 2005-2007, 2008-2015). However model fit diagnostics and uncertainty in the parameter estimates did not improve.

Despite higher uncertainty in the parameters with the trial assessment, the historical perspective of the stock trends is maintained as well as the signal for strong year classes in 1996, 2011 and 2012 and above average recruitment in most recent years.

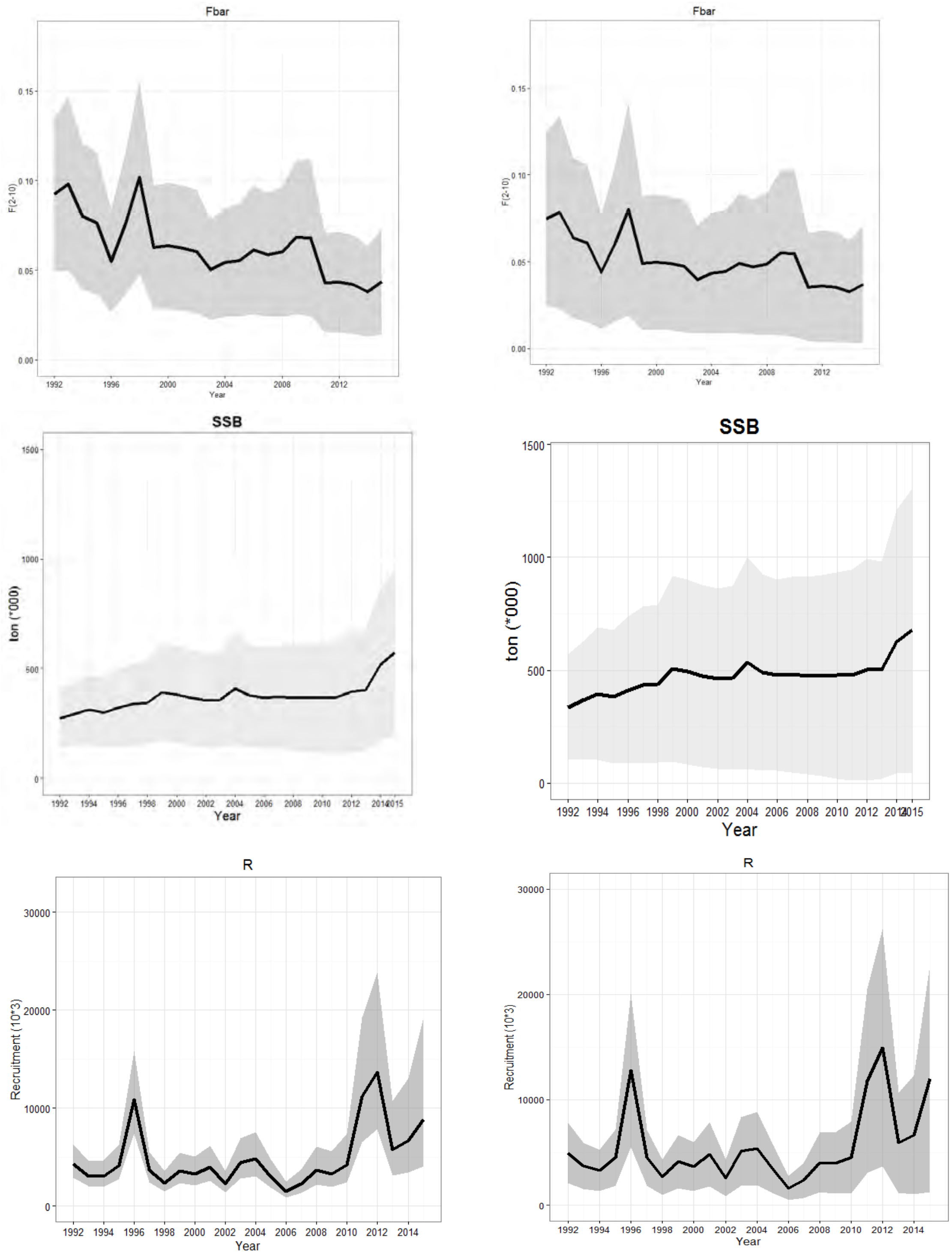


Figure 4.2.1. Time series (1992-2015) of Fishing mortality (Fbar, mean ages 2–10), SSB and Recruitment with 95% confidence intervals (grey) estimated from the assessment model using mean abundance-at-age (WGHANSA 2016, left) and mean abundance-at-age with post-stratification (right).

Table 4.2.1. Point estimates of recruitment (R, 10^3), SSB (th tonnes), Fbar(2-10) and coefficient of variance (CV) from the assessment model using simple mean abundance-at-age (WGHANSA 2016) and mean abundance-at-age with post-stratification and, relative differences in the parameter estimates.

year	WGHANSA 2016						post-stratified						relative differences (%)		
	R	CV	SSB	CV	Fbar	CV	R	CV	SSB	CV	Fbar	CV	R	SSB	Fbar
1992	4242	20	274	24	0.09	24	4954	29	336	35	0.075	34	14	19	-24
1993	3046	21	294	25	0.10	25	3701	30	366	36	0.078	36	18	20	-25
1994	3033	21	314	26	0.08	26	3297	31	395	38	0.064	37	8	21	-26
1995	4096	21	300	27	0.08	26	4533	30	383	39	0.061	38	10	21	-26
1996	10850	19	321	28	0.06	26	12795	29	412	40	0.044	38	15	22	-25
1997	3662	21	338	28	0.08	27	4495	30	434	41	0.061	38	19	22	-26
1998	2322	22	344	28	0.10	27	2662	32	440	40	0.080	39	13	22	-27
1999	3563	22	393	29	0.06	28	4131	31	506	41	0.049	40	14	22	-28
2000	3280	22	382	30	0.06	28	3651	32	493	42	0.050	40	10	23	-28
2001	3984	22	367	30	0.06	29	4836	32	476	43	0.049	40	18	23	-27
2002	2237	24	356	31	0.06	29	2593	34	463	44	0.048	41	14	23	-27
2003	4442	23	358	31	0.05	28	5101	33	467	44	0.040	40	13	23	-26
2004	4796	23	410	32	0.05	29	5369	33	533	45	0.043	41	11	23	-25
2005	2954	24	378	32	0.06	29	3511	34	490	45	0.044	41	16	23	-26
2006	1498	27	367	32	0.06	30	1623	36	477	45	0.049	42	8	23	-25
2007	2271	26	372	32	0.06	30	2365	36	481	46	0.047	42	4	23	-25
2008	3679	26	367	33	0.06	31	4039	36	475	47	0.049	43	9	23	-24
2009	3279	27	367	34	0.07	32	3981	37	476	48	0.055	44	18	23	-24
2010	4230	28	368	35	0.07	33	4538	38	477	49	0.055	45	7	23	-24
2011	11211	28	371	36	0.04	33	11791	38	479	50	0.035	45	5	23	-22
2012	13683	28	394	36	0.04	33	14926	38	502	50	0.036	46	8	21	-21
2013	5741	32	405	35	0.04	33	5925	41	502	49	0.035	46	3	19	-19
2014	6691	34	521	34	0.04	34	6672	43	626	48	0.033	46	-0.3	17	-17
2015	8852	40	573	34	0.04	34	12015	46	677	47	0.037	47	26	15	-18

5. Survey abundance indices (1983-2015)

Additional groundfish survey data was analyzed including the period 1983-1991 which are not included in the stock assessment. Figure 5.1 shows the extended abundance time series from the merged Portuguese and Spanish survey data. Horse mackerel has some very high abundance years, mainly younger individuals from ages 0-3. It is noticeable the signal for the strong year-class of 1986, also observed in the other horse-mackerel stocks (North and Western) and evidences of high recruitment in the early 80´s.

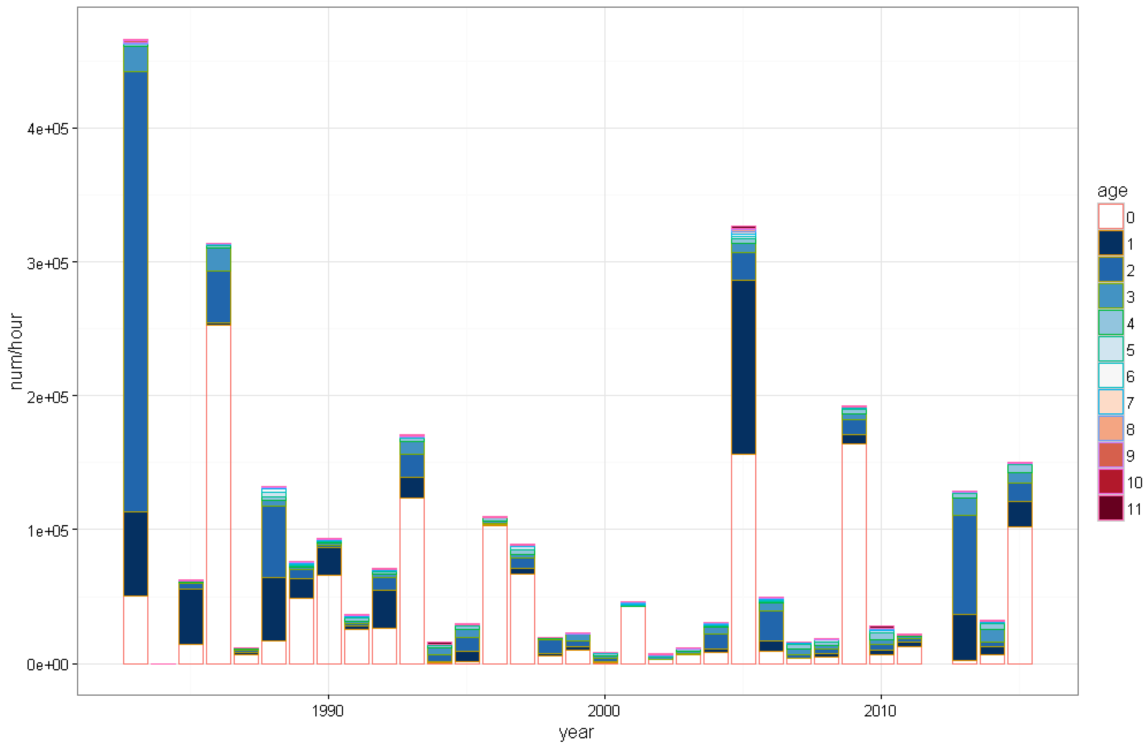


Figure 5.1. Total estimated abundance from 1983-2015 surveys (no Portuguese survey in 1984 and 2012).

To evaluate historical trends in abundance between pre- (1983-1991) and assessment period (1992-2015) we computed two indices for both juveniles and adults. As it is clear that juveniles are regularly caught in the bottom trawl surveys, a juvenile index based on the combined mean abundance of younger ages 0-3. Likewise, we also computed two distinct indices to evaluate the abundance time series for the adult population. One based on the combined mean abundance of old fish (age 6+) and another by computing the mean abundance-at-age * proportion mature to give an index for SSB.

Moreover, the analysis of juvenile and adult survey indices from pre- (1983-1991) and assessment (1992-2015) periods, show a similar historical perspective of the stock. Juvenile abundance has been stable over the entire time series with occasional peaks. Adult indices are rather stable over the period with some peaks of high abundance likely resulting from survivors of strong year-classes.

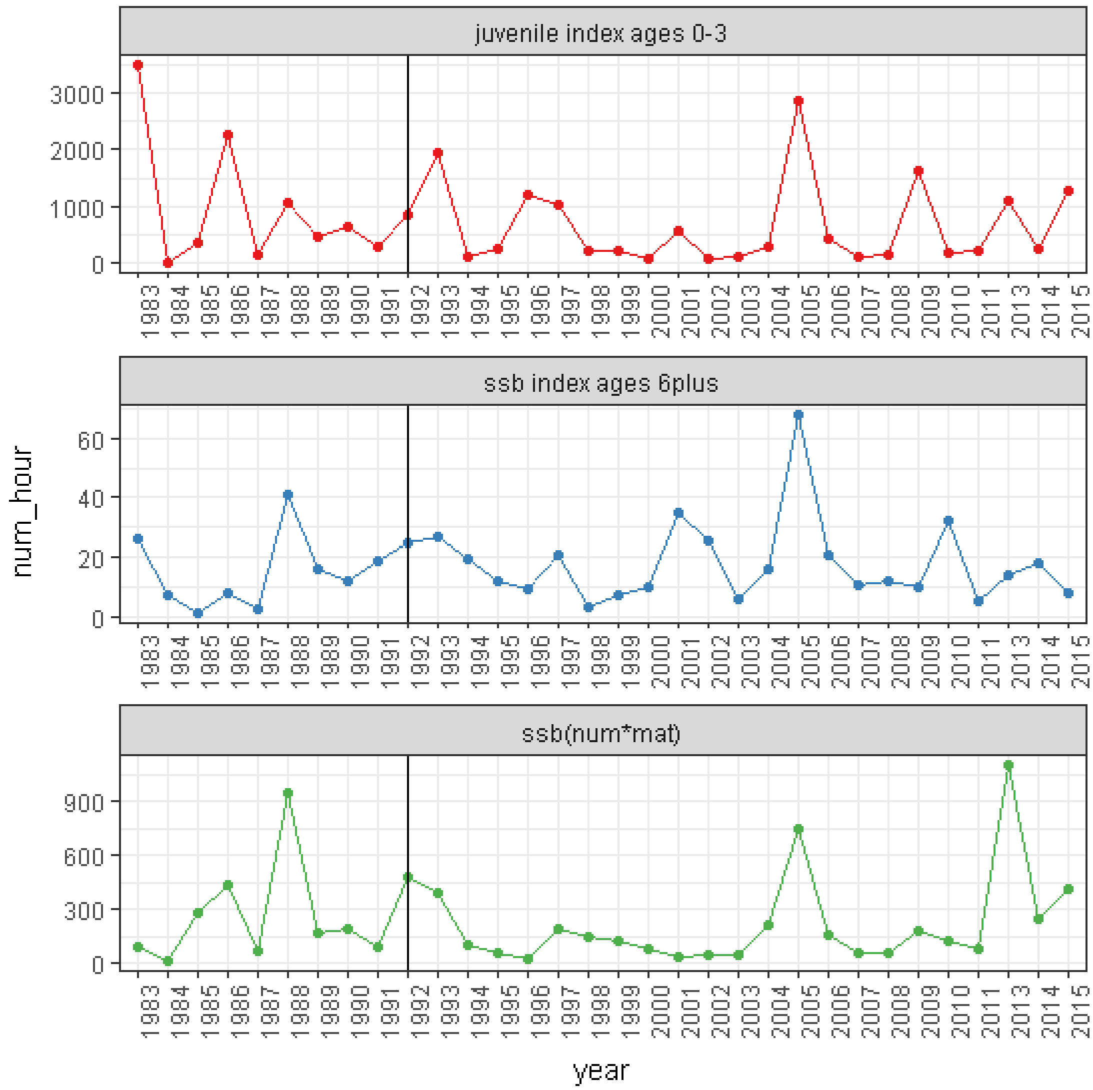


Figure 5.2. Survey juvenile index (total abundance ages 0 to 3), SSB index1 (as abundance at ages 6+) and SSB index2 (as abundance-at-age * maturity-at-age). The vertical line represents the first year of the stock assessment period.

References

Azevedo, M. and Silva, C., 2016. Horse mackerel size spatial distribution in Portuguese waters. Presentation to the ICES Data Evaluation Workshop for Southern horse mackerel (DEWKshom), 21-23 November 2016, Lisbon, 15pp.

Berg, C.W., Nielsen, A., Kristensen, K., 2014. Evaluation of alternative age-based methods for estimating relative abundance from survey data in relation to assessment models. Fisheries Research, 151, p. 91-99.

Borges, L., Cardador, F., Fernández, A., Gil, J., Moguedet, P., Panterne, P., Poulard, J.C., Sánchez, F., Sánchez, R., Sobrino, I. 1999. "Evaluation of Demersal Resources of Southwestern Europe from standardized groundfish surveys." Final Report Study Contract 96-029, 195 pp.

Breiman, L., 2001. Random Forests. Machine Learning, 45: 5-32.

Cochran, W.G., 1960. Sampling Techniques. John Wiley and Sons, inc., 1st edition

Cutler, D.R., Edwards, T.C., Beard, K.H., Cutler, A., Hess, K.T., Gibson, J. and Lawler, J.J., 2007. Random Forests for Classification in ecology. Ecology, 88(1): 2783-2792.

ICES, 2011. Report of the Benchmark Workshop on Roundfish and Pelagic Stocks (WKBENCH). ICES CM 2011/ACOM:38. 24–31 January 2011 Lisbon, Portugal

Hastie, T., Tibshirani, R., Friedman, J., 2001. The Elements of Statistical Learning: Data mining, inference, and prediction. Springer.

Murta A., Abaunza, P.,Fátima, C., Sánchez, F., 2008. Ontogenic migrations of horse mackerel along the Iberian coast. Fisheries Research 89, 186–195.

R Development Core Team, 2010. R: A language and environment for statistical computing.

WKPGFS, 2004. Workshop on Portuguese Groundfish Surveys. Lisbon 6-10 December 2004. NEOMAV, 12 pp.

Gadget for anchovy 9a South: Model description and results to provide catch advice and reference points (WGHANSA-1 2020)

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 main 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 and estimated parameters 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 catches (landings and discards, discards from 2014 onwards) 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:

$$P_{a,l,t,y} = \frac{O_{a,l,y,t}}{\sum_a \sum_l O_{a,l,y,t}} \tag{8}$$

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.

$$\ell_i = \begin{cases} lw_i(val_i - lb_i)^2 & \text{if } val_i < lb_i \\ uw_i(val_i - ub_i)^2 & \text{if } val_i > ub_i \\ 0 & otherwise \end{cases}$$

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 (in bold the terms associated to the more recent assumptions)**

- The model was implemented quarterly from 1989 to the second quarter of **2020**.
- 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 **2020**, provisional catches estimations of Spanish (until May 27th) purse-seine fleet were used and catches for June were estimated as the **38%** of January to May catches based on historical records from 2009 to **2020**. There were not any catches for Portuguese purse-seine in these two quarters.
- For **this year** assessment it was decided to include also discards (available from 2014 onwards). This decision was taken because they were already accounted for some years in the previous assessments but we did not notice about that.
- 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. It was noticed that age 0 was not removed from the length distribution in the previous assessments.
- 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.

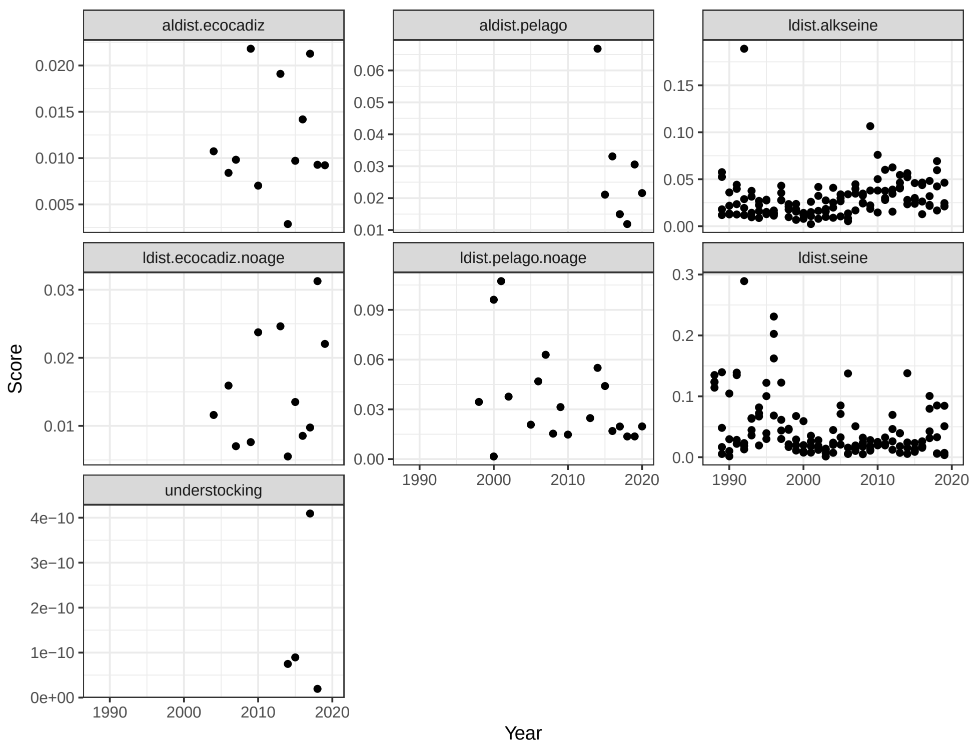


Figure 1: Likelihood scores for age-length key of ECOCADIZ survey, PELAGO survey and commercial landings (Upper panel) and length distribution of ECOCADIZ survey, PELAGO survey and landings. Dots represent the score for each quarter.

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_∞=28.7648
k	Annual growth rate, $k = 0.0756389$
β	Beta-binomial parameter, $\beta = 5000$
ν_a	Age factor, $\nu_0 = 120000, \nu_1 = 180000,$
	$\nu_2 = 0.0603, \nu_3 = 8.72e-07$
μ	Recruitment mean length, $\mu = 10.0644$
σ_t	Recruitment length standard deviation by quarter, $\sigma_2 = 3.00346$, $\sigma_3 = 1.62947$, $\sigma_4 = 3.58913$
$l_{50,T}$	Length with a 50% probability of predation during period T,
	$l_{50,1}^{seine} = 11.6$, $l_{50,2}^{seine} = 11.1$, $l_{50,3}^{ECO} = 13$, $l_{50,3}^{PEL} = 16.8$
α_T	Shape of function, $\alpha_1^{seine} = 0.315$, $\alpha_2^{seine} = 0.769$, $\alpha_3^{ECO} = 1.33$, $\alpha_3^{PEL} = 0.387$
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 caught by commercial fleet (discards 2014-2019)
$S_{l,T}$	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 and parameter estimates after optimization

Data source	type	Timespan	Likelihood function
Commercial catches	Length distribution	All quarters, 1989-2020	See eq. 7
(discards from 2014 onwards)	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, 2013-2019	
	Length distribution	Second quarter 2004, 2006	see eq. 7
		third quarter 2007, 2009, 2010, 2013-2019	
	Age-length key	Second quarter 2004, 2006	see eq. 7
		third quarter 2007, 2009, 2010, 2013-2019	
PELAGO acoustic survey	Biomass survey indexes	First quarter 1999, 2001-2003	see eq. 6
		second quarter 2005-2010 and 2013-2020	
	length distribution	First quarter 1999, 2001-2003	see eq. 7
		second quarter 2000, 2005-2010, 2013-2020	
	Age-length key	second quarter 2014-2020	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

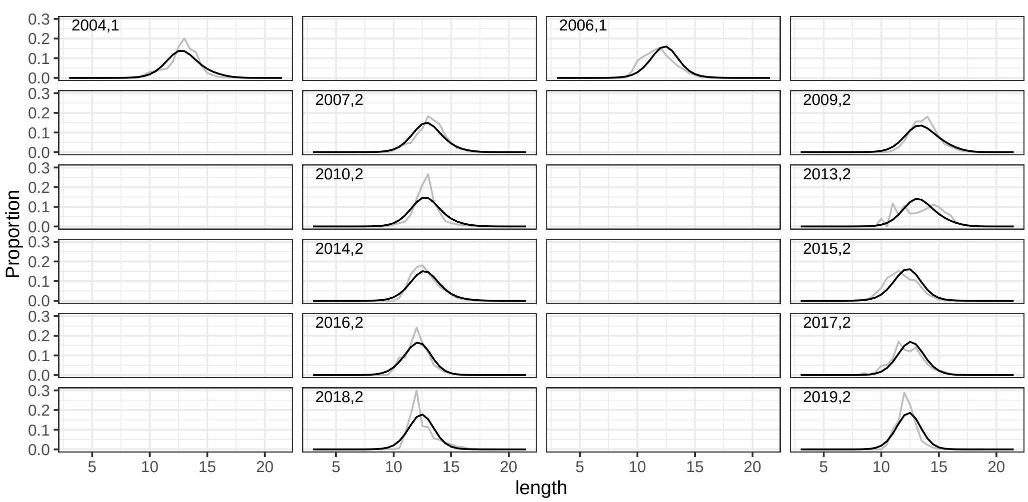


Figure 3: Comparison between observed and estimated catches length distribution for ECOCADIZ survey. Black lines represent estimated data while gray lines represent observed data

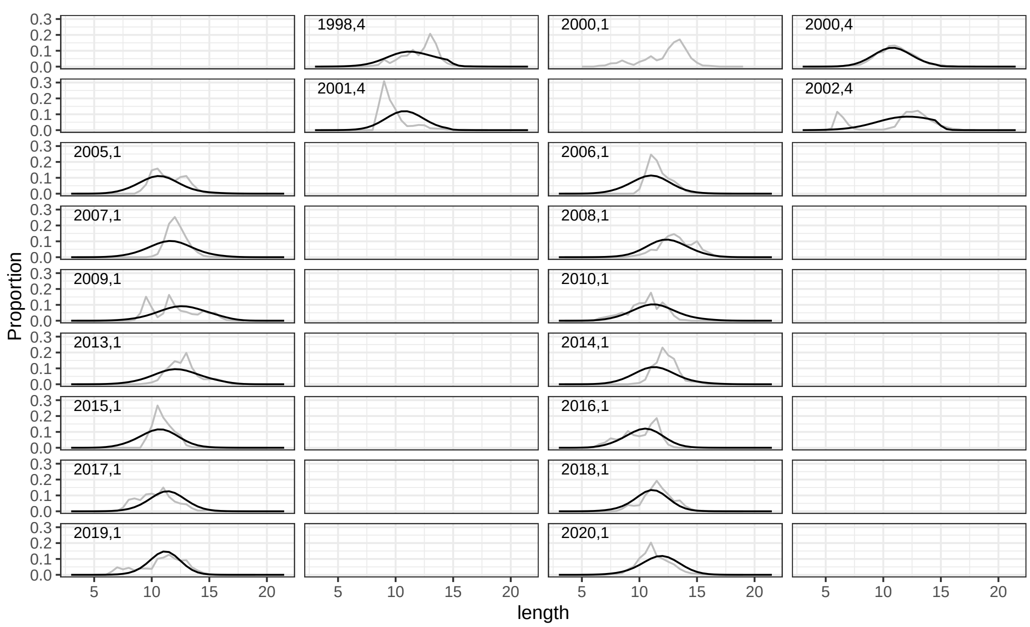


Figure 4: Comparison between observed and estimated catches length distribution for PELAGO survey. Black lines represent estimated data while gray lines represent observed data

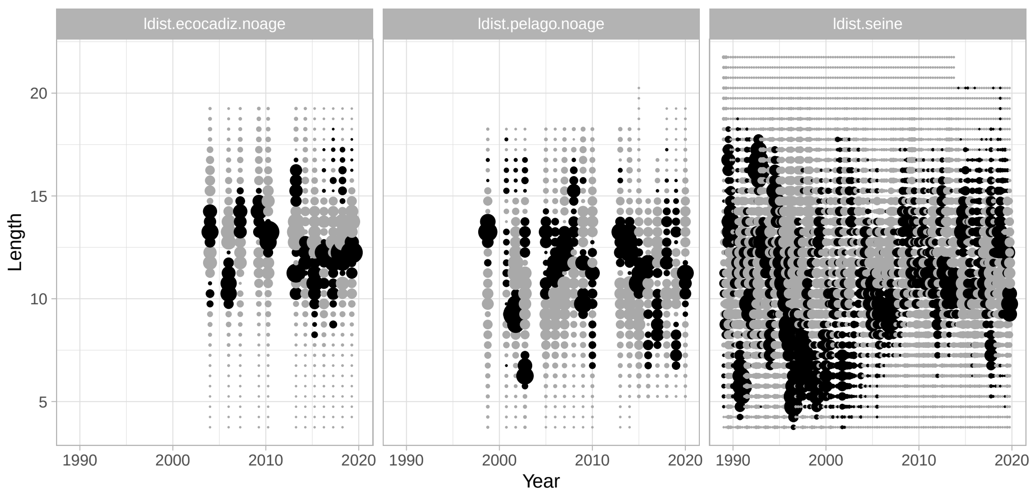


Figure 5: Standardised residual plots for the fitted length distribution from the ECOCADIZ survey, PELAGO survey and commercial landings. Black points denote a model underestimate and gray points an overestimated. The size of the points denote the scale of the standardised residual.

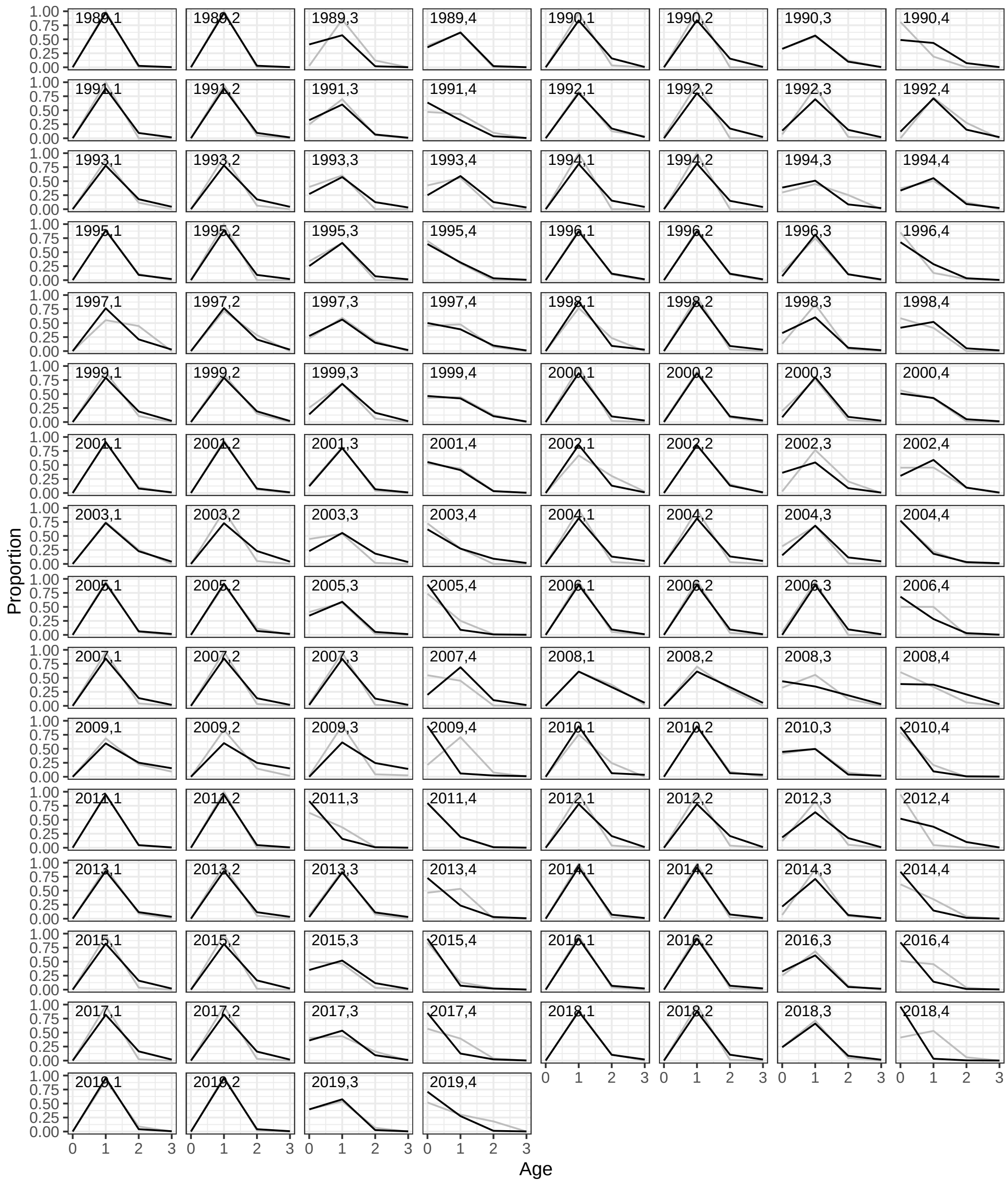


Figure 6: Comparison between observed and estimated catches age distribution. Black lines represent estimated data while gray lines represent observed data.

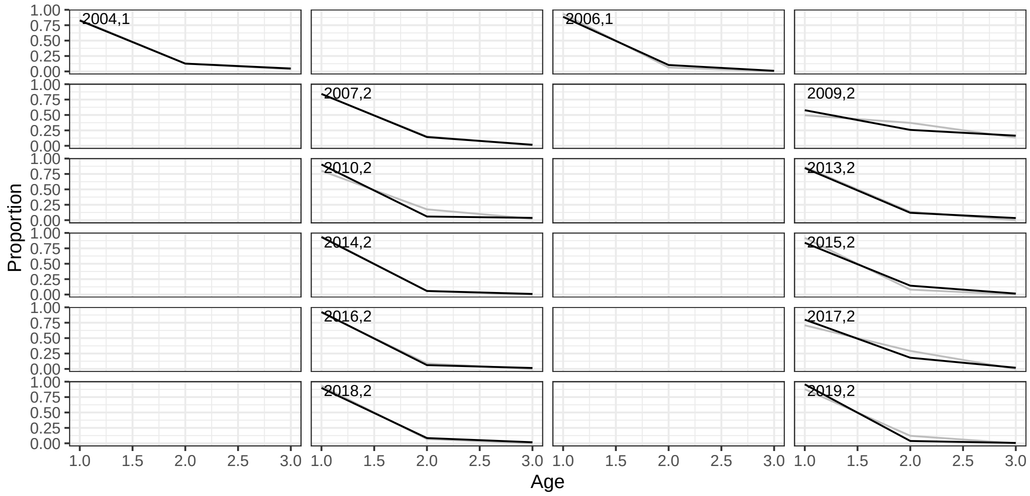


Figure 7: Comparison between observed and estimated ECOCADIZ survey age distribution. Black lines represent estimated data while gray lines represent observed data.

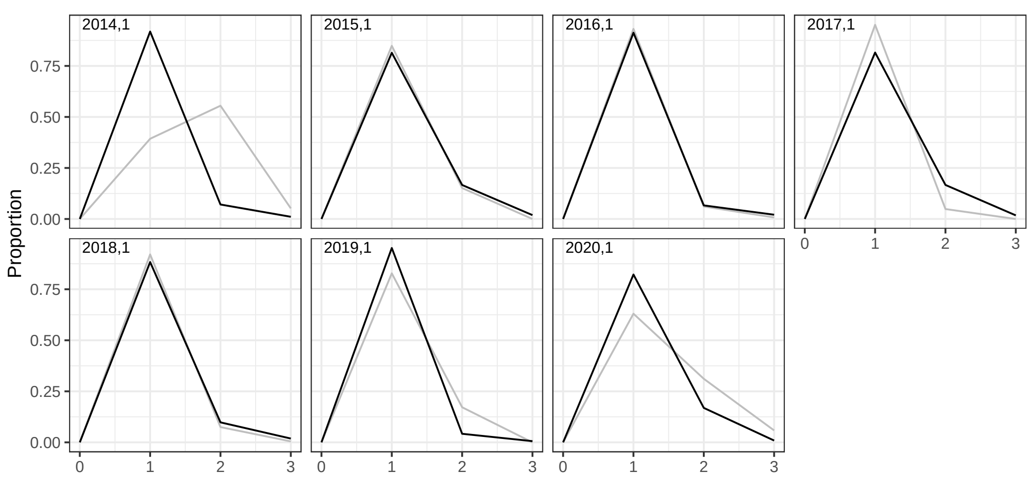


Figure 8: Comparison between observed and estimated PELAGO survey age distribution. Black lines represent estimated data while gray lines represent observed data.

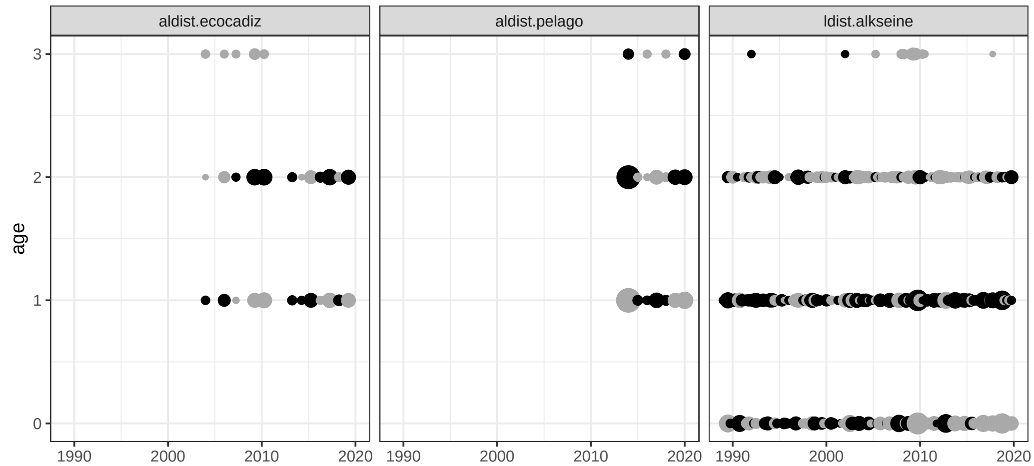


Figure 9: Standardised residual plots for the fitted age distribution from the ECOCADIZ survey, PELAGO survey and commercial fleet. Black points denote a model underestimate and gray points an overestimated. The size of the points denote the scale of the standardised residual.

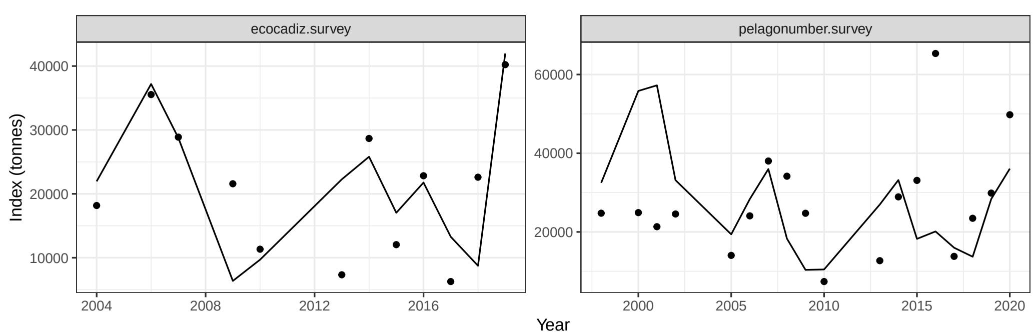


Figure 10: Comparison between observed and estimated survey indices. Black points represent observed data while black line represent estimated data

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

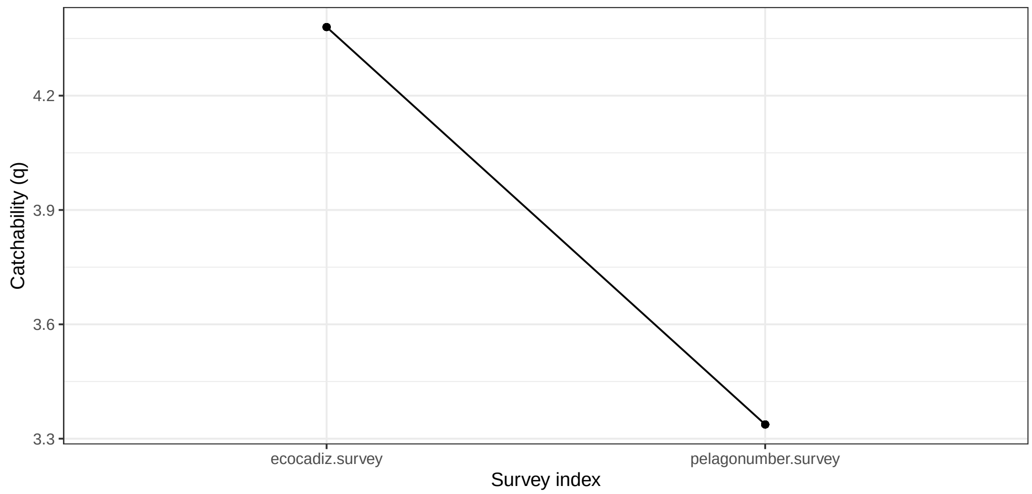


Figure 11: Estimated catchability parameters for the different survey indices

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.

6.4. Comparison with last year estimated time series

A comparison with last year estimated time series is presented as an annex to this document. It was observed that the estimated biomass of the last two years were updated because of the incorporation of PELAGO 2020 and ECOCADIZ 2019 survey indices information. There was a big difference for 2018 estimate. The comparison suggests that ECOCADIZ information is the input that causes this difference.

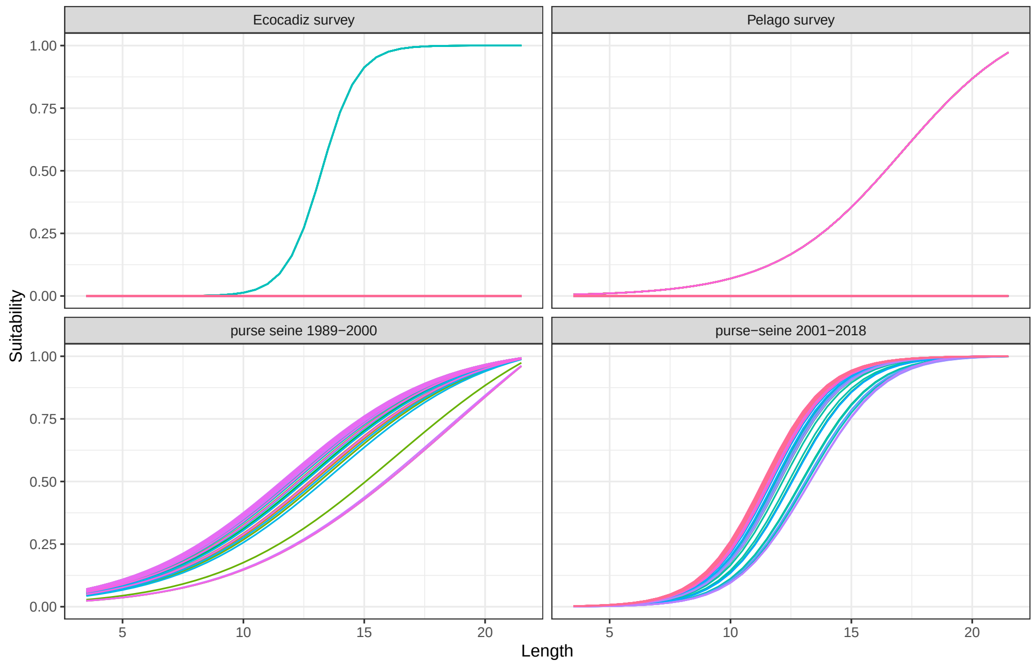


Figure 12: Estimated fleet suitability functions for the commercial fleet and different surveys.

7. Catch advice for July 2020 to June 2021

The ratio between the last year biomass estimate and the mean of the two previous years is:

$$\frac{B_y}{\overline{B_{y-1} + B_{y-2}}} = \frac{7100}{(5660 + 1510)/2} = 1.98$$

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, if this ratio is above 1.8, the advice would be equal to the latest advice mutiplied by 1.8, as follows:

$$C_{y+1} = \hat{C}_y * \min 1.8, \frac{B_y}{(B_{y-1} + B_{y-2})/2}$$

where $\hat{C}_y$ is the value of adviced catches in 2019. Then the adviced catches (in tonnes) for the next year (July 2020 to June 2021) would be:

$$C_{y+1} = 6290 * 1.8 = 11322.$$

This procedure was not specified in the Stock annex for 2020 advice.

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).

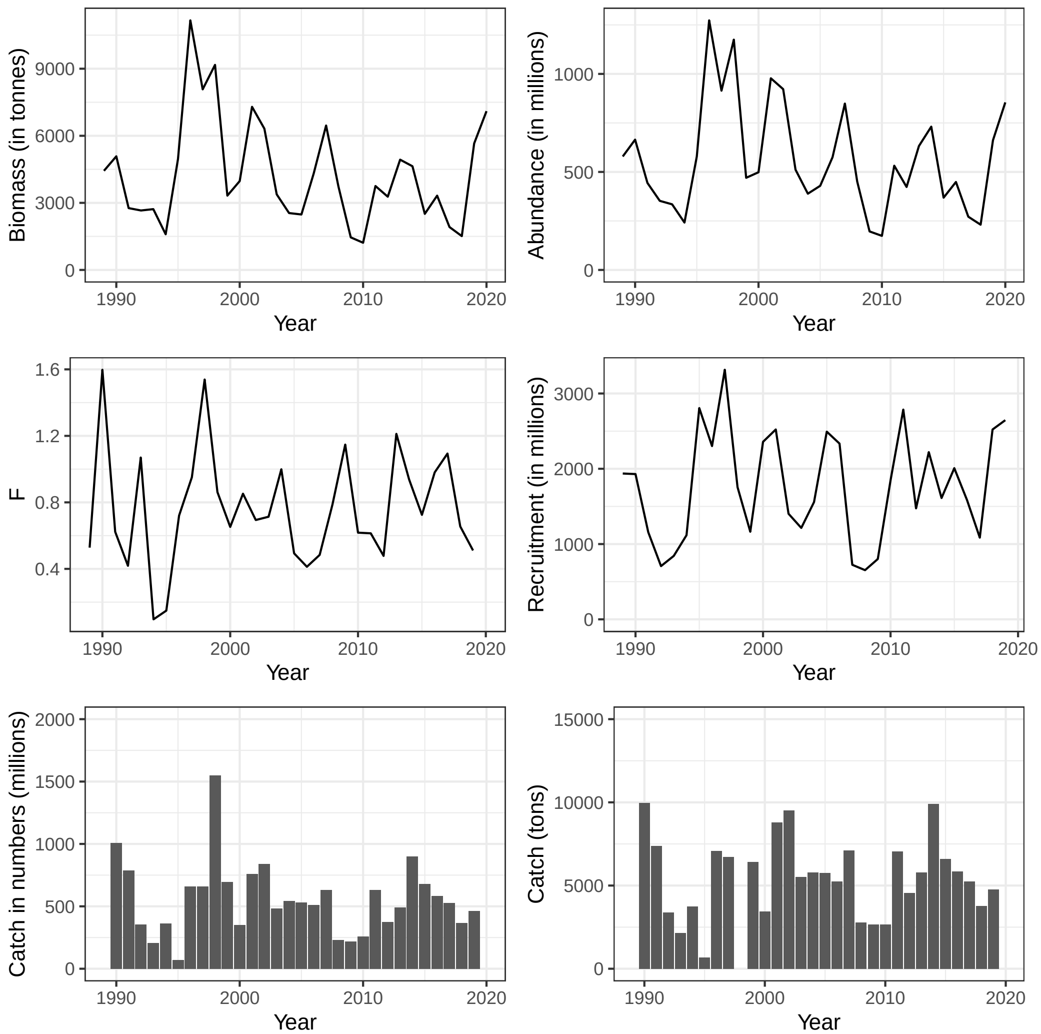


Figure 13: Annual catches time series (in numbers and biomass) compared with annual model estimates for abundance (in numbers and biomass) recruitment and fishing mortality. Measures were summarized at the end of June each year, assuming that a year starts in July and ends in June of the next year.

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 2020 the value of $Bloss$ for the 9a South anchovy corresponds to the estimated SSB in 2010 (1220 t), hence $Blim$ is set at 1220 t and the relative $Blim$ (divided by the mean value of B_1+) results equal to 0.289. 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:

$$Bpa = e^{(1.645\sigma)} Blim,$$

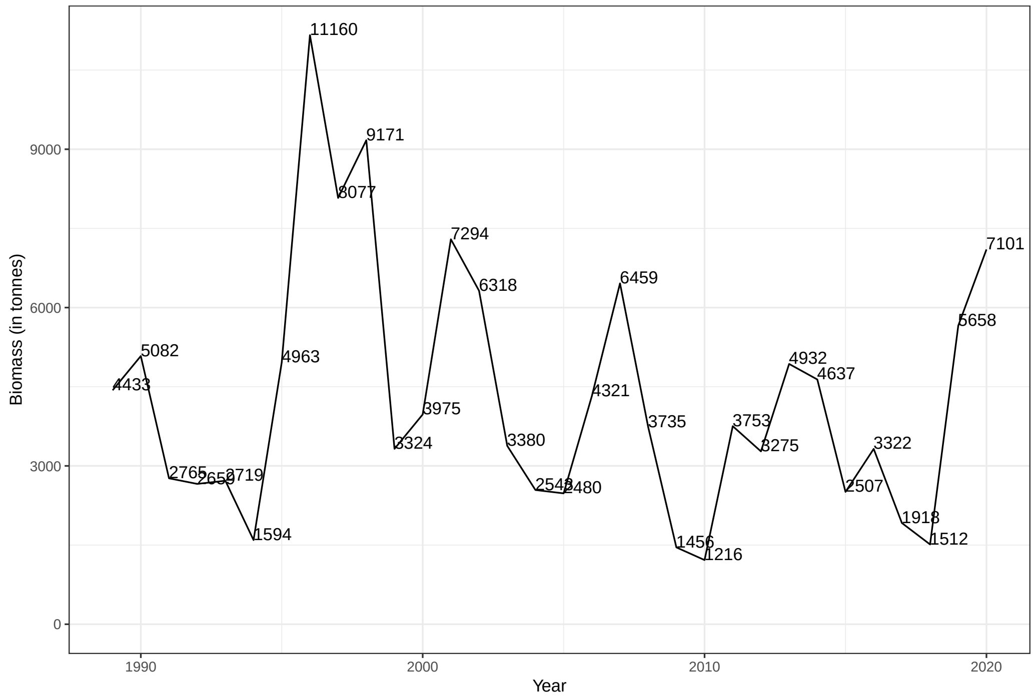


Figure 14: Estimated biomass time series at the end of quarter two (Age 0 removed to be consistent with recruitment at the end of the second quarter of the year). Note that under the assumption that all individuals in $B1+$ class are mature, this biomass is equivalent to SSB

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 2000.8 t.

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.

10. References

Begley, J., 2004. Gadget User Guide. URL: `http://www.hafro.is/gadget/files/userguide.pdf`.

Bellido, J.M., Pierce, G.J., Romero, J.L., Millan, M., 2000. Use of frequency analysis methods to estimate growth of anchovy (*Engraulis encrasicolus L.* 1758) in the gulf of cádiz (SW spain). Fisheries Research 48, 107–115.

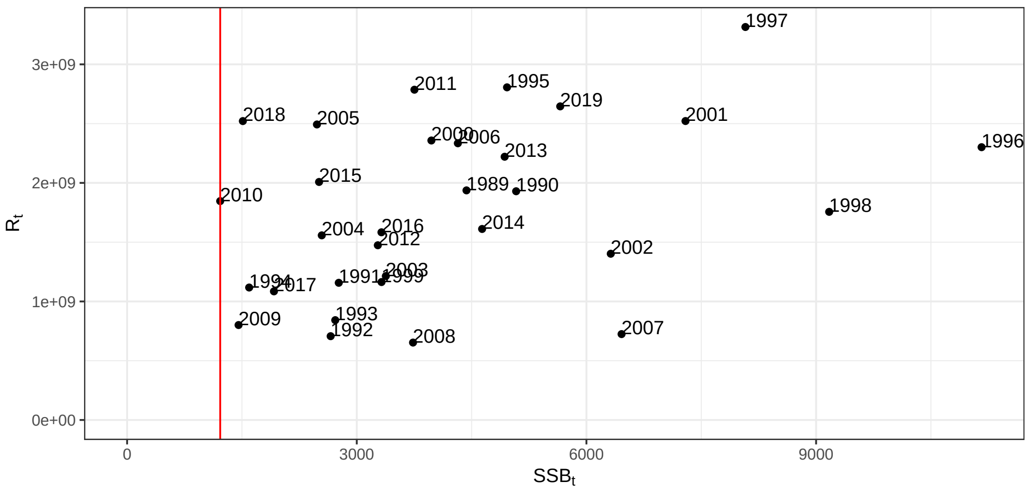


Figure 15: Estimated Stock Spawning biomass (SSB_t) vs. Recruitment (R_t), SSB_t corresponds to the Stock Spawning Biomass at the end of quarter 2 of year t, while R_t corresponds to the sum of the recruitment at the beginning of quarters 3,4 and 1 of years t and $t + 1$, respectively.

Elvarsson, B., Taylor, L., Trenkel, V., Kupca, V., Stefansson, G., 2014. A bootstrap method for estimating bias and variance in statistical fisheries modelling frameworks using highly disparate datasets. African Journal of Marine Science 36, 99–110. URL: http://www.tandfonline.com/doi/abs/10.2989/1814232X.2014.897253, doi:10.2989/1814232X.2014.897253.

Gislason, H., Daan, N., Rice, J.C., Pope, J.G., 2010. Size, growth, temperature and the natural mortality of marine fish. Fish and Fisheries 11, 149–158.

Lentin, J., 2014. mfdb: MareFrame DB Querying Library. R package version 3.2-0.

Stefansson, G., 2003. Issues in Multispecies Models. Natural Resource Modeling 16, 415–437. URL: http://onlinelibrary.wiley.com/doi/10.1111/j.1939-7445.2003.tb00121.x/abstract, doi:10.1111/j.1939-7445.2003.tb00121.x.

Stefánsson, G., 1998. Comparing different information sources in a multispecies context. Fishery stock assessment models. Alaska Sea Grant College Program. AK-SG-98-01 , 741–758URL: http://mdgs.un.org/unsd/envaccounting/ceea/archive/Fish/Iceland.PDF.

Taylor, L., Begley, J., Kupca, V., Stefansson, G., 2007. A simple implementation of the statistical modelling framework Gadget for cod in Icelandic waters. African Journal of Marine Science 29, 223–245. URL: http://www.tandfonline.com/doi/abs/10.2989/AJMS.2007.29.2.7.190, doi:10.2989/AJMS.2007.29.2.7.190.

Working document presented in the ICES Working Group on Southern Horse Mackerel, Sardine and Anchovy (WGHANSA-1). By correspondence, 25-29 May 2020.

Acoustic assessment and distribution of the main pelagic fish species in ICES Subdivision 9a South during the *ECOCADIZ 2019-07* Spanish survey (July-August 2019).

By

Fernando Ramos [1, *], Jorge Tornero [1], Paz Jiménez [1] and Paz Díaz [2]

(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-trawl survey conducted by IEO between 31st July and 13rd August 2019 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 27 valid fishing hauls were carried out for echo-trace ground-truthing purposes. Chub mackerel was the most frequent species in the fishing hauls, followed by horse mackerel, anchovy, sardine, mackerel, blue jack mackerel, Atlantic pomfret (*Brama brama*) and bogue. Longspine snipefish, boarfish and transparent goby (*Aphia minuta*) showed a medium relative frequency of occurrence. Mediterranean horse-mackerel and pearlside showed a low occurrence. Pearlside was the most abundant species in these hauls, followed by sardine, chub mackerel, anchovy and longspine snipefish, 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. Such an increase is the result of the relatively high acoustic contributions of anchovy, sardine, chub mackerel, and the unexpected high contributions of the transparent goby and the Atlantic pomfret, species which usually have showed an accidental occurrence or very low abundance through the time-series. Anchovy was mainly distributed between Cape Santa Maria and Bay of Cadiz, although showing the highest densities in the Spanish central-western shelf waters. Anchovy eggs distribution resembled the adults’ and, although overall egg density was higher than previous years, the spawning area showed a reduction as compared with the observed ones in previous years. Largest anchovies were mainly distributed in the westernmost waters and the smallest ones were concentrated between Doñana and Bay of Cadiz. Anchovy acoustic estimates in summer 2019 were of 5 485 million fish and 57 700 t (i.e. the historical biomass maximum in the time-series), well above the historical average (ca. 24 kt), showing a recent increasing trend. Sardine, widely distributed over the surveyed area, also recorded a high acoustic echo-integration in summer 2019 as a consequence of the occurrence of dense mid-water schools in the coastal fringe (20-60 m depth) comprised between Guadiana river mouth and Doñana. Acoustic estimates were of 2 917 million fish and 62 682 t, a biomass well above the historical average (ca. 47 kt). Spanish waters concentrated the bulk of the population. Chub mackerel was distributed all over the surveyed area but showing the highest densities in the Portuguese shelf waters. Acoustic estimates were of 465 million fish and 32 696 t, with the bulk of the population concentrated in the Portuguese waters, where the smallest fish were also recorded. Estimates showed a relative stable recent trend, with the recent biomasses very close to the historical average (ca. 35 kt).

INTRODUCTION

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

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

The present Working Document reports the main results from the *ECOCADIZ 2019-07* survey, namely the acoustic estimates of abundance and biomass (age-structured for anchovy, sardine and chub mackerel) and the spatial distribution of the assessed species.

MATERIAL AND METHODS

The *ECOCADIZ 2019-07* survey was carried out between 31st July and 13rd August 2019 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 2019* 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, mackerel and horse-mackerel species, and bogue. Otoliths were dissected from anchovy, sardine and chub mackerel sampled specimens.

The following TS/length relationship table was used for acoustic estimation of assessed species (following recent IEO standards after ICES, 1998 and recommendations by ICES, 2006a,b. b_{20} values for transparent goby and Atlantic pomfret following to Foote, 1987 for physoclists):

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
Transparent goby (*Aphia minuta*)	-67.5
Atlantic pomfret (*Brama brama*)	-67.5
Blue whiting (*Micromesistius poutassou*)	-67.5
Silvery lightfish/pearlside (*Maurolicus muelleri*)	-72.2
Longspine snipefish (*Macroramphosus scolopax*)	-80.0
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, 121 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 biological (ichthyoplankton and *in vivo* fluorescence) and hydrographical variables (sub-surface sea temperature and salinity). Vertical profiles of hydrographical variables were also recorded by night from 150 CTD casts distributed in 15 transects 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 six (26) *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 seven (27) 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 or when the echotraces to be identified either are very scarce or very located in the bathymetric gradient. Given that all of these situations were not very uncommon in the sampled area, 41% of valid hauls (11 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 42-183 m.

During the survey were captured 2 Chondrichthyan, 37 Osteichthyes, 6 Cephalopod, 3 Crustacean and Echinoderm 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 table includes all the species under study and also those species with a higher occurrence than the former ones. 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, 89% presence index) followed by horse mackerel and anchovy (with relative occurrences of 74 and 63%, respectively), sardine, mackerel, jack mackerel, Atlantic pomfret (*Brama brama*) and bogue (between 37 and 48%), snipefish, boarfish and transparent goby (*Aphia minuta*) (19-22%), Mediterranean horse-mackerel and pearlside (7% each one). Round sardinella was absent in the catches and the occurrence of blue whiting (4%) was incidental.

For the purposes of the acoustic assessment, anchovy, sardine, mackerel species, horse & jack mackerel species, bogue, goby, pomfret, snipefish and pearlside 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 25.9 tonnes and 841 thousand fish (**Table 3**). 49% of this fished biomass corresponded to chub mackerel, 33% to sardine, 8% to anchovy, and contributions lower than 3% to the remaining species. The most abundant species in ground-truthing trawl hauls was pearlside (27%), followed by sardine (27%), chub mackerel (24%), anchovy (17%) and snipefish (3%), with the remaining species showing lower contributions than 1.5%.

Species	# of fishing stations	Occurrence (%)	Total weight (kg)	Total number
Merluccius merluccius	25	93	118,878	1054
Scomber colias	24	89	12658,800	199954
Trachurus trachurus	20	74	654,182	5566
Loligo subulata	19	70	6,465	1041
Engraulis encrasicolus	17	63	2036,631	144812
Sardina pilchardus	13	48	8498,372	216529
Loligo media	12	44	3,131	1124
Scomber scombrus	12	44	35,398	375
Trachurus picturatus	12	44	184,676	3560
Brama brama	11	41	666,044	945
Boops boops	10	37	24,650	216
Spondyliosoma cantharus	9	33	12,683	61
Trachinus draco	9	33	3,671	35
Diplodus annularis	8	30	4,804	77
Pagellus erythrinus	8	30	56,959	327
Alosa fallax	7	26	2,684	10
Macroramphosus scolopax	6	22	204,464	28328
Capros aper	5	19	7,486	1221
Aphia minuta	5	19	4,593	11844
Pagellus acarne	5	19	35,573	108
Illex coindetii	5	19	1,100	29
Polybius henslowi	4	15	5,520	311
Diplodus bellottii	4	15	13,982	234
Lepidopus caudatus	4	15	0,138	5
Spicara flexuosa	3	11	15,226	243
Diplodus vulgaris	3	11	62,924	362
Chelidonichthys obscurus	2	7	0,214	2
Zeus faber	2	7	4,286	3
Trachurus mediterraneus	2	7	320,380	661
Maurolicus muelleri	2	7	167,214	226431
Loligo vulgaris	2	7	0,134	2
Lepidotrigla cavillone	1	4	0,088	3
Arnoglossus laterna	1	4	0,004	1
Mola mola	1	4	54,000	1
Microchirus boscanion	1	4	0,022	2
Raja clavata	1	4	0,368	1
Goneplax rhomboides	1	4	0,003	1
Micromesistius poutassou	1	4	0,022	1

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 was captured between Cape Santa María and Cape Trafalgar, although the highest yields were recorded in the Spanish central 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 catches showed a quite similar distribution to the above described for anchovy, but showing the highest yields in the surroundings of the Cadiz Bay and between Cape Santa María and the Guadiana river mouth. Juvenile sardines were mainly captured in the shallowest hauls conducted in the coastal fringe between Matalascañas and the Bay of Cadiz (**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, pomfret and transparent goby were restricted to the central and easternmost Spanish waters. The size composition of these last species in fishing hauls is shown in **Figures 8** to **18**.

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

A total of 328 nmi (ESDU) from 21 transects has been acoustically sampled by echo-integration for assessment purposes. From this total, 214 nmi (11 transects) were sampled in Spanish waters, and 114 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	VAM	HOM	HMM	JAA	BOG	FIM	POA	SNS	MAV
Total Area	259503	50456	74313	44	45335	6474	4904	2744	1265	12772	45617	6273	9307
(%)	(100,0)	(19,4)	(28,6)	(0,02)	(17,5)	(2,5)	(1,9)	(1,1)	(0,5)	(4,9)	(17,6)	(2,4)	(3,6)
Portugal	71465	10780	1402	2	43856	4889	0	2717	1206	0	0	6272	341
(%)	(27,5)	(21,4)	(1,9)	(4,5)	(96,7)	(75,5)	(0,0)	(99,0)	(95,3)	(0,0)	(0,0)	(99,9)	(3,7)
Spain	188038	39675	72910	41	1479	1585	4904	27	60	12772	45617	1	8967
(%)	(72,5)	(78,6)	(98,1)	(93,2)	(3,3)	(24,5)	(100,0)	(1,0)	(4,7)	(100,0)	(100,0)	(0,1)	(96,3)

For this "pelagic fish assemblage" has been estimated a total of 259 503 m^2 nmi^{-2}, the highest estimate ever recorded within the time-series (**Figure 19**). Portuguese waters accounted for 28% of this total back-scattering energy and the Spanish waters the remaining 72%. 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 19**. By species, anchovy (29%), sardine (19%), pomfret and chub mackerel (18% each) were the most important species in terms of their contributions to the total back-scattering energy. Transparent goby (5%), pearlside (4%), Atlantic and Mediterranean horse mackerel and snipe fish (2-3%) were the following species in importance. The remaining species contributed with less than 1%.

Some inferences on the species' distribution may be carried out from regional contributions to the total energy attributed to each species: Mediterranean horse mackerel, pomfret, transparent goby, sardine, pearlside, mackerel and anchovy seemed to show greater densities in the Spanish waters, whereas chub mackerel, blue jack mackerel, horse mackerel, bogue and snipefish 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, transparent goby, Atlantic pomfret, longspine snipefish and pearlside.

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 post-strata considered for the acoustic estimation are shown in **Figure 20**. The estimated abundance and biomass by size class and age group are given in **Tables 5** and **6**, and **Figures 21** and **22**.

Anchovy was mainly distributed between Cape Santa Maria and Bay of Cadiz, although showing the highest densities in the Spanish shelf waters between El Rompido (RA10) and Bay of Cadiz (RA03) (**Figure 20**).

Five (5) coherent post-strata have been differentiated according to the S_A value distribution and the size composition in the fishing stations (**Figure 20**). The acoustic estimates by homogeneous post-stratum and total area are shown in **Table 5** and **Figure 21**. Overall acoustic estimates in summer 2019 were of 5485 million fish and 57 700 tonnes. By geographical strata, the Spanish waters yielded 99% (5405 million) and 97% (56 139 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 80 million and 1560 t. The current biomass estimate (57 700 t) becomes in the historical maximum within the time-series (2006: 35 539 t; 2016: 34 184 t; 2018: 34 908 t; see **Figure 48**). The *PELAGO 19* spring Portuguese survey previously estimated for this same area 29 876 t (3 398 million), with all the anchovy located in the Spanish waters.

The size class range of the assessed population varied between the 8.5 and 17.5 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 in the westernmost waters and the smallest (and youngest) ones concentrated in the surroundings of the Guadalquivir river mouth and adjacent shallow waters (**Table 5; Figure 21;** 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 42 and 30% of the total estimated abundance and biomass, respectively. Age 1 fish represented 55% and 66% of the total abundance and biomass (**Table 6**; **Figure 22**).

The Gulf of Cadiz anchovy egg distribution from CUFES sampling is shown in **Figure 23**. Anchovy egg distribution and densities in summer 2019 are quite coincident with that of adults. The estimated total egg density is higher than the observed in the most recent years but the spawning area showed a reduction as compared with those observed ones in previous years.

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 post-strata considered for the acoustic estimation are shown in **Figure 24**. Estimated abundance and biomass by size class and age group are given in **Tables 7** and **8**, and **Figures 25** and **26**.

Sardine also recorded a high acoustic echo-integration in summer 2019 as a consequence of the occurrence of dense mid-water schools in the coastal fringe (20-60 m depth) comprised between Ayamonte (RA11) and Doñana (RA06), (**Figure 24**).

Seven (7) size-based homogeneous sectors were delimited for the acoustic assessment (**Figure 24**). The estimates of Gulf of Cadiz sardine abundance and biomass in summer 2019 were 2 917 million fish and 62 682 t (**Table 7**), a biomass well above the historical average (ca. 47 kt), but lower than the biomass estimated in 2018 (114 631 t; see **Figure 48**). Spanish waters concentrated the bulk of the population (2 495 million and 44 899 t). The estimates for the Portuguese waters were 422 million and 17 783 t.

Sizes of the assessed population ranged between 10.5 and 20.0 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 15.0 cm (**Table 7**; **Figure 25**). The relatively important juvenile fraction in the estimated population (≤11.5 cm), was mainly located in relatively shallow waters along the coastal fringe comprised between Matalascañas and the Bay of Cadiz (**Table 7**; **Figure 25**; see also **Figure 7**).

The population was composed by fishes not older than 3 years, with the 61% of the estimated numbers belonging to the age group 0 (40% of the estimated biomass; **Table 8**; **Figure 26**). Age 1 sardines accounted for 39% and 59% of the abundance and biomass of the whole population, respectively. Age 0 sardines occurred almost exclusively in Spanish waters (99% of the age 0 fish estimated in the entire Gulf), where they also were the dominant age group (71% and 55% of abundance and biomass). Age 1 fish was the dominant age group in the Portuguese waters (95% in abundance and biomass), although only accounted 23% of the one year olds estimated in the whole surveyed area.

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 and the coherent post-strata considered for the acoustic estimation are shown in **Figure 27**. Estimated abundance and biomass by size class are given in **Table 9** and **Figure 28**.

Atlantic mackerel showed very scattered and low acoustic records during the 2019 survey, which were mainly observed over the shelf located in the central part of the Gulf of Cadiz (**Figure 27**). Juveniles were mainly recorded in the Spanish outer shelf central waters, whereas larger fish occurred in shallower waters.

Three (3) size-based homogeneous sectors were delimited for the acoustic assessment (**Figure 27**). The estimates of Gulf of Cadiz mackerel abundance and biomass in summer 2019 were 22 million fish and 1 115 t (**Table 9**). Spanish waters concentrated the bulk of the population (20 million and 1 049 t). The estimates for the Portuguese waters were 1 million and 66 t.

The size class range of the assessed population varied between the 15.5 and 33.0 cm size classes, with one main modal class at 17.0 cm (juvenile/sub-adult fish) and secondary modes at 28.5 and 32.5 cm (**Table 9**, **Figure 28**).

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 and the coherent post-strata considered for the acoustic estimation are shown in **Figure 29**. Estimated abundance and biomass by size class and age group are given in **Tables 10** and **11**, and **Figures 30** and **31**.

Chub mackerel was widely distributed in the surveyed area, although the highest densities occurred all over the Portuguese shelf waters. In the Spanish waters the species occurred in the middle-outer shelf waters, where the largest fish were also found (**Figure 29**).

Five (5) size-based homogeneous sectors were delimited for the acoustic assessment (**Figure 29**). The estimates of Gulf of Cadiz chub mackerel abundance and biomass in summer 2019 were 465 million fish and 32 696 t (**Table 10**). These estimates and the most recent ones show a relative stable recent trend, with biomasses very close to the historical average (ca. 35 kt; see **Figure 48**). Portuguese waters concentrated the bulk of the population (454 million and 31 536 t). The estimates for the Spanish waters were 11 million and 1 159 t.

Sizes of the assessed population ranged between 16.5 and 27.5 cm size classes. The length frequency distribution of the population was clearly mixed, with one main mode at 19.5 cm size class and a secondary one at 23.5 cm (**Table 10**; **Figure 30**).

The population was composed by fishes not older than 3 years, with the 49% of the estimated numbers belonging to the age group 1 (51% of the estimated biomass; **Table 11**; **Figure 31**). Age 0 fish accounted for 35% and 26% of the abundance and biomass of the whole population, respectively. Age 0 occurred almost exclusively in Portuguese waters (99% of the age 0 fish estimated in the entire Gulf), where they accounted for 35% and 27% of abundance and biomass. Age 1 fish was the dominant age group in the Portuguese waters (49% in abundance and 51% in biomass), and accounted 98% of the one year olds estimated in the whole surveyed area.

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 and the coherent post-strata considered for the acoustic estimation are illustrated in **Figure 32**. Estimated abundance and biomass by size class are given in **Table 12** and **Figure 33**.

The species was mainly distributed all over the Portuguese outer shelf waters. An incidental occurrence was also recorded in the Spanish easternmost waters. The surveyed population was composed by juveniles and sub-adults (**Figure 32**).

Five (5) size-based homogeneous sectors were delimited for the acoustic assessment (**Figure 32**). The estimates of blue jack mackerel abundance and biomass in summer 2019 were 31 million fish and 2 291 t (**Table 12**). Portuguese waters concentrated the bulk of the population (30 million and 2 272 t). The estimates for the Spanish waters were 1 million and 19 t.

The size class range of the assessed population was comprised between the 13.5 and 25.5 cm size classes, with one main modal class at 23.0 cm and a secondary mode at 15.0 cm (**Table 12**, **Figure 33**).

Horse mackerel

The survey's length-weight relationship for horse mackerel is shown in **Table 4**. The distribution of the back-scattering energy attributed to this species and the coherent post-strata considered for the acoustic estimation are illustrated in **Figure 34**. Estimated abundance and biomass by size class are given in **Table 13** and **Figure 35**.

Horse mackerel showed a quite similar distribution pattern to the abovementioned one for blue jack mackerel, 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. Juveniles were scarce and occurred incidentally in the Spanish outer shelf central waters (**Figure 34**).

Four (4) size-based homogeneous sectors were delimited for the acoustic assessment (**Figure 34**). The estimates of horse mackerel abundance and biomass in summer 2019 were 51 million fish and 6 156 t (**Table 13**). Portuguese waters concentrated the bulk of the population (39 million and 4 592 t). The estimates for the Spanish waters only were 1 million and 19 t.

The size class range of the assessed population was comprised between the 14.5 and 31.5 cm size classes, with one main modal class at 25.0 cm and a very residual secondary mode at 15.5 cm (**Table 13**, **Figure 35**).

Mediterranean horse-mackerel

The survey's length-weight relationship for this species is shown in **Table 4**. Back-scattering energy attributed to the species and the coherent post-strata are represented in **Figure 36**. Estimated abundance and biomass by size class are given in **Table 14** and **Figure 37**.

Mediterranean horse mackerel was restricted, as usual, to the Spanish waters, more specifically between Doñana and Sancti-Petri, with the population being composed by adult fish (**Figure 36**).

Two (2) size-based homogeneous sectors were delimited for the acoustic assessment (**Figure 36**). The estimates of Mediterranean horse mackerel abundance and biomass in summer 2019 were 15 million fish and 7 170 t (**Table 14**).

The size class range of the assessed population was comprised between the 32.0 and 46.0 cm size classes, with one main modal class at 38.5-39.0 cm and a secondary mode at 42.0 cm (**Table 14**, **Figure 37**).

Bogue

Parameters of the survey's length-weight relationship for bogue are shown in **Table 4**. Back-scattering energy attributed to bogue and their coherent post-strata for the acoustic assessment are shown in **Figure 38**. Estimated abundance and biomass by size class are given in **Table 15** and **Figure 39**.

Bogue showed a distribution pattern quite similar to the described ones for blue jack mackerel and horse-mackerel, with a very incidental occurrence in Spanish waters (just in front of the Bay of Cadiz) and the highest densities being recorded in the westernmost waters of the Gulf (**Figure 38**).

Two (2) size-based homogeneous sectors were delimited for the acoustic assessment (**Figure 38**). The estimates of bogue abundance and biomass in summer 2019 were 8 million fish and 863 t (**Table 15**). Portuguese waters concentrated the bulk of the population (7 million and 823 t). The estimates for the Spanish waters only were 0.4 million and 41 t.

The size class range of the assessed population was comprised between the 19.0 and 26.0 cm size classes, with one main modal class at 22.0 cm (**Table 15**, **Figure 39**).

Transparent goby

Parameters of the survey's length-weight relationship for transparent goby are shown in **Table 4**. Back-scattering energy attributed to the species and coherent post-strata are shown in **Figure 40**. Estimated abundance and biomass by size class are given in **Table 16** and **Figure 41**.

This gobiid species showed this year unusually high acoustic integration and densities, which were exclusively recorded over the inner-middle shelf waters of the Spanish part of the Gulf, between Mazagón and Bay of Cadiz. Its occurrence was associated to the typical (plankton-) scattering layer recorded close to the bottom in the Guadalquivir river mouth's influence area (**Figure 40**).

Two (2) size-based homogeneous sectors were delimited for the acoustic assessment (**Figure 40**). The estimates of transparent goby abundance and biomass in summer 2019 were 8 million fish and 863 t (**Table 16**).

The size class range of the assessed population was comprised between the 2.0 and 5.5 cm size classes, with one modal class at 4.5 cm (**Table 16**, **Figure 41**).

Atlantic pomfret

Parameters of the survey's length-weight relationship for *Brama brama* are shown in **Table 4**. Back-scattering energy attributed to the species and coherent post-strata are shown in **Figure 42**. Estimated abundance and biomass by size class are given in **Table 17** and **Figure 43**.

The Atlantic pomfret showed an unexpected high frequency of occurrence and abundance in the fishing hauls not recorded in previous surveys. The species acoustically contributed with 17% of the total NASC recorded in the survey, although it was restricted to the Spanish middle-outer shelf waters (**Figure 42**).

One (1) size-based homogeneous sector was delimited for the acoustic assessment (**Figure 42**). The estimates of Atlantic pomfret abundance and biomass in summer 2019 were 8 million fish and 62 573 t (**Table 17**).

The size class range of the assessed population was comprised between the 35.5 and 51.5 cm size classes, with one main modal class at 41.5 cm (**Table 17**, **Figure 43**).

Longspine snipefish

The survey's length-weight relationship for this species is shown in **Table 4**. Back-scattering energy attributed to the species and coherent post-strata are represented in **Figure 44**. Estimated abundance and biomass by size class are given in **Table 18** and **Figure 45**.

M. scolopax showed an incidental occurrence mainly restricted to the westernmost outer shelf waters just to the west of Portimão (**Figure 44**).

Three (3) size-based homogeneous sectors were delimited for the acoustic assessment (**Figure 44**). The estimates of snipefish abundance and biomass in summer 2019 were 2 931 million fish and 22 468 t (**Table 18**). Portuguese waters concentrated the bulk of the population (2 931 million and 22 465 t). The estimates for the Spanish waters only were 0.4 million and 3 t.

The size class range of the assessed population was comprised between the 10.0 and 12.5 cm size classes, with one modal class at 11.0 cm (**Table 18**, **Figure 45**).

Pearlside

The survey's length-weight relationship for this species is shown in **Table 4**. Back-scattering energy attributed to the species and coherent post-strata are illustrated in **Figure 46**. Estimated abundance and biomass by size class are given in **Table 19** and **Figure 47**.

Pearlside was located close to the deepest limit of the surveyed area (200 m), just in the transition between outer shelf and upper slope waters. The highest densities were recorded in the Spanish outer shelf (**Figure 46**).

Three (3) size-based homogeneous sectors were delimited for the acoustic assessment (**Figure 46**). The estimates of pearlside abundance and biomass in summer 2019 were 4 615 million fish and 3 412 t (**Table 19**). Spanish waters concentrated the bulk of the population (4 413 million and 3 262 t). The estimates for the Portuguese waters were 203 million and 150 t.

The size class range of the assessed population was comprised between the 3.0 and 5.5 cm size classes, with one modal class at 4.0 cm (**Table 19**, **Figure 47**).

(SHORT) DISCUSSION

The total NASC estimated in this survey for “pelagic fish assemblage”, 259 503 m^2 nmi^{-2}, is the highest estimate ever recorded within the time-series (**Figure 19**), a situation which was repeated in the last year’s survey. In the current survey such an increase in acoustic energy is the result of the relatively high partial contributions of anchovy, sardine, chub mackerel (as was also the case the last year), and the unexpected high contributions of the transparent goby and the Atlantic pomfret, species which usually have showed an accidental occurrence or very low abundance through the time-series. Anchovy has shown an increased contribution in relation to the one recorded last year, but almost exclusively restricted to the Spanish waters. In many of the anchovy positive hauls, this species was the dominant in terms of numbers and weight. Sardine also showed during the 2019 survey the occurrence of dense schools in the coastal (20-60 m) waters in the central part of the Gulf (between the Guadiana river mouth and Doñana), although not so numerous as in the 2018 survey.

The current anchovy biomass estimate (57 700 t) becomes in the historical maximum within the time-series (2006: 35 539 t; 2018: 34 908 t; see **Figure 48**) and denotes a strong increase in relation to the previous years, up to levels well above the historical average (ca. 24 kt), showing a recent increasing trend. Although the spring *PELAGO 19* survey also estimated increased population levels (29 876 t), 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 2019 were 2 917 million fish and 62 682 t, a biomass well above the historical average (ca. 47 kt), but lower than the biomass estimated the previous year (114 631 t, **Figure 48**).

Chub mackerel acoustic estimates were of 465 million fish and 32 696 t, with the bulk of the population concentrated in the Portuguese waters, where the smallest fish were also recorded. Estimates showed a relative stable recent trend, with the recent biomasses very close to the historical average (ca. 35 kt; **Figure 48**).

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.

REFERENCES

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

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

Foote, K.G., 1987. Fish target strengths for use in echo integrator surveys. *J. Acoust. Soc. Am*., 82 (3): 981-987.

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

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

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

Iglesias, M., Brothers, E.B., Morales-Nin, B., 1997. Validation of daily increment deposition in otoliths. Age and growth determination of *Aphia minuta* (Pisces: Gobiidae) from the northwest Mediterranean. *Mar. Biol*. 129: 279-287.

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

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

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

Table 1. *ECOCADIZ 2019-07 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	01/08/19	36º 12,975' N	6º 08,870' W	06:06	23	36º 02,200' N	6º 28,800' W	10:02	241
R02	Sancti-Petri	01/08/19	36º 08,890' N	6º 34,190' W	11:04	149	36º 19,350' N	6º 14,860' W	14:48	28
R03	Cádiz	02/08/19	36º 26,712' N	6º 19,122' W	06:00	25	36º 17,150' N	6º 36,730' W	09:42	201
R04	Rota	02/08/19	36º 24,510' N	6º 40,720' W	10:39	200	36º 34,881' N	6º 21,885' W	00:00	20
R05	Chipiona	03/08/19	36º 31,220' N	6º 46,330' W	06:06	201	36º 40,347' N	6º 29,483' W	09:30	20
R06	Doñana	03/08/19	36º 46,610' N	6º 35,780' W	10:23	20	36º 38,050' N	6º 51,520' W	13:50	241
R07	Matalascañas	04/08/19	36º 54,300' N	6º 39,340' W	05:59	20	36º 44,006' N	6º 58,304' W	10:05	208
R08	Mazagón	04/08/19	36º 49,450' N	7º 06,060' W	13:58	192	37º 01,060' N	6º 44,720' W	17:36	23
R09	Punta Umbría	05/08/19	37º 03,902' N	6º 56,385' W	06:01	27	36º 49,663' N	7º 06,613' W	09:38	200
R10	El Rompido	05/08/19	36º 50,110' N	7º 07,200' W	13:20	156	37º 07,950' N	7º 07,190' W	16:38	21
R11	Isla Cristina	06/08/19	37º 06,762' N	7º 17,190' W	06:02	25	36º 53,379' N	7º 17,156' W	08:27	200
R12	V.R. do Sto. Antonio	06/08/19	36º 51,310' N	7º 27,130' W	10:52	129	37º 06,420' N	7º 27,140' W	13:25	21
R13	Tavira	07/08/19	37º 04,780' N	7º 37,140' W	06:00	20	36º 56,950' N	7º 37,090' W	06:44	214
R14	Fuzeta	07/08/19	36º 59,122' N	7º 47,076' W	15:44	44	36º 55,480' N	7º 47,040' W	16:06	65
R15	Cabo Sta. María	08/08/19	36º 55,590' N	7º 57,010' W	06:00	65	36º 52,070' N	7º 56,960' W	6:20	214
R16	Quarteira	08/08/19	36º 49,750' N	8º 06,880' W	10:26	111	37º 01,760' N	8º 07,040' W	11:38	20
R17	Albufeira	09/08/19	37º 01,452' N	8º 16,979' W	06:10	31	36º 49,376' N	8º 16,788' W	07:21	198
R18	Alfanzina	09/08/19	36º 50,290' N	8º 26,770' W	11:56	193	37º 04,550' N	8º 27,030' W	15:29	21
R19	Portimao	10/08/19	37º 05,990' N	8º 37,050' W	06:02	24	36º 51,270' N	8º 36,740' W	08:00	203
R20	Burgau	10/08/19	36º 51,960' N	8º 46,690' W	13:15	200	37º 02,644' N	8º 46,985' W	15:40	44
R21	Ponta de Sagres	11/08/19	36º 59,160' N	8º 56,800' W	05:59	26	36º 50,610' N	8º 56,610' W	06:49	208

Table 2. *ECOCADIZ 2019-07* 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	01-08-2019	36º 02.8258 N	6º 27.5187 W	118.26	36º 04.6665 N	6º 24.2185 W	92.6	08:17	09:02	0:45	1:10	3.246	R01	Cape Trafalgar
PE02	01-08-2019	36º 12.2035 N	6º 28.0417 W	100.28	36º 10.4644 N	6º 31.2328 W	120.76	12:07	12:50	0:43	1:12	3.113	R02	Sancti-Petri
PE03	02-08-2019	36º 22.2477 N	6º 27.1795 W	62.66	36º 24.1798 N	6º 23.7697 W	49.62	07:17	08:08	0:51	1:17	3.362	R03	Cádiz
PE04	02-08-2019	36º 23.9902 N	6º 39.4744 W	175.4	36º 25.6666 N	6º 40.9363 W	183.04	11:37	12:05	0:27	1:02	2.048	R04	Rota
PE05	02-08-2019	36º 29.0500 N	6º 32.7102 W	73.03	36º 27.2992 N	6º 35.7808 W	96.73	13:34	14:16	0:42	1:07	3.032	R04	Rota
PE06	03-08-2019	36º 37.4764 N	6º 35.0545 W	46.66	36º 35.7088 N	6º 38.0509 W	68.01	07:41	08:23	0:41	1:02	2.989	R05	Chipiona
PE07	03-08-2019	36º 39.8023 N	6º 48.2119 W	108.63	36º 41.6428 N	6º 44.9131 W	79.21	12:03	12:49	0:45	1:11	3.228	R06	Doñana
PE08	04-08-2019	36º 48.2986 N	6º 47.7196 W	57.98	36º 51.2457 N	6º 50.2405 W	57.49	07:47	8:37	0:50	1:10	3.572	R07	Matalascañas
PE09	04-08-2019	36º 47.1990 N	6º 52.5756 W	94.96	36º 45.3591 N	6º 55.7908 W	118.79	11:50	12:35	0:45	1:11	3.17	R07	Matalascañas
PE10	04-08-2019	36º 53.5684 N	6º 55.1256 W	72.92	36º 55.4394 N	6º 56.9512 W	69.32	15:26	15:59	0:33	0:59	2.374	R08	Mazagón
PE11	05-08-2019	36º 58.8694 N	6º 59.2051 W	54.47	37º 00.7732 N	7º 01.8807 W	48.83	07:21	08:03	0:41	1:16	2.865	R09	Punta Umbría
PE12	05-08-2019	36º 52.7992 N	7º 03.8962 W	109.65	36º 50.4193 N	7º 05.2735 W	141.78	12:09	12:46	0:37	1:05	2.621	R09	Punta Umbría
PE13	05-08-2019	36º 58.1839 N	7º 07.1824 W	81.75	36º 55.8414 N	7º 07.1809 W	99.68	14:34	15:07	0:32	0:57	2.34	R10	El Rompido
PE14	06-08-2019	36º 58.9606 N	7º 27.0352 W	105.34	36º 56.8828 N	7º 27.0894 W	135.35	11:36	12:05	0:28	0:56	2.076	R12	Vila Real do Santo Antonio
PE15	06-08-2019	37º 04.6033 N	7º 25.0948 W	43.02	37º 04.6153 N	7º 28.6036 W	44.79	14:31	15:10	0:39	0:59	2.808	R12	Vila Real do Santo Antonio
PE16	07-08-2019	36º 57.8844 N	7º 35.8137 W	126.63	36º 58.3597 N	7º 39.6316 W	124.62	07:51	08:34	0:42	1:20	3.096	R13	Tavira
PE17	07-08-2019	36º 59.7265 N	7º 35.1627 W	103.56	36º 59.1631 N	7º 37.8753 W	103.27	12:09	12:41	0:31	1:02	2.245	R13	Tavira
PE18	07-08-2019	37º 03.4497 N	7º 34.8718 W	45.56	37º 02.8950 N	7º 37.0614 W	42.44	14:09	14:35	0:25	0:47	1.838	R13	Tavira
PE19	08-08-2019	36º 54.6022 N	7º 56.9863 W	77.54	36º 52.6036 N	7º 56.9668 W	108.33	07:03	07:31	0:28	1:01	1.996	R15	Cape Santa María
PE20	08-08-2019	36º 57.7930 N	8º 06.8919 W	44.07	36º 56.3266 N	8º 06.8956 W	48.78	12:14	12:34	0:20	0:51	1.464	R16	Quarteira
PE21	08-08-2019	36º 51.8557 N	8º 05.6689 W	111.81	36º 50.7514 N	8º 07.9687 W	107.01	14:18	14:48	0:29	1:07	2.15	R16	Quarteira
PE22	09-08-2019	36º 50.5998 N	8º 15.6259 W	118.65	36º 51.9970 N	8º 18.5947 W	116.37	08:50	09:29	0:39	1:06	2.761	R17	Albufeira
PE23	09-08-2019	36º 57.2746 N	8º 26.9154 W	85.23	36º 53.8497 N	8º 26.8420 W	123.63	13:13	14:01	0:48	1:14	3.421	R18	Alfanzina
PE24	10-08-2019	36º 52.8750 N	8º 36.7405 W	115.4	36º 55.0627 N	8º 36.7875 W	101.16	08:34	09:04	0:30	0:58	2.185	R19	Portimao
PE25	10-08-2019	36º 52.3045 N	8º 35.9494 W	114.11	36º 52.8616 N	8º 38.8939 W	117.34	11:35	12:09	0:34	1:04	2.427	R19	Portimao
PE26	10/08/2019	36º 56.9764 N	8º 46.7872 W	109.7	36º 55.4947 N	8º 46.7656 W	113.93	14:16	14:36	0:20	0:46	1.48	R20	Burgau
PE27	11/08/2019	36º 51.7239 N	8º 56.6149 W	145.45	36º 54.4681 N	8º 56.6929 W	116.09	7:22	8:01	0:38	1:09	2.741	R21	Ponta de Sagres

Table 3. *ECOCADIZ 2019-07* survey. Catches by species in number (upper panel) and weight (in kg, lower panel) from valid fishing stations.

CATCH IN NUMBERS																
Fishing station	**ANE**	**PIL**	**MAS**	**MAC**	**HOM**	**JAA**	**HMM**	**BOG**	**FIM**	**POA**	**WHB**	**BOC**	**SNS**	**MAV**	**OTHERS SPP**	**TOTAL**
01	0	0	6	0	3	0	0	0	0	0	0	334	4	0	16	**363**
02	1	0	27	1	658	6	646	0	0	76	0	8	0	0	80	**1503**
03	152	4431	0	4	2	0	0	1	0	14	0	0	0	0	269	**4873**
04	0	0	0	0	0	0	0	0	0	106	0	0	0	226417	2	**226525**
05	3695	12	6	13	2	0	0	0	7343	274	0	0	0	0	132	**11477**
06	6517	3229	0	0	1	0	15	0	1603	9	0	0	0	0	51	**11425**
07	6364	0	28	0	2	0	0	0	452	20	0	0	0	0	34	**6900**
08	551	3	1	105	0	0	0	0	2430	395	0	0	0	0	67	**3552**
09	5778	0	61	116	0	0	0	0	0	4	0	0	0	0	39	**5998**
10	6147	0	1	37	1	0	0	0	16	4	0	0	0	0	68	**6274**
11	2182	16	17	13	2	0	0	0	0	41	0	0	0	0	217	**2488**
12	34223	0	15	2	0	1	0	0	0	0	0	0	0	0	45	**34286**
13	53810	621	22	39	1	0	0	0	0	2	0	0	0	0	42	**54537**
14	16713	88584	2095	0	0	0	0	0	0	0	0	0	0	0	5	**107397**
15	188	109	1	21	5	0	0	14	0	0	0	0	0	0	138	**476**
16	1	59	7228	0	0	487	0	0	0	0	0	0	10	0	0	**7785**
17	8134	86254	34326	0	0	0	0	0	0	0	0	0	0	0	6	**128720**
18	0	29945	32	23	634	40	0	34	0	0	0	0	0	0	401	**31109**
19	353	12	3146	1	448	14	0	18	0	0	0	0	0	0	436	**4428**
20	0	3254	147256	0	49	0	0	0	0	0	0	0	0	0	0	**150559**
21	3	0	344	0	3194	88	0	20	0	0	0	0	0	0	97	**3746**
22	0	0	1839	0	30	810	0	0	0	0	0	824	22	0	62	**3587**
23	0	0	852	0	297	7	0	67	0	0	1	15	3	14	225	**1481**
24	0	0	1347	0	12	18	0	18	0	0	0	0	1	0	12	**1408**
25	0	0	101	0	14	211	0	13	0	0	0	40	28288	0	2	**28669**
26	0	0	1180	0	177	7	0	22	0	0	0	0	0	0	36	**1422**
27	0	0	23	0	34	36	0	9	0	0	0	0	0	0	22	**124**
TOTAL	**144812**	**216529**	**199954**	**375**	**5566**	**1725**	**661**	**216**	**11844**	**945**	**1**	**1221**	**28328**	**226431**	**2504**	**841112**

Table 3. *ECOCADIZ 2019-07* survey. Cont'd.

CATCH IN WEIGHT (kg)																
Fishing station	**ANE**	**PIL**	**MAS**	**MAC**	**HOM**	**JAA**	**HMM**	**BOG**	**FIM**	**POA**	**WHB**	**BOC**	**SNS**	**MAV**	**OTHERS SPP**	**TOTAL**
01	0	0	0,780	0	0,148	0	0	0	0	0	0	1,866	0,024	0	2,662	**5,480**
02	0,008	0	3,080	0,166	94,050	2,340	316,800	0	0	52,367	0	0,044	0	0	7,869	**476,724**
03	1,678	102,700	0	1,632	0,142	0	0	0,278	0	9,550	0	0	0	0	38,754	**154,734**
04	0	0	0	0	0	0	0	0	0	81,647	0	0	0	167,200	0,074	**248,921**
05	43,550	0,225	0,520	1,030	0,007	0	0	0	3,130	189,050	0	0	0	0	13,908	**251,420**
06	50,480	38,784	0	0	0,003	0	3,580	0	0,774	6,900	0	0	0	0	4,218	**104,739**
07	79,550	0	1,664	0	0,006	0	0	0	0,232	13,950	0	0	0	0	3,490	**98,892**
08	5,730	0,074	0,182	5,754	0	0	0	0	0,450	274,650	0	0	0	0	6,655	**293,495**
09	78,240	0	6,250	4,902	0	0	0	0	0	3,200	0	0	0	0	4,966	**97,558**
10	75,550	0	0,140	1,587	0,005	0	0	0	0,007	3,372	0	0	0	0	6,072	**86,733**
11	25,550	0,326	2,213	3,474	0,032	0	0	0	0	29,450	0	0	0	0	13,662	**74,707**
12	444,700	0	1,192	0,070	0	0,013	0	0	0	0	0	0	0	0	4,379	**450,354**
13	712,850	11,350	0,738	2,572	0,014	0	0	0	0	1,908	0	0	0	0	4,734	**734,166**
14	334,672	3218,545	137,601	0	0	0	0	0	0	0	0	0	0	0	1,720	**3692,538**
15	2,234	2,080	0,193	6,660	0,420	0	0	1,970	0	0	0	0	0	0	15,665	**29,222**
16	0,019	2,780	521,050	0	0	70,837	0	0	0	0	0	0	0,121	0	0	**594,807**
17	174,312	3739,108	2191,580	0	0	0	0	0	0	0	0	0	0	0	2,222	**6107,222**
18	0	1216,776	2,446	7,225	50,486	1,702	0	4,188	0	0	0	0	0	0	48,193	**1331,016**
19	7,410	0,462	315,480	0,326	55,150	0,834	0	2,728	0	0	0	0	0	0	97,366	**479,756**
20	0	165,162	8908,991	0	1,595	0	0	0	0	0	0	0	0	0	0	**9075,748**
21	0,098	0	37,300	0	390,500	6,654	0	2,640	0	0	0	0	0	0	5,570	**442,762**
22	0	0	201,850	0	3,696	80,950	0	0	0	0	0	4,830	0,227	0	8,728	**300,281**
23	0	0	74,750	0	31,300	0,300	0	7,285	0	0	0,022	0,084	0,032	0,014	31,472	**145,259**
24	0	0	120,600	0	1,316	1,690	0	1,028	0	0	0	0	0,010	0	1,072	**125,716**
25	0	0	10,470	0	0,761	15,350	0	1,355	0	0	0	0,662	204,050	0	54,096	**286,744**
26	0	0	117,250	0	20,200	0,454	0	2,137	0	0	0	0	0	0	6,884	**146,925**
27	0	0	2,480	0	4,351	3,552	0	1,041	0	0	0	0	0	0	6,270	**17,694**
TOTAL	**2036,631**	**8498,372**	**12658,800**	**35,398**	**654,182**	**184,676**	**320,380**	**24,650**	**4,593**	**666,044**	**0,022**	**7,486**	**204,464**	**167,214**	**390,701**	**25853,613**

Table 4. *ECOCADIZ 2019-07* 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*; FIM: *Aphia minuta*; POA: *Brama brama*: BOC: *Capros aper*; SNS: *Macrorhamphosus scolopax*; MAV: *Maurolicus muelleri*. (*) FIM's LW relationship parameters following Iglesias *et al*. (1997).

PARAMETER	ANE	PIL	MAS	MAC	HOM	JAA	HMM	BOG	FIM(*)	POA
Size range (mm)	92-173	108-202	132-343	158-381	66-336	121-384	282-463	193-297		358-517
n	723	469	766	229	408	320	65	167		388
a	0,002644	0,002409	0,003183	0,002395	0,008879	0,007130	0,029374	0,005556	0,004000	0,027261
b	3,356048	3,460818	3,286908	3,351769	2,974619	3,048874	2,630445	3,157324	3,690000	2,722180
r^2	0,95	0,95	0,96	0,99	0,94	0,99	0,97	0,84		0,71

PARAMETER	BOC	SNS	MAV
Size range (mm)	53-104	94-164	36-64
n	181	96	98
a	0,034164	0,003662	0,010578
b	2,743768	3,158905	2,869503
r^2	0,99	0,80	0,96

Table 5. *ECOCADIZ 2019-07* 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 20**.

***ECOCADIZ 2019-07 . Engraulis encrasicolus* . ABUNDANCE (in numbers and million fish)**											
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	***n***			**Millions**		
						PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
6	0	0	0	0	0	0	0	0	0	0	0
6,5	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0
7,5	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0
8,5	0	0	0	0	75490733	0	75490733	75490733	0	75	75
9	0	0	0	0	320755985	0	320755985	320755985	0	321	321
9,5	0	0	0	0	339549037	0	339549037	339549037	0	340	340
10	0	30229	0	28787841	396246718	30229	425034559	425064788	0,03	425	425
10,5	0	88331	0	84121160	396246718	88331	480367878	480456209	0,1	480	480
11	0	296251	0	282131250	301962933	296251	584094183	584390434	0,3	584	584
11,5	0	684742	0	652106300	75490733	684742	727597033	728281775	1	728	728
12	526172	1027334	85251	978369750	94283785	1553506	1072738786	1074292292	2	1073	1074
12,5	4276461	727989	692874	693292319	56697682	5004450	750682875	755687325	5	751	756
13	12520921	423300	2028645	403124967	18793052	12944221	423946664	436890885	13	424	437
13,5	17191270	122965	2785336	117104394	0	17314235	119889730	137203965	17	120	137
14	18025661	57916	2920525	55155988	0	18083577	58076513	76160090	18	58	76
14,5	10746620	14341	1741172	13657314	0	10760961	15398486	26159447	11	15	26
15	5221908	5029	846056	4789252	0	5226937	5635308	10862245	5	6	11
15,5	3803656	2933	616270	2793205	0	3806589	3409475	7216064	4	3	7
16	1918459	2096	310830	1996047	0	1920555	2306877	4227432	2	2	4
16,5	1266905	0	205264	0	0	1266905	205264	1472169	1	0,2	1
17	633641	0	102663	0	0	633641	102663	736304	1	0,1	1
17,5	128131	0	20760	0	0	128131	20760	148891	0,1	0,02	0,1
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
TOTAL *n*	76259805	3483456	12355646	3317429787	2075517376	79743261	5405302809	5485046070	**80**	**5405**	**5485**
Millions	**76**	**3**	**12**	**3317**	**2076**						

Table 5. *ECOCADIZ 2019-07* survey. Anchovy (*E. encrasicolus*). Cont'd.

***ECOCADIZ 2019-07 . Engraulis encrasicolus* . BIOMASS (t)**								
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**PORTUGAL**	**SPAIN**	**TOTAL**
6	0	0	0	0	0	**0**	**0**	**0**
6,5	0	0	0	0	0	**0**	**0**	**0**
7	0	0	0	0	0	**0**	**0**	**0**
7,5	0	0	0	0	0	**0**	**0**	**0**
8	0	0	0	0	0	**0**	**0**	**0**
8,5	0	0	0	0	288,531	**0**	**288,531**	**288,531**
9	0	0	0	0	1478,103	**0**	**1478,103**	**1478,103**
9,5	0	0	0	0	1868,042	**0**	**1868,042**	**1868,042**
10	0	0,197	0	187,412	2579,613	**0,197**	**2767,026**	**2767,222**
10,5	0	0,675	0	642,860	3028,146	**0,675**	**3671,007**	**3671,682**
11	0	2,638	0	2512,574	2689,189	**2,638**	**5201,763**	**5204,402**
11,5	0	7,059	0	6722,832	778,265	**7,059**	**7501,097**	**7508,156**
12	6,241	12,186	1,011	11605,228	1118,376	**18,427**	**12724,614**	**12743,042**
12,5	58,038	9,880	9,403	9409,065	769,477	**67,918**	**10187,945**	**10255,864**
13	193,418	6,539	31,338	6227,295	290,307	**199,957**	**6548,940**	**6748,896**
13,5	300,825	2,152	48,740	2049,178	0	**302,977**	**2097,917**	**2400,894**
14	355,721	1,143	57,634	1088,457	0	**356,864**	**1146,092**	**1502,956**
14,5	238,178	0,318	38,590	302,688	0	**238,496**	**341,278**	**579,774**
15	129,476	0,125	20,978	118,749	0	**129,601**	**139,727**	**269,328**
15,5	105,129	0,081	17,033	77,201	0	**105,210**	**94,234**	**199,444**
16	58,906	0,064	9,544	61,288	0	**58,970**	**70,832**	**129,802**
16,5	43,077	0	6,979	0	0	**43,077**	**6,979**	**50,057**
17	23,787	0	3,854	0	0	**23,787**	**3,854**	**27,641**
17,5	5,296	0	0,858	0	0	**5,296**	**0,858**	**6,154**
18	0	0	0	0	0	**0**	**0**	**0**
18,5	0	0	0	0	0	**0**	**0**	**0**
TOTAL	**1518,093**	**43,057**	**245,962**	**41004,828**	**14888,048**	**1561,150**	**56138,839**	**57699,989**

Table 6. *ECOCADIZ 2019-07* 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 20** and ordered from west to east.

Age class	POL01	POL02	POL03	POL04	POL05	PT	ES	TOTAL
	N	N	N	N	N	N	N	N
0	1873	713	304	679480	1638068	2587	2317852	2320439
I	60390	2661	9784	2534559	423530	63051	2967873	3030925
II	13997	109	2268	103390	13919	14105	119577	133683
III	0	0	0	0	0	0	0	0
TOTAL	76260	3483	12356	3317430	2075517	79743	5405303	5485046

Age class	POL01	POL02	POL03	POL04	POL05	PT	ES	TOTAL
	B	B	B	B	B	B	B	B
0	32	7	5	7025	10410	39	17440	17479
I	1149	34	186	32505	4336	1183	37027	38210
II	337	2	55	1475	142	339	1671	2010
III	0	0	0	0	0	0	0	0
TOTAL	1518	43	246	41005	14888	1561	56139	57700

Table 7. *ECOCADIZ 2019-07* 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 24**.

***ECOCADIZ 2019-07 . Sardina pilchardus* . ABUNDANCE (in numbers and million fish)**													
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	***n***			**Millions**		
								PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
6	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
7	0	0	0	0	0	0	0	0	0	0	0	0	0
7,5	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0
8,5	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0
9,5	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0
10,5	0	0	0	0	0	46134625	0	0	46134625	46134625	0	46	46
11	0	0	0	0	0	401738683	0	0	401738683	401738683	0	402	402
11,5	0	0	5287	344650	0	434808636	6533734	5287	441687020	441692307	0,01	442	442
12	0	0	123877	8075256	0	230673126	51803176	123877	290551558	290675435	0,1	291	291
12,5	0	0	477036	31096837	0	158000885	174544036	477036	363641758	364118794	0,5	364	364
13	0	0	623775	40662444	0	39602289	103373005	623775	183637738	184261513	1	184	184
13,5	0	689625	435540	28391856	12	0	103373005	1125165	131764873	132890038	1	132	133
14	0	0	263791	17195950	0	0	90538885	263791	107734835	107998626	0,3	108	108
14,5	0	5858790	173399	11303478	101	0	168010302	6032189	179313881	185346070	6	179	185
15	0	18549645	50371	3283575	320	0	168010302	18600016	171294197	189894213	19	171	190
15,5	0	55071293	15861	1033950	951	6532336	90538885	55087154	98106122	153193276	55	98	153
16	421819	77868987	0	0	1344	0	58103563	78290806	58104907	136395713	78	58	136
16,5	1068476	95100475	19899	1297138	1642	0	19367854	96188850	20666634	116855484	96	21	117
17	1522131	80488671	0	0	1390	0	0	82010802	1390	82012192	82	0,001	82
17,5	1619626	49191791	0	0	849	0	0	50811417	849	50812266	51	0,001	51
18	907309	20445846	0	0	353	408271	0	21353155	408624	21761779	21	0,4	22
18,5	712317	4423230	0	0	76	0	0	5135547	76	5135623	5	0,0001	5
19	161167	5773899	0	0	100	0	0	5935066	100	5935166	6	0,0001	6
19,5	31835	0	0	0	0	0	0	31835	0	31835	0,03	0	0,03
20	31835	0	0	0	0	0	0	31835	0	31835	0,03	0	0,03
20,5	0	0	0	0	0	0	0	0	0	0	0	0	0
21	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
TOTAL *n*	6476515	413462252	2188836	142685134	7138	1317898851	1034196747	422127603	2494787870	2916915473	**422**	**2495**	**2917**
Millions	**6**	**413**	**2**	**143**	**0,01**	**1318**	**1034**	**422**	**2495**	**2917**			

Table 7. *ECOCADIZ 2019-07* survey. Sardine (*S. pilchardus*). Cont'd.

ECOCADIZ 2019-07 . Sardina pilchardus . BIOMASS (t)										
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**PORTUGAL**	**SPAIN**	**TOTAL**
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	412,386	0	0	412,386	412,385673
11	0	0	0	0	0	4202,917	0	0	4202,917	4202,91701
11,5	0	0	0,064	4,191	0	5287,667	79,456	0,064	5371,314	5371,37823
12	0	0	1,740	113,438	0	3240,392	727,708	1,740	4081,537	4083,27737
12,5	0	0	7,696	501,701	0	2549,110	2816,010	7,696	5866,822	5874,51786
13	0	0	11,497	749,442	0	729,902	1905,249	11,497	3384,593	3396,08951
13,5	0	14,449	9,125	594,856	0,0003	0	2165,834	23,574	2760,690	2784,2644
14	0	0	6,254	407,689	0	0	2146,535	6,254	2554,224	2560,47808
14,5	0	156,511	4,632	301,959	0,003	0	4488,197	161,143	4790,159	4951,30207
15	0	556,131	1,510	98,444	0,010	0	5037,059	557,641	5135,513	5693,15333
15,5	0	1846,099	0,532	34,660	0,032	218,977	3035,043	1846,631	3288,712	5135,34216
16	15,755	2908,488	0	0	0,050	0	2170,228	2924,243	2170,279	5094,52169
16,5	44,322	3944,889	0,825	53,807	0,068	0	803,403	3990,036	857,278	4847,31409
17	69,906	3696,548	0	0	0,064	0	0	3766,453	0,064	3766,51731
17,5	82,115	2494,022	0	0	0,043	0	0	2576,137	0,043	2576,18052
18	50,643	1141,211	0	0	0,020	22,788	0	1191,853	22,808	1214,66132
18,5	43,657	271,097	0	0	0,005	0	0	314,755	0,005	314,759189
19	10,820	387,623	0	0	0,007	0	0	398,443	0,007	398,449639
19,5	2,336	0	0	0	0	0	0	2,336	0	2,335535
20	2,547	0	0	0	0	0	0	2,547	0	2,546617
20,5	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0
21,5	0	0	0	0	0	0	0	0	0	0
TOTAL	**322,100**	**17417,066**	**43,876**	**2860,187**	**0,301**	**16664,139**	**25374,722**	**17783,042**	**44899,349**	**62682,392**

Table 8. *ECOCADIZ 2019-07* 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 24** and ordered from west to east.

Age class	POL01	POL02	POL03	POL04	POL05	POL06	POL07	PT	ES	TOTAL
	N	N	N	N	N	N	N	N	N	N
0	41	8435	1329	86617	0,1	1272721	402704	9805	1762043	1771848
I	5686	396584	860	56068	7	45152	631493	403130	732719	1135849
II	661	7165	0	0	0,1	0	0	7826	0,1	7826
III	89	1278	0	0	0,02	26	0	1366	26	1392
TOTAL	6477	413462	2189	142685	7	1317899	1034197	422128	2494788	2916915

Age class	POL01	POL02	POL03	POL04	POL05	POL06	POL07	PT	ES	TOTAL
	B	B	B	B	B	B	B	B	B	B
0	2	301	24	1569	0,01	15831	7423	326	24822	25149
I	274	16610	20	1292	0,3	832	17952	16904	20075	36980
II	41	435	0	0	0,01	0	0	475	0,01	475
III	6	71	0	0	0,001	1	0	77	1	78
TOTAL	322	17417	44	2860	0,3	16664	25375	17783	44899	62682

Table 9. *ECOCADIZ 2019-07* survey. Mackerel (*Scomber scombrus*). Estimated abundance (absolute numbers and million fish) and biomass (t) by size class (in cm). Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figure 27**.

ECOCADIZ 2019-07 . Scomber scombrus . ABUNDANCE (in numbers and million fish)									
Size class	**POL01**	**POL02**	**POL03**	***n***			**Millions**		
				PORTUGAL	**SPAIN**	**TOTAL**	**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	13662	151087	65914	13662	217001	230663	0.01	0.2	0.2
16	50445	557880	243384	50445	801264	851709	0.1	1	1
16.5	208620	2307161	1006535	208620	3313696	3522316	0.2	3	4
17	358380	3963378	1729085	358380	5692463	6050843	0.4	6	6
17.5	321859	3559485	1552881	321859	5112366	5434225	0.3	5	5
18	143198	1583648	690891	143198	2274539	2417737	0.1	2	2
18.5	25258	279329	121862	25258	401191	426449	0.03	0.4	0.4
19	8169	90341	39413	8169	129754	137923	0.01	0.1	0.1
19.5	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0
20.5	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0
21.5	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0
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	0	0	0	0	0	0	0	0	0
25.5	0	0	0	0	0	0	0	0	0
26	13662	151087	65914	13662	217001	230663	0.01	0.2	0.2
26.5	22406	247792	108103	22406	355895	378301	0.02	0.4	0.4
27	10986	121493	53003	10986	174496	185482	0.01	0.2	0.2
27.5	15171	167776	73195	15171	240971	256142	0.02	0.2	0.3
28	20053	221765	96748	20053	318513	338566	0.02	0.3	0.3
28.5	28867	319249	139277	28867	458526	487393	0.03	0.5	0.5
29	0	0	0	0	0	0	0	0	0
29.5	14237	157451	68690	14237	226141	240378	0.01	0.2	0.2
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	3034	33555	14639	3034	48194	51228	0.003	0.05	0.1
32.5	8169	90341	39413	8169	129754	137923	0.01	0.1	0.1
33	8169	90341	39413	8169	129754	137923	0.01	0.1	0.1
33.5	0	0	0	0	0	0	0	0	0
34	0	0	0	0	0	0	0	0	0
TOTAL *n*	1274345	14093159	6148360	1274345	20241519	21515864	**1**	**20**	**22**
Millions	**1**	**14**	**6**						

Table 9. *ECOCADIZ 2019-07* survey. Mackerel (*Scomber scombrus*). Cont'd.

ECOCADIZ 2019-07 . Scomber scombrus . BIOMASS (t)						
Size class	**POL01**	**POL02**	**POL03**	**PORTUGAL**	**SPAIN**	**TOTAL**
14	0	0	0	0	0	0
14.5	0	0	0	0	0	0
15	0	0	0	0	0	0
15.5	0.338	3.734	1.629	0.338	5.363	5.701
16	1.384	15.308	6.678	1.384	21.986	23.370
16.5	6.336	70.071	30.570	6.336	100.641	106.977
17	12.012	132.838	57.953	12.012	190.791	202.803
17.5	11.871	131.287	57.276	11.871	188.563	200.434
18	5.797	64.108	27.968	5.797	92.076	97.873
18.5	1.119	12.379	5.401	1.119	17.780	18.899
19	0.395	4.373	1.908	0.395	6.281	6.676
19.5	0	0	0	0	0	0
20	0	0	0	0	0	0
20.5	0	0	0	0	0	0
21	0	0	0	0	0	0
21.5	0	0	0	0	0	0
22	0	0	0	0	0	0
22.5	0	0	0	0	0	0
23	0	0	0	0	0	0
23.5	0	0	0	0	0	0
24	0	0	0	0	0	0
24.5	0	0	0	0	0	0
25	0	0	0	0	0	0
25.5	0	0	0	0	0	0
26	1.869	20.672	9.019	1.869	29.691	31.560
26.5	3.266	36.116	15.756	3.266	51.872	55.138
27	1.704	18.841	8.220	1.704	27.061	28.765
27.5	2.501	27.653	12.064	2.501	39.717	42.218
28	3.509	38.806	16.929	3.509	55.735	59.244
28.5	5.357	59.246	25.847	5.357	85.093	90.450
29	0	0	0	0	0	0
29.5	2.963	32.766	14.295	2.963	47.061	50.024
30	0	0	0	0	0	0
30.5	0	0	0	0	0	0
31	0	0	0	0	0	0
31.5	0	0	0	0	0	0
32	0.827	9.150	3.992	0.827	13.142	13.969
32.5	2.346	25.939	11.316	2.346	37.255	39.601
33	2.468	27.290	11.906	2.468	39.196	41.664
33.5	0	0	0	0	0	0
34	0	0	0	0	0	0
TOTAL	**66.062**	**730.577**	**318.727**	**66.062**	**1049.304**	**1115.366**

Table 10. *ECOCADIZ 2019-07* 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 29**.

ECOCADIZ 2019-07 . 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	0	0	0	0	0	0	0	0
16,5	0	0	77681	59963	0	137644	0	137644	0,1	0	0,1
17	0	0	0	246882	0	246882	0	246882	0,2	0	0,2
17,5	1300	3129413	392794	609828	0	4133335	0	4133335	4	0	4
18	14944	35976560	1290155	1344685	0	38626344	0	38626344	39	0	39
18,5	12345	29719859	605556	1229431	0	31567191	0	31567191	32	0	32
19	17544	42235385	372795	2174674	0	44800398	0	44800398	45	0	45
19,5	25341	61005487	638051	3094861	0	64763740	0	64763740	65	0	65
20	23392	56312430	532860	4631120	0	61499802	0	61499802	61	0	61
20,5	19493	46926317	2146888	8474131	0	57566829	0	57566829	58	0	58
21	8447	20335870	4786827	5736797	0	30867941	0	30867941	31	0	31
21,5	5848	14079170	8587093	3710154	564893	26382265	564893	26947158	26	1	27
22	1300	3129413	10340636	1568805	1506382	15040154	1506382	16546536	15	2	17
22,5	0	0	13177806	893268	753191	14071074	753191	14824265	14	1	15
23	0	0	14085391	773343	2824466	14858734	2824466	17683200	15	3	18
23,5	0	0	15833475	623566	2071275	16457041	2071275	18528316	16	2	19
24	0	0	10953874	79489	2447871	11033363	2447871	13481234	11	2	13
24,5	0	0	8232993	39744	753191	8272737	753191	9025928	8	1	9
25	0	0	5789958	0	188298	5789958	188298	5978256	6	0,2	6
25,5	0	0	3752320	583821	188298	4336141	188298	4524439	4	0,2	5
26	0	0	1602233	0	0	1602233	0	1602233	2	0	2
26,5	0	0	678786	0	0	678786	0	678786	1	0	1
27	0	0	765255	34523	0	799778	0	799778	1	0	1
27,5	0	0	70230	0	0	70230	0	70230	0,1	0	0,1
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*	129954	312849904	104713657	35909085	11297865	453602600	11297865	464900465	**454**	**11**	**465**
Millions	**0,1**	**313**	**105**	**36**	**11**						

Table 10. *ECOCADIZ 2019-07* survey. Chub mackerel (*S. colias*). Cont'd.

ECOCADIZ 2019-07 . 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	0	0	0	0
16,5	0	0	2,608	2,013	0	4,621	0	4,621
17	0	0	0	9,131	0	9,131	0	9,131
17,5	0,053	127,133	15,957	24,774	0	167,917	0	167,917
18	0,665	1601,288	57,424	59,851	0	1719,228	0	1719,228
18,5	0,601	1445,705	29,457	59,805	0	1535,568	0	1535,568
19	0,931	2240,150	19,773	115,344	0	2376,197	0	2376,197
19,5	1,462	3520,251	36,818	178,585	0	3737,117	0	3737,117
20	1,465	3527,752	33,382	290,121	0	3852,721	0	3852,721
20,5	1,323	3185,141	145,721	575,185	0	3907,370	0	3907,370
21	0,620	1492,672	351,358	421,086	0	2265,736	0	2265,736
21,5	0,463	1115,520	680,372	293,963	44,758	2090,319	44,758	2135,076
22	0,111	267,182	882,860	133,941	128,612	1284,095	128,612	1412,706
22,5	0	0	1210,350	82,045	69,179	1292,395	69,179	1361,573
23	0	0	1389,538	76,291	278,636	1465,829	278,636	1744,465
23,5	0	0	1675,139	65,972	219,135	1741,111	219,135	1960,246
24	0	0	1241,031	9,006	277,334	1250,037	277,334	1527,371
24,5	0	0	997,484	4,815	91,254	1002,300	91,254	1093,554
25	0	0	749,160	0	24,364	749,160	24,364	773,524
25,5	0	0	517,833	80,569	25,986	598,402	25,986	624,388
26	0	0	235,542	0	0	235,542	0	235,542
26,5	0	0	106,172	0	0	106,172	0	106,172
27	0	0	127,209	5,739	0	132,948	0	132,948
27,5	0	0	12,393	0	0	12,393	0	12,393
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	**7,694**	**18522,796**	**10517,581**	**2488,236**	**1159,258**	**31536,307**	**1159,258**	**32695,565**

Table 11. *ECOCADIZ 2019-07* survey. Chub mackerel (*S. colias*). Estimated abundance (thousands of individuals) and biomass (tonnes) by age group. Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figure 29** and ordered from west to east.

Age class	POL01	POL02	POL03	POL04	POL05	PT	ES	TOTAL
	N	N	N	N	N	N	N	N
0	61	145896	4695	9637	104	160289	104	160392
I	63	152817	49677	20990	5453	223548	5453	229002
II	6	14136	49246	5241	5723	68630	5723	74353
III	0	0	1095	41	17	1136	17	1153
TOTAL	130	312850	104714	35909	11298	453603	11298	464900

Age class	POL01	POL02	POL03	POL04	POL05	PT	ES	TOTAL
	B	B	B	B	B	B	B	B
0	3	7813	280	546	9	8643	9	8652
I	4	9796	4782	1498	546	16079	546	16626
II	0.4	1060	5302	452	602	6815	602	7417
III	0	0	158	6	2	164	2	167
TOTAL	8	18669	10522	2502	1160	31701	1160	32861

Table 12. *ECOCADIZ 2019-07* survey. Blue jack mackerel (*Trachurus picturatus*). Estimated abundance (absolute numbers and million fish) and biomass (t) by size class (in cm). Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figure 32**.

***ECOCADIZ 2019-07*. *Trachurus picturatus*. ABUNDANCE (in numbers and million fish)**											
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	***n***			**Millions**		
						PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
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	59854	82	4984	59854	5066	64920	0.1	0.01	0.1
14	220233	2586	551283	755	45903	774102	46658	820760	1	0.05	1
14.5	192704	0	1193921	1635	99413	1386625	101048	1487673	1	0.1	1
15	573107	3879	1590845	2179	132464	2167831	134643	2302474	2	0.1	2
15.5	391665	6465	1162419	1592	96790	1560549	98382	1658931	2	0.1	2
16	297815	2586	979709	1342	81577	1280110	82919	1363029	1	0.1	1
16.5	579297	3879	519781	712	43280	1102957	43992	1146949	1	0.04	1
17	750795	3879	551283	755	45903	1305957	46658	1352615	1	0.05	1
17.5	792240	6465	182711	250	15214	981416	15464	996880	1	0.02	1
18	498103	6465	59854	82	4984	564422	5066	569488	1	0.01	1
18.5	554489	10344	0	0	0	564833	0	564833	1	0	1
19	95177	3879	31502	43	2623	130558	2666	133224	0.1	0.003	0.1
19.5	85242	0	0	0	0	85242	0	85242	0.1	0	0.1
20	378671	0	0	0	0	378671	0	378671	0.4	0	0.4
20.5	192704	0	0	0	0	192704	0	192704	0.2	0	0.2
21	514990	0	0	0	0	514990	0	514990	1	0	1
21.5	1839264	0	0	0	0	1839264	0	1839264	2	0	2
22	2893353	0	0	0	0	2893353	0	2893353	3	0	3
22.5	3677390	0	0	0	0	3677390	0	3677390	4	0	4
23	4474774	0	0	0	0	4474774	0	4474774	4	0	4
23.5	2480729	0	0	0	0	2480729	0	2480729	2	0	2
24	968857	0	0	0	0	968857	0	968857	1	0	1
24.5	446252	0	0	0	0	446252	0	446252	0.4	0	0.4
25	122639	0	0	0	0	122639	0	122639	0.1	0	0.1
25.5	324232	0	3150	4	262	327382	266	327648	0.3	0.0003	0.3
26	0	0	0	0	0	0	0	0	0	0	0
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	0	0	0	0	0	0	0	0	0	0
TOTAL *n*	23344722	50427	6886312	9431	573397	30281461	582828	30864289	**30**	**1**	**31**
Millions	**23**	**0.1**	**7**	**0.01**	**1**						

Table 12. *ECOCADIZ 2019-07* survey. Blue jack mackerel (*Trachurus picturatus*). Cont'd.

***ECOCADIZ 2019-07 . Trachurus picturatus* . BIOMASS (t)**								
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**PORTUGAL**	**SPAIN**	**TOTAL**
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	1.271	0.002	0.106	1.271	0.108	1.379
14	5.214	0.061	13.051	0.018	1.087	18.326	1.105	19.431
14.5	5.065	0	31.383	0.043	2.613	36.448	2.656	39.104
15	16.668	0.113	46.268	0.063	3.853	63.049	3.916	66.965
15.5	12.563	0.207	37.285	0.051	3.105	50.055	3.156	53.211
16	10.503	0.091	34.551	0.047	2.877	45.145	2.924	48.069
16.5	22.398	0.150	20.097	0.028	1.673	42.645	1.701	44.346
17	31.739	0.164	23.305	0.032	1.940	55.208	1.972	57.180
17.5	36.525	0.298	8.423	0.012	0.701	45.246	0.713	45.959
18	24.984	0.324	3.002	0.004	0.250	28.310	0.254	28.564
18.5	30.190	0.563	0.000	0.000	0.000	30.753	0	30.753
19	5.613	0.229	1.858	0.003	0.155	7.700	0.158	7.858
19.5	5.434	0	0	0	0	5.434	0	5.434
20	26.041	0	0	0	0	26.041	0	26.041
20.5	14.270	0	0	0	0	14.270	0	14.270
21	40.994	0	0	0	0	40.994	0	40.994
21.5	157.116	0	0	0	0	157.116	0	157.116
22	264.809	0	0	0	0	264.809	0	264.809
22.5	360.048	0	0	0	0	360.048	0	360.048
23	467.998	0	0	0	0	467.998	0	467.998
23.5	276.755	0	0	0	0	276.755	0	276.755
24	115.142	0	0	0	0	115.142	0	115.142
24.5	56.423	0	0	0	0	56.423	0	56.423
25	16.476	0	0	0	0	16.476	0	16.476
25.5	46.231	0	0.449	0.001	0.037	46.680	0.038	46.718
26	0	0	0	0	0	0	0	0
26.5	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0
27.5	0	0	0	0	0	0	0	0
TOTAL	**2049.199**	**2.200**	**220.943**	**0.304**	**18.397**	**2272.342**	**18.701**	**2291.043**

Table 13. *ECOCADIZ 2019-07* 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 34**.

***ECOCADIZ 2019-07*. *Trachurus trachurus*. ABUNDANCE (in numbers and million fish)**										
Size class	**POL01**	**POL02**	**POL03**	**POL04**	***n***			**Millions**		
					PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
14	0	0	0	0	0	0	0	0	0	0
14.5	486424	0	0	0	486424	0	486424	0.5	0	0.5
15	0	0	4314	0	4314	0	4314	0.004	0	0.004
15.5	486424	0	7190	0	493614	0	493614	0.5	0	0.5
16	0	0	21570	0	21570	0	21570	0.02	0	0.02
16.5	486424	0	47453	0	533877	0	533877	1	0	1
17	0	0	76213	0	76213	0	76213	0.1	0	0.1
17.5	0	247635	54643	0	302278	0	302278	0.3	0	0.3
18	0	0	25884	0	25884	0	25884	0.03	0	0.03
18.5	0	41854	14380	0	56234	0	56234	0.1	0	0.1
19	0	131681	25884	0	157565	0	157565	0.2	0	0.2
19.5	0	104121	47453	69130	151574	69130	220704	0.2	0.1	0.2
20	0	214875	66147	0	281022	0	281022	0.3	0	0.3
20.5	0	682477	73337	69130	755814	69130	824944	1	0.1	1
21	0	327659	87716	69130	415375	69130	484505	0.4	0.1	0.5
21.5	0	787688	51767	120978	839455	120978	960433	1	0.1	1
22	0	1445795	61833	120978	1507628	120978	1628606	2	0.1	2
22.5	0	2040512	73337	241957	2113849	241957	2355806	2	0.2	2
23	0	4159331	76213	915979	4235544	915979	5151523	4	1	5
23.5	0	3662512	51767	985109	3714279	985109	4699388	4	1	5
24	0	4984986	25884	915979	5010870	915979	5926849	5	1	6
24.5	0	4702223	18694	1296196	4720917	1296196	6017113	5	1	6
25	0	5371279	4314	1348044	5375593	1348044	6723637	5	1	7
25.5	0	2040649	0	1175218	2040649	1175218	3215867	2	1	3
26	0	2914523	0	1036957	2914523	1036957	3951480	3	1	4
26.5	0	1298862	0	915979	1298862	915979	2214841	1	1	2
27	0	851237	0	743153	851237	743153	1594390	1	1	2
27.5	0	110240	0	432065	110240	432065	542305	0.1	0.4	1
28	0	614956	0	311087	614956	311087	926043	1	0.3	1
28.5	0	0	0	69130	0	69130	69130	0	0.1	0.1
29	0	41340	0	311087	41340	311087	352427	0.04	0.3	0.4
29.5	0	41340	0	0	41340	0	41340	0.04	0	0.04
30	0	222912	0	69130	222912	69130	292042	0.2	0.1	0.3
30.5	0	0	0	0	0	0	0	0	0	0
31	0	0	0	120978	0	120978	120978	0	0	0.1
31.5	0	0	0	69130	0	69130	69130	0	0	0.1
32	0	0	0	0	0	0	0	0	0	0
TOTAL *n*	1459272	37040687	915993	11406524	39415952	11406524	50822476	**39**	**11**	**51**
Millions	**1**	**37**	**1**	**11**						

Table 13. *ECOCADIZ 2019-07* survey. Horse mackerel (*T. trachurus*). Cont'd.

ECOCADIZ 2019-07 . Trachurus trachurus . BIOMASS (t)							
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**PORTUGAL**	**SPAIN**	**TOTAL**
14	0	0	0	0	0	0	0
14.5	12.945	0	0	0	12.945	0	12.945
15	0	0	0.127	0	0.127	0	0.127
15.5	15.734	0	0.233	0	15.967	0	15.967
16	0	0	0.766	0	0.766	0	0.766
16.5	18.896	0	1.843	0	20.739	0	20.739
17	0	0	3.231	0	3.231	0	3.231
17.5	0	11.431	2.522	0	13.953	0	13.953
18	0	0	1.298	0	1.298	0	1.298
18.5	0	2.274	0.781	0	3.055	0	3.055
19	0	7.737	1.521	0	9.258	0	9.258
19.5	0	6.603	3.009	4.384	9.612	4.384	13.996
20	0	14.678	4.519	0	19.197	0	19.197
20.5	0	50.129	5.387	5.078	55.516	5.078	60.594
21	0	25.834	6.916	5.450	32.750	5.450	38.200
21.5	0	66.552	4.374	10.221	70.926	10.221	81.147
22	0	130.700	5.590	10.936	136.290	10.936	147.226
22.5	0	197.069	7.083	23.368	204.152	23.368	227.520
23	0	428.536	7.852	94.373	436.388	94.373	530.761
23.5	0	402.004	5.682	108.127	407.686	108.127	515.813
24	0	582.144	3.023	106.967	585.167	106.967	692.134
24.5	0	583.492	2.320	160.843	585.812	160.843	746.655
25	0	707.371	0.568	177.531	707.939	177.531	885.470
25.5	0	284.885	0	164.066	284.885	164.066	448.951
26	0	430.837	0	153.287	430.837	153.287	584.124
26.5	0	203.088	0	143.221	203.088	143.221	346.309
27	0	140.636	0	122.779	140.636	122.779	263.415
27.5	0	19.225	0	75.350	19.225	75.350	94.575
28	0	113.096	0	57.212	113.096	57.212	170.308
28.5	0	0	0	13.395	0.000	13.395	13.395
29	0	8.432	0	63.449	8.432	63.449	71.881
29.5	0	8.868	0	0	8.868	0	8.868
30	0	50.246	0	15.582	50.246	15.582	65.828
30.5	0	0	0	0.000	0	0	0
31	0	0	0	30.039	0	30.039	30.039
31.5	0	0	0	17.995	0	17.995	17.995
32	0	0	0	0	0	0	0
TOTAL	**47.575**	**4475.867**	**68.645**	**1563.653**	**4592.087**	**1563.653**	**6155.740**

Table 14. *ECOCADIZ 2019-07* 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 36**.

***ECOCADIZ 2019-07* . *Trachurus mediterraneus* . ABUNDANCE (in numbers and million fish)**								
Size class	**POL01**	**POL02**	***n***			**Millions**		
			PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
30	0	0	0	0	0	0	0	0
30.5	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0
31.5	0	0	0	0	0	0	0	0
32	14879	54325	0	69204	69204	0	0.1	0.1
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	14879	54325	0	69204	69204	0	0.1	0.1
34.5	14879	54325	0	69204	69204	0	0.1	0.1
35	0	0	0	0	0	0	0	0
35.5	29759	108649	0	138408	138408	0	0.1	0.1
36	44638	162974	0	207612	207612	0	0.2	0.2
36.5	173593	633787	0	807380	807380	0	1	1
37	173593	633787	0	807380	807380	0	1	1
37.5	213271	778653	0	991924	991924	0	1	1
38	257910	941627	0	1199537	1199537	0	1	1
38.5	312467	1140817	0	1453284	1453284	0	1	1
39	312467	1140817	0	1453284	1453284	0	1	1
39.5	272789	995951	0	1268740	1268740	0	1	1
40	287668	1050276	0	1337944	1337944	0	1	1
40.5	158714	579463	0	738177	738177	0	1	1
41	143834	525138	0	668972	668972	0	1	1
41.5	128955	470813	0	599768	599768	0	1	1
42	183513	670004	0	853517	853517	0	1	1
42.5	143834	525138	0	668972	668972	0	1	1
43	128955	470813	0	599768	599768	0	1	1
43.5	59518	217298	0	276816	276816	0	0.3	0.3
44	69437	253515	0	322952	322952	0	0.3	0.3
44.5	14879	54325	0	69204	69204	0	0.1	0.1
45	29759	108649	0	138408	138408	0	0.1	0.1
45.5	0	0	0	0	0	0	0	0
46	29759	108649	0	138408	138408	0	0.1	0.1
46.5	0	0	0	0	0	0	0	0
47	0	0	0	0	0	0	0	0
TOTAL *n*	3213949	11734118	0	14948067	14948067	**0**	**15**	**15**
Millions	**3**	**12**	**0**					

Table 14. *ECOCADIZ 2019-07* survey. Mediterranean horse mackerel (*T. mediterraneus*). Cont'd.

ECOCADIZ 2019-07 . Trachurus mediterraneus . BIOMASS (t)					
Size class	**POL01**	**POL02**	**PORTUGAL**	**SPAIN**	**TOTAL**
30	0	0	0	0	0
30.5	0	0	0	0	0
31	0	0	0	0	0
31.5	0	0	0	0	0
32	4.061	14.828	0	18.889	18.889
32.5	0	0	0	0	0
33	0	0	0	0	0
33.5	0	0	0	0	0
34	4.758	17.370	0	22.128	22.128
34.5	4.942	18.045	0	22.987	22.987
35	0	0	0	0	0
35.5	10.651	38.887	0	49.538	49.538
36	16.571	60.501	0	77.072	77.072
36.5	66.807	243.913	0	310.720	310.720
37	69.225	252.739	0	321.964	321.964
37.5	88.083	321.592	0	409.675	409.675
38	110.271	402.599	0	512.870	512.870
38.5	138.240	504.715	0	642.955	642.955
39	142.982	522.026	0	665.008	665.008
39.5	129.052	471.167	0	600.219	600.219
40	140.640	513.476	0	654.116	654.116
40.5	80.156	292.648	0	372.804	372.804
41	75.009	273.858	0	348.867	348.867
41.5	69.415	253.434	0	322.849	322.849
42	101.926	372.129	0	474.055	474.055
42.5	82.398	300.836	0	383.234	383.234
43	76.169	278.092	0	354.261	354.261
43.5	36.234	132.290	0	168.524	168.524
44	43.556	159.022	0	202.578	202.578
44.5	9.613	35.098	0	44.711	44.711
45	19.797	72.278	0	92.075	92.075
45.5	0	0	0	0	0
46	20.969	76.556	0	97.525	97.525
46.5	0	0	0	0	0
47	0	0	0	0	0
TOTAL	**1541.525**	**5628.099**	**0**	**7169.624**	**7169.624**

Table 15. *ECOCADIZ 2019-07* 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 38**.

***ECOCADIZ 2019-07* . *Boops boops* . ABUNDANCE (in numbers and million fish)**								
Size class	**POL01**	**POL02**	***n***			**Millions**		
			PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
17	0	0	0	0	0	0	0	0
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	53604	2641	53604	2641	56245	0.1	0.003	0.1
19.5	0	0	0	0	0	0	0	0
20	53604	2641	53604	2641	56245	0.1	0.003	0.1
20.5	264868	13048	264868	13048	277916	0.3	0.01	0.3
21	53604	2641	53604	2641	56245	0.1	0.003	0.1
21.5	214417	10563	214417	10563	224980	0.2	0.01	0.2
22	1592364	78444	1592364	78444	1670808	2	0.1	2
22.5	1488308	73318	1488308	73318	1561626	1	0.1	2
23	1278621	62988	1278621	62988	1341609	1	0.1	1
23.5	586494	28892	586494	28892	615386	1	0.03	1
24	268022	13203	268022	13203	281225	0.3	0.01	0.3
24.5	745731	36737	745731	36737	782468	1	0.04	1
25	53604	2641	53604	2641	56245	0.1	0.003	0.1
25.5	264868	13048	264868	13048	277916	0.3	0.01	0.3
26	264868	13048	264868	13048	277916	0.3	0.01	0.3
26.5	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0
27.5	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0
28.5	0	0	0	0	0	0	0	0
TOTAL *n*	7182977	353853	7182977	353853	7536830	**7**	**0.4**	**8**
Millions	**7**	**0.4**						

Table 15. *ECOCADIZ 2019-07* survey. Bogue (*Boops boops*). Cont'd.

ECOCADIZ 2019-07 . Boops boops **. BIOMASS (t)**					
Size class	**POL01**	**POL02**	**PORTUGAL**	**SPAIN**	**TOTAL**
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	3.383	0.167	3.383	0.167	3.550
19.5	0	0	0	0	0
20	3.970	0.196	3.970	0.196	4.166
20.5	21.187	1.044	21.187	1.044	22.231
21	4.623	0.228	4.623	0.228	4.851
21.5	19.900	0.980	19.900	0.980	20.880
22	158.780	7.822	158.780	7.822	166.602
22.5	159.191	7.842	159.191	7.842	167.033
23	146.480	7.216	146.480	7.216	153.696
23.5	71.858	3.540	71.858	3.540	75.398
24	35.071	1.728	35.071	1.728	36.799
24.5	104.075	5.127	104.075	5.127	109.202
25	7.969	0.393	7.969	0.393	8.362
25.5	41.890	2.064	41.890	2.064	43.954
26	44.512	2.193	44.512	2.193	46.705
26.5	0	0	0	0	0
27	0	0	0	0	0
27.5	0	0	0	0	0
28	0	0	0	0	0
28.5	0	0	0	0	0
TOTAL	**822.889**	**40.540**	**822.889**	**40.540**	**863.429**

Table 16. *ECOCADIZ 2019-07* survey. Transparent goby (*Aphia minuta*). 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 40**.

ECOCADIZ 2019-07. *Aphia minuta*. ABUNDANCE (in numbers and million fish)								
Size class	POL01	POL02	*n*			Millions		
			PORTUGAL	SPAIN	TOTAL	PORTUGAL	SPAIN	TOTAL
0	0	0	0	0	0	0	0	0
0.5	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0
1.5	0	0	0	0	0	0	0	0
2	2661545	12333851	0	14995396	14995396	0	15	15
2.5	23953907	11553762	0	35507669	35507669	0	36	36
3	27946225	156302835	0	184249060	184249060	0	184	184
3.5	14638499	418416273	0	433054772	433054772	0	433	433
4	2661545	439347706	0	442009251	442009251	0	442	442
4.5	0	815291412	0	815291412	815291412	0	815	815
5	0	222005100	0	222005100	222005100	0	222	222
5.5	0	45730865	0	45730865	45730865	0	46	46
6	0	0	0	0	0	0	0	0
6.5	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0
7.5	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0
TOTAL *n*	71861721	2120981804	0	2192843525	2192843525	**0**	**2193**	**2193**
Millions	**72**	**2121**						

ECOCADIZ 2019-07. *Aphia minuta*. BIOMASS (t)					
Size class	POL01	POL02	PORTUGAL	SPAIN	TOTAL
0	0	0	0	0	0
0.5	0	0	0	0	0
1	0	0	0	0	0
1.5	0	0	0	0	0
2	0.021	0.098	0	0.119	0.119
2.5	0.400	0.193	0	0.593	0.593
3	0.865	4.840	0	5.705	5.705
3.5	0.769	21.971	0	22.740	22.740
4	0.222	36.612	0	36.834	36.834
4.5	0	102.417	0	102.417	102.417
5	0	40.347	0	40.347	40.347
5.5	0	11.626	0	11.626	11.626
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
TOTAL	**2**	**218**	**0**	**220**	**220**

Table 17. *ECOCADIZ 2019-07* survey. Atlantic pomfret (*Brama brama*). 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 42**.

***ECOCADIZ 2019-07*. *Brama brama*. ABUNDANCE (in numbers and million fish)**							
Size class	**POL01**	***n***			**Millions**		
		PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
32	0	0	0	0	0	0	0
32.5	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0
33.5	0	0	0	0	0	0	0
34	0	0	0	0	0	0	0
34.5	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0
35.5	231316	0	231316	231316	0	0.2	0.2
36	0	0	0	0	0	0	0
36.5	231316	0	231316	231316	0	0.2	0.2
37	596210	0	596210	596210	0	1	1
37.5	267716	0	267716	267716	0	0.3	0.3
38	2107910	0	2107910	2107910	0	2	2
38.5	1665824	0	1665824	1665824	0	2	2
39	2942393	0	2942393	2942393	0	3	3
39.5	6244919	0	6244919	6244919	0	6	6
40	8545465	0	8545465	8545465	0	9	9
40.5	10109583	0	10109583	10109583	0	10	10
41	9371484	0	9371484	9371484	0	9	9
41.5	11495967	0	11495967	11495967	0	11	11
42	7734935	0	7734935	7734935	0	8	8
42.5	5509642	0	5509642	5509642	0	6	6
43	5909669	0	5909669	5909669	0	6	6
43.5	5942562	0	5942562	5942562	0	6	6
44	2083677	0	2083677	2083677	0	2	2
44.5	1631460	0	1631460	1631460	0	2	2
45	1671034	0	1671034	1671034	0	2	2
45.5	886809	0	886809	886809	0	1	1
46	852878	0	852878	852878	0	1	1
46.5	518020	0	518020	518020	0	1	1
47	0	0	0	0	0	0	0
47.5	89239	0	89239	89239	0	0.1	0.1
48	0	0	0	0	0	0	0
48.5	0	0	0	0	0	0	0
49	231316	0	231316	231316	0	0.2	0.2
49.5	566174	0	566174	566174	0	1	1
50	0	0	0	0	0	0	0
50.5	231316	0	231316	231316	0	0.2	0.2
51	0	0	0	0	0	0	0
51.5	231316	0	231316	231316	0	0.2	0.2
52	0	0	0	0	0	0	0
52.5	0	0	0	0	0	0	0
53	0	0	0	0	0	0	0
53.5	0	0	0	0	0	0	0
54	0	0	0	0	0	0	0
54.5	0	0	0	0	0	0	0
55	0	0	0	0	0	0	0
TOTAL *n*	87900150	0	87900150	87900150	**0**	**88**	**88**
Millions	**88**						

Table 17. *ECOCADIZ 2019-07* survey. Atlantic pomfret (*Brama brama*). Cont'd.

***ECOCADIZ 2019-07 . Brama brama* . BIOMASS (t)**				
Size class	**POL01**	**PORTUGAL**	**SPAIN**	**TOTAL**
32	0	0	0	0
32.5	0	0	0	0
33	0	0	0	0
33.5	0	0	0	0
34	0	0	0	0
34.5	0	0	0	0
35	0	0	0	0
35.5	103.684	0	103.684	103.684
36	0	0	0	0
36.5	112.414	0	112.414	112.414
37	301.447	0	301.447	301.447
37.5	140.752	0	140.752	140.752
38	1151.797	0	1151.797	1151.797
38.5	945.540	0	945.540	945.540
39	1734.071	0	1734.071	1734.071
39.5	3819.458	0	3819.458	3819.458
40	5421.483	0	5421.483	5421.483
40.5	6650.077	0	6650.077	6650.077
41	6388.828	0	6388.828	6388.828
41.5	8118.780	0	8118.780	8118.780
42	5656.552	0	5656.552	5656.552
42.5	4170.520	0	4170.520	4170.520
43	4628.364	0	4628.364	4628.364
43.5	4813.551	0	4813.551	4813.551
44	1744.952	0	1744.952	1744.952
44.5	1411.979	0	1411.979	1411.979
45	1494.091	0	1494.091	1494.091
45.5	818.854	0	818.854	818.854
46	813.010	0	813.010	813.010
46.5	509.611	0	509.611	509.611
47	0	0	0	0
47.5	93.407	0	93.407	93.407
48	0	0	0	0
48.5	0	0	0	0
49	265.090	0	265.090	265.090
49.5	668.331	0	668.331	668.331
50	0	0	0	0
50.5	289.450	0	289.450	289.450
51	0	0	0	0
51.5	306.482	0	306.482	306.482
52	0	0	0	0
52.5	0	0	0	0
53	0	0	0	0
53.5	0	0	0	0
54	0	0	0	0
54.5	0	0	0	0
55	0	0	0	0
TOTAL	**62572.575**	**0**	**62572.575**	**62572.575**

Table 18. *ECOCADIZ 2019-07* survey. Longspine snipefish (*Macroramphosus scolopax*). 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 44**.

ECOCADIZ 2019-07 . Macroramphosus scolopax . ABUNDANCE (in numbers and million fish)									
Size class	**POL01**	**POL02**	**POL03**	***n***			**Millions**		
				PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
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	234469295	101	31764	234469396	31764	234501160	234	0.03	235
10.5	781529781	336	105876	781530117	105876	781635993	782	0.1	782
11	1094224582	471	148238	1094225053	148238	1094373291	1094	0.1	1094
11.5	625285991	269	84709	625286260	84709	625370969	625	0.1	625
12	117286453	50	15889	117286503	15889	117302392	117	0.02	117
12.5	78121895	34	10583	78121929	10583	78132512	78	0.01	78
13	0	0	0	0	0	0	0	0	0
13.5	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0
14.5	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0
TOTAL *n*	2930917997	1261	397059	2930919258	397059	2931316317	**2931**	**0.4**	**2931**
Millions	**2931**	**0.001**	**0.4**						

ECOCADIZ 2019-07 . Macroramphosus scolopax . BIOMASS (t)						
Size class	**POL01**	**POL02**	**POL03**	**PORTUGAL**	**SPAIN**	**TOTAL**
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	1338.417	0.001	0.181	1338.418	0.181	1338.599
10.5	5185.511	0.002	0.702	5185.513	0.702	5186.215
11	8381.506	0.004	1.135	8381.510	1.135	8382.645
11.5	5494.793	0.002	0.744	5494.795	0.744	5495.539
12	1175.685	0.001	0.159	1175.686	0.159	1175.845
12.5	888.585	0	0.120	888.585	0.120	888.705
13	0	0	0	0	0	0
13.5	0	0	0	0	0	0
14	0	0	0	0	0	0
14.5	0	0	0	0	0	0
15	0	0	0	0	0	0
TOTAL	**22464.497**	**0.010**	**3.041**	**22464.507**	**3.041**	**22467.548**

Table 19. *ECOCADIZ 2019-07* 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 46**.

***ECOCADIZ 2019-07* . *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	0.00	0
2.5	0	0	0	0	0	0	0	0.0	0
3	138484	6099031	135781454	6237515	135781454	142018969	6	135.8	142
3.5	1038582	45740545	1018312180	46779127	1018312180	1065091307	47	1018.3	1065
4	2077164	91481090	2036624360	93558254	2036624360	2130182614	94	2036.62	2130
4.5	692381	30493405	678868290	31185786	678868290	710054076	31	678.87	710
5	346201	15247140	339443890	15593341	339443890	355037231	16	339	355
5.5	207716	9148109	203662436	9355825	203662436	213018261	9	204	213
6	0	0	0	0	0	0	0	0	0
6.5	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0
TOTAL *n*	4500528	198209320	4412692610	202709848	4412692610	4615402458	**203**	**4413**	**4615**
Millions	**5**	**198**	**4413**						

***ECOCADIZ 2019-07* . *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	0.043	1.899	42.275	1.942	42.275	44.217
3.5	0.488	21.472	478.036	21.960	478.036	499.996
4	1.396	61.502	1369.211	62.898	1369.211	1432.109
4.5	0.640	28.208	627.994	28.848	627.994	656.842
5	0.427	18.797	418.468	19.224	418.468	437.692
5.5	0.332	14.642	325.968	14.974	325.968	340.942
6	0	0	0	0	0	0
6.5	0	0	0	0	0	0
7	0	0	0	0	0	0
TOTAL	**3.326**	**146.520**	**3261.952**	**149.846**	**3261.952**	**3411.798**

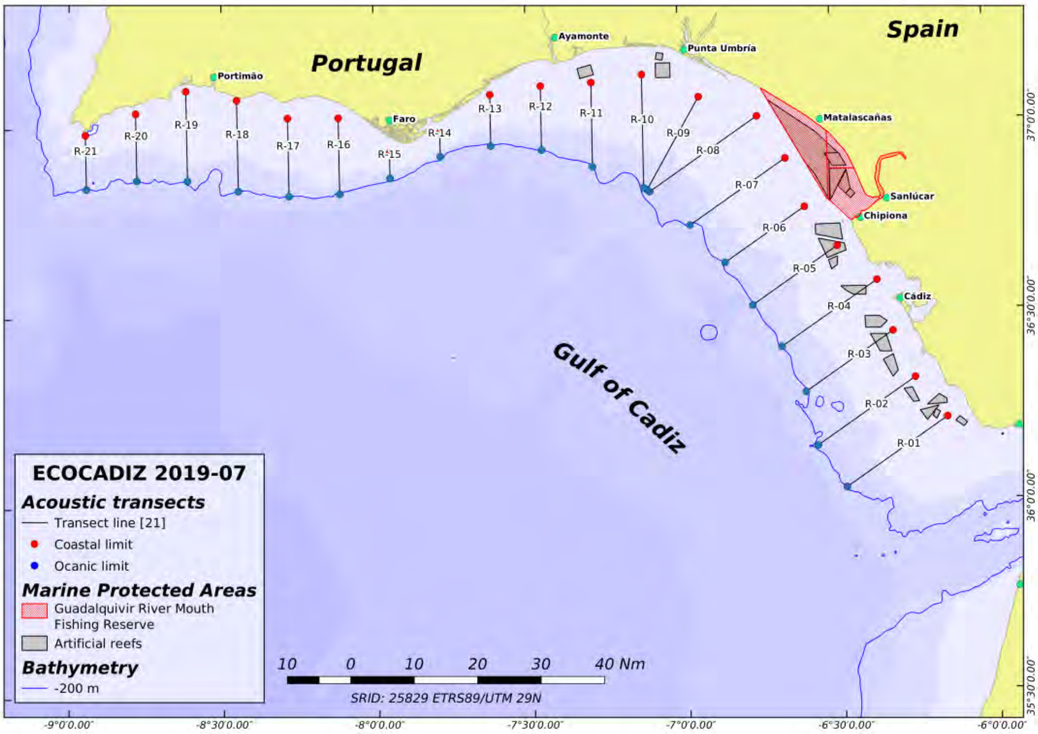


Figure 1. *ECOCADIZ 2019-07* survey. Location of the acoustic transects sampled during the survey. The different protected areas inside the Guadalquivir river mouth Fishing Reserve and artificial reef polygons are also shown.

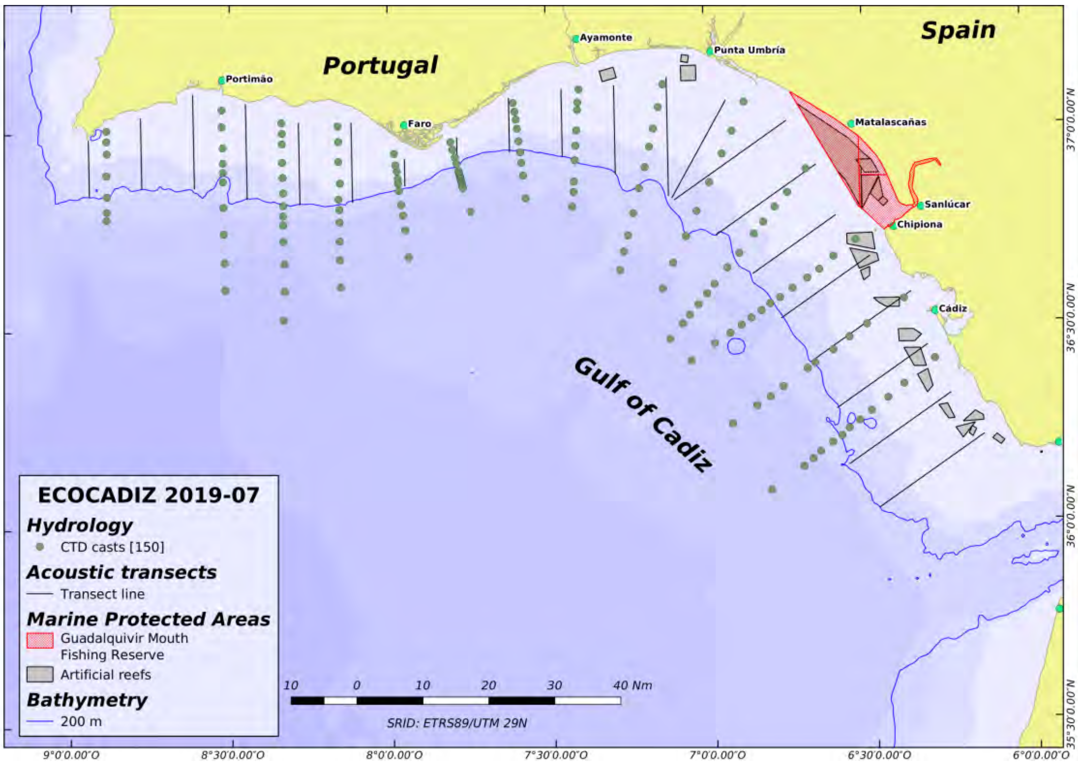


Figure 2. *ECOCADIZ 2019-07* survey. Location of CTD-LADCP stations.

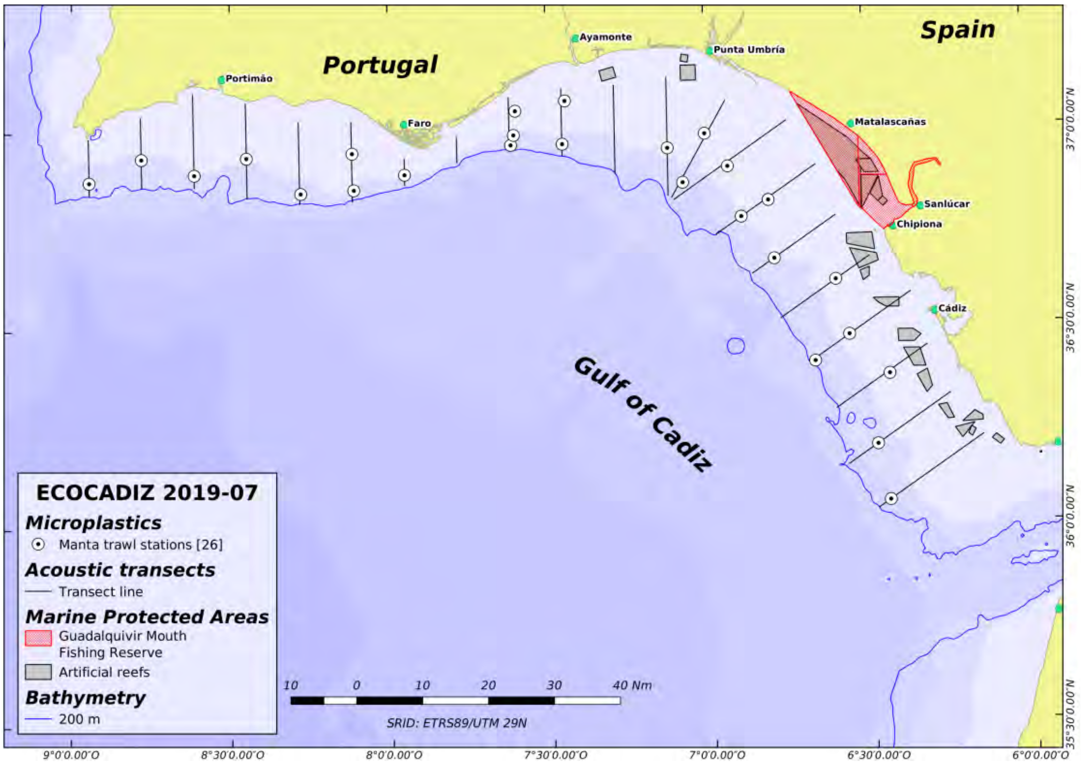


Figure 3. *ECOCADIZ 2019-07* survey. Location of Manta trawl hauls (micro-plastics).

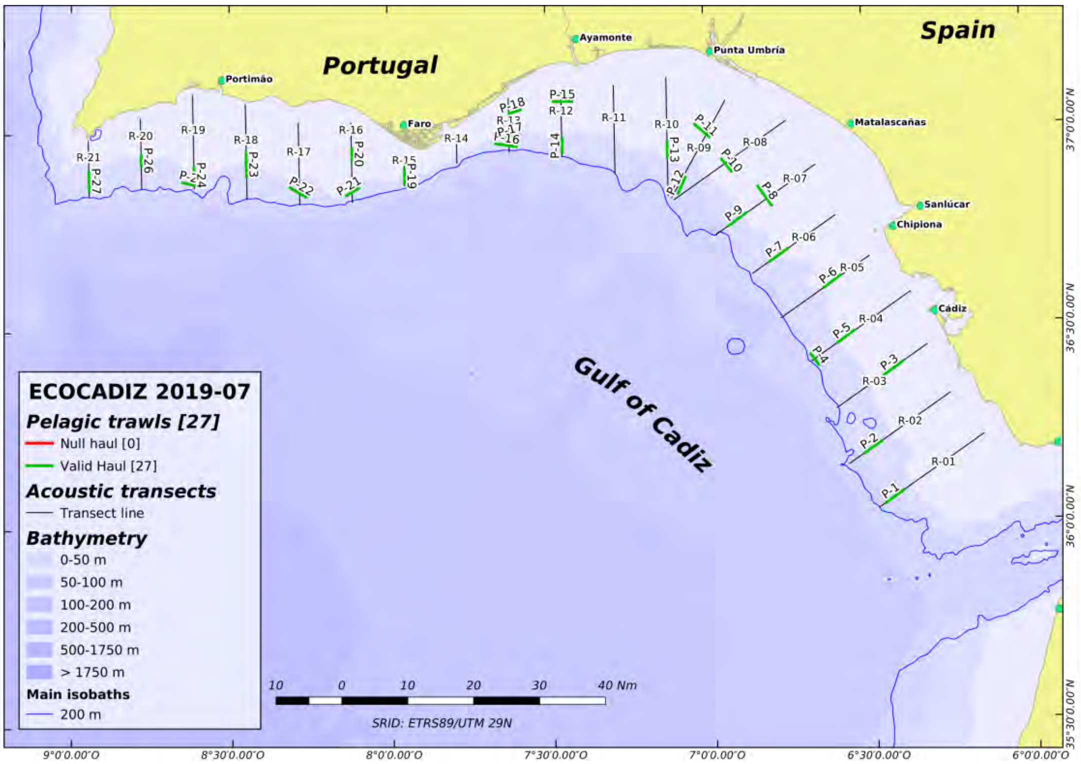


Figure 4. *ECOCADIZ 2019-07* survey. Location of ground-truthing fishing hauls.

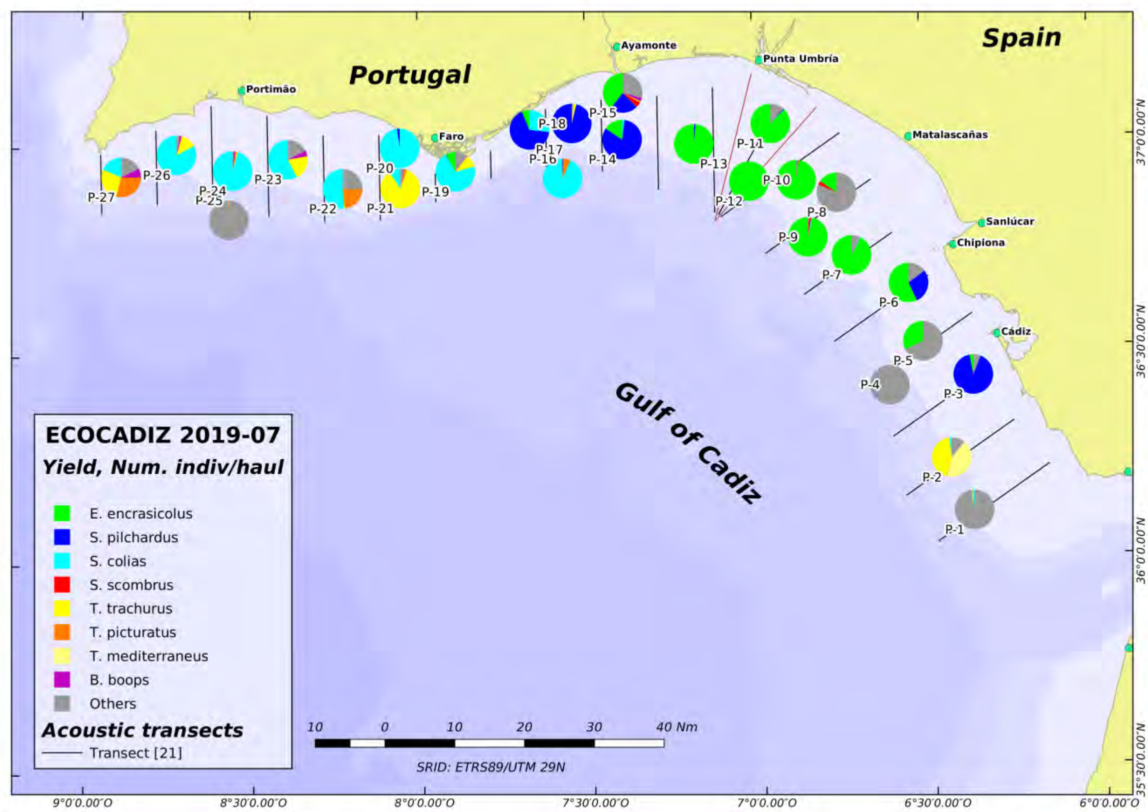


Figure 5. *ECOCADIZ 2019-07* survey. Species composition (percentages in number) in fishing hauls.

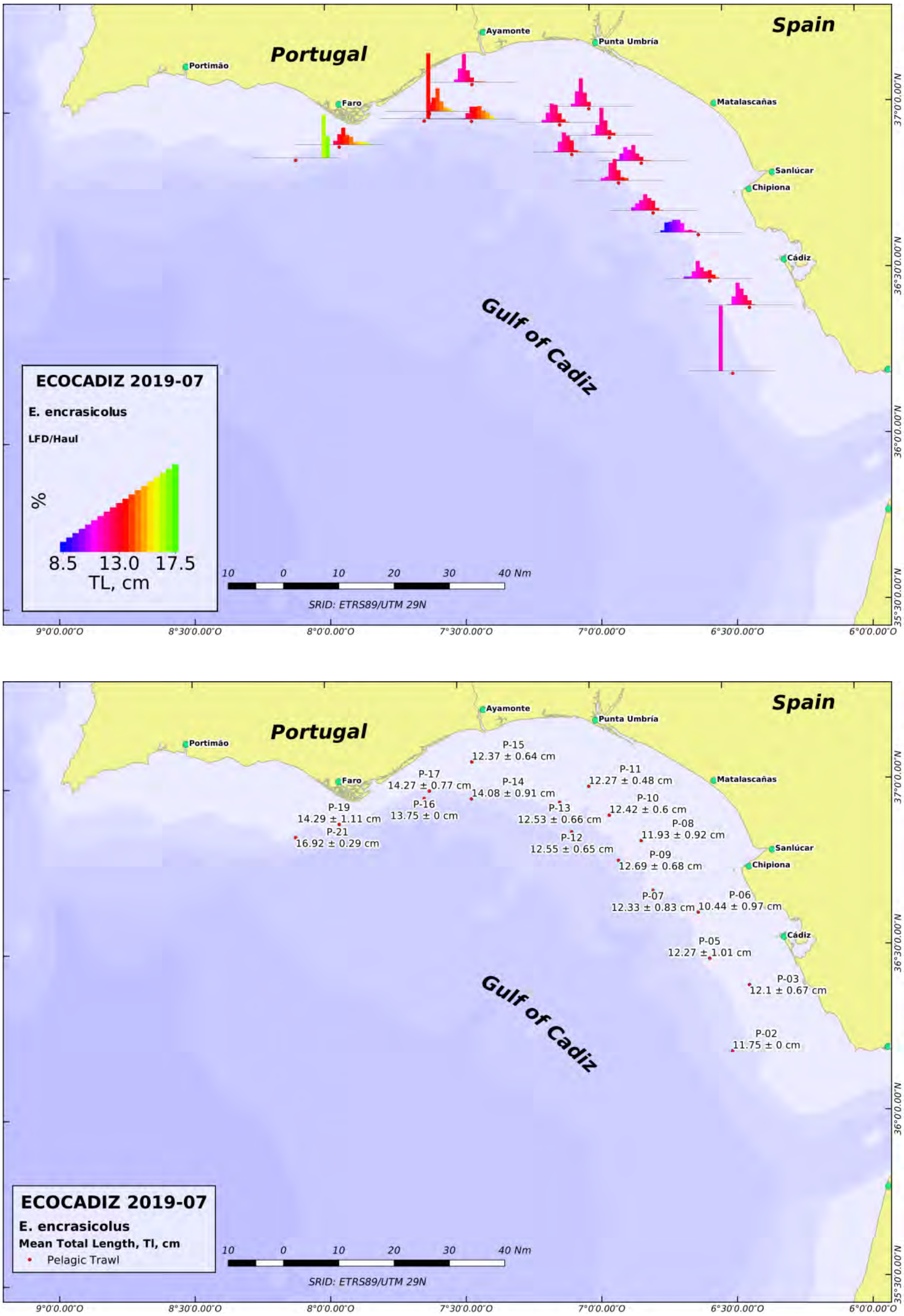


Figure 6. *ECOCADIZ 2019-07* survey. *Engraulis encrasicolus*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

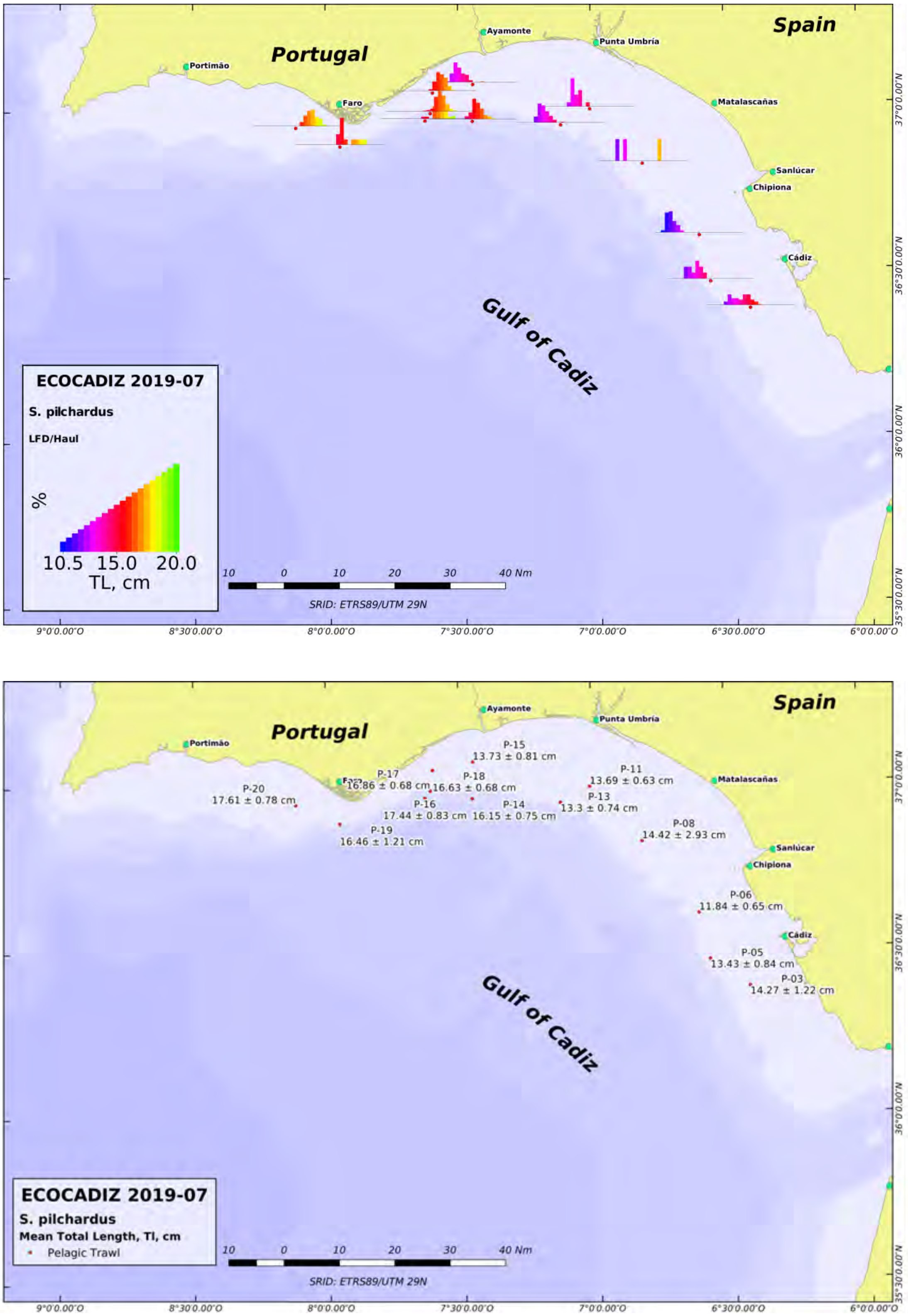
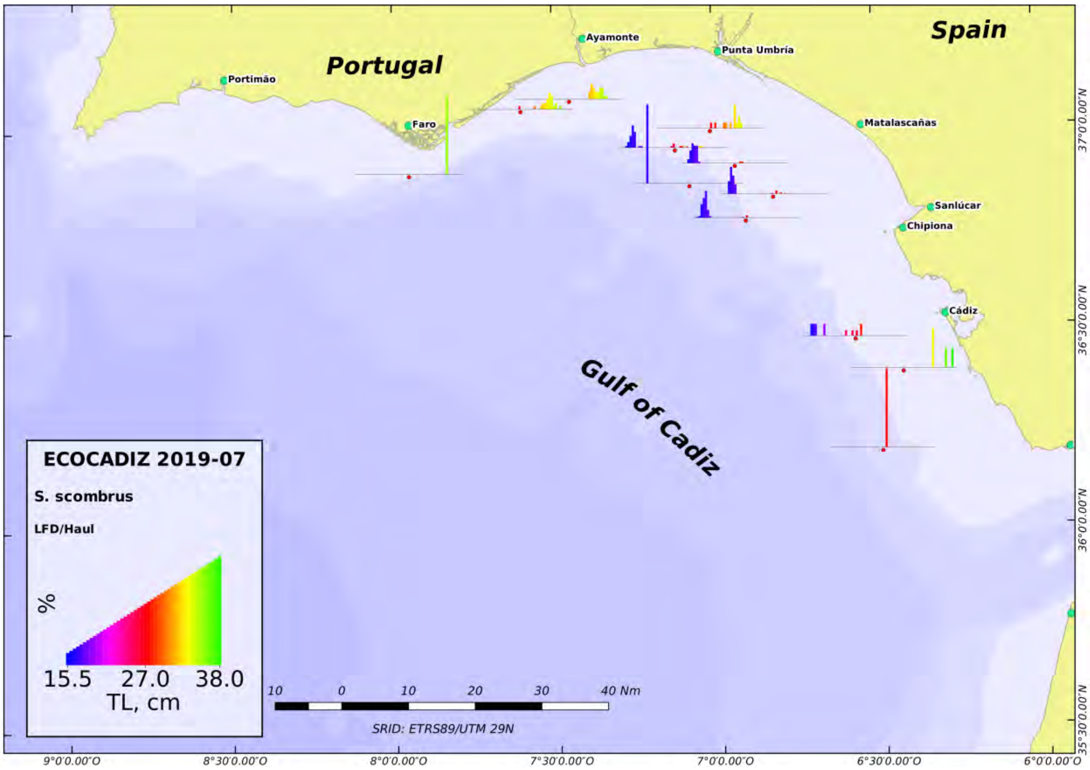


Figure 7. *ECOCADIZ 2019-07* survey. *Sardina pilchardus*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.



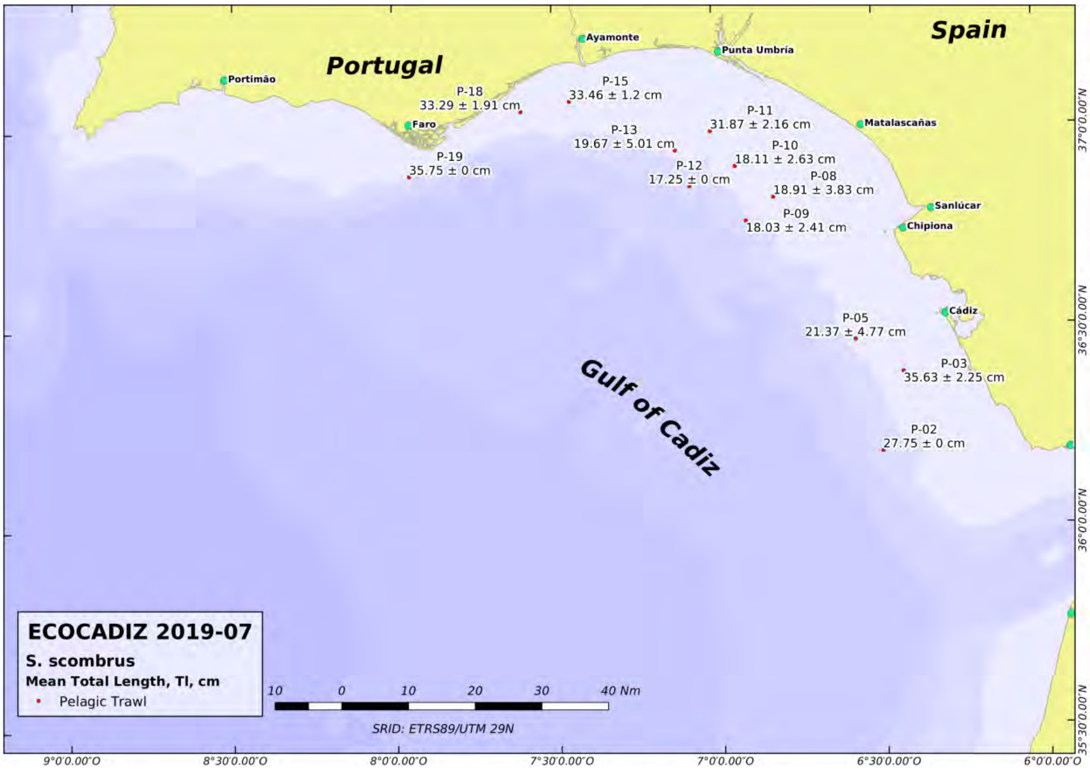


Figure 8. *ECOCADIZ 2019-07* survey. *Scomber scombrus*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

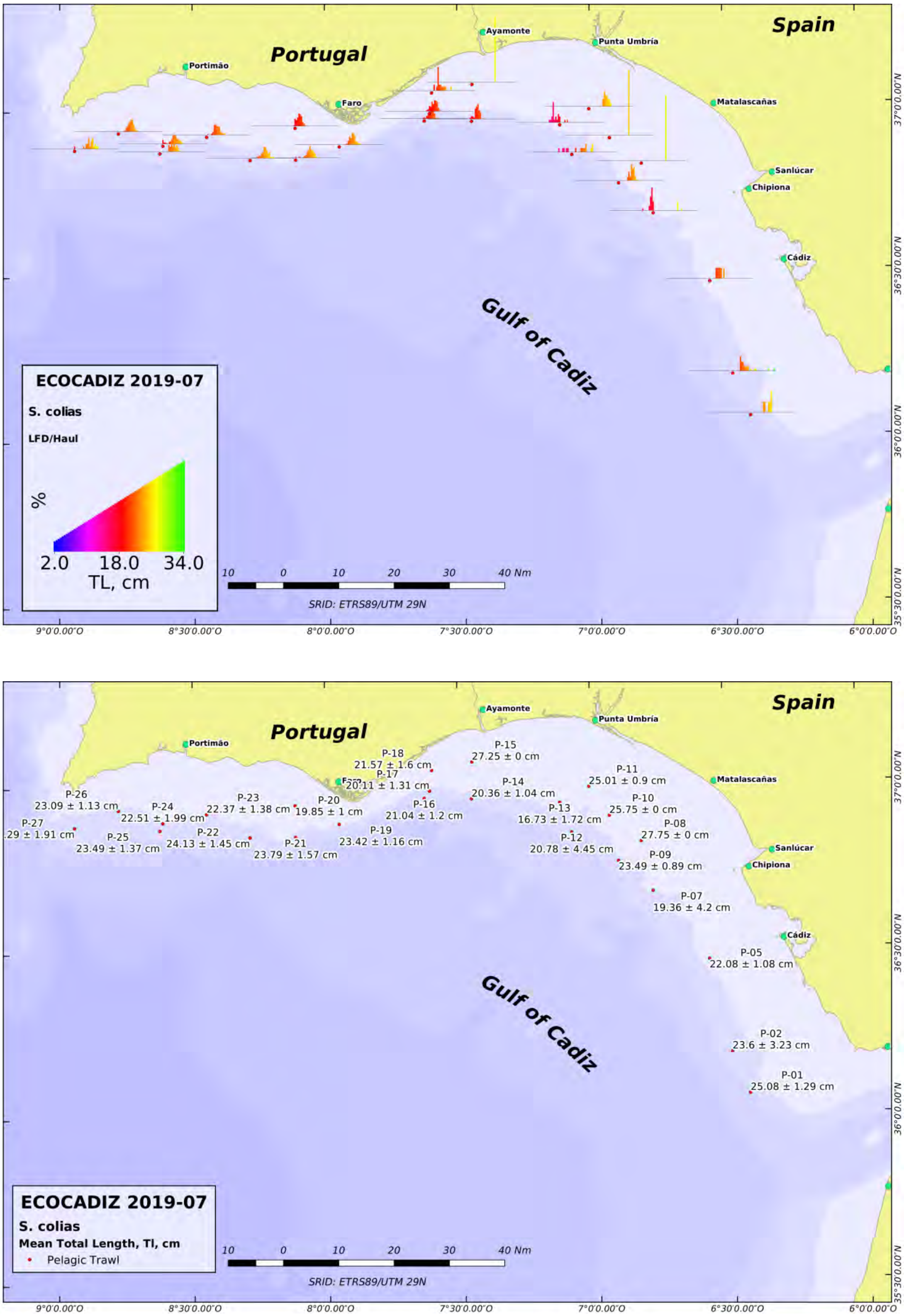
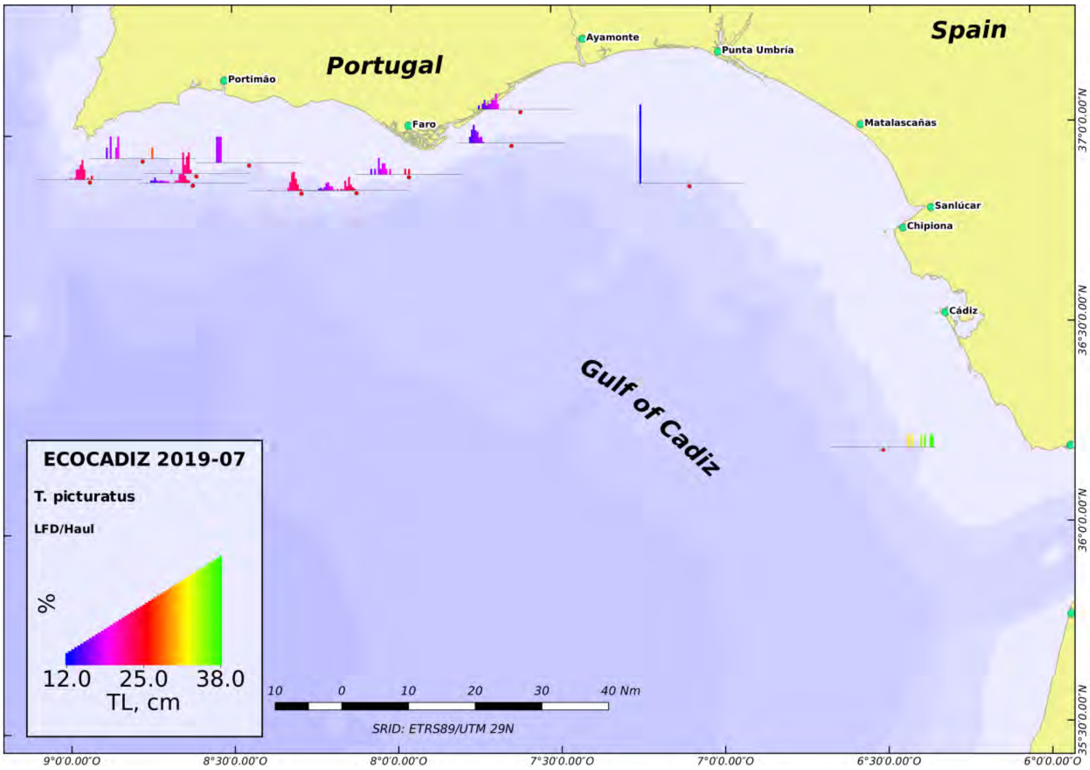


Figure 9. *ECOCADIZ 2019-07* survey. *Scomber colias*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.



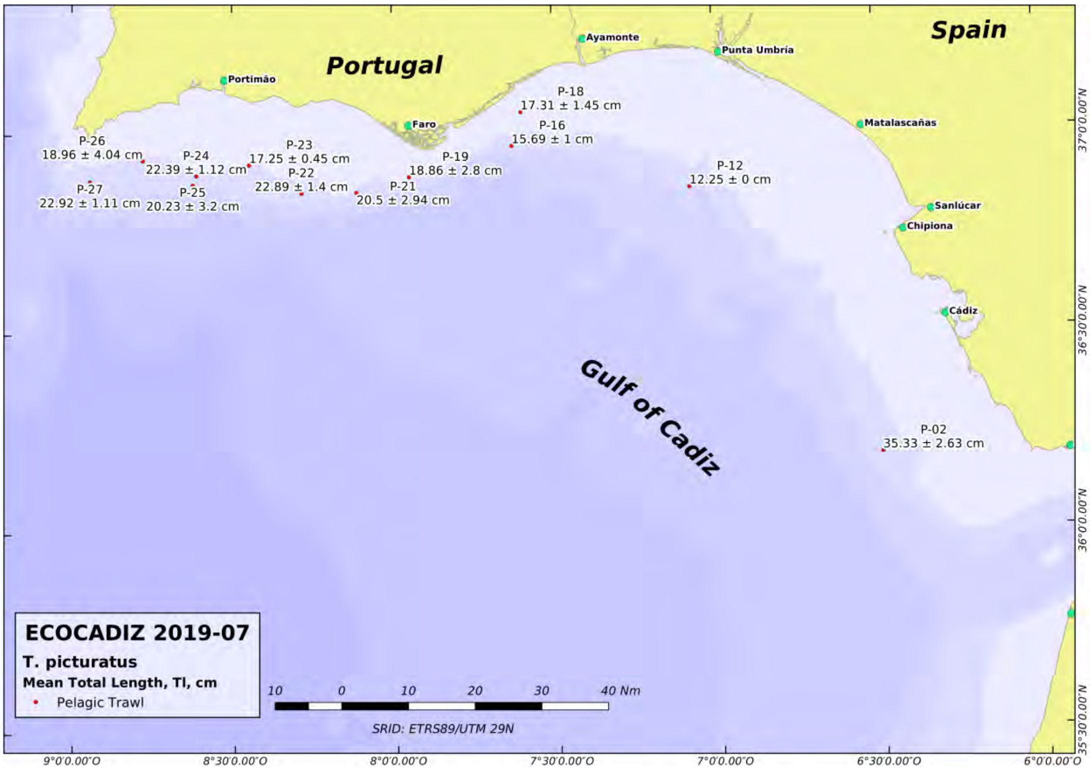


Figure 10. *ECOCADIZ 2019-07* survey. *Trachurus picturatus*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

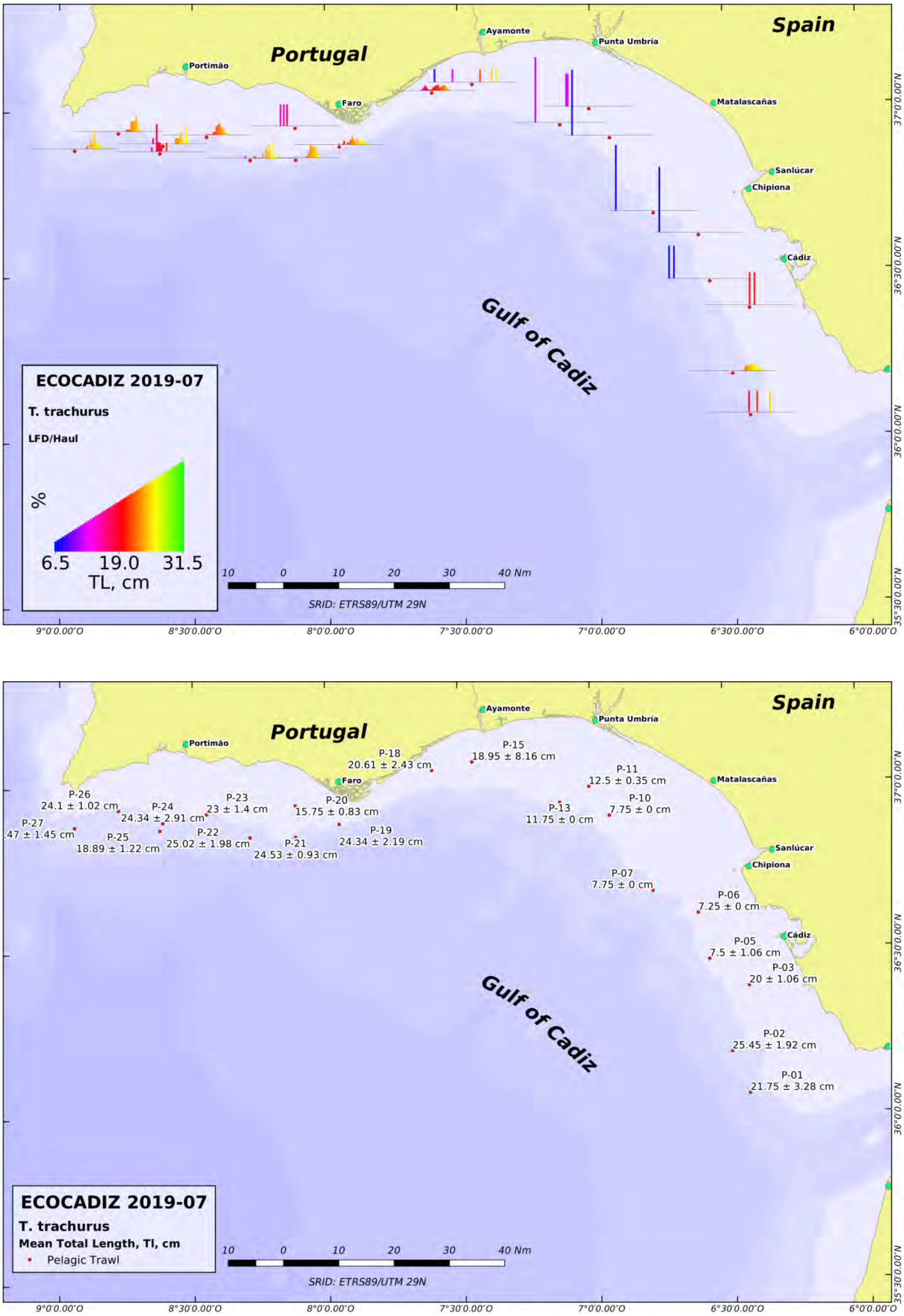
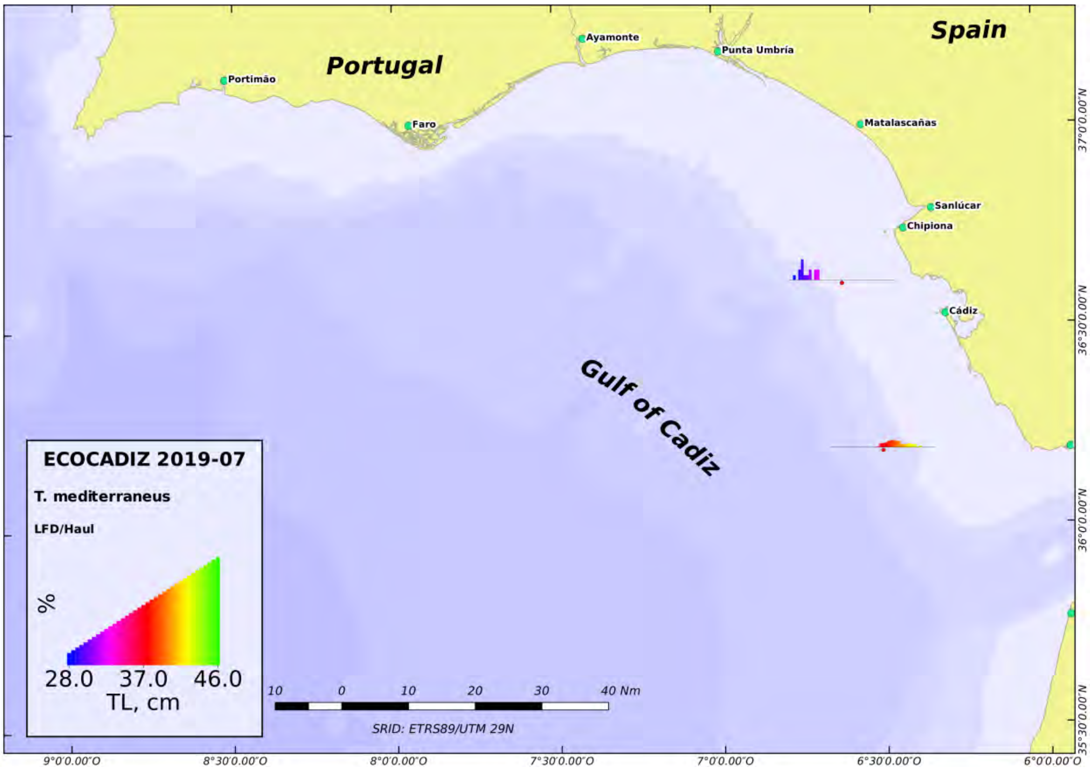


Figure 11. *ECOCADIZ 2019-07* survey. *Trachurus trachurus*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.



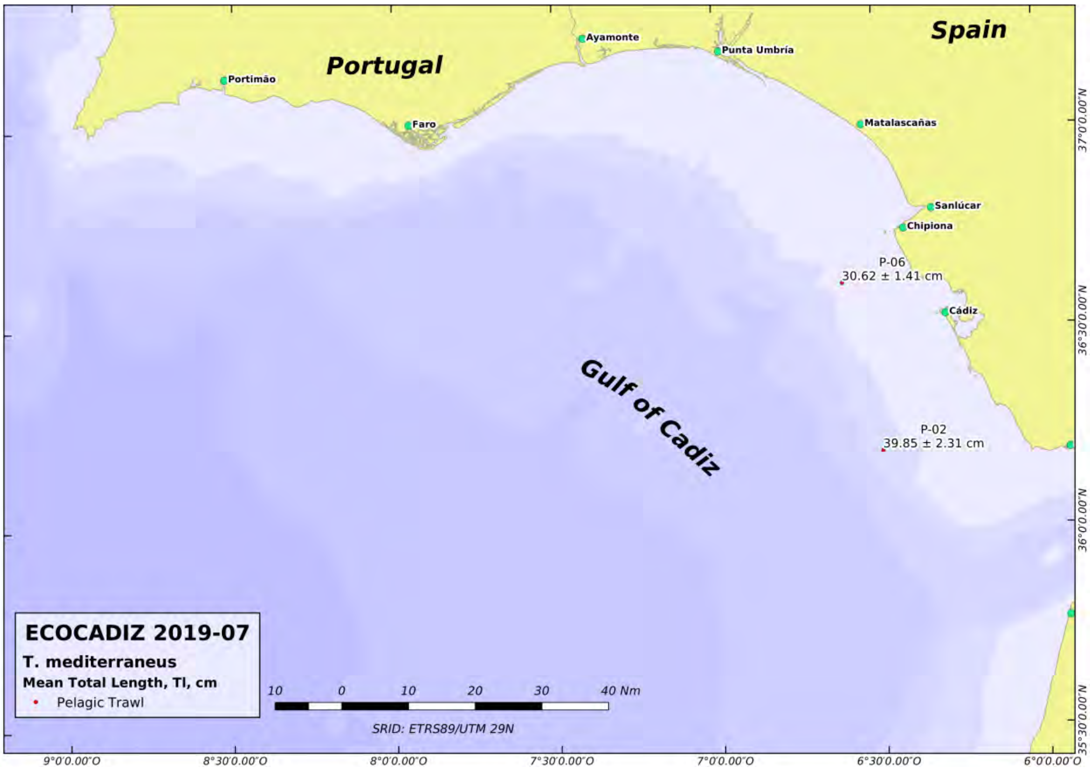


Figure 12. *ECOCADIZ 2019-07* survey. *Trachurus mediterraneus*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

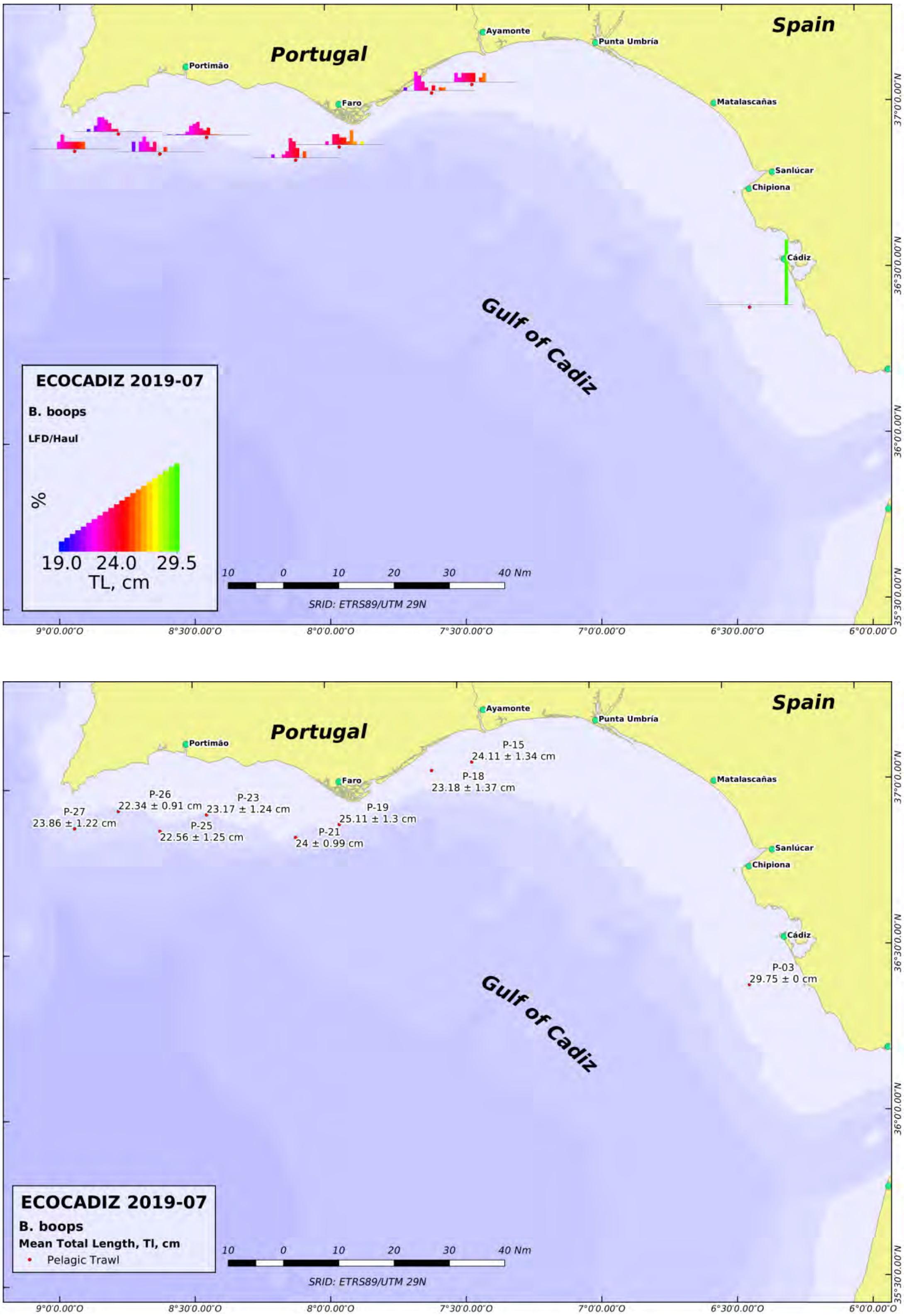


Figure 13. *ECOCADIZ 2019-07* survey. *Boops boops*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

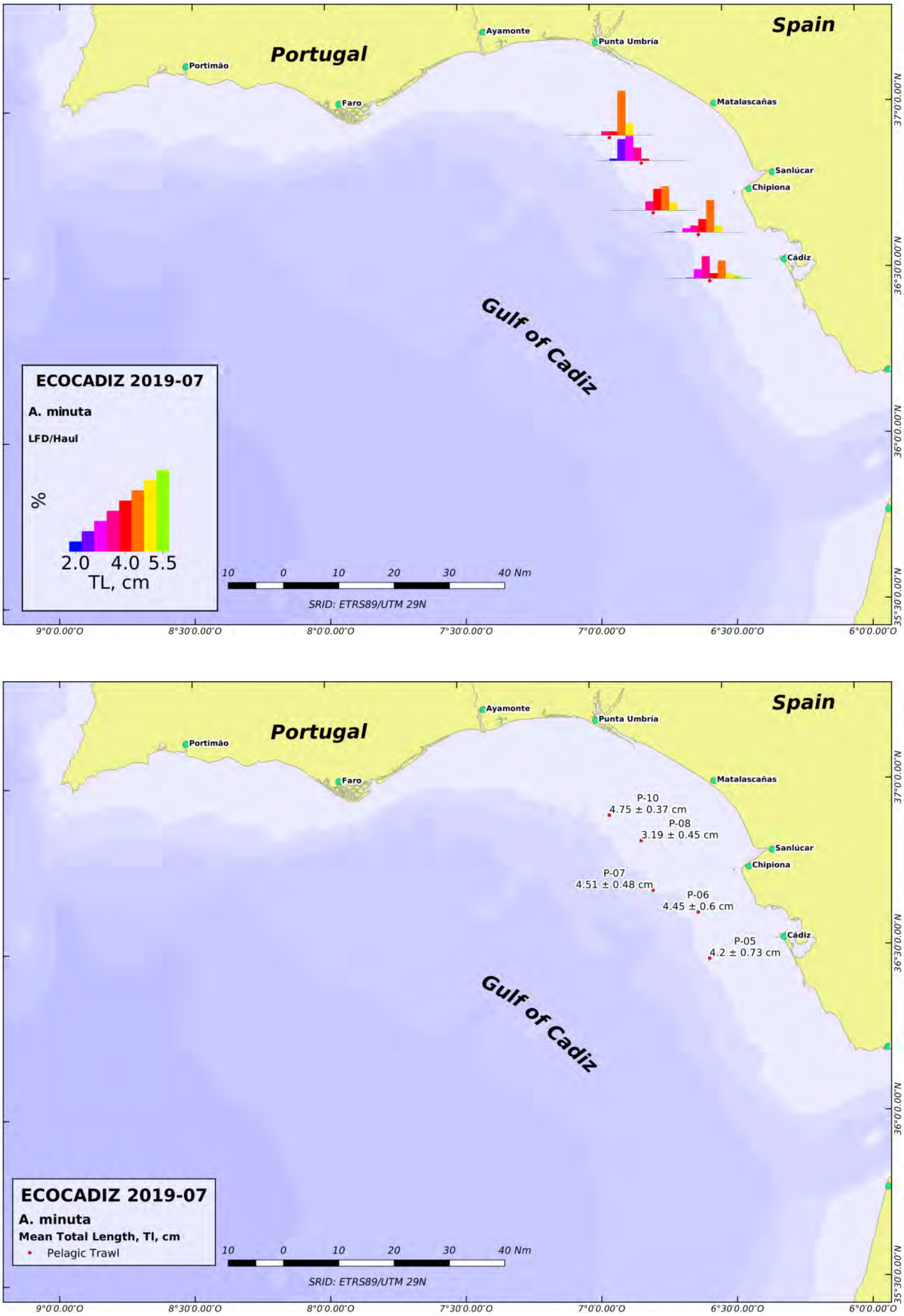


Figure 14. *ECOCADIZ 2019-07* survey. *Aphia minuta*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

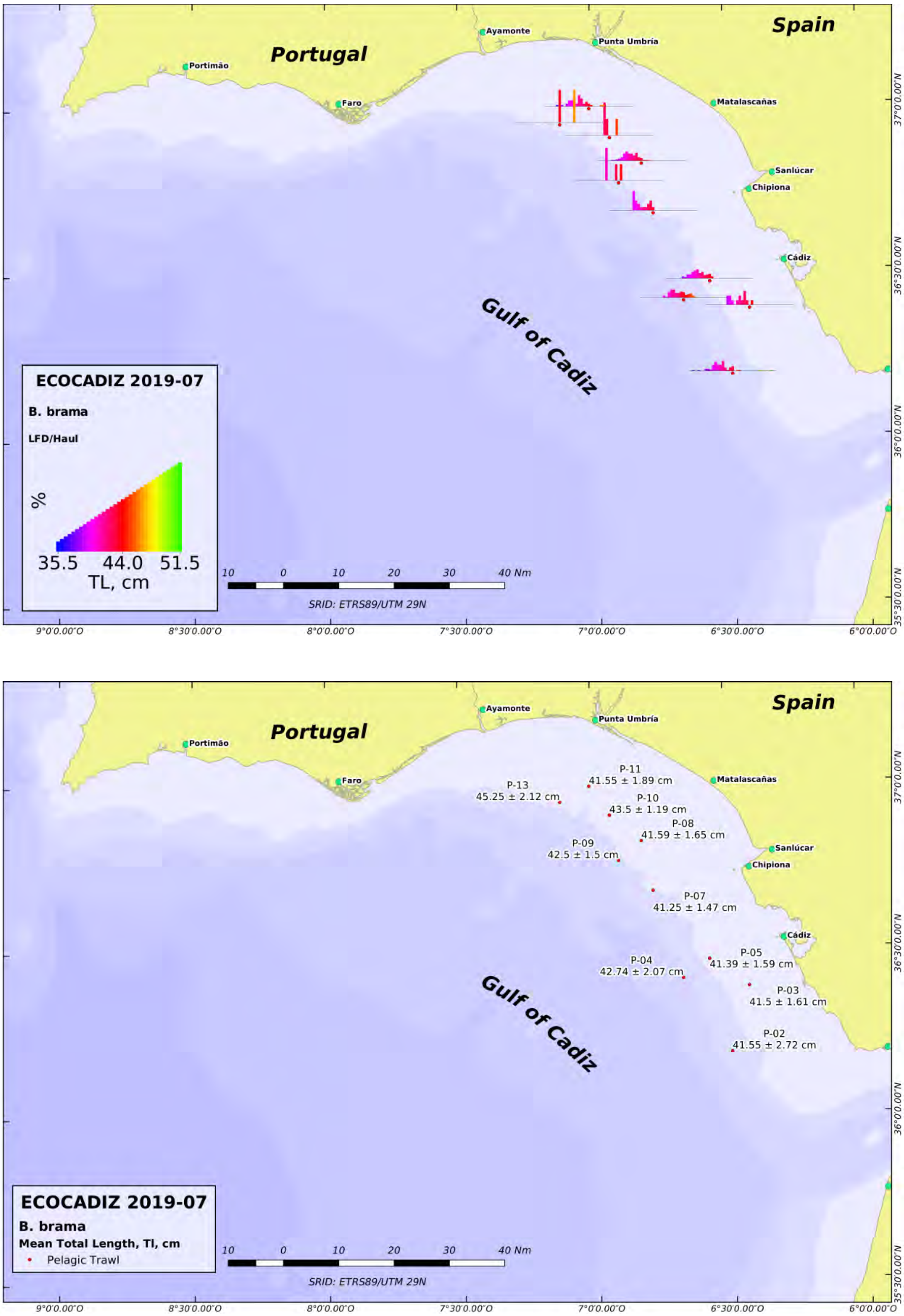
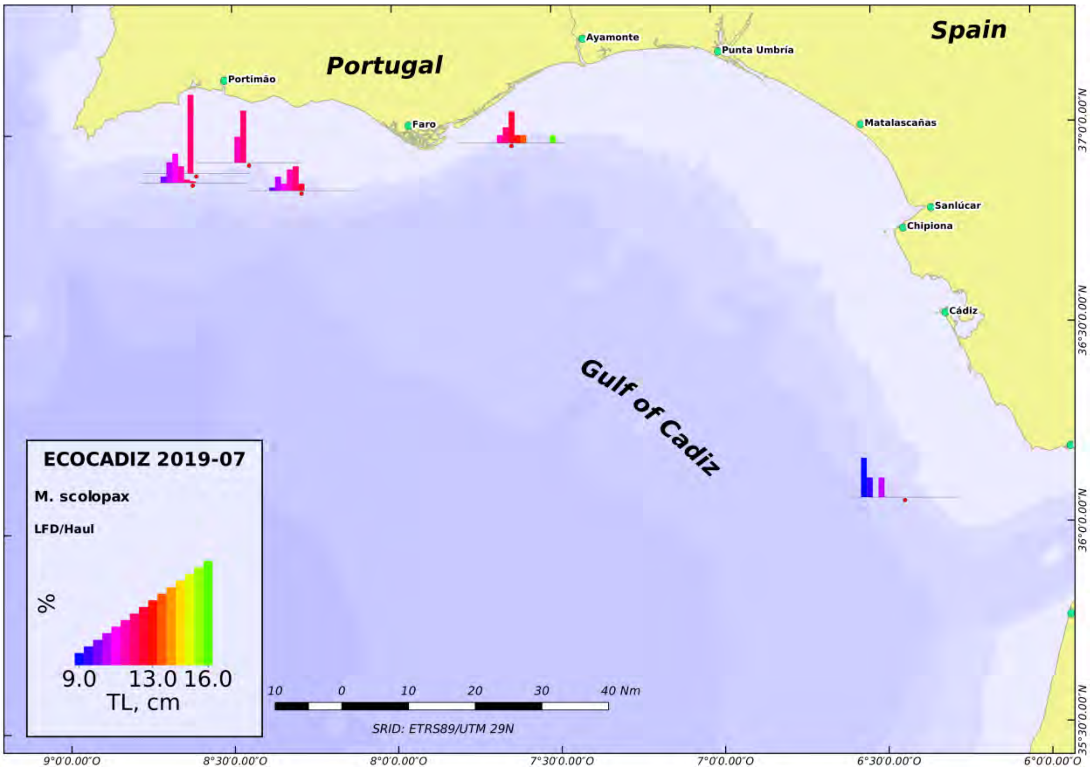


Figure 15. *ECOCADIZ 2019-07* survey. *Brama brama*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.



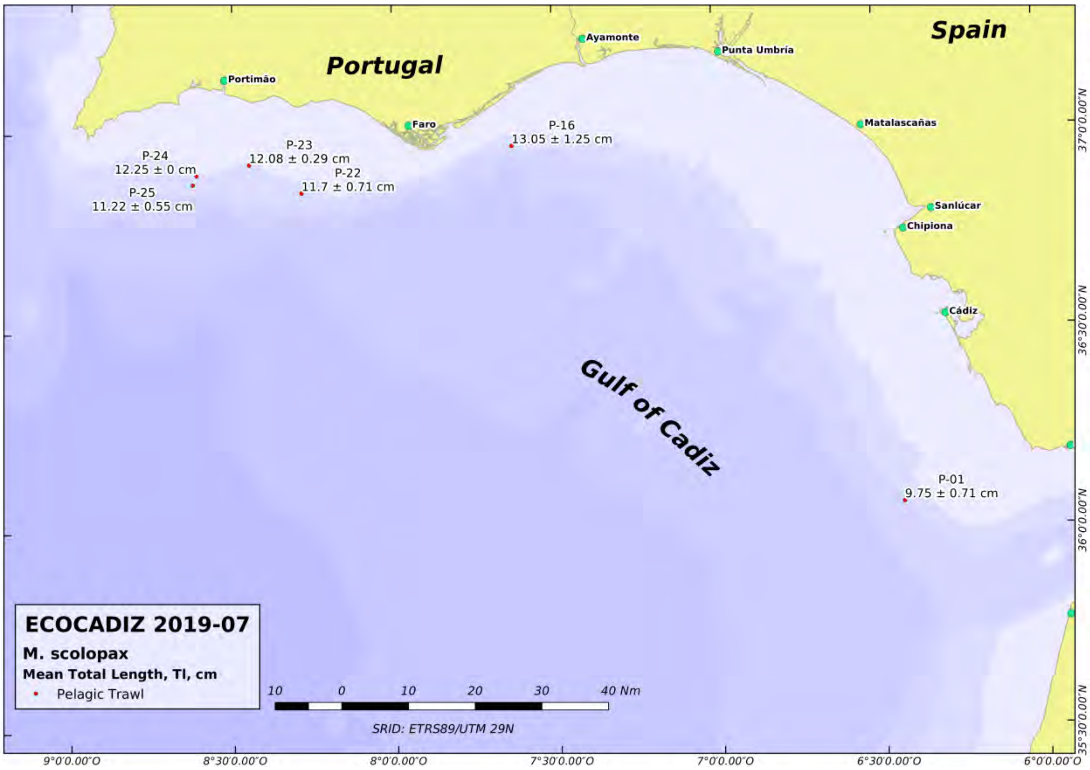


Figure 16. *ECOCADIZ 2019-07* survey. *Macrorhamphosus scolopax*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

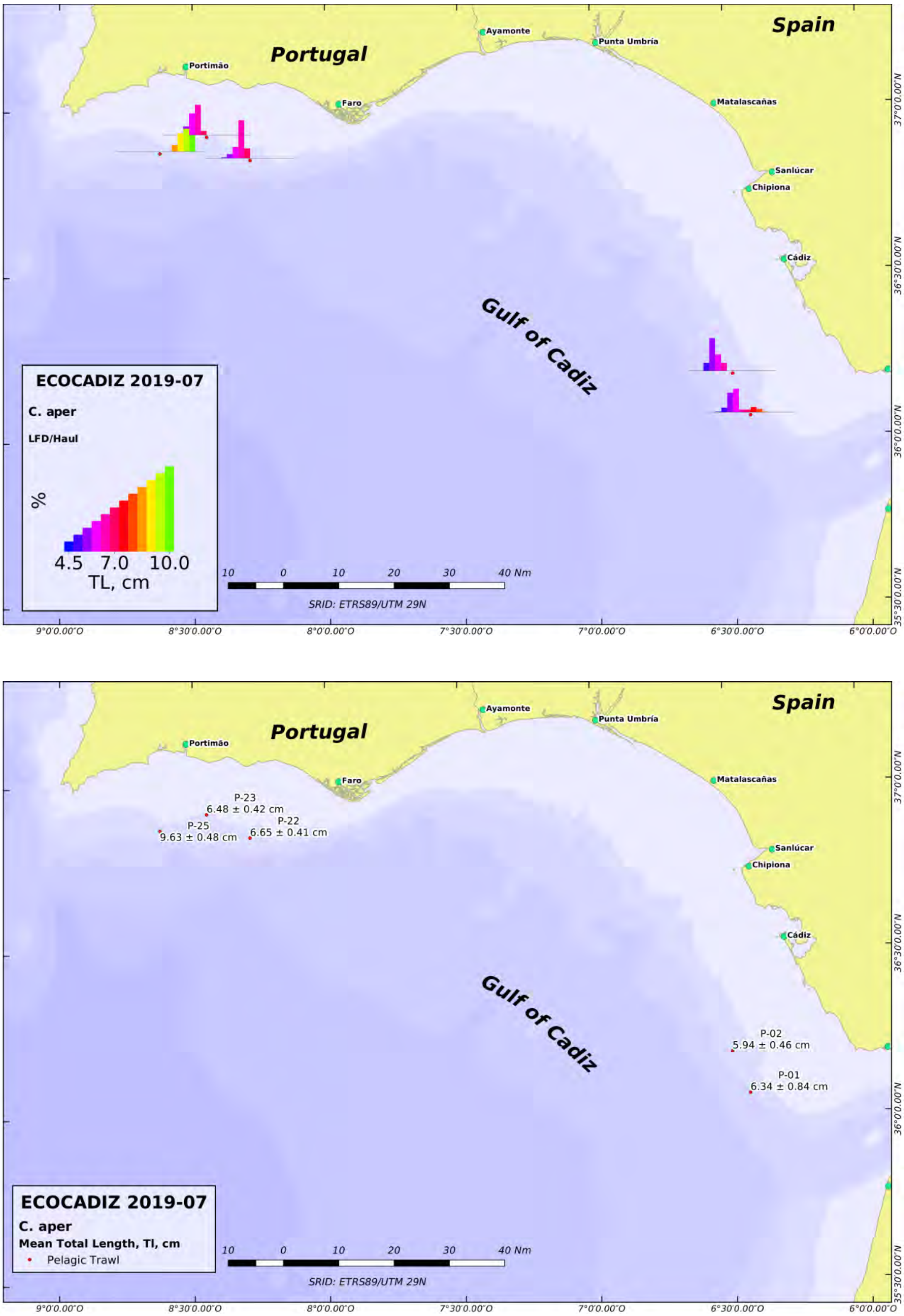
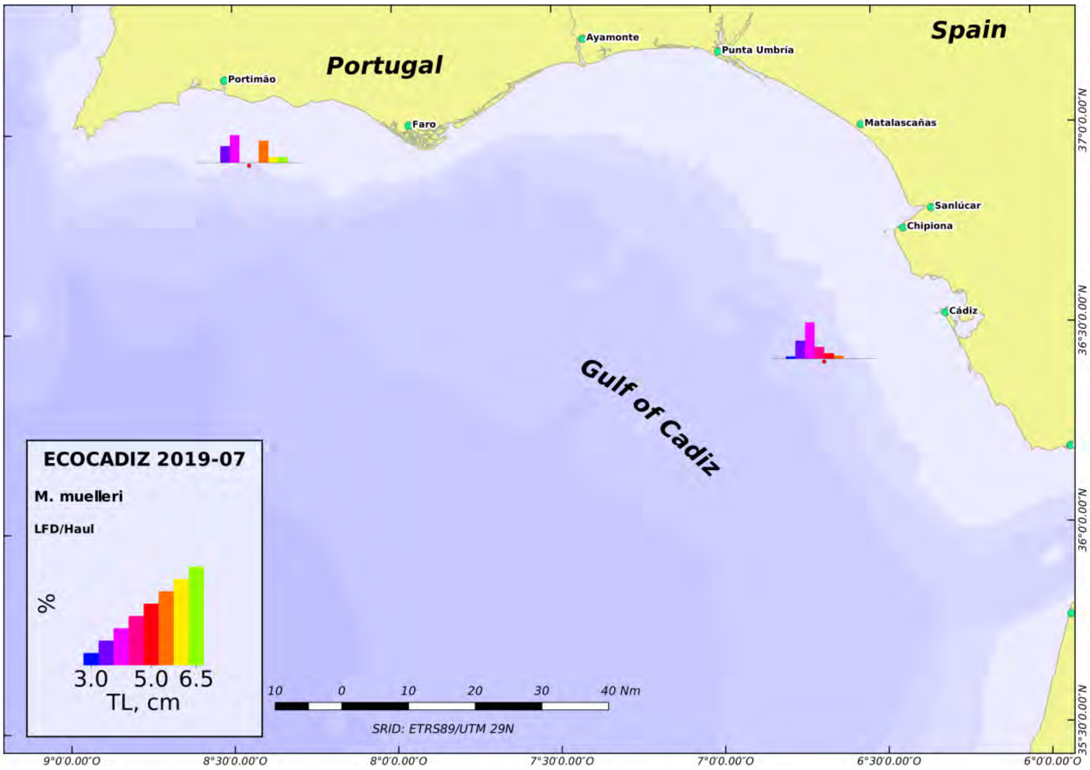


Figure 17. *ECOCADIZ 2019-07* survey. *Capros aper*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.



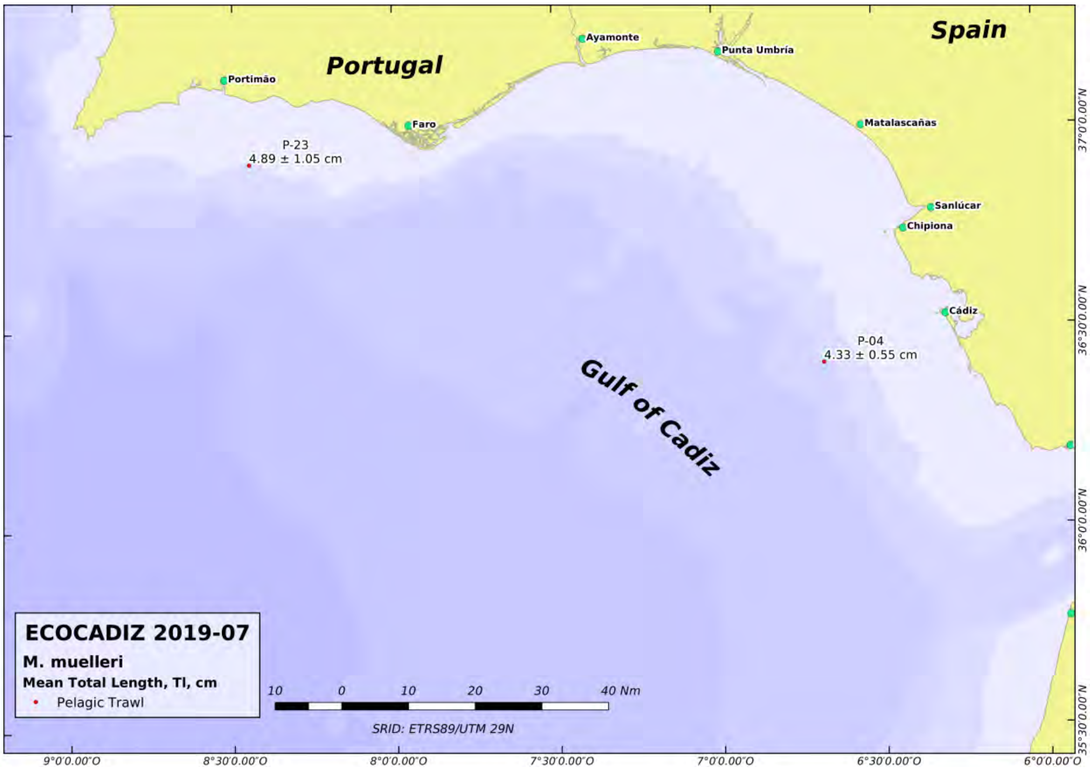


Figure 18. *ECOCADIZ 2019-07* survey. *Maurolicus muelleri*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

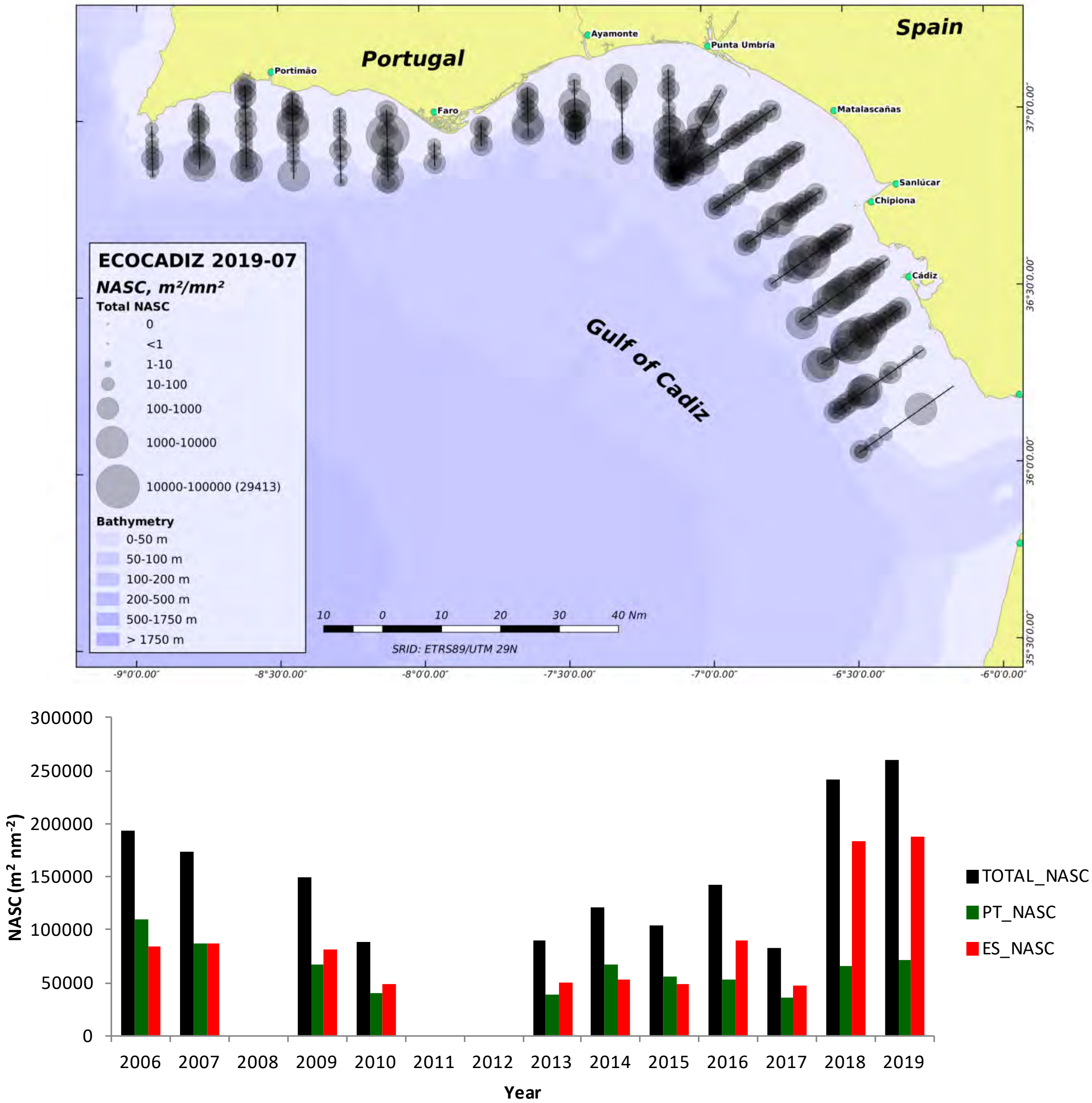
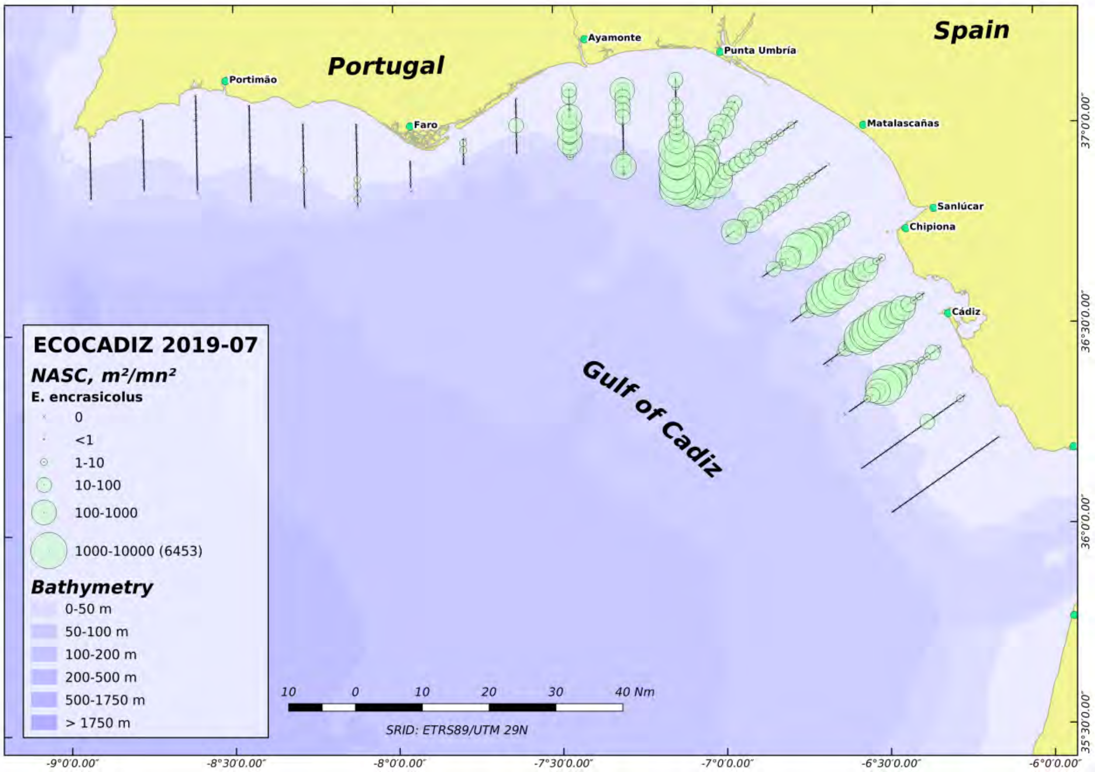


Figure 19. *ECOCADIZ 2019-07* survey. Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the pelagic fish species assemblage. Bottom: time-series of total NASC estimates per survey.



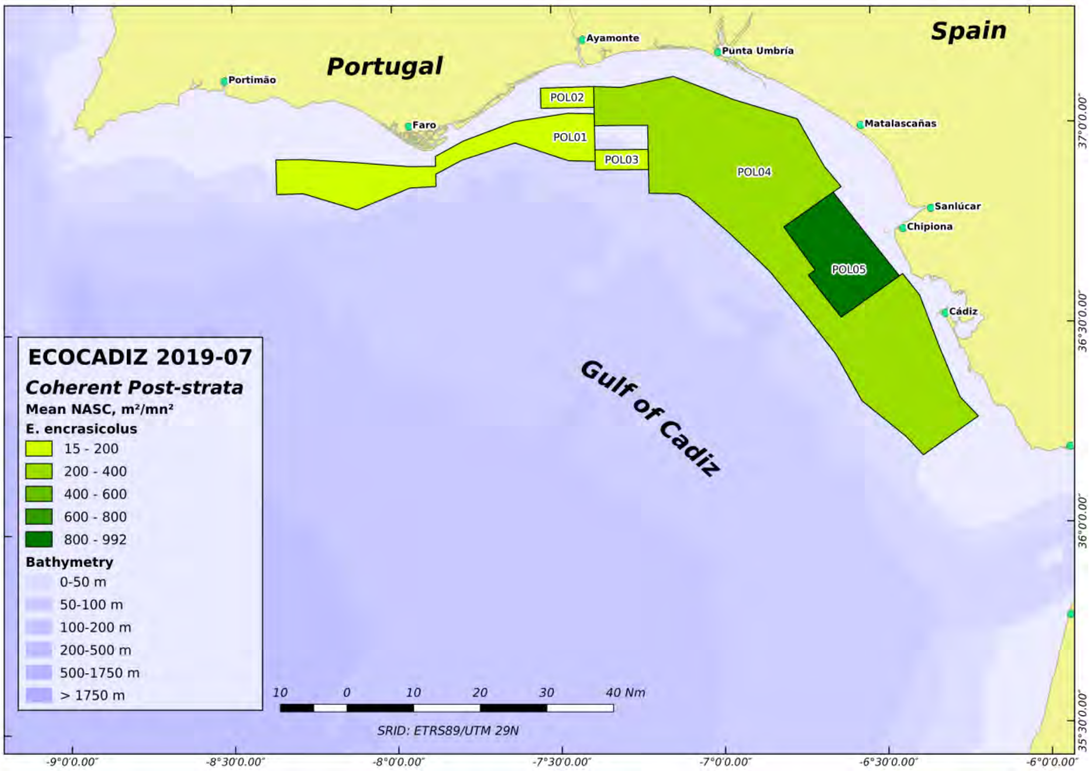


Figure 20. *ECOCADIZ 2019-07* survey. Anchovy (*Engraulis encrasicolus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

***ECOCADIZ 2019-07*: Anchovy (*E. encrasicolus*)**

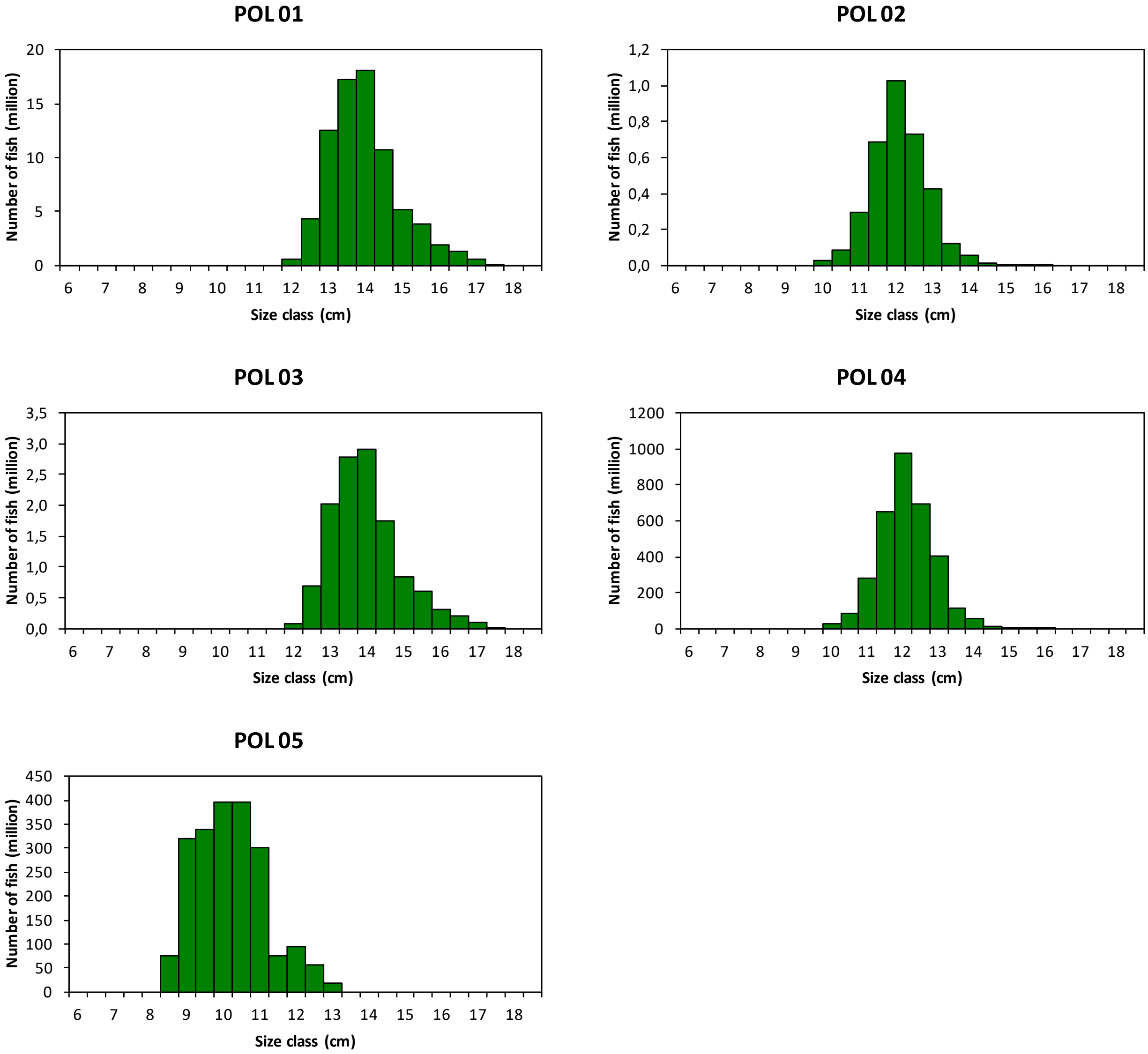


Figure 21. *ECOCADIZ 2019-07* survey. Anchovy (*E. encrasicolus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 20**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the *y* axis.

***ECOCADIZ 2019-07*: Anchovy (*E. encrasicolus*)**

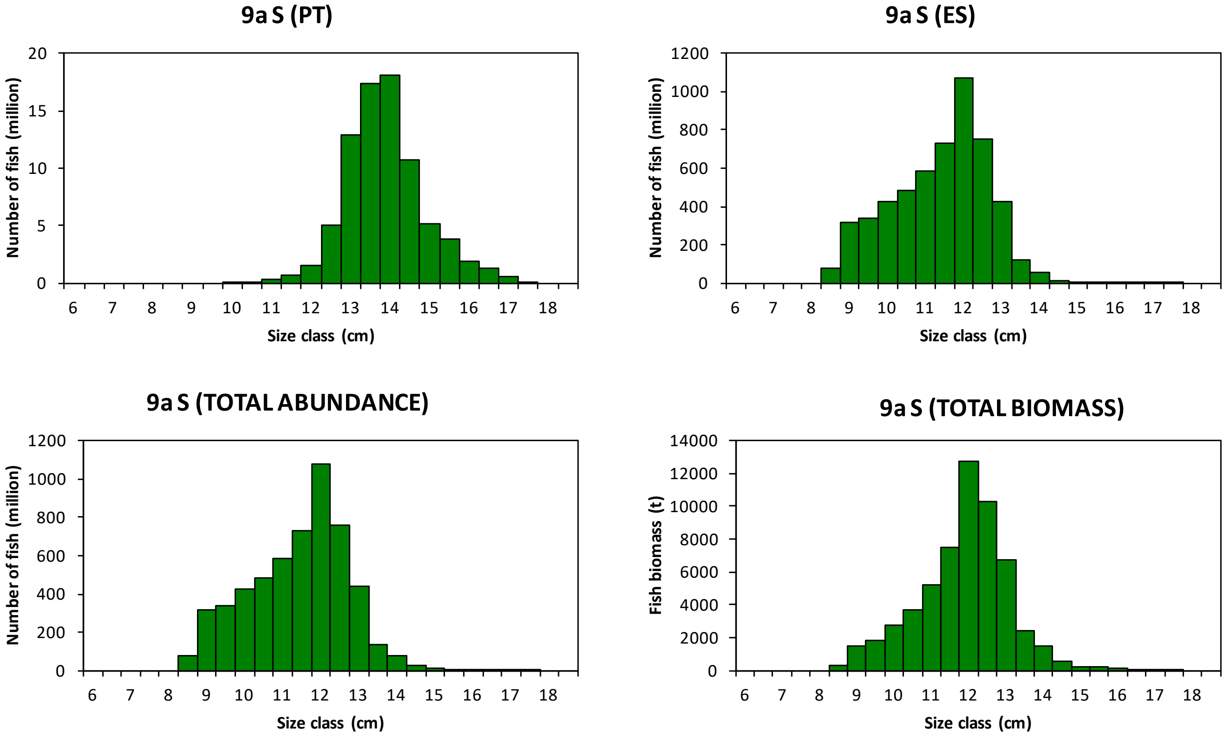


Figure 21. *ECOCADIZ 2019-07* survey. Anchovy (*E. encrasicolus*). Cont'd.

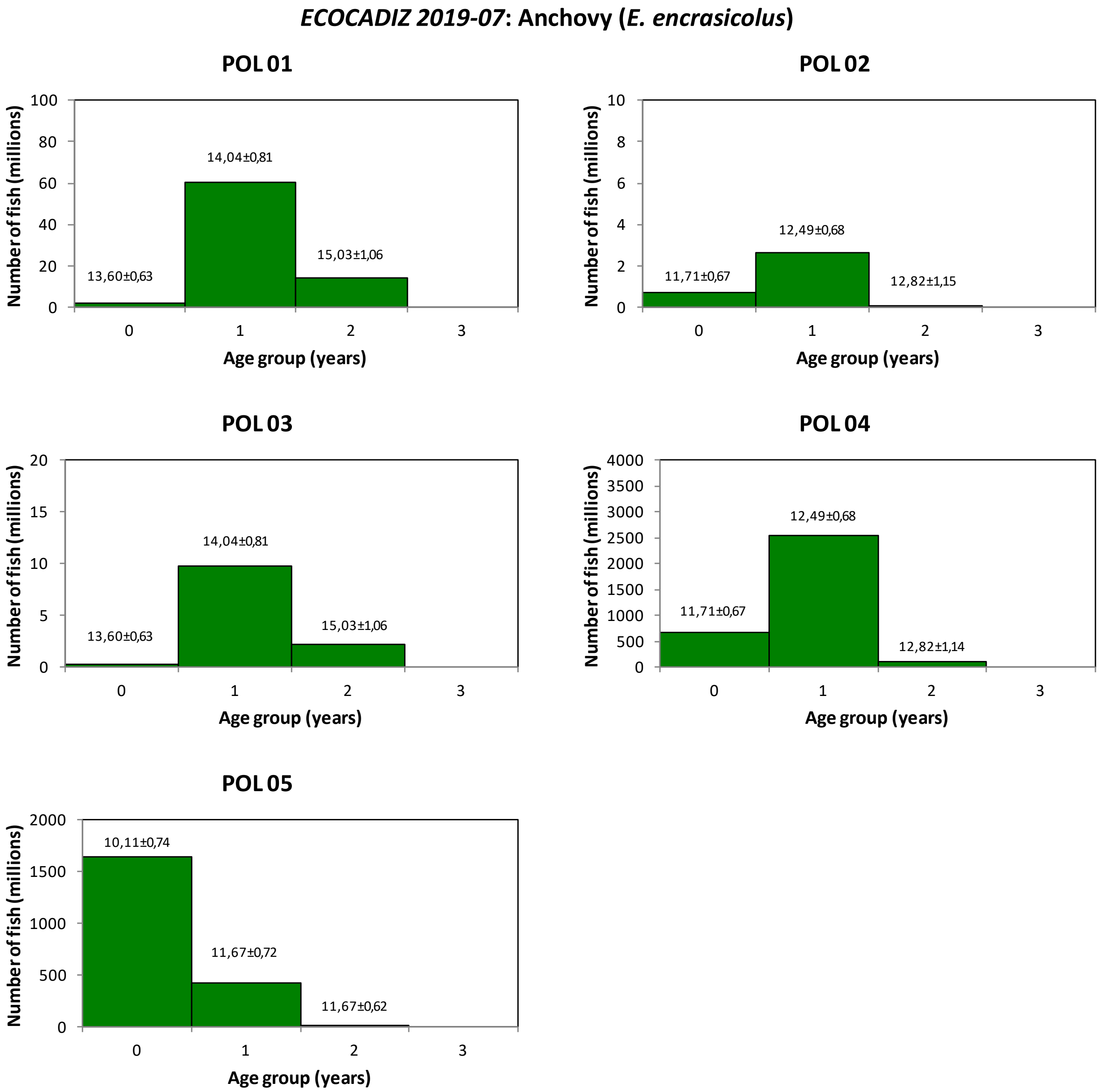


Figure 22. *ECOCADIZ 2019-07* survey. Anchovy (*E. encrasicolus*). Estimated abundances (number of fish in millions) by age group (years) by homogeneous stratum (POL01-POLn, numeration as in **Figure 20**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by age group for the whole sampled area is also shown for comparison. Note the different scales in the *y* axis.

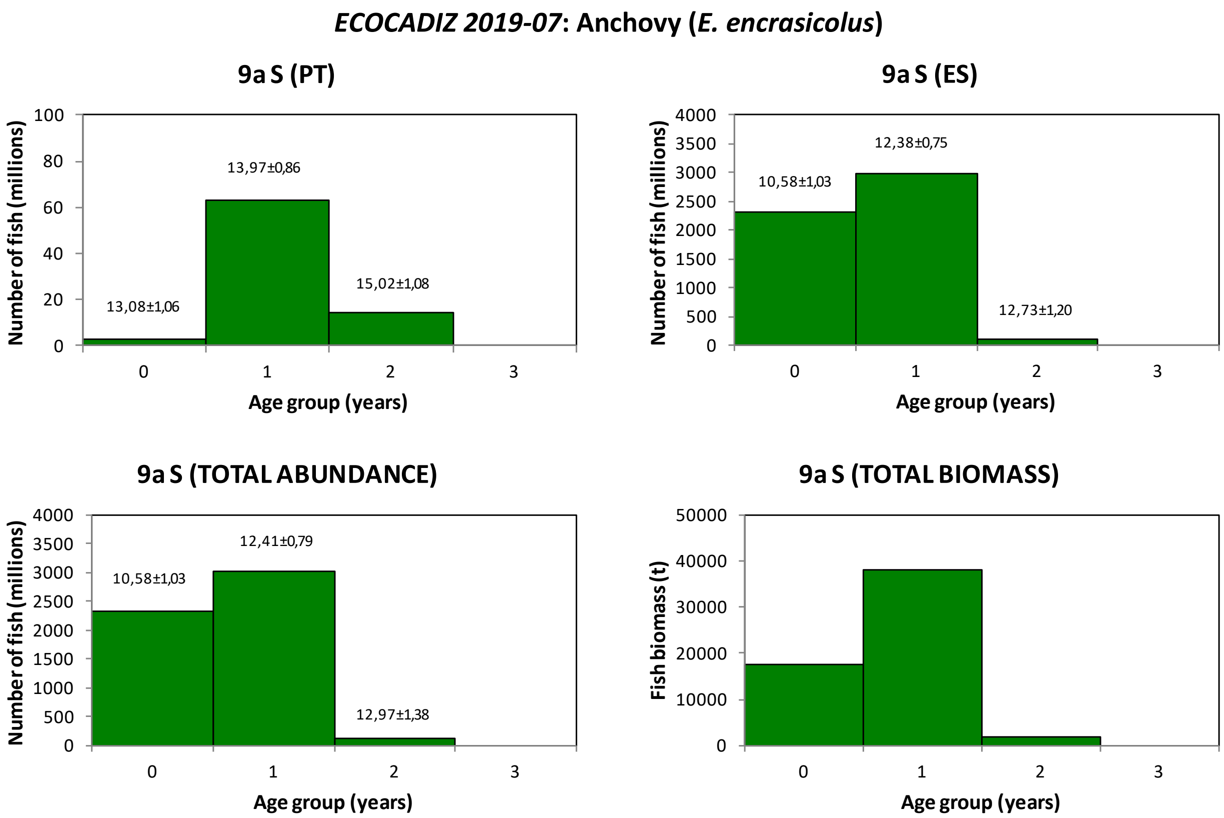
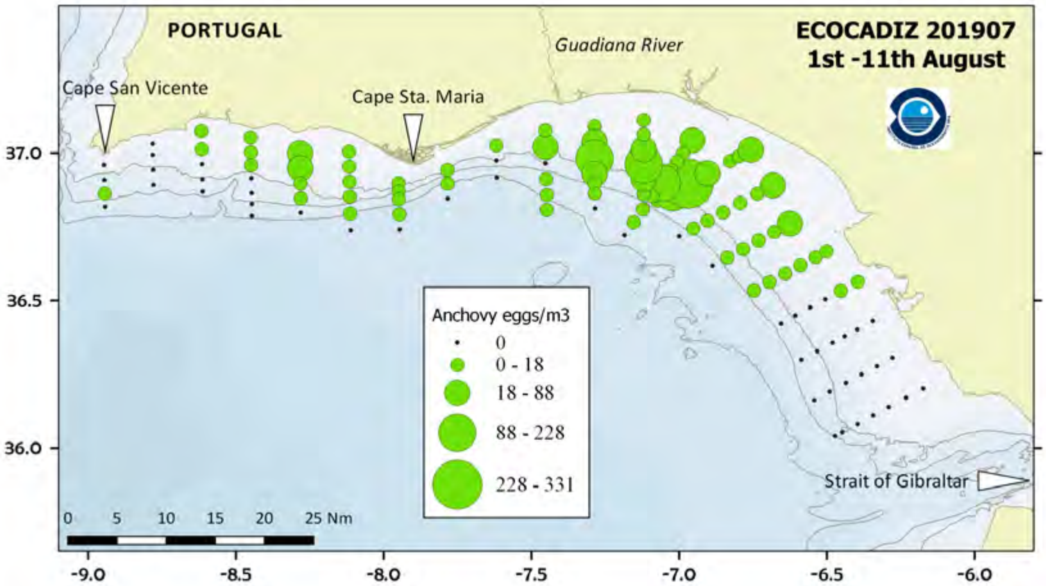
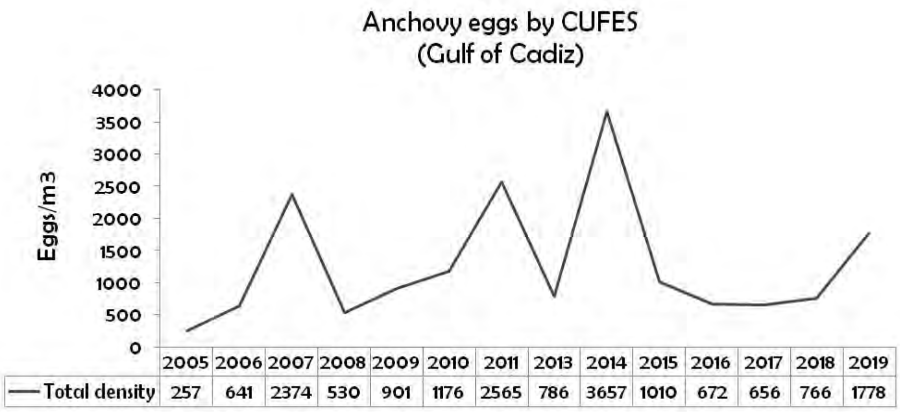


Figure 22. *ECOCADIZ 2019-07* survey. Anchovy (*E. encrasicolus*). Cont'd.



ECOCADIZ 2019-07	
CUFES st	121
Positive anchovy st8	73 (60.3 %)
Max number eggs by st	3599
Total anchovy eggs (in number)	19031
Max density by st (eggs/m^3)	331.4
Total density (eggs/m^3)	1778

Figure 23. *ECOCADIZ 2019-07* survey. Anchovy (*E. encrasicolus*). Top: distribution of anchovy egg densities sampled by CUFES (eggs m^{-3}). Bottom: main descriptors of the CUFES sampling.



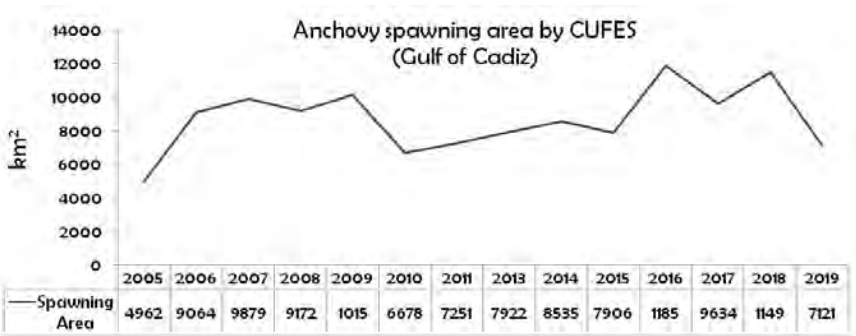


Figure 23. *ECOCADIZ 2019-07* survey. Anchovy (*E. encrasicolus*). Cont'd. Top: historical series of GoC anchovy egg total densities (eggs * m^{-3}) sampled by CUFES. Bottom: historical series of estimates of the extension of the GoC anchovy spawning area (in km^2).

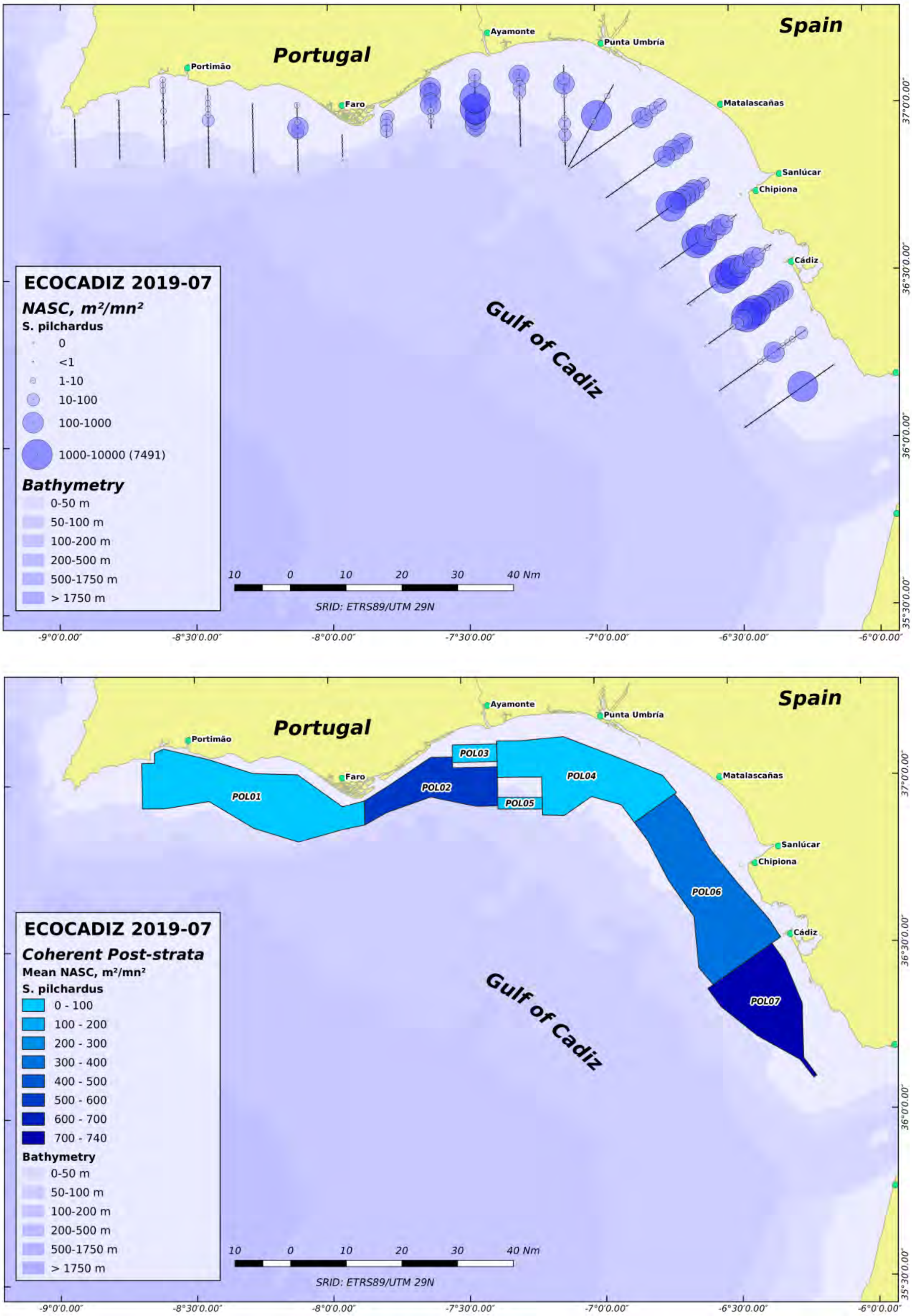


Figure 24. *ECOCADIZ 2019-07* survey. Sardine (*Sardina pilchardus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

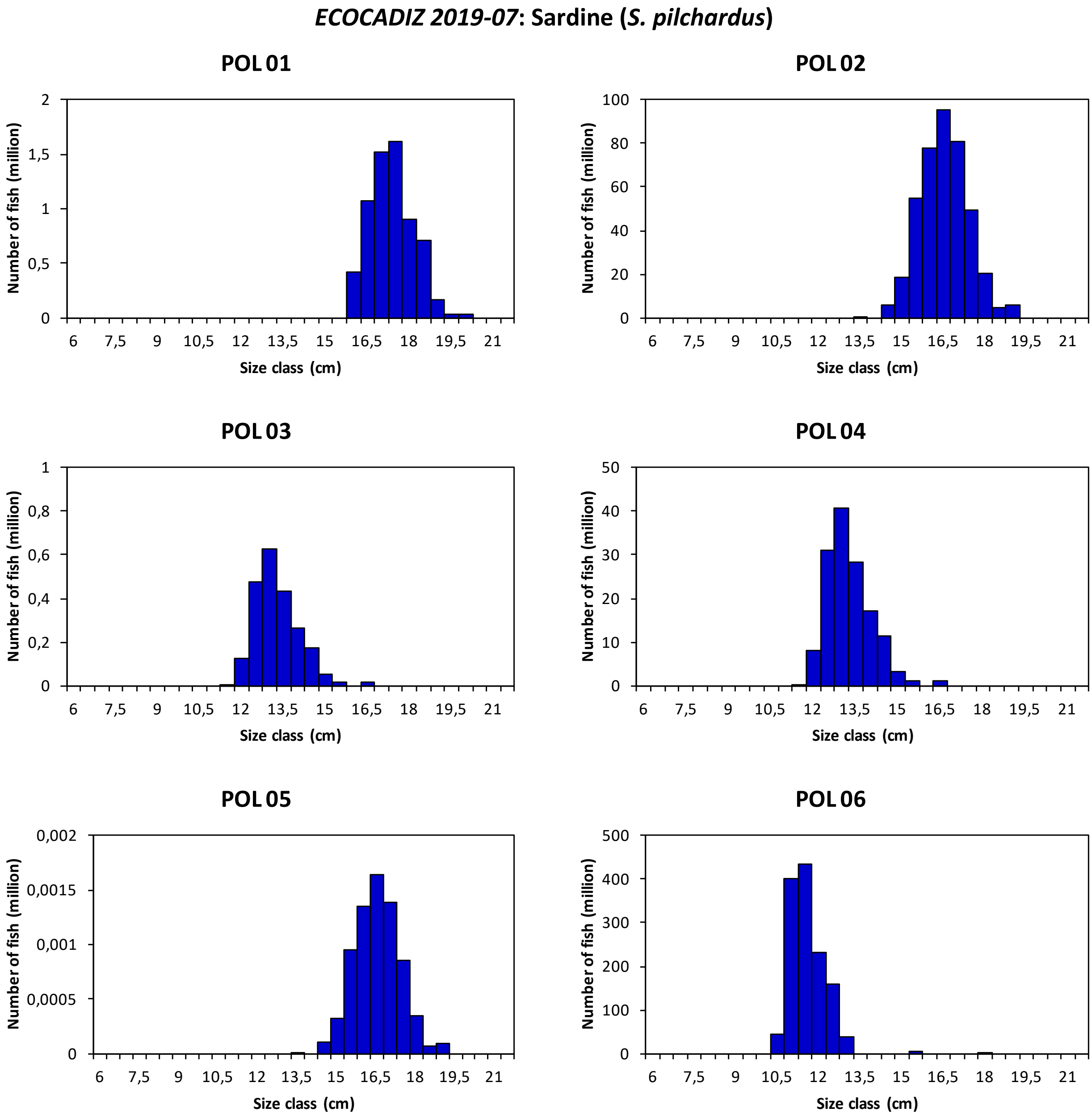


Figure 25. *ECOCADIZ 2019-07* survey. Sardine (*S. pilchardus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 24**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the *y* axis.

ECOCADIZ 2019-07: Sardine (*S. pilchardus*)

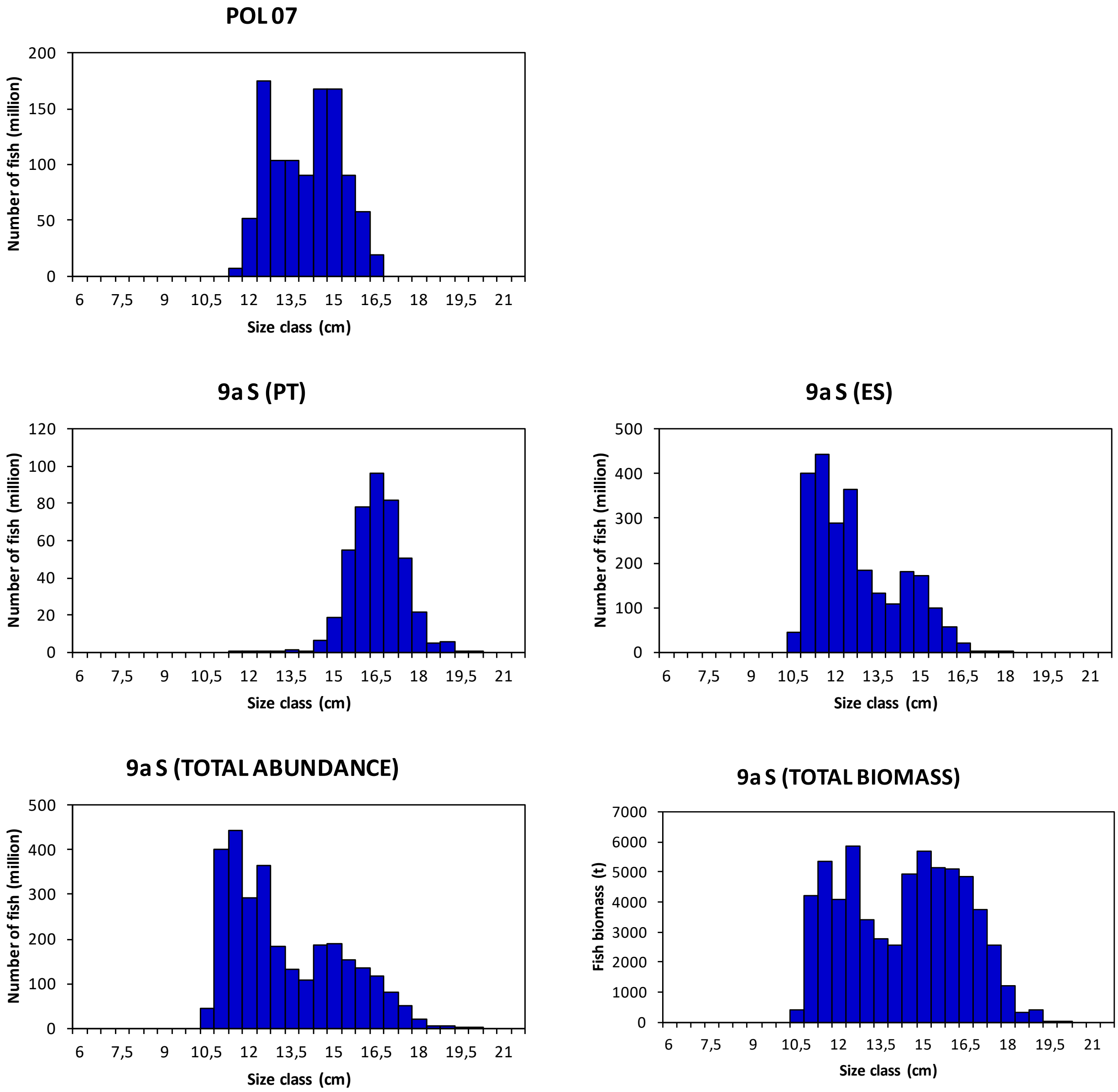


Figure 25. *ECOCADIZ 2019-07* survey. Sardine (*S. pilchardus*). Cont'd.

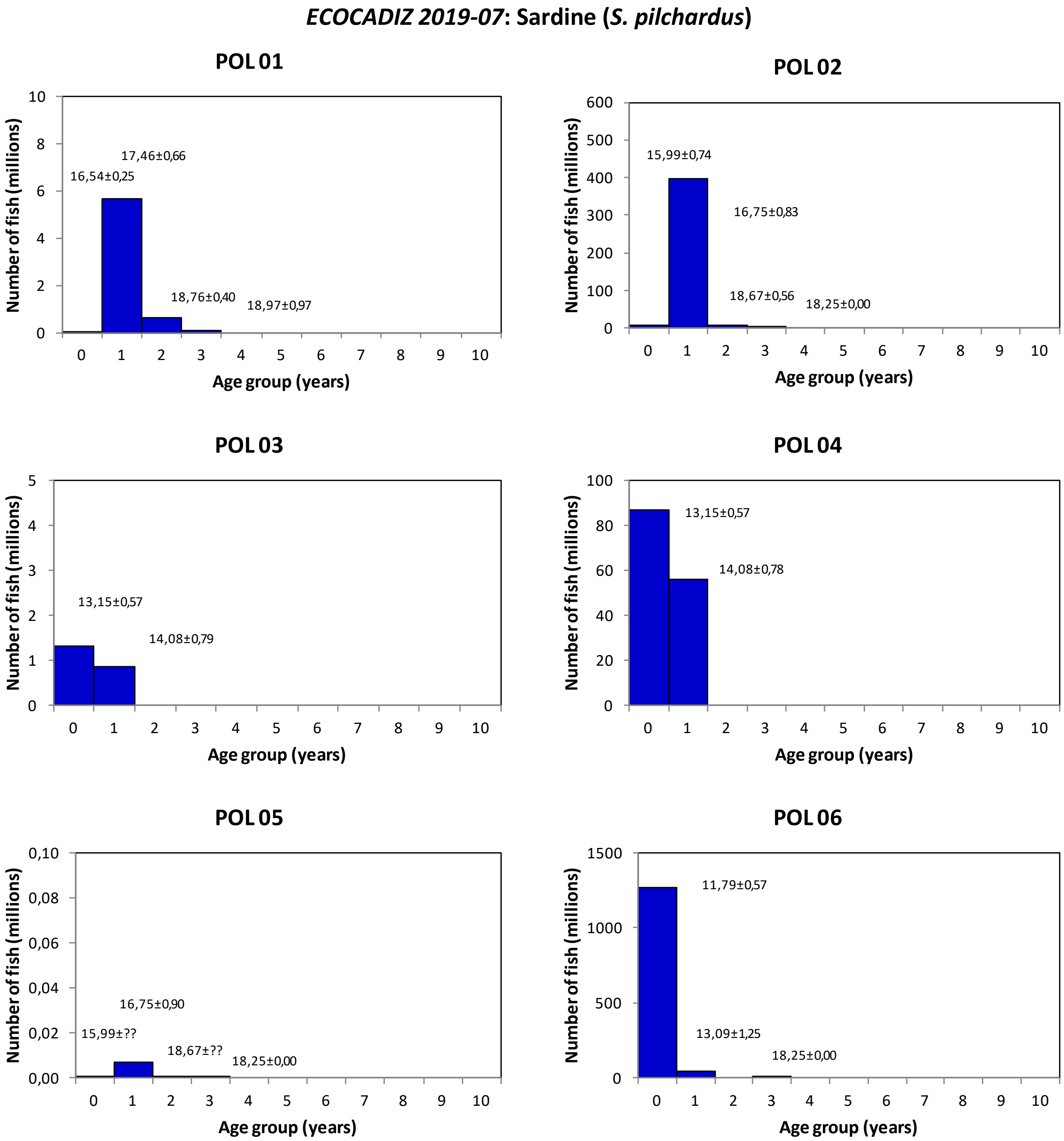


Figure 26. *ECOCADIZ 2019-07* survey. Sardine (*S. pilchardus*). Estimated abundances (number of fish in millions) by age group (years) by homogeneous stratum (POL01-POLn, numeration as in **Figure 24**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the *y* axis.

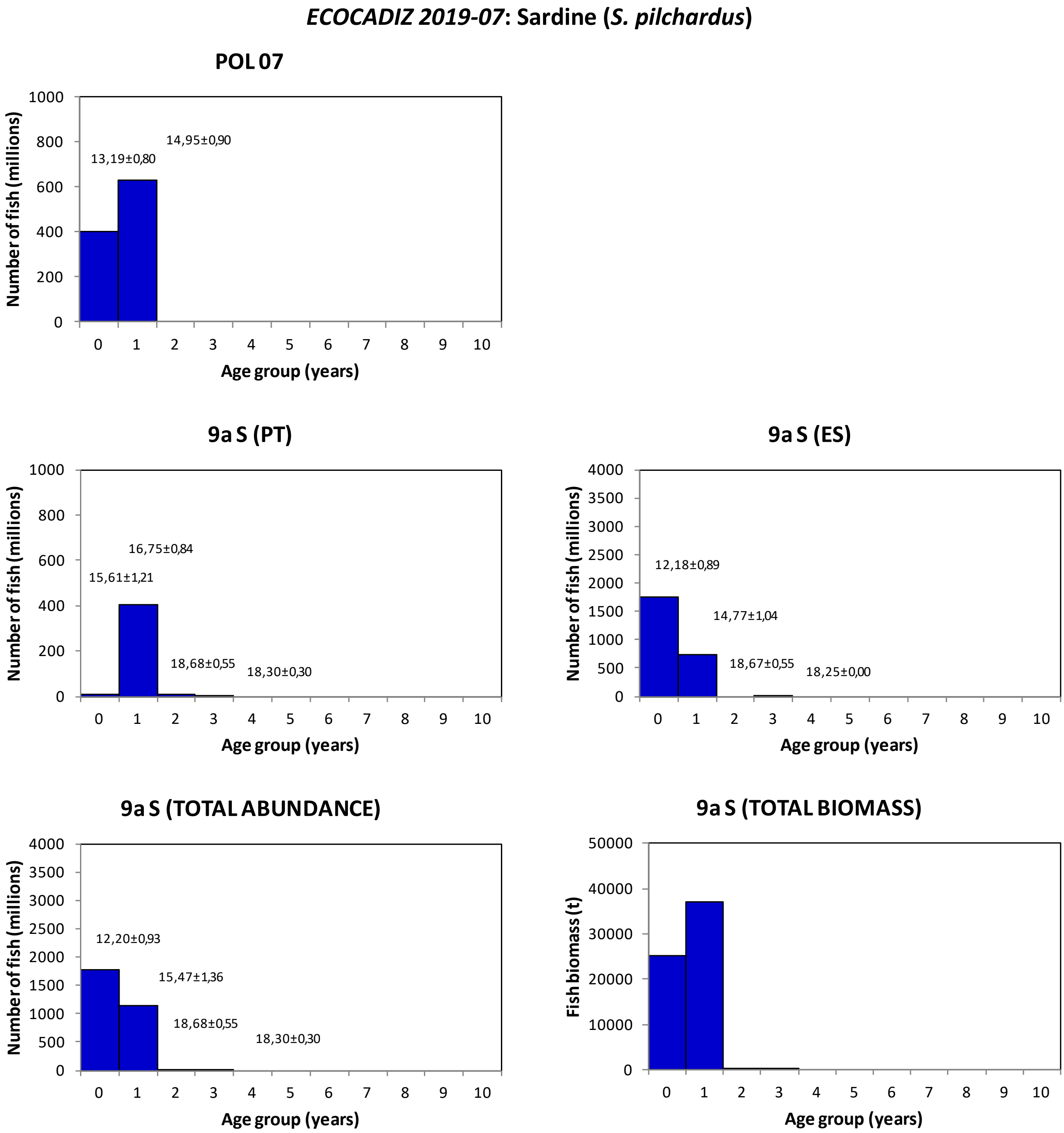


Figure 26. *ECOCADIZ 2019-07* survey. Sardine (*S. pilchardus*). Cont'd.

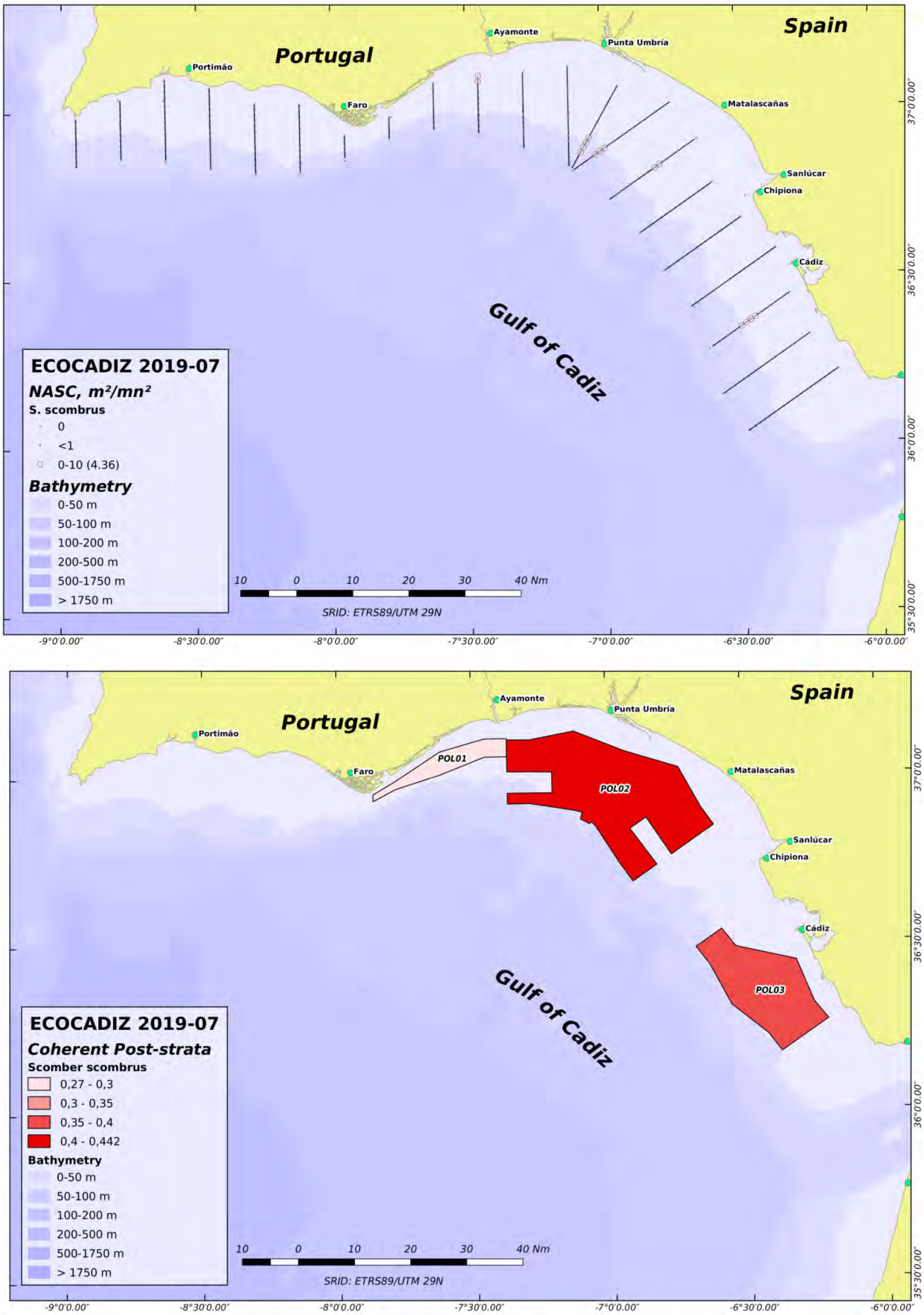


Figure 27. *ECOCADIZ 2019-07* survey. Mackerel (*Scomber scombrus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

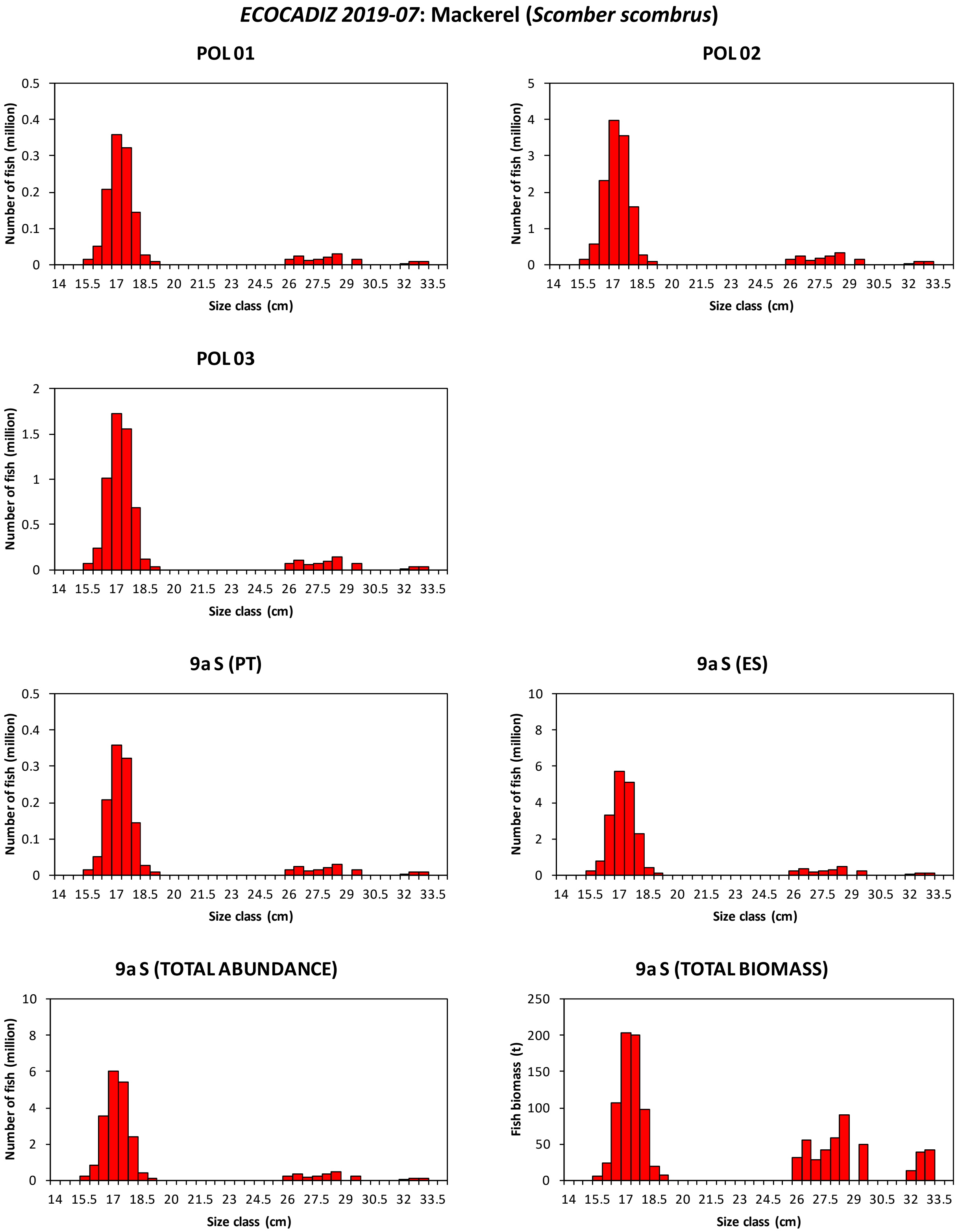
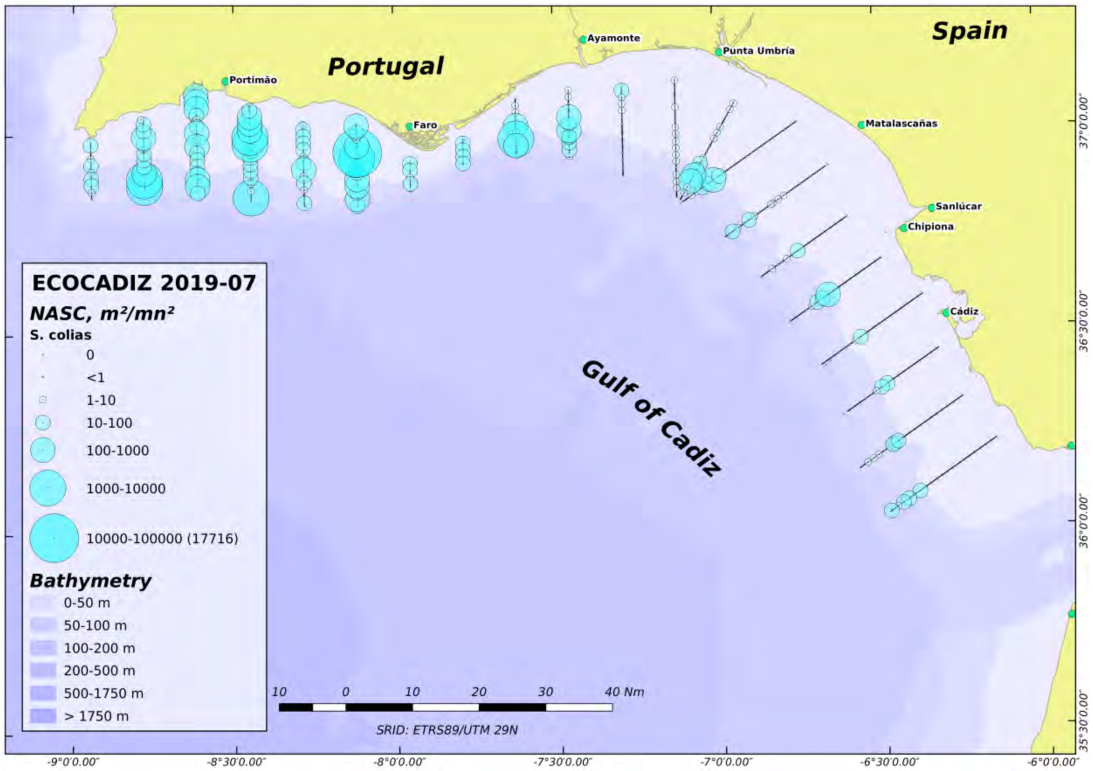


Figure 28. *ECOCADIZ 2019-07* survey. Mackerel (*Scomber scombrus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 27**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the *y* axis.



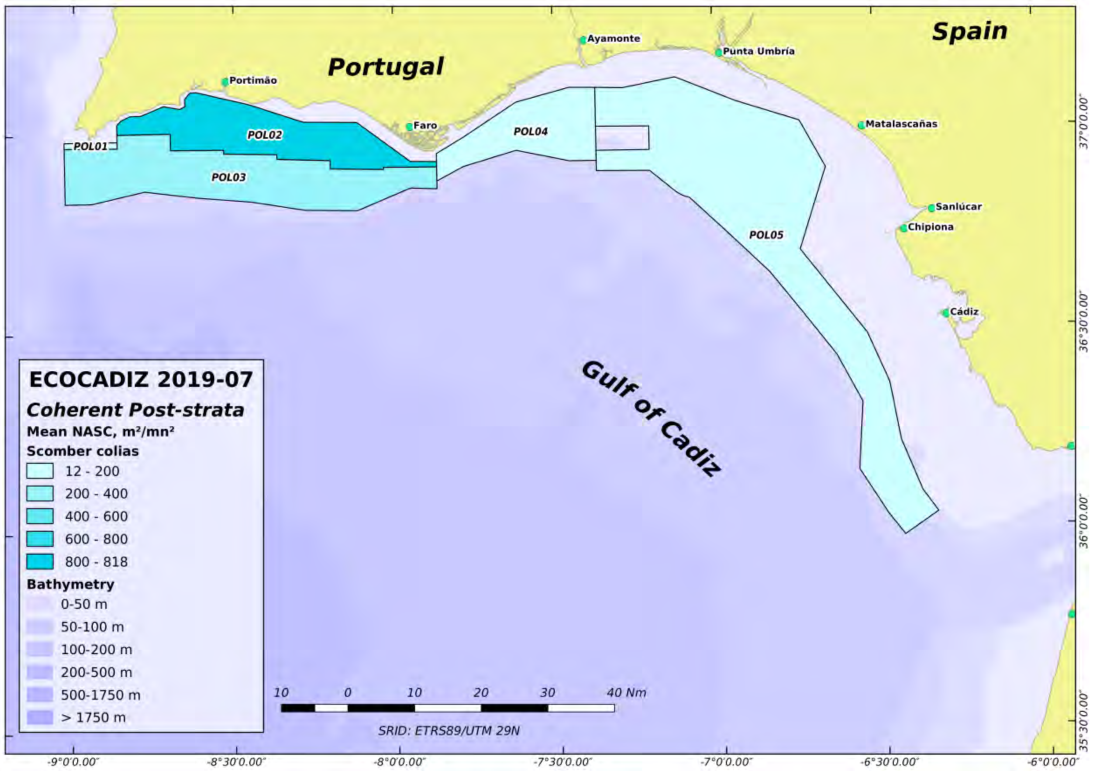


Figure 29. *ECOCADIZ 2019-07* survey. Chub mackerel (*Scomber colias*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

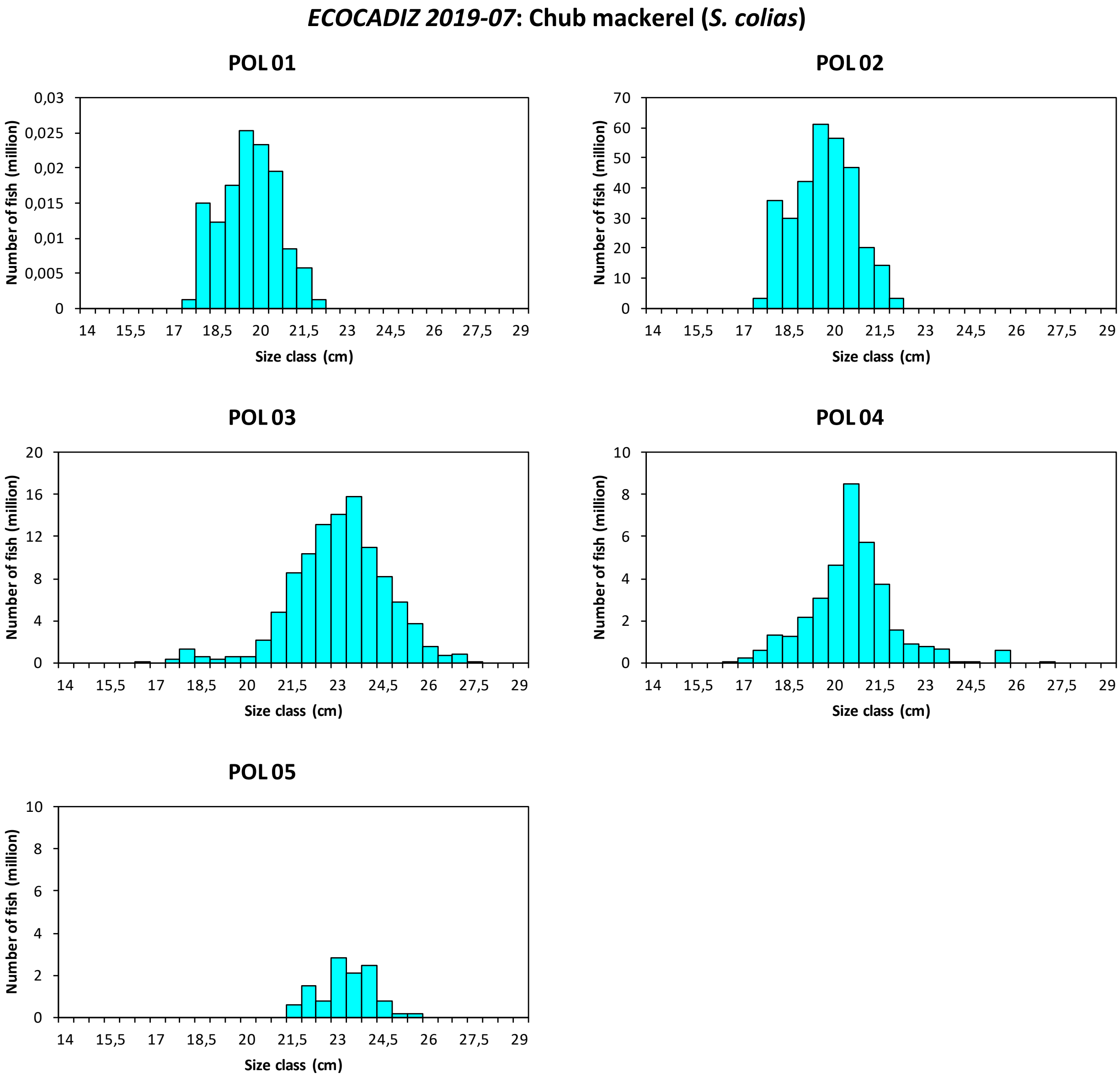


Figure 30. *ECOCADIZ 2019-07* survey. Chub mackerel (*Scomber colias*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 29**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the *y* axis.

ECOCADIZ 2019-07: Chub mackerel (*S. colias*)

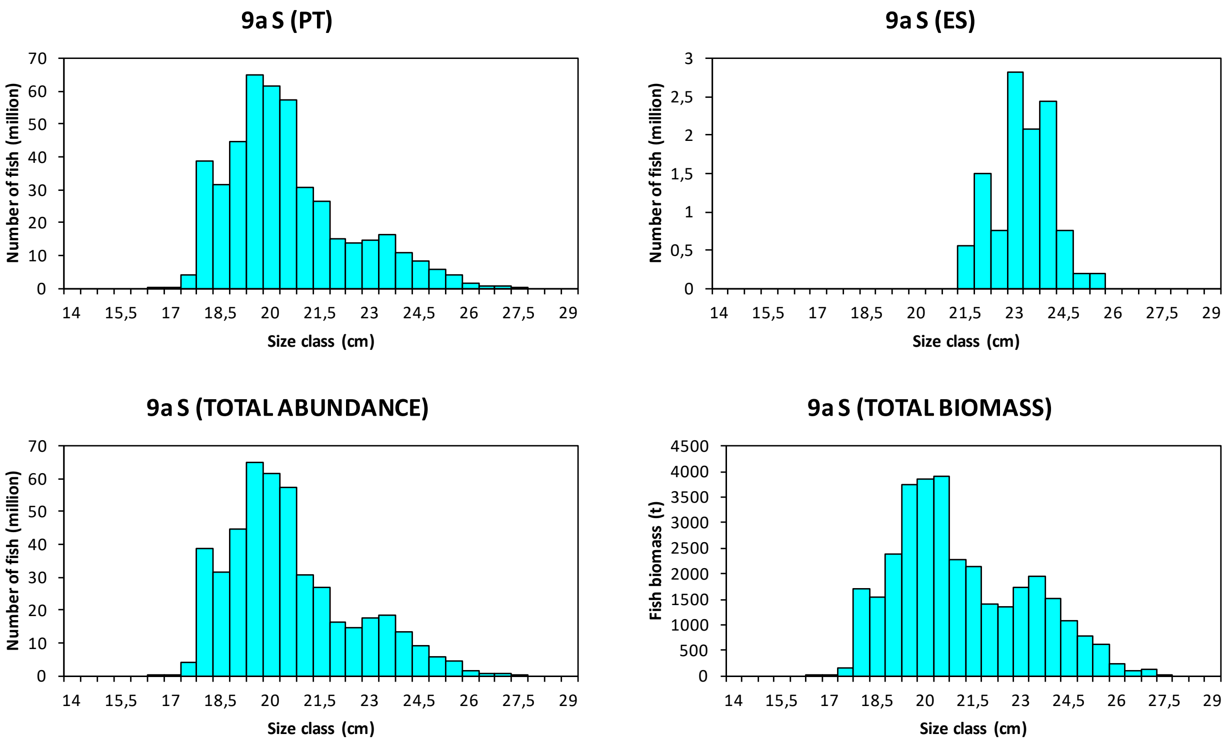


Figure 30. *ECOCADIZ 2019-07* survey. Chub mackerel (*Scomber colias*). Cont'd.

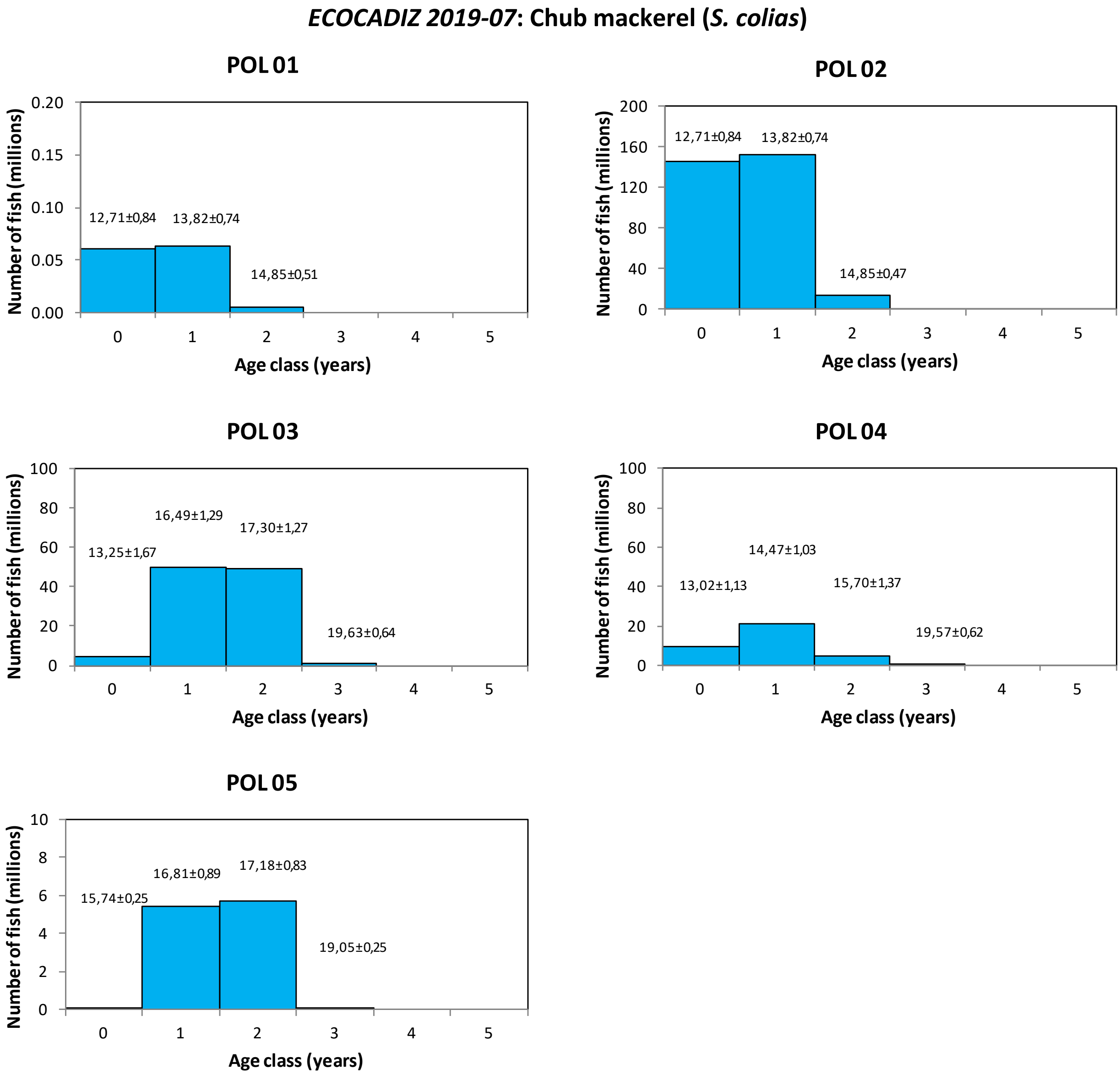


Figure 31. *ECOCADIZ 2019-07* survey. Chub mackerel (*Scomber colias*). Estimated abundances (number of fish in millions) by age group (years) by homogeneous stratum (POL01-POLn, numeration as in **Figure 29**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the *y* axis.

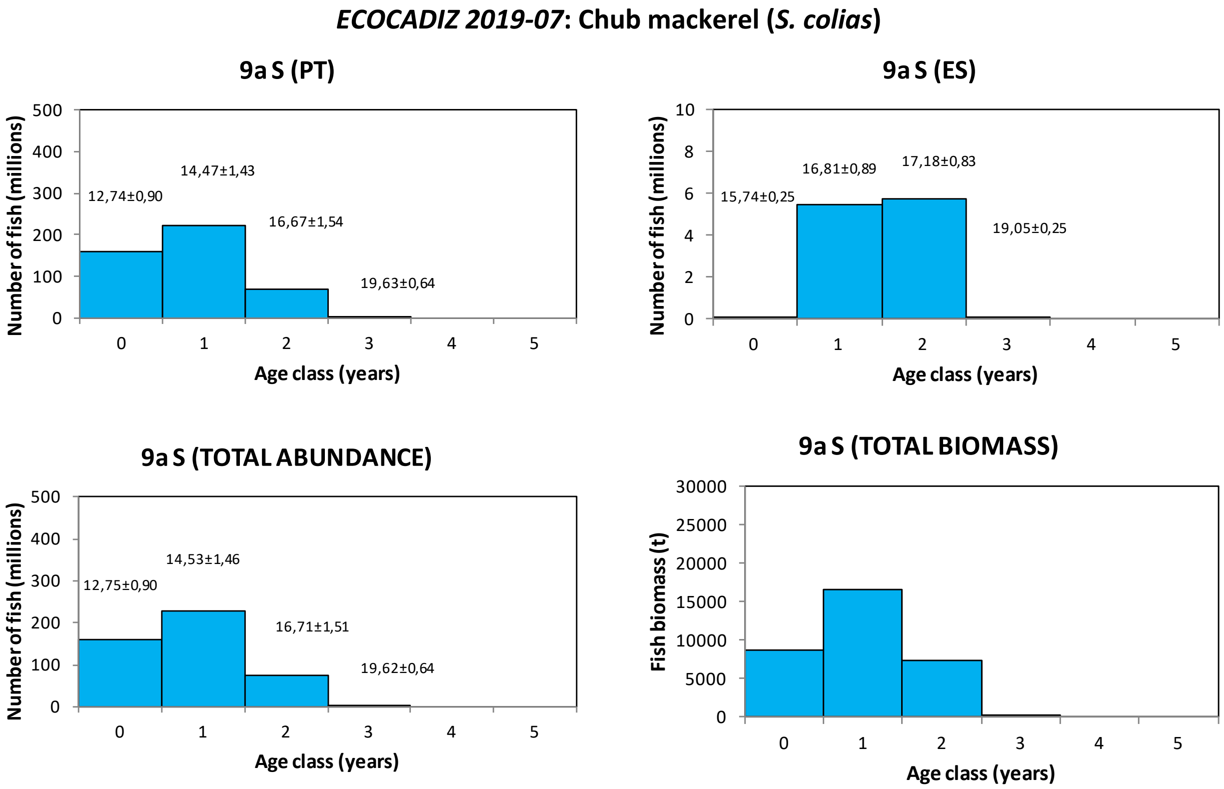


Figure 31. *ECOCADIZ 2019-07* survey. Chub mackerel (*Scomber colias*). Cont'd.

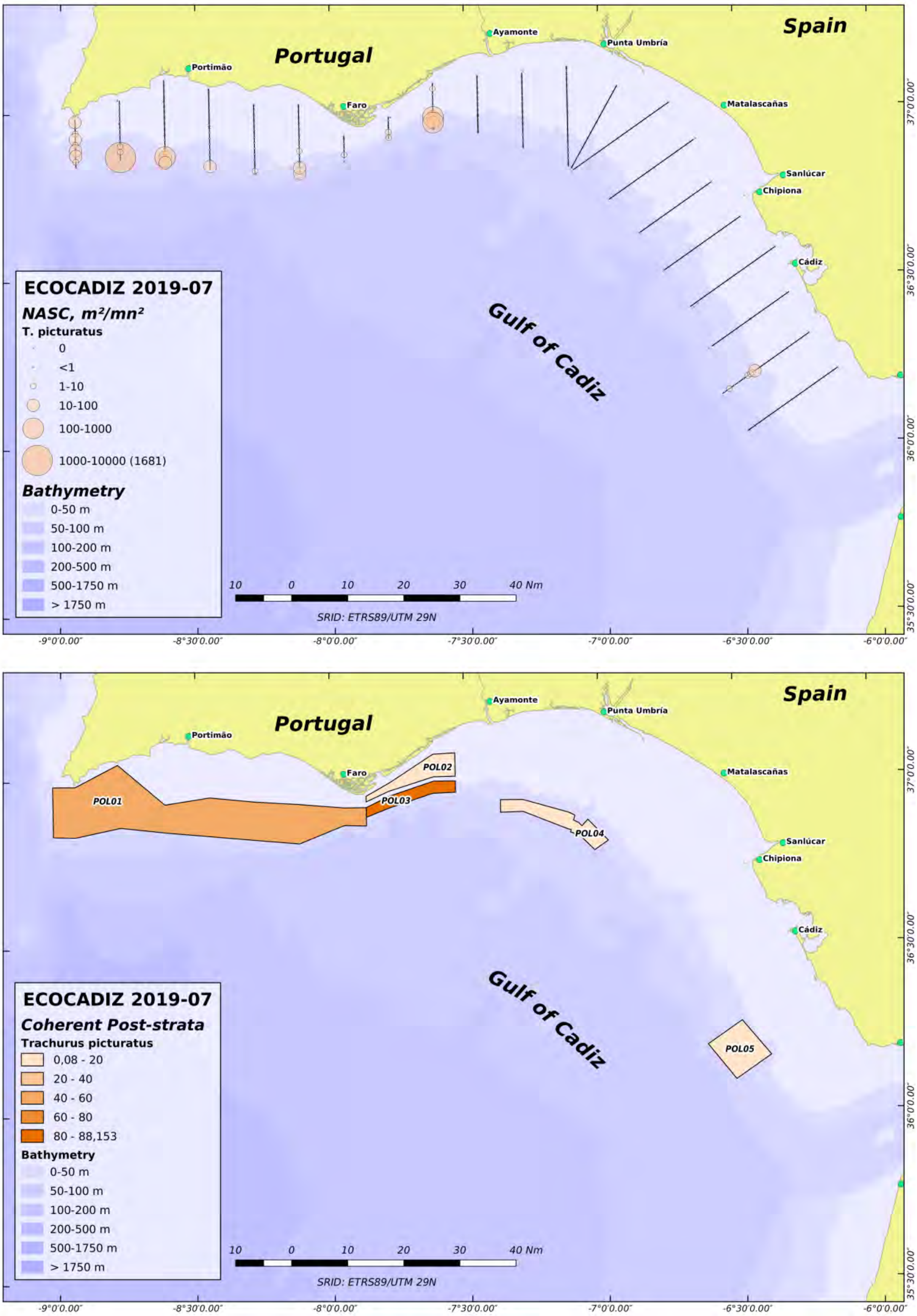


Figure 32. *ECOCADIZ 2019-07* survey. Blue jack mackerel (*Trachurus picturatus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

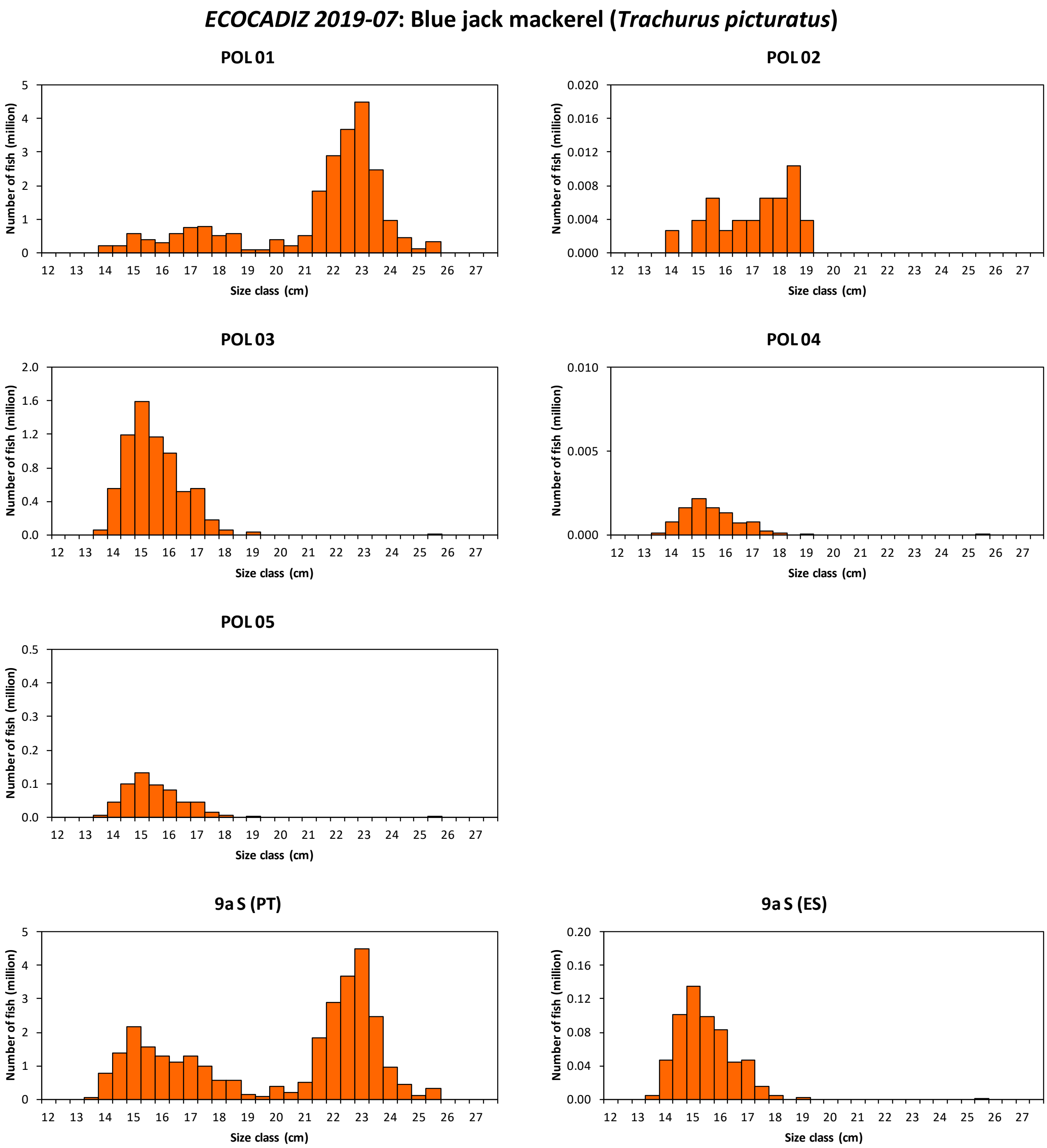


Figure 33. *ECOCADIZ 2019-07* survey. Blue jack mackerel (*Trachurus picturatus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 32**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the *y* axis.

***ECOCADIZ 2019-07*: Blue jack mackerel (*Trachurus picturatus*)**

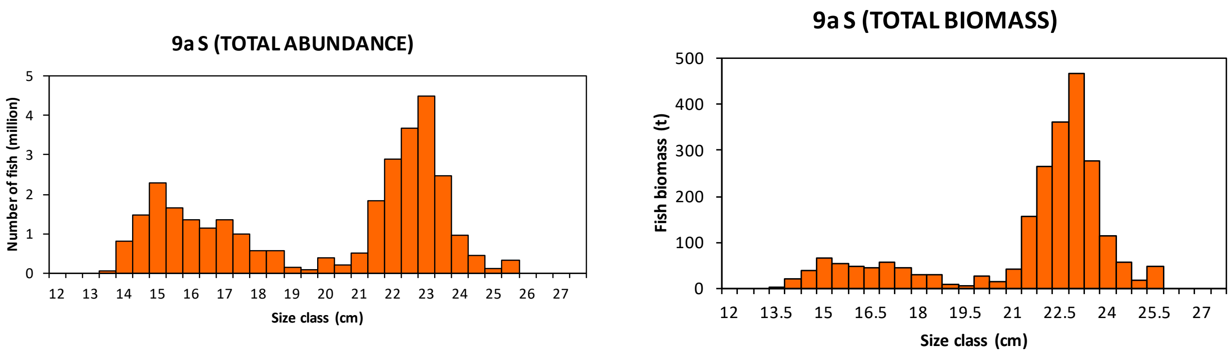


Figure 33. *ECOCADIZ 2019-07* survey. Blue jack mackerel (*Trachurus picturatus*). Cont'd.

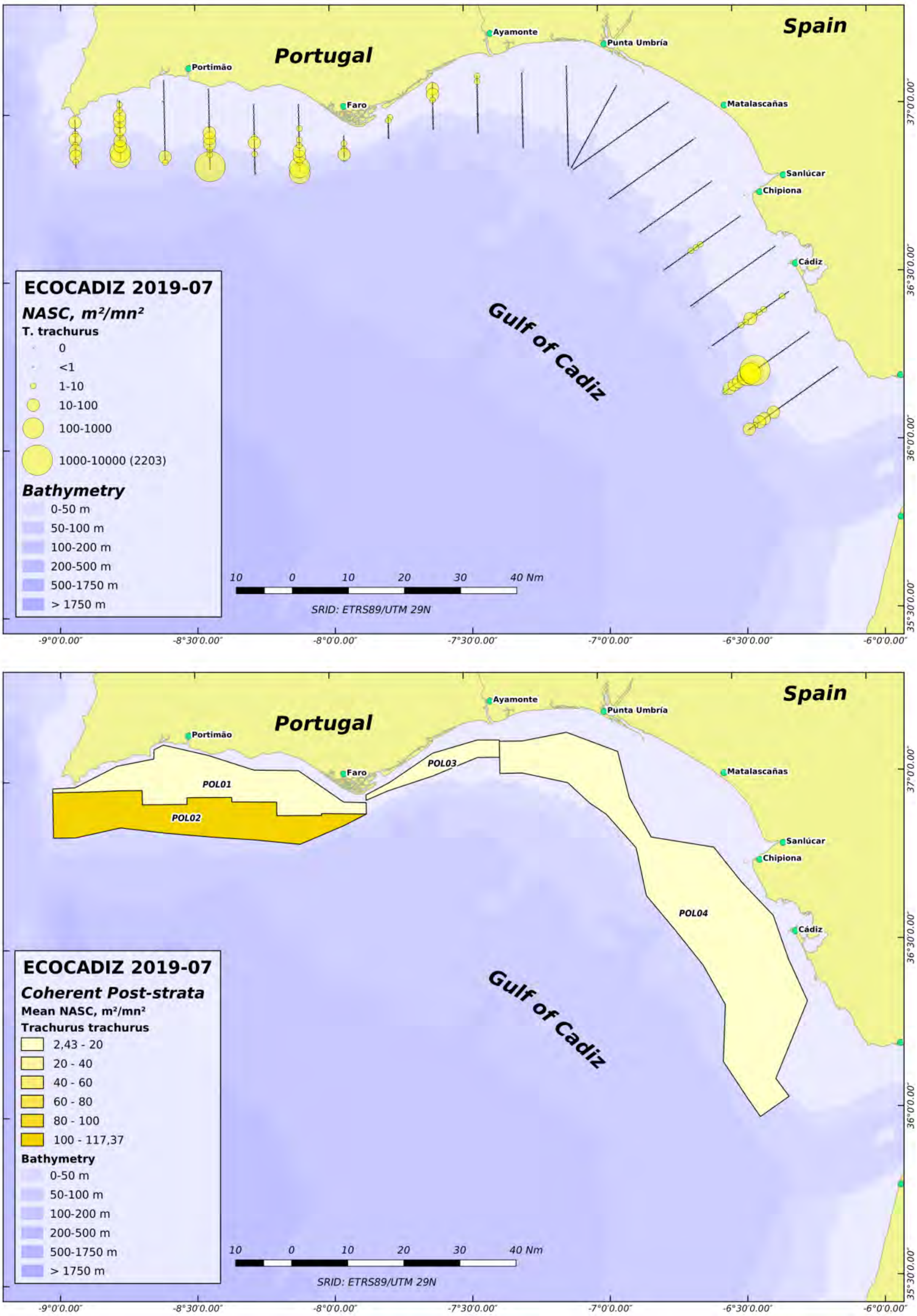


Figure 34. *ECOCADIZ 2019-07* survey. Horse mackerel (*Trachurus trachurus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

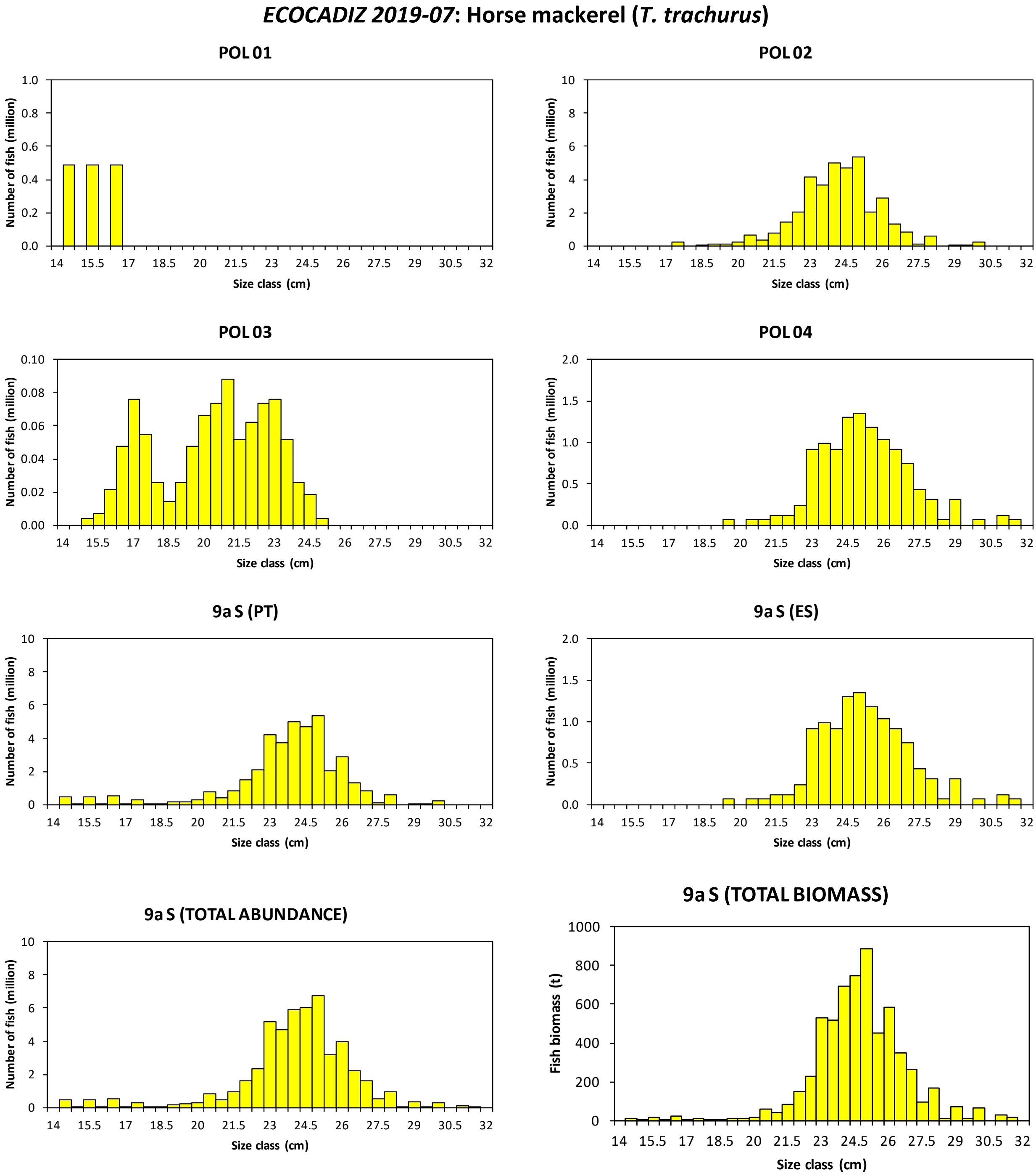
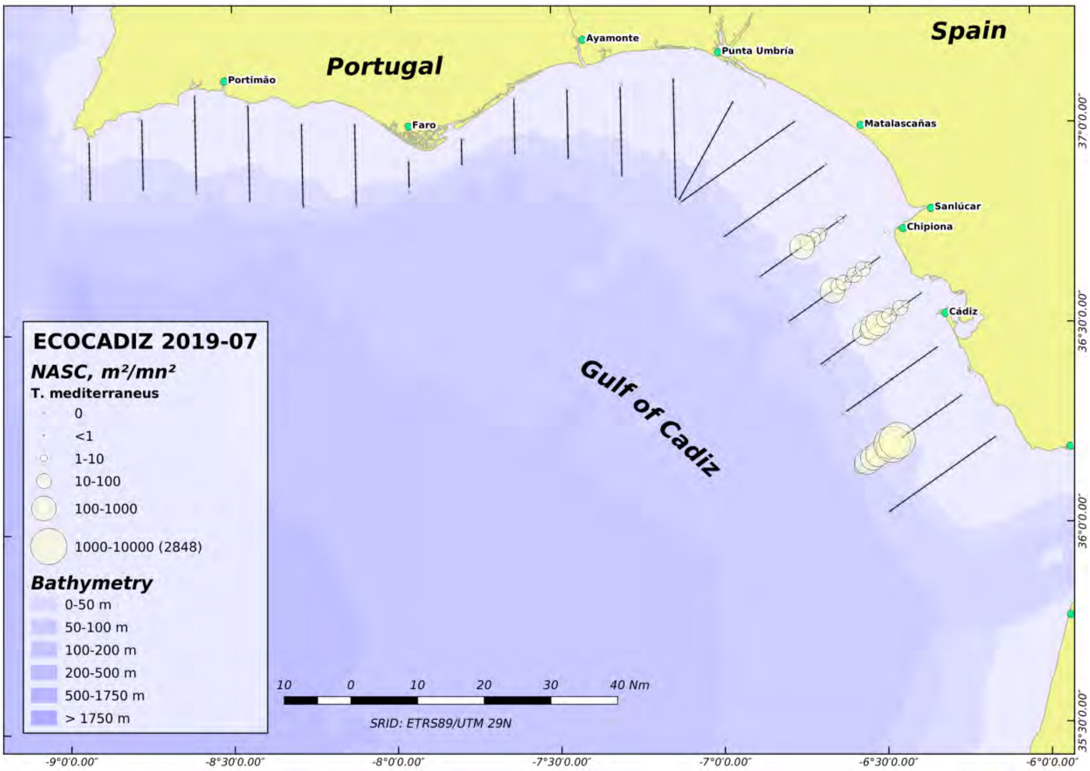


Figure 35. *ECOCADIZ 2019-07* survey. Horse mackerel (*Trachurus trachurus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 34**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the *y* axis.



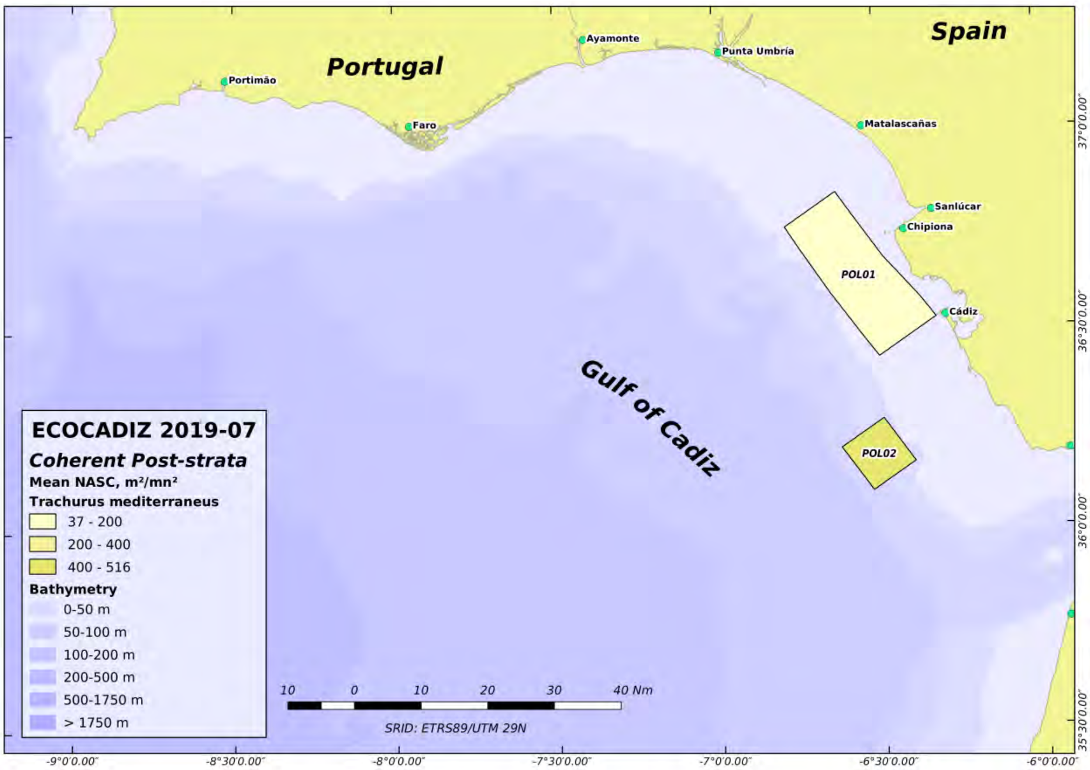


Figure 36. *ECOCADIZ 2019-07* survey. Mediterranean horse mackerel (*Trachurus mediterraneus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

***ECOCADIZ 2019-07*: Mediterranean horse mackerel (*T. mediterraneus*)**

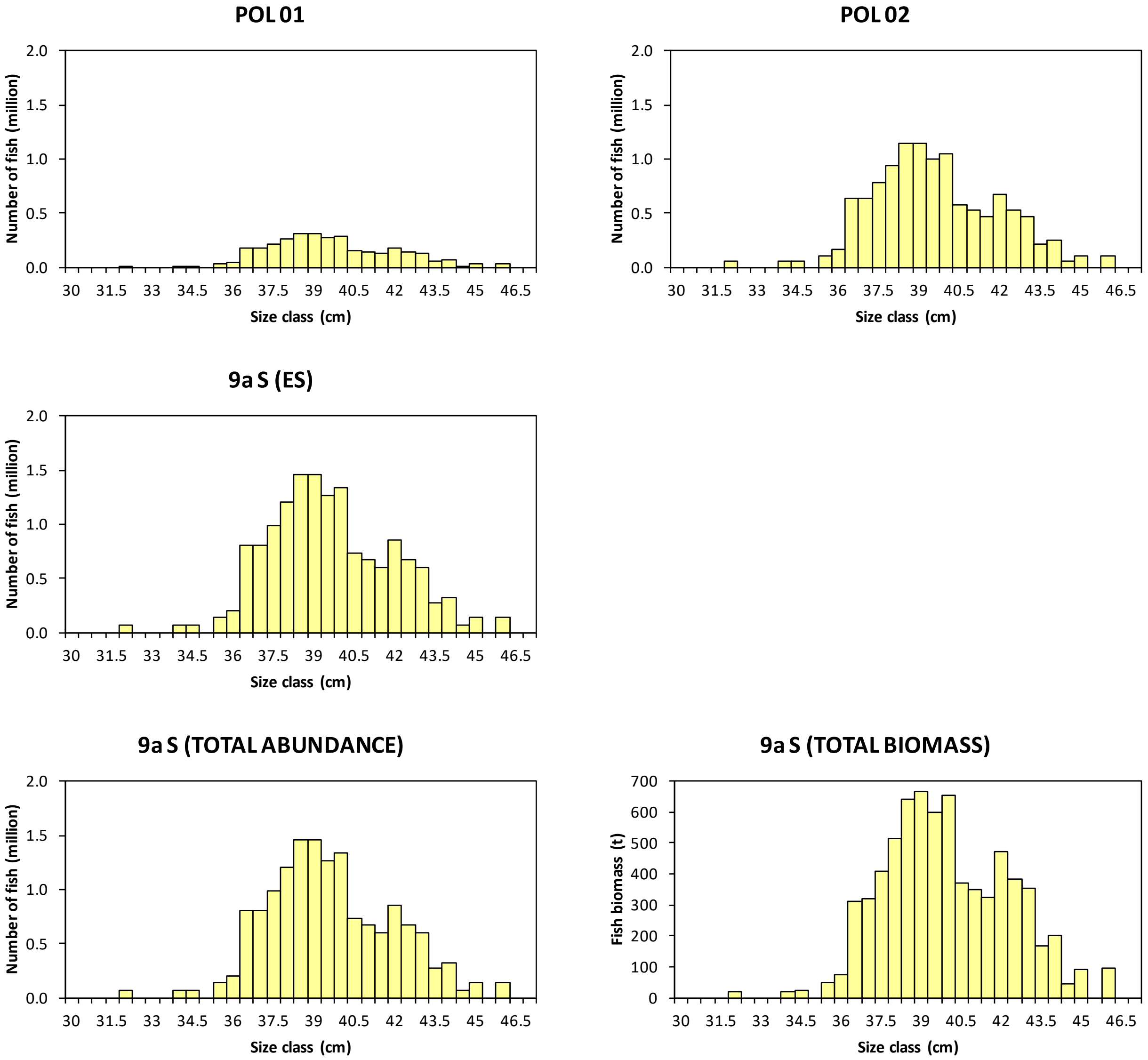
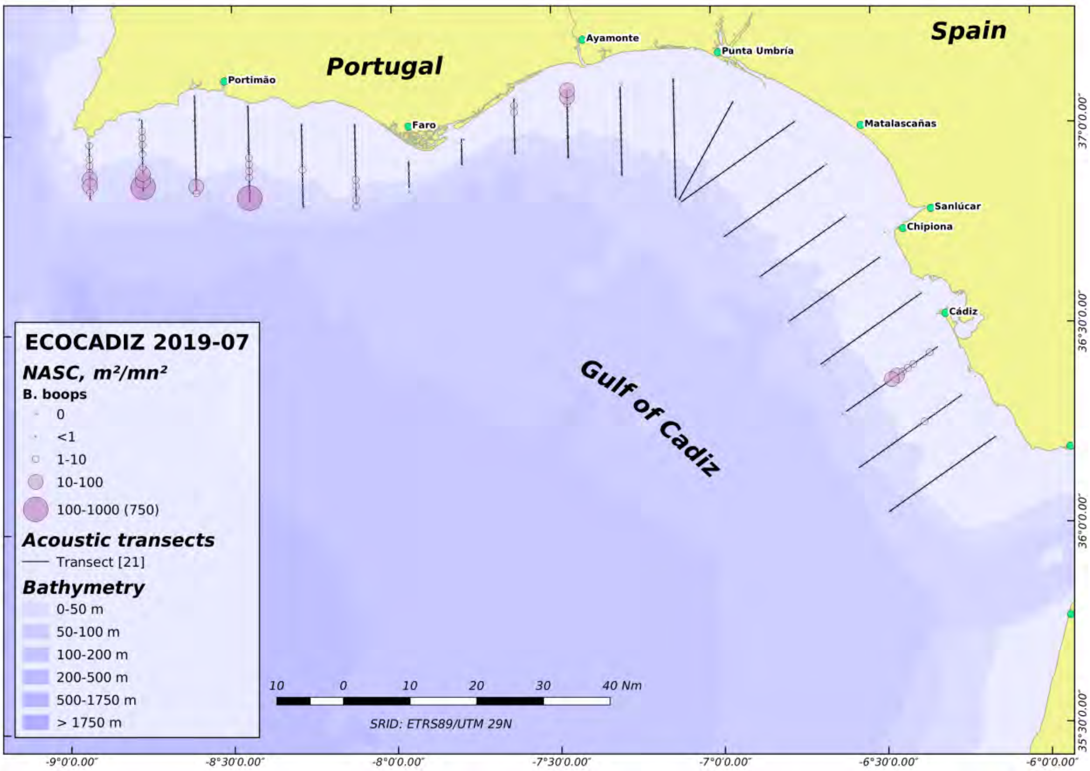


Figure 37. *ECOCADIZ 2019-07* survey. Mediterranean horse mackerel (*Trachurus mediterraneus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 36**) and total sampled area. Post-strata ordered in the W-E direction. 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.



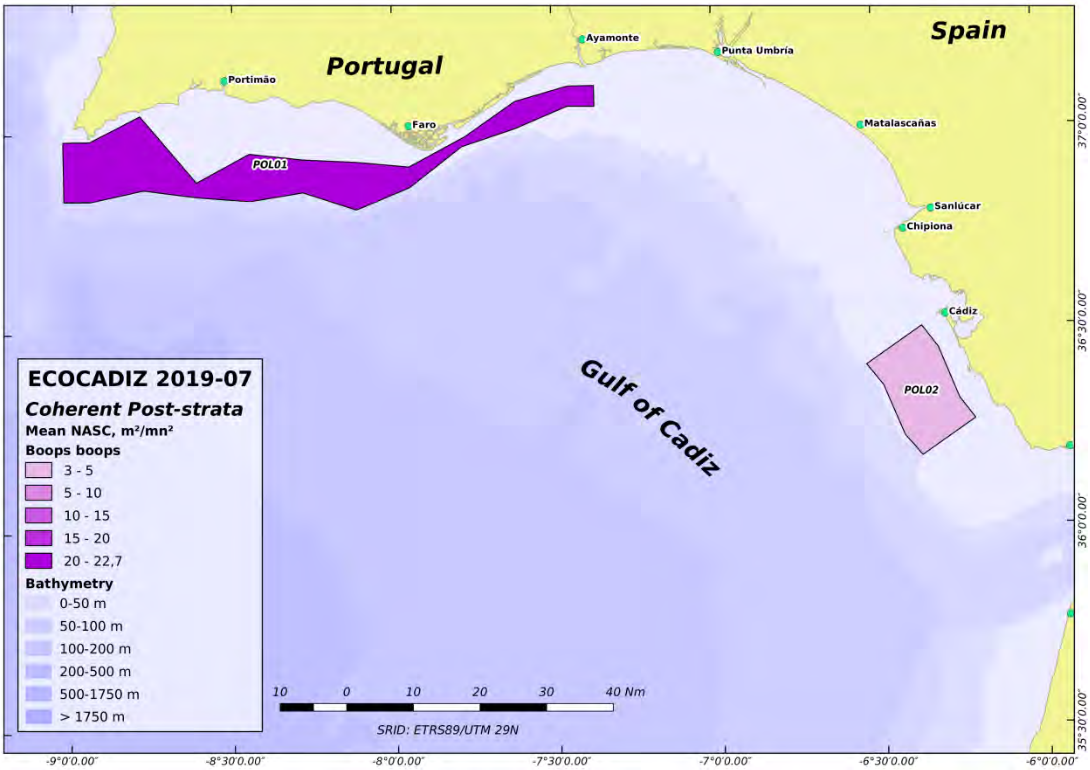


Figure 38. *ECOCADIZ 2019-07* survey. Bogue (*Boops boops*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

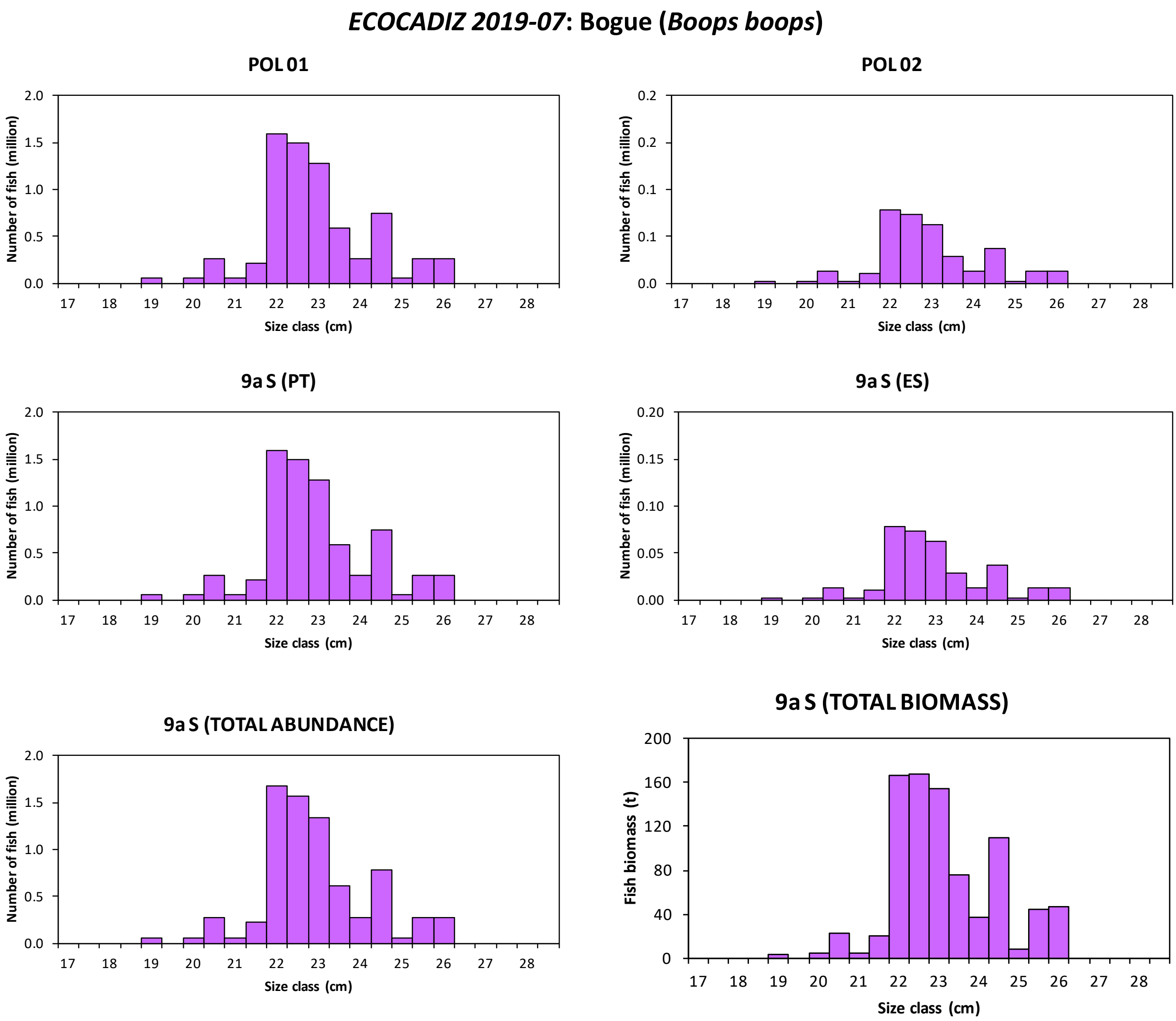
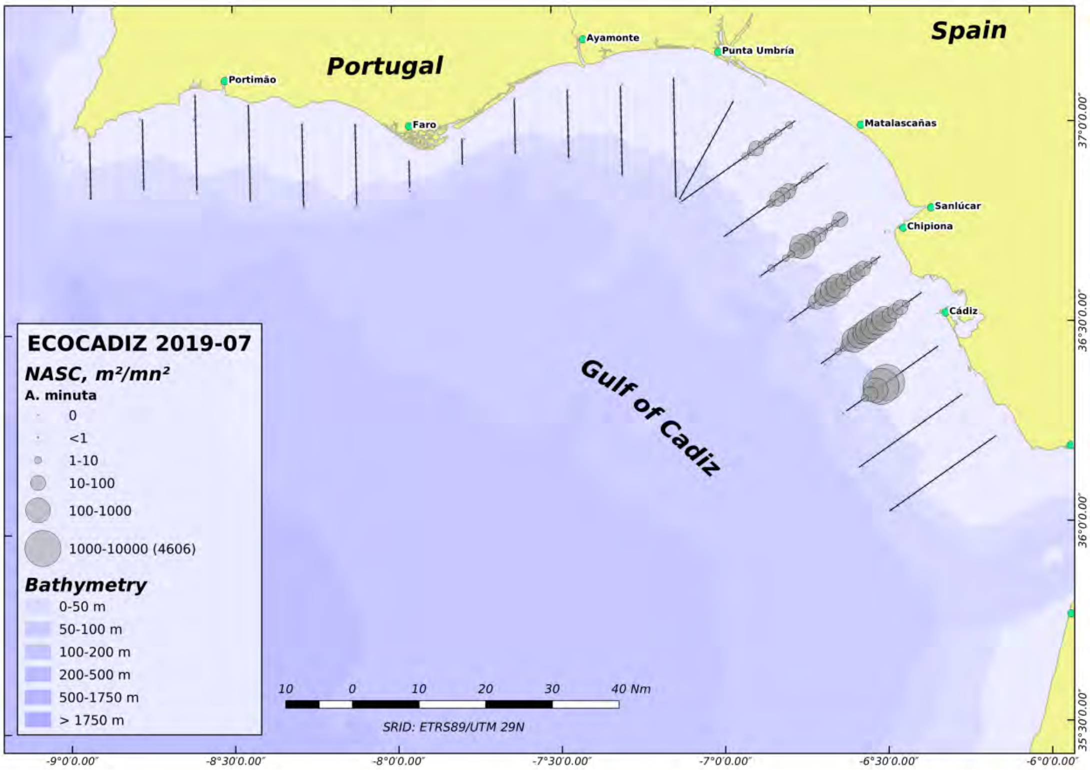


Figure 39. *ECOCADIZ 2019-07* survey. Bogue (*Boops boops*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 38**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the *y* axis.



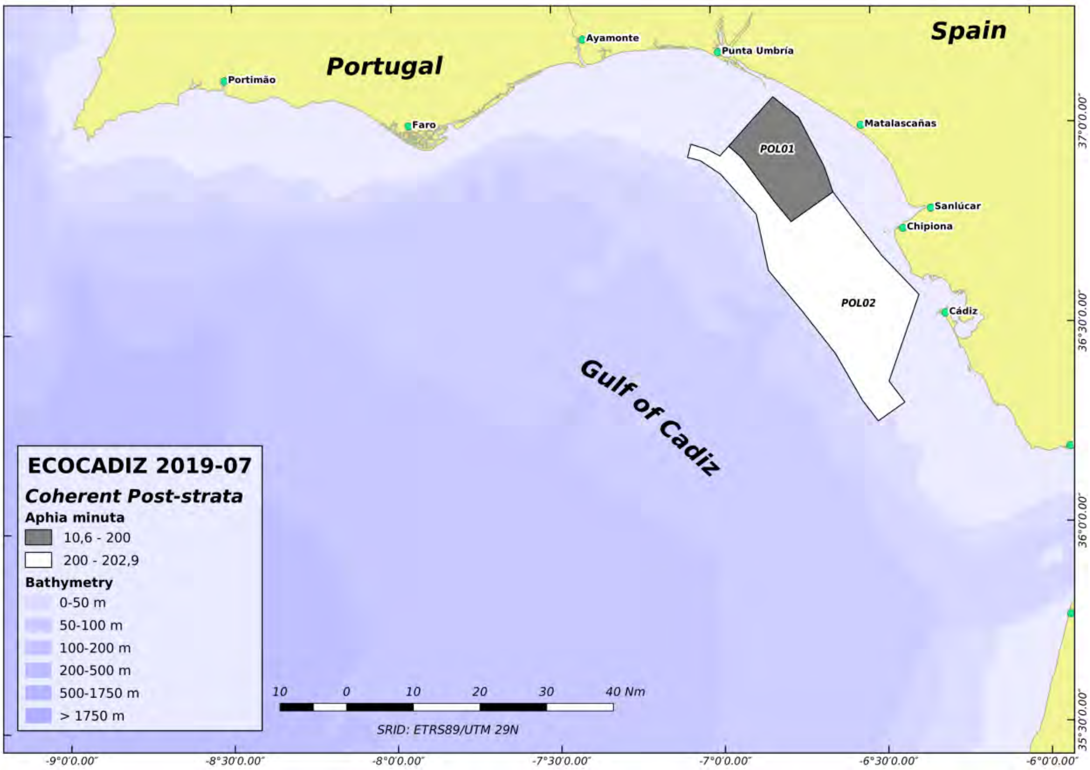


Figure 40. *ECOCADIZ 2019-07* survey. Transparent goby (*Aphia minuta*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

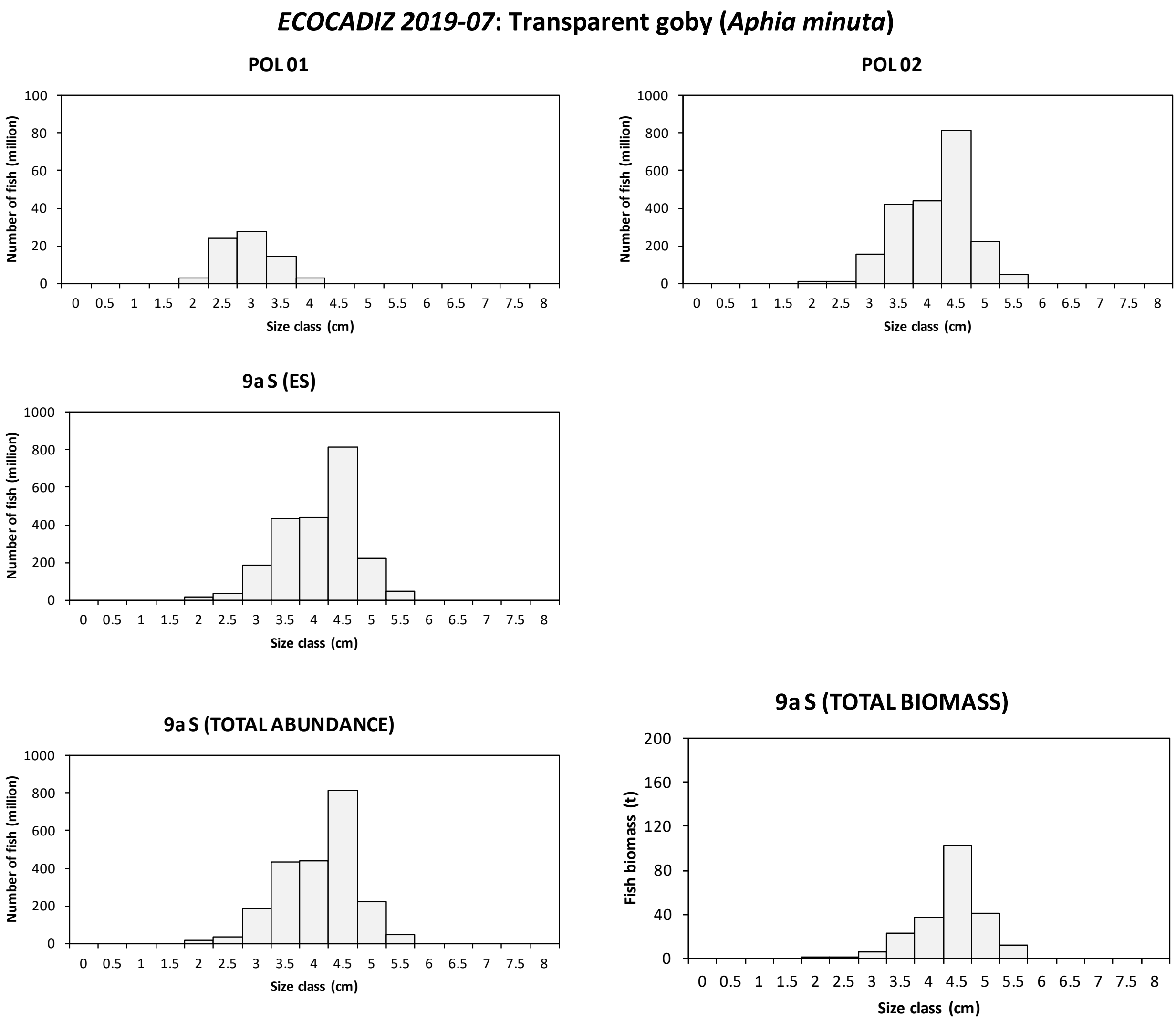


Figure 41. *ECOCADIZ 2019-07* survey. Transparent goby (*Aphia minuta*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 40**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the *y* axis.

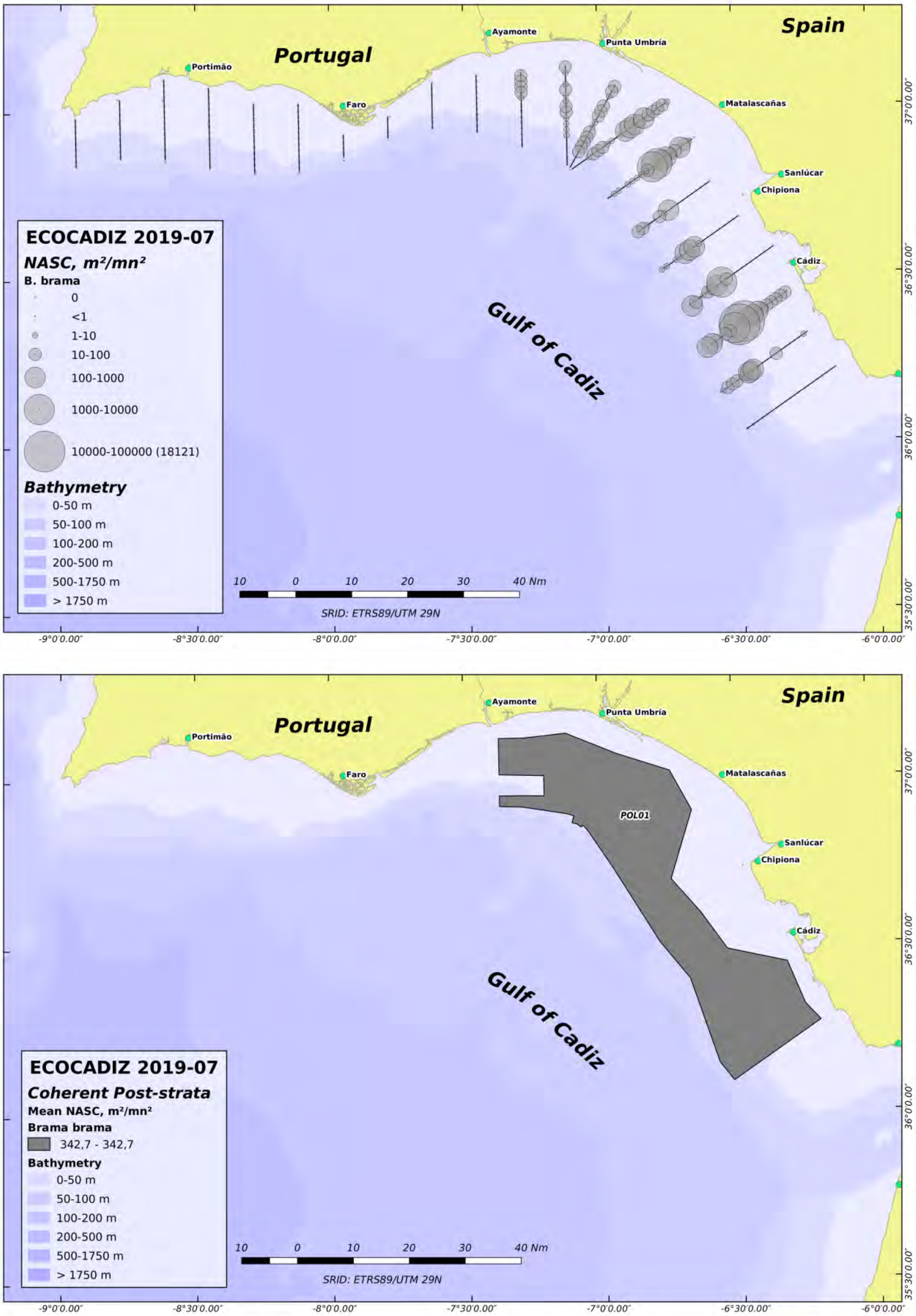


Figure 42. *ECOCADIZ 2019-07* survey. Atlantic pomfret (*Brama brama*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

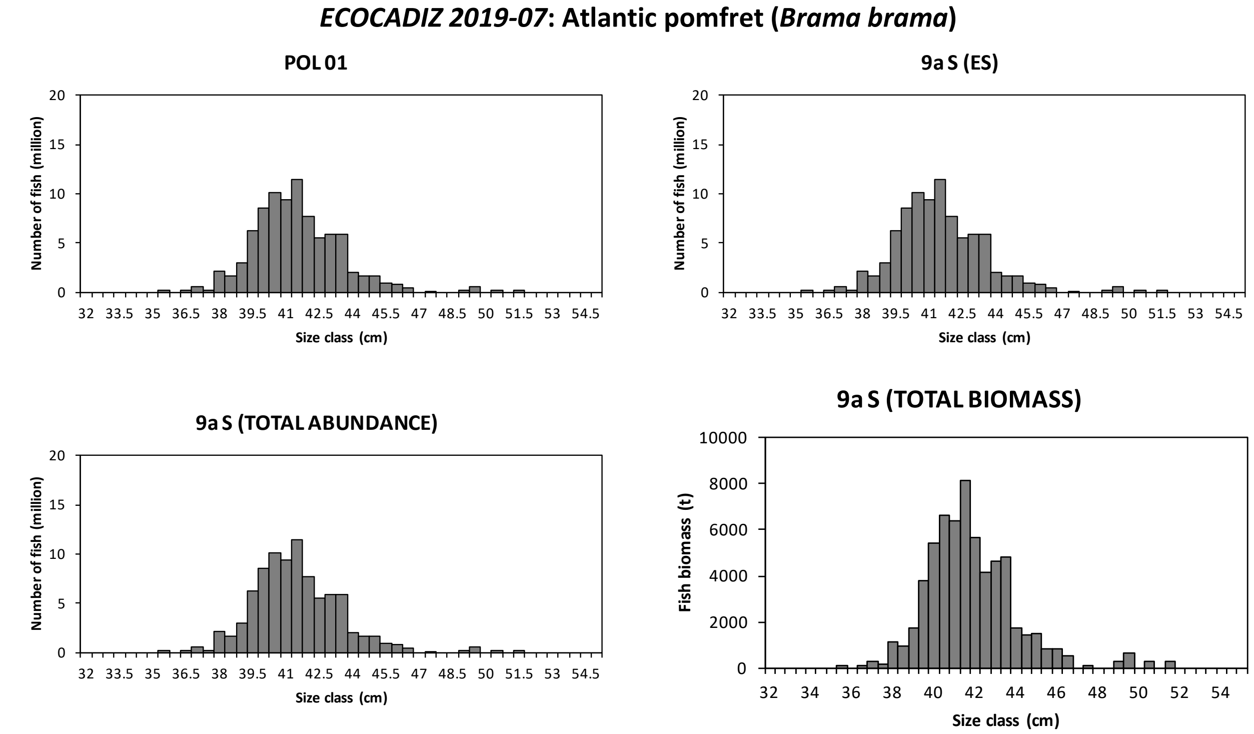
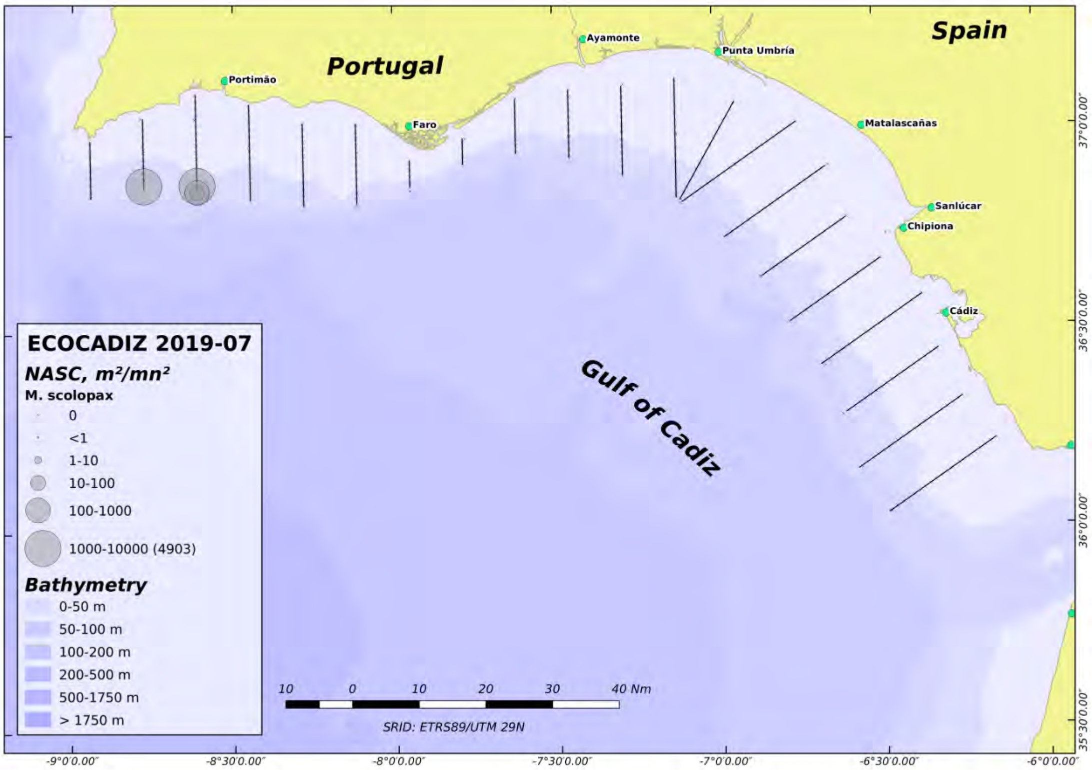


Figure 43. *ECOCADIZ 2019-07* survey. Atlantic pomfret (*Brama brama*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 42**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the *y* axis.



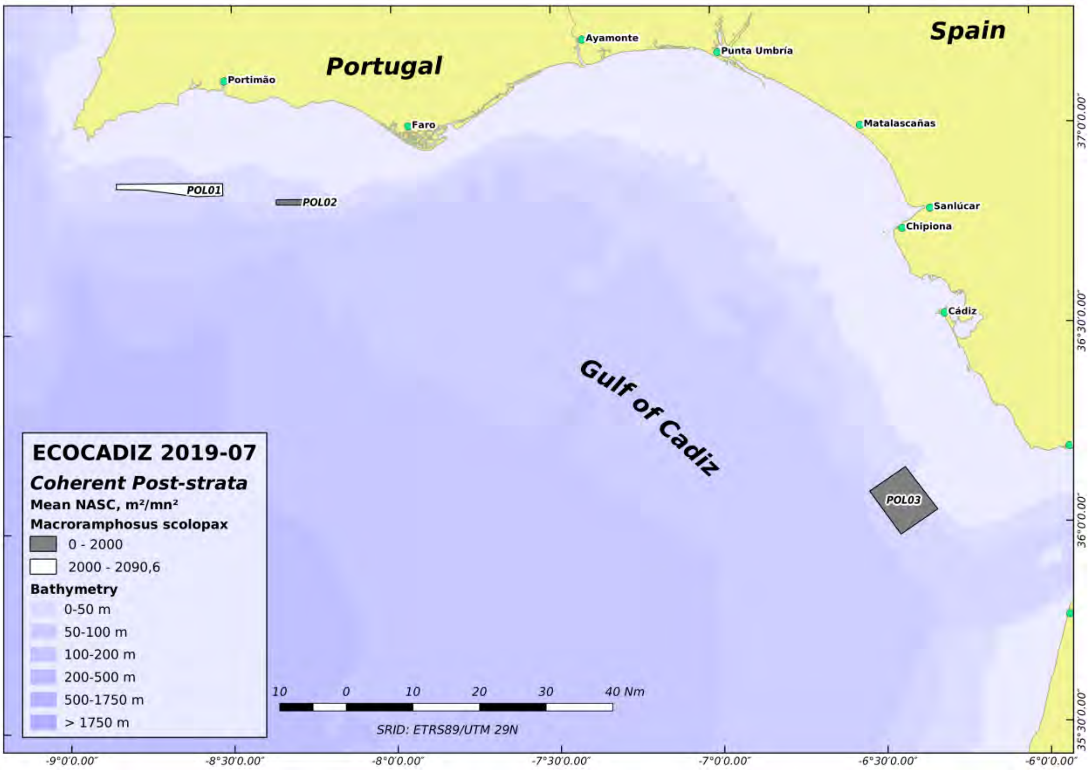


Figure 44. *ECOCADIZ 2019-07* survey. Longspine snipefish (*Macroramphosus scolopax*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

***ECOCADIZ 2019-07*: Longspine snipefish (*Macroramphosus scolopax*)**

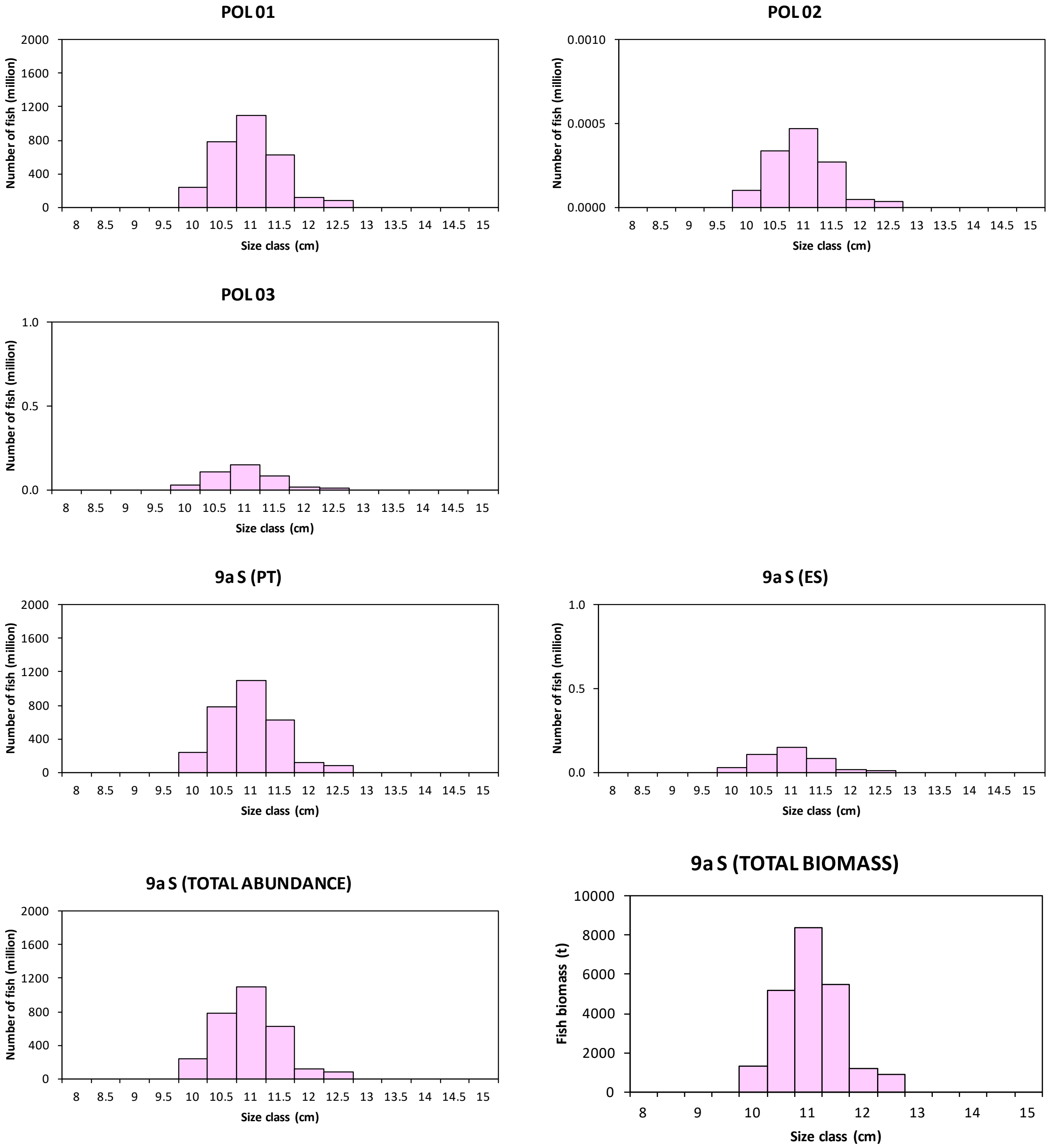


Figure 45. *ECOCADIZ 2019-07* survey. Longspine snipefish (*Macroramphosus scolopax*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 44**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

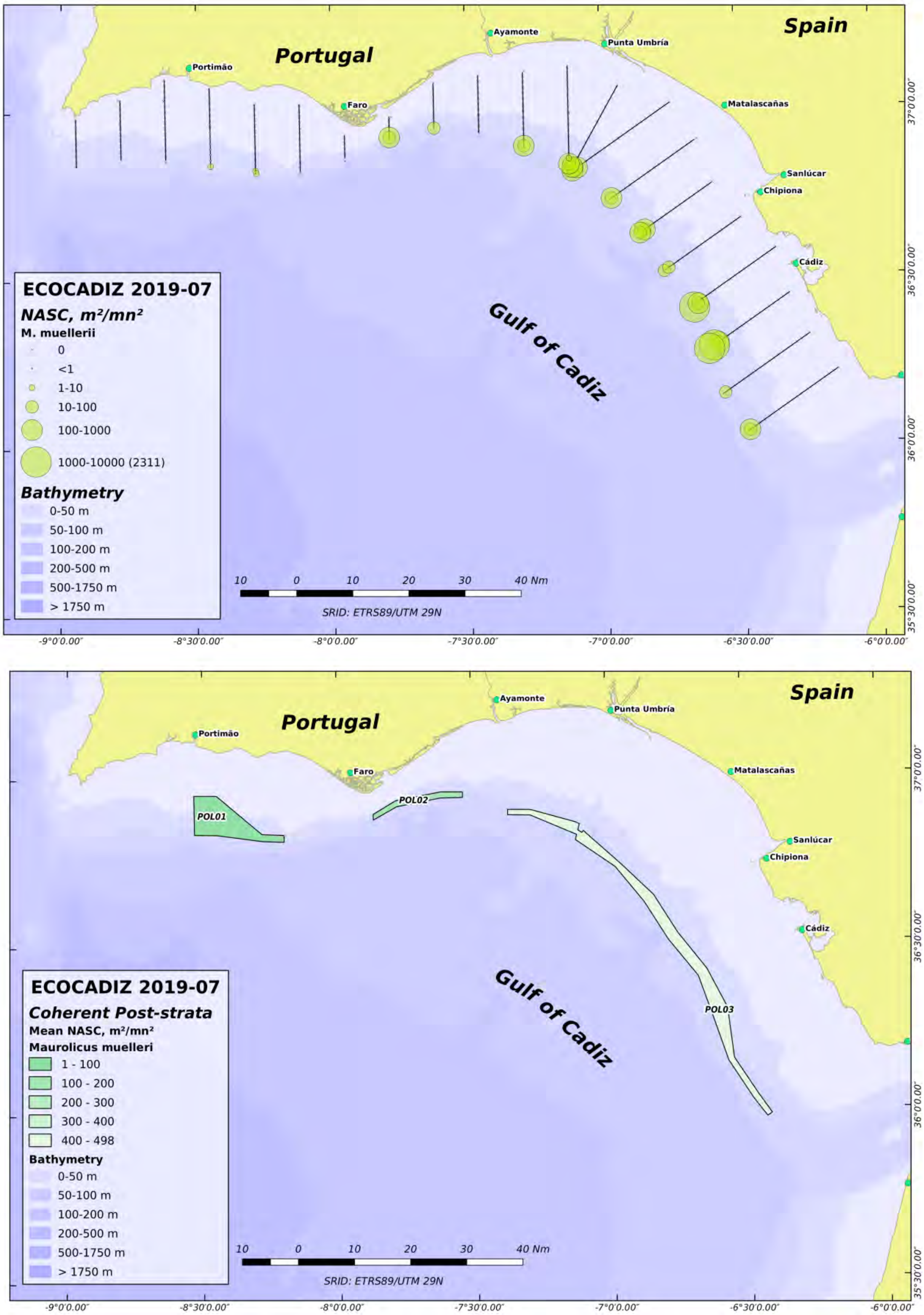


Figure 46. *ECOCADIZ 2019-07* survey. Pearlside (*Maurolicus muelleri*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

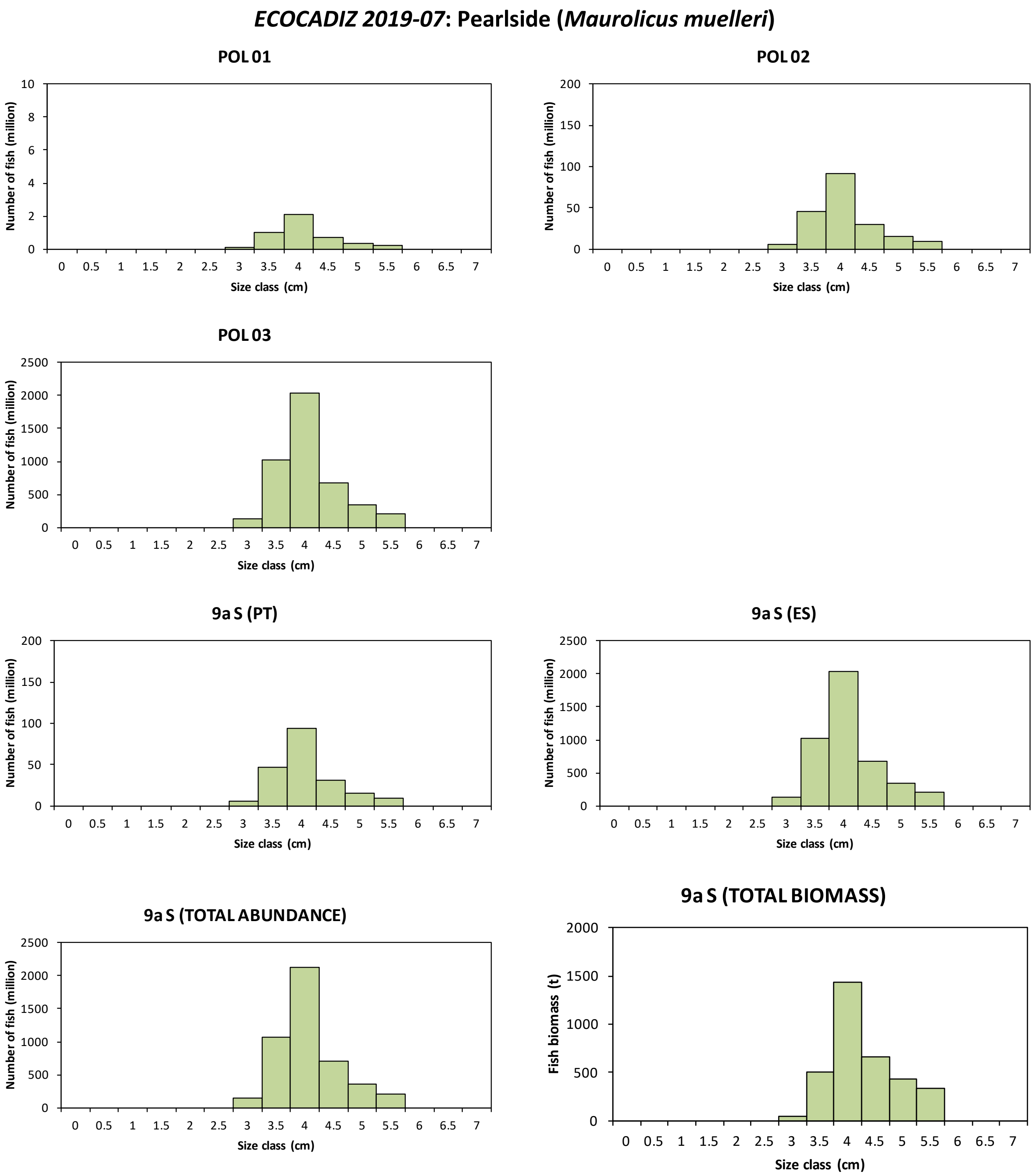
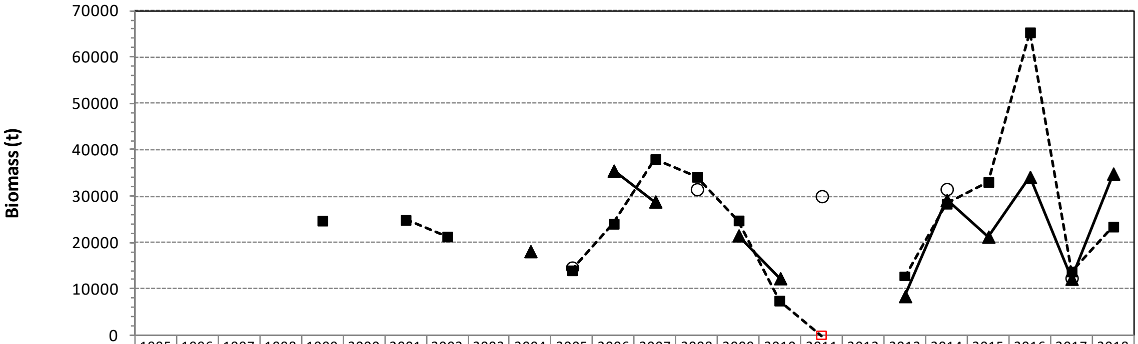


Figure 47. *ECOCADIZ 2019-07* survey. Pearlside (*Maurolicus muelleri*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 46**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

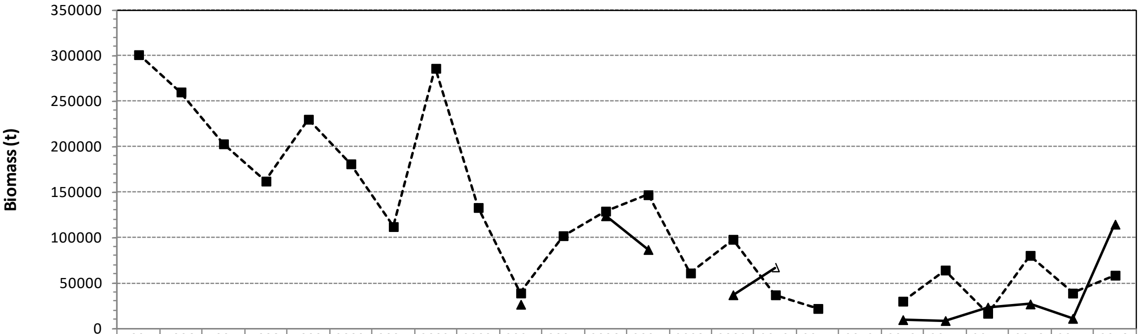
Biomass trends (in tons)

Anchovy biomass estimates



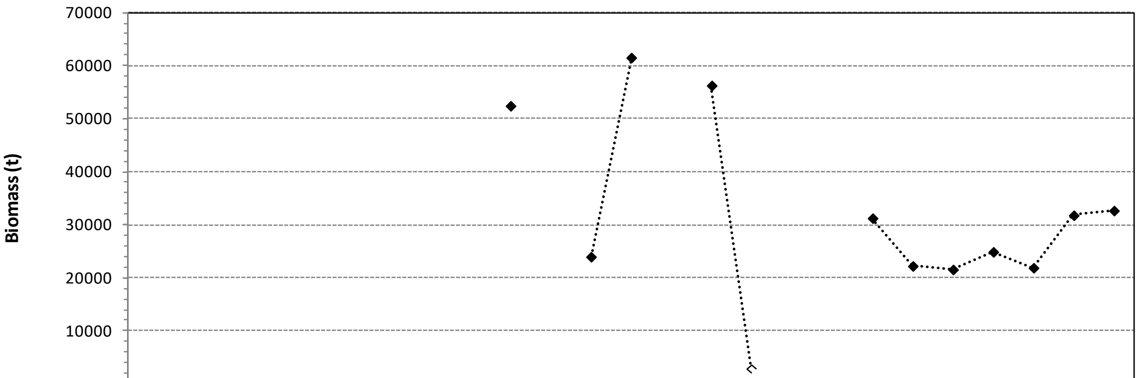
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
PELAGO					24763		24913	21335			14041	24082	38020	34200	24800	7395	0		12700	28408	33100	65345	13797	23473
ECOCADIZ										18177		35539	28882		21580	12339			8487	29219	21305	34184	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	2019
ECOCADIZ										52440		23994	61530		56276	2861			31267	22258	21593	24918	21918	31811	32696

Figure 48. 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.

Working document presented in the ICES Working Group on Southern Horse Mackerel, Sardine and Anchovy (WGHANSA-1). By correspondence, 25-29 May 2020.

Acoustic assessment and distribution of the main pelagic fish species in ICES Subdivision 9a South during the *ECOCADIZ-RECLUTAS 2019-10* Spanish survey (October 2019).

By

Fernando Ramos [1, *], Jorge Tornero [1], Pilar Córdoba [2], Pablo Carrera [3]

(1) Instituto Español de Oceanografía (IEO), Centro Oceanográfico Costero de Cádiz.
(2) IEO, Centro Oceanográfico de las Islas Baleares.
(3) IEO, Centro Oceanográfico de Vigo.
(*) 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 2019-10* Spanish (pelagic ecosystem-) acoustic survey. The survey was conducted by IEO between 10th and 30th October 2019 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. From the pelagic fish species set, anchovy and chub mackerel were the most frequent species in those hauls, followed by horse mackerel, mackerel and sardine. Anchovy abundance and biomass were of 5518 million fish and 48 398 t. The abundance and biomass of age-0 anchovies were estimated at 4845 million fish and 36 405 t, 88% and 75% of the total population abundance and biomass, respectively. These estimates suggest a recent increase in relation to previous years (the 2019 juveniles estimate is the maximum record in terms of biomass and the second maximum in terms of abundance). The estimates for Gulf of Cadiz sardine in the surveyed area were of 937 million fish and 36 465 t and they were either close to (abundance) or above (biomass) their respective historical means. Estimates of age-0 sardine were of 384 million fish and 7858 t, 41% and 22% of the total estimated abundance and biomass, and both estimates were well below the historical mean.

INTRODUCTION

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 general objective of these surveys is 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 of these species the next year.

The present Working Document reports the main results from the *ECOCADIZ-RECLUTAS 2019-10* survey, namely the acoustic estimates of abundance and biomass (age-structured for anchovy, sardine and chub mackerel) and the spatial distribution of the assessed species.

MATERIAL AND METHODS

The *ECOCADIZ-RECLUTAS 2019-10* survey was conducted between 10th and 30th October 2019 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, mackerel (2 spp.) and horse-mackerel species (3 spp.), and bogue. Otoliths were extracted from anchovy, sardine and chub mackerel sampled specimens.

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
Transparent goby (*Aphia minuta*)	-67.5
Atlantic pomfret (*Brama brama*)	-67.5
Blue whiting (*Micromesistius poutassou*)	-67.5
Silvery lightfish/pearlside (*Maurolicus muelleri*)	-72.2
Longspine snipefish (*Macroramphosus scolopax*)	-80.0
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 181 $CTDO_2$ 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

<u>Acoustic sampling</u>

The acoustic sampling was restricted to the period comprised between 16th 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 conduction of OTAN naval exercises during the survey. Thus, the acoustic sampling started by the coastal end of the transect R01 on 16th October and proceeded westward up to the R06 on 20th October. The acoustic sampling was previously interrupted on 18-19th October in order to satisfy the R/V's refueling and provisioning needs. The second leg proceeded between 20st and 28th October. Aiming at avoiding the naval exercises, on 21th October the acoustic sampling started by the R09, followed by the R10, whereas on 22th the RA07 was the first sampled transect, followed by the R08. 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.

<u>Groundtruthing hauls</u>

A total of twenty six (26) fishing operations for echo-trace ground-truthing (25 of them were valid according to a correct gear performance and resulting catches), were carried out during the survey (**Table 2**, **Figure 3**). The pelagic trawl gear initially utilized had to be replaced after the trawl PE03 by other gear of similar characteristics because a serious gear breaking caused by a snagging with the bottom during that haul. Because of many echo-traces usually occurred close to the bottom, all the pelagic hauls but PE04 (a pelagic haul *sensu stricto*) 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 33 and 135 m.

During the survey were captured 2 Chondrichthyan, 32 Osteichthyes, 1 Crustacean, 7 Cephalopod, 1 Echinoderm, and 1 Cnidarian species. The percentage of occurrence of the more frequent fish species (sharks excluded) in the hauls is shown in the enclosed Text Table below (see also **Figure 4**). The pelagic ichthyofauna was both the most frequently captured species set and the one composing the bulk of the overall yields of the catches. Within this pelagic fish species set, anchovy and chub mackerel were the most frequent species in the valid hauls (76% and 72% presence index), followed by horse mackerel (60%), mackerel and sardine (56% each), Mediterranean horse mackerel (36%), blue jack mackerel (28%), and bogue (24%). Round sardinella, Atlantic pomfret, pearlside, boarfish and snipefish showed either a low or an incidental occurrence in the hauls performed in the surveyed area.

For the purposes of the acoustic assessment, anchovy, sardine, mackerel species, horse & jack mackerel species, bogue, Atlantic pomfret, boarfish, snipefish and pearlside were initially considered as the survey target species. All the invertebrates, skates, rays and benthic fish species 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 fish species were included in an operational category termed as “Others”.

According to the above premises, during the survey were captured a total of 12 717 kg and 371 thousand fish (**Table 3**). Thirty eight per cent (38%) of this “total” fished biomass corresponded to chub mackerel, 26% to sardine, 21% to anchovy, 8% to Atlantic pomfret, 4% to blue jack mackerel, and contributions lower than 1% for the remaining species. The most abundant species in ground-truthing trawl hauls was anchovy (65%), followed by sardine and chub mackerel (18% and 14%, respectively), with each of the remaining species accounting for equal to or less than 1%.

Species	# of fishing stations	Occurrence (%)	Total weight (kg)	Total number
Merluccius merluccius	23	92	19,37	161
Engraulis encrasicolus	19	76	2674,673	240807
Scomber colias	18	72	4857,623	53205
Trachurus trachurus	15	60	18,771	439
Scomber scombrus	14	56	30,325	281
Sardina pilchardus	14	56	3348,456	66976
Trachurus mediterraneus	9	36	82,201	270
Pagellus erythrinus	8	32	5,519	37
Spondyliosoma cantharus	7	28	22,893	126
Trachurus picturatus	7	28	480,541	3985
Boops boops	6	24	5,833	46
Diplodus vulgaris	5	20	29,877	167
Brama brama	4	16	1023,305	1481
Lepidopus caudatus	4	16	0,173	12
Serranus hepatus	3	12	0,063	4
Pagellus acarne	3	12	3,400	20
Diplodus annularis	3	12	1,183	21
Maurolicus muelleri	2	8	0,024	14
Macroramphosus scolopax	2	8	1,084	88
Capros aper	2	8	24,080	2411
Stromateus fiatola	2	8	17,923	33
Aphia minuta	2	8	0,003	6
Diplodus bellottii	2	8	0,775	9
Arnoglossus laterna	1	4	0,039	2
Citharus linguatula	1	4	0,041	1
Cepola macrophthalma	1	4	0,179	2
Spicara flexuosa	1	4	0,101	2
Sardinella aurita	1	4	0,48	2
Mullus barbatus	1	4	0,225	2
Sarda sarda	1	4	1,34	1
Spicara smaris	1	4	0,217	3
Trachinotus ovatus	1	4	0,34	1

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

<u>Back-scattering energy attributed to the "pelagic assemblage" and individual species</u>

A total of 310 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	VAM	HOM	HMM	JAA	BOG	POA
Total Area (%)	149941 (100,0)	22427 (15,0)	65266 (43,5)	8 (0,01)	34331 (22,9)	579 (0,4)	15335 (10,2)	1678 (1,1)	158 (0,1)	3166 (2,1)
Portugal (%)	71975 (48,0)	17624 (78,6)	16960 (26,0)	7 (87,5)	33846 (98,6)	423 (73,1)	180 (1,2)	1645 (98,0)	81 (51,3)	0 (0,0)
Spain (%)	77966 (52,0)	4802 (21,4)	48307 (74,0)	1 (12,5)	485 (1,4)	156 (26,9)	15155 (988)	32 (1,9)	78 (49,4)	3166 (100)

S_A (m^2 nmi^{-2})	BOC	SNS	MAV
Total Area (%)	202 (0,1)	21 (0,01)	6769 (4,5)
Portugal (%)	202 (100)	21 (100)	985 (14,6)
Spain (%)	0 (0,0)	0 (0,0)	5784 (85,4)

For this "pelagic fish assemblage" has been estimated a total of 149 941 m^2 nmi^{-2}. The highest NASC value was recorded in the mid-shelf waters (80 m) in front of Portimão (transect R19, **Figure 5**). By species, anchovy accounted for 44% of this total back-scattered energy, followed by chub mackerel (23%), sardine (15%) and Mediterranean horse mackerel (10%), 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, blue jack mackerel, horse mackerel, Mediterranean horse mackerel, bogue, Atlantic pomfret, boarfish, snipefish 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**.

The spatial pattern of distribution of the acoustic density was characterized by a concentration of the bulk of the population practically all over the shelf between Alfanzinha (west of Cape Santa Maria) and Bay of Cadiz (**Figure 7**). The size composition of anchovy catches indicates that smallest recruits occurred mainly in the Spanish coastal waters (**Figure 6**).

Gulf of Cadiz anchovy abundance and biomass in autumn 2019 were of 5 518 million fish and 48 398 t. Spanish waters concentrated 78% (4 301 million) and 67% (32 309 t) of the total estimated abundance and biomass respectively. Portuguese estimates amounted to 1 217 million and 16 089 t (**Table 5**, **Figure 8**).

The size range recorded for the estimated population was comprised between 8.0 and 19.0 cm size classes, with a marked mode at the 10.0 cm size class (**Table 5**, **Figure 8**). The mean size and weight of the estimated population were 11.1 cm and 8.8 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 Chipiona-Rota area, with the coastal area comprised between Guadiana and Guadalquivir rivers being the area where the highest densities of anchovy juveniles were recorded (**Table 5**, **Figure 8**).

The population was composed by the age groups 0 to 2. Age 0 was the dominant age group (88% of total abundance and 75% of the total biomass: 4845 million, 36 405 t), followed by 1-year olds (563 million, 10%; 9307 t, 19%). Spanish waters concentrated 84% of age-0 fish (4082 million, 29 792 t), whereas the Portuguese ones recorded the remaining 16% of the recruits' population (763 million, 6613 t), (**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 the highest acoustic densities were recorded in Portuguese waters (**Figure 11**). The sardine size composition in the positive hauls indicates that juveniles were mainly distributed in the Spanish coastal waters between Guadiana river mouth and Bay of Cadiz (**Figure 10**).

Sardine abundance and biomass in the surveyed area were of 937 million fish and 36 465 t (**Table 8**, **Figure 12**). Portuguese waters concentrated 67% (629 million) and 85% (30 877 t) of the total estimated abundance and biomass, respectively. Estimates from Spanish waters amounted to 308 million and 5 588 t (**Table 8**, **Figure 12**).

The size range recorded for the estimated population was comprised between 9.5 and 23.0 cm size classes, with a dominant mode at 17.0 cm size class and a secondary one at 13.5 cm (**Table 8**, **Figure 12**). The mean size and weight of the estimated population were 16.0 cm and 38.9 g, respectively. The sardine size and age composition by coherent post-strata in the surveyed area confirm that juveniles were widely distributed and more abundant in the coastal-inner shelf waters between the Guadiana river mouth and Bay of Cadiz (**Tables 8** and **9**, **Figures 12** and **13**).

The population was composed by the age groups 0 to 5. Age 1 was the dominant age group (45% of total abundance and 54% of the total biomass: 424 million, 19 656 t), followed by 0 olds. The age-0 population fraction in the surveyed area was estimated at 384 million fish and 7 858 t, 41% and 22% of the total estimated abundance and biomass, respectively. Spanish waters concentrated 76% of age-0 fish (290 million, 4 993 t), whereas the Portuguese ones recorded the remaining 24% of the recruits' population (94 million, 2 865 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 was distributed over the shelf waters comprised between Portimão and Punta Umbría, with the relatively highest densities being located in the Portuguese waters (**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 3 million fish and 261 t (**Table 11**, **Figure 16**). Eighty eight per cent (88%) of both total abundance and biomass were estimated in the Portuguese waters (2.7 million; 230 t). Spanish waters yielded a population of 0.4 million and 31 t.

The size range recorded for the estimated population was comprised between 20.5 and 34.5 cm size classes, with a dominant mode at 22.0 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 and age class are given in **Tables 12** and **13** and **Figures 19** and **20**.

Chub mackerel, although widely distributed, showed, however, a relatively scattered distribution in Spanish waters. The highest integration values were recorded between Cape San Vicente and Cape Santa Maria, in the western Algarve (**Figure 18**). Size composition in the species' positive hauls indicates that juvenile/sub-adult fish mainly occurred in the Portuguese westernmost shelf waters of the surveyed area whereas larger fish were distributed in shallower waters between Punta Umbría and Matalascañas (**Figure 17**).

Chub mackerel abundance and biomass in the surveyed area were of 367 million fish and 26 212 t (**Table 12**, **Figure 19**). Portuguese waters accounted for 99% (363 million) and 98% (25 782 t) of the total abundance and biomass, respectively. Spanish waters yielded a population of only 4 million and 430 t.

The size range recorded for the estimated population was comprised between 17.5 and 27.0 cm size classes, with a dominant mode at 20.0 cm size class. A rather similar size composition is also recorded for the estimated biomass (**Table 12**, **Figure 19**). Portuguese and Spanish waters hosted very contrasted fractions of the population in terms of size composition, with larger fish being recorded in Spanish waters (mode at 22.5 cm *vs* mode at 20.0 cm size class in Spanish waters).

The population was structured by the age groups 0 to 3. Age 1 was the dominant age group (67% of total abundance and biomass: 245 million, 17 655 t). The age-0 population fraction in the surveyed area was estimated at 88 million fish and 5 265 t, 24% and 20% of the total estimated abundance and biomass, respectively. Portuguese waters concentrated 99.8% of age-0 fish (88 million, 5 254 t), whereas the Spanish ones recorded the remaining 0.2% of the recruits' population (0.1 million, 11 t), (**Table 13**, **Figure 20**).

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 21**. 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 22**. Estimated abundance and biomass by size class are given in **Table 15** and **Figure 23**.

The species showed a scattered distribution with a scarce occurrence in the easternmost third of the surveyed area and the highest densities in the Portuguese waters (**Figure 22**). Size composition in the species' positive hauls seems to suggest the localisation of larger specimens in the outer shelf of the western Algarve waters, whereas spots of juvenile fish are mainly located in Spanish waters (**Figure 21**).

Horse mackerel abundance and biomass in the surveyed area were of 32 million fish and 335 t (**Table 15**, **Figure 23**). Portuguese waters accounted for 61% (19 million) and 79% (264 t) of the total abundance and biomass, respectively. Spanish waters yielded a population of 13 million and 21 t.

The size range recorded for the estimated population was comprised between 3.5 and 27.5 cm size classes, with a dominant mode at 6.5 cm size class, a secondary mode at 18.0 cm and a third mode at 25.5 cm size class. A rather similar size composition is also recorded for the estimated biomass, although in this case those modes corresponding to larger sizes were the dominant ones (**Table 15**, **Figure 23**).

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 24**. 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 25**. Estimated abundance and biomass by size class are given in **Table 16** and **Figure 26**.

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 25**). Size composition in the species' positive hauls shows that the largest specimens were located in the outer shelf of the easternmost waters of the surveyed area, whereas the rest of the surveyed area is frequented by smaller but adult fish. Some incidental spots of juvenile fish were recorded in front of the Matalascañas area (**Figure 24**).

Mediterranean horse mackerel abundance and biomass in the surveyed area were of 55 million fish and 19 307 t (**Table 16**, **Figure 26**). Spanish waters accounted for 99% of both the total abundance (54 million) and biomass (19 050 t), respectively. Portuguese waters yielded a population of 1 million and 258 t.

The size range recorded for the estimated population was comprised between 29.0 and 42.0 cm size classes, with a main mode at 31.0 cm and a secondary one at 37.0 cm. About the same modal classes but with reversed relative importance were also recorded in the distribution of the estimated biomass by size class (**Table 16**, **Figure 26**).

Blue jack 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 27**. 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 28**. Estimated abundance and biomass by size class are given in **Table 17** and **Figure 29**.

The species was mainly distributed over the Portuguese shelf between Portimão and Tavira, although a residual nucleus was also recorded in the easternmost Spanish waters (**Figure 28**). 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 positive area is frequented by sub-adult and adult fish (**Figure 27**).

Blue jack mackerel abundance and biomass in the surveyed area were of 17 million fish and 1 422 t (**Table 17**, **Figure 29**). Portuguese waters accounted for more than 97% of both the total abundance (17 million) and biomass (1 387 t), respectively. Spanish waters yielded a population of 0.4 million and 36 t.

The size range recorded for the estimated population was comprised between 14.5 and 25.0 cm size classes, with a main mode at 22.0 cm and a secondary one at 16.5 cm. The same modal classes and relative importance were also recorded in the distribution of the estimated biomass by size class (**Table 17**, **Figure 29**).

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 30**. 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 31**. Estimated abundance and biomass by size class are given in **Table 18** and **Figure 32**.

The species was restricted to the central and western waters of the surveyed area, where showed a scattered distribution all over the shelf, with several spots of high acoustic density (**Figure 31**). Size composition in the species' positive hauls shows that larger specimens are located in the middle-outer shelf of the central waters of the surveyed area, whereas the rest of the positive area was frequented by smaller adult fish (**Figure 30**).

Bogue abundance and biomass in the surveyed area were less of 1 million fish and 117 t (**Table 18**, **Figure 32**). Portuguese and Spanish waters similarly contributed in the total abundance and biomass. Portuguese waters yielded 0.4 million fish and 55 t. Spanish waters yielded a population of 0.4 million and 62 t.

The size range recorded for the estimated population was comprised between 17.5 and 29.0 cm size classes, with a main mode at 24.0 cm and a secondary one at 21.5 cm. The same dominant modal classes were also recorded in the distribution of the estimated biomass by size class (**Table 18**, **Figure 32**).

Atlantic pomfret

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 33**. 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 34**. Estimated abundance and biomass by size class are given in **Table 19** and **Figure 35**.

The species was recorded in a restricted area comprising the Spanish middle-outer shelf waters between the Guadalquivir river mouth and the Bay of Cadiz (**Figure 34**). Size composition in the species' positive hauls shows that larger specimens are occurred in shallower waters (**Figure 33**).

Pomfret abundance and biomass in the surveyed area were of 6 million fish and 4333 t (**Table 19**, **Figure 35**).

The size range recorded for the estimated population was comprised between 36.0 and 45.5 cm size classes, with a main mode at 41.5 cm. The same dominant modal class was also recorded in the distribution of the estimated biomass by size class (**Table 19**, **Figure 35**).

Boarfish

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 36**. 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 37**. Estimated abundance and biomass by size class are given in **Table 20** and **Figure 38**.

The species was confined to a small area of the middle-outer shelf just to the west of Cape Santa María (**Figure 37**).

Boarfish abundance and biomass in the surveyed area were of 10 million fish and 99 t (**Table 20**, **Figure 38**).

The size range recorded for the estimated population was comprised between 6.0 and 13.0 cm size classes, with a main mode at 7.5 cm. The same dominant modal class was also recorded in the distribution of the estimated biomass by size class (**Table 20**, **Figures 36** and **38**).

Longspine snipefish

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 39**. 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 40**. Estimated abundance and biomass by size class are given in **Table 21** and **Figure 41**.

The species showed a concurrent distribution with boarfish (**Figure 40**).

Snipefish abundance and biomass in the surveyed area were of 10 million fish and 124 t (**Table 21**, **Figure 41**).

The size range recorded for the estimated population was comprised between 10.5 and 14.5 cm size classes, with a not clearly defined main mode at 12.0 or 13 cm. A similar figure is also observed in the distribution of the estimated biomass by size class (**Table 21**, **Figures 39** and **41**).

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 42**. 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 43**. Estimated abundance and biomass by size class are given in **Table 22** and **Figure 44**.

Pearlside was located close to the deepest limit of the surveyed area (200 m), just in the transition between outer shelf and upper slope waters. The highest densities were recorded in the Spanish outer shelf (**Figure 43**).

Pearlside abundance and biomass in the surveyed area were of 1 668 million fish and 1 823 t (**Table 22**, **Figure 44**). Spanish waters accounted for 80-81% of both the total abundance (1 351 million) and biomass (1 454 t), respectively. Portuguese waters yielded estimates of 317 million and 368 t.

The size range recorded for the estimated population was comprised between 5.0 and 6.0 cm size classes, with a single mode at 5.5 cm size class. The same modal class was also recorded in the distribution of the estimated biomass by size class (**Table 22**, **Figure 44**).

(SHORT) DISCUSSION

The time series of anchovy and sardine estimates from this survey series are described in **Tables 7** and **10** and **Figure 45**. For those surveys covering the whole survey's area (i.e. 2014-2016, 2018-2019), the 2019 anchovy estimates were the highest ones in the series, both for the total population (abundance and biomass) and for the juveniles biomass. Anchovy juveniles abundance in autumn 2019 was the second peak in the series after the maximum recorded in 2015 (**Table 7**).

Sardine total biomass in autumn 2019 experienced a noticeable increase, reaching the second peak in the autumn series. However, total abundance showed an opposite trend, suggesting a population sustained by large fish. Thus, abundance and biomass levels of sardine juveniles were estimated well below the historical average (**Table 10**, **Figure 45**).

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.

ECOCADIZ-RECLUTAS 2019-10 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.

REFERENCES

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

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

Foote, K.G., H.P. Knudsen, G. Vestnes, D.N. MacLennan, E.J. Simmonds, 1987. Calibration of acoustic instruments for fish density estimation: a practical guide. *ICES Coop. Res. Rep*., 144, 57 pp.

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

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

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

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

Ramos, F., M. Iglesias, J. Miquel, D. Oñate, J. Tornero, A. Ventero, N. Díaz, 2013. Acoustic assessment and distribution of the main pelagic fish species in the ICES Subdivision IXa South during the *ECOCÁDIZ-RECLUTAS 1112* Spanish survey (November 2012). Working document presented in the ICES Working Group on Southern Horse Mackerel, Anchovy and Sardine (WGHANSA), Bilbao (Basque Country), Spain, 21-26 June 2013 and in the ICES Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VIII and IX (WGACEGG). Lisbon, Portugal, 25-29 November 2013.

Table 1. *ECOCADIZ-RECLUTAS 2019-10* 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**	16/10/2019	36º 12,933' N	6º 08,968' W	06:55	24	36º 02,190' N	6º 28,790' W	10:55	200
R02	**Sancti-Petri**	16/10/2019	36º 08,850' N	6º 34,250' W	11:48	200	36º 19,330' N	6º 14,940' W	17:36	27
R03	**Cádiz**	17/10/2019	36º 26,611' N	6º 19,380' W	06:54	27	36º 17,330' N	6º 36,290' W	10:56	189
R04	**Rota**	17/10/2019	36º 24,589' N	6º 40,726' W	11:51	200	36º 34,711' N	6º 22,075' W	15:47	21
R05	**Chipiona**	20/10/2019	36º 31,216' N	6º 46,319' W	08:39	200	36º 40,339' N	6º 29,519' W	10:17	22
R06	**Doñana**	20/10/2019	36º 37,927' N	6º 51,557' W	15:53	202	36º 47,165' N	6º 34,689' W	17:36	20
R07	**Matalascañas**	22/10/2019	36º 44,032' N	6º 58,302' W	6:56	200	36º 54,262' N	6º 39,423' W	10:21	20
R08	**Mazagón**	22/10/2019	37º 01,190' N	6º 44,406' W	13:49	21	36º 49,350' N	7º 06,156' W	18:05	200
R09	**Punta Umbría**	21/10/2019	36º 49,740' N	7º 06,532' W	06:53	197	37º 04,639' N	6º 55,868' W	10:49	24
R10	**El Rompido**	21/10/2019	37º 07,564' N	7º 07,115' W	11:59	20	36º 50,076' N	7º 07,171 'W	17:44	200
R11	**Isla Cristina**	23/10/2019	37º 06,837' N	7º 17,178' W	7:08	24	36º 53,433' N	7º 17,121' W	10:39	234
R12	**V.R. do Sto. Antonio**	23/10/2019	37º 06,581' N	7º 27,057' W	12:28	20	36º 56,288' N	7º 27,087' W	15:04	202
R13	**Tavira**	24/10/2019	37º 04,609' N	7º 37,105' W	07:05	20	36º 57,031' N	7º 37,052' W	07:50	199
R14	**Fuzeta**	24/10/2019	36º 55,474' N	7º 47,030' W	13:27	200	36º 59,330' N	7º 47,036' W	13:49	37
R15	**Cabo Sta. María**	25/10/2019	36º 55,810' N	7º 57,005' W	07:09	60	36º 52,1104' N	7º 56,929' W	07:31	205
R16	**Quarteira**	25/10/2019	36º 49,736' N	8º 06,934' W	10:32	200	37º 01,575' N	8º 06,975' W	13:08	48
R17	**Albufeira**	26/10/2019	37º 01,794' N	8º 16,920' W	07:09	25	36º 49,402' N	8º 16,815' W	10:14	107
R18	**Alfanzinha**	26/10/2019	36º 50,309' N	8º 26,748' W	11:27	200	37º 04,659' N	8º 27,038' W	15:13	21
R19	**Portimao**	27/10/2019	37º 05,393' N	8º 36,979' W	07:46	29	36º 51,321' N	8º 36,758' W	11:03	201
R20	**Burgau**	27/10/2019	36º 51,989' N	8º 46,656' W	14:37	197	37º 02,607' N	8º 46,971' W	15:39	46
R21	**Ponta de Sagres**	28/10/2019	36º 59,161' N	8º 56,853' W	8:01	26	36º 50,672' N	8º 57,264' W	10:21	117

Table 2. *ECOCADIZ-RECLUTAS 2019-10* 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	16-10-2019	36º 03.8140 N	6º 25.5317 W	36º 05.3881 N	6º 22.8491 W	09:00	09:40	102,56	79,38	0:40	1:23	2,683	R01	Trafalgar
2	16-10-2019	36º 12.5328 N	6º 26.9486 W	36º 10.8599 N	6º 30.4071 W	12:56	13:44	88,52	114,74	0:48	1:27	3,260	R02	Sancti-Petri
3	16-10-2019	36º 16.0562 N	6º 20.7204 W	36º 14.8724 N	6º 22.7704 W	15:39	16:09	48,25	52,63	0:29	1:12	2,036	R02	Sancti-Petri
4	17-10-2019	36º 22.3298 N	6º 27.1413 W	36º 24.1247 N	6º 23.7157 W	08:25	09:14	62,12	49,35	0:48	1:18	3,296	R03	Cádiz
5	17-10-2019	36º 29.2443 N	6º 32.1474 W	36º 27.4997 N	6º 35.1720 W	13:08	13:51	68,16	90,76	0:43	1:24	2,998	R04	Rota
6	20-10-2019	36º 36.2217 N	6º 36.9126 W	36º 34.5781 N	6º 39.8945 W	11:09	11:52	60,37	81,22	0:43	1:26	2,909	R05	Chipiona
7	20-10-2019	36º 30.6422 N	6º 43.0233 W	36º 33.1271 N	6º 44.5460 W	13:48	14:29	119,76	120,78	0:40	1:29	2,768	R05	Chipiona
8	21-10-2019	36º 50.7991 N	7º 05.1267 W	36º 52.5506 N	7º 04.1154 W	08:20	08:49	132,84	111,50	0:29	1:23	1,928	R09	Punta Umbría
9	21/10/2019	37º 01.8776 N	7º 07.1545 W	37º 04.6160 N	7º 07.2459 W	13:03	13:43	48,72	32,91	0:40	1:19	2,736	R10	El Rompido
10	21/10/2019	36º 55.5919 N	7º 07.2061 W	36º 58.2915 N	7º 07.2247 W	15:41	16:20	98,09	79,25	0:39	1:23	2,696	R10	El Rompido
11	22/10/2019	36º 45.7332 N	6º 55.1433 W	36º 45.2861 N	6º 55.9368 W	07:54	08:06	113,77	120,57	0:11	1:00	0,778	R07	Matalascañas
12	22/10/2019	36º 51.2179 N	6º 45.0416 W	36º 49.6247 N	6º 48.0559 W	11:08	11:50	33,98	53,87	0:42	1:16	2,896	R07	Matalascañas
13	22/10/2019	36º 56.4020 N	6º 53.2854 W	36º 58.2832 N	6º 49.8260 W	15:07	15:56	48,89	36,06	0:49	1:30	3,349	R08	Mazagón
14	23/10/2019	37º 02.4192 N	7º 17.0105 W	37º 05.2068 N	7º 17.0339 W	08:03	08:46	53,67	32,84	0:42	1:28	2,784	R11	Isla Cristina
15	23/10/2019	36º 58.4180 N	7º 27.2595 W	36º 59.6580 N	7º 27.0902 W	13:49	14:08	110,98	99,05	0:19	1:01	1,246	R12	V. R. Sto. Antonio
16	24/10/2019	37º 02.8723 N	7º 36.9136 W	37º 00.7518 N	7º 36.9597 W	08:50	09:20	44,60	95,27	0:30	1:15	2,118	R13	Tavira
17	24/10/2019	37º 00.4089 N	7º 37.0353 W	36º 57.9952 N	7º 37.0192 W	11:00	11:35	96,58	126,42	0:35	1:31	2,411	R13	Tavira
18	24/10/2019	36º 58.3203 N	7º 46.9955 W	36º 56.1834 N	7º 46.9914 W	14:23	14:55	73,10	108,50	0:31	1:20	2,134	R14	Fuzeta
19	25/10/2019	36º 54.7034 N	7º 56.9667 W	36º 52.1844 N	7º 56.9489 W	08:15	08:50	74,89	188,35	0:35	1:29	2,516	R15	Cabo de Sta Mª
20	25/10/2019	36º 55.8915 N	8º 06.7695 W	36º 53.3990 N	8º 07.0200 W	11:38	12:15	52,39	93,54	0:36	1:15	2,497	R16	Quarteira
21	25/10/2019	36º 59.5280 N	8º 07.0209 W	36º 56.4144 N	8º 07.0539 W	14:12	14:58	40,11	48,18	0:46	1:21	3,110	R16	Quarteira
22	26/10/2019	36º 53.2862 N	8º 16.8967 W	36º 56.1687 N	8º 17.1895 W	08:34	09:17	103,55	79,35	0:42	1:21	2,888	R17	Albufeira
23	26/10/2019	36º 54.4352 N	8º 26.8725 W	36º 50.9401 N	8º 26.7866 W	12:20	13:11	116,63	134,59	0:50	1:39	3,491	R18	Alfanzina
24	27/10/2019	37º 03.4728 N	8º 36.2125 W	37º 03.0031 N	8º 38.3574 W	09:03	09:29	40,62	40,32	0:25	0:52	1,780	R19	Portimão
25	27/10/2019	36º 52.3146 N	8º 36.7508 W	36º 55.4934 N	8º 36.7452 W	12:10	12:56	117,25	96,04	0:46	1:25	3,175	R19	Portimão
26	28/10/2019	36º 54.1791 N	8º 54.5330 W	36º 53.7336 N	8º 57.2315 W	09:49	10:21	118,06	116,68	0:31	1:12	2,210	R21	Ponta de Sagres

Table 3. *ECOCADIZ-RECLUTAS 2019-10* 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*	*Atlantic pomfret*	*Transp. goby*	*Boarfish*	*Snipefish*	*Pearlside*	Other spp.	TOTAL
01	0	0	0	6	0	1	1	66	0	0	0	0	0	0	2	**76**
02	0	0	0	2	0	0	0	163	0	0	0	0	0	0	5	**170**
03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
04	0	0	2	0	0	0	0	10	0	0	0	0	0	0	0	**12**
05	439	38	0	0	0	0	0	2	0	6	0	0	0	0	10	**495**
06	2805	110	0	0	0	0	0	0	0	1466	0	0	0	0	4	**4385**
07	49981	0	0	2010	0	0	0	0	0	8	0	0	0	0	25	**52024**
08	54859	2	0	29	8	0	4	0	0	0	0	0	0	13	18	**54933**
09	8485	78	0	3	2	0	0	12	5	0	0	0	0	0	38	**8623**
10	21608	8	0	0	0	0	53	0	0	0	2	0	0	1	13	**21685**
11	23159	0	0	0	1	0	0	0	0	1	0	0	0	0	13	**23174**
12	22100	916	0	0	0	0	34	4	0	0	4	0	0	0	44	**23102**
13	3739	410	0	1	0	0	4	4	0	0	0	0	0	0	25	**4183**
14	5097	1	0	0	3	0	156	7	0	0	0	0	0	0	24	**5288**
15	6734	0	0	3	0	0	0	0	0	0	0	0	0	0	2	**6739**
16	6585	2702	0	103	13	4	0	0	3	0	0	0	0	0	9	**9419**
17	2326	280	0	28338	153	65	3	0	5	0	0	0	0	0	3	**31173**
18	744	0	0	21	2	27	14	0	0	0	0	0	0	0	6	**814**
19	12515	0	0	102	47	2	2	0	0	0	0	2395	85	0	49	**15197**
20	982	13	0	3	6	0	1	0	0	0	0	16	3	0	10	**1034**
21	0	4109	0	11409	3	163	84	2	29	0	0	0	0	0	262	**16061**
22	163	0	0	3285	5	0	3	0	0	0	0	0	0	0	12	**3468**
23	17934	1	0	907	29	3723	56	0	2	0	0	0	0	0	11	**22663**
24	0	58308	0	192	0	0	0	0	0	0	0	0	0	0	0	**58500**
25	0	0	0	5272	8	0	2	0	0	0	0	0	0	0	8	**5290**
26	552	0	0	1519	1	0	22	0	2	0	0	0	0	0	4	**2100**
TOTAL	**240807**	**66976**	**2**	**53205**	**281**	**3985**	**439**	**270**	**46**	**1481**	**6**	**2411**	**88**	**14**	**597**	**370608**

Table 3. *ECOCADIZ-RECLUTAS 2019-10* 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*	*Atlantic pomfret*	*Transp. goby*	*Boarfish*	*Snipefish*	*Pearlside*	Other spp.	TOTAL
01	0	0	0	0,421	0	0,236	0,037	25,946	0	0	0	0	0	0	0,250	**26,890**
02	0	0	0	0,126	0	0	0	49,027	0	0	0	0	0	0	0,719	**49,872**
03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
04	0	0	0,480	0	0	0	0	1,935	0	0	0	0	0	0	0	**2,415**
05	5,173	0,759	0,0	0	0	0	0	0,374	0	4,664	0	0	0	0	1,192	**12,162**
06	25,900	2,159	0	0	0	0	0	0	0	1012,160	0	0	0	0	41,638	**1081,857**
07	449,550	0	0	264,720	0	0	0	0	0	5,908	0	0	0	0	4,904	**725,082**
08	446,460	0,025	0	2,139	0,715	0	0,017	0	0	0	0	0	0	0,023	2,565	**451,944**
09	50,320	1,064	0	0,917	0,519	0	0	2,508	1,202	0	0	0	0	0	43,134	**99,664**
10	170,340	0,153	0	0	0	0	0,212	0	0	0	0,001	0	0	0,001	0,898	**171,605**
11	243,460	0	0	0	0,084	0	0	0	0	0,573	0	0	0	0	1,151	**245,268**
12	111,280	12,585	0	0	0	0	0,193	0,082	0	0	0,002	0	0	0	4,925	**129,067**
13	18,860	5,540	0	0,221	0	0	0,138	0,664	0	0	0	0	0	0	2,336	**27,759**
14	38,920	0,017	0	0	0,738	0	0,734	1,544	0	0	0	0	0	0	2,247	**44,200**
15	112,820	0	0	0,227	0	0	0	0	0	0	0	0	0	0	0,026	**113,073**
16	90,080	87,380	0	9,202	3,315	0,184	0	0	0,302	0	0	0	0	0	1,590	**192,053**
17	35,296	16,335	0	2997,544	13,357	3,438	0,143	0	0,828	0	0	0	0	0	0,737	**3067,678**
18	15,260	0	0	2,002	0,267	1,077	0,652	0	0	0	0	0	0	0	0,951	**20,209**
19	291,780	0	0	10,252	3,607	0,092	0,163	0	0	0	0	23,930	1,049	0	11,637	**342,510**
20	22,673	0,667	0	0,250	0,450	0	0,136	0	0	0	0	0,150	0,035	0	1,194	**25,555**
21	0	186,280	0	710,78	0,442	6,614	4,849	0,121	3,030	0	0	0	0	0	43,201	**955,317**
22	4,211	0	0	270,000	1,714	0	0,353	0	0	0	0	0	0	0	1,433	**277,711**
23	525,150	0,044	0	68,860	4,406	468,900	8,219	0	0,258	0	0	0	0	0	1,626	**1077,463**
24	0	3035,448	0	11,582	0	0	0	0	0	0	0	0	0	0	0	**3047,030**
25	0	0	0	400,300	0,633	0	0,218	0	0	0	0	0	0	0	0,856	**402,007**
26	17,140	0	0	108,080	0,078	0	2,707	0	0,213	0	0	0	0	0	0,507	**128,725**
TOTAL	**2674,673**	**3348,456**	**0,480**	**4857,623**	**30,325**	**480,541**	**18,771**	**82,201**	**5,833**	**1023,305**	**0,003**	**24,080**	**1,084**	**0,024**	**169,717**	**12717,116**

Table 4. *ECOCADIZ-RECLUTAS 2019-10* 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*; VAM: *Scomber colias*; MAC: S. *scombrus*; JAA: *Trachurus picturatus*; HOM: *T. trachurus*; HMM: *T. mediterraneus*; BOG: *Boops boops*; POA: *Brama brama*; BOC: *Capros aper*; SNS: *Macroramphosus scolopax*; MAV: *Maurolicus muelleri* (LW relationship from *ECOCADIZ-RECLUTAS 2018-10* survey).

Parameter	ANE	PIL	VAM	MAC	JAA	HOM	HMM	BOG	POA	BOC	SNS	MAV
Size range (mm)	85-191	110-226	182-323	212-384	157-310	45-275	97-420	175-290	362-459	62-108	105-145	32-66
n	1015	463	565	177	158	218	140	46	167	100	85	129
a	0,002527603	0,002004432	0,003528031	0,001779081	0,003881192	0,009617424	0,011285218	0,004010563	0,005845242	0,033443272	0,012431483	0,006143344
b	3,353568996	3,52240318	3,262952516	3,436861614	3,246707232	2,956537435	2,893014429	3,272984272	3,129312126	2,791647808	2,7186097	3,028111499
r^2	0,989734159	0,987590659	0,948187114	0,98908085	0,9751995	0,998313258	0,984256772	0,914810497	0,721867302	0,911656079	0,702710433	0,93733259

Table 5. *ECOCADIZ-RECLUTAS 2019-10* 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 2019-10 . Engraulis encrasicolus* . 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**
6	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
7	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
8	0	0	0	0	543228	811548	7976001	0	993406	3121872	543228	12902827	13446055	1	13	13
8.5	0	0	0	0	1055879	1577415	66184169	0	1930895	25905029	1055879	95597508	96653387	1	96	97
9	0	0	0	517976	5694386	8507041	254215755	0	10413370	99502140	6212362	372638306	378850668	6	373	379
9.5	0	0	0	564754	42484424	63468957	419829463	0	77691611	164324710	43049178	725314741	768363919	43	725	768
10	0	0	0	4719451	137553722	205496283	201059753	4027121	251545608	78696443	142273173	740825208	883098381	142	741	883
10.5	0	0	0	15189215	173360393	258989113	50595741	29242089	317025559	19803590	188549608	675656092	864205700	189	676	864
11	0	0	0	13012272	128411819	191838876	42285301	152042426	234827736	16550815	141424091	637545154	778969245	141	638	779
11.5	0	0	0	23568127	80185136	119791361	13245870	196965254	146635211	5184542	103753263	481822238	585575501	104	482	586
12	0	0	0	19772660	53330127	79671729	4416226	158087310	97525237	1728547	73102787	341429049	414531836	73	341	415
12.5	0	0	158621	23548078	20359687	30416044	3515119	65873533	37231926	1375846	44066386	138412468	182478854	44	138	182
13	0	0	2208143	53127771	5507242	8227460	0	33559316	10071138	0	60843156	51857914	112701070	61	52	113
13.5	0	0	7899004	73299096	3056166	4565713	1757559	6709026	5588836	687923	84254266	19309057	103563323	84	19	104
14	46655	1707881	28257379	61852242	543228	811548	0	4376182	993406	0	92407385	6181136	98588521	92	6	99
14.5	62092	2272966	38226124	34193725	0	0	0	0	0	0	74754907	0	74754907	75	0	75
15	215640	7893801	38100112	16138853	0	0	0	1342374	0	0	62348406	1342374	63690780	62	1	64
15.5	335415	12278331	21084540	5149656	0	0	0	0	0	0	38847942	0	38847942	39	0	39
16	385659	14117601	11986727	2932708	0	0	0	0	0	0	29422695	0	29422695	29	0	29
16.5	308130	11279550	4741005	648890	0	0	0	0	0	0	16977575	0	16977575	17	0	17
17	163041	5968342	2865573	517976	0	0	0	0	0	0	9514932	0	9514932	10	0	10
17.5	76954	2817006	238905	0	0	0	0	0	0	0	3132865	0	3132865	3	0	3
18	19041	697023	0	0	0	0	0	0	0	0	716064	0	716064	1	0	1
18.5	2929	107234	0	0	0	0	0	0	0	0	110163	0	110163	0.1	0	0.1
19	1465	53617	0	0	0	0	0	0	0	0	55082	0	55082	0.1	0	0.1
19.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL *n*	1617021	59193352	155766133	348753450	652085437	974173088	1065080957	652224631	1192473939	416881457	1217415393	4300834072	5518249465	**1217**	**4301**	**5518**
Millions	**2**	**59**	**156**	**349**	**652**	**974**	**1065**	**652**	**1192**	**417**						

Table 5. *ECOCADIZ-RECLUTAS 2019-10* survey. Anchovy (*E. encrasicolus*). Cont'd.

***ECOCADIZ-RECLUTAS 2019-10 . Engraulis encrasicolus* . BIOMASS (t)**													
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	**POL09**	**POL10**	**PORTUGAL**	**SPAIN**	**TOTAL**
6	0	0	0	0	0	0	0	0	0	0	0	0	0
6.5	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0
7.5	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	1.626	2.429	23.872	0	2.973	9.344	1.626	38.618	40.243
8.5	0	0	0	0	3.850	5.751	241.297	0	7.040	94.446	3.850	348.533	352.383
9	0	0	0	2.275	25.014	37.369	1116.694	0	45.743	437.083	27.289	1636.889	1664.178
9.5	0	0	0	2.960	222.656	332.633	2200.275	0	407.172	861.206	225.616	3801.287	4026.902
10	0	0	0	29.250	852.537	1273.635	1246.138	24.959	1559.042	487.749	881.788	4591.524	5473.312
10.5	0	0	0	110.444	1260.545	1883.171	367.894	212.626	2305.168	143.997	1370.989	4912.856	6283.845
11	0	0	0	110.198	1087.493	1624.643	358.105	1287.615	1988.707	140.165	1197.691	5399.236	6596.927
11.5	0	0	0	230.930	785.685	1173.762	129.788	1929.942	1436.789	50.800	1016.615	4721.082	5737.697
12	0	0	0	222.799	600.926	897.744	49.762	1781.334	1098.918	19.477	823.725	3847.236	4670.961
12.5	0	0	2.044	303.437	262.352	391.937	45.295	848.837	479.766	17.729	567.833	1783.564	2351.398
13	0	0	32.372	778.859	80.737	120.615	0	491.983	147.644	0	891.967	760.243	1652.210
13.5	0	0	131.117	1216.702	50.730	75.787	29.174	111.364	92.770	11.419	1398.548	320.514	1719.062
14	0.873	31.957	528.736	1157.343	10.165	15.185	0	81.885	18.588	0	1729.073	115.658	1844.731
14.5	1.304	47.745	802.960	718.257	0	0	0	0	0	0	1570.266	0	1570.266
15	5.065	185.427	894.978	379.104	0	0	0	31.533	0	0	1464.574	31.533	1496.107
15.5	8.779	321.374	551.869	134.788	0	0	0	0	0	0	1016.810	0	1016.810
16	11.210	410.346	348.409	85.243	0	0	0	0	0	0	855.208	0	855.208
16.5	9.914	362.927	152.545	20.878	0	0	0	0	0	0	546.264	0	546.264
17	5.790	211.944	101.760	18.394	0	0	0	0	0	0	337.888	0	337.888
17.5	3.008	110.095	9.337	0	0	0	0	0	0	0	122.440	0	122.440
18	0.817	29.901	0	0	0	0	0	0	0	0	30.718	0	30.718
18.5	0.138	5.037	0	0	0	0	0	0	0	0	5.174	0	5.174
19	0.075	2.751	0	0	0	0	0	0	0	0	2.826	0	2.826
19.5	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0
20.5	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	**46.973**	**1719.503**	**3556.126**	**5521.862**	**5244.314**	**7834.663**	**5808.295**	**6802.079**	**9590.320**	**2273.415**	**16088.777**	**32308.772**	**48397.550**

Table 6. *ECOCADIZ-RECLUTAS 2019-10* 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 group	POL01	POL02	POL03	POL04	POL05	POL06	POL07	POL08	POL09	POL10	PORTUGAL	SPAIN	SURVEYED AREA
	N	N	N	N	N	N	N	N	N	N	N	N	N
0	3	105	4392	139405	619436	925397	1051309	560967	1132767	411491	763341	4081931	4845272
I	675	24715	108658	191171	32088	47938	5796	90738	58680	2269	357307	205422	562729
II	939	34373	42716	18178	18	27	0	519	33	0	96224	579	96802
III	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	1617	59193	155766	348753	651542	973362	1057105	652225	1191481	413760	1216872	4287931	5504803

Age group	POL01	POL02	POL03	POL04	POL05	POL06	POL07	POL08	POL09	POL10	PORTUGAL	SPAIN	SURVEYED AREA
	B	B	B	B	B	B	B	B	B	B	B	B	B
0	0.1	2	74	1662	4874	7282	5719	5638	8914	2239	6613	29792	36405
I	18	657	2367	3431	368	550	65	1152	673	26	6841	2465	9307
II	29	1060	1115	428	0.3	0.5	0	12	1	0	2633	13	2645
III	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	47	1720	3556	5522	5243	7832	5784	6802	9587	2264	16087	32270	48357

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**	**2019**
Biomass (t)	13680 (13354)	8113 (5131)	30827 (29219)	19861 (15969)	7642 (7290)	10493 (3834)	48357 (36405)
Abundance (millions)	2469 (2619)	986 (814)	5227 (5117)	3667 (3445)	1492 (1433)	953 (543)	5505 (4845)

Table 8. *ECOCADIZ-RECLUTAS 2019-10* 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 2019-10 . *Sardina pilchardus* . ABUNDANCE (in numbers and million fish)												
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	***n***			**Millions**		
							PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
6	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
7	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
8	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
9	0	0	0	0	0	0	0	0	0	0	0	0
9.5	0	0	701	545438	0	0	701	545438	546139	0.001	1	1
10	0	0	400	311299	0	0	400	311299	311699	0.0004	0.3	0.3
10.5	0	0	1502	1168035	0	0	1502	1168035	1169537	0.002	1	1
11	0	0	16284	12664444	0	0	16284	12664444	12680728	0.02	13	13
11.5	0	0	39838	30983062	1105	811103	39838	31795270	31835108	0.04	32	32
12	0	0	60176	46799955	17685	12977645	60176	59795285	59855461	0.1	60	60
12.5	0	0	33212	25829881	29756	21835742	33212	47695379	47728591	0.03	48	48
13	2294113	0	8672	6744451	44794	32871010	2302785	39660255	41963040	2	40	42
13.5	2294113	217048	1403	1090875	78099	57310819	2512564	58479793	60992357	3	58	61
14	13830224	0	0	0	26004	19082261	13830224	19108265	32938489	14	19	33
14.5	18418450	0	1102	856736	22775	16712987	18419552	17592498	36012050	18	18	36
15	31275938	0	0	0	10879	7982959	31275938	7993838	39269776	31	8	39
15.5	34265724	0	701	545438	4421	3244411	34266425	3794270	38060695	34	4	38
16	82016048	2407228	0	0	0	0	84423276	0	84423276	84	0	84
16.5	69224107	3179688	0	0	7650	5613685	72403795	5621335	78025130	72	6	78
17	72842611	13077176	0	0	0	0	85919787	0	85919787	86	0	86
17.5	49140261	13160536	0	0	1105	811103	62300797	812208	63113005	62	1	63
18	33917085	17909529	0	0	0	0	51826614	0	51826614	52	0	52
18.5	42533380	8872786	119	92790	1105	811103	51406285	904998	52311283	51	1	52
19	40239267	10088591	0	0	0	0	50327858	0	50327858	50	0	50
19.5	26062009	10940088	0	0	0	0	37002097	0	37002097	37	0	37
20	11539126	6368625	0	0	0	0	17907751	0	17907751	18	0	18
20.5	3615489	2297923	0	0	0	0	5913412	0	5913412	6	0	6
21	0	1338683	0	0	0	0	1338683	0	1338683	1	0	1
21.5	5280885	217048	0	0	0	0	5497933	0	5497933	5	0	5
22	0	0	0	0	0	0	0	0	0	0	0	0
22.5	0	0	0	0	0	0	0	0	0	0	0	0
23	0	217048	0	0	0	0	217048	0	217048	0.2	0	0.2
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	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL *n*	538788830	90291997	164110	127632404	245378	180064828	629244937	307942610	937187547	**629**	**308**	**937**
Millions	**539**	**90**	**0.2**	**128**	**0.2**	**180**	**629**	**308**	**937**			

Table 8. *ECOCADIZ-RECLUTAS 2019-10* survey. Sardine (*Sardina pilchardus*). Cont'd.

***ECOCADIZ-RECLUTAS 2019-10 . Sardina pilchardus* . BIOMASS (t)**									
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**PORTUGAL**	**SPAIN**	**TOTAL**
6	0	0	0	0	0	0	0	0	0
6.5	0	0	0	0	0	0	0	0	0
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	0.004	3.330	0	0	0.004	3.330	3.334
10	0	0	0.003	2.266	0	0	0.003	2.266	2.269
10.5	0	0	0.013	10.057	0	0	0.013	10.057	10.070
11	0	0	0.165	127.985	0	0	0.165	127.985	128.150
11.5	0	0	0.469	364.939	0.013	9.554	0.469	374.506	374.975
12	0	0	0.821	638.397	0.241	177.028	0.821	815.666	816.487
12.5	0	0	0.522	405.664	0.467	342.935	0.522	749.066	749.588
13	41.258	0	0.156	121.293	0.806	591.155	41.413	713.253	754.667
13.5	47.008	4.447	0.029	22.353	1.600	1174.327	51.484	1198.280	1249.764
14	321.382	0	0	0	0.604	443.427	321.382	444.032	765.414
14.5	483.283	0	0.029	22.480	0.598	438.533	483.312	461.610	944.922
15	922.901	0	0	0	0.321	235.564	922.901	235.885	1158.786
15.5	1132.808	0	0.023	18.032	0.146	107.259	1132.831	125.437	1258.267
16	3026.941	88.843	0	0	0	0	3115.784	0	3115.784
16.5	2842.644	130.572	0	0	0.314	230.522	2973.216	230.837	3204.052
17	3317.774	595.628	0	0	0	0	3913.402	0	3913.402
17.5	2475.193	662.896	0	0	0.056	40.855	3138.089	40.911	3179.000
18	1884.023	994.837	0	0	0	0	2878.860	0	2878.860
18.5	2598.634	542.095	0.007	5.669	0.068	49.555	3140.736	55.292	3196.028
19	2697.270	676.246	0	0	0	0	3373.516	0	3373.516
19.5	1912.093	802.642	0	0	0	0	2714.735	0	2714.735
20	924.528	510.261	0	0	0	0	1434.789	0	1434.789
20.5	315.666	200.630	0	0	0	0	516.295	0	516.295
21	0	127.105	0	0	0	0	127.105	0	127.105
21.5	544.213	22.368	0	0	0	0	566.580	0	566.580
22	0	0	0	0	0	0	0	0	0
22.5	0	0	0	0	0	0	0	0	0
23	0	28.290	0	0	0	0	28.290	0	28.290
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	0	0	0	0	0	0	0	0	0
TOTAL	**25487.617**	**5386.860**	**2.240**	**1742.465**	**5.234**	**3840.714**	**30876.718**	**5588.414**	**36465.131**

Table 9. *ECOCADIZ-RECLUTAS 2019-07* 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 group	POL01	POL02	POL03	POL04	POL05	POL06	PORTUGAL	SPAIN	SURVEYED AREA
	N	N	N	N	N	N	N	N	N
0	92142	1389	161	125367	224	164362	93692	289953	383645
I	349756	56396	3	2227	21	15232	406155	17480	423635
II	58609	20119	0.04	27	0.5	352	78728	380	79108
III	27855	10464	0.01	7	0.1	88	38318	95	38414
IV	5146	1491	0.004	3	0.04	30	6637	34	6670
V	5281	217	0	0	0	0	5498	0	5498
VI	0	0	0	0	0	0	0	0	0
TOTAL	538789	90075	164	127632	245	180065	629028	307943	936970

Age group	POL01	POL02	POL03	POL04	POL05	POL06	PORTUGAL	SPAIN	SURVEYED AREA
	B	B	B	B	B	B	B	B	B
0	2810	53	2	1699	4	3290	2865	4993	7858
I	16048	3042	0.1	41	1	524	19090	566	19656
II	3831	1366	0.002	2	0.03	20	5196	22	5218
III	1907	771	0.001	0.4	0.01	5	2679	6	2684
IV	347	104	0.0003	0.2	0.003	2	452	2	454
V	544	22	0	0	0	0	567	0	567
VI	0	0	0	0	0	0	0	0	0
TOTAL	25488	5359	2	1742	5	3841	30848	5588	36437

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**	**2019**
Biomass (t)	22119 (9182)	36571 (705)	30992 (8645)	35173 (21899)	12119 (8778)	20679 (15224)	36465 (7858)
Abundance (millions)	603 (359)	507 (26)	861 (509)	2379 (1940)	591 (483)	1134 (1036)	937 (384)

Table 11. *ECOCADIZ-RECLUTAS 2019-10* 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 2019-10 . Scomber scombrus .* ABUNDANCE (in numbers and million fish)**								
Size class	**POL01**	**POL02**	***n***			**Millions**		
			PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
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	26608	3646	26608	3646	30254	0.03	0.00	0.03
21	144553	19805	144553	19805	164358	0.1	0.02	0.2
21.5	515184	70585	515184	70585	585769	1	0.1	1
22	1173978	160847	1173978	160847	1334825	1	0.2	1
22.5	636526	87210	636526	87210	723736	1	0.1	1
23	146252	20038	146252	20038	166290	0.1	0.02	0.2
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	0	0	0	0	0	0	0	0
26.5	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0
27.5	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0
28.5	26608	3646	26608	3646	30254	0.03	0.004	0.03
29	0	0	0	0	0	0	0	0
29.5	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0
30.5	26608	3646	26608	3646	30254	0.03	0.004	0.03
31	0	0	0	0	0	0	0	0
31.5	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0
32.5	26608	3646	26608	3646	30254	0.03	0.004	0.03
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
34.5	26608	3646	26608	3646	30254	0.03	0.004	0.03
35	0	0	0	0	0	0	0	0
35.5	0	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0	0
36.5	0	0	0	0	0	0	0	0
TOTAL *n*	2749533	376715	2749533	376715	3126248	**3**	**0.4**	**3**
Millions	**3**	**0.4**						

Table 11. *ECOCADIZ-RECLUTAS 2019-10* survey. Atlantic mackerel (*Scomber scombrus*). Cont'd.

***ECOCADIZ-RECLUTAS 2019-10 . Scomber scombrus* . BIOMASS (t)**					
Size class	**POL01**	**POL02**	**PORTUGAL**	**SPAIN**	**TOTAL**
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	1.591	0.218	1.591	0.218	1.809
21	9.379	1.285	9.379	1.285	10.664
21.5	36.209	4.961	36.209	4.961	41.170
22	89.216	12.224	89.216	12.224	101.439
22.5	52.212	7.154	52.212	7.154	59.365
23	12.927	1.771	12.927	1.771	14.698
23.5	0	0	0	0	0
24	0	0	0	0	0
24.5	0	0	0	0	0
25	0	0	0	0	0
25.5	0	0	0	0	0
26	0	0	0	0	0
26.5	0	0	0	0	0
27	0	0	0	0	0
27.5	0	0	0	0	0
28	0	0	0	0	0
28.5	4.879	0.669	4.879	0.669	5.548
29	0	0	0	0	0
29.5	0	0	0	0	0
30	0	0	0	0	0
30.5	6.148	0.842	6.148	0.842	6.990
31	0	0	0	0	0
31.5	0	0	0	0	0
32	0	0	0	0	0
32.5	7.634	1.046	7.634	1.046	8.681
33	0	0	0	0	0
33.5	0	0	0	0	0
34	0	0	0	0	0
34.5	9.360	1.283	9.360	1.283	10.642
35	0	0	0	0	0
35.5	0	0	0	0	0
36	0	0	0	0	0
36.5	0	0	0	0	0
TOTAL	**229.556**	**31.452**	**229.556**	**31.452**	**261.007**

Table 12. *ECOCADIZ-RECLUTAS 2019-10* 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 2019-10 . *Scomber colias* . ABUNDANCE (in numbers and million fish)														
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	***n***			**Millions**		
									PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
14	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
15	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
16	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
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17.5	1310473	291540	0	0	0	0	0	0	1602013	0	1602013	2	0	2
18	6294458	291540	0	33595	0	0	0	0	6619593	0	6619593	7	0	7
18.5	15027266	1567366	0	0	0	0	0	0	16594632	0	16594632	17	0	17
19	28037599	8242491	14561	0	484	3091	17395	6612	36294651	27582	36322233	36	0	36
19.5	39657146	9341874	0	0	0	0	0	0	48999020	0	48999020	49	0	49
20	37276380	25750542	0	67190	484	3091	17395	6612	63094112	27582	63121694	63	0	63
20.5	9495329	32142009	43683	335948	3950	25201	141834	53916	42016969	224901	42241870	42	0	42
21	4983985	44183005	97963	403137	969	6181	34790	13225	49668090	55165	49723255	50	0	50
21.5	2444712	31638230	195978	772679	4434	28292	159229	60529	35051599	252484	35304083	35	0	35
22	655236	24905407	426470	638300	11812	75365	424165	161240	26625413	672582	27297995	27	1	27
22.5	0	15427894	499274	403137	13787	87966	495083	188198	16330305	785034	17115339	16	1	17
23	0	11180871	346979	302353	11812	75365	424165	161240	11830203	672582	12502785	12	1	13
23.5	0	3373950	372190	134379	10359	66093	371981	141403	3880519	589836	4470355	4	1	4
24	0	985236	264819	235163	8384	53493	301064	114445	1485218	477386	1962604	1	0	2
24.5	0	1695018	378823	0	3465	22110	124440	47304	2073841	197319	2271160	2	0	2
25	0	291540	192014	67190	2459	15691	88312	33570	550744	140032	690776	1	0	1
25.5	0	0	83402	33595	484	3091	17395	6612	116997	27582	144579	0	0	0
26	0	0	54280	0	484	3091	17395	6612	54280	27582	81862	0	0	0
26.5	0	0	0	33595	484	3091	17395	6612	33595	27582	61177	0	0	0
27	0	0	0	0	969	6181	34790	13225	0	55165	55165	0	0	0
27.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28.5	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
TOTAL *n*	145182584	211308513	2970436	3460261	74820	477393	2686828	1021355	362921794	74820	362996614	**363**	**4**	**367**
Millions	**145**	**211**	**3**	**3**	**0.1**	**0.5**	**3**	**1**						

Table 12. *ECOCADIZ-RECLUTAS 2019-10* survey. Chub mackerel (*Scomber colias*). Cont'd.

ECOCADIZ-RECLUTAS 2019-10 . Scomber colias . BIOMASS (t)											
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	**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	0	0	0	0	0	0	0	0
16.5	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0
17.5	55.085	12.255	0	0	0	0	0	0	67.340	0	67.340
18	289.689	13.417	0	1.546	0	0	0	0	304.652	0	304.652
18.5	755.362	78.785	0	0	0	0	0	0	834.147	0	834.147
19	1535.712	451.468	0.798	0	0.027	0.169	0.953	0.362	1987.978	1.511	1989.489
19.5	2361.717	556.340	0	0	0	0	0	0	2918.057	0	2918.057
20	2408.624	1663.879	0	4.342	0.031	0.200	1.124	0.427	4076.844	1.782	4078.626
20.5	664.370	2248.915	3.056	23.506	0.276	1.763	9.924	3.772	2939.847	15.736	2955.583
21	376.893	3341.157	7.408	30.486	0.073	0.467	2.631	1.000	3755.944	4.172	3760.115
21.5	199.446	2581.135	15.988	63.037	0.362	2.308	12.990	4.938	2859.607	20.598	2880.205
22	57.571	2188.265	37.471	56.083	1.038	6.622	37.268	14.167	2339.390	59.095	2398.485
22.5	0	1457.488	47.167	38.085	1.302	8.310	46.771	17.779	1542.739	74.163	1616.902
23	0	1133.917	35.189	30.663	1.198	7.643	43.017	16.352	1199.770	68.210	1267.980
23.5	0	366.772	40.460	14.608	1.126	7.185	40.437	15.371	421.840	64.119	485.959
24	0	114.636	30.813	27.362	0.976	6.224	35.030	13.316	172.811	55.546	228.357
24.5	0	210.803	47.113	0	0.431	2.750	15.476	5.883	257.916	24.540	282.455
25	0	38.703	25.490	8.920	0.326	2.083	11.724	4.457	73.113	18.590	91.703
25.5	0	0	11.803	4.755	0.068	0.437	2.462	0.936	16.558	3.904	20.461
26	0	0	8.179	0	0.073	0.466	2.621	0.996	8.179	4.156	12.336
26.5	0	0	0	5.384	0.078	0.495	2.788	1.060	5.384	4.420	9.804
27	0	0	0	0	0.165	1.052	5.923	2.251	0	9.391	9.391
27.5	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0	0
28.5	0	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0
TOTAL	**8704.469**	**16457.935**	**310.936**	**308.775**	**7.550**	**48.176**	**271.138**	**103.069**	**25782.115**	**429.933**	**26212.048**

Table 13. *ECOCADIZ-RECLUTAS 2019-07* survey. Chub mackerel (*Scomber colias*). Estimated abundance (thousands of individuals) and biomass (tonnes) by age group. Polygons (i.e., coherent or homogeneous post-strata) numbered as in **Figure 18** and ordered from west to east.

Age group	POL01	POL02	POL03	POL04	POL05	POL06	POL07	POL08	PORTUGAL	SPAIN	SURVEYED AREA
	N	N	N	N	N	N	N	N	N	N	N
0	56223	30976	68	258	2	15	87	33	87524	137	87662
I	87948	150595	1488	2261	41	259	1458	554	242291	2311	244602
II	1012	28488	1186	819	27	169	952	362	31505	1509	33014
III	0	1250	229	122	5	34	191	73	1601	303	1904
IV	0	0	0	0	0	0	0	0	0	0	0
V	0	0	0	0	0	0	0	0	0	0	0
VI	0	0	0	0	0	0	0	0	0	0	0
TOTAL	145183	211309	2970	3460	75	477	2687	1021	362922	4260	367182

Age group	POL01	POL02	POL03	POL04	POL05	POL06	POL07	POL08	PORTUGAL	SPAIN	SURVEYED AREA
	B	B	B	B	B	B	B	B	B	B	B
0	3151	2079	6	19	0.2	1	7	3	5254	11	5265
I	5473	11626	144	193	4	25	138	52	17436	219	17655
II	81	2617	133	81	3	18	101	38	2911	160	3071
III	0	136	29	16	1	4	25	10	181	40	221
IV	0	0	0	0	0	0	0	0	0	0	0
V	0	0	0	0	0	0	0	0	0	0	0
VI	0	0	0	0	0	0	0	0	0	0	0
TOTAL	8704	16458	311	309	8	48	271	103	25782	430	26212

Table 14. *ECOCADIZ-RECLUTAS 2019-10* 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 22**.

***ECOCADIZ-RECLUTAS 2019-10* . *Trachurus trachurus* . ABUNDANCE (in numbers and million fish)**

Size class	POL01	POL02	POL03	POL04	POL05	POL06	POL07	POL08	*n*			Millions		
									PORTUGAL	SPAIN	TOTAL	PORTUGAL	SPAIN	TOTAL
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.5	0	0	0	56106	15796	0	19547	0	56106	35343	91449	0.1	0.04	0.1
4	0	0	0	392743	110573	0	136832	0	392743	247405	640148	0.4	0.2	1
4.5	0	0	0	224425	63184	0	78190	0	224425	141374	365799	0.2	0.1	0.4
5	0	0	0	1066018	300126	0	371402	0	1066018	671528	1737546	1	1	2
5.5	0	0	0	1693087	476671	80142	589874	0	1693087	1146687	2839774	2	1	3
6	0	0	0	3138647	883653	160284	1093510	0	3138647	2137447	5276094	3	2	5
6.5	0	0	0	4000042	1126170	160284	1393622	0	4000042	2680076	6680118	4	3	7
7	0	0	0	3640302	1024889	213712	1268288	0	3640302	2506889	6147191	4	3	6
7.5	0	0	0	1366351	384682	400710	476039	0	1366351	1261431	2627782	1	1	3
8	0	0	0	425747	119865	133570	148331	0	425747	401766	827513	0.4	0.4	1
8.5	0	0	0	369641	104069	186998	128784	0	369641	419851	789492	0.4	0.4	1
9	0	0	0	0	0	53428	0	0	0	53428	53428	0	0.1	0.1
9.5	0	0	0	112212	31592	26714	39095	0	112212	97401	209613	0.1	0.1	0.2
10	0	0	0	56106	15796	0	19547	0	56106	35343	91449	0.1	0.04	0.1
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	56106	15796	0	19547	0	56106	35343	91449	0.1	0.04	0.1
13.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	56106	15796	0	19547	0	56106	35343	91449	0.1	0.04	0.1
14.5	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
15.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	55722	0	0	0	0	0	5604	55722	5604	61326	0.1	0.01	0.1
16.5	0	97513	0	0	0	0	0	9807	97513	9807	107320	0.1	0.01	0.1
17	0	83583	0	112212	31592	0	39095	8406	195795	79093	274888	0.2	0.1	0.3
17.5	0	125374	0	257428	72476	0	89689	12609	382802	174774	557576	0.4	0.2	1
18	0	153235	0	369641	104069	0	128784	15410	522876	248263	771139	1	0.2	1
18.5	0	208956	0	0	0	0	0	21014	208956	21014	229970	0.2	0.02	0.2
19	0	139304	0	0	0	0	0	14010	139304	14010	153314	0.1	0.01	0.2
19.5	0	55722	0	56106	15796	0	19547	5604	111828	40947	152775	0.1	0.04	0.2
20	5846	69652	7065	56106	15796	0	19547	7005	138669	42348	181017	0.1	0.04	0.2
20.5	0	27861	0	0	0	0	0	2802	27861	2802	30663	0.03	0.003	0.03
21	5846	27861	7065	0	0	0	0	2802	40772	2802	43574	0.04	0.003	0.04
21.5	5846	41791	7065	0	0	0	0	4203	54702	4203	58905	0.1	0.004	0.1
22	5846	13930	7065	0	0	0	0	1401	26841	1401	28242	0.03	0.001	0.03
22.5	5846	27861	7065	0	0	0	0	2802	40772	2802	43574	0.04	0.003	0.04
23	0	0	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	0	0
24	11692	13930	14131	0	0	0	0	1401	39753	1401	41154	0.04	0.001	0.04
24.5	23384	0	28261	0	0	0	0	0	51645	0	51645	0.1	0	0.1
25	40922	0	49458	0	0	0	0	0	90380	0	90380	0.1	0	0.1
25.5	75999	13930	91850	0	0	0	0	1401	181779	1401	183180	0.2	0.001	0.2
26	75999	0	91850	0	0	0	0	0	167849	0	167849	0.2	0	0.2
26.5	29230	13930	35327	0	0	0	0	1401	78487	1401	79888	0.1	0.001	0.1
27	35076	0	42392	0	0	0	0	0	77468	0	77468	0.1	0	0.1
27.5	5846	0	7065	0	0	0	0	0	12911	0	12911	0.01	0	0.01
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28.5	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
29.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL *n*	327378	1170155	395659	17505132	4928387	1415842	6098817	117682	19398324	12560728	31959052	**19**	**13**	**32**
Millions	**0.3**	**1**	**0.4**	**18**	**5**	**1**	**6**	**0.1**						

Table 14. *ECOCADIZ-RECLUTAS 2019-10* survey. Horse mackerel (*Trachurus trachurus*). Cont'd.

ECOCADIZ-RECLUTAS 2019-10 . Trachurus trachurus . BIOMASS (t)											
Size class	POL01	POL02	POL03	POL04	POL05	POL06	POL07	POL08	*n*		
									PORTUGAL	SPAIN	TOTAL
2	0	0	0	0	0	0	0	0	0	0	0
2.5	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0
3.5	0	0	0	0.027	0.008	0	0.009	0	0.027	0.017	0.044
4	0	0	0	0.272	0.077	0	0.095	0	0.272	0.172	0.444
4.5	0	0	0	0.216	0.061	0	0.075	0	0.216	0.136	0.352
5	0	0	0	1.380	0.389	0	0.481	0	1.380	0.870	2.250
5.5	0	0	0	2.869	0.808	0.136	1.000	0	2.869	1.943	4.812
6	0	0	0	6.805	1.916	0.348	2.371	0	6.805	4.635	11.440
6.5	0	0	0	10.889	3.066	0.436	3.794	0	10.889	7.296	18.185
7	0	0	0	12.241	3.446	0.719	4.265	0	12.241	8.430	20.671
7.5	0	0	0	5.596	1.575	1.641	1.950	0	5.596	5.166	10.762
8	0	0	0	2.098	0.591	0.658	0.731	0	2.098	1.980	4.077
8.5	0	0	0	2.167	0.610	1.096	0.755	0	2.167	2.462	4.629
9	0	0	0	0	0	0.369	0	0	0	0.369	0.369
9.5	0	0	0	0.906	0.255	0.216	0.316	0	0.906	0.786	1.692
10	0	0	0	0.525	0.148	0	0.183	0	0.525	0.331	0.856
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	0	0	0	0	0	0	0	0	0	0	0
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	1.122	0.316	0	0.391	0	1.122	0.707	1.829
13.5	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	1.391	0.392	0	0.485	0	1.391	0.876	2.267
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	2.037	0	0	0	0	0	0.205	2.037	0.205	2.242
16.5	0	3.899	0	0	0	0	0	0.392	3.899	0.392	4.291
17	0	3.646	0	4.895	1.378	0	1.705	0.367	8.540	3.450	11.990
17.5	0	5.951	0	12.218	3.440	0	4.257	0.598	18.169	8.295	26.465
18	0	7.896	0	19.046	5.362	0	6.636	0.794	26.942	12.792	39.734
18.5	0	11.662	0	0	0	0	0	1.173	11.662	1.173	12.835
19	0	8.404	0	0	0	0	0	0.845	8.404	0.845	9.249
19.5	0	3.626	0	3.651	1.028	0	1.272	0.365	7.278	2.665	9.943
20	0.410	4.881	0.495	3.932	1.107	0	1.370	0.491	9.717	2.967	12.684
20.5	0	2.098	0	0	0	0	0	0.211	2.098	0.211	2.309
21	0.472	2.251	0.571	0	0	0	0	0.226	3.295	0.226	3.521
21.5	0.506	3.617	0.612	0	0	0	0	0.364	4.735	0.364	5.099
22	0.541	1.290	0.654	0	0	0	0	0.130	2.485	0.130	2.614
22.5	0.578	2.754	0.698	0	0	0	0	0.277	4.031	0.277	4.308
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	1.396	1.663	1.687	0	0	0	0	0.167	4.747	0.167	4.914
24.5	2.966	0	3.584	0	0	0	0	0	6.550	0	6.550
25	5.506	0	6.655	0	0	0	0	0	12.161	0	12.161
25.5	10.836	1.986	13.096	0	0	0	0	0.200	25.919	0.200	26.119
26	11.470	0	13.863	0	0	0	0	0	25.333	0	25.333
26.5	4.665	2.223	5.638	0	0	0	0	0.224	12.525	0.224	12.749
27	5.913	0	7.146	0	0	0	0	0	13.059	0	13.059
27.5	1.040	0	1.257	0	0	0	0	0	2.297	0	2.297
28	0	0	0	0	0	0	0	0	0	0	0
28.5	0	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0
29.5	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0
TOTAL	**46.299**	**69.885**	**55.956**	**92.247**	**25.971**	**5.619**	**32.139**	**7.028**	**264.388**	**70.758**	**335.145**

Table 15. *ECOCADIZ-RECLUTAS 2019-10* 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 25**.

***ECOCADIZ-RECLUTAS 2019-10* . *Trachurus mediterraneus* . ABUNDANCE (in numbers and million fish)**											
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	***n***			**Millions**		
						PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
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	0	0	0	0	0	0	0	0	0	0
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	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0	0
28.5	0	0	0	0	0	0	0	0	0	0	0
29	75	0	0	372353	0	75	372353	372428	0.0001	0.4	0.4
29.5	149	0	0	744707	0	149	744707	744856	0.0001	1	1
30	149	0	0	744707	0	149	744707	744856	0.0001	1	1
30.5	411	0	0	2047944	0	411	2047944	2048355	0.0004	2	2
31	1046	0	0	5212948	0	1046	5212948	5213994	0.001	5	5
31.5	561	0	0	2792651	0	561	2792651	2793212	0.001	3	3
32	523	0	0	2606474	0	523	2606474	2606997	0.001	3	3
32.5	336	0	0	1675590	0	336	1675590	1675926	0.0003	2	2
33	299	0	0	1489414	0	299	1489414	1489713	0.0003	1	1
33.5	262	0	0	1303237	0	262	1303237	1303499	0.0003	1	1
34	374	9401	6694	1861767	358616	9775	2227077	2236852	0.01	2	2
34.5	224	9401	6694	1117060	358616	9625	1482370	1491995	0.01	1	1
35	336	28202	20082	1675590	1075848	28538	2771520	2800058	0.03	3	3
35.5	112	18801	13388	558530	717232	18913	1289150	1308063	0.02	1	1
36	149	47003	33471	744707	1793080	47152	2571258	2618410	0.05	3	3
36.5	112	65804	46859	558530	2510312	65916	3115701	3181617	0.1	3	3
37	112	103406	73636	558530	3944775	103518	4576941	4680459	0.1	5	5
37.5	262	84605	60247	1303237	3227543	84867	4591027	4675894	0.1	5	5
38	149	84605	60247	744707	3227543	84754	4032497	4117251	0.1	4	4
38.5	112	75204	53553	558530	2868927	75316	3481010	3556326	0.1	3	4
39	75	37602	26777	372353	1434464	37677	1833594	1871271	0.04	2	2
39.5	0	28202	20082	0	1075848	28202	1095930	1124132	0.03	1	1
40	112	9401	6694	558530	358616	9513	923840	933353	0.01	1	1
40.5	37	0	0	186177	0	37	186177	186214	0.00004	0.2	0.2
41	37	0	0	186177	0	37	186177	186214	0.00004	0.2	0.2
41.5	0	9401	6694	0	358616	9401	365310	374711	0.01	0.4	0.4
42	75	9401	6694	372353	358616	9476	737663	747139	0.01	1	1
42.5	0	0	0	0	0	0	0	0	0	0	0
43	0	0	0	0	0	0	0	0	0	0	0
43.5	0	0	0	0	0	0	0	0	0	0	0
44	0	0	0	0	0	0	0	0	0	0	0
44.5	0	0	0	0	0	0	0	0	0	0	0
45	0	0	0	0	0	0	0	0	0	0	0
TOTAL *n*	6089	620439	441812	30346803	23668652	626528	54457267	55083795	**1**	**54**	**55**
Millions	**0.01**	**1**	**0.4**	**30**	**24**						

Table 15. *ECOCADIZ-RECLUTAS 2019-10* survey. Mediterranean horse mackerel (*Trachurus mediterraneus*). Cont'd.

ECOCADIZ-RECLUTAS 2019-10 . Trachurus mediterraneus . **BIOMASS (t)**								
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**PORTUGAL**	**SPAIN**	**TOTAL**
25	0	0	0	0	0	0	0	0
25.5	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0
26.5	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0
27.5	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0
28.5	0	0	0	0	0	0	0	0
29	0.015	0	0	73.280	0	0.015	73.280	73.295
29.5	0.031	0	0	153.927	0	0.031	153.927	153.958
30	0.032	0	0	161.531	0	0.032	161.531	161.563
30.5	0.093	0	0	465.785	0	0.093	465.785	465.878
31	0.249	0	0	1242.270	0	0.249	1242.270	1242.519
31.5	0.140	0	0	696.776	0	0.140	696.776	696.915
32	0.137	0	0	680.396	0	0.137	680.396	680.532
32.5	0.092	0	0	457.305	0	0.092	457.305	457.397
33	0.085	0	0	424.708	0	0.085	424.708	424.793
33.5	0.078	0	0	388.018	0	0.078	388.018	388.096
34	0.116	2.921	2.080	578.403	111.413	3.037	691.895	694.932
34.5	0.073	3.046	2.169	361.902	116.183	3.118	480.254	483.372
35	0.113	9.522	6.781	565.759	363.257	9.636	935.797	945.433
35.5	0.039	6.612	4.708	196.429	252.243	6.652	453.381	460.033
36	0.055	17.208	12.254	272.644	656.463	17.263	941.361	958.624
36.5	0.043	25.065	17.849	212.749	956.202	25.108	1186.801	1211.909
37	0.044	40.959	29.167	221.232	1562.511	41.003	1812.910	1853.913
37.5	0.108	34.830	24.802	536.509	1328.696	34.938	1890.006	1924.944
38	0.064	36.181	25.764	318.472	1380.249	36.245	1724.486	1760.730
38.5	0.050	33.392	23.779	247.999	1273.862	33.442	1545.639	1579.081
39	0.035	17.327	12.339	171.580	660.999	17.362	844.917	862.279
39.5	0.000	13.480	9.599	0.000	514.240	13.480	523.839	537.320
40	0.056	4.659	3.317	276.801	177.726	4.715	457.844	462.559
40.5	0.019	0	0	95.622	0	0.019	95.622	95.641
41	0.020	0	0	99.056	0	0.020	99.056	99.076
41.5	0	5.179	3.688	0	197.571	5.179	201.258	206.438
42	0.043	5.361	3.817	212.327	204.494	5.403	420.638	426.041
42.5	0	0	0	0	0	0	0	0
43	0	0	0	0	0	0	0	0
43.5	0	0	0	0	0	0	0	0
44	0	0	0	0	0	0	0	0
44.5	0	0	0	0	0	0	0	0
45	0	0	0	0	0	0	0	0
TOTAL	**1.828**	**255.742**	**182.113**	**9111.478**	**9756.110**	**257.570**	**19049.700**	**19307.271**

Table 16. *ECOCADIZ-RECLUTAS 2019-10* survey. Blue jack mackerel (*Trachurus picturatus*). Estimated abundance (absolute numbers and million fish) and biomass (t) by size class (in cm). Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figure 28**.

***ECOCADIZ-RECLUTAS 2019-10* . *Trachurus picturatus* . ABUNDANCE (in numbers and million fish)**													
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	***n***			**Millions**		
								PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
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	91653	0	25	0	0	0	2678	91678	2678	94356	0.1	0.003	0.1
15	0	0	0	0	0	0	0	0	0	0	0	0	0
15.5	0	80893	0	23	0	21376	0	102292	0	102292	0.1	0	0.1
16	0	444910	0	125	0	117567	0	562602	0	562602	1	0	1
16.5	91653	498839	25	141	0	131817	2678	722475	2678	725153	1	0.003	1
17	0	498839	0	141	0	131817	0	630797	0	630797	1	0	1
17.5	91653	283125	25	80	45916	74815	2678	495614	2678	498292	0.5	0.003	0.5
18	91653	242678	25	68	45916	64127	2678	444467	2678	447145	0.4	0.003	0.4
18.5	0	134821	0	38	290798	35626	0	461283	0	461283	0.5	0	0.5
19	91653	13482	25	4	336714	3563	2678	445441	2678	448119	0.4	0.003	0.4
19.5	91653	0	25	0	76526	0	2678	168204	2678	170882	0.2	0.003	0.2
20	556969	0	149	0	168357	0	16273	725475	16273	741748	1	0.02	1
20.5	930631	0	249	0	45916	0	27190	976796	27190	1003986	1	0.03	1
21	930631	0	249	0	0	0	27190	930880	27190	958070	1	0.03	1
21.5	1674431	0	448	0	0	0	48922	1674879	48922	1723801	2	0.05	2
22	2700240	0	723	0	0	0	78893	2700963	78893	2779856	3	0.1	3
22.5	1861262	0	498	0	0	0	54380	1861760	54380	1916140	2	0.1	2
23	1861262	0	498	0	0	0	54380	1861760	54380	1916140	2	0.1	2
23.5	1304293	0	349	0	0	0	38107	1304642	38107	1342749	1	0.04	1
24	556969	0	149	0	0	0	16273	557118	16273	573391	1	0.02	1
24.5	91653	0	25	0	0	0	2678	91678	2678	94356	0.1	0.003	0.1
25	91653	0	25	0	0	0	2678	91678	2678	94356	0.1	0.003	0.1
25.5	0	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0	0
26.5	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0	0	0
27.5	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL *n*	13109912	2197587	3512	620	1010143	580708	383032	16902482	383032	17285514	**17**	**0.4**	**17**
Millions	**13**	**2**	**0.004**	**0.001**	**1**	**1**	**0.4**						

Table 16. *ECOCADIZ-RECLUTAS 2019-10* survey. Blue jack mackerel (*Trachurus picturatus*). Cont'd.

ECOCADIZ-RECLUTAS 2019-10 . Trachurus picturatus **. BIOMASS (t)**										
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**PORTUGAL**	**SPAIN**	**TOTAL**
12	0	0	0	0	0	0	0	0	0	0
12.5	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0
13.5	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0
14.5	2.217	0	0.001	0	0	0	0.065	2.218	0.065	2.283
15	0	0	0	0	0	0	0	0	0	0
15.5	0	2.422	0	0.001	0	0.640	0	3.062	0	3.062
16	0	14.741	0	0.004	0	3.895	0	18.640	0	18.640
16.5	3.351	18.237	0.001	0.005	0	4.819	0.098	26.412	0.098	26.510
17	0	20.064	0	0.006	0	5.302	0	25.372	0	25.372
17.5	4.045	12.495	0.001	0.004	2.026	3.302	0.118	21.872	0.118	21.990
18	4.427	11.721	0.001	0.003	2.218	3.097	0.129	21.466	0.129	21.596
18.5	0	7.109	0	0.002	15.333	1.878	0	24.322	0	24.322
19	5.264	0.774	0.001	0	19.337	0.205	0.154	25.581	0.154	25.735
19.5	5.721	0	0.002	0	4.776	0	0.167	10.499	0.167	10.666
20	37.703	0	0.010	0	11.397	0	1.102	49.110	1.102	50.211
20.5	68.189	0	0.018	0	3.364	0	1.992	71.572	1.992	73.564
21	73.670	0	0.020	0	0	0	2.152	73.689	2.152	75.842
21.5	142.946	0	0.038	0	0	0	4.176	142.984	4.176	147.160
22	248.172	0	0.066	0	0	0	7.251	248.239	7.251	255.490
22.5	183.863	0	0.049	0	0	0	5.372	183.912	5.372	189.284
23	197.309	0	0.053	0	0	0	5.765	197.362	5.765	203.127
23.5	148.155	0	0.040	0	0	0	4.329	148.195	4.329	152.524
24	67.694	0	0.018	0	0	0	1.978	67.712	1.978	69.690
24.5	11.903	0	0.003	0	0	0	0.348	11.906	0.348	12.254
25	12.701	0	0.003	0	0	0	0.371	12.705	0.371	13.076
25.5	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0
26.5	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0
27.5	0	0	0	0	0	0	0	0	0	0
TOTAL	**1217.329**	**87.561**	**0.326**	**0.025**	**58.451**	**23.138**	**35.567**	**1386.830**	**35.567**	**1422.396**

Table 17. *ECOCADIZ-RECLUTAS 2019-10* 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 31**.

***ECOCADIZ-RECLUTAS 2019-10 . Boops boops*. ABUNDANCE (in numbers and million fish)**										
Size class	**POL01**	**POL02**	**POL03**	**POL04**	***n***			**Millions**		
					PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
17	0	0	0	0	0	0	0	0	0	0
17.5	69	4056	0	0	4125	0	4125	0.004	0	0.004
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	69	4056	0	0	4125	0	4125	0.004	0	0.004
21	69	4056	7716	42400	11841	42400	54241	0.01	0.04	0.1
21.5	1424	83158	0	0	84582	0	84582	0.1	0	0.1
22	486	28395	7716	42400	36597	42400	78997	0.04	0.04	0.1
22.5	278	16226	7716	42400	24220	42400	66620	0.02	0.04	0.1
23	208	12169	0	0	12377	0	12377	0.01	0	0.01
23.5	208	12169	0	0	12377	0	12377	0.01	0	0.01
24	2153	125751	4629	25440	132533	25440	157973	0.1	0.03	0.2
24.5	1007	58819	4629	25440	64455	25440	89895	0.1	0.03	0.1
25	69	4056	4629	25440	8754	25440	34194	0.01	0.03	0.03
25.5	0	0	4629	25440	4629	25440	30069	0.005	0.03	0.03
26	0	0	0	0	0	0	0	0	0	0
26.5	0	0	9259	50880	9259	50880	60139	0.01	0.1	0.1
27	0	0	0	0	0	0	0	0	0	0
27.5	0	0	0	0	0	0	0	0	0	0
28	0	0	9259	50880	9259	50880	60139	0.01	0.1	0.1
28.5	0	0	4629	25440	4629	25440	30069	0.005	0.03	0.03
29	0	0	4629	25440	4629	25440	30069	0.005	0.03	0.03
29.5	0	0			0	0	0	0	0	0
30	0	0			0	0	0	0	0	0
30.5	0	0			0	0	0	0	0	0
TOTAL *n*	6040	352911	69440	381600	428391	381600	809991	**0.4**	**0.4**	**1**
Millions	**0.01**	**0.4**	**0.1**	**0.4**						

Table 17. *ECOCADIZ-RECLUTAS 2019-10* survey. Bogue (*Boops boops*). Cont'd.

***ECOCADIZ-RECLUTAS 2019-10 . Boops boops* . BIOMASS (t)**							
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**PORTUGAL**	**SPAIN**	**TOTAL**
17	0	0	0	0	0	0	0
17.5	0.003	0.199	0	0	0.203	0	0.203
18	0	0	0	0	0	0	0
18.5	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0
19.5	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0
20.5	0.006	0.333	0	0	0.338	0	0.338
21	0.006	0.360	0.684	3.758	1.050	3.758	4.808
21.5	0.136	7.954	0	0	8.090	0	8.090
22	0.050	2.926	0.795	4.369	3.771	4.369	8.140
22.5	0.031	1.798	0.855	4.698	2.684	4.698	7.382
23	0.025	1.448	0	0	1.473	0	1.473
23.5	0.027	1.552	0	0	1.579	0	1.579
24	0.294	17.173	0.632	3.474	18.100	3.474	21.574
24.5	0.147	8.588	0.676	3.714	9.410	3.714	13.125
25	0.011	0.632	0.722	3.966	1.365	3.966	5.330
25.5	0	0	0.769	4.228	0.769	4.228	4.998
26	0	0	0	0	0	0	0
26.5	0	0	1.743	9.580	1.743	9.580	11.323
27	0	0	0	0	0	0	0
27.5	0	0	0	0	0	0	0
28	0	0	2.084	11.453	2.084	11.453	13.537
28.5	0	0	1.104	6.065	1.104	6.065	7.168
29	0	0	1.168	6.417	1.168	6.417	7.585
29.5	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0
30.5	0	0	0	0	0	0	0
TOTAL	**0.735**	**42.963**	**11.232**	**61.723**	**54.930**	**61.723**	**116.652**

Table 18. *ECOCADIZ-RECLUTAS 2019-10* survey. Atlantic pomfret (*Brama brama*). 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-RECLUTAS 2019-10 . *Brama brama* . ABUNDANCE (in numbers and million fish)							
Size class	**POL01**	***n***			**Millions**		
		PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
32	0	0	0	0	0	0	0
32.5	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0
33.5	0	0	0	0	0	0	0
34	0	0	0	0	0	0	0
34.5	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0
35.5	0	0	0	0	0	0	0
36	38361	0	38361	38361	0	0.04	0.04
36.5	38361	0	38361	38361	0	0.04	0.04
37	38361	0	38361	38361	0	0.04	0.04
37.5	149183	0	149183	149183	0	0.1	0.1
38	38361	0	38361	38361	0	0.04	0.04
38.5	110821	0	110821	110821	0	0.1	0.1
39	225905	0	225905	225905	0	0.2	0.2
39.5	225905	0	225905	225905	0	0.2	0.2
40	524270	0	524270	524270	0	1	1
40.5	562632	0	562632	562632	0	1	1
41	673453	0	673453	673453	0	1	1
41.5	822636	0	822636	822636	0	1	1
42	750175	0	750175	750175	0	1	1
42.5	750175	0	750175	750175	0	1	1
43	485909	0	485909	485909	0	0.5	0.5
43.5	225905	0	225905	225905	0	0.2	0.2
44	187544	0	187544	187544	0	0.2	0.2
44.5	110821	0	110821	110821	0	0.1	0.1
45	149183	0	149183	149183	0	0.1	0.1
45.5	149183	0	149183	149183	0	0.1	0.1
46	0	0	0	0	0	0	0
46.5	0	0	0	0	0	0	0
47	0	0	0	0	0	0	0
47.5	0	0	0	0	0	0	0
48	0	0	0	0	0	0	0
48.5	0	0	0	0	0	0	0
49	0	0	0	0	0	0	0
49.5	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0
50.5	0	0	0	0	0	0	0
51	0	0	0	0	0	0	0
51.5	0	0	0	0	0	0	0
52	0	0	0	0	0	0	0
52.5	0	0	0	0	0	0	0
53	0	0	0	0	0	0	0
53.5	0	0	0	0	0	0	0
54	0	0	0	0	0	0	0
54.5	0	0	0	0	0	0	0
55	0	0	0	0	0	0	0
TOTAL *n*	6257144	0	6257144	6257144	**0**	**6**	**6**
Millions	**6**	**0**					

Table 18. *ECOCADIZ-RECLUTAS 2019-10* survey. Atlantic pomfret (*Brama brama*). Cont'd.

ECOCADIZ-RECLUTAS 2019-10 . Brama brama . BIOMASS (t)				
Size class	**POL01**	**PORTUGAL**	**SPAIN**	**TOTAL**
32	0	0	0	0
32.5	0	0	0	0
33	0	0	0	0
33.5	0	0	0	0
34	0	0	0	0
34.5	0	0	0	0
35	0	0	0	0
35.5	0	0	0	0
36	16.992	0	16.992	16.992
36.5	17.737	0	17.737	17.737
37	18.503	0	18.503	18.503
37.5	75.022	0	75.022	75.022
38	20.102	0	20.102	20.102
38.5	60.481	0	60.481	60.481
39	128.336	0	128.336	128.336
39.5	133.522	0	133.522	133.522
40	322.234	0	322.234	322.234
40.5	359.434	0	359.434	359.434
41	446.967	0	446.967	446.967
41.5	566.957	0	566.957	566.957
42	536.642	0	536.642	536.642
42.5	556.767	0	556.767	556.767
43	373.997	0	373.997	373.997
43.5	180.244	0	180.244	180.244
44	155.054	0	155.054	155.054
44.5	94.901	0	94.901	94.901
45	132.272	0	132.272	132.272
45.5	136.900	0	136.900	136.900
46	0	0	0	0
46.5	0	0	0	0
47	0	0	0	0
47.5	0	0	0	0
48	0	0	0	0
48.5	0	0	0	0
49	0	0	0	0
49.5	0	0	0	0
50	0	0	0	0
50.5	0	0	0	0
51	0	0	0	0
51.5	0	0	0	0
52	0	0	0	0
52.5	0	0	0	0
53	0	0	0	0
53.5	0	0	0	0
54	0	0	0	0
54.5	0	0	0	0
55	0	0	0	0
TOTAL	**4333.065**	**0**	**4333.065**	**4333.065**

Table 19. *ECOCADIZ-RECLUTAS 2019-10* survey. Boarfish (*Capros aper*). Estimated abundance (absolute numbers and million fish) and biomass (t) by size class (in cm). Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figure 37**.

***ECOCADIZ-RECLUTAS 2019-10* . *Capros aper* . ABUNDANCE (in numbers and million fish)**							
Size class	**POL01**	***n***			**Millions**		
		PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
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	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0
5.5	0	0	0	0	0	0	0
6	71593	71593	0	71593	0.1	0	0.1
6.5	787518	787518	0	787518	1	0	1
7	2505738	2505738	0	2505738	3	0	3
7.5	3937588	3937588	0	3937588	4	0	4
8	1718220	1718220	0	1718220	2	0	2
8.5	143185	143185	0	143185	0.1	0	0.1
9	71593	71593	0	71593	0.1	0	0.1
9.5	71593	71593	0	71593	0.1	0	0.1
10	143185	143185	0	143185	0.1	0	0.1
10.5	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0
11.5	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0
12.5	0	0	0	0	0	0	0
13	71593	71593	0	71593	0.1	0	0.1
13.5	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0
14.5	0	0	0	0	0	0	0
TOTAL *n*	9521806	9521806	0	9521806	**10**	**0**	**10**
Millions	**10**	**10**	**0**	**10**			

Table 19. *ECOCADIZ-RECLUTAS 2019-10* survey. Boarfish (*Capros aper*). Cont'd.

ECOCADIZ-RECLUTAS 2019-10 . Capros aper . BIOMASS (t)				
Size class	**POL01**	**PORTUGAL**	**SPAIN**	**TOTAL**
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	0	0	0
5	0	0	0	0
5.5	0	0	0	0
6	0.399	0.399	0	0.399
6.5	5.441	5.441	0	5.441
7	21.135	21.135	0	21.135
7.5	40.009	40.009	0	40.009
8	20.788	20.788	0	20.788
8.5	2.042	2.042	0	2.042
9	1.192	1.192	0	1.192
9.5	1.381	1.381	0	1.381
10	3.175	3.175	0	3.175
10.5	0	0	0	0
11	0	0	0	0
11.5	0	0	0	0
12	0	0	0	0
12.5	0	0	0	0
13	3.251	3.251	0	3.251
13.5	0	0	0	0
14	0	0	0	0
14.5	0	0	0	0
TOTAL	**98.813**	**98.813**	**0**	**98.813**

Table 20. *ECOCADIZ-RECLUTAS 2019-10* survey. Longspine snipefish (*Macroramphosus scolopax*). 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 40**.

ECOCADIZ-RECLUTAS 2019-10 . Macroramphosus scolopax . ABUNDANCE (in numbers and million fish)							
Size class	**POL01**	***n***			**Millions**		
		PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
8	0	0	0	0	0	0	0
8.5	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0
9.5	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0
10.5	465063	465063	0	465063	0.5	0	0.5
11	232531	232531	0	232531	0.2	0	0.2
11.5	1162657	1162657	0	1162657	1	0	1
12	2325314	2325314	0	2325314	2	0	2
12.5	1743985	1743985	0	1743985	2	0	2
13	2441579	2441579	0	2441579	2	0	2
13.5	1162657	1162657	0	1162657	1	0	1
14	232531	232531	0	232531	0.2	0	0.2
14.5	116266	116266	0	116266	0.1	0	0.1
15	0	0	0	0	0	0	0
15.5	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0
TOTAL *n*	9882583	9882583	0	9882583	**10**	**0**	**10**
Millions	**10**						

ECOCADIZ-RECLUTAS 2019-10 . Macroramphosus scolopax . BIOMASS (t)				
Size class	**POL01**	**PORTUGAL**	**SPAIN**	**TOTAL**
8	0	0	0	0
8.5	0	0	0	0
9	0	0	0	0
9.5	0	0	0	0
10	0	0	0	0
10.5	3.682	3.682	0	3.682
11	2.083	2.083	0	2.083
11.5	11.722	11.722	0	11.722
12	26.256	26.256	0	26.256
12.5	21.954	21.954	0	21.954
13	34.124	34.124	0	34.124
13.5	17.971	17.971	0	17.971
14	3.961	3.961	0	3.961
14.5	2.175	2.175	0	2.175
15	0	0	0	0
15.5	0	0	0	0
16	0	0	0	0
TOTAL	**123.927**	**123.927**	**0.000**	**123.927**

Table 21. *ECOCADIZ-RECLUTAS 2019-10* 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 43**.

***ECOCADIZ-RECLUTAS 2019-10 . Maurolicus muelleri* . ABUNDANCE (in numbers and million fish)**

Size class	POL01	POL02	POL03	POL04	*n*			Millions		
					PORTUGAL	SPAIN	TOTAL	PORTUGAL	SPAIN	TOTAL
0	0	0	0	0	0	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	0	0	0
1.5	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
2.5	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0
3.5	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0
4.5	0	0	0	0	0	0	0	0	0	0
5	78696032	18745874	384800210	31001127	97441906	415801337	513243243	97	416	513
5.5	157392063	37491747	769600421	62002253	194883810	831602674	1026486484	195	832	1026
6	19674008	4686468	96200053	7750282	24360476	103950335	128310811	24	104	128
6.5	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0
TOTAL *n*	255762103	60924089	1250600684	100753662	316686192	1351354346	1668040538	**317**	**1351**	**1668**
Millions	**256**	**61**	**1251**	**101**						

***ECOCADIZ-RECLUTAS 2019-10 . Maurolicus muelleri* . BIOMASS (t)**

Size class	POL01	POL02	POL03	POL04	PORTUGAL	SPAIN	TOTAL
0	0	0	0	0	0	0	0
0.5	0	0	0	0	0	0	0
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	0	0	0	0	0	0	0
5	73.296	17.460	358.396	28.874	90.756	387.270	478.025
5.5	193.084	45.994	944.124	76.063	239.078	1020.187	1259.265
6	31.068	7.401	151.913	12.239	38.468	164.151	202.620
6.5	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0
TOTAL	**297.448**	**70.854**	**1454.432**	**117.175**	**368.302**	**1454.432**	**1822.734**

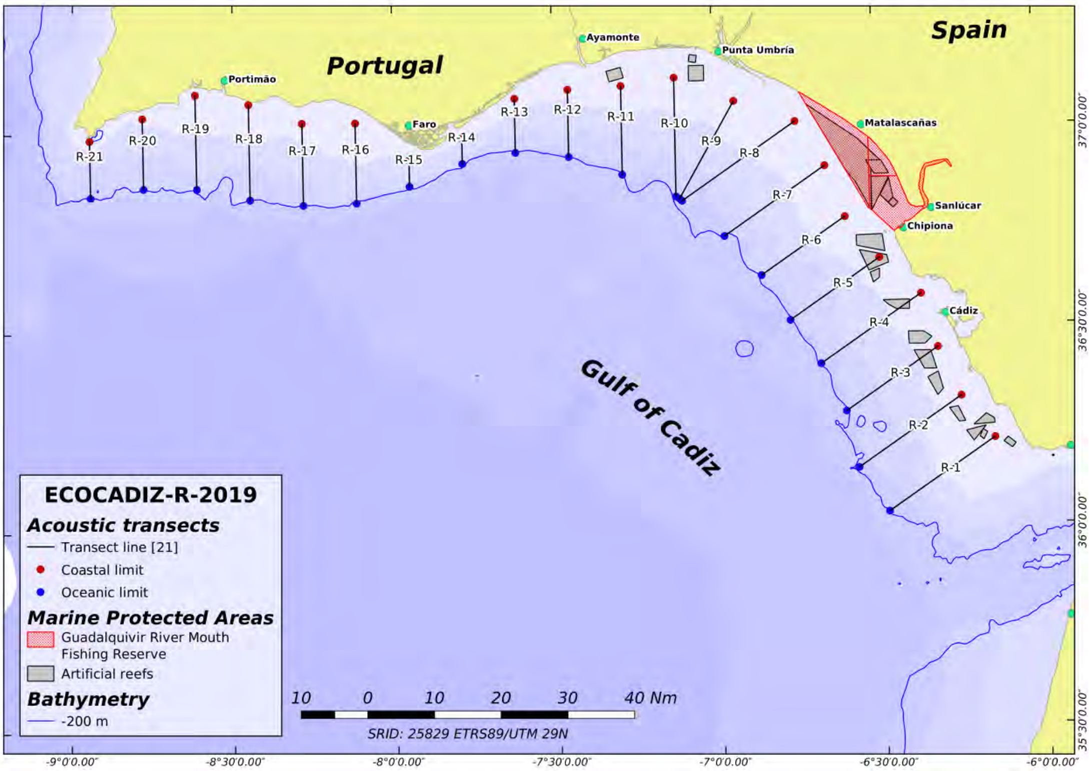


Figure 1. *ECOCADIZ-RECLUTAS 2019-10* survey. Location of the acoustic transects sampled during the survey. The different protected areas inside the Guadalquivir river mouth Fishing Reserve and artificial reef polygons are also shown.

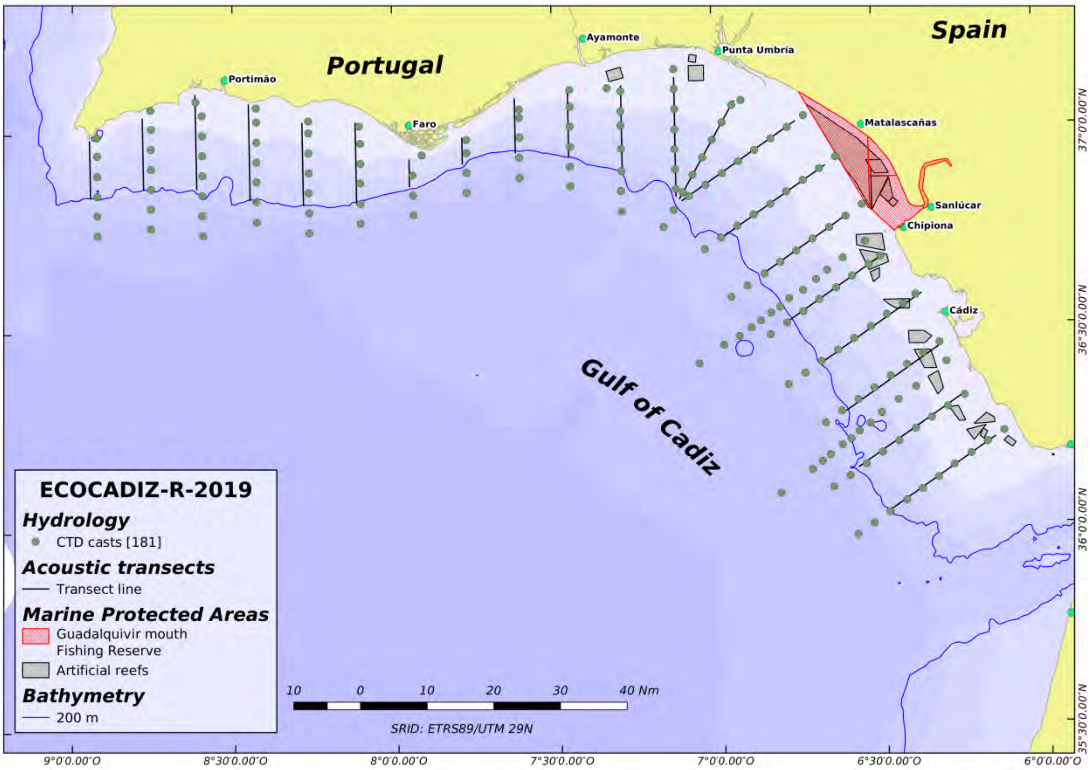


Figure 2. *ECOCADIZ-RECLUTAS 2019-10* survey. Location of CTD stations.

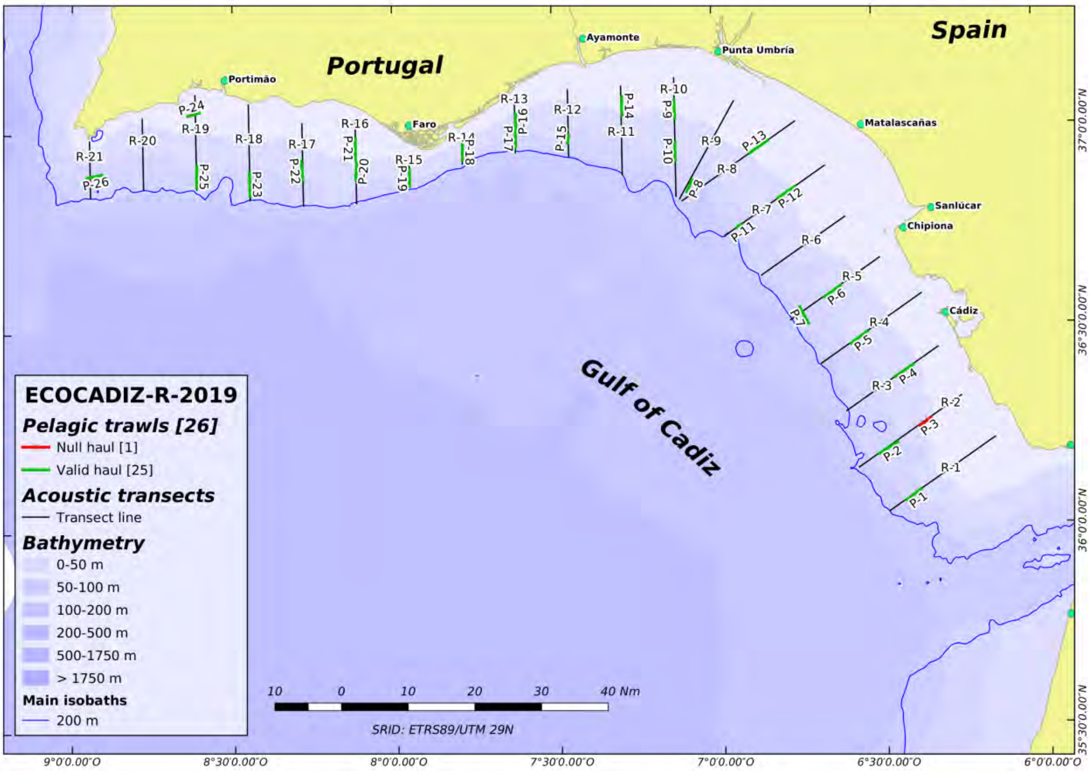


Figure 3. *ECOCADIZ-RECLUTAS 2019-10* survey. Location of ground-truthing fishing hauls.

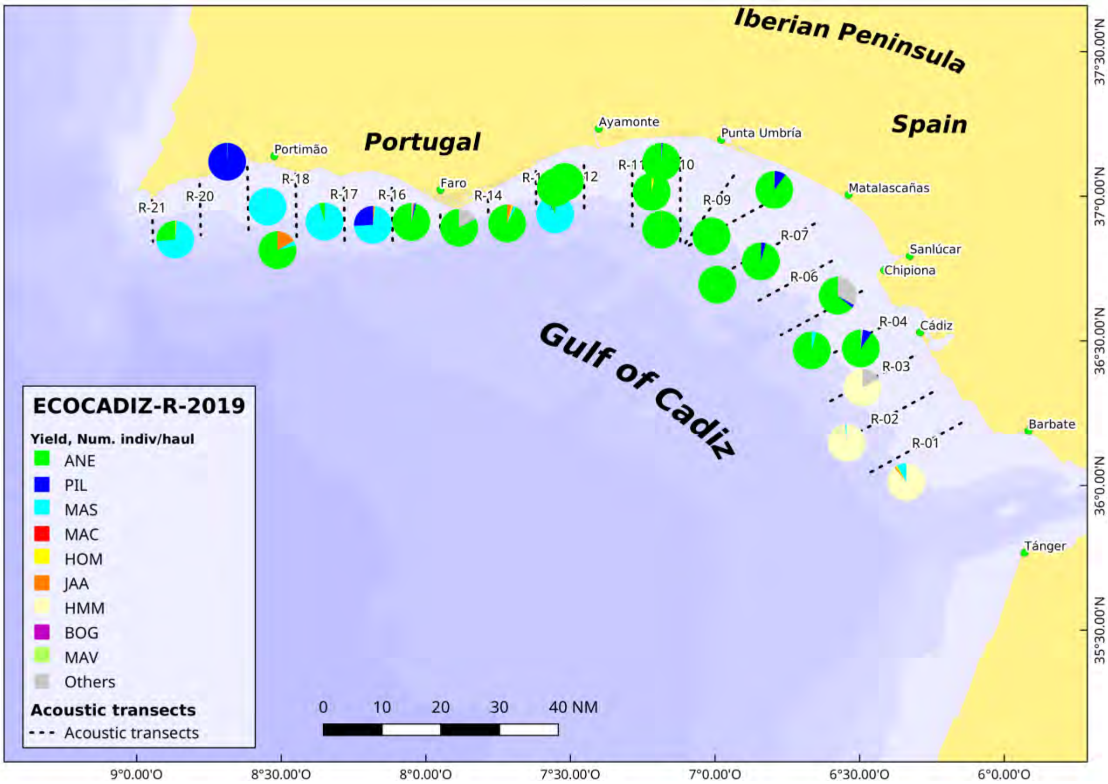


Figure 4. *ECOCADIZ-RECLUTAS 2019-10* survey. Species composition (percentages in number) in valid fishing hauls.

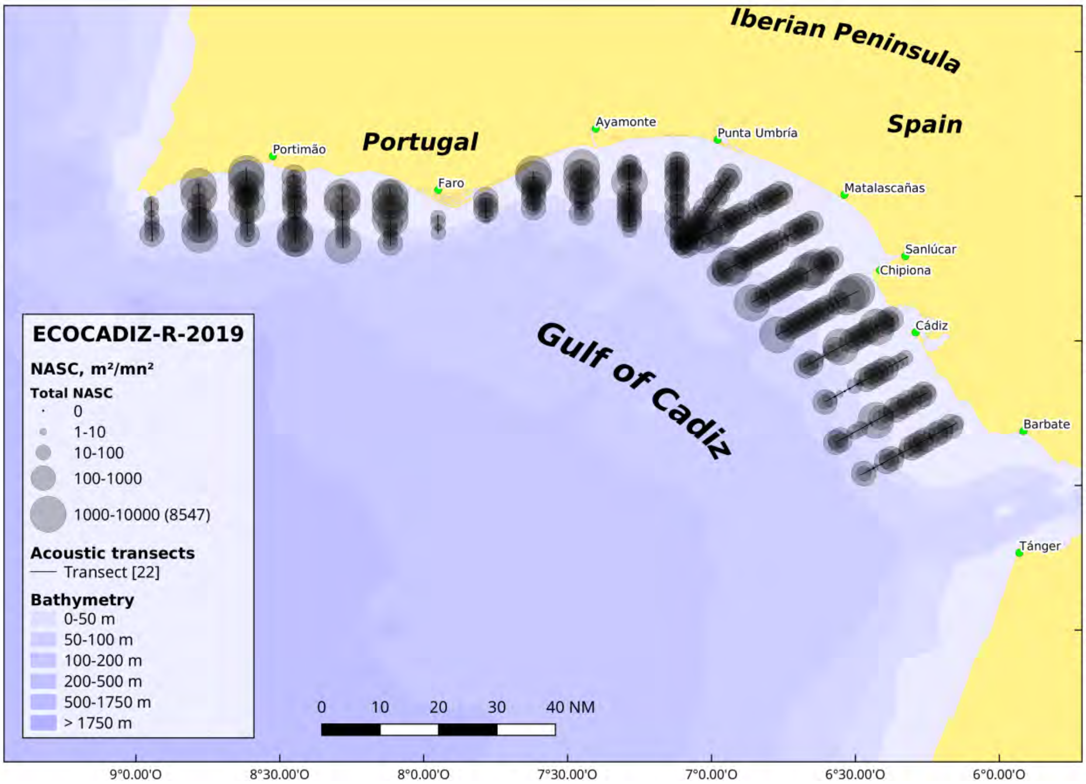


Figure 5. *ECOCADIZ-RECLUTAS 2019-10* survey. Distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the pelagic fish species assemblage.

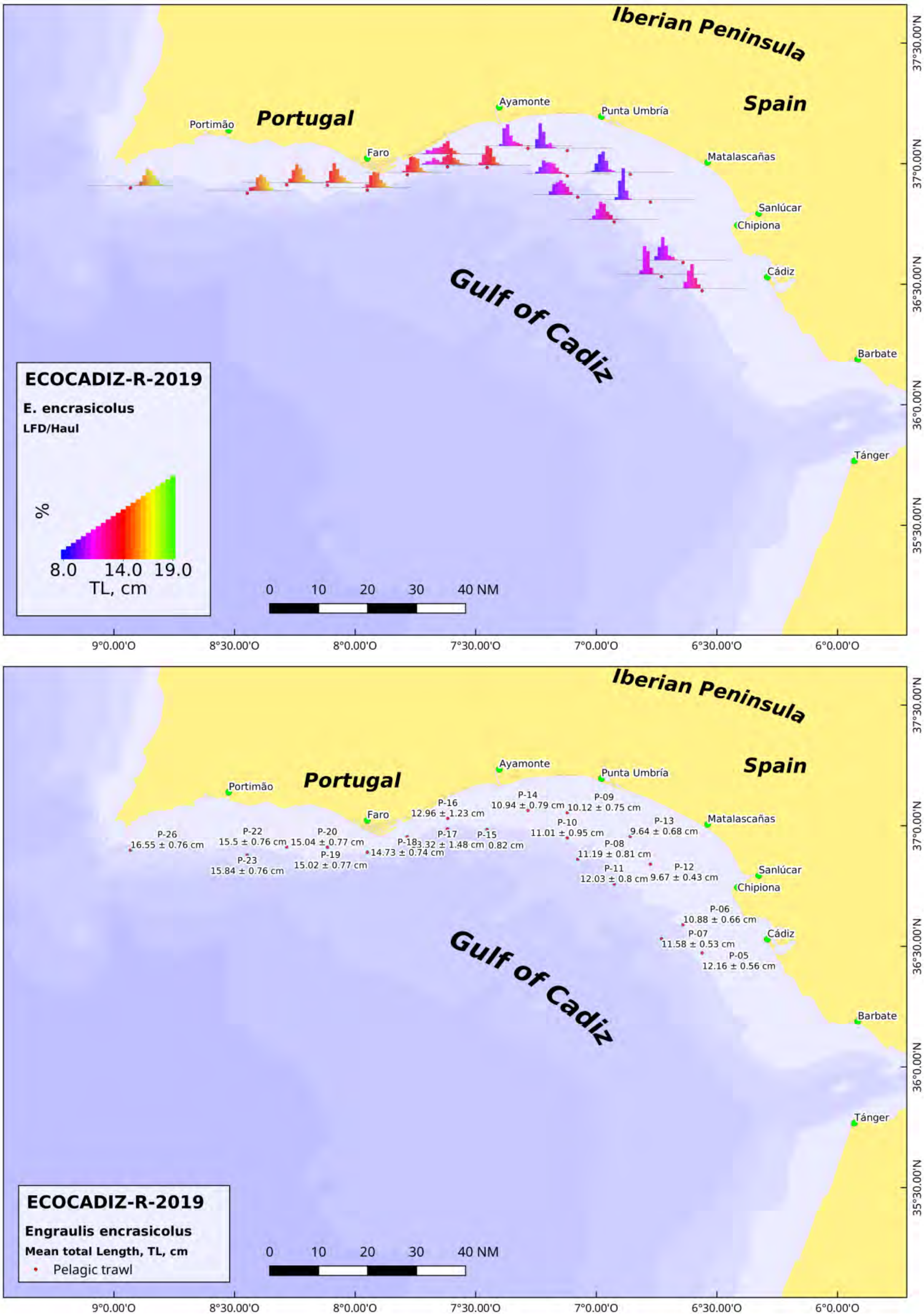


Figure 6. *ECOCADIZ-RECLUTAS 2019-10* survey. Anchovy (*Engraulis encrasicolus*). Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

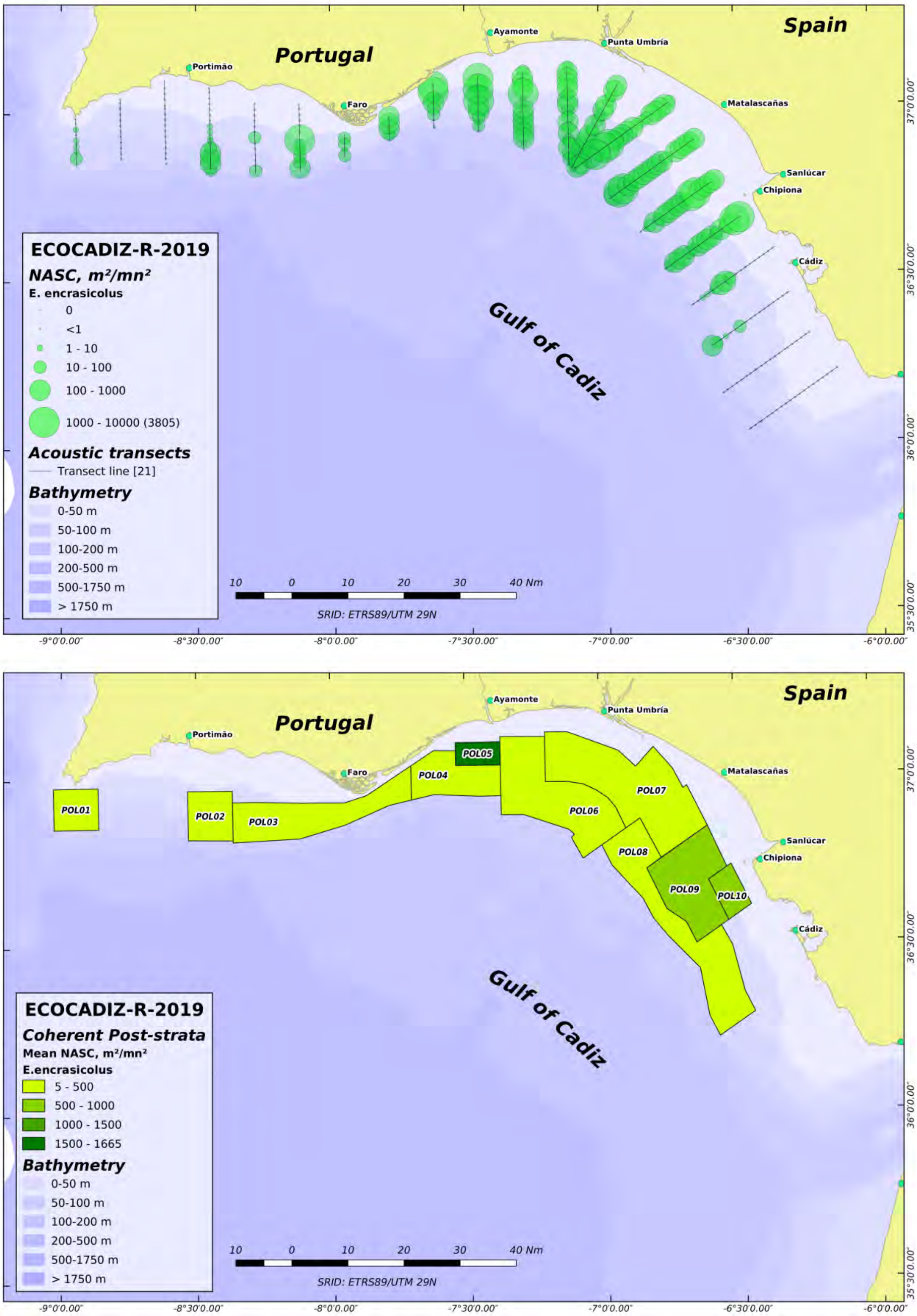


Figure 7. *ECOCADIZ-RECLUTAS 2019-10* survey. Anchovy (*Engraulis encrasicolus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

***ECOCADIZ-RECLUTAS 2019-10*: Anchovy (*E. encrasicolus*)**

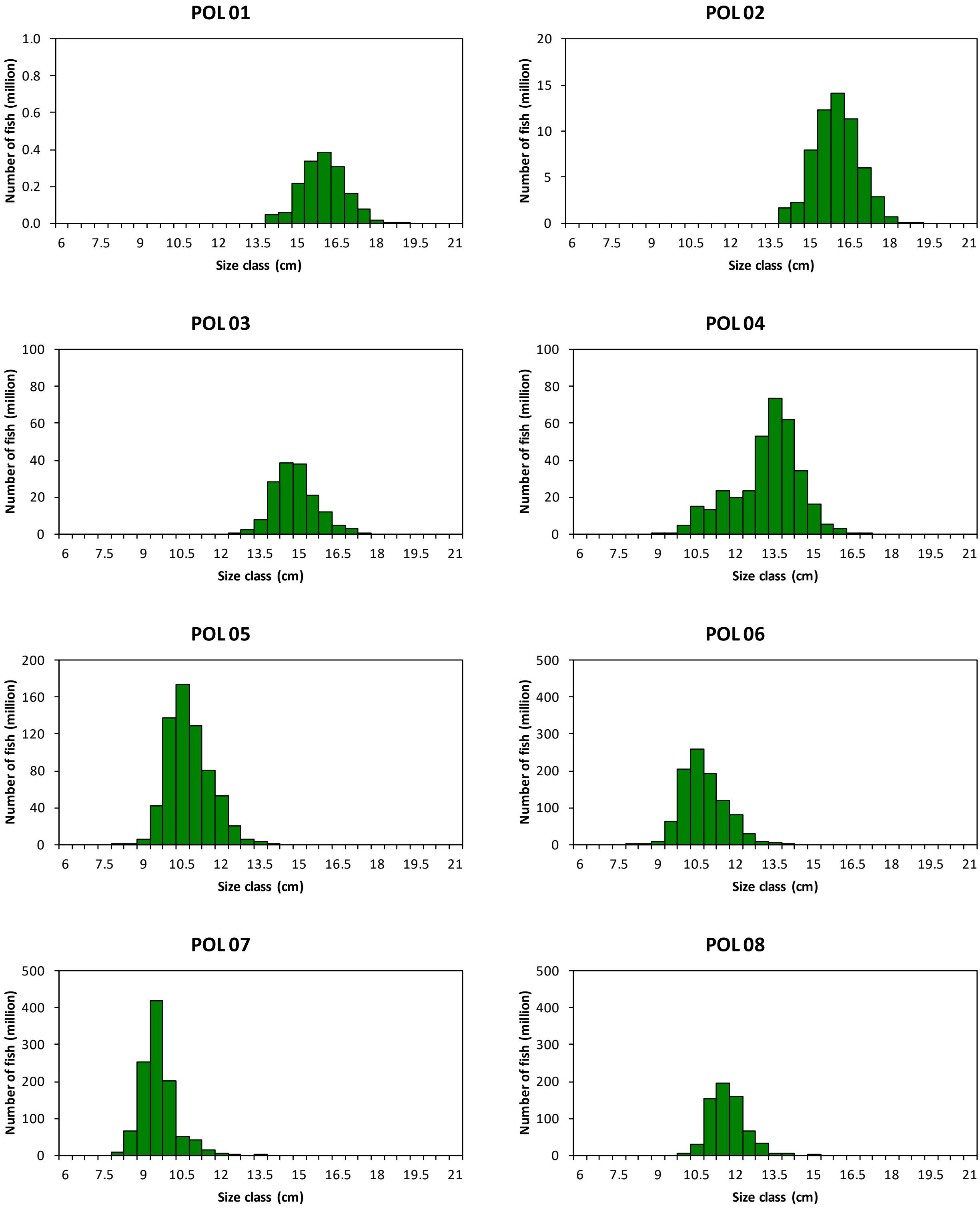


Figure 8. *ECOCADIZ-RECLUTAS 2019-10* survey. Anchovy (*Engraulis encrasicolus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 7**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

***ECOCADIZ-RECLUTAS 2019-10*: Anchovy (*E. encrasicolus*)**

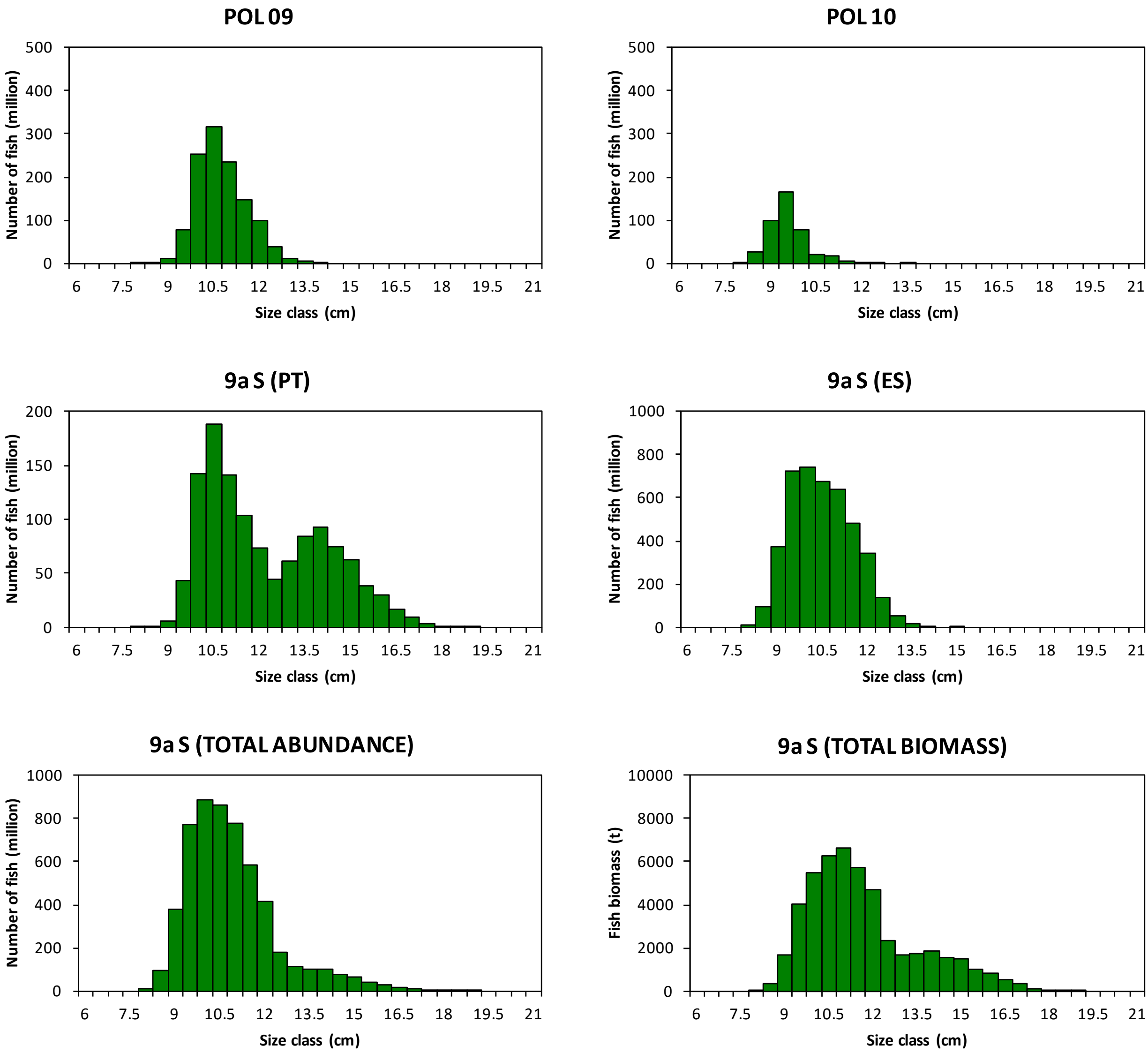


Figure 8. *ECOCADIZ-RECLUTAS 2019-10* survey. Anchovy (*Engraulis encrasicolus*). Cont'd.

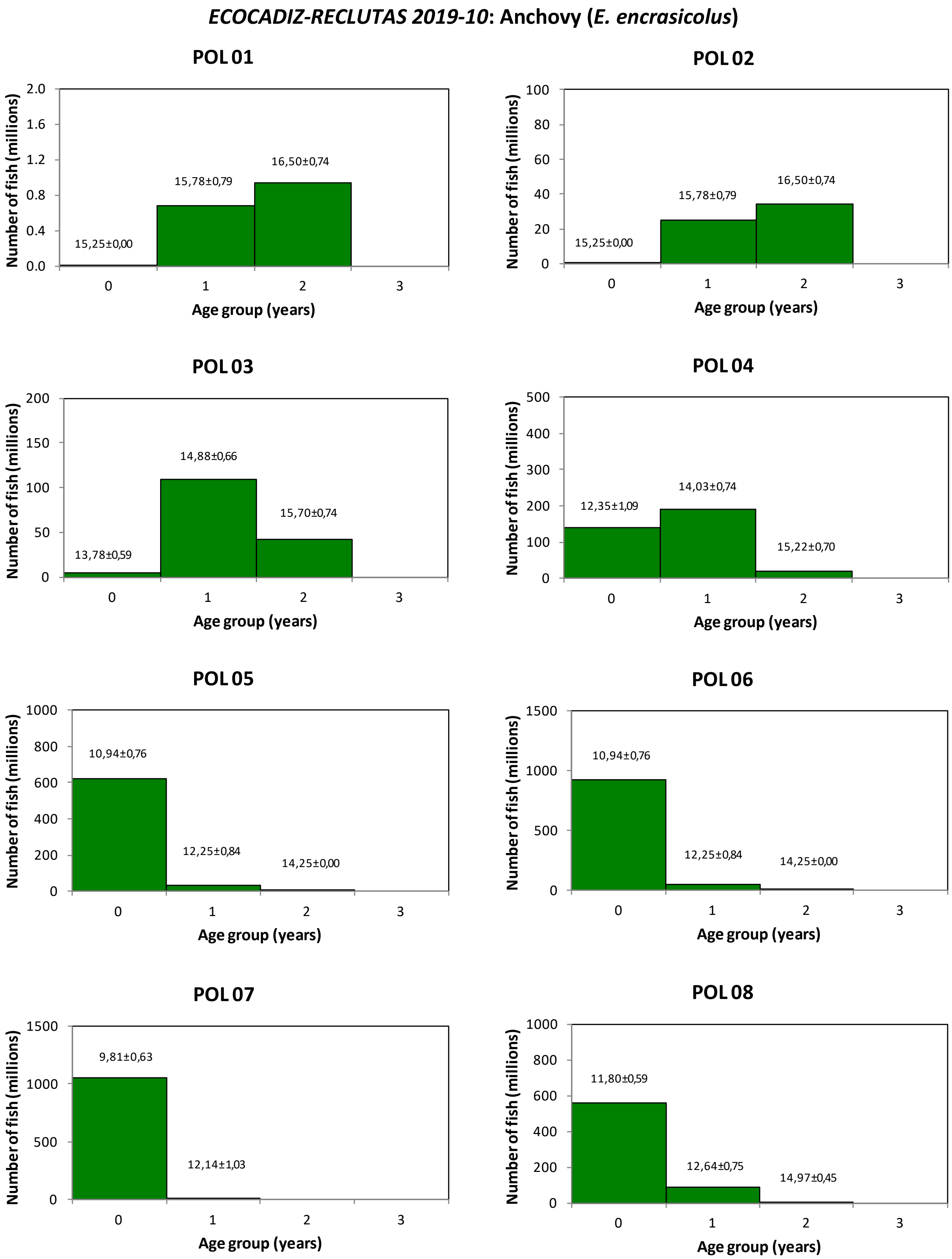


Figure 9. *ECOCADIZ-RECLUTAS 2019-10* survey. Anchovy (*Engraulis encrasicolus*). Estimated abundances (number of fish in millions) by age group (years) by homogeneous stratum (POL01-POLn, numeration as in **Figure 7**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by age group for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

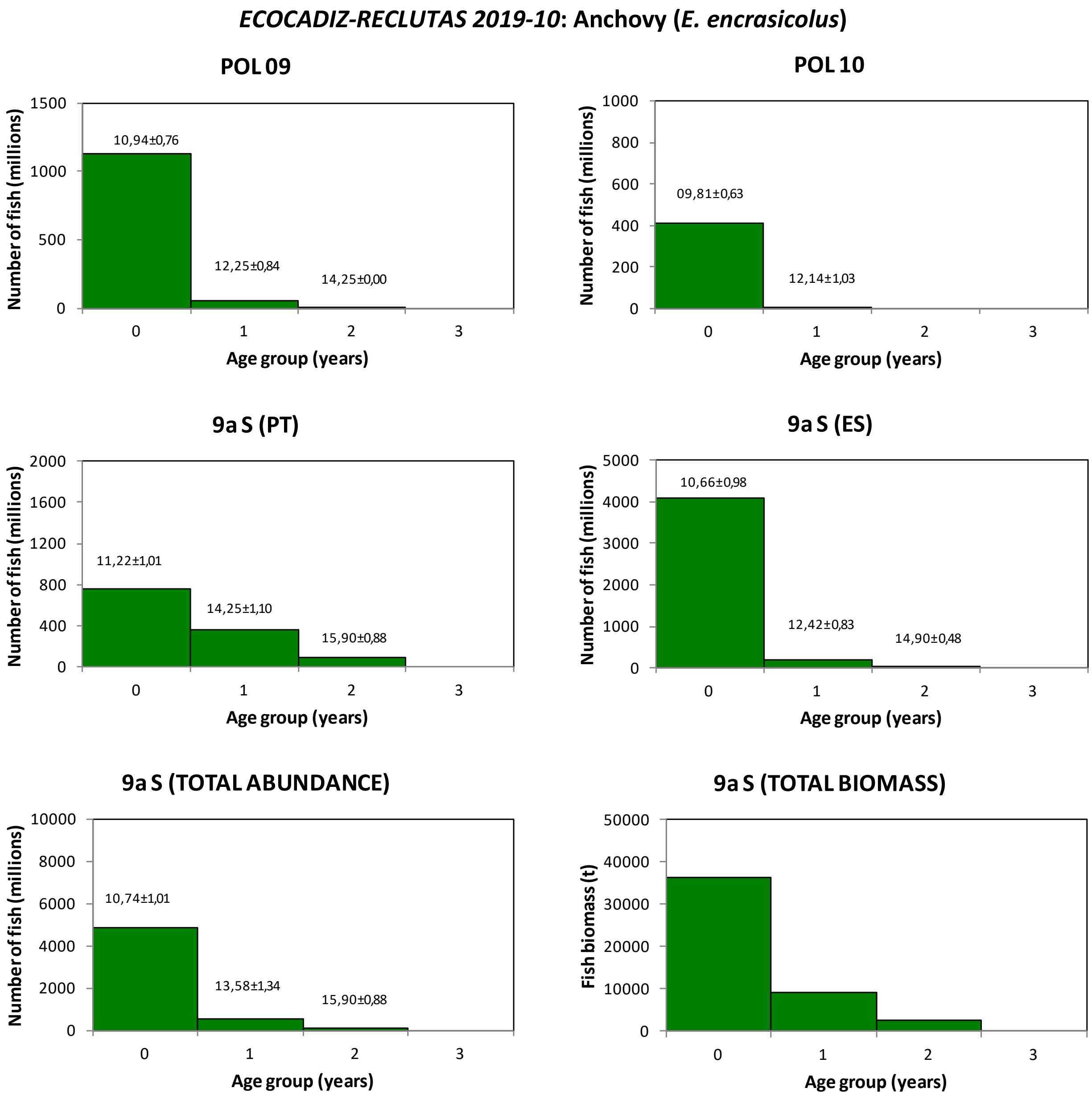


Figure 9. *ECOCADIZ-RECLUTAS 2019-10* survey. Anchovy (*Engraulis encrasicolus*). Cont'd.

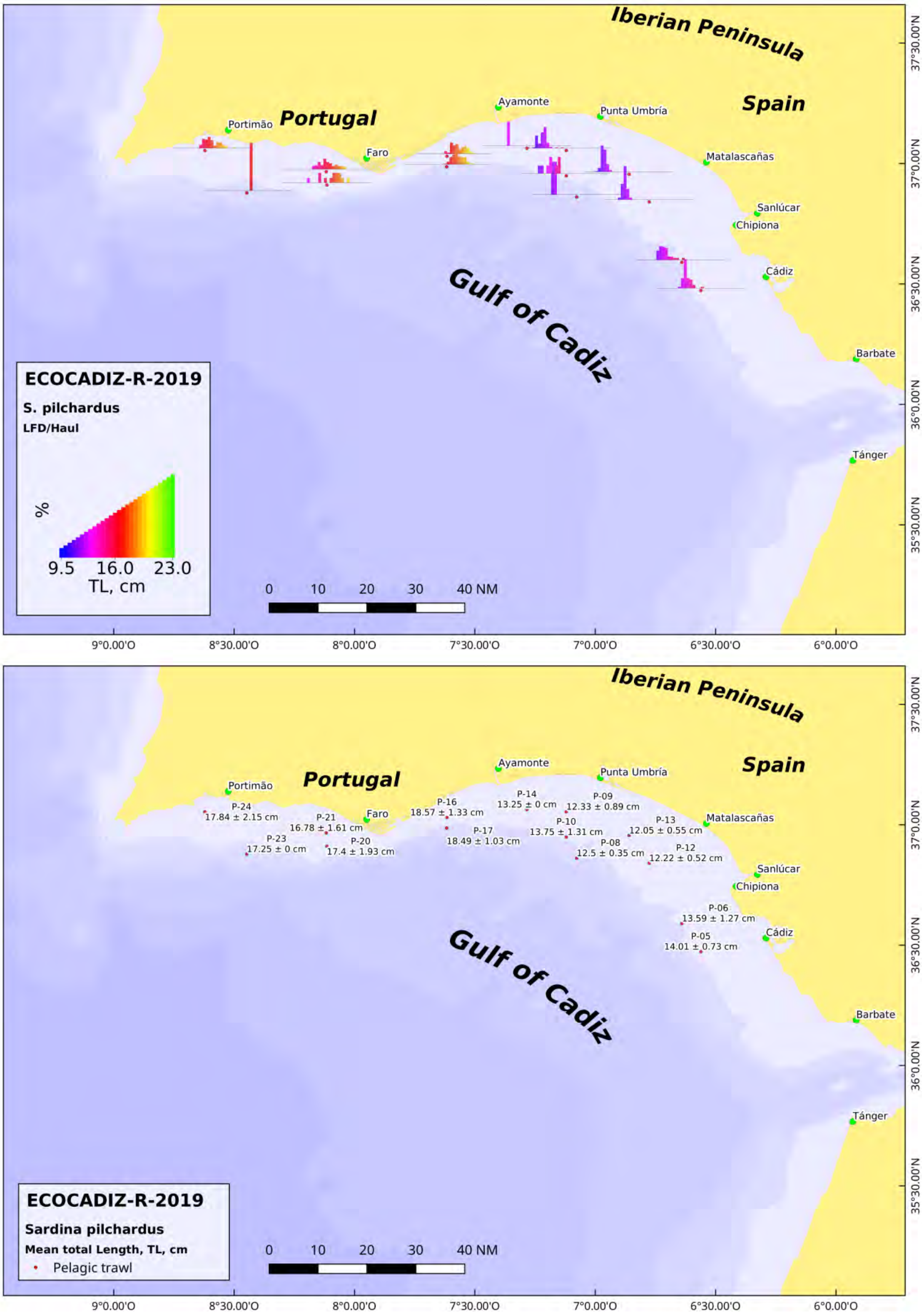
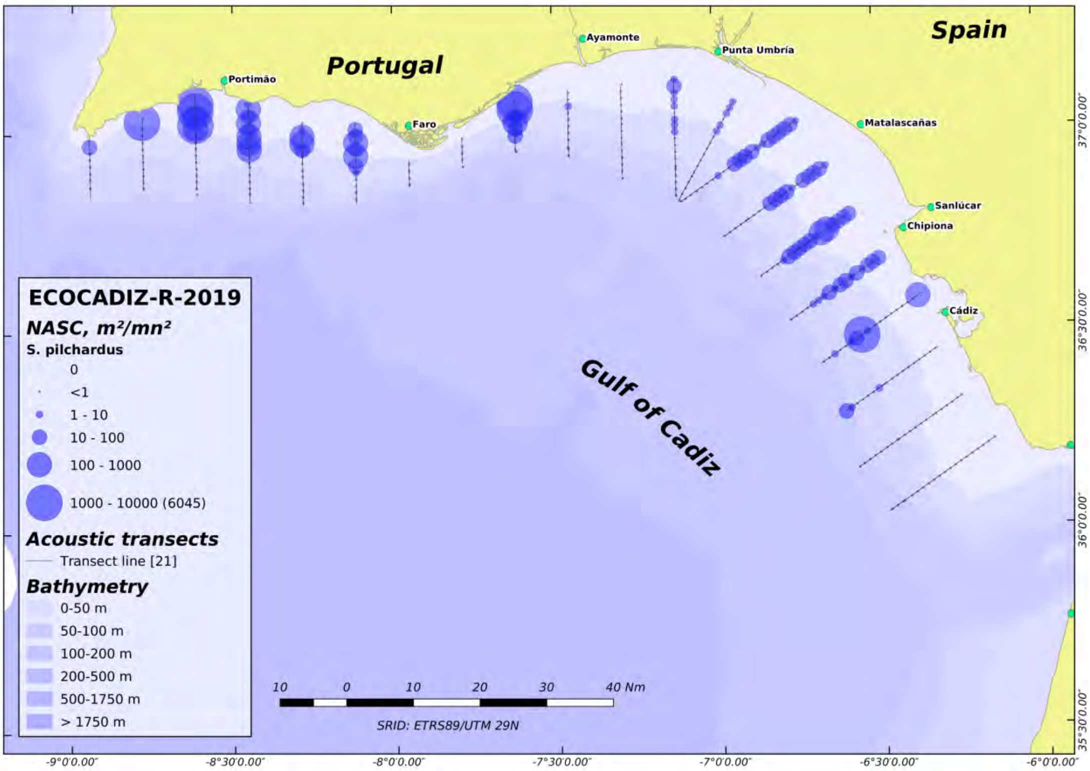


Figure 10. *ECOCADIZ-RECLUTAS 2019-10* survey. Sardine (*Sardina pilchardus*). Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.



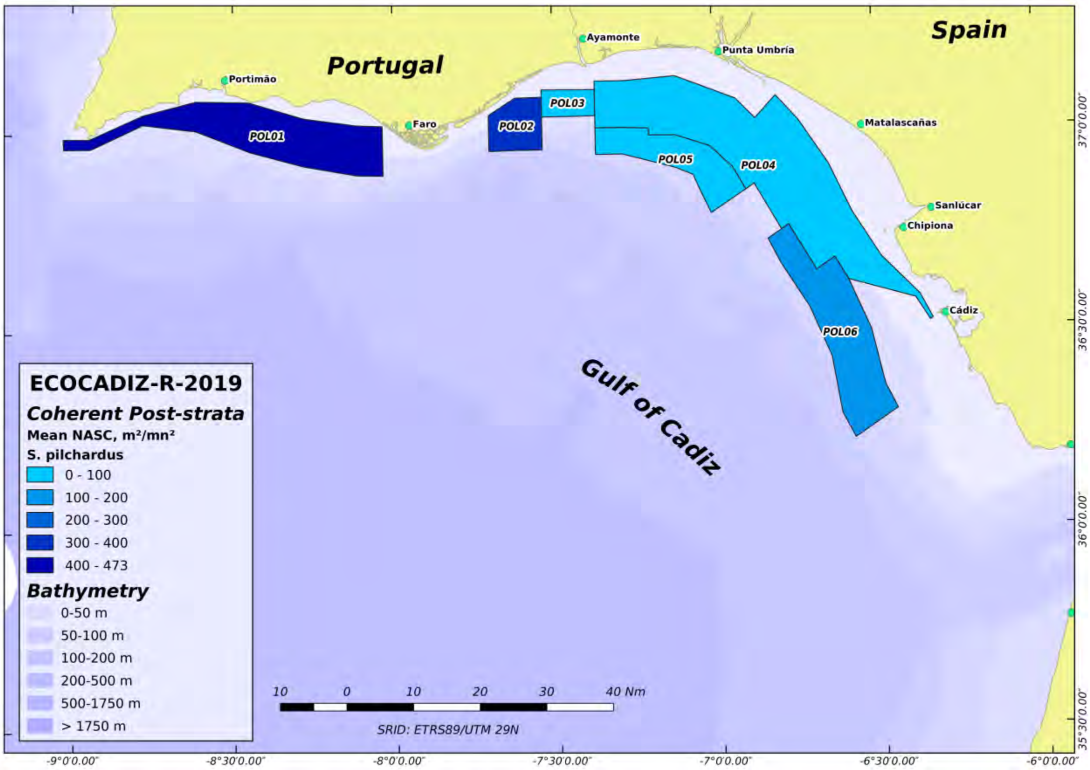


Figure 11. *ECOCADIZ-RECLUTAS 2019-10* survey. Sardine (*Sardina pilchardus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

ECOCADIZ-RECLUTAS 2019-10: Sardine (*S. pilchardus*)

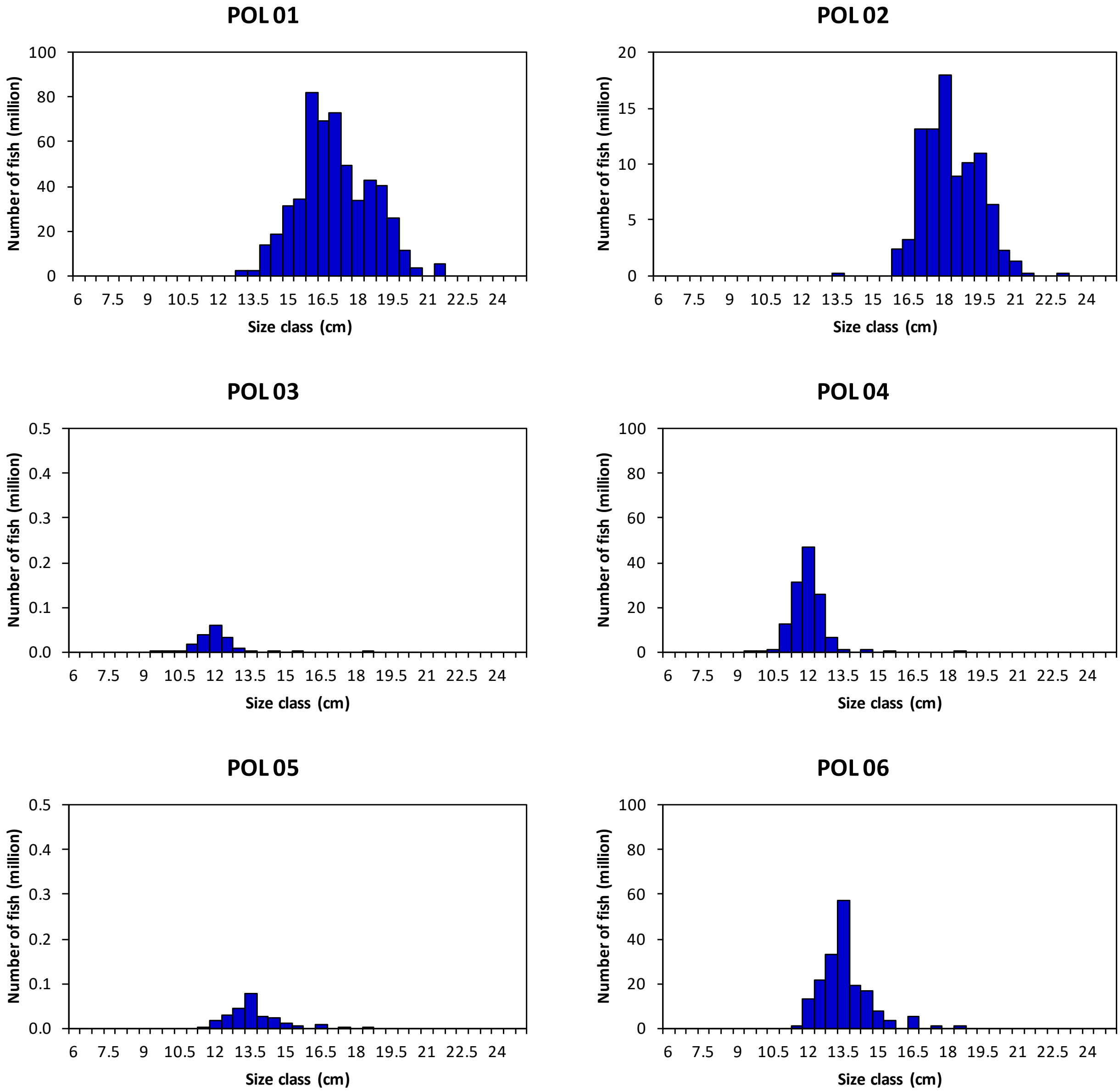


Figure 12. *ECOCADIZ-RECLUTAS 2019-10* survey. Sardine (*Sardina pilchardus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 11**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

***ECOCADIZ-RECLUTAS 2019-10*: Sardine (*S. pilchardus*)**

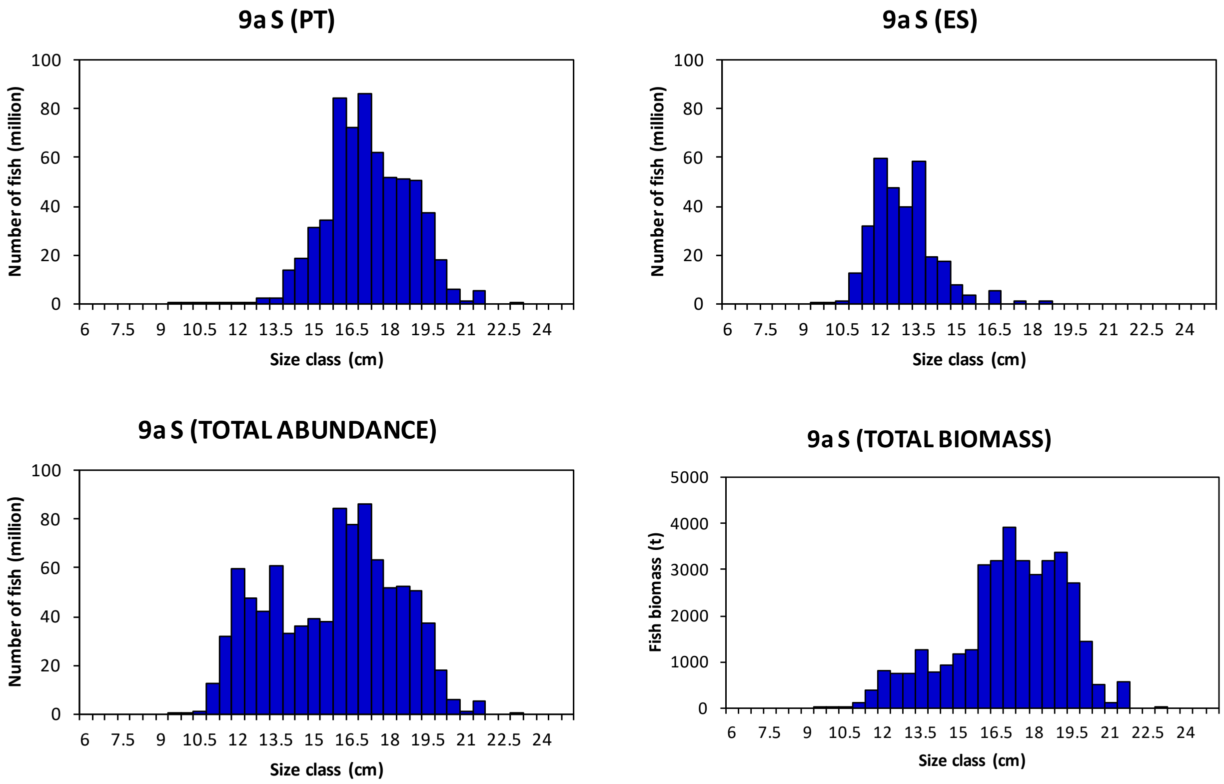


Figure 12. *ECOCADIZ-RECLUTAS 2019-10* survey. Sardine (*Sardina pilchardus*). Cont'd.

ECOCADIZ-RECLUTAS 2019-10: Sardine (*S. pilchardus*)

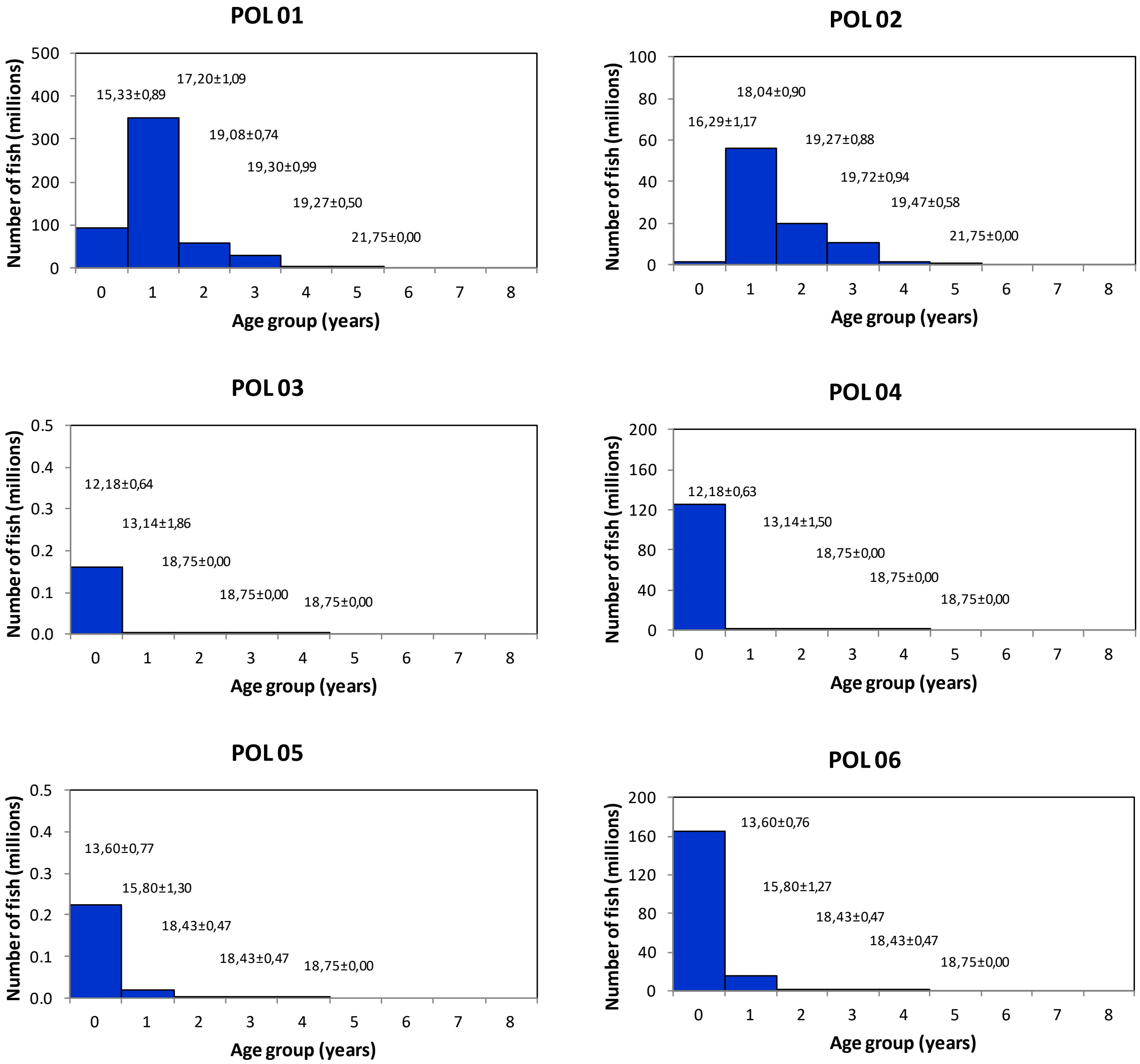


Figure 13. *ECOCADIZ-RECLUTAS 2019-10* survey. Sardine (*Sardina pilchardus*). Estimated abundances (number of fish in millions) by age group (years) by homogeneous stratum (POL01-POLn, numeration as in **Figure 11**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by age group for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

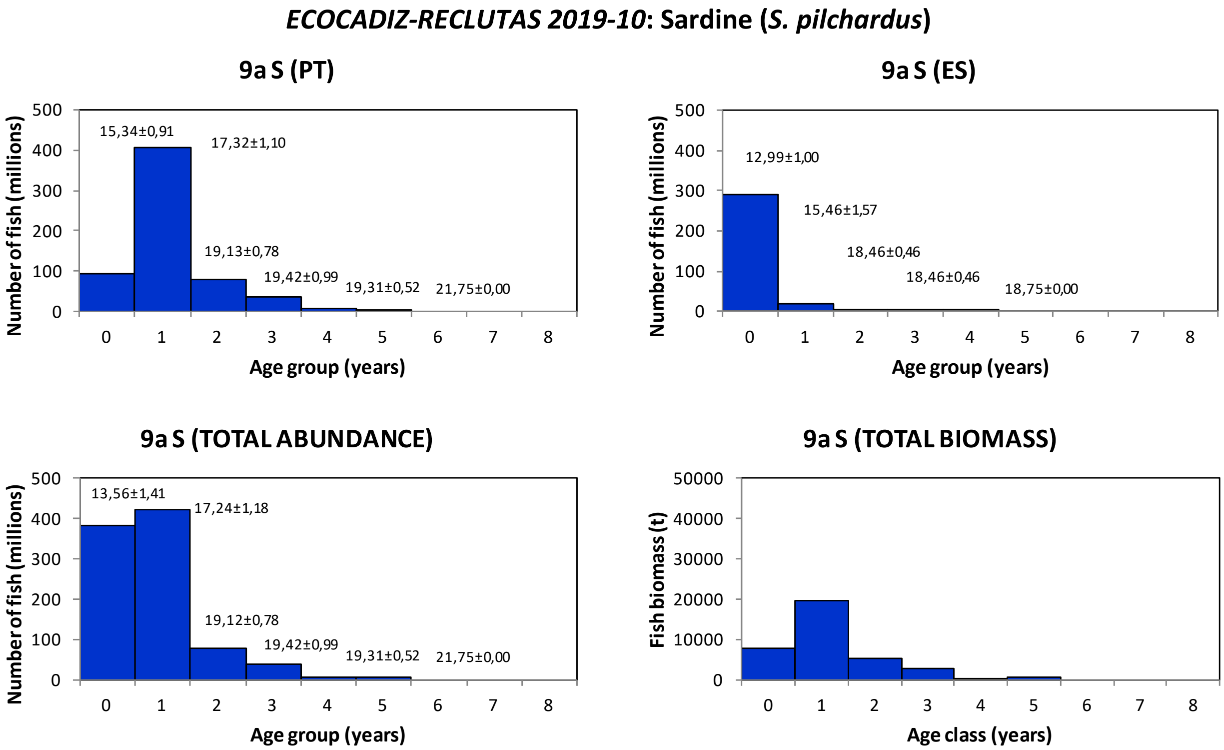


Figure 13. *ECOCADIZ-RECLUTAS 2019-10* survey. Sardine (*Sardina pilchardus*). Cont'd

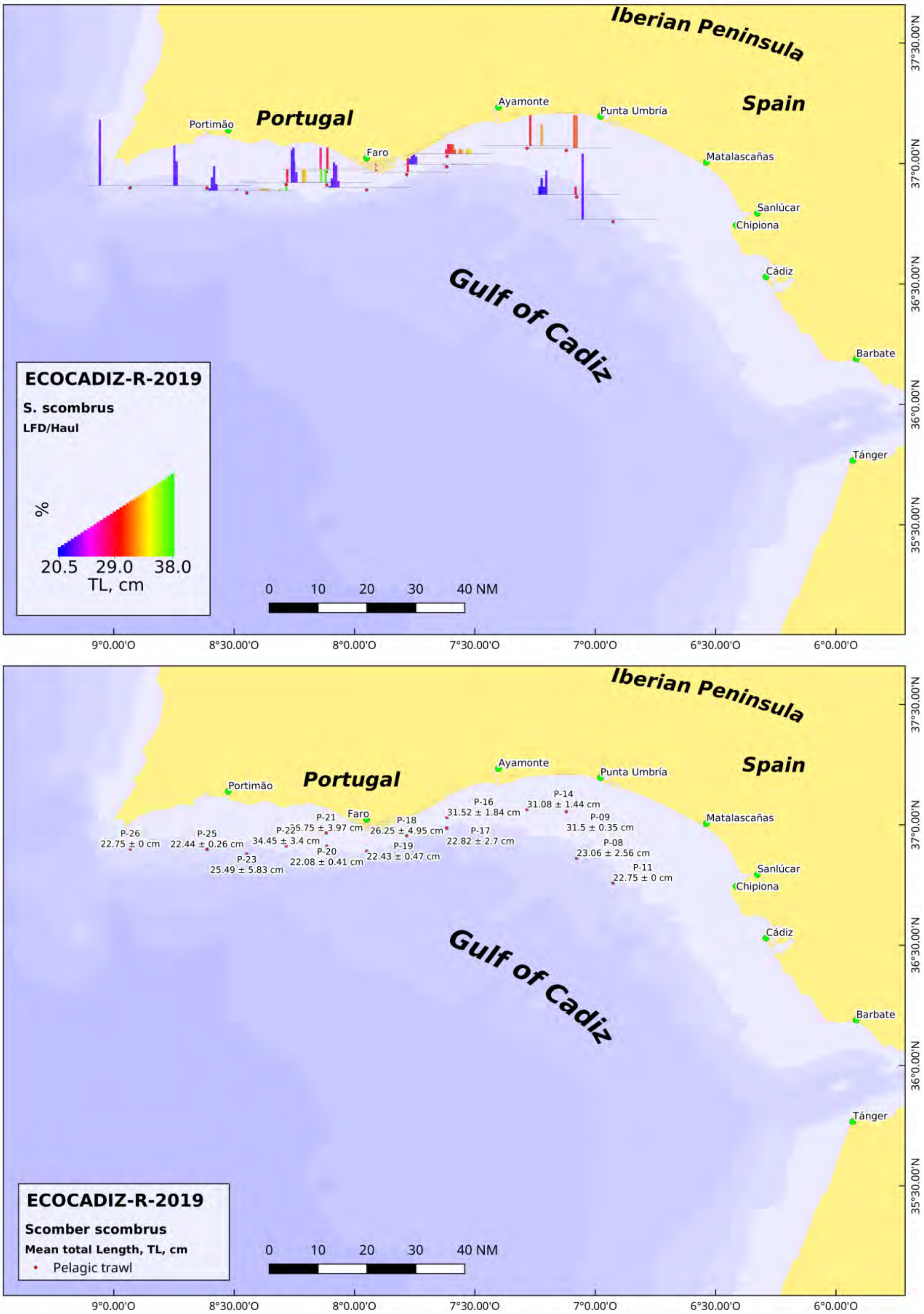


Figure 14. *ECOCADIZ-RECLUTAS 2019-10* survey. Atlantic mackerel (*Scomber scombrus*). Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

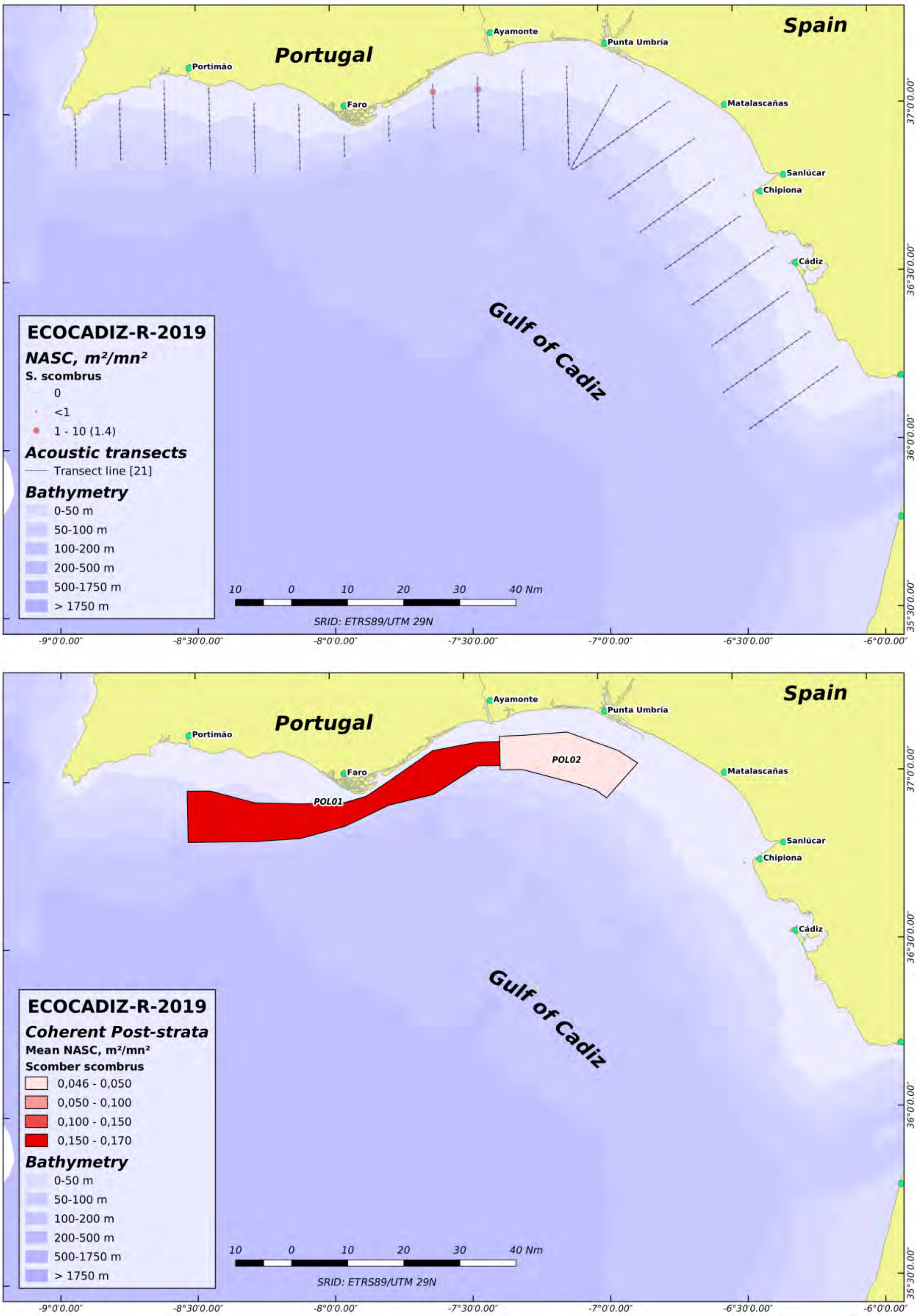


Figure 15. *ECOCADIZ-RECLUTAS 2019-10* survey. Atlantic mackerel (*Scomber scombrus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

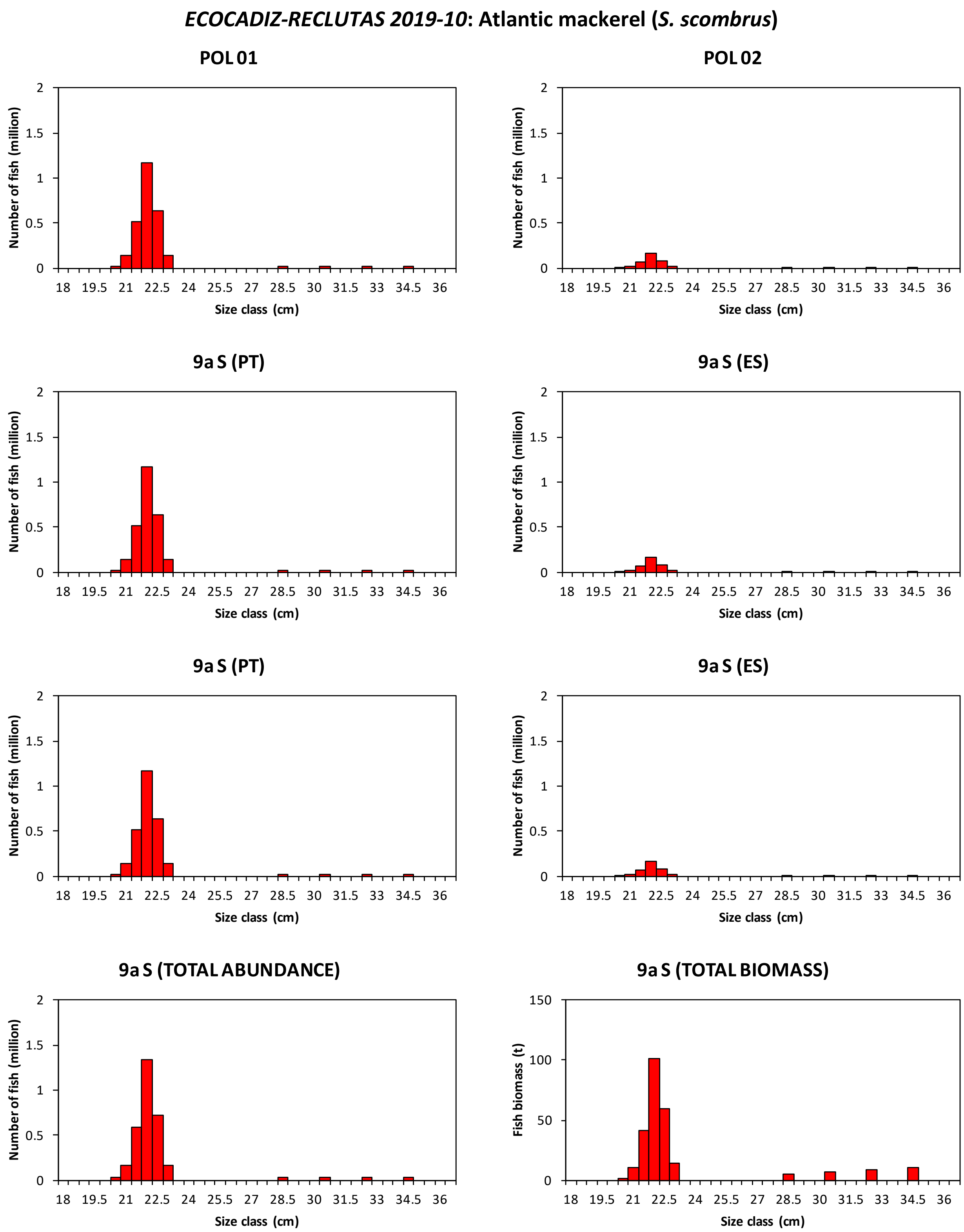


Figure 16. *ECOCADIZ-RECLUTAS 2019-10* survey. Atlantic mackerel (*Scomber scombrus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 15**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

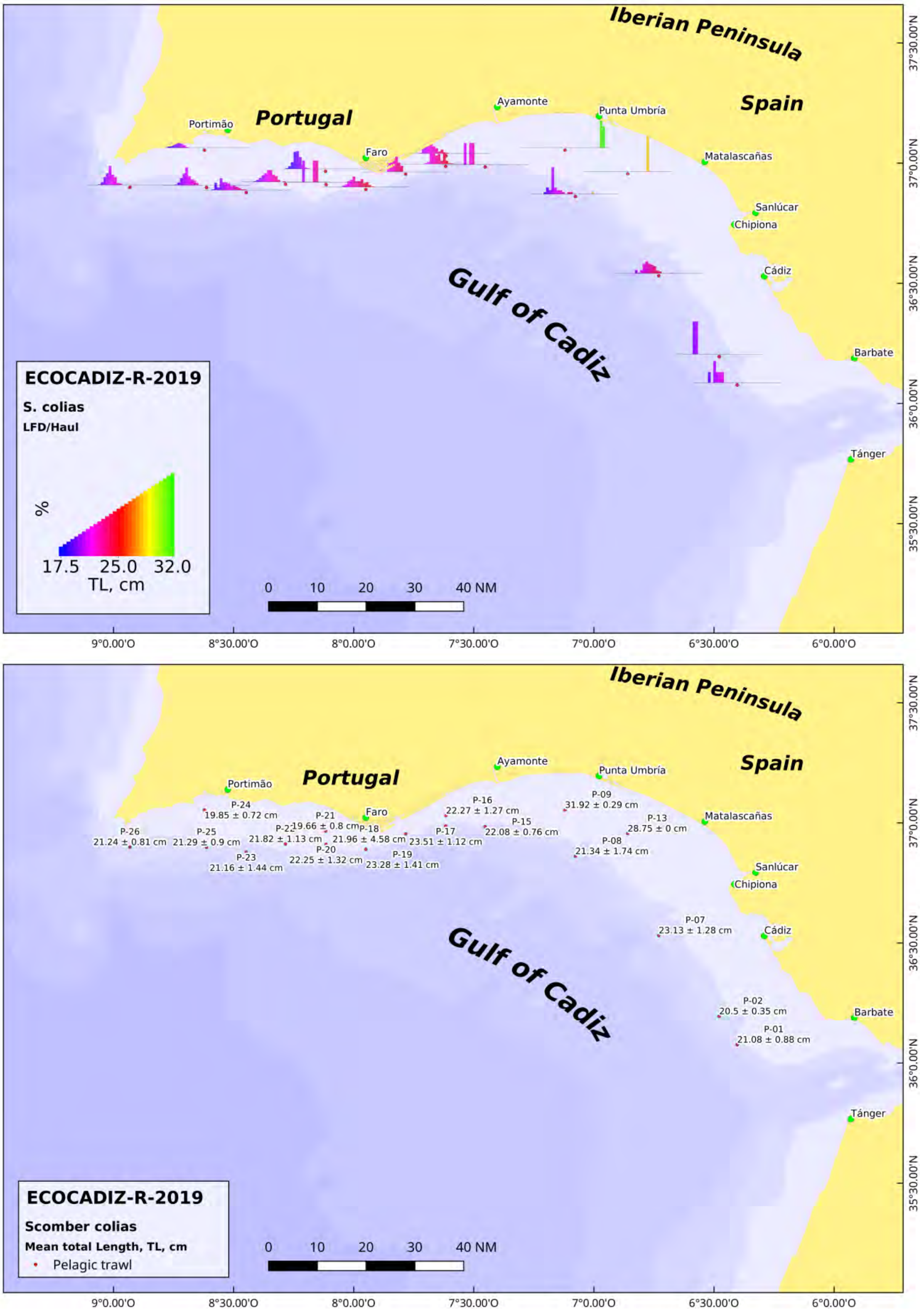


Figure 17. *ECOCADIZ-RECLUTAS 2019-10* survey. Chub mackerel (*Scomber colias*). Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

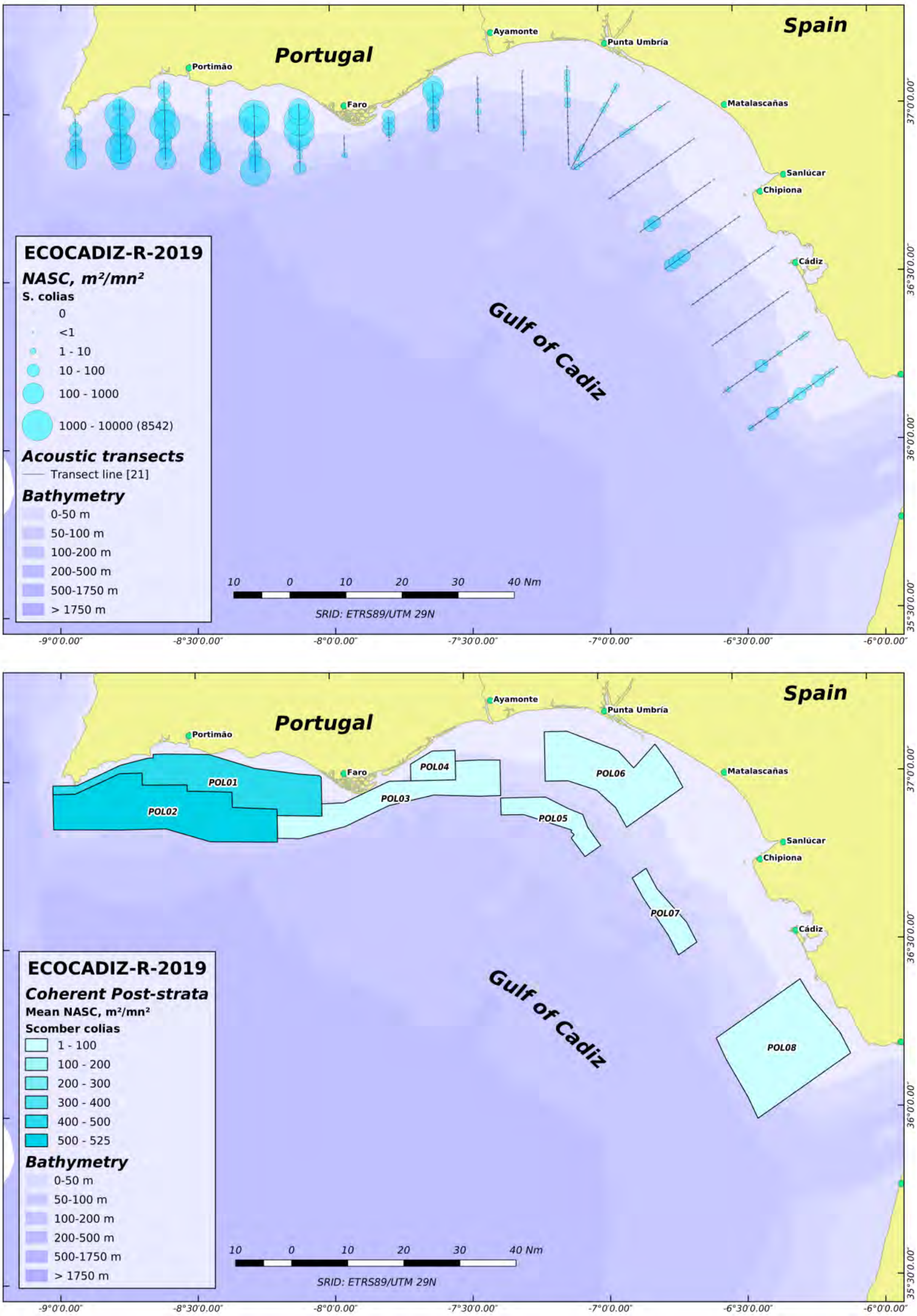


Figure 18. *ECOCADIZ-RECLUTAS 2019-10* survey. Chub mackerel (*Scomber colias*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

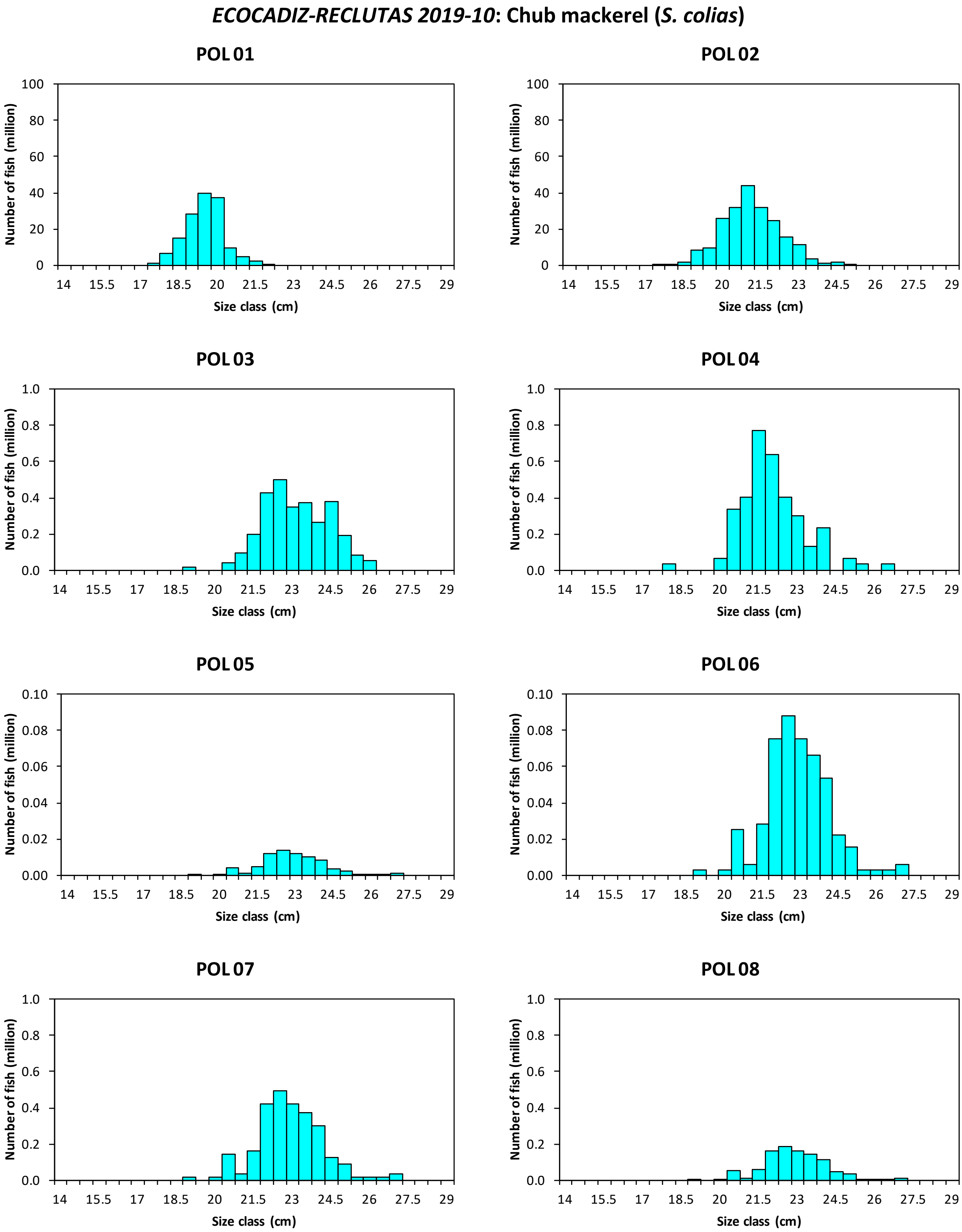


Figure 19. *ECOCADIZ-RECLUTAS 2019-10* survey. Chub mackerel (*Scomber colias*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 18**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

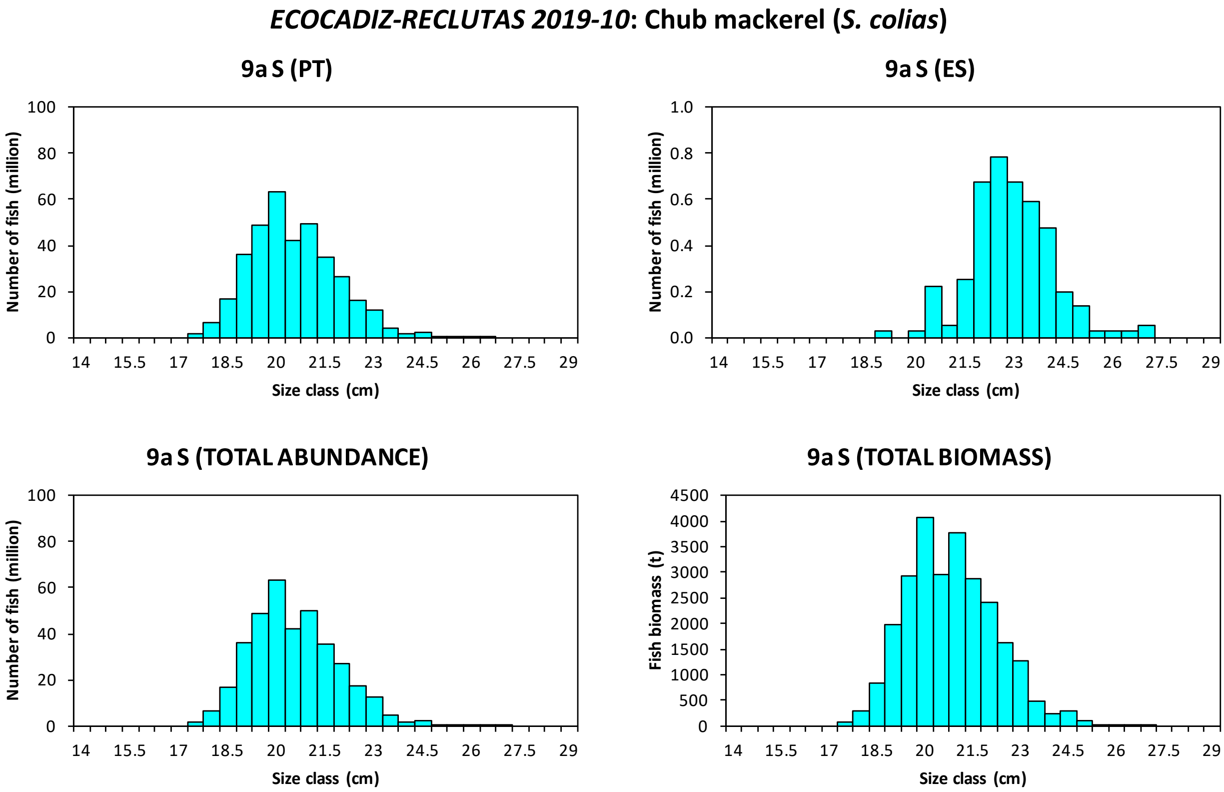


Figure 19. *ECOCADIZ-RECLUTAS 2019-10* survey. Chub mackerel (*Scomber colias*). Cont'd.

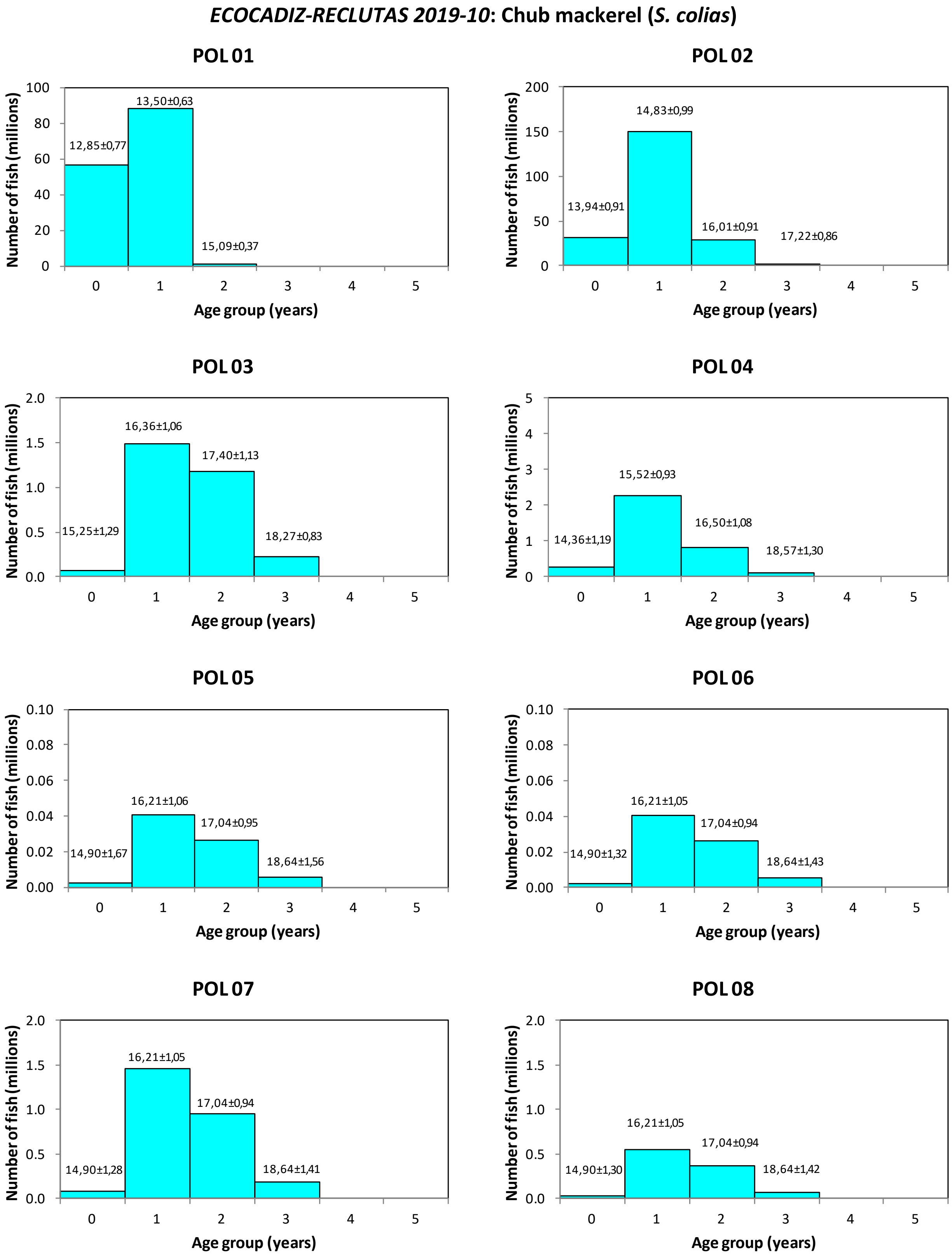


Figure 20. *ECOCADIZ-RECLUTAS 2019-10* survey. Chub mackerel (*Scomber colias*). Estimated abundances (number of fish in millions) by age group (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 18**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by age group for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

***ECOCADIZ-RECLUTAS 2019-10*: Chub mackerel (*S. colias*)**

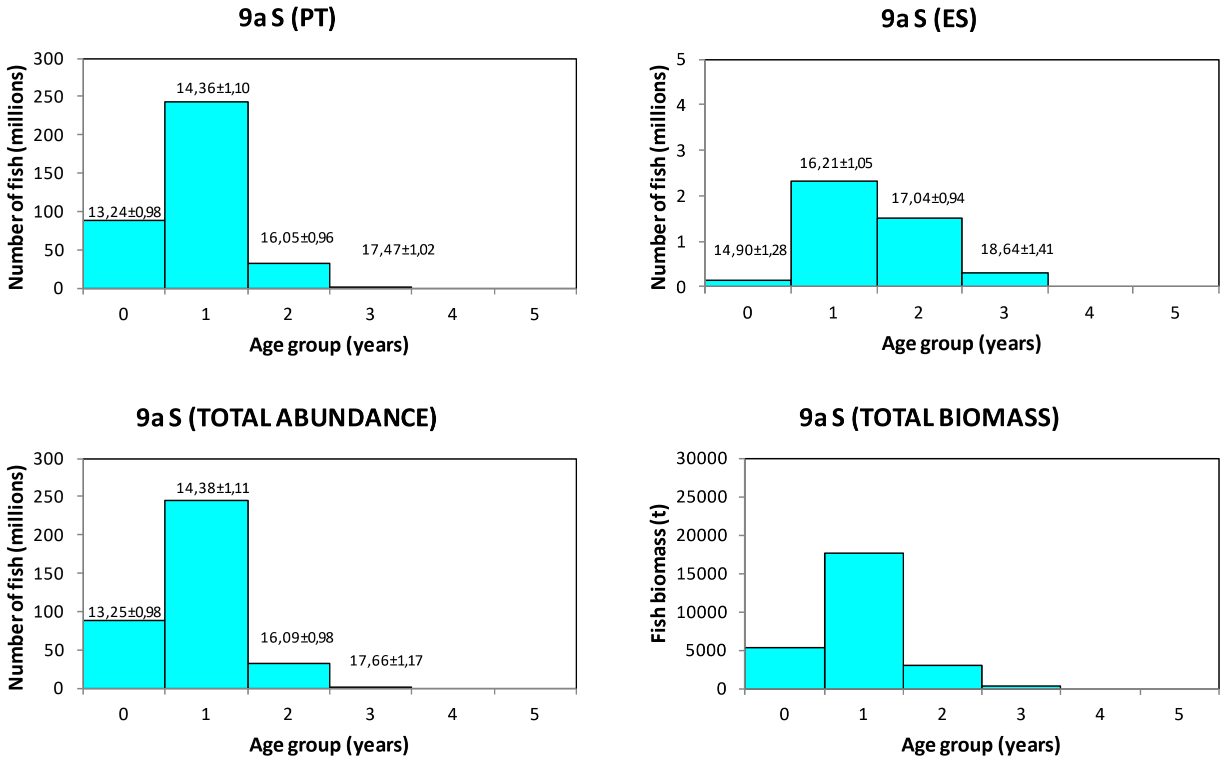


Figure 20. *ECOCADIZ-RECLUTAS 2019-10* survey. Chub mackerel (*Scomber colias*). Cont'd.

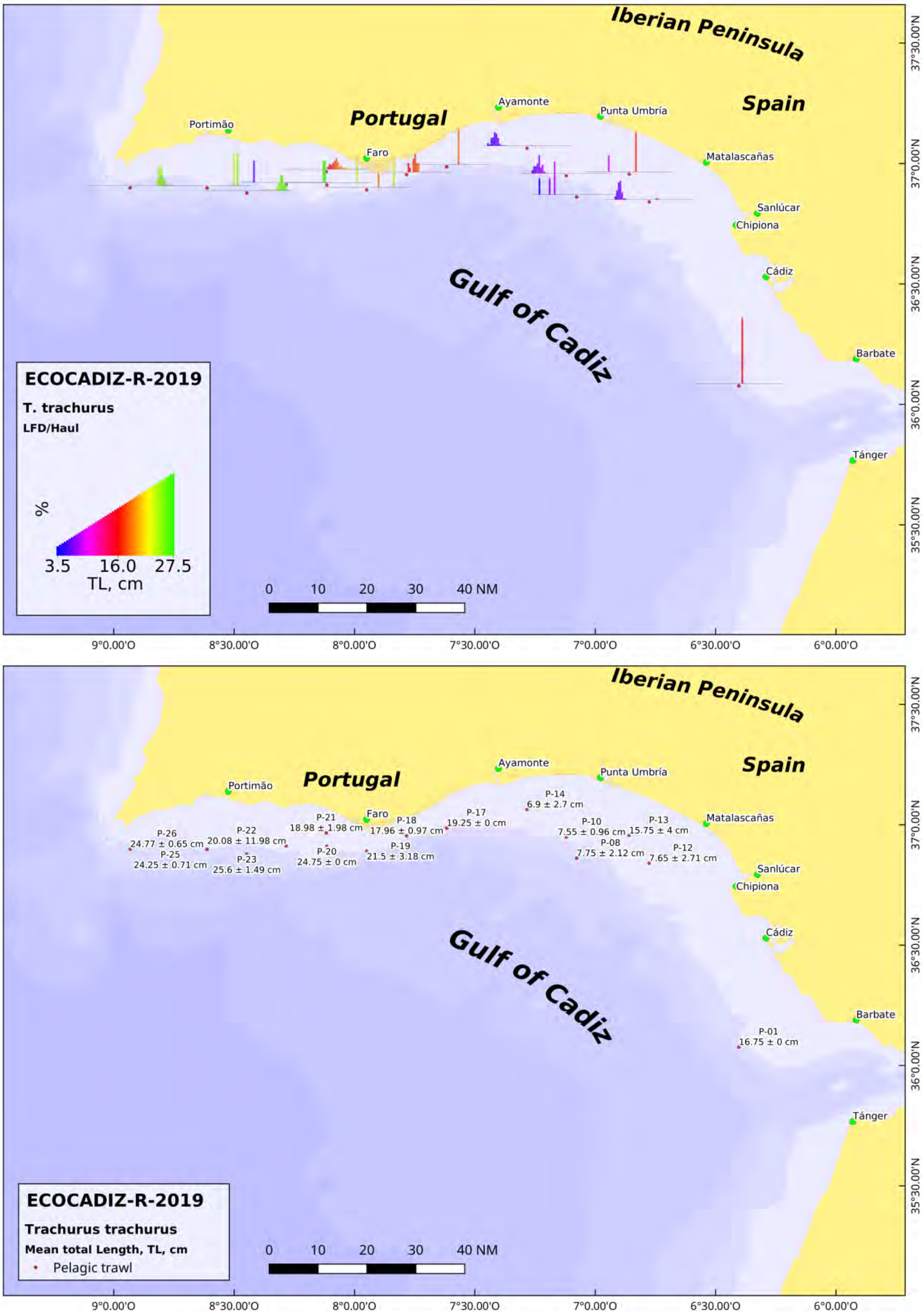


Figure 21. *ECOCADIZ-RECLUTAS 2019-10* survey. Horse mackerel (*Trachurus trachurus*). Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

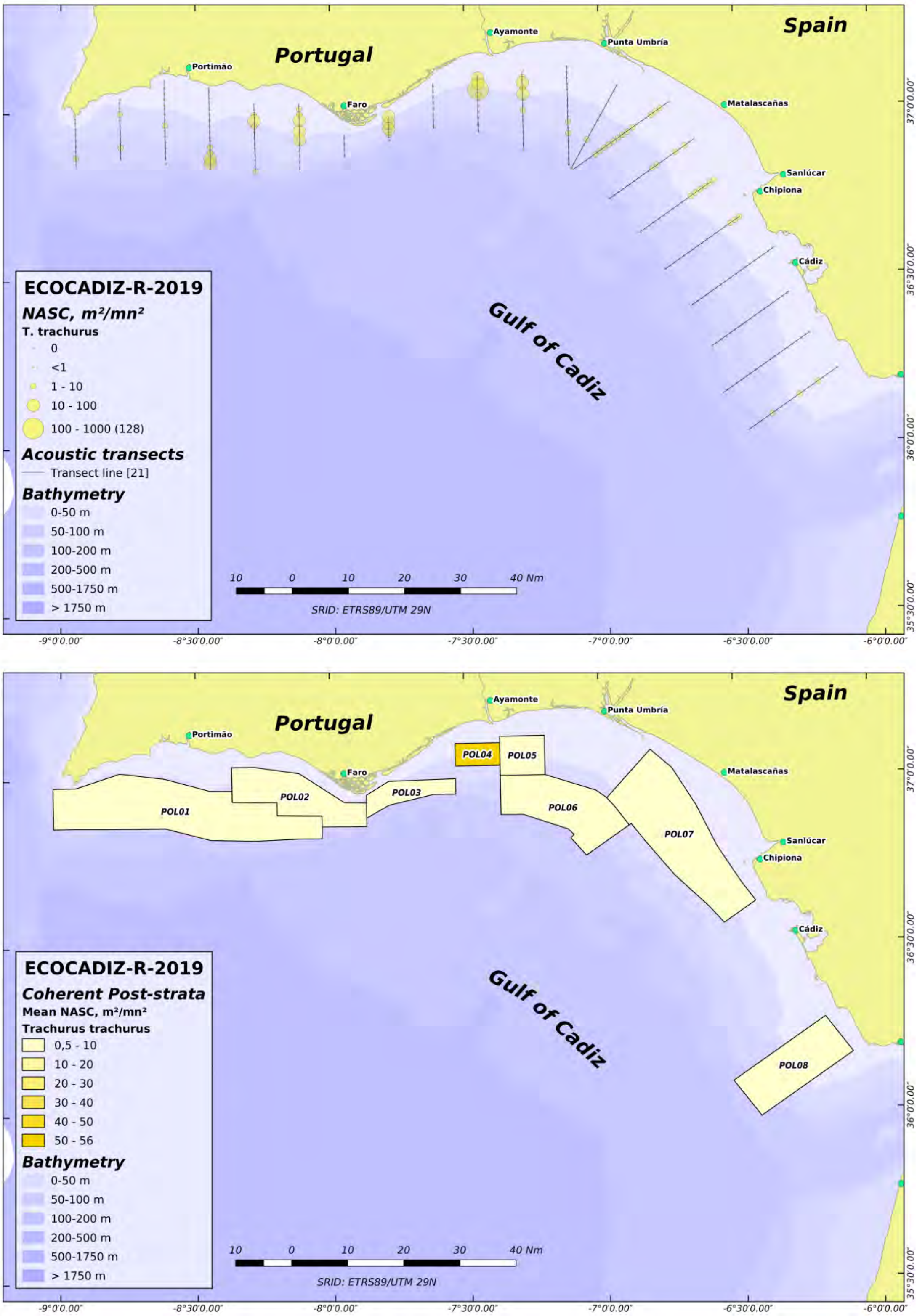


Figure 22. *ECOCADIZ-RECLUTAS 2019-10* survey. Horse mackerel (*Trachurus trachurus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

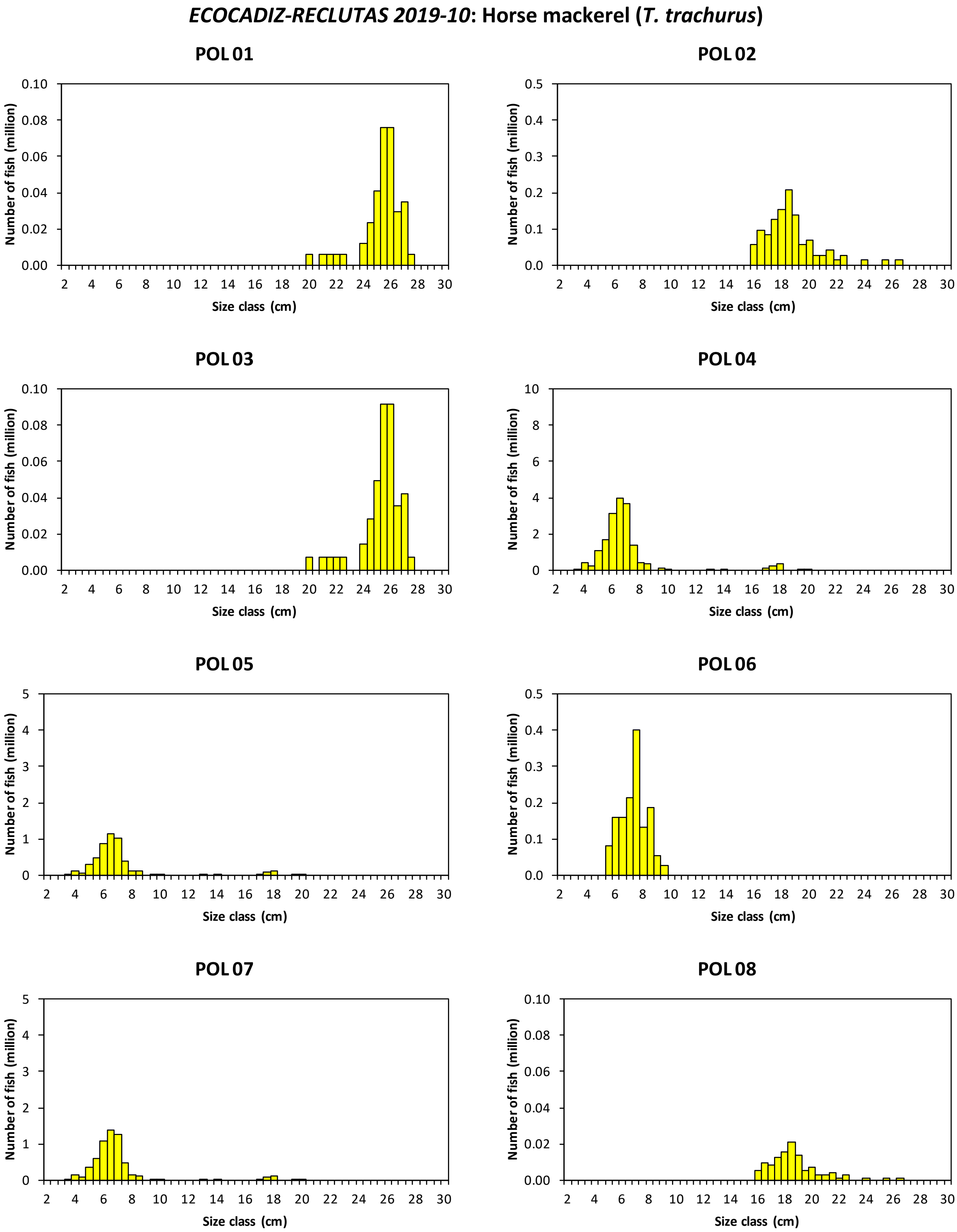


Figure 23. *ECOCADIZ-RECLUTAS 2019-10* survey. Horse mackerel (*Trachurus trachurus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 22**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

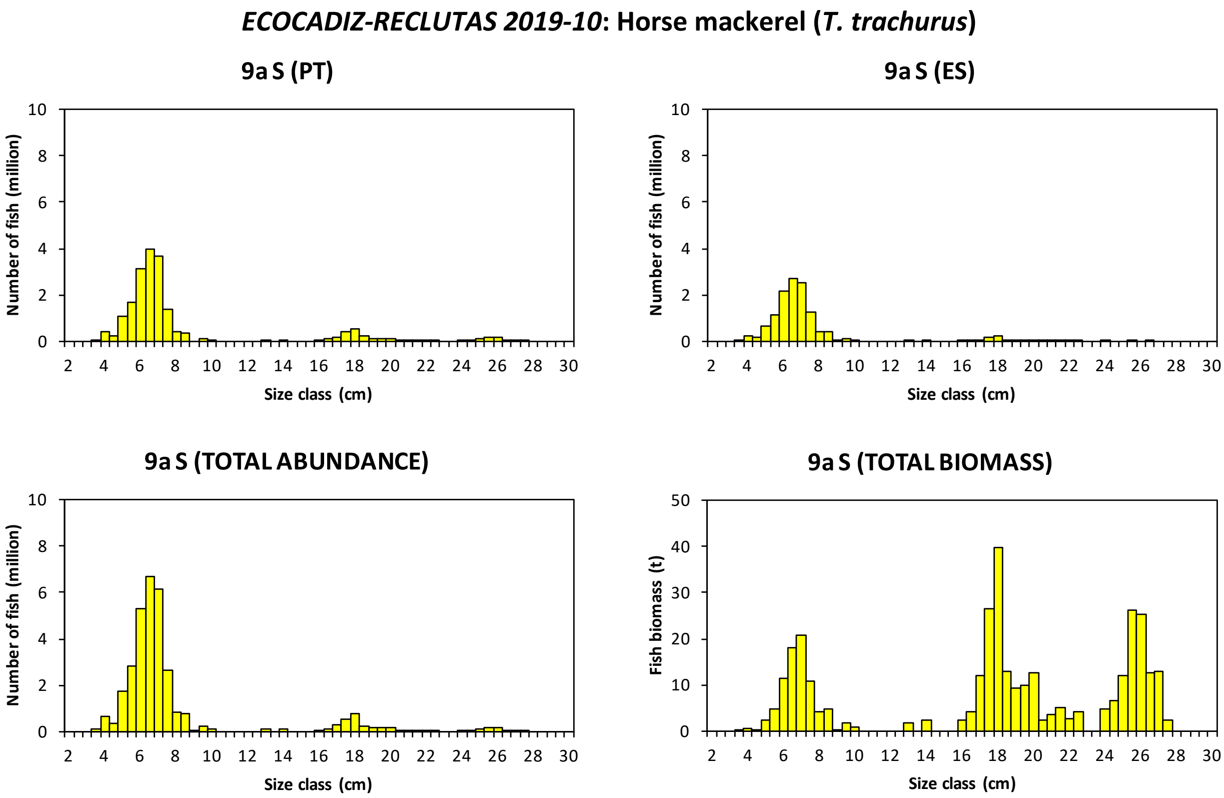


Figure 23. *ECOCADIZ-RECLUTAS 2019-10* survey. Horse mackerel (*Trachurus trachurus*). Cont'd.

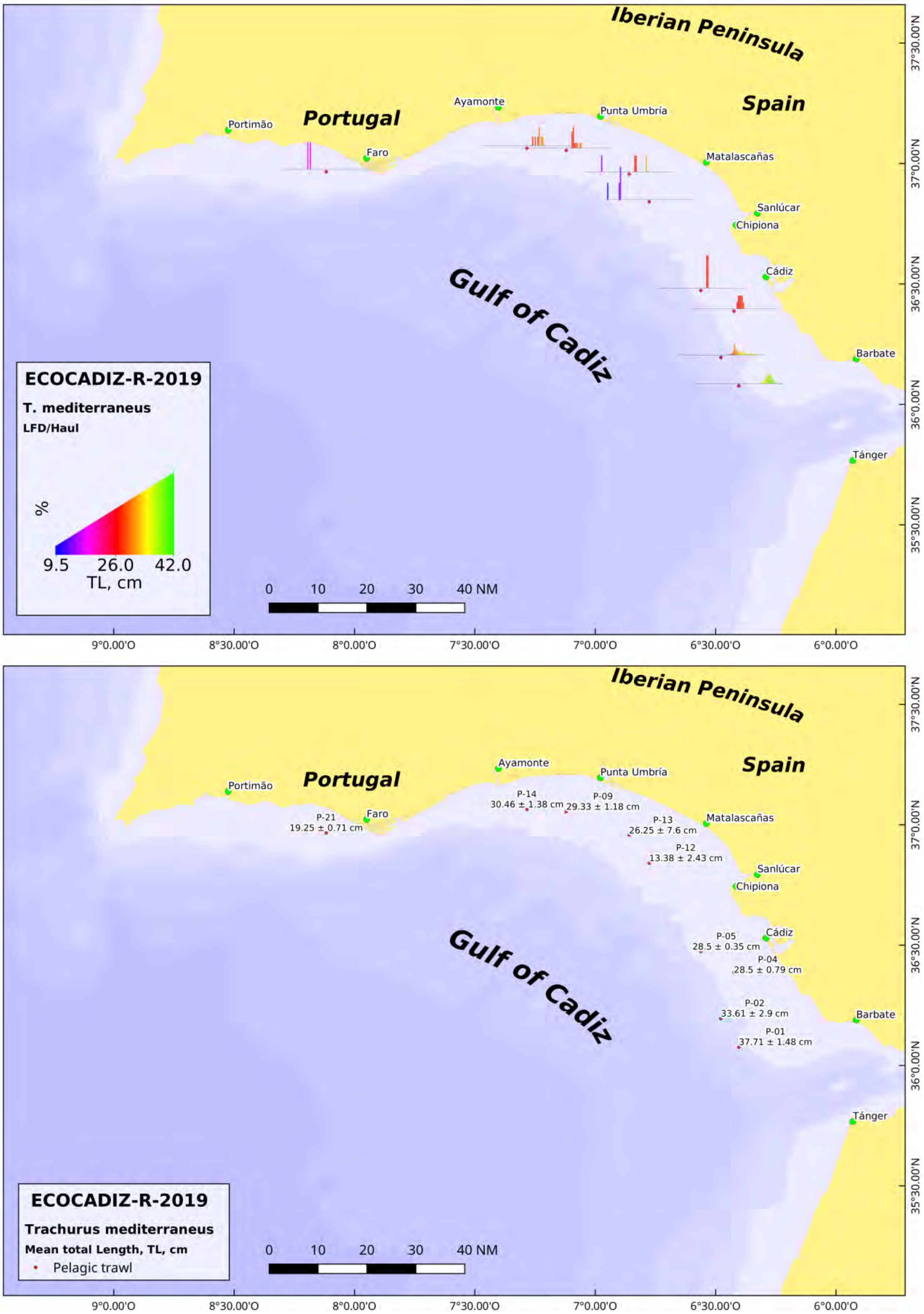


Figure 24. *ECOCADIZ-RECLUTAS 2019-10* survey. Mediterranean horse mackerel (*Trachurus mediterraneus*). Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

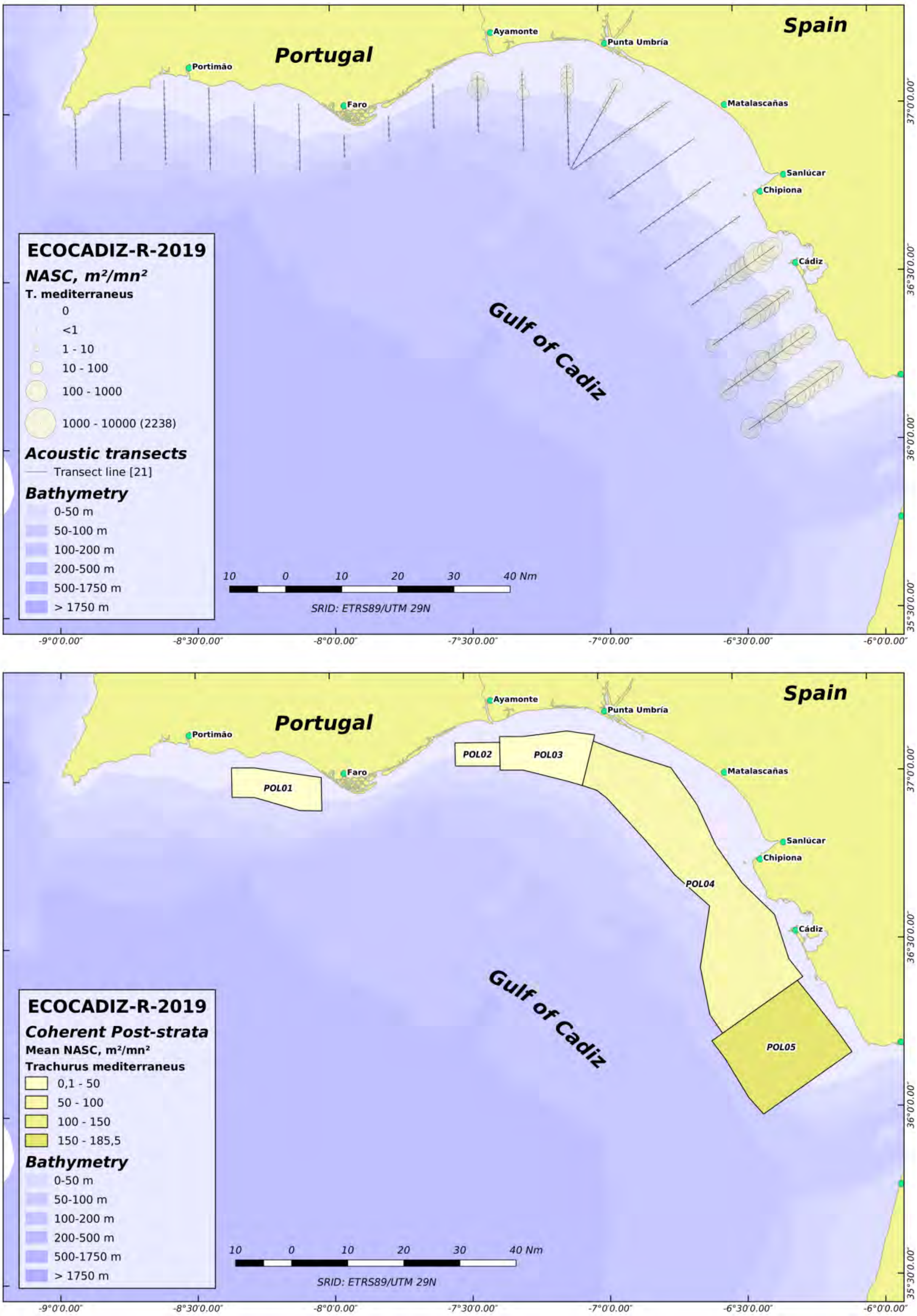


Figure 25. *ECOCADIZ-RECLUTAS 2019-10* survey. Mediterranean horse mackerel (*Trachurus mediterraneus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata 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 2019-10*: Mediterranean horse mackerel (*T. mediterraneus*)**

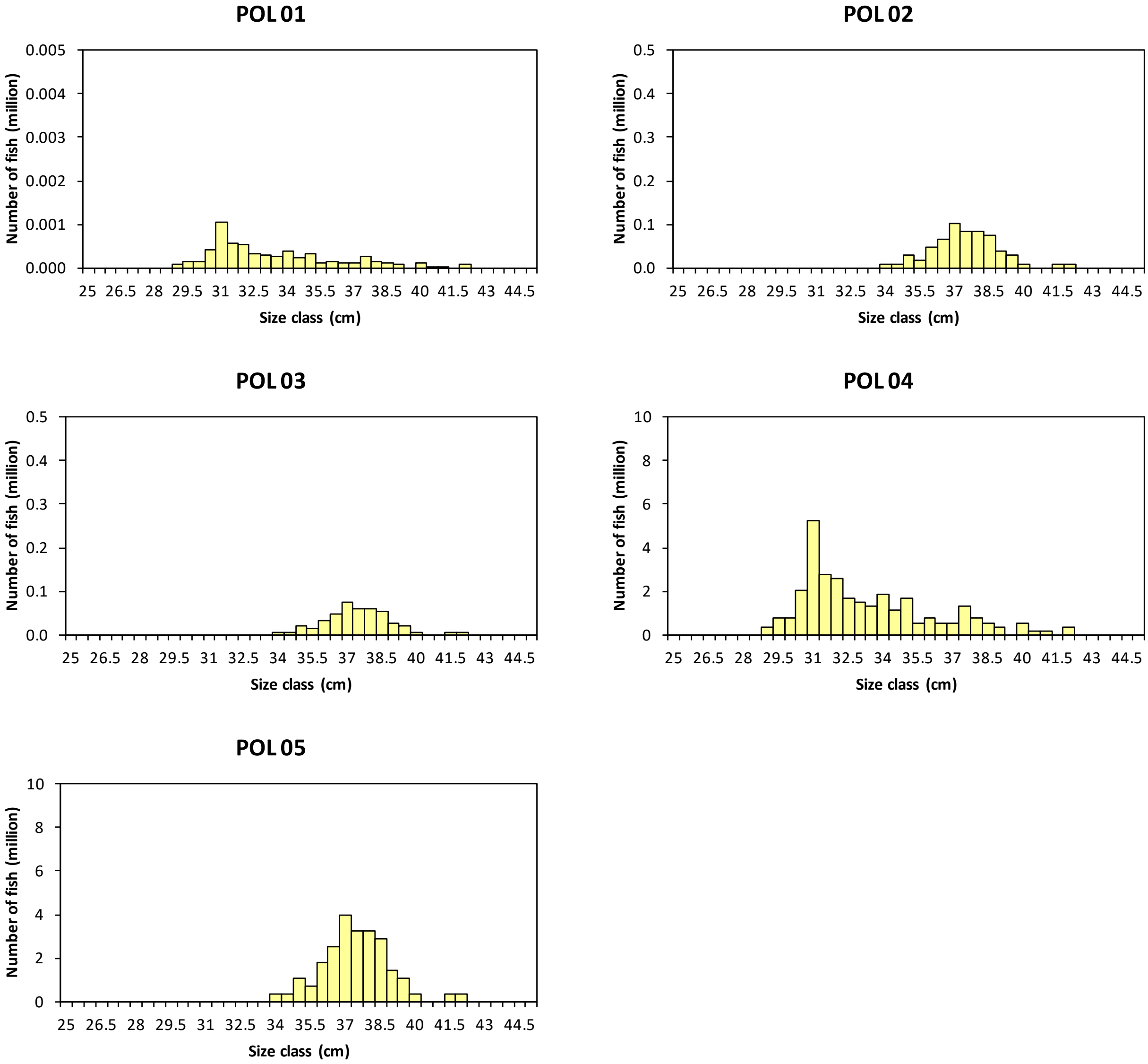


Figure 26. *ECOCADIZ-RECLUTAS 2019-10* survey. Mediterranean horse mackerel (*Trachurus mediterraneus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 25**) and total sampled area. Post-strata ordered in the W-E direction. 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 2019-10: Mediterranean horse mackerel (*T. mediterraneus*)

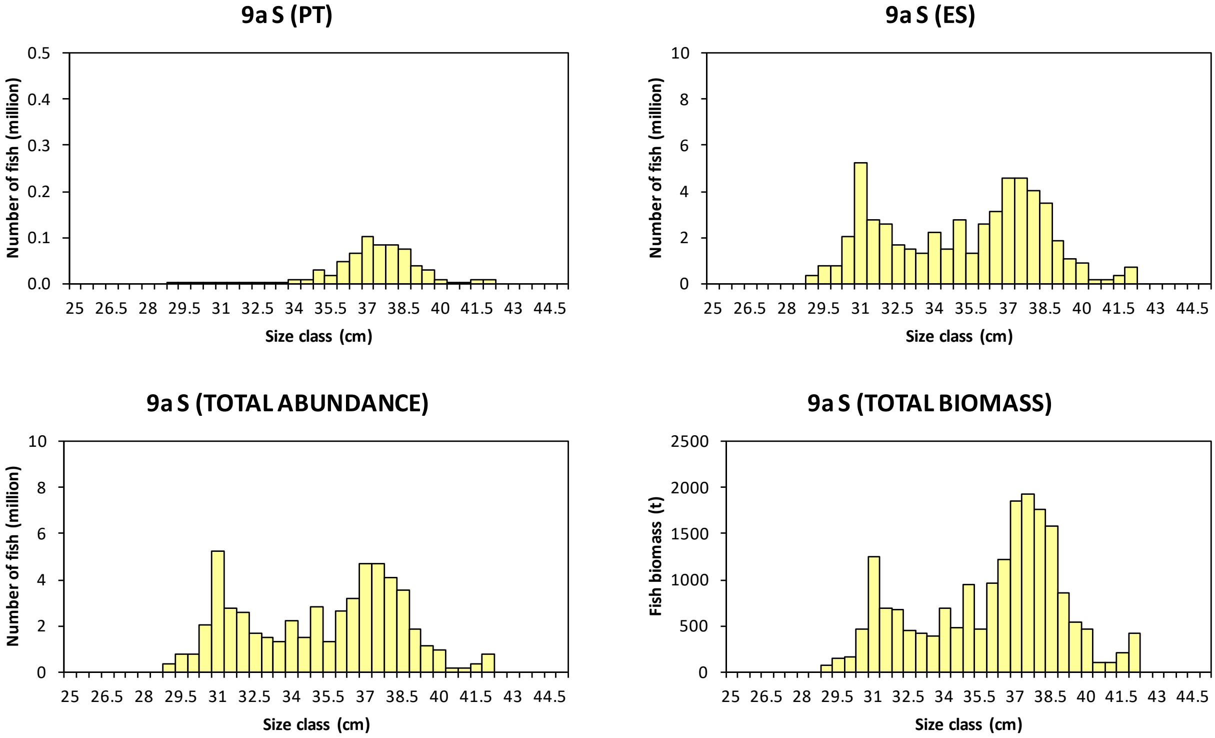


Figure 26. *ECOCADIZ-RECLUTAS 2019-10* survey. Mediterranean horse mackerel (*Trachurus mediterraneus*).Cont'd.

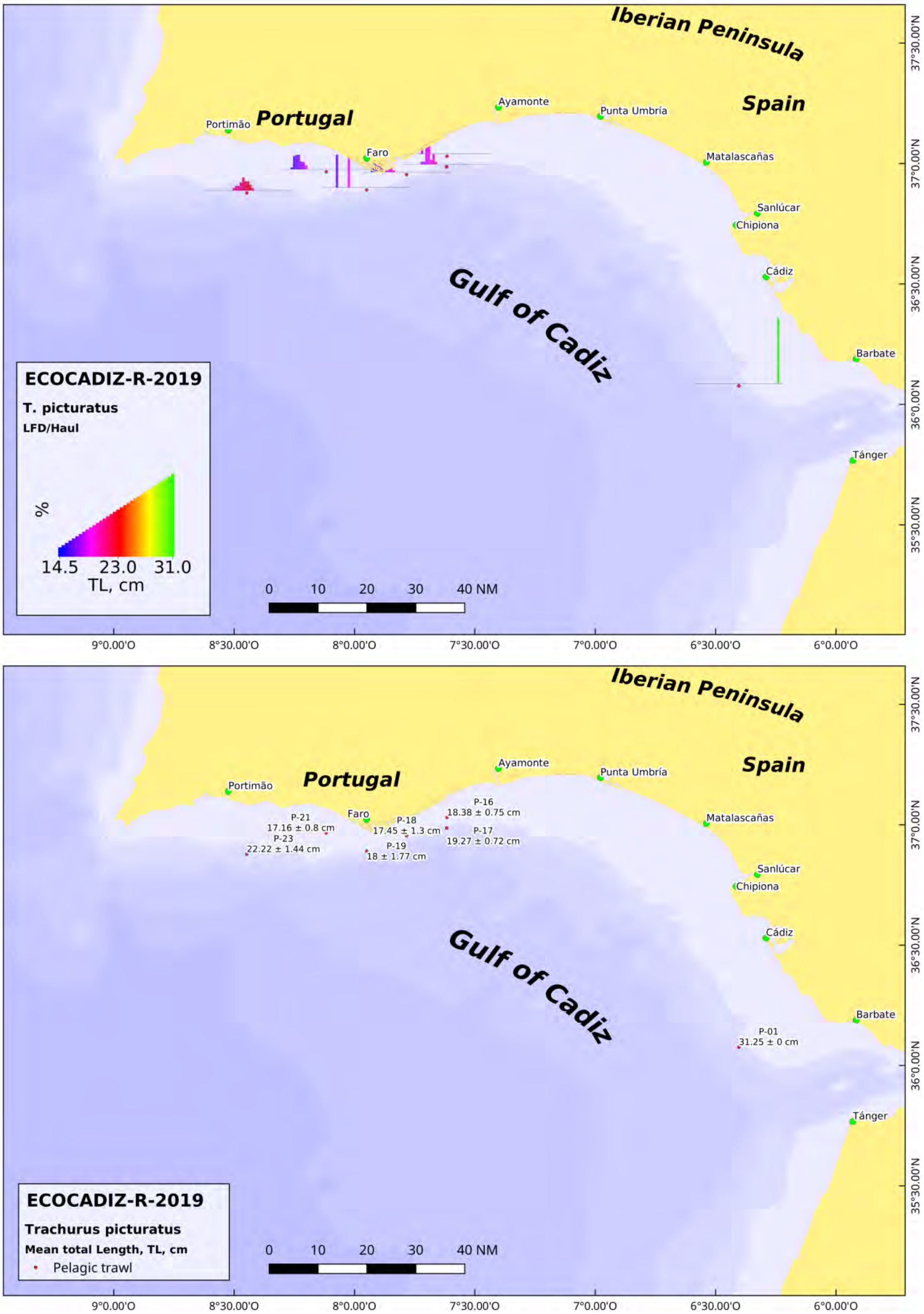


Figure 27. *ECOCADIZ-RECLUTAS 2019-10* survey. Blue jack mackerel (*Trachurus picturatus*). Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

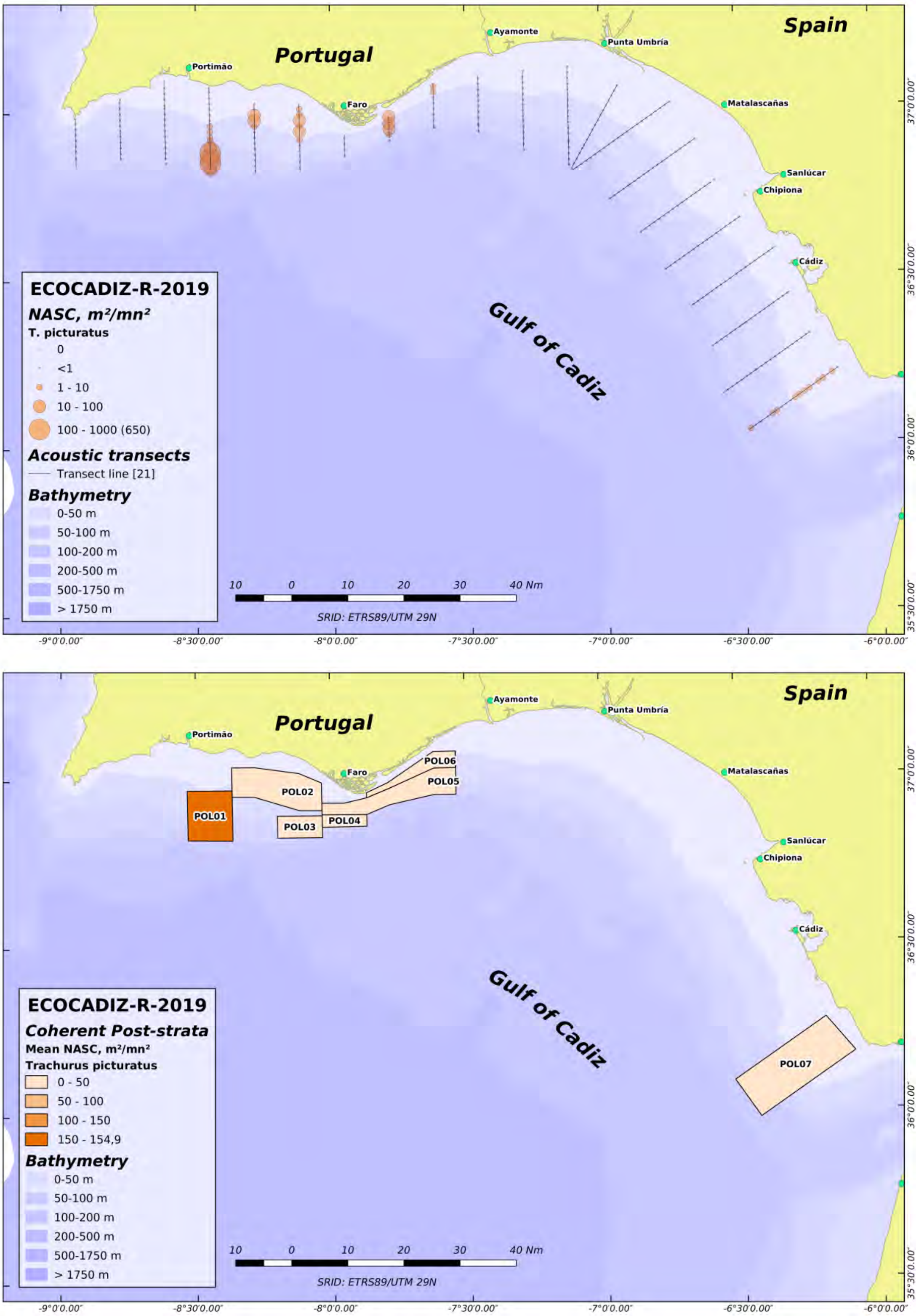


Figure 28. *ECOCADIZ-RECLUTAS 2019-10* survey. Blue jack mackerel (*Trachurus picturatus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

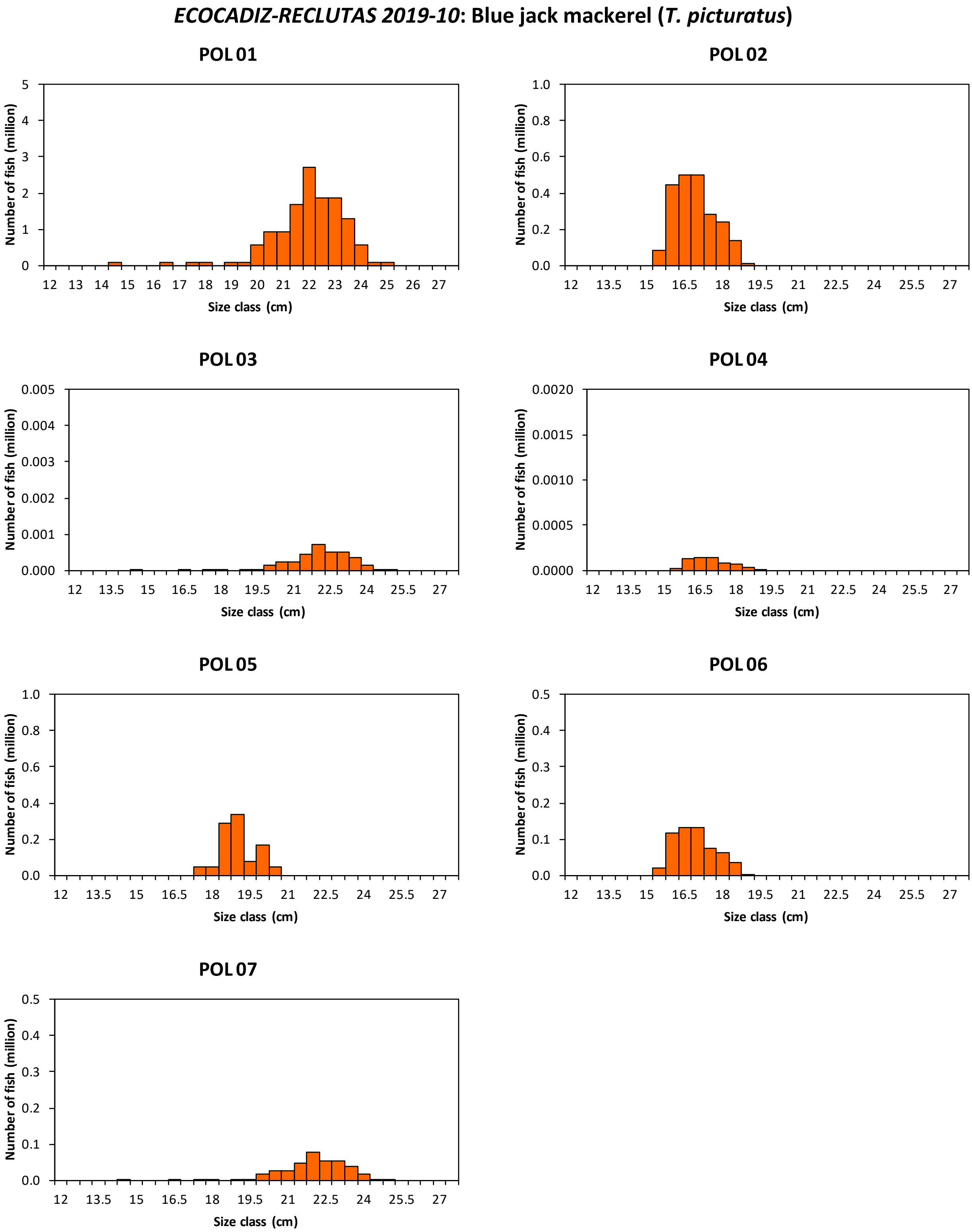


Figure 29. *ECOCADIZ-RECLUTAS 2019-10* survey. Blue jack mackerel (*Trachurus picturatus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 28**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

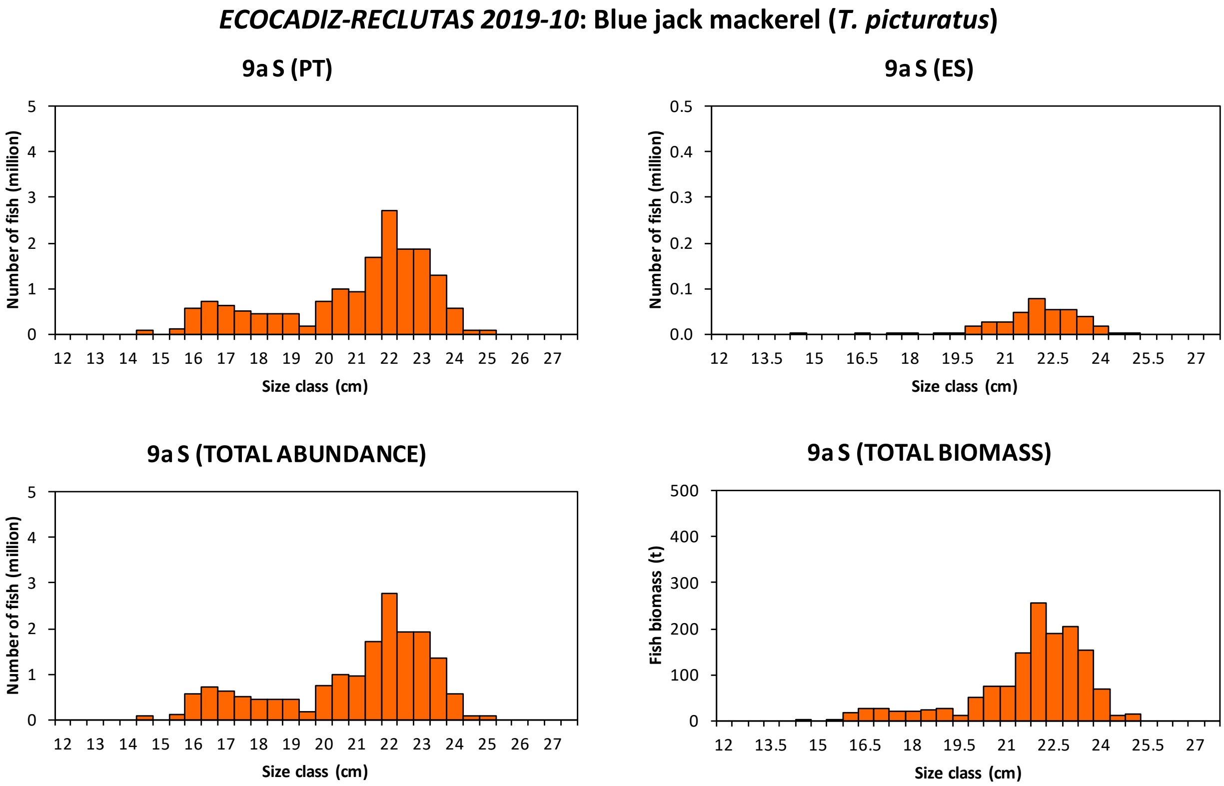


Figure 29. *ECOCADIZ-RECLUTAS 2019-10* survey. Blue jack mackerel (*Trachurus picturatus*). Cont'd.

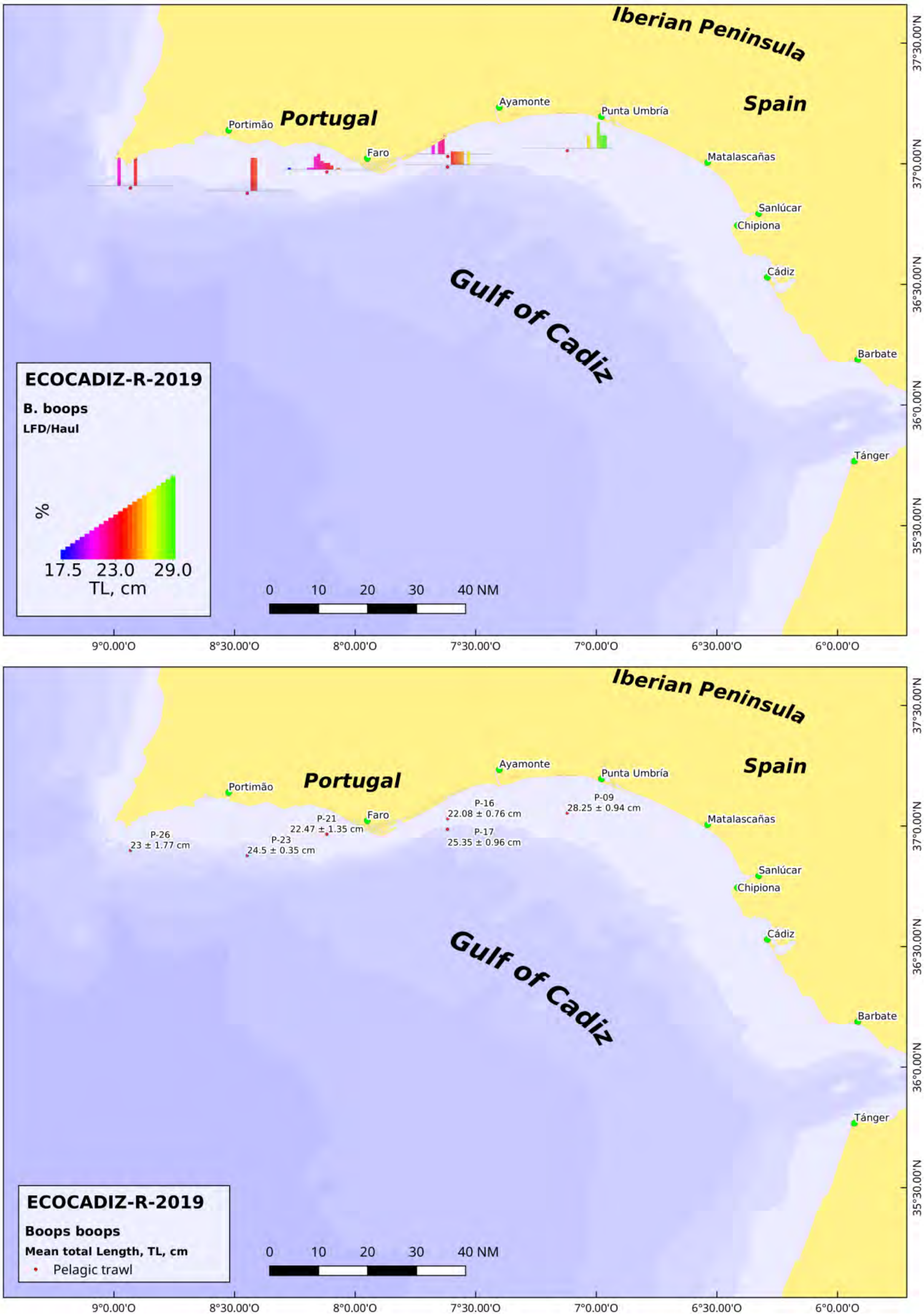
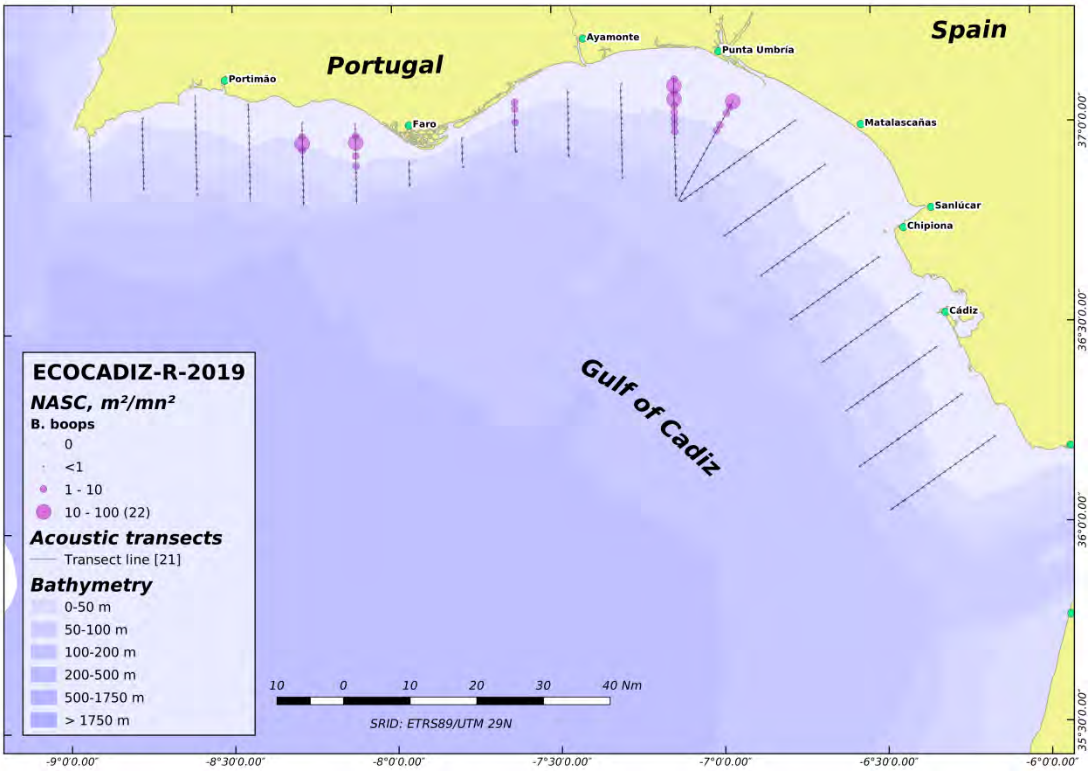


Figure 30. *ECOCADIZ-RECLUTAS 2019-10* survey. Bogue (*Boops boops*). Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.



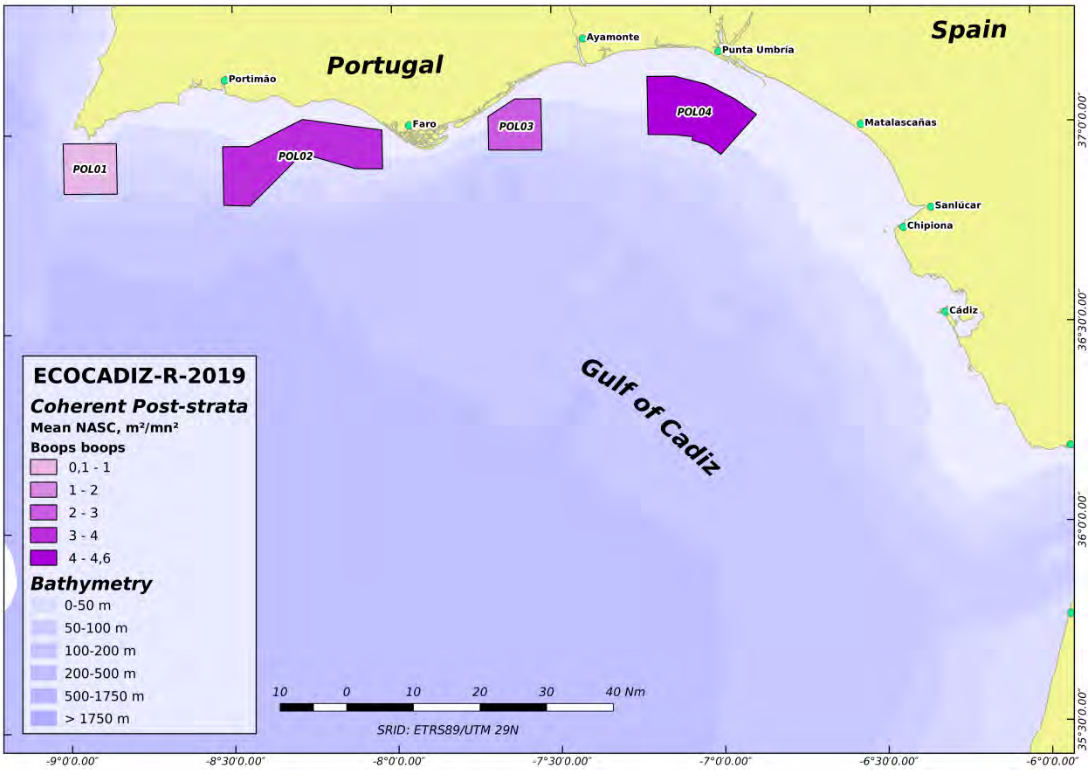


Figure 31. *ECOCADIZ-RECLUTAS 2019-10* survey. Bogue (*Boops boops*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

ECOCADIZ-RECLUTAS 2019-10: Bogue (*B. boops*)

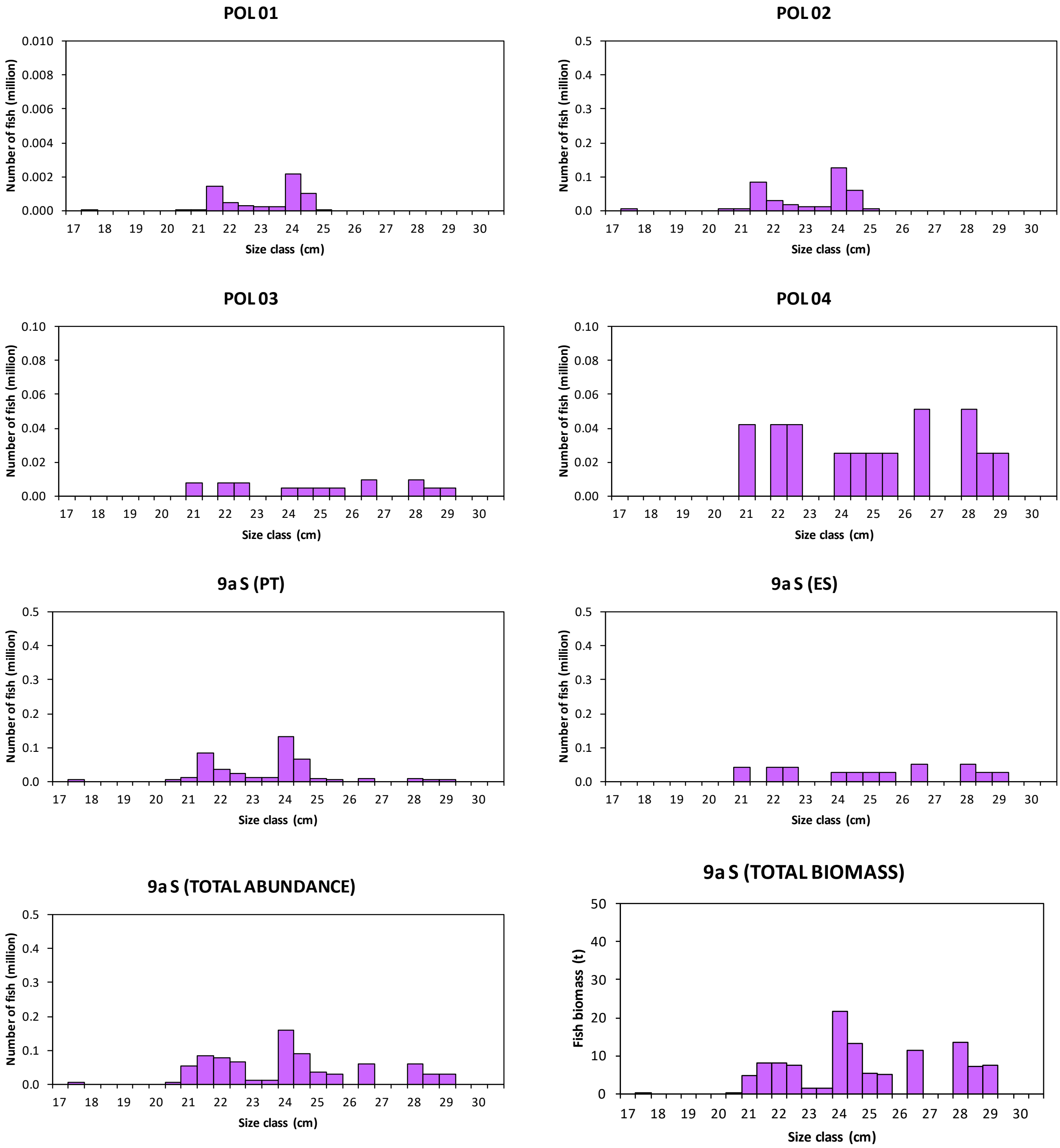
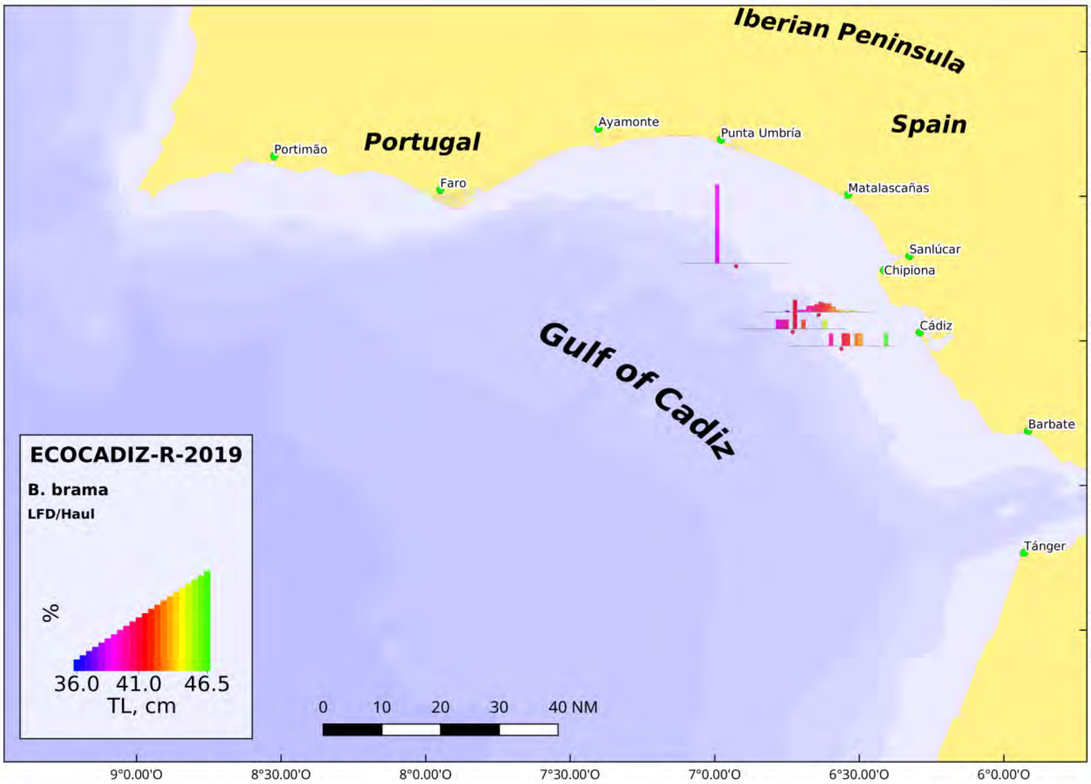


Figure 32. *ECOCADIZ-RECLUTAS 2019-10* survey. Bogue (*Boops boops*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 31**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.



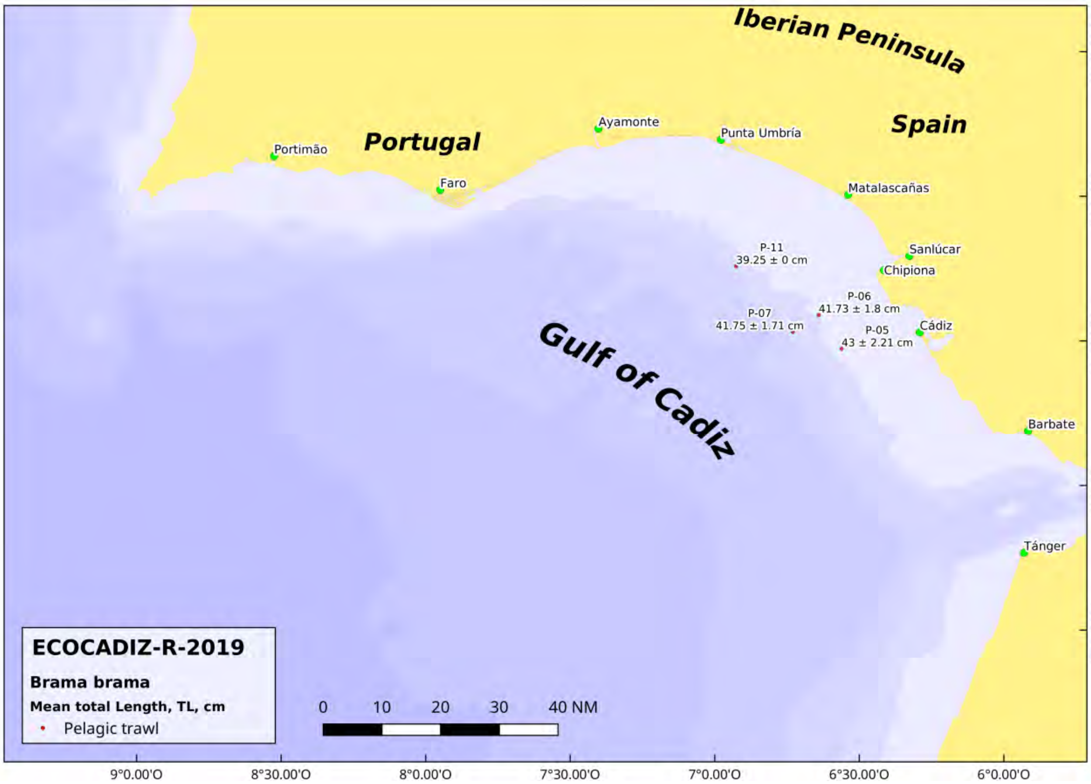


Figure 33. *ECOCADIZ-RECLUTAS 2019-10* survey. Atlantic pomfret (*Brama brama*). Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

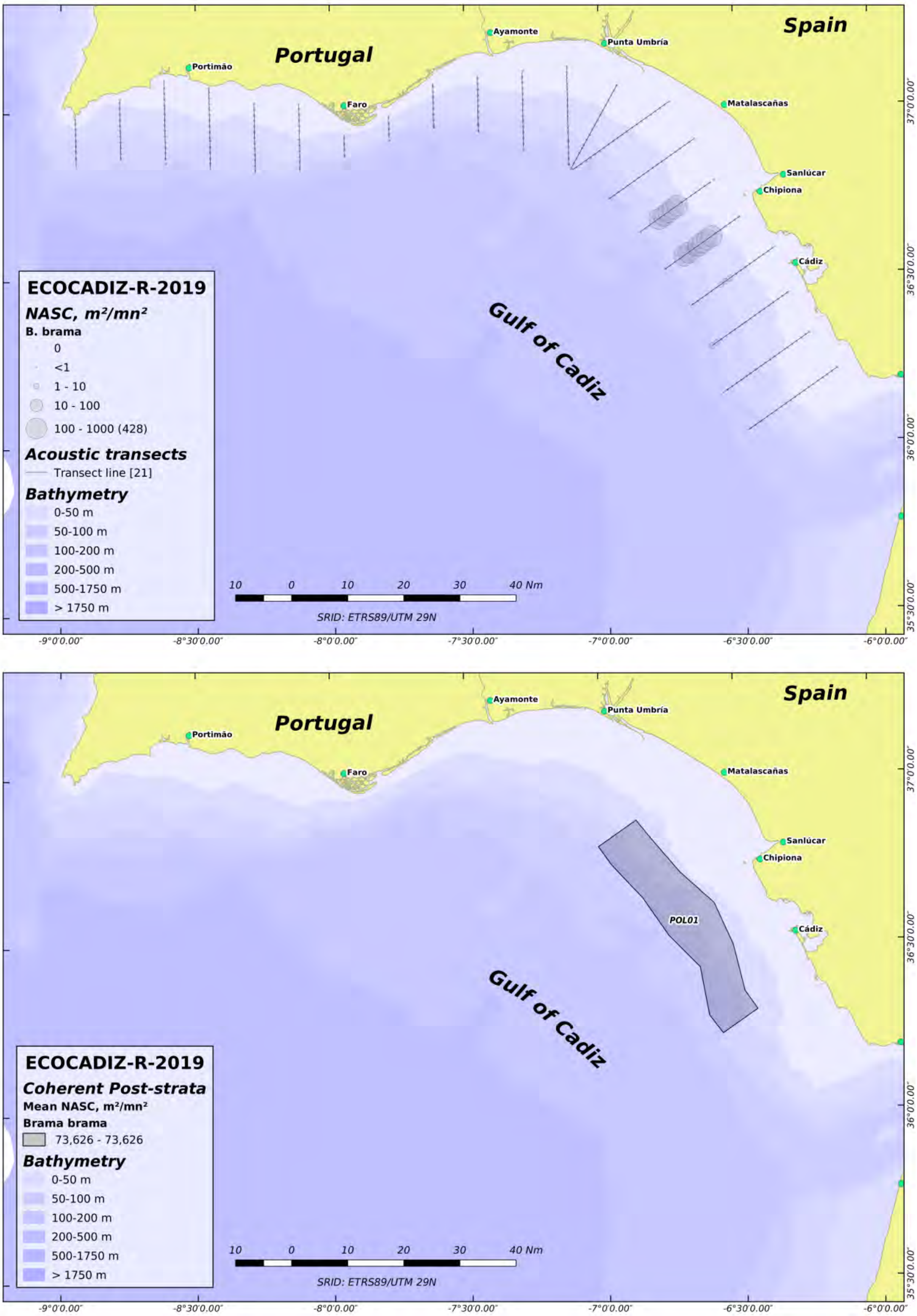


Figure 34. *ECOCADIZ-RECLUTAS 2019-10* survey. Atlantic pomfret (*Brama brama*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

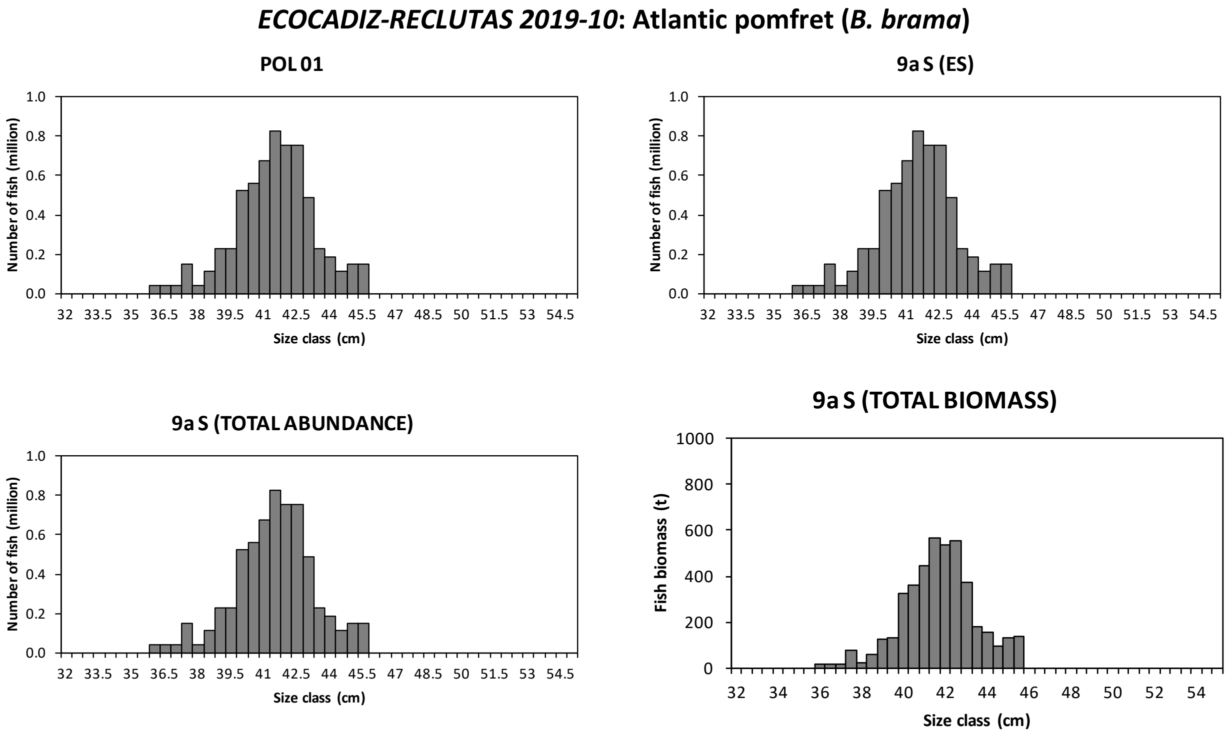


Figure 35. *ECOCADIZ-RECLUTAS 2019-10* survey. Atlantic pomfret (*Brama brama*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 34**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

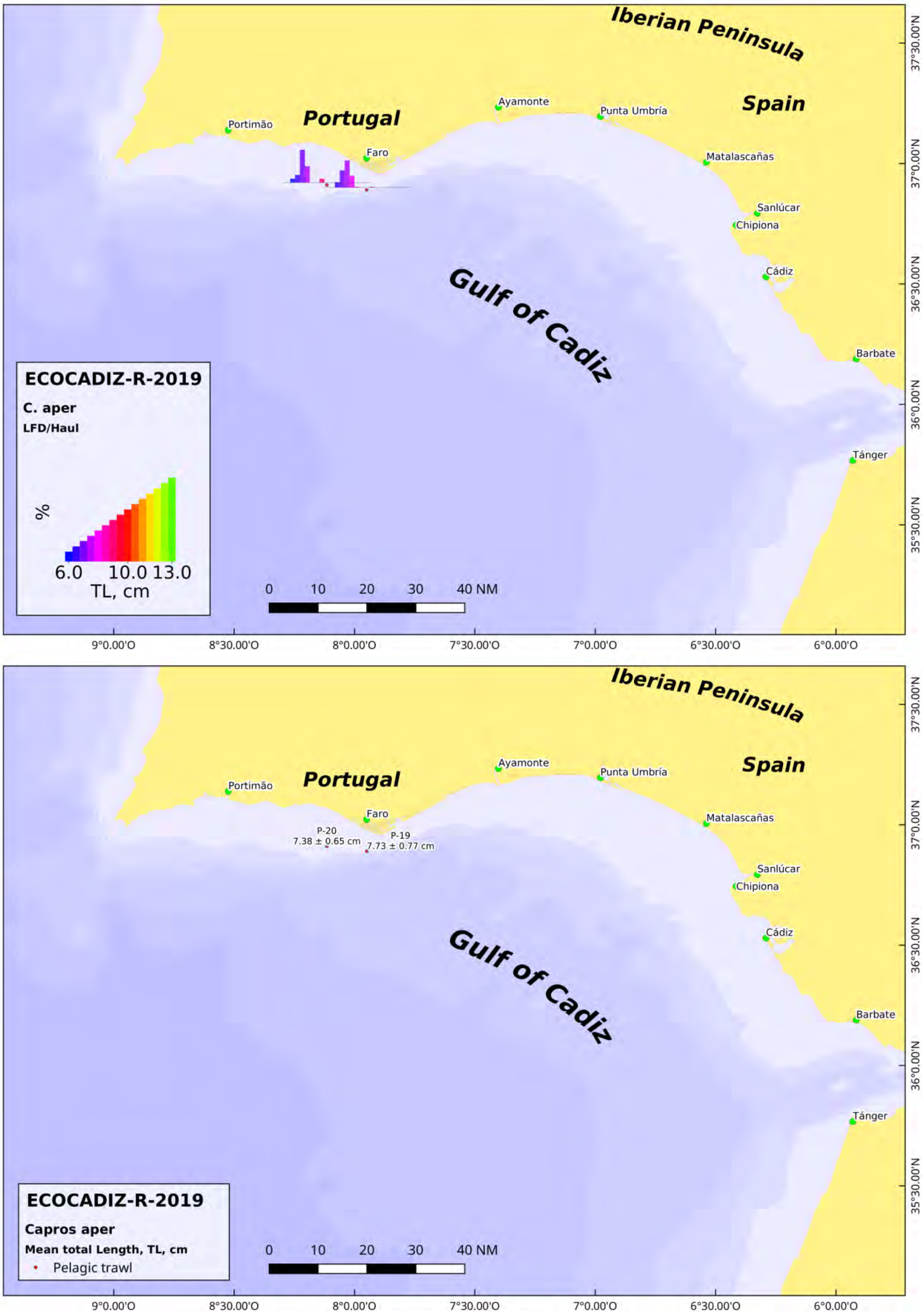
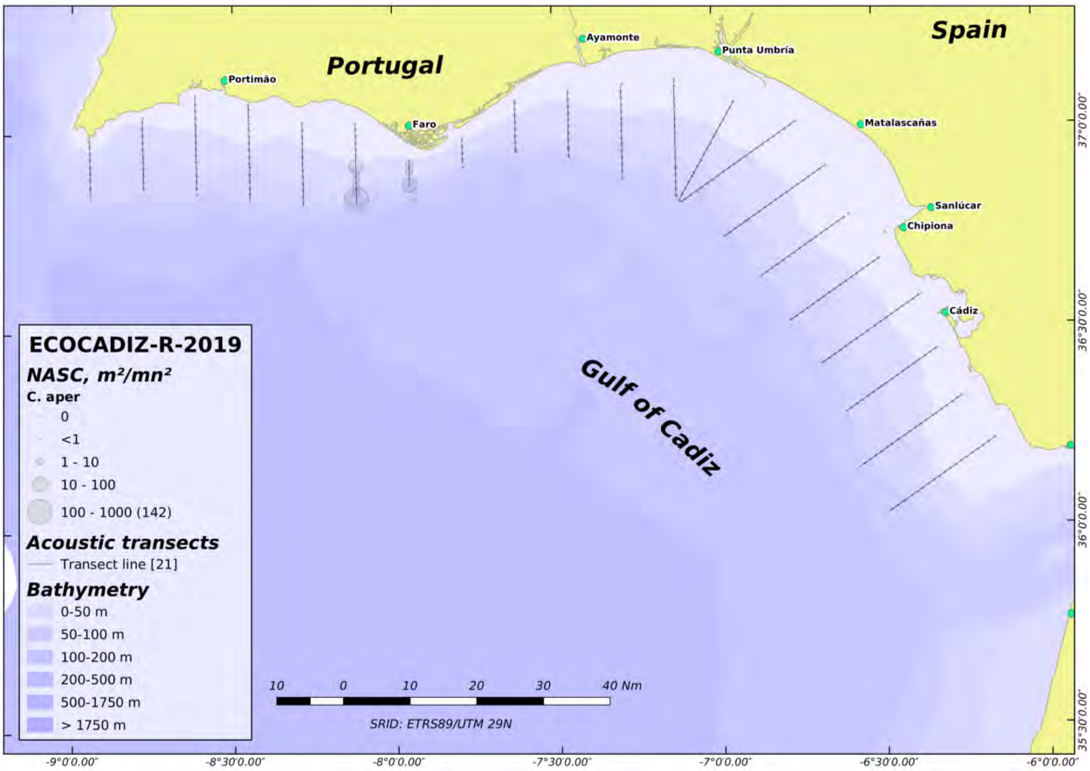


Figure 36. *ECOCADIZ-RECLUTAS 2019-10* survey. Boarfish (*Capros aper*). Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.



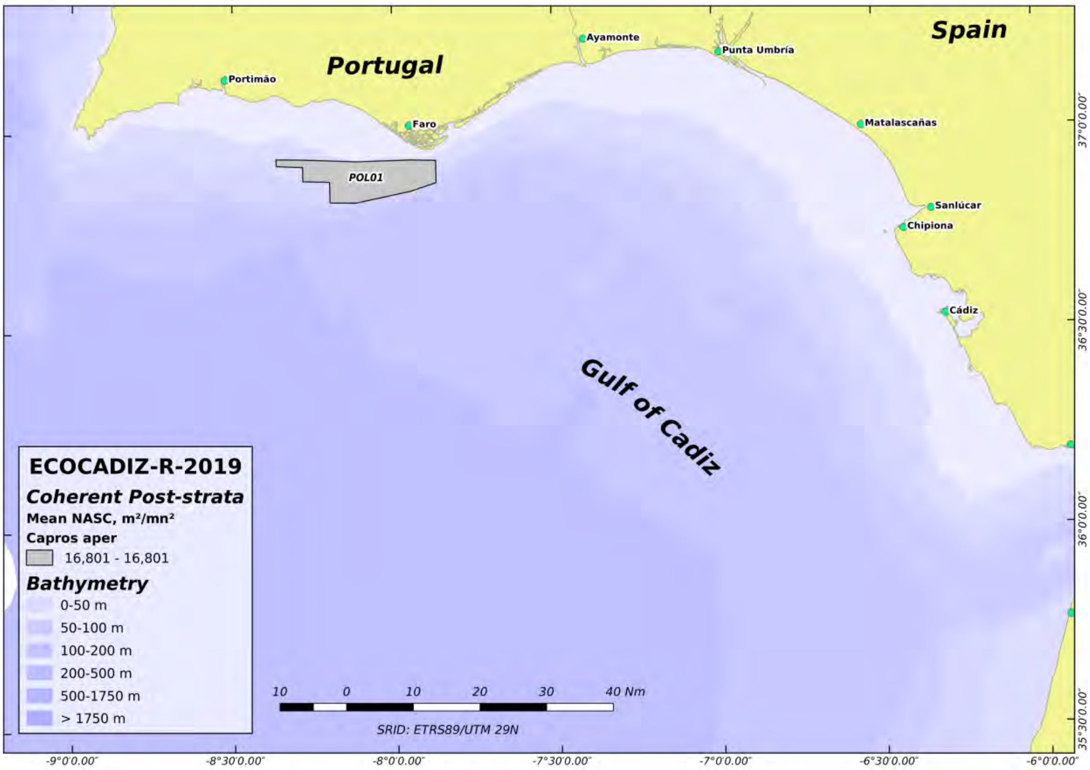


Figure 37. *ECOCADIZ-RECLUTAS 2019-10* survey. Boarfish (*Capros aper*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

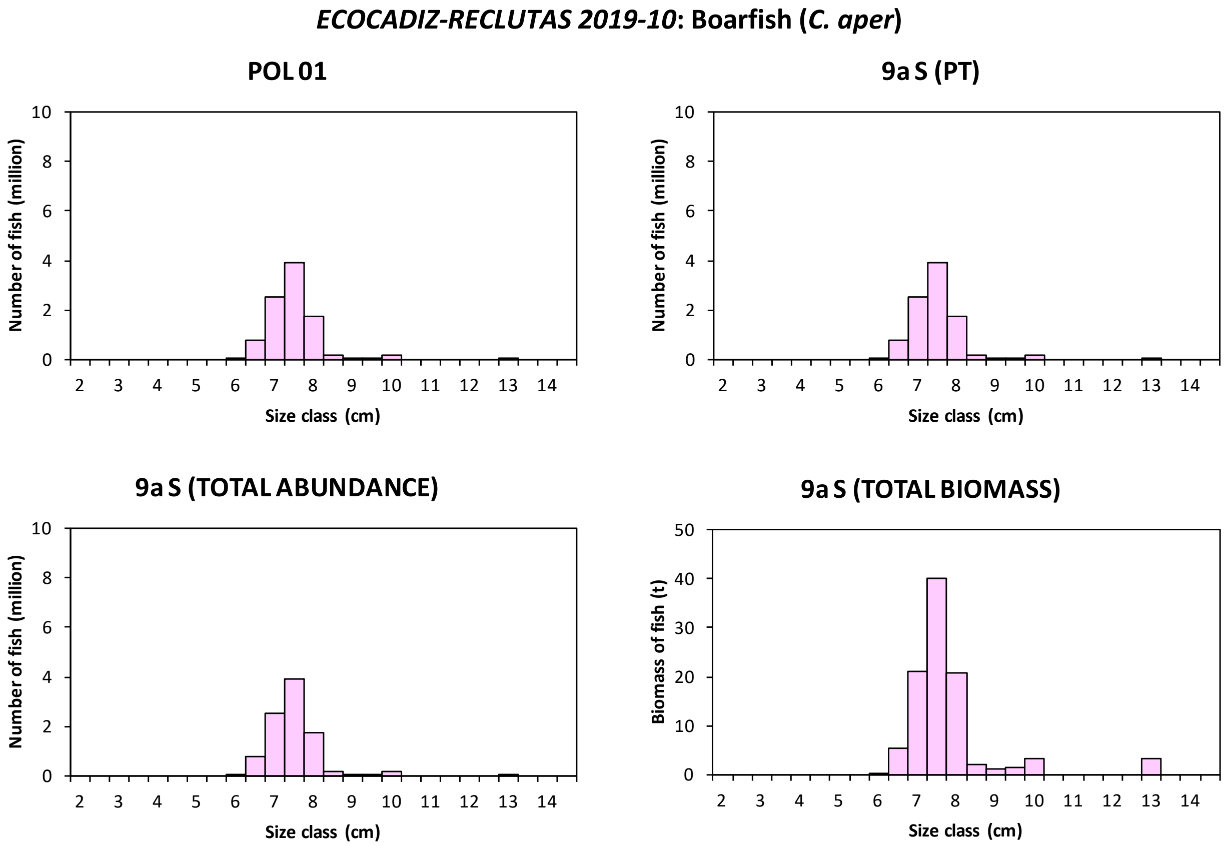


Figure 38. *ECOCADIZ-RECLUTAS 2019-10* survey. Boarfish (*Capros aper*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 37**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

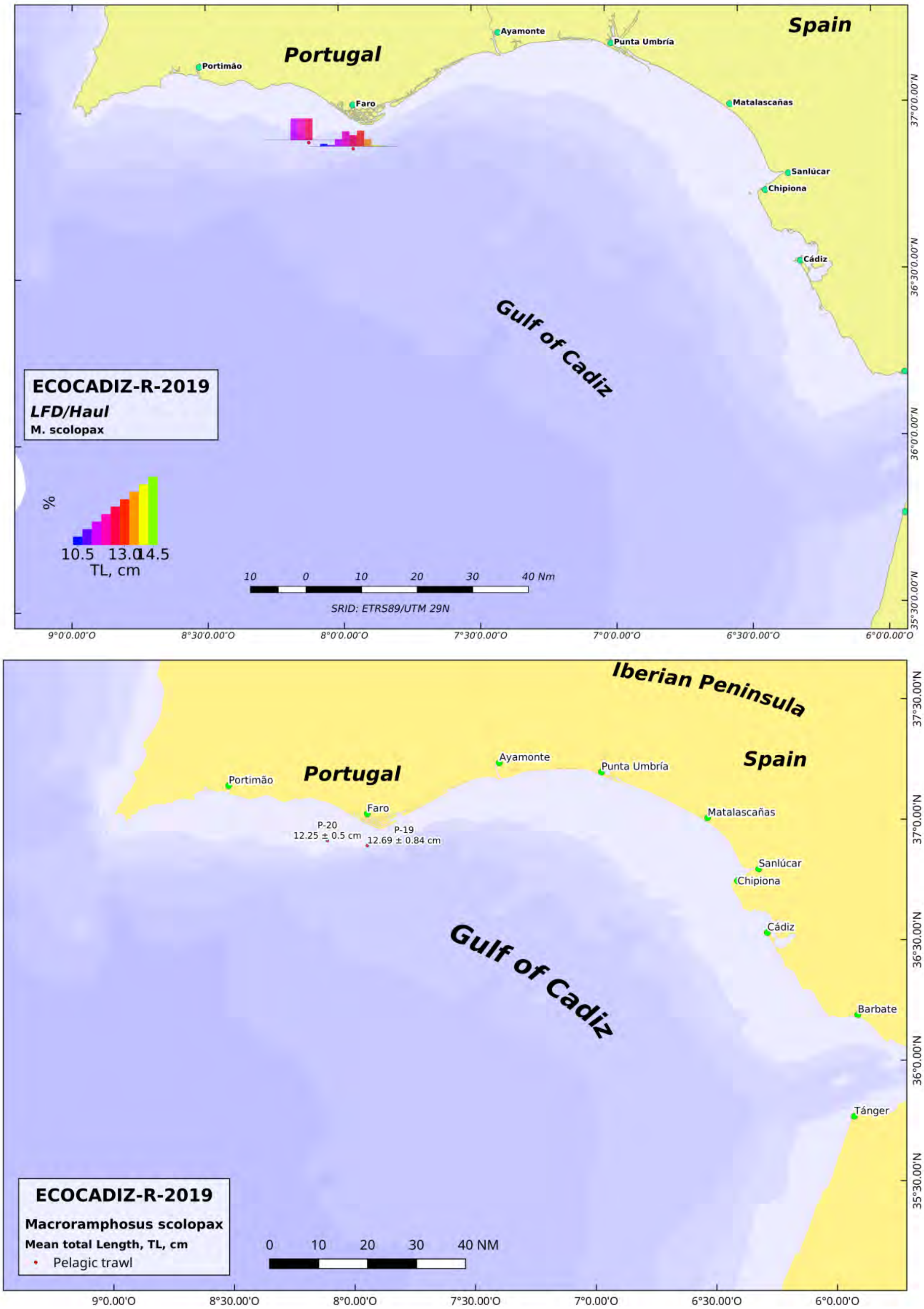
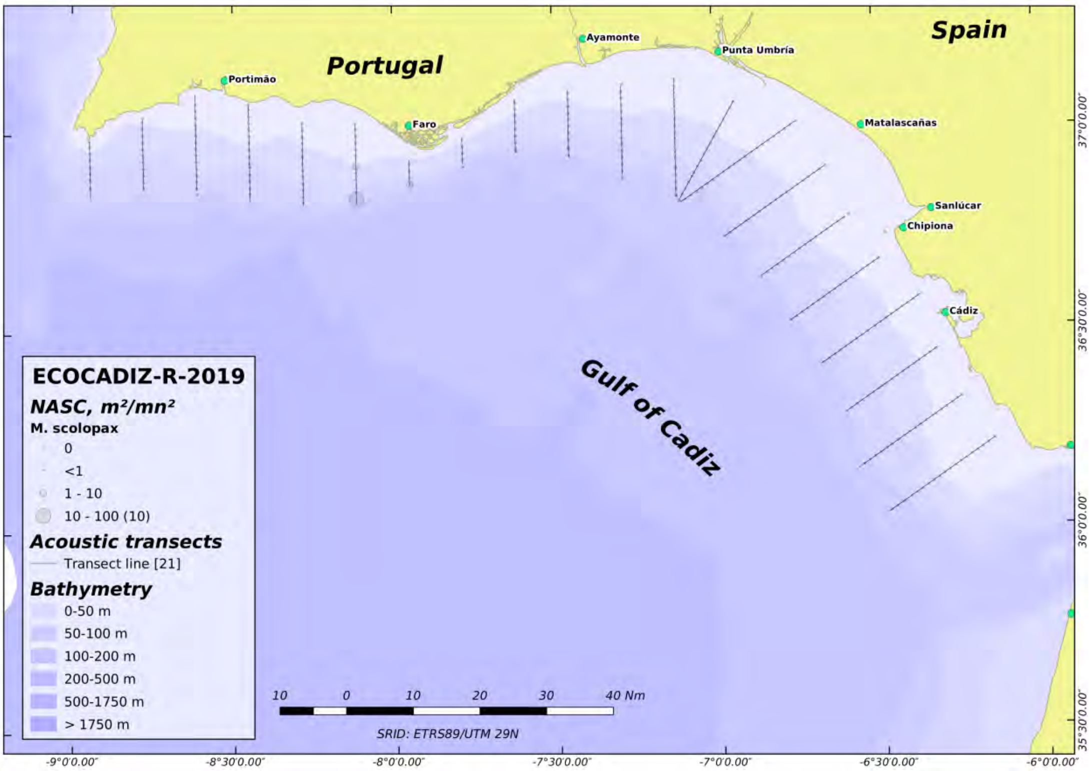


Figure 39. *ECOCADIZ-RECLUTAS 2019-10* survey. Longspine snipefish (*Macroramphosus scolopax*). Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.



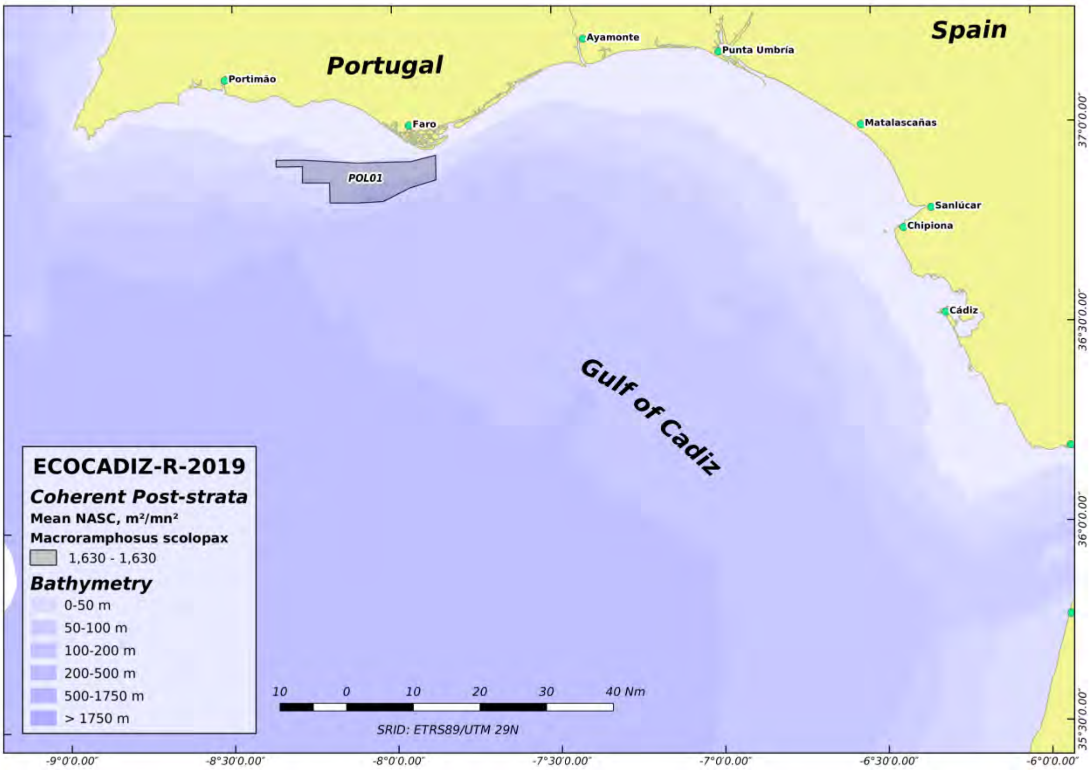


Figure 40. *ECOCADIZ-RECLUTAS 2019-10* survey. Longspine snipefish (*Macroramphosus scolopax*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used 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 2019-10: Longspine snipefish (_M. scolopax_)

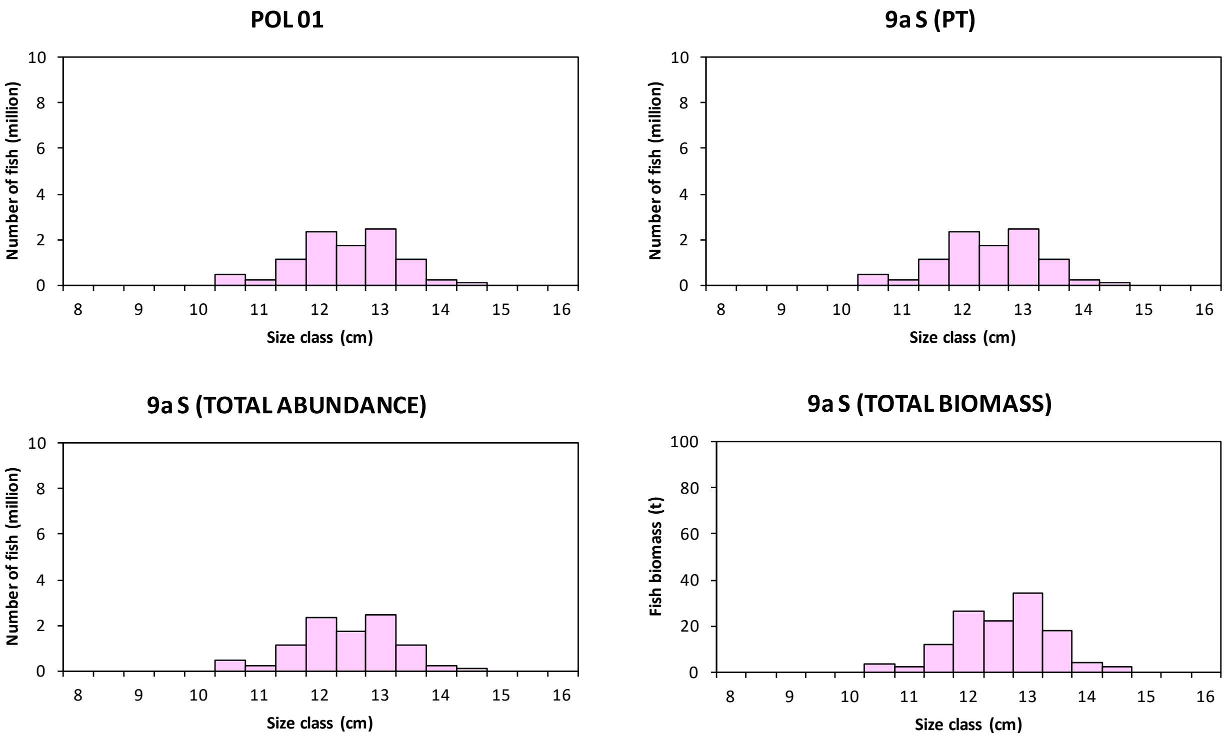


Figure 41. *ECOCADIZ-RECLUTAS 2019-10* survey. Longspine snipefish (*Macroramphosus scolopax*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 40**) and total sampled area. Post-strata ordered in the W-E direction. 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.

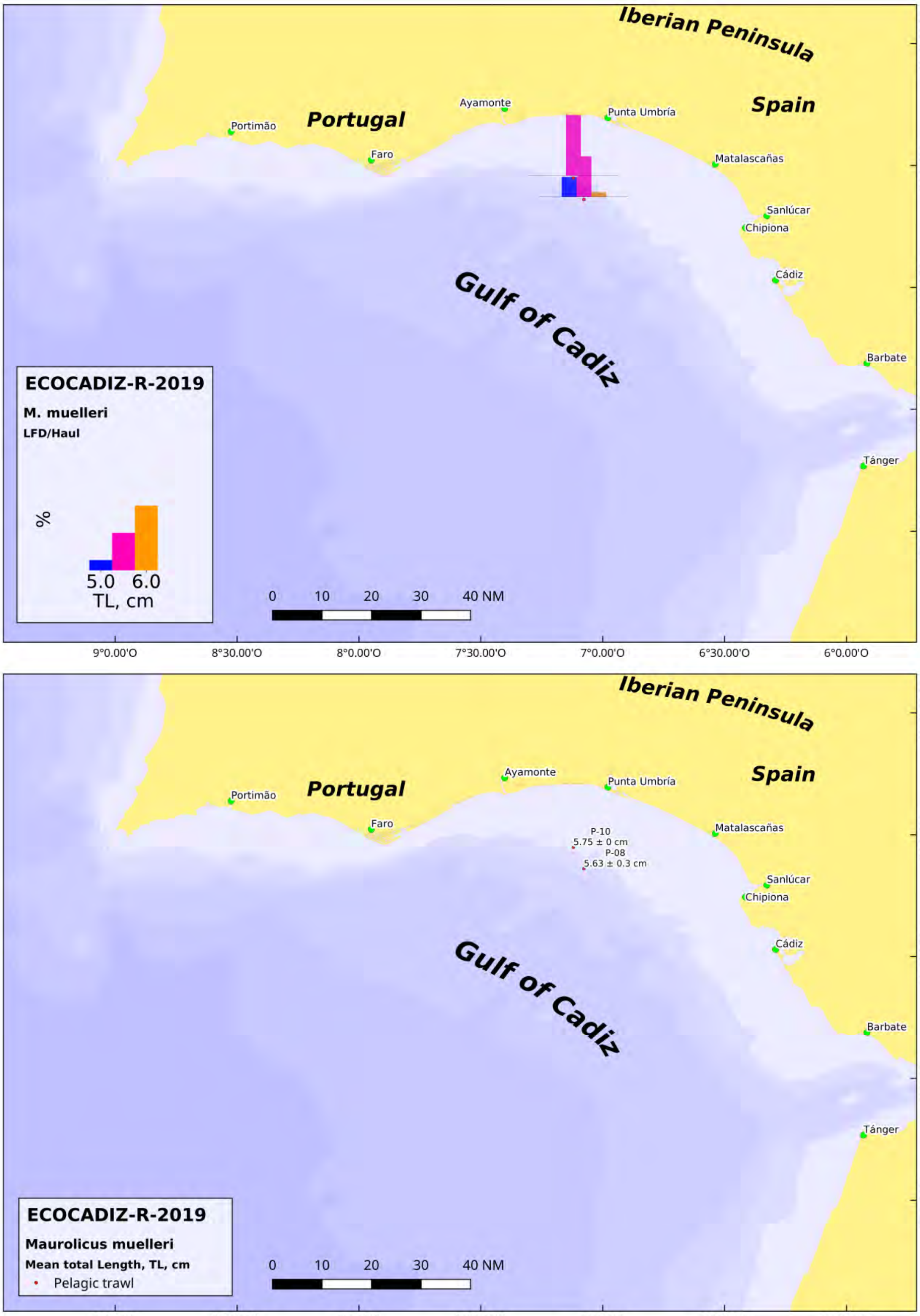
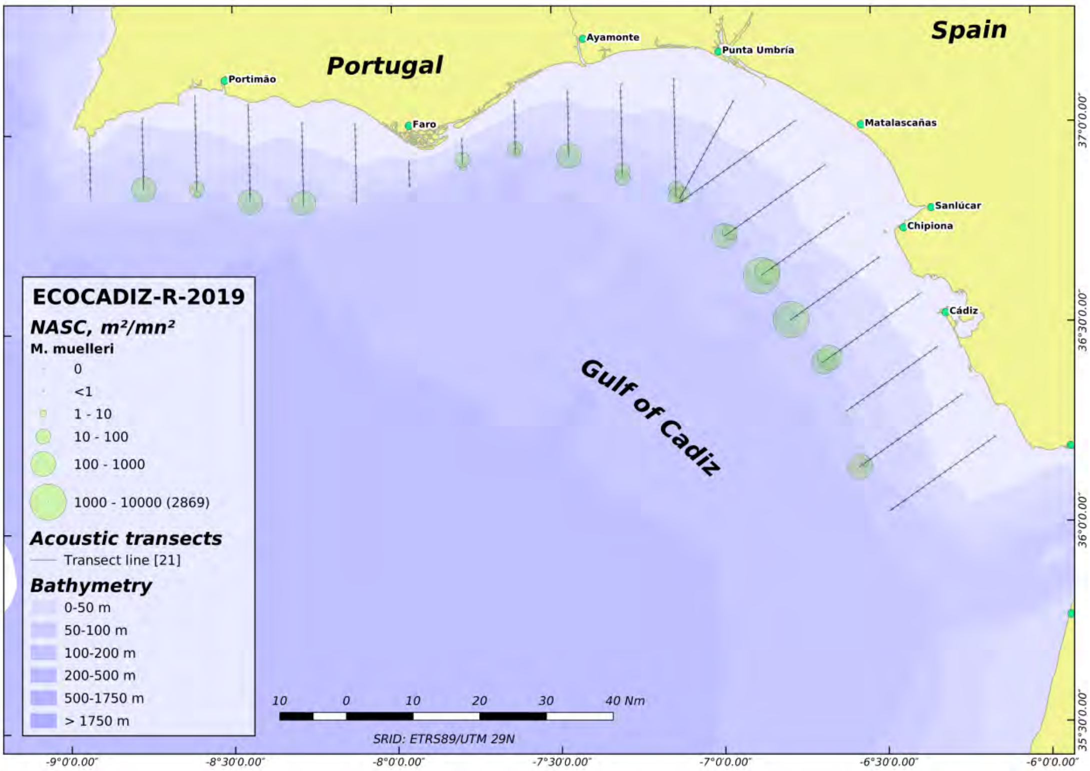


Figure 42. *ECOCADIZ-RECLUTAS 2019-10* survey. Pearlside (*Maurolicus muelleri*). Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.



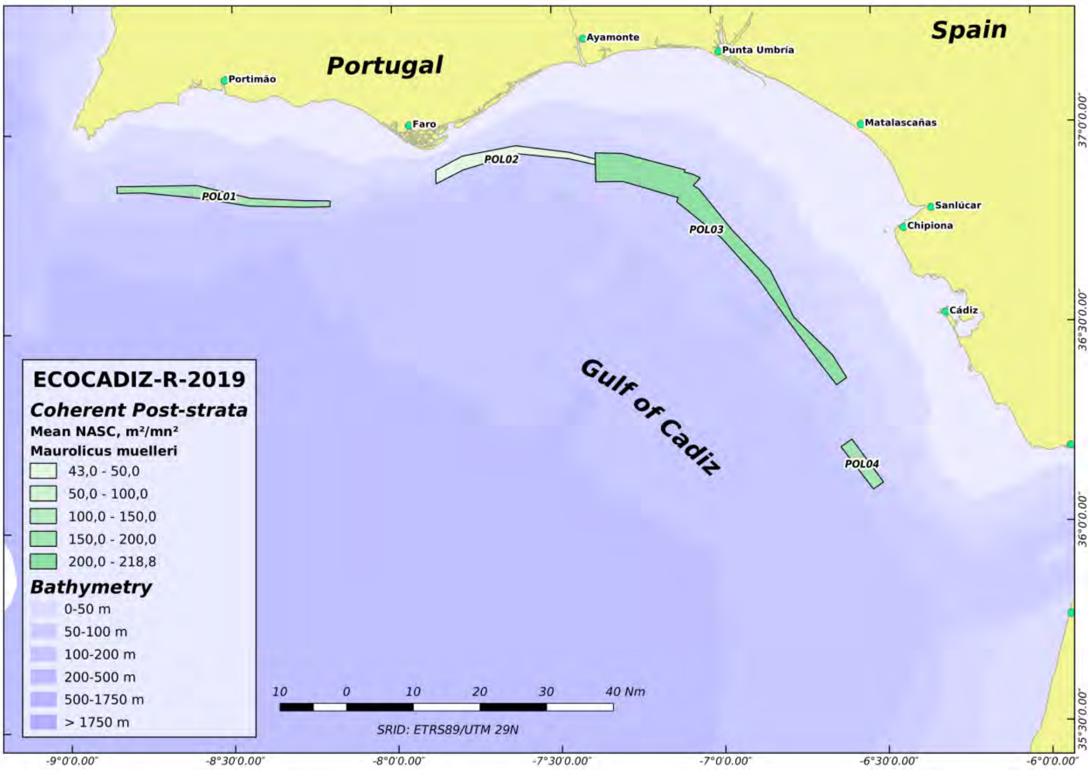


Figure 43. *ECOCADIZ-RECLUTAS 2019-10* survey. Pearlside (*Maurolicus muelleri*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

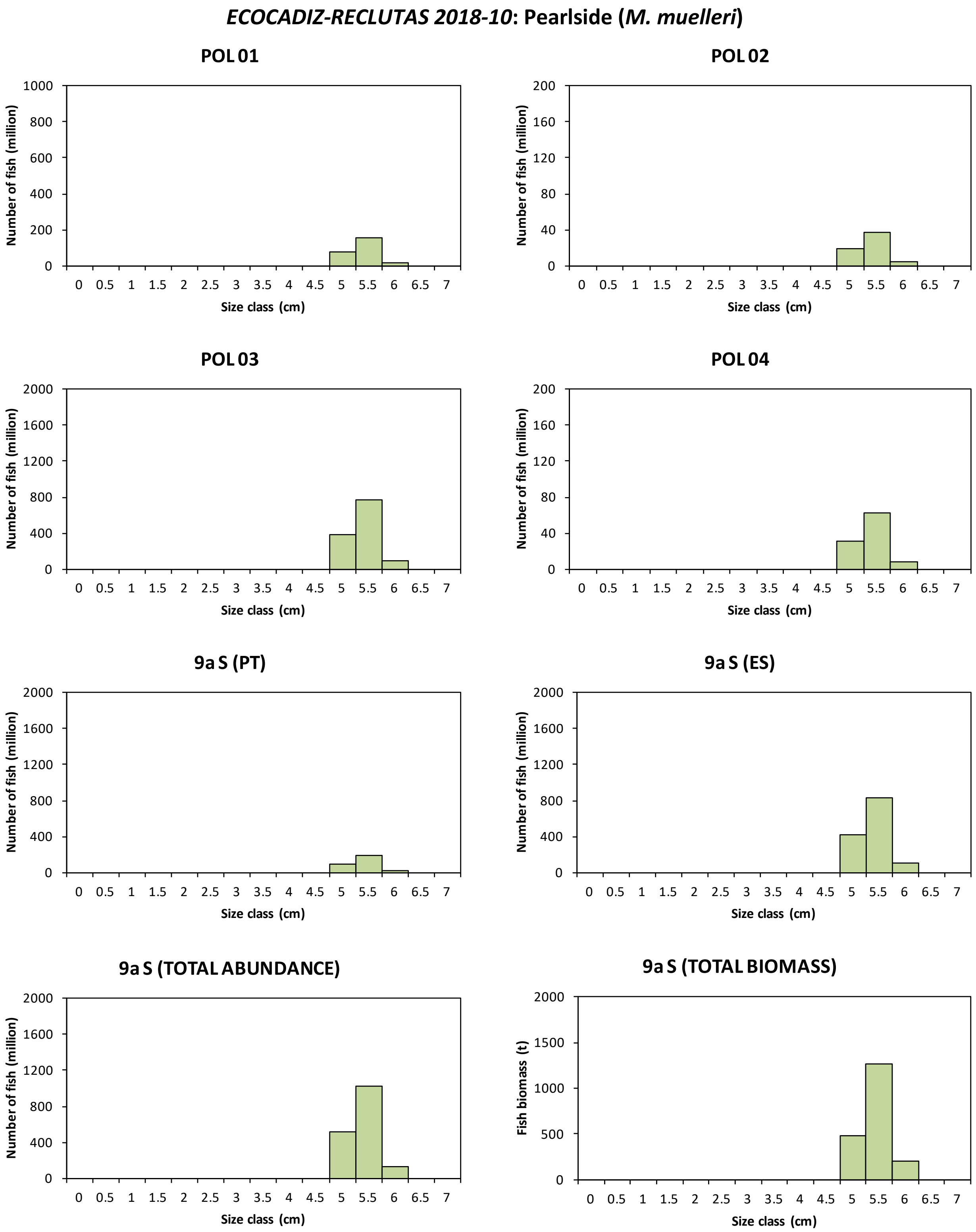


Figure 44. *ECOCADIZ-RECLUTAS 2019-10* survey. Pearlside (*Maurolicus muelleri*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 43**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

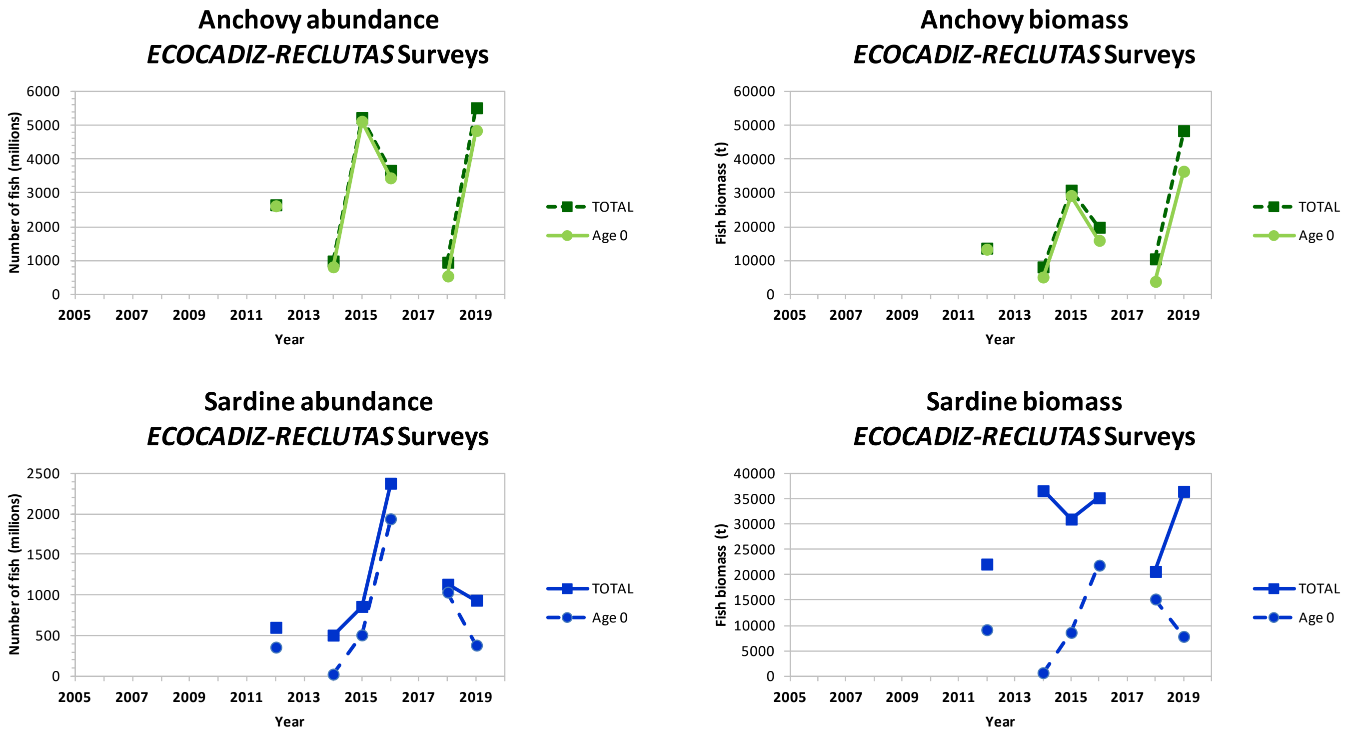


Figure 45. *ECOCADIZ-RECLUTAS* surveys series. Historical series of autumn acoustic estimates of anchovy and sardine abundance (million) and biomass (t) in Sub-division 9.a South. The estimates correspond to the total population and age 0 fish. The 2012 survey only surveyed the Spanish waters. No survey 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.

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

Date: 02/06/2020

Auditor: Andrés Uriarte and Alexandra Silva

General

The stock of anchovy in 9a is divided in western and southern components following the 2018 benchmark. Each component is assessed separately. Both components are classified in category 3 stocks. And Catch advice is based on the recently approved by ACOM, guidelines for Short-Lived Species category 3 stocks, whereby catch advice is changed from year to year according to the 1over2 trend rule subject to an uncertainty cap of +/- 80% (maximum relative allowable change between years).

Anchovy 9a South

For the southern component of anchovy in 9a (distributed in 9a South) the stock size indicator is the SSB (that equals B1+) at the end of the second quarter, as estimated from the GADGET model. This is the third year where advice will be provided and the second subject to the 80% Uncertainty cap.

The assessment of Anchovy 9a South

- carried out as expected (SALY) incorporating the new information from surveys (ECOCADIZ 2019 and PELAGO2020), and commercial catch in the last year (2019) with their quarterly ALKs and total for the first half of the year 2020 (assuming catches in May and June).

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 relative indicator of stock trends (not as absolute estimates).
3. **Forecast**: not presented/ Not required (this is like In-year advice following Catch advice Rule for category 3 short lived data limited stocks)
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, 2020 index included) and ECOCADIZ (Summer, 2019 index is the latest index available).
5. **Data issues:** are the data available as described in stock annex or have there been any issues with specific data / new data?

   Data were fully used. Information on the age structure (ALKs) from the spring acoustic surveys in 2019 and 2020.

   Some additional surveys (Iberas-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).

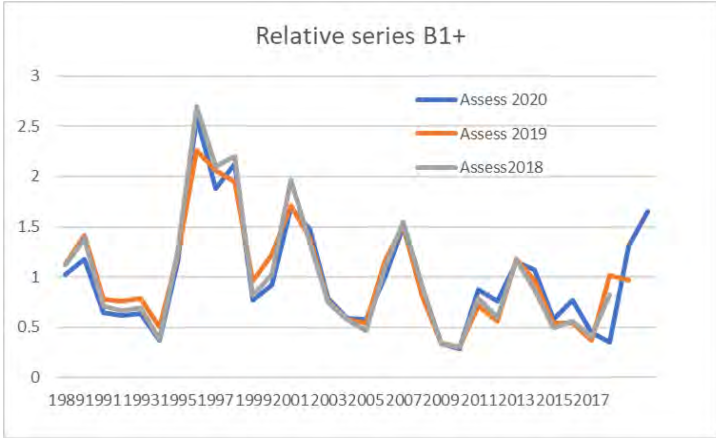
- An error in the Length– frequency distribution (LFD) input data from the ECOCADIZ series was discovered and amended during the working group. In previous years, the LFD corresponding with age 0 had not been removed from the LFD of this survey series. This was required because for this survey age 0 estimates are not taken as valid indicators of the age 0 abundance. Such correction is consistent with the settings of the stock annex. And age 0 had already been omitted from the ALKs corresponding to this ECOCADIZ survey series in previous years assessments.
- Discards started to be estimated in 2014. The discards amount to less than 5% of landings. And the catches used to fit the model should include those discards since 2014. However in the group, it has been noticed that in the assessment carried out in 2019, discards from years 2017 and 2018 were not included. This has been corrected now, and all catches since 2014 include now Landings & Discards. Sensitivity Analysis carried out during the meeting shows that the effect of including these discards is negligible in terms of the assessment (B1+ output).

6. **Consistency**: This new assessment is carried out accordingly to stock annex.

   Compared to last year assessment, there has been some revision of the series in absolute terms, whereby biomass has been rescaled downwards (by about 20%) and Fishing mortality inversely upwards. However, as regards this category 3 stock, the assessment is taken in relative terms, and from that point of view the assessment is basically unchanged and consistent in relative terms with past year relative series of B1+. The only remarkable change appears in the estimate of B1+ in year 2018, which is assessed to be about 35% of the estimate arising from the assessment carried out in WGHANSA 2019.

   Sensitivity analysis carried out during the group show that changes in the overall absolute level of the assessment were mainly due to the corrections in the LFD of the ECOCADIZ summery acoustic series, but this has no major influence on the relative output of the assessment of B1+. The same sensitivity analysis shows that the revision of the 2018 B1+ estimate is due to the new information coming from the most recent survey inputs included for the assessment carried out in this year 2020. In particular, the ECOCADIZ 2019 new input has been detected to induce the change in the 2018 estimate. As the 2018 B1+ estimate enters into the denominator of the rule followed to provide advice for the new management period it partly affects directly such advice.

   The reasons for the downward revision of the 2018 B1+ estimate is related to a lower than expected proportion of age 2 in the ECOCADIZ 2019 population at age estimates (which basically remains at 5% of the total Population 1+, and this value is almost equal to that observed in the other year 4%, therefore the strength of those two cohort should be quite similar as suggested by the current assessment). The fitting to this age 2 index is globally satisfactory and balanced between years, without any trend in residuals.



7. **Stock status**: Although the assessment is not taken as absolute but as relative, current B around 7101 t is 65% above historical mean series and supposes that $B>B_{lim}$ (taken as B_{loss} in 2010 in this assessment i.e. around 1220 t, or 0.289 in relative terms) and $B>B_{pa}$ (deduced from B_{lim} at 2000 t, or 0.46 in relative terms).
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, with an uncertainty cap of +/- 80%, applied to the advised catch for the previous management season (from 1 July 2019 to 30 June 2020). This is like in-year advice as approved in the stock annex for this category 3 stock. The 1over2 ratio is 1.98 and in this year the standard recommendation of applying a 80% uncertainty cap (in ICES guidelines for short lived species category 3 stocks) has been applied (see technical comments), so that a factor of 1.8 is used to multiply past year advice for this stock component. This implied a catch advice for the 2020 management period 80% higher than in 2019.

General comments

The assessment was well documented and the corrections to accommodate to the stock annex were duly justified and explained in the report.

Technical comments

The group acknowledges that the estimated SSB time-series for this year had changed in comparison with the SSB time series estimated last year. There were discrepancies for two points in the time-series, the estimates for 2019 and 2018. The discrepancy regarding 2019 estimate, was considered as expected considering that information for year 2019, in the assessment of 2019, was preliminary. However, for 2018, the estimates showed a big difference (being reduced to 35% of the level in the past assessment in WGHANSA 2019), which is produced mainly by new information provided on age composition by the latest two surveys (ECOCADIZ performed in July 2019 and PELAGO in April 2020).

By using the former ICES advice for 2019 (6287 t) the resulting advice for 2020 is 11 322 tonnes in the advice sheet, But by using what might have been the ICES advice for 2019, in case of having perceived the population as done from the current assessment (the advice for 2019 would have been 8057 t), then the catch advice for 2020 would have been of 14 502 t.
This implies the fact that the rule assumes that past advice was unbiased, but as far as our new assessment updates the past series estimates of the indicator B1+, it is saying at the same time that the trend based indicator for providing advice in 2019 was partially biased (as far as those biomass estimates B1+ have now been changed). Therefore the new application of the rule is incorporating a catch advise for the previous year which is now known to be not consistent with

what would have been advised in case of perceiving the population as in the current (most recent) assessment. This is probably a general problem, which may affect others stock in category 3 with an indicator linked to an analytical assessment.

This situation was not considered when putting forward the guidelines for category 3 short-lived species. Certainly, the stability/variability of the assessment producing the stock trend indicators is something has to be incorporated when assessing the performance of these HCRs for category 3 stocks, and it requires further investigations.

On the basis of the advice: ADVICE does not deviate from the standard ICES guidelines for category 3 short-lived stocks.

Conclusions

- The assessment has been performed correctly SALY.
- The stock is assessed to be above historical mean value in 2019 and 2020.
- A revision of the B1+ estimated in 2018 changes the perception of the biomass trends in recent years, affecting the provision of advice. The revision of the estimates of B1+ in recent years would have induced some changes in the advice produced in last year for 2019/2020. The current advice, which modifies former advice by a trend based rule (one over two) does not include any change in the previous advice.
- The advice does not deviates from the recently adopted standard ICES guidelines for category 3 stocks advice which allows a 80% uncertainty cap 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.
- 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? 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. but the revision of the estimates of B1+ in recent years may have induced some changes in the advice in previous years affecting current advice (if taken into account).
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice? Yes, but debatable… see comments above. Better formulation of HCR for category 3 short-lived stocks is required (see comments for the western component).

Audit of Anchovy 9a West

For the western component of anchovy in 9a (distributed in 9a South) the stock size indicator is the combined acoustic biomass (B1+) estimated from PELAGO spring acoustic survey over the continental wester shelf of Portugal (9a CN + 9aCS) and PELACUS in 9a N in spring as well. This is the third year where advice will be provided and the second subject to the 80% Uncertainty cap.

The assessment of Anchovy 9a western

Carried out as expected (SALY) incorporating the new information from PELAGO survey in 2020, raised up to account for the missing estimates in 9a N (as PELACUS survey could not take place in 2020 as result of the Covid19 alarm), plus the commercial catch in the last year (2019) and the first half of the year 2020 catches (assuming catches in May and June).

For single stock summary sheet advice (Western Component)

1. Assessment type: SALY (benchmarked in 2018)
2. **Assessment**: Direct input from the combined spring acoustic survey covering the subdivisions 9aN+9aCS+9aCN, but for this Category 3 stock the survey estimates are used just as relative indicator of stock trends (not as absolute estimates).
3. **Forecast**: not presented/ Not required (this is like In-year advice following Catch advice Rule One-over-Two for category 3 short-lived data-limited stocks).
4. **Assessment model**: Not applicable.
5. **Data issues:** The non-coverage of the area 9aNorth by the missing survey PELACUS2020 forced to infer the missing biomass from a regression between PELACUS and PELAGO B1+ estimates, which was highly significant. On average PELAGO accounts on average for about 88% of the total anchovy biomass estimates.

   Some additional surveys on recruits (Juvesar, or Iberas), though available, are not used in the assessment as agreed in the benchmark until proving a satisfactory performance in relation to the combined spring acoustic surveys in spring.

- This year a major increase in the spring acoustic estimate in 2020 compared to the 2019 estimate (larger than 1000%) has been reported. Part of this was due to a high abundance of age 2 individuals which do not follow from a local strong cohort detected in past years surveys.. Nor the PELAGO+PELACU estimates in 2019, neither the Iberan autumn survey can explain where these huge biomass (and high abundance of age 2) could come from, and concerns on accuracy of the acoustic biomass estimates, stock identity or connections with neighbouring populations, or age readings are put forward for considerations in the text.

  Minor data corrections: It was detected this year that the survey data prior to 2007, previously included in the summary tables and plots, corresponded only to PELAGO estimates. Therefore, the stock summary includes data only since 2007; earlier PELAGO estimates are kept in a table in the report and the advice sheet.

  The harvest rate was corrected to include catches instead of landings; since discards are tiny, the values are practically the same when rounded.

6. **Consistency**: This new assessment is carried out accordingly to stock annex.

   This year a major increase in the spring acoustic estimate in 2020 compared to the 2019 estimate (larger than 1000%) has been reported.

The inner consistency between the acoustic estimates can be weak (see bullet point above).

7. **Stock status**: Although the assessment is not taken as absolute but as relative, current B1+ around 565 000 t is well above historical mean series. No B_{lim} or $B_{trigger}$ has been defined for this western component.
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 combined acoustic estimate, with an uncertainty cap of +/- 80%, applied to the advised catch for the previous management season (from 1 July 2019 to 30 June 2020). This is like in-year advice as approved in the stock annex for this category 3 stock. The One-over-two ratio is 1.633 and for this year, there is no need of applying an 80% uncertainty cap. This implied a catch advice for the 2020 management of 4347 tonnes, corresponding to a Harvest rate HR=0.07.

General comments

In 2020, the acoustic index has reached the second highest value (50 282 tonnes from PELAGO without the PELACUS, and 56 526 tonnes after extrapolation with the regression between surveys for the missing coverage). Such estimate is similar to the historical maximum (65 096 tonnes record in 2018) that corresponded to an advice of 13 308 tonnes (HR=0.16). This year the advice will be 4347 tonnes, corresponding to a HR=0.07.

Technical comments

This is a copy of the draft comments for the summary sheet written by the group in the Issues relevant for the advice.

The expert group considered that the current advice procedure for short-lived species category 3 stocks, based on the 1over2 ratio with uncertainty cap of 80%, is still not flexible enough to adapt to the highly fluctuating nature of this stock. In the last year, when the rule was applied for the second time to the western component, the -80% uncertainty cap was applied to account for the greater decrease of the population and led to an advice for catches implying a harvest rate of about 62% over the biomass acoustic estimate in 2019. This year (2020), a sharp increase of the population was observed (by more than 1000% compared to the 2019 estimate), restoring the biomass to a similar level as the maximum recorded two years ago. The advised catch, however, following the 1over2 rule indicated just an upward revision of a 63% of previous catch advice. This implies an advised harvest rate of 7% in 2020 compared to the estimate of biomass provided by the acoustic survey in this year. This implies a huge change in harvest rates between these two consecutive years (63% in 2019 to 7% in 2020).

The WG considers that the current Rule (1over2 with 80% UCap) cannot accommodate to the highly fluctuating biomasses. To restore previous levels of catches (as the one in 2018) after the reduction by 80% adopted in 2019, it would be required an increase of about 500% (a result from 1/(1–0.8)). This would never be allowed by the 80% Uncertainty Cap. This catch diminishing property of this rule was already mentioned in the section of caveats of the guidelines for provision of advice for SLS Category 3 stocks adopted by ACOM. For the observed high interannual changes in abundances this may result in a too intense and fast reduction of catches in a very short period of years, damaging unnecessarily the fishing opportunities. This confirms that this approach (1over2 with 80%UC) can only be taken as an interim approach while a better formulation for providing advice can be established, either by allowing greater uncertainty caps (such as being capable of restoring catch levels when sharp increases of the population occurs) or simply by applying harvest rates to the most recent biomass estimates from surveys.

Another problem related to this formulation derives directly from the 1over2 trend based rule. This rule implies that the mean in the denominator, referring to the mean biomass of the two previous years, is presumed to be a good indicator of the previous status of the stock. However, for rapidly changing resources, the ratio between current biomass estimates and the mean of the two previous year may be misleading, compared with the trend between the current and previous year biomass estimates. This suggests that moving the rules from the 1over2 to the 1over1 might be necessary, which is equal to just applying a constant harvest rate in future years. This consideration again suggest that HCRs based on either fixed or gradually changing harvest rates might be preferable to the 1over2 to better accommodate the fluctuations in abundance of these populations.

Current comments do also apply to the Anchovy Southern component.

On the basis of the advice: ADVICE does not deviate from the standard ICES guidelines for category 3 short-lived stocks.

Conclusions

- The assessment has been performed correctly SALY.
- The stock is assessed to be above historical mean value in 2020 (but it was not in 2019) according to the acoustic estimates.
- The advice does not deviate from the recently adopted standard ICES guidelines for category 3 stocks advice which allows an 80% uncertainty cap for short-lived species, though serious doubts were raised up by the group on the suitability of this approach (1over2 with 80% UCap) to this highly oscillating anchovy resources.

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? Yes, except for the raising procedure adopted to infer the missing biomass for the uncovered 9aN region.
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex? Not applicable.
- Is there any **major** reason to deviate from the standard procedure for this stock? No. The indicator is still to be based on the combined spring acoustic survey estimates.
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice? Serious concern on the applicability of the current rule for short-lived category 3 stocks are passed to ACOM. Better formulation of HCR for category 3 short-lived stocks is recommended, and suggestions go in line with either allowing greater uncertainty caps (such as being capable of restoring catch levels when sharp increases of the population occur) or simply by applying fixed or gradually changing harvest rates to the most recent biomass estimates from surveys.

Audit of Southern Horse Mackerel (hom.27.9a)

Date: 01/06/2020

Auditor: Manuela Azevedo

General

Input data for stock assessment and short-term forecast was checked by confronting the report tables and the input data codes; no errors were found.

For single-stock summary sheet advice

1. Assessment type: update.
2. Assessment: analytical.
3. Forecast: presented.
4. Assessment model: AMISH (as in stock annex) - tuning by 1 survey (IBTS Q4: combined PT + SP surveys).
5. Data issues: Missing PT survey in 2019 hence assessment tuning performed with survey time-series 1992–2018.
6. Consistency: stock perception consistent with last year: Fishing mortality well below F_{MSY} over the whole time-series; SSB increasing since 2011; R above the time-series average since 2011.
7. Stock status: SSB >> $MSYB_{trigger}$; F << F_{MSY}, R high
8. Management Plan: A management plan has been evaluated by ICES and considered to be precautionary. However, ICES was requested by the EU to base the advice for 2021 on the ICES MSY approach.

Technical comments

Due to the lack of PT IBTS survey Q4 in 2019, a combined survey index (PT + SP) for 2019 was not available for assessment tuning purposes. The group discussed the ACOM document made available this year with proposed approaches to deal with missing survey abundance series and performed a sensitivity analysis. The sensitivity analysis was conducted by removing the survey index in 2018 and in 2017 and comparing the stock trajectories of SSB and F_{bar} with the 2017, 2018 and 2019 assessments estimates. Results supported accepting an updated assessment without survey index in 2019. However, uncertainty in the 2018 and 2019 year-classes (R) estimates was very high. The R2018 and R2019 assumed in the short-term forecast were replaced by the geometric mean of 2008 to 2017. This is a deviation from the stock annex (GM based on the whole time-series, i.e. period starting in 1992) but the period 2008–2017 was selected to reflect the stronger year-classes observed in the last years, which was also a recommendation from ADGHANSA 2019.

Conclusions

The update assessment gives a valid basis for advice. It is noted, however, that there has been a continued and significant shift in relative catch contribution from bottom trawls to purse-seines in recent years (particularly in the last two years) which has led to a change in the age composition of catches, with an increase in the proportion of 1–2 year old fish (juveniles and young immature fish). This may violate the assumption of constant selectivity on the last period of the assessment (since 2011) and should be further investigated.

Audit of Sardine in 8c9a (pil.8c9a)

Date: 29/5/2020

Auditor: Leire Ibaibarriaga

General

The last assessment of this stock was carried out in November 2019 and the ICES advice was published on December 2019. The stock in 2019 was assessed to be below B_{lim} and ICES advised catches in 2020 to be no more than 4142 tonnes. Based on the most recent survey results (PELAGO 2020, IBERAS 2019) that pointed out to an increase in recruitment, there has been a special request of Portugal and Spain to update the scientific advice for 2020. In addition, DGMARE requested ICES that the advice to 2021 was moved from November to June. Therefore, the assessment results will be used to answer both requests: update 2020 advice and release 2021 advice.

Due to the Covid-19 disruption, the Spanish PELACUS acoustic survey was not conducted in 2020. The total biomass and the age structure indices of this survey are used in combination with the Portuguese PELAGO survey to tune the assessment model. The lack of part of the indices lead the WG to take decisions on how to deal with this issue. All the decisions (see below) were endorsed by an in-depth analysis based on the historical series.

The stock is classified in Category 1. The stock was last benchmarked in February 2017 (ICES, WKPELA 2017). In November 2019, new reference points were calculated to reflect the recent lower productivity of the stock and the stock annex was updated accordingly. For the audit, the stock annex that was last updated in November 2019 was used.

For single-stock summary sheet advice

1. Assessment type: SALY
2. Assessment: analytical
3. Forecast: presented
4. Assessment model: Stock Synthesis (SS3) V3.30.11.00 (Methot and Wetzel, 2013).

   The model is tuned by SSB from the triennial Portuguese and Spanish DEPM surveys (PT-DEPM and SP-DEPM) and total abundance (numbers) and age structure from the Portuguese and Spanish spring acoustic surveys (PELAGO and PELACUS). These joint surveys provide a full coverage of the stock area (ICES areas 8.c and 9.a). In addition, total catch and age proportions in the catch are used.

5. **Data issues:** Due to the Covid-19 disruption, the PELACUS survey was not conducted in 2020. To overcome this, a statistically significant linear regression model between the total abundance of the PELAGO and the PELACUS surveys was used to infer the total abundance of the PELACUS survey in 2020. Regarding the age structure of the combined PELACUS-PELAGO index, the age structure of the PELAGO index was used. Although the age structure provided by both indices cannot be assumed to be the same, the larger contribution comes from the PELAGO survey and a sensitivity analysis with past assessments showed the results to be quite robust to this assumption.

   This year there was a change in the vessel used to conduct the PELAGO survey, but WGACEGG supported its use for assessment purposes (online meeting).

In 2020, the triennial Portuguese and Spanish DEPM surveys were expected to be conducted. However, the Spanish DEPM survey was not conducted. These results are not ready yet to be included in the assessment, but the lack of part of this index should be dealt in the next assessment when the DEPM SSB estimates are provided.

6. Consistency: The assessment is consistent with last year assessment. The recruitment in 2018 and 2019 have been revised upwards significantly. As a result B1+ in these years has been also revised upwards. Fishing mortality remains basically the same in 2019 as in the last assessment.
7. **Stock status**: After some years in which B has been below B_{lim}, SSB in 2020 is assessed to be above MSY $B_{trigger}$. $F_{MSY} < F < F_{pa}$. R is the highest since 2004.
8. Management Plan: There is no official TAC for this stock. ICES advice is based on the MSY approach. However, there is a bilateral agreement between Portugal and Spain stating that the fishery will be managed based on HCR12. This rule was assessed by ICES as precautionary in 2019.

General comments

The assessment was well documented, and deviations from the stock annex that were caused by the Covid-19 disruption were duly justified and explained in the report.

Technical comments

None

Conclusions

The assessment has been performed correctly. Deviations from the stock annex were due to the lack of surveys occasioned by the Covid-19 disruption. A new section to deal with the problems caused by the Covid-19 disruption has been added to the report. Everything is well justified and documented in the report.

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? Deviations from the stock annex due to the Covid-19 disruption have been well documented in the report.
- 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? ICES advice is based on the MSY approach, however there is a HCR evaluated as precautionary by ICES.
- 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? The deviations are due to the lack of surveys because of the Covid-19 disruption.
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice? Yes

Annex 5: Resolutions

Resolution to be submitted December 2019

2019/2/FRSG13 The **Working Group on Southern Horse Mackerel Anchovy and Sardine (WGHANSA)**, chaired by Alexandra Silva, Portugal, will meet by correspondence on 25–29 May 2020 (WGHANSA1) and at IPMA in Lisbon, Portugal, on 23–26 November 2020 (WGHANSA2) to:

a) Address generic ToRs for Regional and Species Working Groups for relevant stocks (hom.27.9a, ane.27.9a and pil.27.8c9a in WGHANSA1 and pil.27.7, pil.27.8abd, ane.27.8 and jaa.27.10a2 in WGHANSA2);
b) Explore data from juvenile surveys (e.g. JUVESAR, JUVENA, ECOCADIZ, RECLUTAS) for future incorporation in the assessments;
c) c) Address the special request from Portugal-Spain on a revised advice on fishing opportunities for 2020 for pil.27.8c9a by updating the catch advice for 2020 based on the results of an updated stock assessment.

The assessments will be carried out on the basis of the Stock Annexes. The assessments must be available for audit on the first day of the meeting.

Material and data relevant for the meeting must be available to the group on the dates specified in the 2020 ICES data call.

WGHANSA1 will report by 5 June 2020 and WGHANSA2 will report by 2 December 2020 for the attention of ACOM.

Only experts appointed by national Delegates or appointed in consultation with the national Delegates of the expert's country can attend this Expert Group

Due to the COVID-19 disruption that started early 2020, ACOM drafted a "spring 2020 approach" for recurring fishing opportunities advice. The generic Terms of Reference have been adjusted as described in the letter to ICES chairs below.

Chairs of Expert Groups

Our Ref: C 4.e/MDC/mo 13 March 2020

Subject: **Spring 2020 approach to advice production**

Dear Expert Group Chair,

I am writing this letter to keep you up to date about the approach of ACOM to the COVID-19 disruption. Many of our institutes now have travel bans and/or working from home policies. ACOM has developed a "spring 2020 approach" to this year's spring advice season. This letter covers the recurrent fishing opportunities advice. Any special request processes and non-fisheries advice will be dealt with separately. The expert groups effected are listed in Annex 1.

ACOM is encouraging all expert groups to keep working, and stick broadly to the time line, but clearly this needs to be through virtual meetings. ICES secretariat will support your efforts and make WebEx available. They will also produce a broad training document on WebEx. We know that the use of virtual meetings will result in an increased burden on the Chairs and members of the expert groups, therefore we have made changes to the generic terms of reference (see Annex 2 below) categorizing them as high, medium and low priority for this year's work. We also suggest that the expert group works virtually through smaller subgroups, and only hold larger virtual meetings when necessary.

The requesters of advice have been informed that there will be disruption/change to the delivery of advice for the spring 2020 season.

ACOM will also change the way that ICES gives advice for the spring 2020 season. There will be three types of advice:

- **Standard advice** sheet (the advice sheet following the January 2020 guidelines)
- **Abbreviated advice** sheet (a shortened advice sheet)
- **Rollover advice** (the same advice as in 2019)

ICES CIEM
International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer
H. C. Andersens Boulevard 44-46, 1553 Copenhagen V Denmark
+45 33 38 67 00
info@ices.dk | www.ices.dk

The choice of which type of advice to apply to a stock is based on criteria determined by ACOM:

a. **Standard advice** - stocks with 2020 benchmarked methods
b. **Abbreviated advice** – most stocks, including management plan and MSY advice stocks, and some Cat 3 stocks. The abbreviated advice will contain the advice of the headline advice, catch scenario tables, plots and automated tables (last years' advice will be added as an annex to each sheet). The guidance for abbreviated advice is being written now and you should receive it in a few days.
c. **Rollover advice** – same as 2019 advice. This will be provided for stocks in the following categories:
    - zero TAC has been advised in recent years and no change likely,
    - category 3 or greater roll over advice, except if due to be reviewed in 2020
    - long lived stable stocks, with no strong trends in dynamics in recent years
    - some non-standard stocks (e.g. North Atlantic salmon)

We need to consult both you and the requesters of advice about which type of advice to apply to each stock. Today the ACOM criteria are being used by the secretariat to allocate advice types to stocks. This is the first version. We would like you to consider this list and comment if you think that the allocation needs changing. Please remember that the abbreviated advice is being developed to help your processes and also the ACOM processes during the disruption. The list of allocated advice type for each stock will hopefully be sent to you today or Monday. Please reply with your comments by 19th March so that we can start the dialogue with requesters. ACOM hopes that we could have a definitive list by 25th March. (This is too late for HAWG, so we suggest that HAWG use the list compiled in cooperation with Secretariat expecting requesters of advice to agree).

ACOM is recommending that for North Sea stocks with re-opening of advice in the autumn, the stock assessments be carried out in the spring but not the forecasts (postponed until early autumn). The advice would be delivered in the autumn of 2020.

You will shortly receive the first version of the **list of advice types allocated to stocks** and the **guidelines for abbreviated advice**. Please respond by 19th March with your comments on the first version of the list. Your professional officer has been briefed about these changes. The changes are designed to reduce both expert group and ACOM workload. Lotte, your professional officer, the ACOM leadership and the FRSG Chair are available for further explanation.

Best regards

Mark

Mark Dickey-Collas
ACOM Chair

Annex 1. Expert groups associated with 2020 spring advice season

Herring Assessment Working Group for the Area South of 62°N
Working Group on North Atlantic Salmon*
Assessment Working Group on Baltic Salmon and Trout*
Baltic Fisheries Assessment Working Group
Arctic Fisheries Working Group
Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak
North-Western Working Group
Working Group on the Biology and Assessment of Deep-sea Fisheries Resources
Working Group for the Bay of Biscay and the Iberian Waters Ecoregion
Working Group for the Celtic Seas Ecoregion
Working Group on Southern Horse Mackerel, Anchovy, and Sardine
Working Group on Elasmobranch Fishes

* These groups already have different approaches.

Annex 2. Spring 2020 adapted generic terms of reference. [Agreed by ACOM 12 March 2020]

In light of the disruptions caused by COVID-19 in 2020, the generic terms of reference for the FRSG stock assessment groups have been re-prioritised. This applies to expert groups that feed into the spring advice season process[1]. ACOM is encouraging expert groups to use virtual meetings (e.g. WebEx) and subgroups to deliver the high priority terms of reference. See letter from the ACOM Chair to expert groups.

High Priority for spring 2020 advice season

c) Conduct an assessment on the stock(s) to be addressed in 2020 using the method (analytical, forecast or trends indicators) as described in the stock annex and produce a brief report of the work carried out regarding the stock, summarising where the item is relevant. **Check the list of the stocks to be done in detail and those to roll over.**
   i) Input data and examination of data quality;
   ii) Where misreporting of catches is significant, provide qualitative and where possible quantitative information and describe the methods used to obtain the information;
   iii) For relevant stocks (i.e., all stocks with catches in the NEAFC Regulatory Area) estimate the percentage of the total catch that has been taken in the NEAFC Regulatory Area in 2019.
   v) The developments in spawning stock biomass, total stock biomass, fishing mortality, catches (wanted and unwanted landings and discards) using the method described in the stock annex;
   vi) The state of the stocks against relevant reference points;
   vii) Catch scenarios for next year(s) for the stocks for which ICES has been requested to provide advice on fishing opportunities;
   viii) Historical and analytical performance of the assessment and catch options with a succinct description of quality issues with these. For the analytical performance of category 1 and 2 age-structured assessment, report the mean Mohn's rho (assessment retrospective (bias) analysis) values for R, SSB and F. The WG report should include a plot of this retrospective analysis. The values should be calculated in accordance with the "Guidance for completing ToR viii) of the Generic ToRs for Regional and Species Working Groups - Retrospective bias in assessment" and reported using the ICES application for this purpose.

d) Produce a first draft of the advice on the stocks under considerations according to ACOM guidelines. Check list to confirm whether the stock requires a concise advice sheet or a traditional advice sheet.

f) Prepare the data calls for the next year update assessment and for planned data evaluation workshops;

j) Audit all data and methods used to produce stock assessments and projections.

[1] These do not apply to Assessment Working Group on Baltic Salmon and Trout and Working Group on North Atlantic Salmon.

Medium Priority for spring 2020 advice season

a) Consider and comment on Ecosystem and Fisheries overviews where available;

b) For the aim of providing input for the Fisheries Overviews, consider and comment for the fisheries relevant to the working group on:

  i) descriptions of ecosystem impacts of fisheries

  ii) descriptions of developments and recent changes to the fisheries

  iii) mixed fisheries considerations, and

  iv) emerging issues of relevance for the management of the fisheries;

e) Review progress on benchmark processes of relevance to the Expert Group; High for application;

Low Priority for spring 2020 advice season

c iv) Estimate MSY proxy reference points for the category 3 and 4 stocks

g) Identify research needs of relevance for the work of the Expert Group.

h) Review and update information regarding operational issues and research priorities and the Fisheries Resources Steering Group SharePoint site.

i) Take 15 minutes, and fill a line in the audit spread sheet 'Monitor and alert for changes in ecosystem/fisheries productivity'; for stocks with less information that do not fit into this approach (e.g. higher categories >3) briefly note in the report where and how productivity, species interactions, habitat and distributional changes, including those related to climate-change, have been considered in the advice. ACOM would encourage expert groups to carry out this term of reference later in the year through a webex.

Annex 6: Special Request to ICES pil.27.8c9a

Request to ICES

An updated assessment of the 2020 advice with the most recent information and considering the management plan 2018–2023 already agreed with the harvest control rule (HCR12), already approved by ICES in December 2019. ICES will follow the ICES framework for MSY advice as agreed with DGMARE, who is the advice requester for this stock. Thus, the updated advice will follow the ICES MSY framework and the HCR12 option in the Management Plan (2018–2023) will be presented in the Catch Scenarios.

Background for request

For both Portugal and Spain, an update of the 2020 advice for the Iberian sardine (divisions 8c and 9a) is of utmost priority, using 2019 landings data and the most recent information from the spring 2020 PELAGO survey. We have very positive expectations due to the recruitment level observed last fall by JUVESAR survey and Iberas, and confirmed by the 2020 acoustic survey. Therefore, fishing opportunities for 2020 should be re-evaluated. Sardine fishery is seasonal, will reopen in the summer, and it is very important to have an in-year assessment for to base the 2020 captures.